

Round Hill Surface Water Impact Assessment

Prepared for Darkwater Pty Ltd.

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SURFACE WATER SOLUTIONS

www.surfacewater.biz

15 Grange Crescent
Gooseberry Hill WA 6076

+61 400 367 542
info@surfacewater.biz



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Executive Summary

HanRoy (The Client) is conducting Mining Studies and environmental impact assessments for the proposed Round Hill Iron Ore Project (Round Hill), an open pit iron ore mine in the Pilbara region of Western Australia.

Surface Water Solutions (SWS) have been engaged by Darkwater on behalf of HanRoy to provide technical assistance related to surface water investigations based on proposed conceptual layouts. The scope of services includes rainfall-runoff assessments, hydraulic modelling, and reporting for the 20% Annual Exceedance Probability (AEP), 10% AEP, 5% AEP, and 1% AEP flood events.

A catchment area of approximately 15 km² drains toward the Round Hill site upstream of the proposed pits, and a total catchment area of approximately 41 km² drains to the GNH crossing. Eagle Rock Pool is located approximately 20 km downstream of the site. Mean annual rainfall is approximately 320 mm.

Hydraulic models were developed to simulate flows conditions for a range of events under existing and developed conditions. The results show that diversion drains, bunds, and culverts can be constructed in the proposed locations with reasonable amounts of excavation to avoid ponding and significant reduction of downstream flow rates. Maximum velocities indicate that rock lining would generally not be required along the proposed diversion drain alignments.

Project features have the potential to impact downstream surface water runoff. Mitigation measures are implemented in the project designs to reduce impacts to flow volumes and avoid excessive scour and sedimentation. Surface water impacts associated with development of the project were assessed using completed hydraulic models in support of environmental submissions.

Comparisons of flow conditions were developed at the Great Northern Highway, located just downstream of the project area, and at Eagle Rock Pool, located approximately 20 km downstream of the site. Relative to baseline conditions, downstream project conditions flow rates and volumes are reduced by approximately 10% - 20% at the Great Northern Highway crossing and approximately 2% - 3% at Eagle Rock Pool. The results show a maximum water surface elevation increase of approximately 0.5 m upstream of roadway constrictions. The maximum downstream decrease in the 10% AEP event is approximately 0.2 m.

Onsite surface water management measures are incorporated to prevent the impoundment of runoff, scour, and deposition of sediment in the downstream environment.



Abbreviations:

AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
DEM	Digital Elevation Model
DFD	Depth-Frequency-Duration
DWER	WA Department of Water and Environmental Regulation
EA	Engineers Australia
FFA	Flood Frequency Analysis
HEC	Hydrologic Engineering Center
IFD	Intensity-Frequency-Duration
km	Kilometres
MRWA	Main Roads Western Australia
m	Metres
MSL	Mean Sea Level
OoM	Order of Magnitude
RCP	Representative Concentration Pathway
RFFE	Regional Flood Frequency Estimation
SILO	Scientific Information for Land Owners
SSP	Shared Socioeconomic Pathway
USACE	United States Army Corps of Engineers



1. Introduction

1.1. Background

HanRoy (The Client) is conducting Mining Studies and environmental impact assessments for the proposed Round Hill Iron Ore Project (Round Hill), an open pit iron ore mine in the Pilbara region of Western Australia.

1.2. Project Location

The site is located approximately 35 km northwest of Newman. The site location relative to the Great Northern Highway (GNH) is shown in **Figure 1-1**.

1.3. Scope of Work

Darkwater Consulting (Darkwater) have been engaged by the Client (HanRoy) to undertake hydrological and hydrogeological assessments of the Round Hill deposit. Surface Water Solutions (SWS) have been engaged by Darkwater on behalf of HanRoy to provide technical assistance related to surface water investigations based on proposed mine layouts.

SWS have been engaged to assess indicative pre- and post-development hydrology and surface water management at the proposed site in support of ongoing studies and environmental impact assessment. The scope of services includes rainfall-runoff assessments, hydraulic modelling, and reporting for the 20% Annual Exceedance Probability (AEP), 10% AEP, 5% AEP, and 1% AEP flood events. This flood management assessment report describes the project objectives, project requirements, flood assessment approach, and recommended flood controls.

1.4. Previous reports

The following reports and drawings were provided by Darkwater as background references:

- Round Hill Conceptual Study Implementation Plan Rev A (26 Jun 2023)
- Round Hill Hydrology Assessment Rev A (2 Nov 2023)
- Drawing No. RP19190.045-CI-SKT-0003 Rev F Mine Site Layout Plan (July 2025)
- Geospatial data provided electronically by HanRoy 26 Sep 2023

The preliminary general arrangement has been developed by Hanroy, including pit shells, dump and pad footprints, and access roads. The project layout is shown in

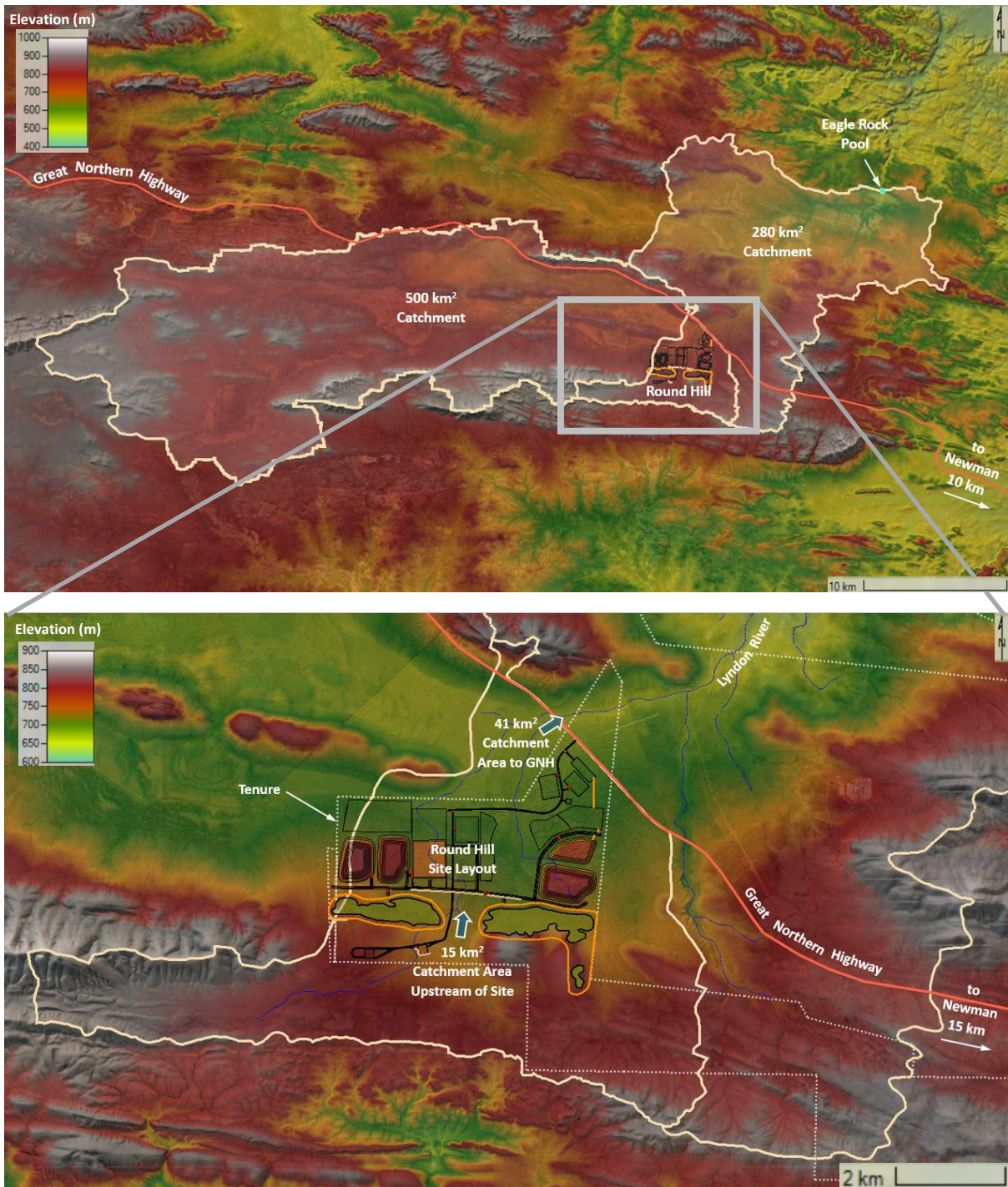


Figure 1-1: Project location

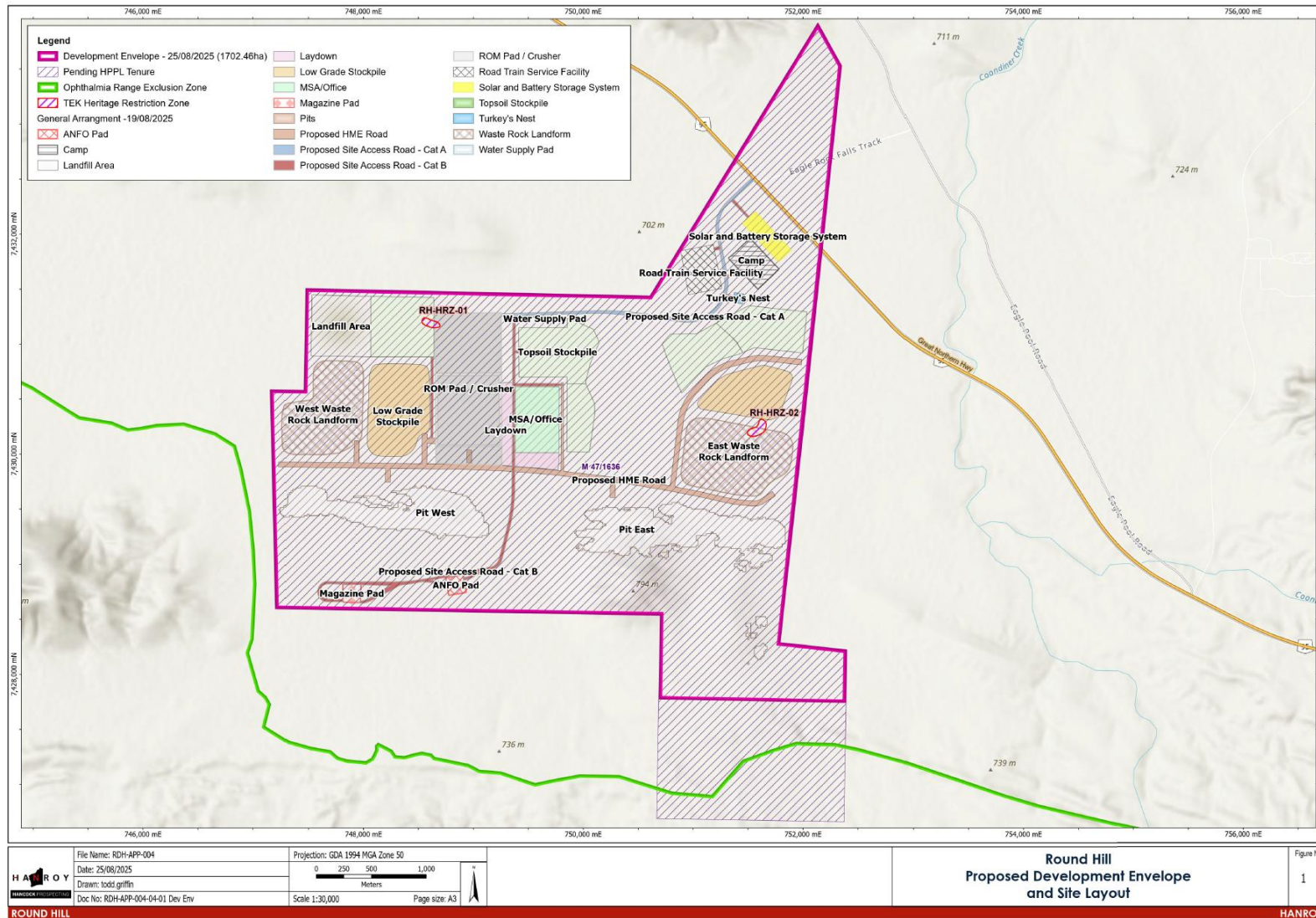


Figure 1-2: Project layout



2. Hydrology

2.1. Catchment Area

Based on the Australian Rainfall and Runoff (ARR) Data Hub (2020) the Round Hill site is located in the Fortescue River Region within the Pilbara-Gascoyne Division (Appendix A). A catchment area of approximately 15 km² drains toward the Round Hill site upstream of the proposed pits, and a total catchment area of approximately 41 km² drains to the GNH crossing along Coondiner Creek. Downstream of the GNH, runoff reaches the Lyndon River, which drains to the Fortescue Marsh. Eagle Rock Pool, located along the Lyndon River, drains a catchment area of approximately 280 km², including the Round Hill catchment area.

The Round Hill site is located adjacent to a 500-km² internally draining catchment area. Based on observations during a November 2023 site visit, some surface water connections appear to be present between the 500-km² catchment area and the GNH during infrequent events; however, the available topographic information is inadequate for defining the level and frequency of the connections. As a conservative measure for assessing downstream surface water impacts, the 500-km² catchment area is modelled without channelised connections in the surface water assessment. Catchment areas are shown in **Figure 1-1**.

2.2. Climate

Climate conditions have been measured at Newman (Gauge 507005), approximately 35 km east of the site, since 1980. Precipitation data are available from the East Giles Station (507008) from 1980-2002. **Figure 2-1** shows Bureau of Meteorology (BoM) Depth-Frequency-Duration (DFD) data for the site catchment. **Figure 2-2** shows the Intensity-Frequency-Duration (IFD) data. Results are summarised in **Table 2-1**. Based on the ARR data hub, Rangelands West temporal precipitation patterns apply to the site area.

According to Newman Airport precipitation records, mean annual rainfall is approximately 320 mm. Extended precipitation and evaporation records are available in the Scientific Information for Land Owners (SILO) database (QDES 2021). Based on the nearest SILO grid point for gauge records, mean monthly pan evaporation exceeds precipitation by a factor of 10.

Updated climate change guidance was incorporated into ARR guidelines in August 2024. The current climate change uplift factors are listed in Appendix A for a range of Shared Socioeconomic Pathway (SSP) models. The updated guidance includes varying uplift factors by project life and critical rainfall duration. The uplift factors are intended to be applied to precipitation intensities. The ARR climate change guidance allows some flexibility for the adoption of selected SSP scenarios, and the design life and relative risk of individual project elements may vary. In light of the inherent uncertainties, an interim uniform uplift factor of 20% has been adopted for this assessment. For consistent comparison of existing and project conditions scenarios, the uplifted precipitation intensities were applied to all model runs.

The uplift to rainfall intensities is offset by increased soil losses; a 10% increase in initial and continuing soil losses has been assumed for natural catchment areas; soil losses in project conditions hardstand areas are not uplifted. If specific climate change guidance is provided for individual project features, this assumption may be revisited for future modelling scenarios.

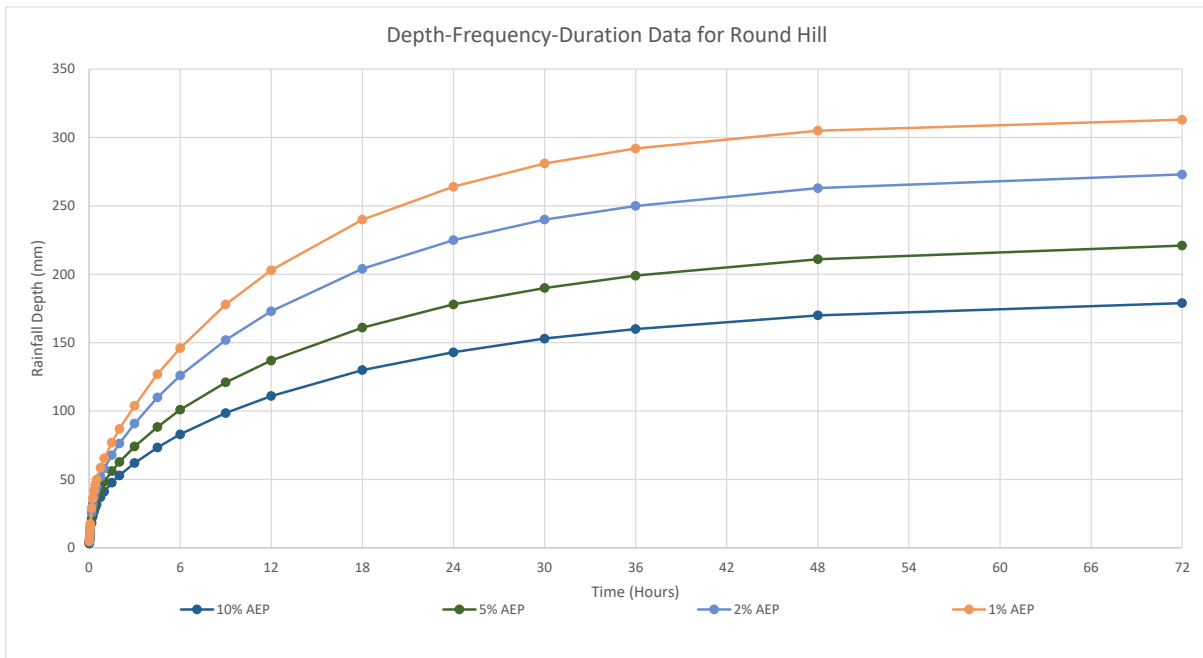


Figure 2-1: Round Hill Depth-Frequency-Duration data

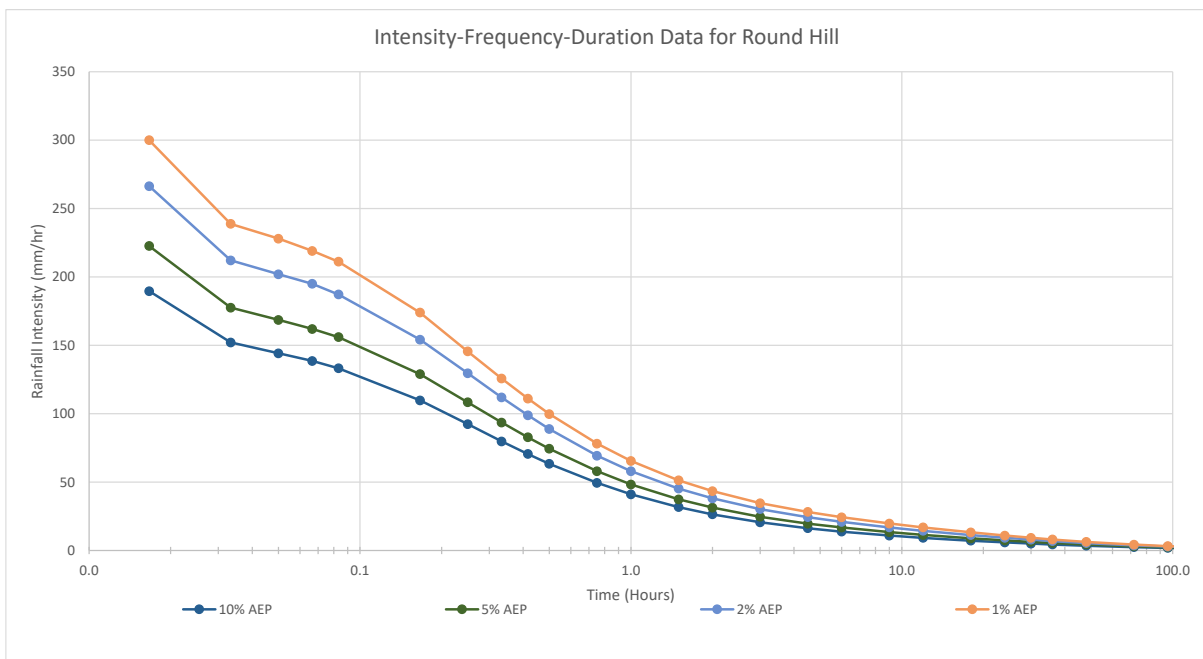


Figure 2-2: Round Hill Intensity-Frequency-Duration data

Table 2-1: Precipitation Depths for Round Hill

Duration	Rainfall in mm			
	10% AEP	5% AEP	2% AEP	1% AEP
1 min	3	4	4	5
5 min	11	13	16	18
10 min	18	22	26	29
15 min	23	27	32	36
30 min	32	37	44	50
1 hour	41	48	58	66
2 hour	53	63	76	87
3 hour	62	74	91	104
6 hour	83	101	126	146
12 hour	111	137	173	203
24 hour	143	178	225	264
48 hour	170	211	263	305
72 hour	179	221	273	313

2.3. Regional Flood Frequency Estimation

Appendix A includes estimated peak discharge rates for the 15 km² upstream of the project site and for the 500 km² internally draining catchment area west of the site. Discharge estimates are based on the Regional Flood Frequency Estimation (RFFE) procedure. The RFFE model provides peak discharge rates by location based on historical gauge records and assigned catchment input values (Engineers Australia, 2015). The nearest gauge applied in the model is located approximately 200 km west of the site, with a contributing catchment area of approximately 250 km². Appendix A shows a map of the remaining gauges used in the RFFE analysis along with discharge versus catchment area relationships for nearby gauged catchments.

The median-confidence 1% Annual Exceedance Probability (AEP) peak discharge rate is 91 m³/s for the 15 km² catchment and 547 m³/s for the 500 km² catchment. The 10% AEP peak discharge rate is 34 m³/s for the local catchment and 207 m³/s for the larger catchment. The considerable distance from the nearest gauge limits the accuracy of the results as reflected by the extremely wide confidence bands. The 2021 RFFE update (currently a beta release) yields a 1% AEP discharge rate of 108 m³/s for the 15 km² catchment using the recommended small catchment model. Results are shown for comparison in Appendix A.

2.4. Flood Mapping

The Department of Water and Environmental Regulation (DWER) floodplain mapping tool (2023) does not show any mapped floodplains in the vicinity of the project; the nearest mapped floodplain is at Roebourne, approximately 300 km northwest of the site.



3. Hydraulic Model Setup

3.1. Approach

The purpose of this assessment is to quantify project conditions impacts to baseline peak discharge rates, flow volumes, and inundated areas under a range of flood events. Hydraulic modelling was conducted with a two-dimensional (2D) approach using HEC-RAS Version 6.7 software (USACE 2025). A direct precipitation or rain-on-grid (ROG) hydraulic model was set up for the Round Hill catchment areas draining to the GNH, covering the site area under baseline and developed conditions. Hydraulic models were developed for the 20%, 10%, 5%, and 1% Annual Exceedance Probability (AEP) flood events under existing and project conditions. Drainage management features were added to the project conditions model to reduce potential ponding and scour.

3.2. Design Criteria

Roadway serviceability design criteria are intended to prevent flood flow overtopping an average of 350 days per year, with a maximum flow depth of 300 mm (aligned with design criteria in Agilitus Engineering Appendix - C2_RP19190.045_Round Hill Haulage Operating Cost_251007). Drains, bunds, and floodway/culvert crossings are designed to prevent long-term ponding and structural failure up to the 1% AEP event..

3.3. Loss Rates

Soil infiltration affects the amount of runoff draining across the site. Assumed loss rates (measured in mm of initial rainfall loss and in mm/hr for ongoing soil losses) are adopted in the hydraulic model. The ARR Data Hub (Engineers Australia 2023) does not provide guidance on loss rates for the Round Hill area. An estimated initial loss of 20 mm was applied to the model, with a continuing loss rate of 5 mm/hr, accounting for pre-burst losses as tabulated in Appendix A.

3.4. Precipitation

Precipitation was applied across the modelled area using a nested frequency storm to represent storm durations up to a 12-hour duration rainfall event. The frequency storm includes all critical durations for rainfall bursts from one minute to 12 hours in a single, synthetic storm pattern. Longer rainfall durations were found to generate lower peak discharge rates due to reduced rainfall intensity over longer durations. **Figure 3-1** shows the applied rainfall hyetographs with initial loss rates and continuing losses removed across the full duration of the precipitation and climate change uplift factors applied. The frequency storm pattern provides conservative runoff estimates for a range of local contributing catchment sizes relative to the Rangelands West temporal patterns provided by the ARR data hub.

3.5. Roughness

A roughness coefficient of 0.08 was applied to the 2D flow area in sheet flow areas. The relatively high coefficient accounts for the high resistance associated with the shallow sheet flow areas within the rain-on-grid model extents. Concentrated channels with significant flow depths exceeding 0.5 m were assigned a roughness coefficient of 0.04.

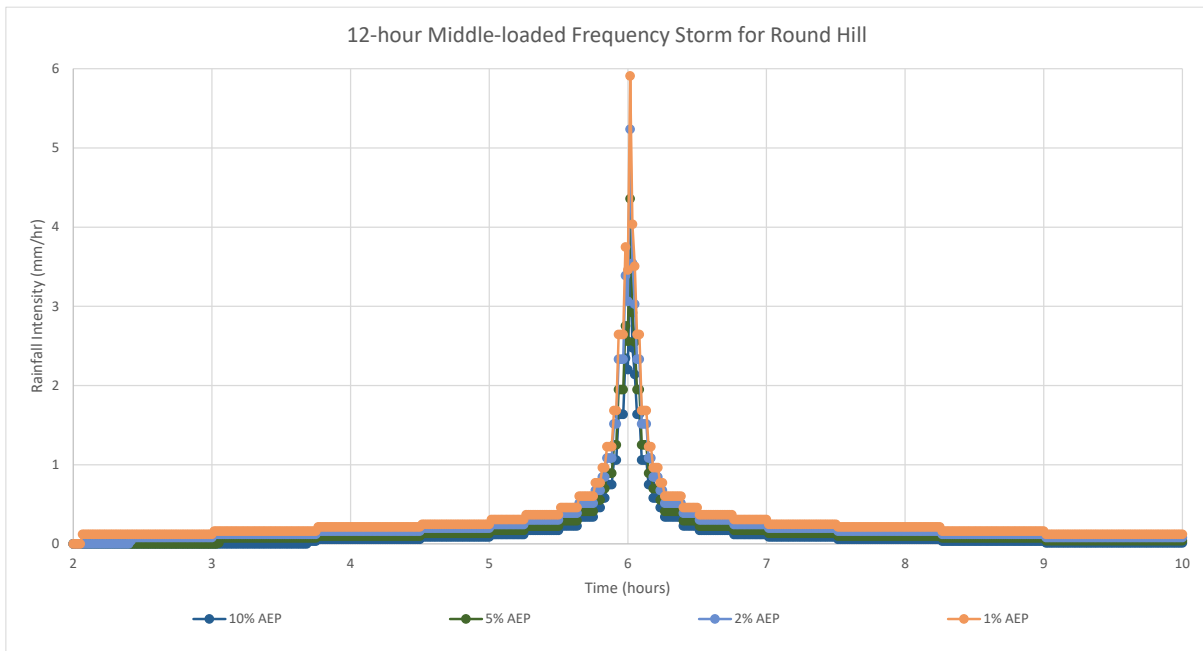


Figure 3-1: Applied precipitation hyetographs

3.6. Terrain

The underlying terrain is based on a 1-metre x 1-metre resolution digital elevation model (DEM) (Hanroy, 2024). The terrain data set covers an approximate area of 85 km², Figure 3-2 shows coverage area of the LiDAR data.

For areas outside the available LiDAR data, publicly available *Shuttle Radar Topography Mission* (SRTM) data with a resolution of 1 arc-second (approximately 30 m x 30 m) were compiled. The SRTM data set was stitched with the LiDAR data and smoothed across interface areas where discrepancies were identified.

The developed conditions layout (Hanroy, 2025) was applied to the hydraulic model as a digital elevation model. Vector terrain modification tools were applied to adjust the proposed features for drainage controls. Project development conditions model runs were set up identical to existing conditions with the exception of the associated terrain.

All geospatial data are projected to the GDA94 MGA Zone 50 horizontal datum. Vertical elevations are based on the 1971 Australian Height Datum (AHD71).

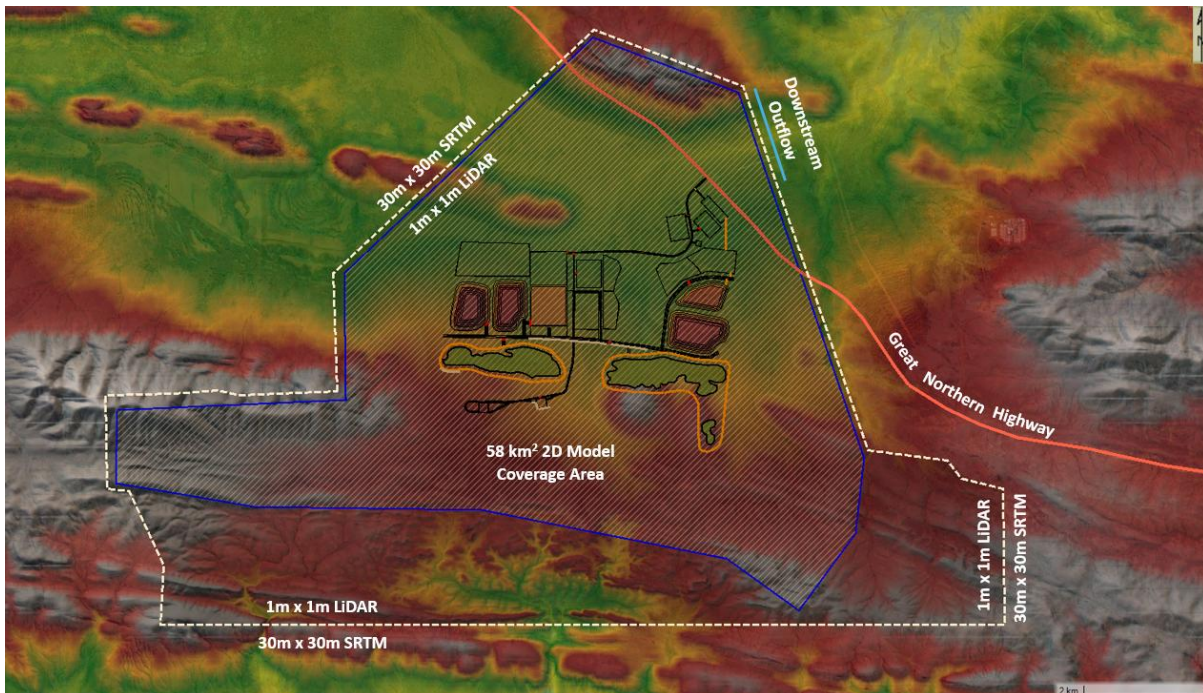


Figure 3-2: Terrain and model coverage areas

3.7. Computational Mesh

A 58 km² 2D flow area was developed within the high-resolution LiDAR coverage area to extend across the entire contributing catchment area to the GNH. A computational mesh spacing of 20 m was applied to the modelled area, with a more refined mesh spacing of 10 m applied along proposed features. Break lines were applied along concentrated flow paths, roadway embankments, and bund crests to align mesh cell faces with flow directions and topographic changes.

3.8. Boundary Conditions

The main channel flows from the western catchment were introduced using peak flow rates based on the expected values from the RFFE assessment. For hydraulic modelling purposes, this approach conservatively assumes that internal storage has filled to the minimum elevation within the LiDAR data (683.4 mRL) prior to the arrival of the flood flow; however, inflow from this area is conservatively excluded from downstream impact assessments. Inflows were applied using triangular hydrographs covering the simulation window.

The downstream boundary condition was assigned approximately 1 km downstream of the Great Northern Highway with a normal depth energy gradient matching the creek profile of approximately 0.2%. All remaining 2D flow area boundaries were assigned a normal depth energy gradient outflow boundary condition of 0.5%.



3.9. Simulation Window and Time Steps

A 12-hour simulation window was applied to the model runs. Results were checked to confirm that the simulation time adequately captured the rise and recession of peak flows throughout the modelled areas. A variable time step was assigned based on a maximum Courant Number of 2.0. Using this option, HEC-RAS selects an adaptive time step based on the assigned computational mesh size and computed velocities. The adopted time step generally ranged between 5 and 10 seconds. Mass balance errors and water surface elevation convergence errors were checked to ensure model stability and that imbalances remained below standard thresholds, confirming compliance with Courant Number criteria in the published guidance (USACE, 2025).

3.10. Structures

The GNH culverts were added based on field measurements of culvert dimensions from the November 2023 site visit. Invert elevations were extracted from the available LiDAR data. No other culverts or other hydraulic structures were included in the existing conditions model. Proposed culverts were added as one dimensional (1D) elements within the hydraulic model. Floodways were added to the proposed design DEM using vector terrain modification features.

3.11. Calculation Options and Tolerances

The full momentum shallow water equation set was applied to all model runs. Except where otherwise noted, program defaults have been applied to all remaining coefficients, options, tolerances, and model settings.

3.12. Summary

The model input parameters applied to each of the hydraulic model runs are summarised in **Table 3-1**.

Table 3-1: Summary of model parameters

Parameter	Adopted Value
Model Area	58 km ²
Inflow	RFFE Peak Discharge Rates
Precipitation	12-hour nested frequency storm + 20% CC uplift
Outflow	0.2% normal depth energy gradient
Initial Loss	20 mm + 10% climate change uplift
Continuing Loss	5 mm + 10% climate change uplift
Simulation window	24 hours
Computational Time Step	5s - 10s
Computational Mesh Size	10m - 20m
Roughness	0.040 - 0.080
Equation Set	Full momentum shallow water equation
DEM Resolution	1m x 1m - 30m x 30m

4. Results

4.1. Design Criteria Compliance

The daily precipitation exceedance at Round Hill is shown in **Figure 4-1**. The plotted values are based on interpolated SILO data, which does not take climate change and non-stationarity into consideration. The adopted design criterion of providing access over roadway crossings an average of 350 days per year correlates to a 24-hour precipitation depth of 5 mm. Unless the catchment is entirely saturated prior to the event, a 5 mm precipitation depth is unlikely to generate any runoff. The adopted loss rates in the hydraulic model (20 mm initial loss and 5 mm/hr continuing loss) are conservatively low; initial loss rates may be as high as 60 mm without antecedent rainfall, and no runoff would be expected in events that fall within the adopted design criterion.

To generate 300mm of flow depth across the roadway to the point where roadways would be impassable, it is estimated that a minimum 24-hour rainfall depth of 50 mm would be required. This threshold has been exceeded approximately 20 times in the 135-year timeframe covered by the SILO database. This exceedance correlates to approximately 365 days per year of service (out of an average of 365.25 days per year). **Figure 4-2** shows the exceedance times for the modelled events based on a 300 mm depth threshold. Out-of-service exceedance times vary from 11 hours in the 20% AEP event to 18 hours in the 1% AEP event.

As reflected in the hydraulic model, the adopted drainage design seeks to avoid ponded water and provide positive drainage throughout and around the site. For roadway designs, there is no required culvert capacity based on the adopted design criterion, so roadway profiles are designed as at-grade crossings. Roadway designs are based on minimising erosion and sedimentation criteria issues and reducing maintenance requirements rather than adhering to specified rainfall/runoff exceedance criteria. It may be desirable to install a raised roadbed with relief culverts or to place gravel/cobble material at crossings to prevent bogging and reduce remedial works following flow events; these solutions may warrant further exploration during future design phases.

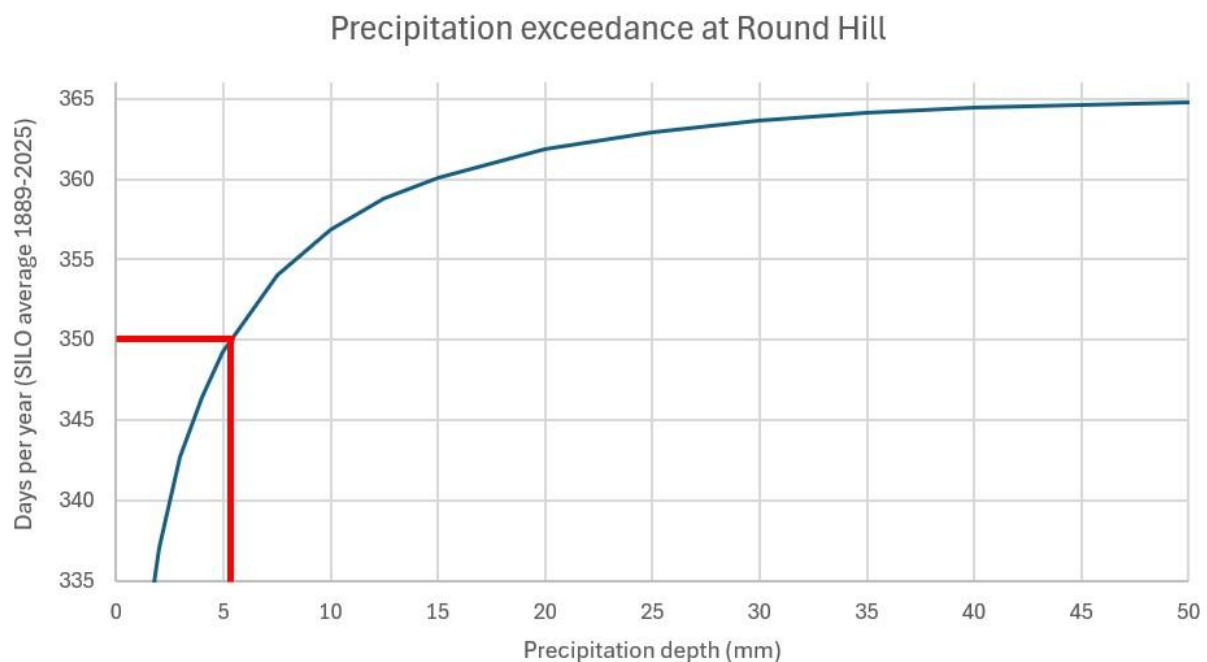


Figure 4-1: Round Hill daily precipitation exceedance

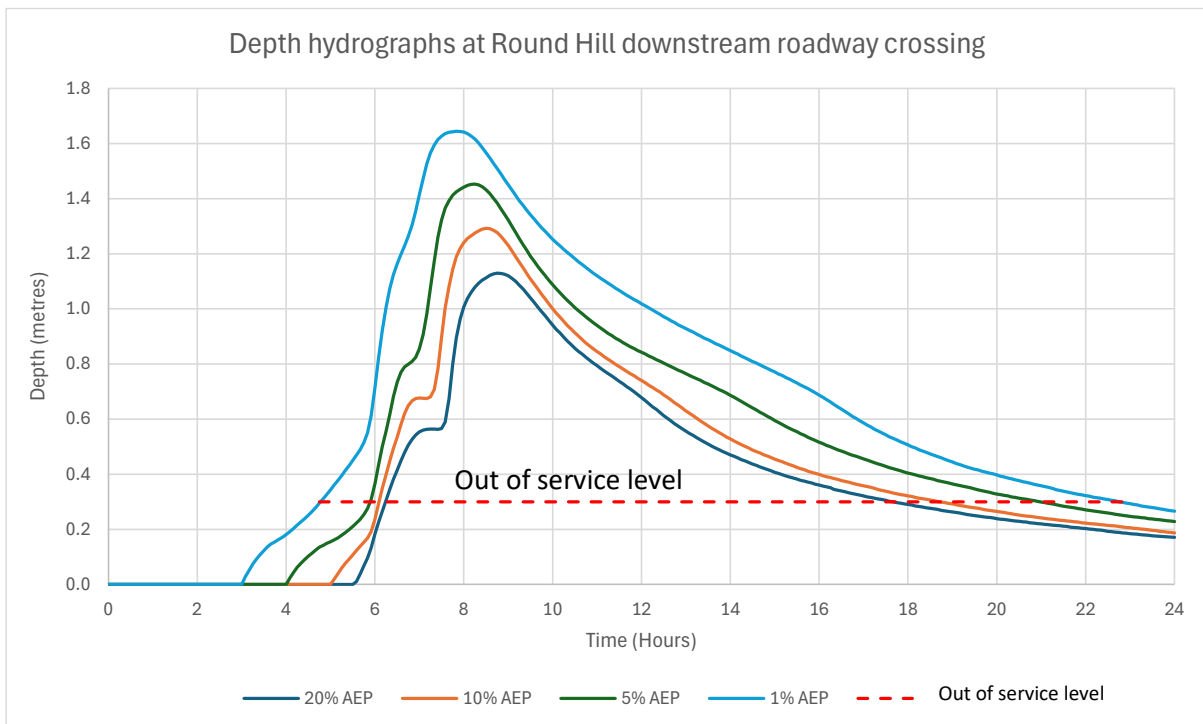


Figure 4-2: Depth hydrographs at downstream crossing location

4.2. Peak discharge rates

The discharge hydrographs upstream of the site features based on the ROG approach are shown in **Figure 4 3**. The location for the extracted hydrographs corresponds to the 15 km² catchment area location applied using the RFFE approach (**Figure 4-3**).

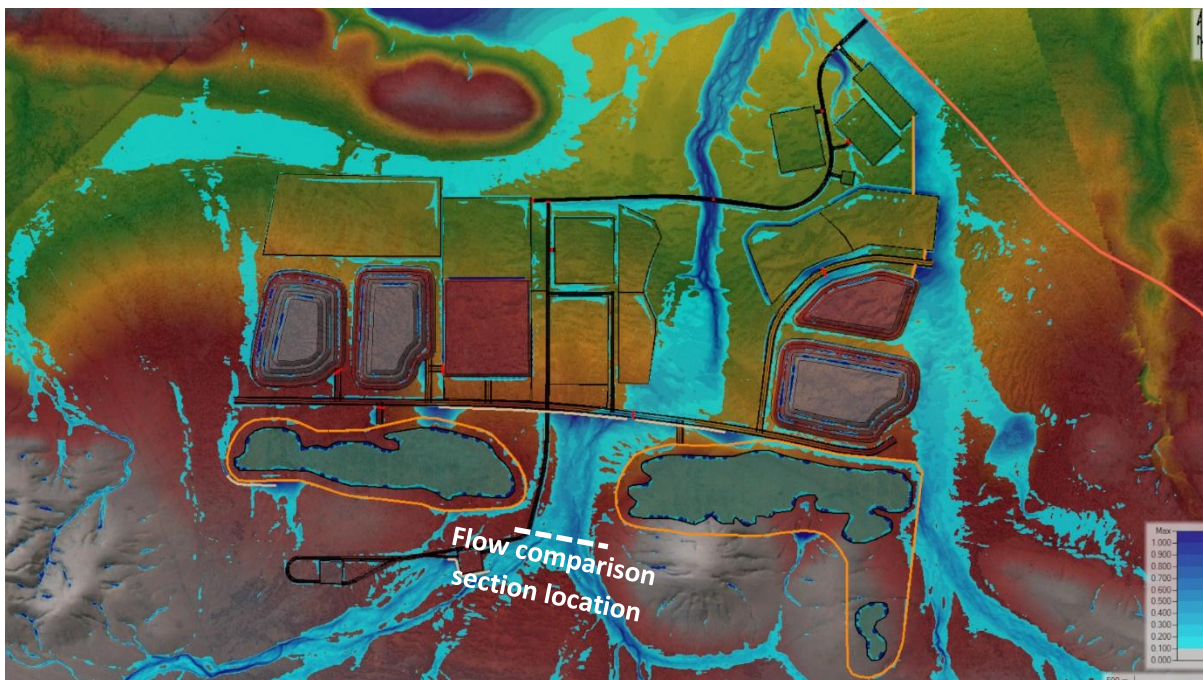


Figure 4-3: Peak flow comparison section



As shown in Appendix A, the peak ROG discharge rates are higher than the median-confidence peak discharge rates predicted by the RFFE method. The RFFE results do not reflect climate change conditions, whereas the rain-on-grid incorporate a 20% uplift in rainfall intensities. As such, peak discharge rates predicted by the ROG model are expected to be higher than the RFFE results. The ROG values fall well within the 5% - 95% confidence limits of the RFFE values. The adopted values exceed the median confidence (50%) results, corresponding to a confidence limit of approximately 60% - 65%.

The predicted peak discharge rates from the ROG model vary with the adopted roughness coefficient. Based on the sensitivity analyses presented in Appendix C, the adopted roughness coefficient of 0.08 provides a reasonably conservative estimate of peak discharge rates.

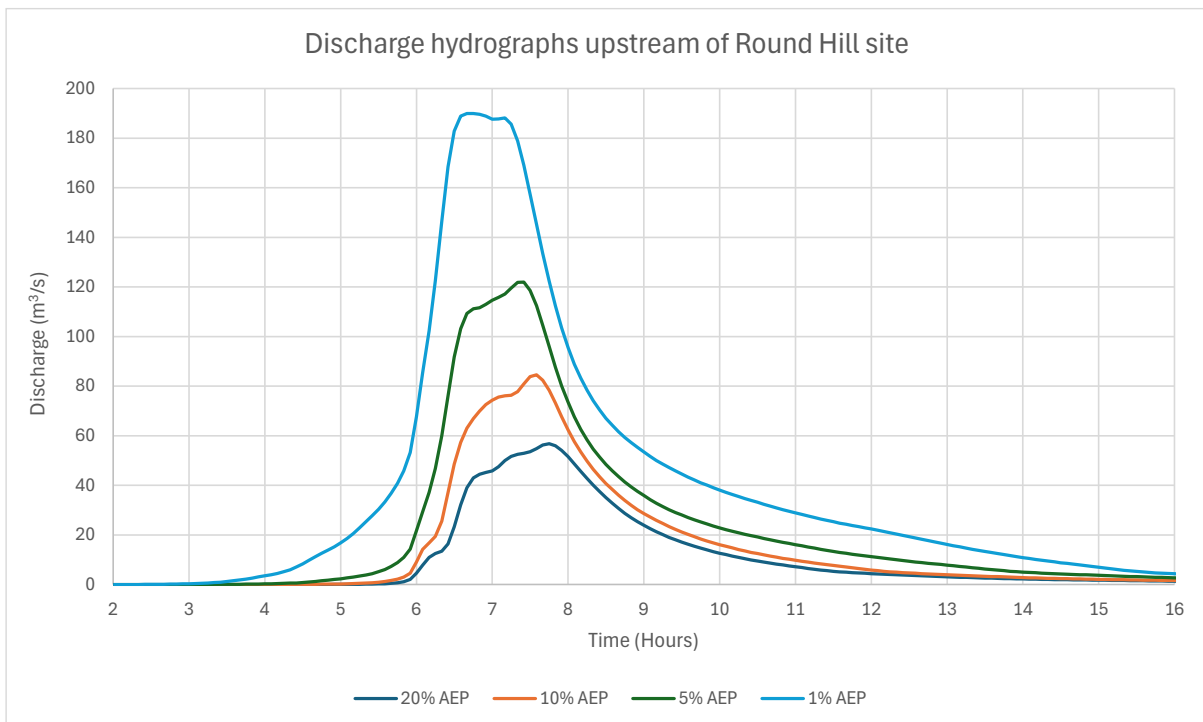


Figure 4-4: Discharge hydrographs upstream of Round Hill site

4.3. Inundation depths and extents

The maximum inundation depths and flood extents in the 20% AEP event are shown in **Figure 4-4**.

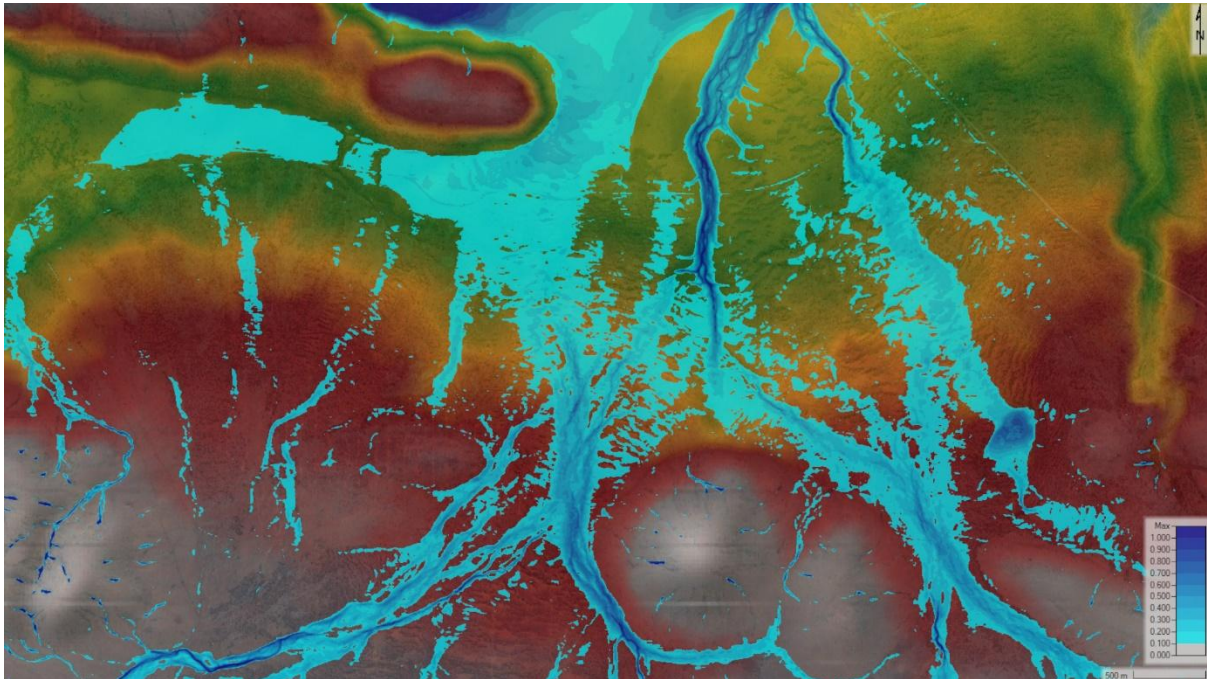


Figure 4-5: Baseline 20% AEP maximum depth (m) and flood extents

Additional maximum inundation depths and flood extent figures are shown in Appendix B for both baseline and project conditions under the 20%, 10%, 5%, and 1% AEP events. Figures are shown with a 10 cm display threshold. The afflux maps in Appendix B show the difference between the maximum water surface elevations between existing and project conditions.

The drainage features included in the project conditions hydraulic models are shown in **Figure 4-6**. Diversion drains and bunds are included to maintain downstream flows where feasible. Pit inflow volumes are shown along the southern perimeter of the eastern pit. In this area, the required excavation depth for construction of a diversion drain would exceed 30 m. The contributing catchment area (40 ha) is relatively small, and future design iterations may make accommodations for a stable entry point for pit inflow in this area.

4.4. Velocity

Appendix B includes maximum velocity maps for the project conditions scenarios under 20%, 10%, 5%, and 1% AEP events. As shown in the figures, velocities are relatively low, falling below Main Roads WA criteria for armour rock requirements (2006).

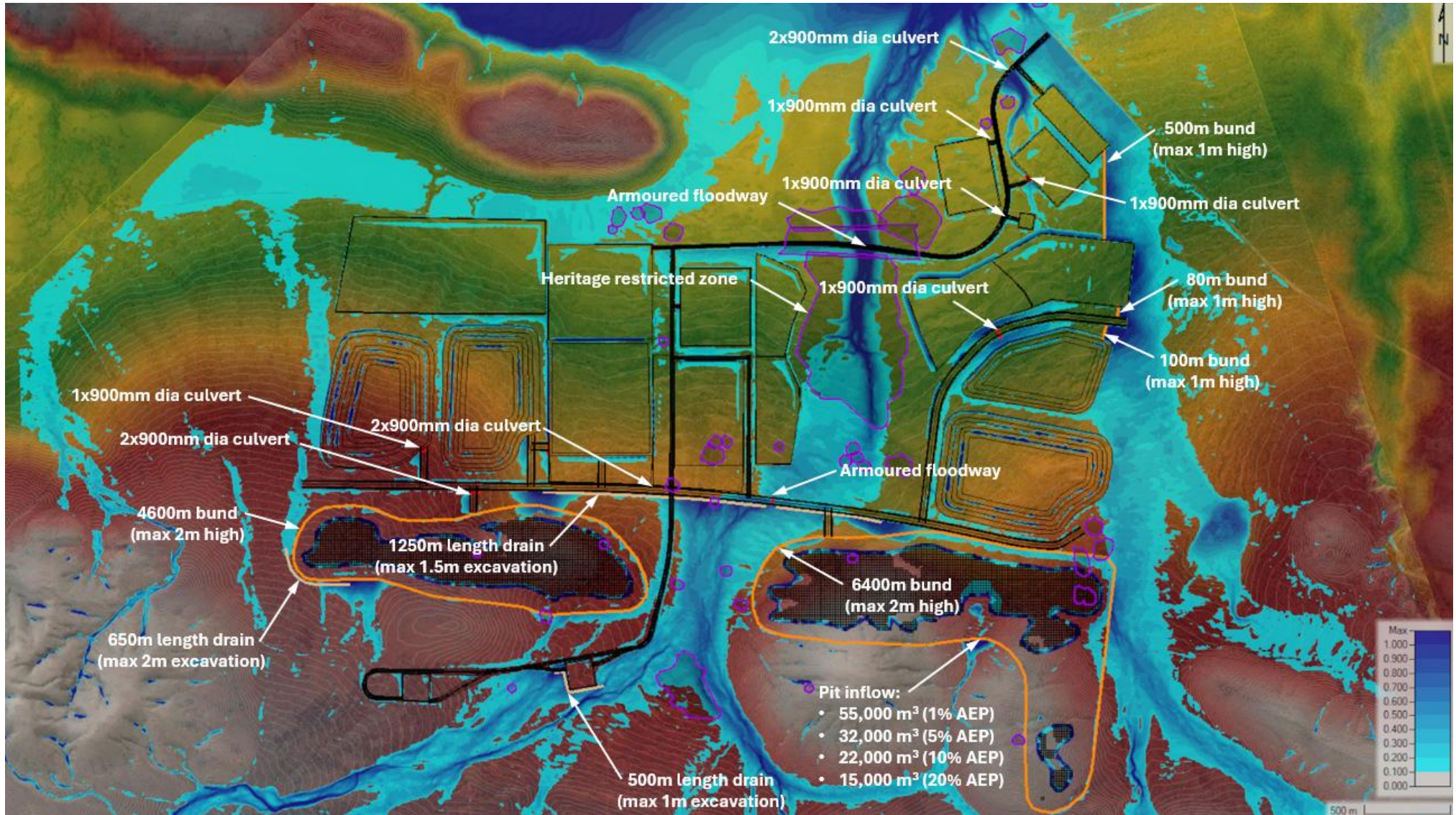


Figure 4-6: Drainage features included in project conditions models with 10% AEP maximum depth (m)



5. Surface water impacts

5.1. Potential impacts

The 8-km² disturbance area of the proposed site relative to the natural catchments is shown in **Figure 5-2**. The disturbance area amounts to approximately 20% of the 41 km² Round Hill catchment area measured at the GNH crossing. The development of the proposed project features has the potential to impact surface water runoff in the downstream environment. Without adequate mitigation measures, there is a potential for erosion and sedimentation. Exposed fill and excavated surface slopes may erode during construction and operation activities. The eroded material can be transported downstream, accumulating in areas with milder slopes and lower sediment transport capacities. Sedimentation can reduce the available storage volume of downstream pools. Reduced peak flow rates can decrease the frequency of floodplain connectivity, which may impact surface water dependent vegetation. Floodplain connectivity may be affected by reductions in peak discharge rates even if the total volume of runoff is unaffected due to the inclusion of diversion drains.

Preliminary model runs without mitigation measures show long-term ponding in some areas where existing flow paths are intercepted behind proposed fill pads and other features. The blocked catchment areas are removed from the contributing catchment areas for downstream receptors, reducing peak discharge rates and flow volumes. Standing water also has the potential to undermine stability of the fill slopes or result in health and safety concerns.

5.2. Mitigation measures

The results of preliminary models were extracted to guide the sizing and placement of drains, bunds, culverts, and floodways in the final model. Bunding was placed to route external runoff around the outside perimeter of the site, avoiding mixing of runoff from natural catchments with site runoff. Bunding was considered to a maximum height of 2m. Culverts were placed at roadway crossings where drainage could be conveyed with reasonable culvert lengths. Excavated drains were added to provide consistent longitudinal slopes along the outside of bunds and in areas where pooling was observed. Bottom widths were sized to limit maximum velocities to less than 1.5 m/s in the 1% AEP event. Roadway drains were incorporated to intercept upstream drainage and route runoff to culvert or floodway crossings. Where channels cross roadway alignments at grade, armoured floodways are proposed to prevent erosion and reduce post-flood maintenance requirements.

5.3. Impact Assessment

Changes in inundation extents, velocity, peak discharge, and cumulative flow volumes were assessed between baseline and project conditions model results.

The maximum water surface elevation afflux in the 20% AEP event is shown in **Figure 5-1**. The afflux shows the vertical difference between project conditions and baseline conditions maximum water surface elevations. The afflux figures show that there is a reduction in maximum water surface elevation downstream of project features, with an increase in water surface elevations within the main channel.



Figure 5-1: 20% AEP maximum water surface elevation afflux

Additional afflux maps are shown in Appendix B

5.3.1. Great Northern Highway

At the Great Northern Highway, the baseline peak discharge rate for the 1% AEP event is 379 m³/s. Under project conditions, pits intercept direct rainfall, reducing the effective contributing catchment area. Proposed landforms are designed to be internally draining and are likewise removed from the contributing catchment area. Runoff along outer batter slopes will be directed to sediment ponds prior to discharge into the downstream environment. Some of the constructed features attenuate peak discharge rates whilst providing for the downstream flow volumes to be maintained.

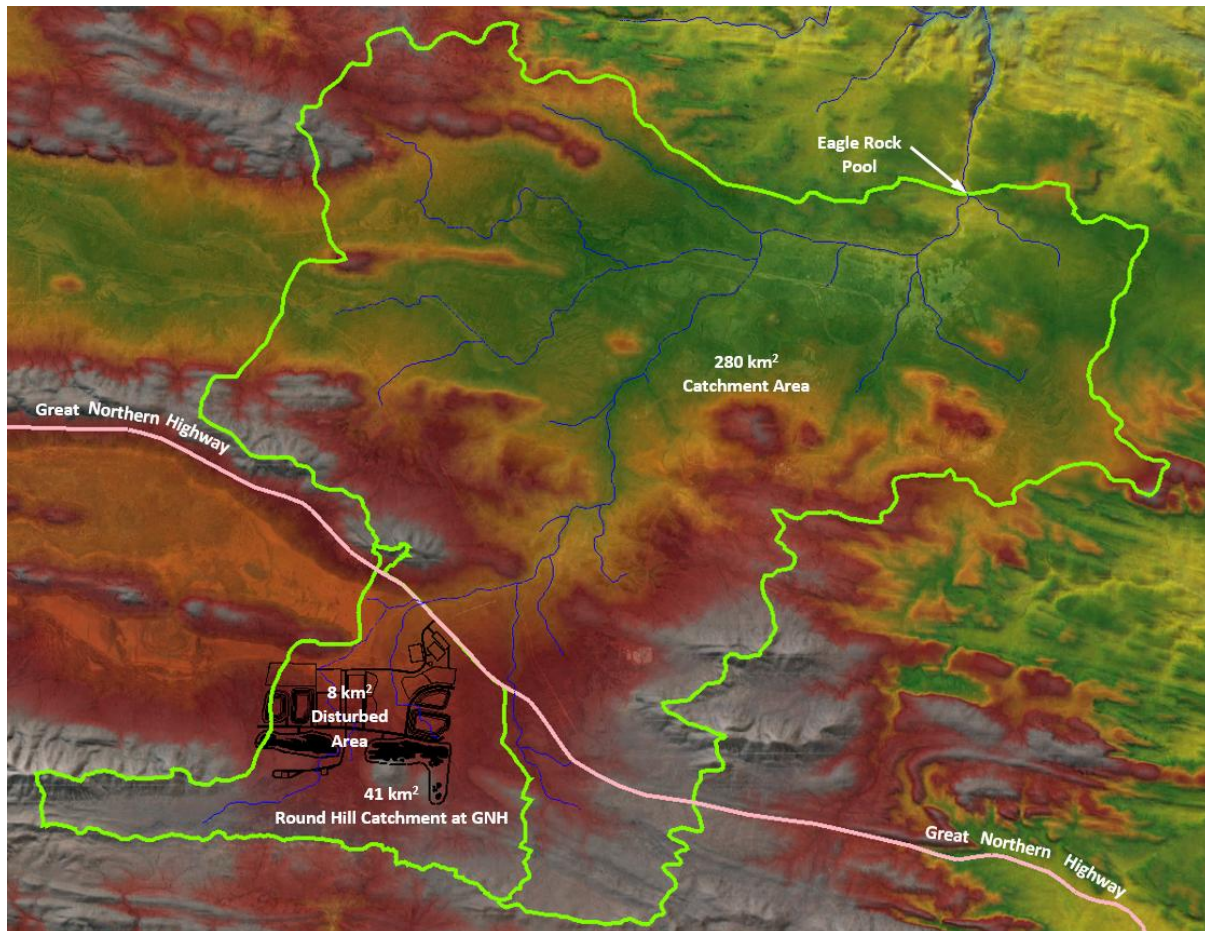


Figure 5-2: Disturbance area relative to natural catchments

The 1% AEP peak discharge rate at the GNH crossing is reduced to 316 m³/s, a reduction of approximately 17%. Reductions in peak flow rates can affect floodplain connectivity during runoff events. Peak flow rates that result in overbank flow under the baseline condition may be lower in project conditions, reducing the amount of overbank flows. There is a lesser reduction in total flow volume (approximately 12%) due to the presence of drains and culverts in the proposed design. Runoff that is released from sediment basins following the arrival of the event will reduce the overall impacts on downstream receptors.

5.3.2. Eagle Rock Pool

The 8-km² disturbance area is shown in **Figure 5-2** relative to the 280 km² natural catchment draining to Eagle Rock Pool along the Lyndon River. Eagle Rock Pool is located approximately 20 km downstream of the project site; the pool is outside of the available high-resolution topography and was not included in the hydraulic model. Potential impacts at Eagle Rock Pool are assessed based on a comparison of the relative catchment area reduction.

Proposed project features cover an area of approximately 8 km², amounting to approximately 3% of the total 280 km² catchment area draining to Eagle Rock pool. This is a conservative estimate that assumes the entire developed area is removed from the contributing catchment.

Assuming flow volumes are reduced proportionally to the reduced catchment area, inflows into Eagle Rock Pool would be reduced by approximately 3%. Assuming peak discharge rates vary with changes in catchment area using a transposition exponent of 0.7, the impact on peak flow rates into Eagle Rock pool would be a reduction of approximately 2%. Further optimisation of the drainage design features is likely to reduce the total impact by approximately 50%



5.4. Cumulative Impacts

The proposed mitigation measures are intended to reduce the cumulative impacts of all future actions in the catchment, including construction and operation activities. The assessed impacts assume conservative assumptions that are considered to be appropriate in light of the inherent uncertainties in the hydrologic and hydraulic modelling. Detailed designs may reduce the impacts to catchment areas by routing additional flow through the site.

Mine development within the catchment for Eagle Rock pool includes the Hope Downs 4 mine (HD4). Based on the project Environmental Review Document (Strategen, 2010) it is understood that an engineered creek diversion will be implemented and that the design will not impact flow downstream of the project; however, there is insufficient information available regarding rainfall and runoff interception within the HD4 development footprint to quantitatively assess impacts to flow.

The estimated impacts of the project features on peak discharge rates and flow volumes at the GNH crossing and at Eagle Rock Pool between existing and project conditions are shown in **Table 5-1**. Peak discharge rates are reduced by approximately 10-15% for the Round Hill catchment area, and cumulative flow volumes are reduced by approximately 12-14%.

Time series hydrographs for the 10% AEP and 1% AEP events at the GNH crossing are shown in **Figure 5-3**. **Figure 5-4** shows the cumulative flow volumes.

The afflux maps in Appendix B show areas with increased inundation depths in yellow and red, with areas of decreased depth shown in green. The results show a maximum water surface elevation increase of approximately 0.5 m upstream of roadway constrictions. The maximum downstream decrease in the 10% AEP event is approximately 0.2 m.



Table 5-1: Summary of impacts to flow volume and peak discharge rates

Parameter	Round Hill Catchment at GNH	Eagle Rock Pool Catchment
Existing Catchment Area (km ²)	41	280
Residual Project Catchment Area (km ²)	33	272
Percent Change	-19.5%	-2.9%
Existing 1% AEP Peak Discharge (m ³ /s)	379	
Project 1% AEP Peak Discharge (m ³ /s)	316	
Percent Change	-16.8%	-2.0%
Existing 1% AEP Flow Volume (ML)	5,610	
Project 1% AEP Flow Volume (ML)	4,931	
Percent Change	-12.1%	-2.9%
Existing 10% AEP Peak Discharge (m ³ /s)	150	
Project 10% AEP Peak Discharge (m ³ /s)	132	
Percent Change	-11.8%	-2.0%
Existing 10% AEP Flow Volume (ML)	2,145	
Project 10% AEP Flow Volume (ML)	1,844	
Percent Change	-14.0%	-2.9%

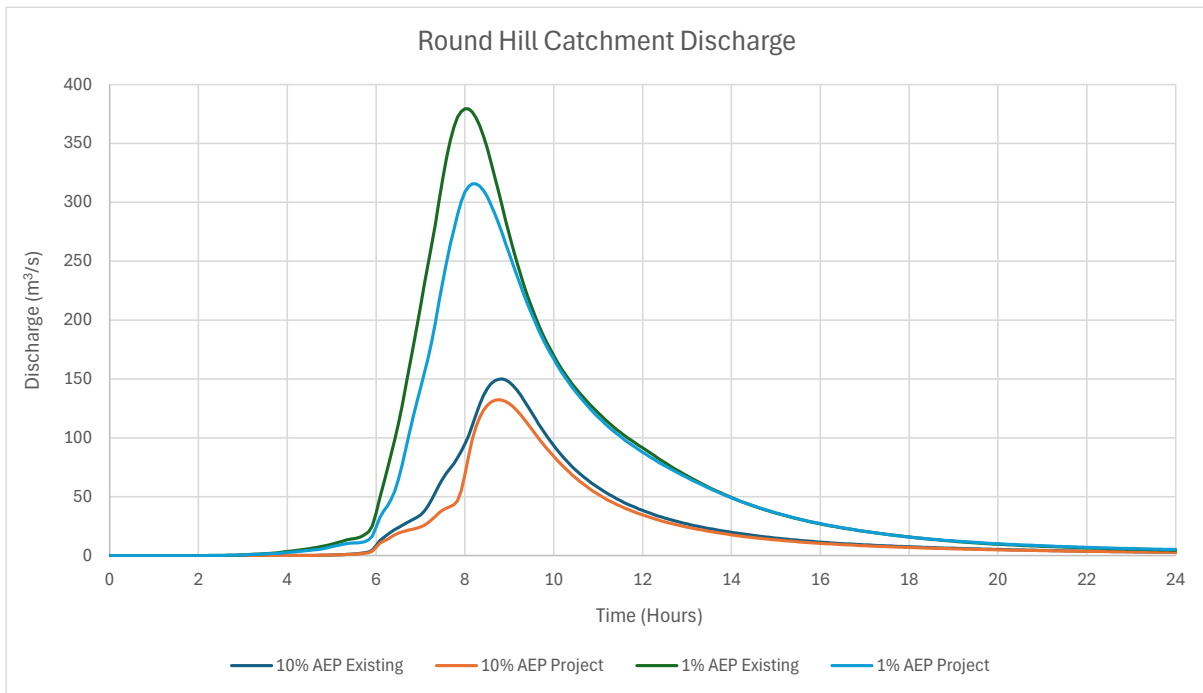


Figure 5-3: Existing vs. proposed 10% and 1% AEP discharge hydrographs

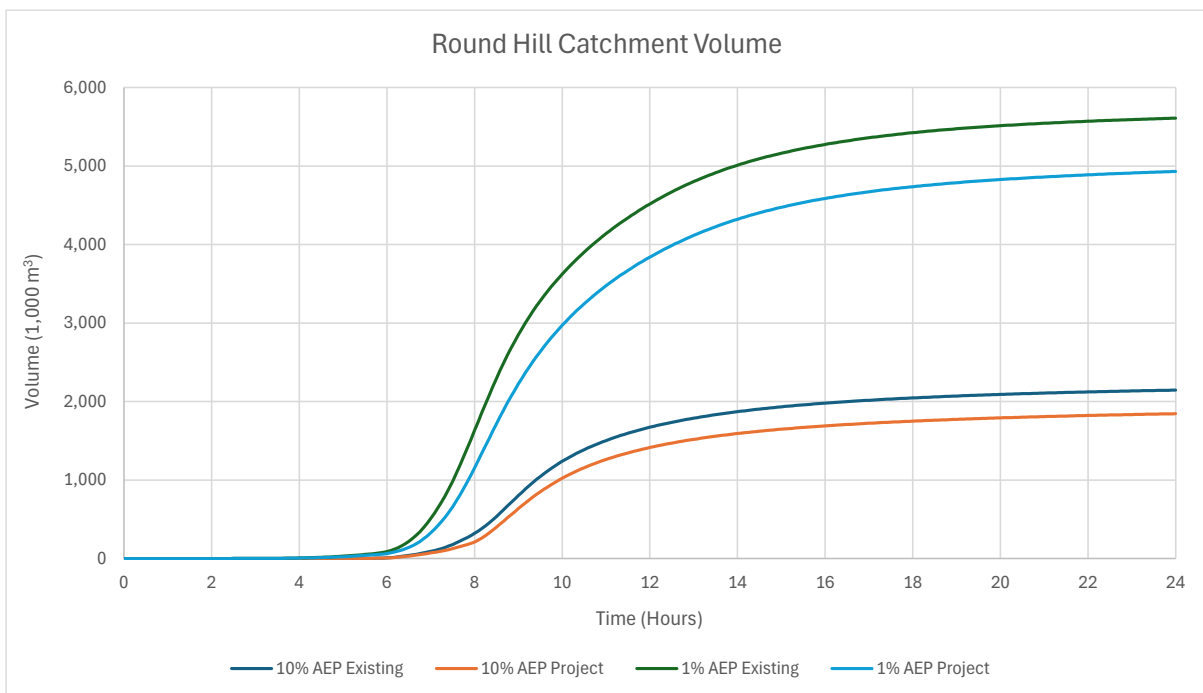


Figure 5-4: Existing vs. proposed 10% and 1% AEP cumulative flow volume



6. Scour and Sedimentation

6.1. Scour mitigation

The flood maps in Appendix B show areas where ponded water will accumulate and where flow constrictions result in relatively high velocities. The velocity maps in Appendix B highlight areas where Type A or Type B rock would be recommended as scour mitigation. Detailed adjustments to the layout may further reduce ponding by providing additional drainage corridors between features. Maximum velocities and accompanying armour rock requirements may likewise be reduced by further, detailed adjustments to fill areas to reduce localised flow constrictions.

Table 6-1 below shows an excerpt from MRWA's Floodway Design Guide (MRWA 2006), which is derived from 1994 Austroads tables and highlights the recommended rock class and section thicknesses associated with specified velocity ranges. **Table 6-2** and **Table 6-3** define the gradation and size ranges for standard rock classes from Specification 406 for rock protection (MRWA 2017). **Figure 6-1** shows the tabulated values graphically.

Batter slopes should be protected with coarse material appropriate for the design slope and pad size to protect against erosion from local rainfall runoff. Based on the predicted velocities, no armour rock is required within the site area to protect against external, impinging flows except where noted above. Batter slopes should use standard erosion protection measures. Any flow concentration related to non-modelled features may require localised scour protection.

Some remedial earthworks requirements would be expected following greater-than-design events. During future project phases, crossings may be assessed individually, incorporating armoured floodways, sacrificial sections, or raised crossings, designed with scour prevention measures.

6.2. Sedimentation

Catch bunds and drains should be placed at the toe of exposed slopes to collect sediments and pollutants. Sediment basins should be incorporated into the design where placed fill material or exposed excavation batter slopes are exposed to direct rainfall and runoff. Additional bunds may be required to separate mine-affected water from external flows. As outlined below, the placement of monitoring equipment is recommended downstream of the proposed features to begin compiling baseline data related to turbidity as early as possible.



Table 6-1: Design of rock slope protection (from Austroads 2023 and MRWA 2006)

Velocity (m/s)	Class of rock protection (tonne)	Section thickness, <i>T</i> (m)
< 2	None	–
2.0–2.6	Facing	0.50
2.6–2.9	Light	0.75
2.9–3.9	¼	1.00
3.9–4.5	½	1.25
4.5–5.1	1.0	1.60
5.1–5.7	2.0	2.00
5.7–6.4	4.0	2.50
> 6.4	Special	–

Table 6-2: Standard classes of rock slope protection (from Austroads 2023 and MRWA 2006)

Rock class	Rock size ⁽¹⁾ (m)	Rock mass (kg)	Minimum percentage of rock larger than
Facing	0.40	100	0
	0.30	35	50
	0.15	2.5	90
Light	0.55	250	0
	0.40	100	50
	0.20	10	90
¼ tonne	0.75	500	0
	0.55	250	50
	0.30	35	90
½ tonne	0.90	1000	0
	0.70	450	50
	0.40	100	90
1 tonne	1.15	2000	0
	0.60	1000	50
	0.55	250	90
2 tonne	1.45	4000	0
	1.15	2000	50
	0.75	500	90
4 tonne	1.80	8000	0
	1.45	4000	50
	0.90	100	90



Table 6-3: Standard classes of rock slope protection (from Table 406.1, MRWA 2017)

Rock Class	Rock Size (m) *	Approximate Rock Mass (kg)	Percentage of Rock Larger than Rock Size in the Second Column	Typical Use (Examples Only)
Type A	0.20 0.10 0.075		0 50 90	Catchpit Surrounds
Type B1	0.30 0.20 0.10		0 50 90	Culvert Outlets
Type B (Facing)	0.40 0.30 0.15	100 35 2.5	0 50 90	Culvert Outlets
Light	0.55 0.40 0.20	250 100 10	0 50 90	Floodway Batters
Quarter Tonne	0.75 0.55 0.30	500 250 35	0 50 90	Floodway Batters
One Tonne	1.15 0.90 0.55	2000 1000 250	0 50 90	Floodway Batters
Two Tonne	1.45 1.15 0.75	4000 2000 500	0 50 90	Floodway Batters
Rock Pitching	0.40 x 0.40 x 0.20 0.15 x 0.15 x 0.15		60 100	Landscaped Slopes (Typically Limestone)

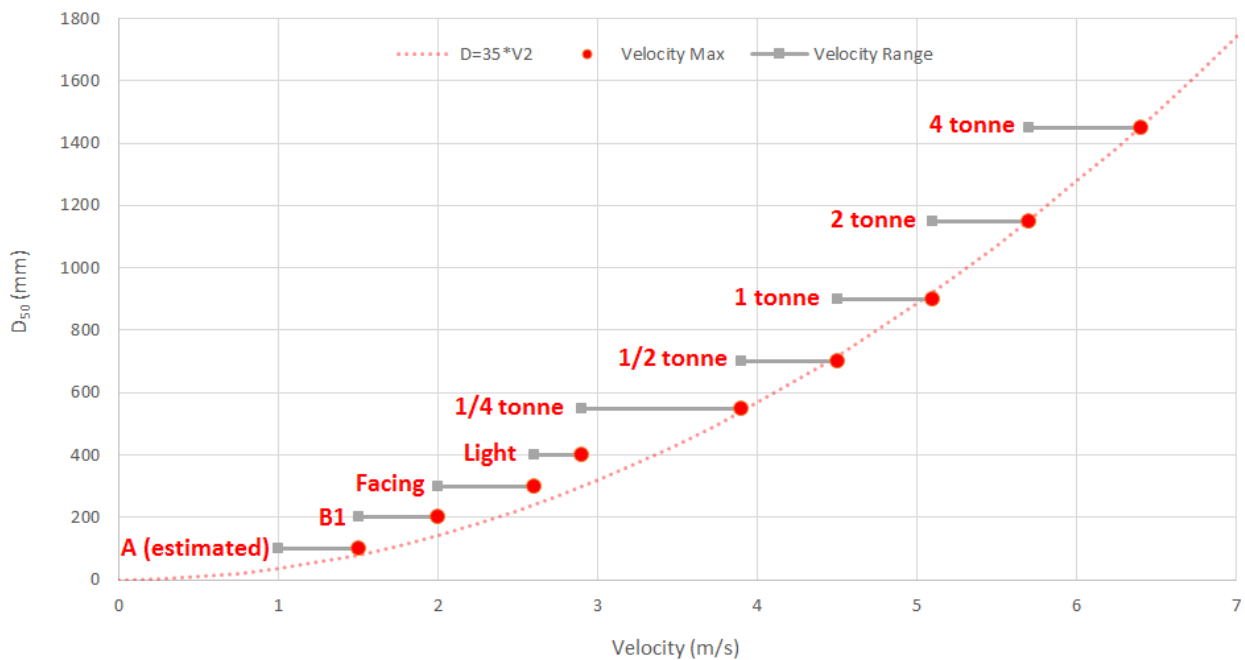


Figure 6-1: Velocity vs. median stone size (based on Austroads 2023)



7. Surface water risks and management

7.1. Risk assessment

Project-related risks are assessed based on July 2025 conceptual designs. The Project is located near a catchment divide without concentrated flow paths. Based upon the project location and the scale of impacts assessed, risks associated with the Project are relatively low. Residual risks to the Project related to surface water management involve potential flood inundation, sedimentation, and scour. Predicted rainfall and runoff is based on assumed modelling parameters that apply some conservatism to offset uncertainties related to a lack of long-term, local gauge records.

7.2. Model calibration

Local observations of surface water levels prior to the operational phase of the Project may provide opportunities for the calibration of model results. Pre-operational baseline conditions models can be developed based on local observations to more accurately predict impacts of proposed project scenarios and to further limit downstream surface water impacts.

7.3. Mine layout updates

Any changes to the mine layout should be reflected in updated surface water modelling. Impacts on exclusion zones or sensitive receptors should be re-assessed with any changes in the proposed layout. The adopted design criteria should be formalised as early in the design process as possible. Additional sensitivity analyses should be conducted on key input parameters to highlight risks and uncertainties in the applied modelling results if sensitive receptors are shown to be impacted.

7.4. Drainage design details

Detailed designs should incorporate floodway armouring and other details to provide scour mitigation. Culvert details, including end treatment, type, dimensions, substrate, blockage, inlet/outlet coordinates and levels, apron designs, and other details should be added to detailed designs for each crossing. Final culvert configurations should be reflected in the hydraulic model to accurately represent head losses and culvert conveyance capacity.

The hydraulic design should be iteratively updated for consistency with civil design surfaces to ensure design flows are adequately conveyed in accordance with the adopted design criteria. Individual culverts and floodways should be further optimised to reduce out-of-service periods, with a focus on the most critical corridors.



8. Recommendations and Conclusions

8.1. Summary

As reflected in the rainfall-runoff and hydraulic modelling, the accompanying drainage design minimises surface water impacts to the downstream environment. No specific downstream features have been identified for environmental impacts; to evaluate changes in flow rates and volumes at local and regional catchment scales, this assessment provides comparisons at the Great Northern Highway and at Eagle Rock Pool, located approximately 20 km downstream of the site.

Potential impacts without mitigation include scour, sedimentation, and reduction in floodplain connectivity and surface water delivery. Mitigation measures were implemented in the adopted drainage design to minimise disruptions to downstream flows. To guide the assessment and the development of drainage design features, hydraulic models were developed to simulate flows conditions for a range of events under existing and developed conditions, with blockages applied where pits and landforms are present in the design.

The rain-on-grid modelling results that serve as a basis for the inundation maps and impact assessments in this study are higher than the median-confidence RFFE results due to the incorporation of climate change uplifts and conservative parameter selection. Rain-on-grid hydraulic results match RFFE results within approximately 20%; however, due to the lack of local gauge records, there is a high degree of uncertainty associated with the simulated results. Conservative assumptions have been applied to the analyses to account for the potential uncertainty.

The results show that diversion drains can be constructed in the proposed locations with reasonable amounts of excavation to avoid ponding and reduction of downstream flow volumes. Maximum velocities indicate that rock lining would not be required along the proposed diversion drain alignments.

Cumulative impacts from other mining operations in the area are likely to include further reductions in the downstream runoff rates. The impacts of the Round Hill project are assumed to be low relative to the impacted area from additional downstream mining operations. The Project-related impacts can be managed with the incorporation of the proposed drainage designs and standard sediment management and erosion control practices.

Waste rock dumps are designed to be internally draining, and proposed diversion drains and bunds route external runoff around the site perimeter. Sediment basins will collect mine-affected runoff prior to downstream discharge. Detailed diversion designs should seek to avoid velocities that would potentially scour the channel banks, reducing requirements for rock lining along the proposed diversion drain alignments.

Sensitivity analyses show that predicted peak discharge rates vary substantially with changes in the adopted roughness coefficients, temporal patterns, and loss rates. All model runs include a 20% uplift in rainfall intensity to account for climate change through 2050, along with a 10% increase in adopted loss rates.

A comparison of baseline and project conditions model results shows that downstream flow rates and volumes are reduced by approximately 10% - 20% at the GNH and approximately 2% - 3% at Eagle Rock Pool. The modelling approach applies conservative values; based upon the applied approach, further optimisation of drainage design features is likely to reduce these impacts.



8.2. Limitations

The results presented in this report are limited to the accuracy of the available terrain data and the extent of available hydrological records. This assessment relies on the provided layouts, and the impact assessment conservatively removes all intercepted flow from contributing catchment areas.

The results presented in this assessment account for uniform climate change uplift factors. The modelled scenarios do not include water quality assessments, surface water-groundwater interaction, or long-term water balance considerations.



9. References

- AustRoads, 2023. Guide to Road Design, Part 5: Drainage and Hydrology Considerations.
- Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019. Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia (Geoscience Australia).
- Bureau of Meteorology (BoM) 2016. Intensity-Frequency-Duration data. 2016 Rainfall IFD Data System <http://www.bom.gov.au/water/designRainfalls/revised-ifd/>.
- Department of Water and Environmental Regulation (DWER), 2021. Water Information Reporting tool. <http://wir.water.wa.gov.au/Pages/Water-Information-Reporting/>.
- Department of Water and Environmental Regulation, 2023. Floodplain Mapping Tool: <https://www.wa.gov.au/service/natural-resources/water-resources/floodplain-mapping-tool>.
- Engineers Australia, 2015. Regional Flood Frequency Estimation model. Australian Rainfall and Runoff, 4th Edition V1. <https://rffe.arr-software.org/>.
- Engineers Australia, 2019. Australian Rainfall and Runoff Data Hub. <https://data.arr-software.org/>.
- Flavell, D. 2012. Design flood estimation in Western Australia, Australasian Journal of Water Resources, 16:1, 1-20
- Geoscience Australia (GSA), 2025. ARR Data Hub. <https://data.arr-software.org/>.
- Geoscience Australia (GSA) 2015. Digital Elevation Model of Australia derived from LiDAR 5 metre grid.
- Geoscience Australia (GSA), 2024. Elvis Elevation and Depth Foundation Spatial Data. <http://elevation.fsd.org.au>.
- Hanroy, 2025. 0.5 m x 0.5 m digital elevation model "XR-ROUNDHILL_LAYOUT-3D-TINS_0.5M.TIF" dated 18 July 2025.
- Hanroy, 2024. 1m x 1m digital elevation model "RH_LiDAR_1m_Mosaic_20240821.tif" dated 21 Aug 2024.
- MRWA, 2006. Floodway Design Guide.
- QDES 2023. Scientific Information for Land Owners. <https://www.longpaddock.qld.gov.au/silo/>.
- Stratagen, 2010. Hope Downs 4 Mine (HD4) Environmental Review Document, Hamersley HMS Pty Ltd.
- U.S. Army Corps of Engineers, 2025. HEC-RAS 6.7 2D User Manual.
- WMA Water, 2021. Regional Flood Frequency Estimation (beta). <https://rffe-2021.wmawater.com.au/>.



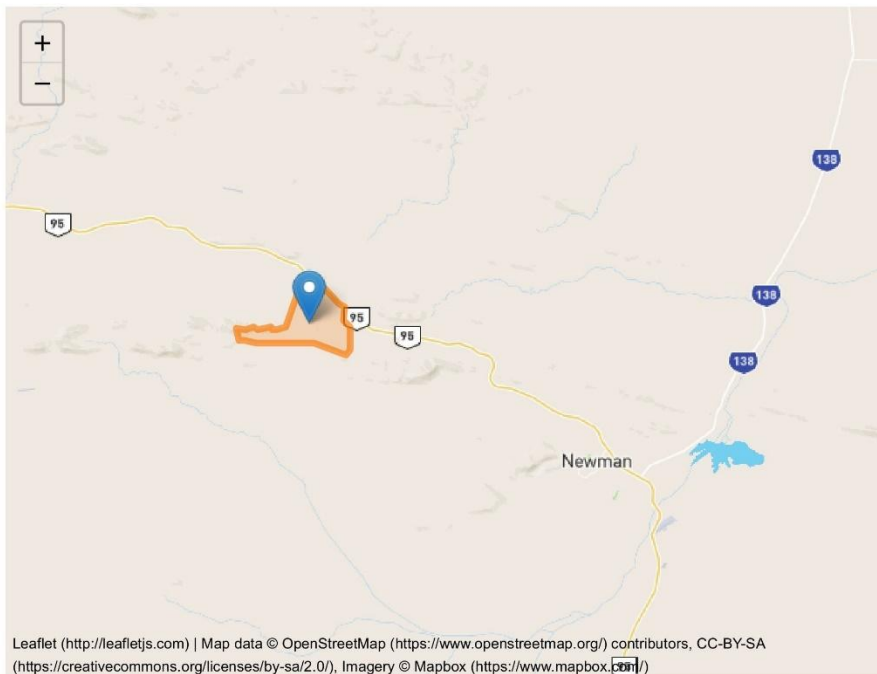
Appendix A. ARR Data Hub and RFFE Results



Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	119.438
Latitude	-23.228
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Climate Change Factors	show
Baseflow Factors	show





Data

River Region

Division	Pilbara-Gascoyne
River Number	8
River Name	Fortescue River
Shape Intersection (%)	100.0

Layer Info

Time Accessed	22 October 2025 05:06PM
Version	2016_v1

ARF Parameters

$$ARF = Min \left\{ 1, \left[1 - a (Area^b - c \log_{10} Duration) Duration^{-d} + e Area^f Duration^g (0.3 + \log_{10} AEP) + h 10^{i Area \frac{Duration}{1440}} (0.3 + \log_{10} AEP) \right] \right\}$$

Zone	a	b	c	d	e	f	g	h	i	Shape Intersection (%)
Northern Coastal	0.326	0.223	0.442	0.323	0.0013	0.58	-0.374	0.013	-0.0015	100.0

Short Duration ARF

$$ARF = Min \left[1, 1 - 0.287 (Area^{0.265} - 0.439 \log_{10}(Duration)) \cdot Duration^{-0.36} + 2.26 \times 10^{-3} \times Area^{0.226} \cdot Duration^{0.125} (0.3 + \log_{10}(AEP)) + 0.0141 \times Area^{0.213} \times 10^{-0.021 \frac{(Duration-180)^2}{1440}} (0.3 + \log_{10}(AEP)) \right]$$

Layer Info

Time Accessed	22 October 2025 05:06PM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Storm Initial Losses (mm)	-50.0
Storm Continuing Losses (mm/h)	-50.0

Layer Info

Time Accessed	22 October 2025 05:06PM
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Version	2016_v1
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Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/Rwest.zip)

code	Rwest
Label	Rangelands West
Shape Intersection (%)	100.0

Layer Info

Time Accessed	22 October 2025 05:06PM
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Version	2016_v2
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Areal Temporal Patterns | Download (.zip)
 (./static/temporal_patterns/Areal/Areal_Rwest.zip)

code	Rwest
arealabel	Rangelands West
Shape Intersection (%)	100.0

Layer Info

Time Accessed	22 October 2025 05:06PM
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Version	2016_v2
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BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/reviced-ifd/?year=2016&coordinate_type=dd&latitude=-23.2281572466&longitude=119.438255294&sdmin=true&sdhr=true&sdday=true&use) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	22 October 2025 05:06PM
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Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.4 (0.017)	1.1 (0.034)	1.6 (0.039)	2.1 (0.043)	2.4 (0.041)	2.6 (0.039)
90 (1.5)	0.5 (0.017)	0.9 (0.024)	1.3 (0.026)	1.6 (0.028)	2.0 (0.029)	2.3 (0.030)
120 (2.0)	0.3 (0.010)	0.9 (0.021)	1.3 (0.025)	1.7 (0.027)	2.4 (0.032)	3.0 (0.034)
180 (3.0)	0.9 (0.028)	2.9 (0.058)	4.2 (0.068)	5.5 (0.074)	7.1 (0.079)	8.4 (0.080)
360 (6.0)	0.0 (0.000)	1.5 (0.022)	2.4 (0.029)	3.4 (0.033)	21.3 (0.170)	34.8 (0.238)
720 (12.0)	0.0 (0.000)	1.3 (0.015)	2.1 (0.019)	2.9 (0.022)	8.6 (0.049)	12.8 (0.063)
1080 (18.0)	0.0 (0.000)	0.9 (0.008)	1.4 (0.011)	2.0 (0.012)	11.6 (0.057)	18.8 (0.078)
1440 (24.0)	0.0 (0.000)	0.6 (0.005)	1.0 (0.007)	1.3 (0.007)	6.3 (0.028)	10.1 (0.038)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	2.3 (0.009)	4.1 (0.014)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	22 October 2025 05:06PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.



10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed 22 October 2025 05:06PM

Version 2018_v1

Note Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.



25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.001)	0.1 (0.001)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	1.3 (0.010)	2.3 (0.016)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.5 (0.003)	0.8 (0.004)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	1.0 (0.005)	1.8 (0.007)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.1 (0.001)	0.2 (0.001)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	22 October 2025 05:06PM
Version	2018_v1
Note	Prebust interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.



75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	11.6 (0.501)	12.7 (0.376)	13.4 (0.327)	14.1 (0.292)	17.3 (0.299)	19.8 (0.302)
90 (1.5)	10.1 (0.377)	22.4 (0.574)	30.6 (0.643)	38.4 (0.686)	32.2 (0.475)	27.5 (0.358)
120 (2.0)	10.6 (0.360)	23.8 (0.549)	32.5 (0.614)	40.9 (0.652)	37.2 (0.489)	34.4 (0.396)
180 (3.0)	17.2 (0.507)	26.6 (0.530)	32.9 (0.531)	38.9 (0.526)	51.6 (0.569)	61.1 (0.586)
360 (6.0)	10.8 (0.248)	21.4 (0.324)	28.4 (0.343)	35.1 (0.349)	53.8 (0.429)	67.8 (0.464)
720 (12.0)	5.5 (0.098)	13.6 (0.156)	19.0 (0.171)	24.1 (0.176)	36.1 (0.208)	45.1 (0.222)
1080 (18.0)	6.9 (0.107)	10.4 (0.102)	12.7 (0.097)	14.9 (0.092)	22.0 (0.108)	27.4 (0.114)
1440 (24.0)	3.2 (0.046)	6.4 (0.058)	8.5 (0.059)	10.6 (0.059)	18.3 (0.081)	24.0 (0.091)
2160 (36.0)	0.0 (0.000)	2.2 (0.017)	3.6 (0.022)	5.0 (0.025)	13.3 (0.053)	19.5 (0.067)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	6.4 (0.024)	11.2 (0.037)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	22 October 2025 05:06PM
Version	2018_v1
Note	Prebust interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.



90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	29.5 (1.268)	41.5 (1.228)	49.5 (1.206)	57.2 (1.186)	70.8 (1.224)	81.0 (1.239)
90 (1.5)	54.8 (2.052)	71.5 (1.831)	82.5 (1.734)	93.1 (1.660)	90.3 (1.335)	88.3 (1.148)
120 (2.0)	30.1 (1.020)	56.4 (1.303)	73.8 (1.393)	90.5 (1.444)	92.2 (1.212)	93.6 (1.077)
180 (3.0)	46.5 (1.372)	62.9 (1.251)	73.8 (1.190)	84.2 (1.139)	100.7 (1.111)	113.1 (1.085)
360 (6.0)	29.6 (0.680)	42.6 (0.644)	51.1 (0.617)	59.4 (0.591)	81.3 (0.648)	97.8 (0.670)
720 (12.0)	30.5 (0.544)	38.2 (0.438)	43.3 (0.389)	48.2 (0.352)	67.1 (0.387)	81.2 (0.400)
1080 (18.0)	21.0 (0.325)	26.5 (0.262)	30.2 (0.232)	33.8 (0.209)	52.2 (0.255)	66.1 (0.275)
1440 (24.0)	22.1 (0.313)	23.6 (0.212)	24.6 (0.172)	25.6 (0.144)	50.1 (0.222)	68.4 (0.259)
2160 (36.0)	15.1 (0.192)	18.3 (0.146)	20.4 (0.127)	22.4 (0.112)	26.8 (0.106)	30.1 (0.103)
2880 (48.0)	4.1 (0.049)	6.9 (0.052)	8.8 (0.052)	10.7 (0.050)	17.2 (0.065)	22.1 (0.072)
4320 (72.0)	0.0 (0.000)	0.1 (0.001)	0.1 (0.001)	0.2 (0.001)	12.0 (0.044)	20.9 (0.066)

Layer Info

Time Accessed	22 October 2025 05:06PM
Version	2018_v1
Note	Prebust interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.



Climate Change Factors

Rainfall Factors

SSP1-2.6

Year	<1 hour	1.5 Hours	2 Hours	3 Hours	4.5 Hours	6 Hours	9 Hours	12 Hours	18 Hours	>24 Hours
2030	1.18	1.17	1.16	1.14	1.13	1.12	1.12	1.11	1.1	1.1
2040	1.21	1.19	1.17	1.16	1.15	1.14	1.13	1.12	1.11	1.11
2050	1.22	1.2	1.18	1.17	1.15	1.15	1.14	1.13	1.12	1.11
2060	1.23	1.21	1.2	1.18	1.17	1.16	1.15	1.14	1.13	1.12
2070	1.24	1.22	1.2	1.18	1.17	1.16	1.15	1.14	1.13	1.12
2080	1.23	1.21	1.2	1.18	1.17	1.16	1.15	1.14	1.13	1.12
2090	1.23	1.21	1.2	1.18	1.17	1.16	1.15	1.14	1.13	1.12
2100	1.22	1.2	1.19	1.17	1.16	1.15	1.14	1.13	1.12	1.12

SSP2-4.5

Year	<1 hour	1.5 Hours	2 Hours	3 Hours	4.5 Hours	6 Hours	9 Hours	12 Hours	18 Hours	>24 Hours
2030	1.18	1.17	1.16	1.14	1.13	1.12	1.12	1.11	1.1	1.1
2040	1.22	1.2	1.19	1.17	1.16	1.15	1.14	1.13	1.12	1.12
2050	1.27	1.24	1.23	1.21	1.19	1.18	1.17	1.16	1.15	1.14
2060	1.3	1.27	1.25	1.23	1.21	1.2	1.19	1.18	1.16	1.16
2070	1.33	1.3	1.28	1.26	1.24	1.22	1.21	1.19	1.18	1.17
2080	1.37	1.33	1.31	1.28	1.26	1.24	1.22	1.21	1.2	1.19
2090	1.4	1.36	1.34	1.31	1.28	1.26	1.24	1.23	1.21	1.2
2100	1.41	1.37	1.35	1.32	1.29	1.27	1.25	1.24	1.22	1.21

SSP3-7.0

Year	<1 hour	1.5 Hours	2 Hours	3 Hours	4.5 Hours	6 Hours	9 Hours	12 Hours	18 Hours	>24 Hours
2030	1.18	1.17	1.16	1.14	1.13	1.12	1.12	1.11	1.1	1.1
2040	1.23	1.21	1.2	1.18	1.17	1.16	1.15	1.14	1.13	1.12
2050	1.29	1.26	1.24	1.22	1.2	1.19	1.18	1.17	1.16	1.15
2060	1.35	1.32	1.3	1.27	1.25	1.23	1.22	1.2	1.19	1.18
2070	1.42	1.38	1.35	1.32	1.29	1.28	1.26	1.24	1.22	1.21
2080	1.5	1.45	1.42	1.38	1.35	1.33	1.3	1.28	1.26	1.25
2090	1.59	1.53	1.49	1.44	1.4	1.38	1.35	1.33	1.3	1.29



Year	<1 hour	1.5 Hours	2 Hours	3 Hours	4.5 Hours	6 Hours	9 Hours	12 Hours	18 Hours	>24 Hours
2100	1.66	1.59	1.55	1.5	1.45	1.42	1.39	1.37	1.34	1.32

SSP5-8.5

Year	<1 hour	1.5 Hours	2 Hours	3 Hours	4.5 Hours	6 Hours	9 Hours	12 Hours	18 Hours	>24 Hours
2030	1.2	1.18	1.17	1.16	1.14	1.13	1.13	1.12	1.11	1.11
2040	1.26	1.24	1.22	1.2	1.18	1.17	1.16	1.15	1.14	1.14
2050	1.34	1.31	1.29	1.26	1.24	1.23	1.21	1.2	1.18	1.18
2060	1.42	1.38	1.35	1.32	1.29	1.28	1.26	1.24	1.22	1.21
2070	1.52	1.47	1.43	1.4	1.36	1.34	1.31	1.29	1.27	1.26
2080	1.63	1.57	1.52	1.48	1.43	1.4	1.37	1.35	1.33	1.31
2090	1.77	1.69	1.64	1.58	1.52	1.49	1.45	1.42	1.39	1.37
2100	1.86	1.77	1.71	1.64	1.58	1.54	1.5	1.47	1.43	1.41

Loss Factors

Initial Loss (Adjustment Factors)

	Losses SSP1-2.6	Losses SSP2-4.5	Losses SSP3-7.0	Losses SSP5-8.5
2030	1.05	1.05	1.05	1.06
2040	1.06	1.06	1.07	1.08
2050	1.07	1.08	1.08	1.1
2060	1.07	1.09	1.1	1.12
2070	1.07	1.1	1.12	1.14
2080	1.07	1.1	1.14	1.17
2090	1.07	1.11	1.16	1.19
2100	1.07	1.11	1.17	1.22

Continuing Loss (Adjustment Factors)

	Losses SSP1-2.6	Losses SSP2-4.5	Losses SSP3-7.0	Losses SSP5-8.5
2030	1.07	1.07	1.07	1.07
2040	1.08	1.08	1.09	1.09
2050	1.08	1.09	1.1	1.12
2060	1.09	1.11	1.12	1.15
2070	1.09	1.12	1.15	1.18
2080	1.09	1.13	1.17	1.21



	Losses SSP1-2.6	Losses SSP2-4.5	Losses SSP3-7.0	Losses SSP5-8.5
2090	1.08	1.14	1.2	1.24
2100	1.08	1.14	1.22	1.27

Temperature Changes (Degrees, Relative to 1961-1990 Baseline)

Year	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
2030	1.2	1.2	1.2	1.3
2040	1.3	1.4	1.5	1.6
2050	1.4	1.7	1.8	2.1
2060	1.5	1.9	2.2	2.5
2070	1.5	2.1	2.5	3
2080	1.5	2.2	2.9	3.5
2090	1.5	2.4	3.3	4.1
2100	1.4	2.5	3.6	4.5

Layer Info

Time Accessed 22 October 2025 05:06PM

Version 2024_v1

Note Updated climate change factors for IFD Initial loss and continuing loss based on IPCC AR6 temperature increases from the updated Climate Change Considerations (Book 1: Chapter 6) in ARR (Version 4.2). ARR recommends the use of Current and near-term (2030 midpoint), Medium-term (2050 midpoint) and Long-term (2090 midpoint)

Baseflow Factors

Downstream	4376
Area (km2)	2571.364608
Catchment Number	4556
Volume Factor	0.156178
Peak Factor	0.026975
Shape Intersection (%)	95.5

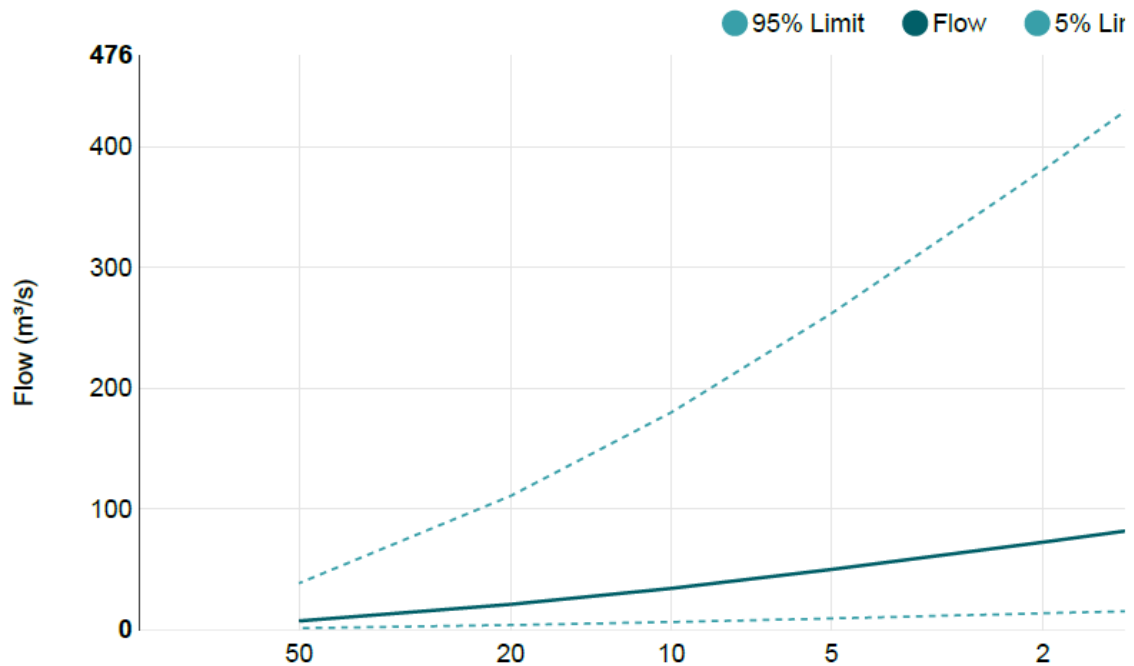
Layer Info

Time Accessed 22 October 2025 05:06PM

Version 2016_v1



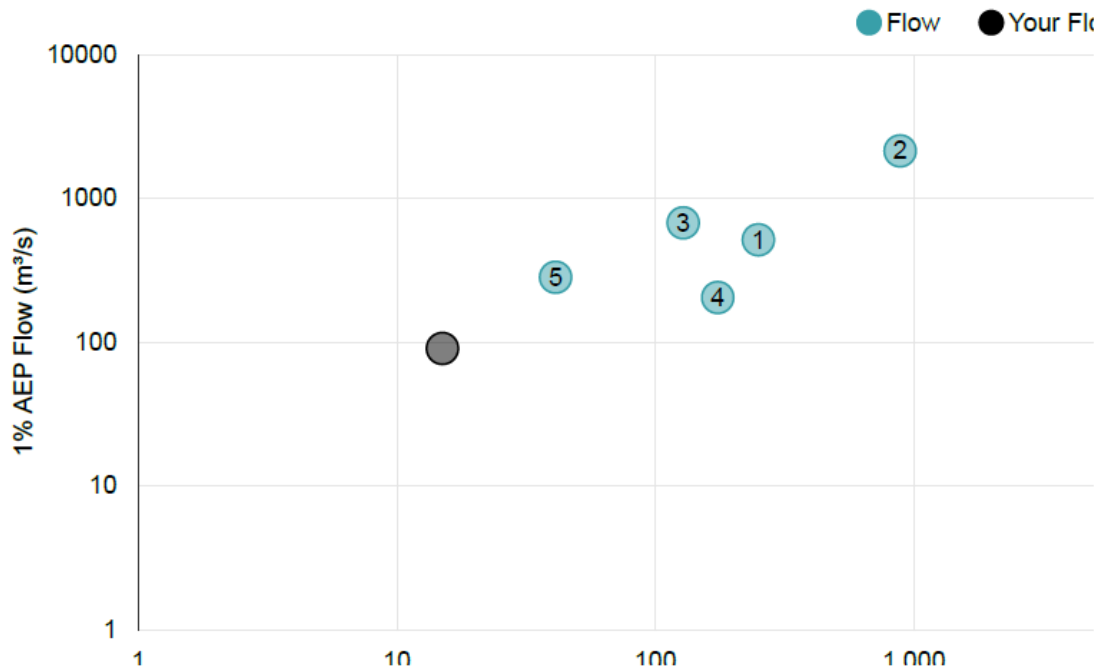
Results | Regional Flood Frequency Estimation Model



AEP (%)	Discharge (m ³ /s)	Lower Confidence Limit (5%) (m ³ /s)	Upper Confidence Limit (95%) (m ³ /s)
50	7.34	1.39	38.6
20	21.1	3.96	111
10	34.3	6.46	180
5	50.0	9.40	262
2	72.6	13.7	381
1	90.6	17.0	476

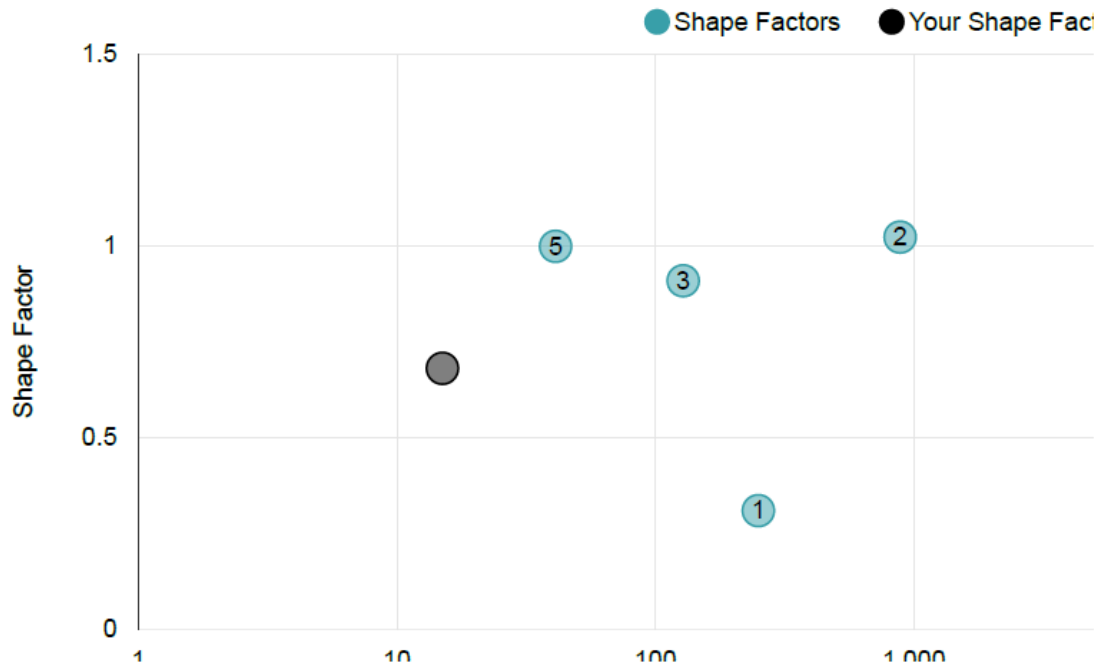


1% AEP Flow vs Catchment Area



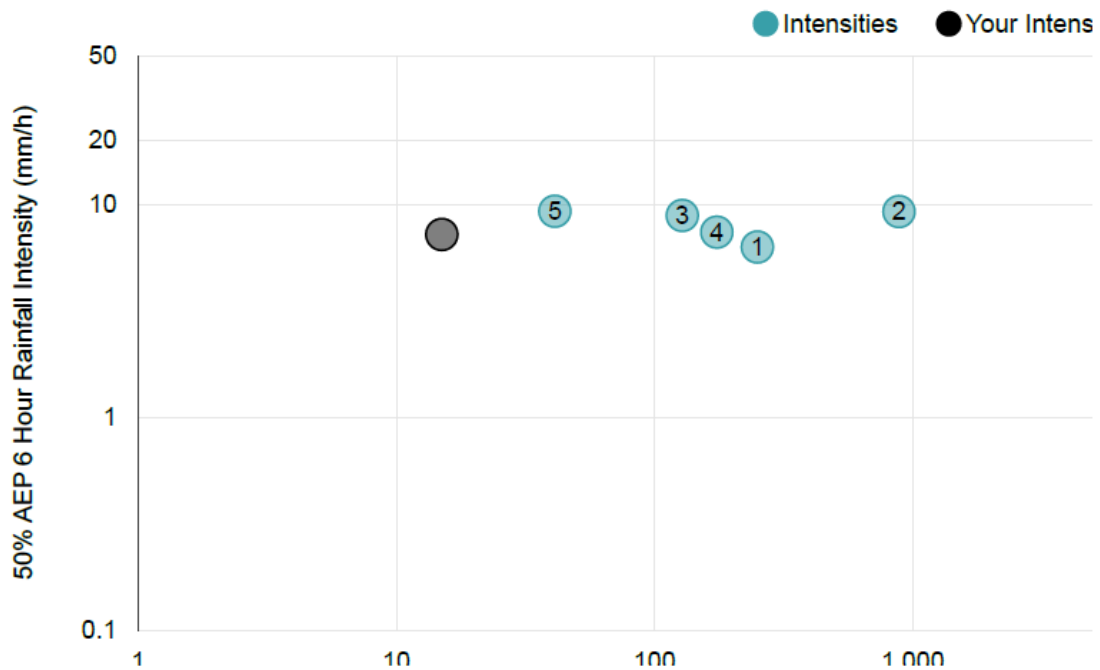
Shape Factor vs Catchment Area

Note: This region does not use shape factors

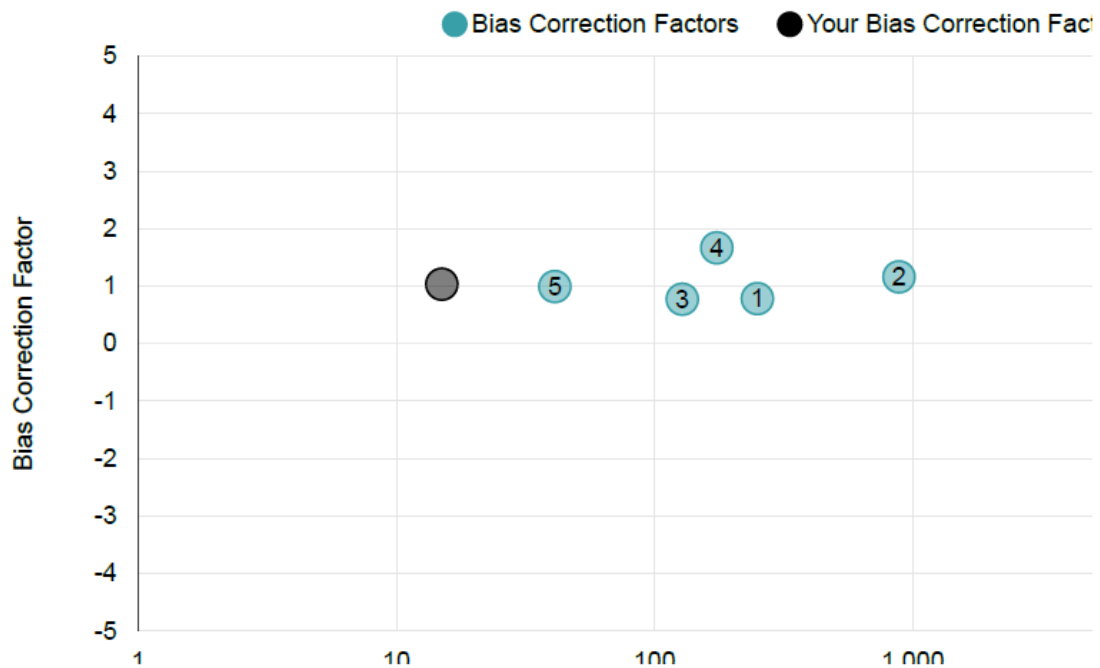




Intensity vs Catchment Area



Bias Correction Factor vs Catchment Area



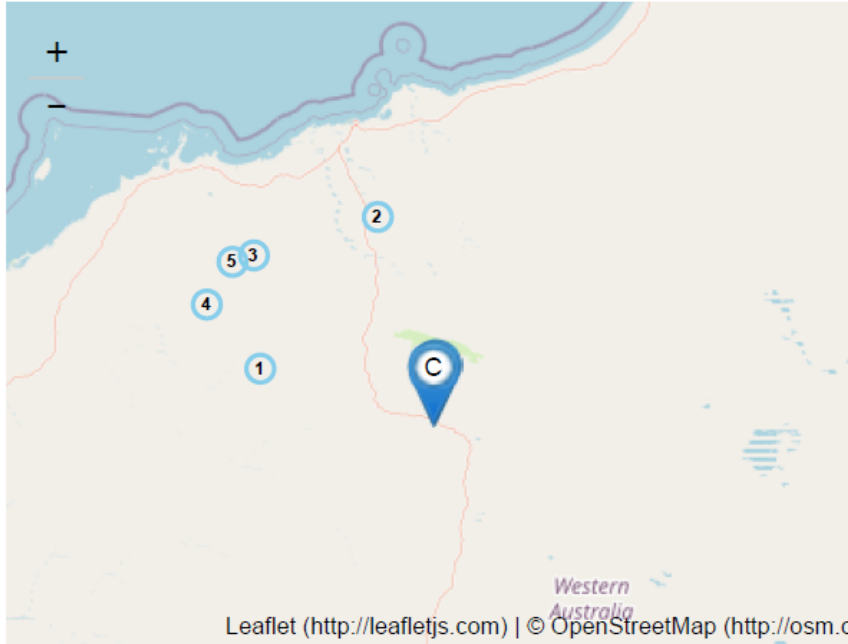


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- [📄 TXT](#)
- [📍 Nearby](#)
- [📄 JSON](#)

Input Data

Date/Time	2023-11-02 12:55
Catchment Name	RH Local
Latitude (Outlet)	-23.228289
Longitude (Outlet)	119.438208
Latitude (Centroid)	-23.238399
Longitude (Centroid)	119.415034
Catchment Area (km ²)	15.0
Distance to Nearest Gauged Catchment (km)	197.22
50% AEP 6 Hour Rainfall Intensity (mm/h)	7.231227
2% AEP 6 Hour Rainfall Intensity (mm/h)	20.864511
Rainfall Intensity Source (User/Auto)	Auto
Region	Pilbara
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.68
Interpolation Method	Natural Neighbour
Bias Correction Value	1.034



Method by Dr Ataur Rahman and Dr Khaled Haddad from Western Sydney University for the Australian Rainfall and Runoff Project. Full description of the project can be found at the project page (<http://arr.ga.gov.au/revision-projects/project-list/projects/project-5>) on the ARR website. Send any questions regarding the method or project here (<mailto:admin@arr-software.org>).



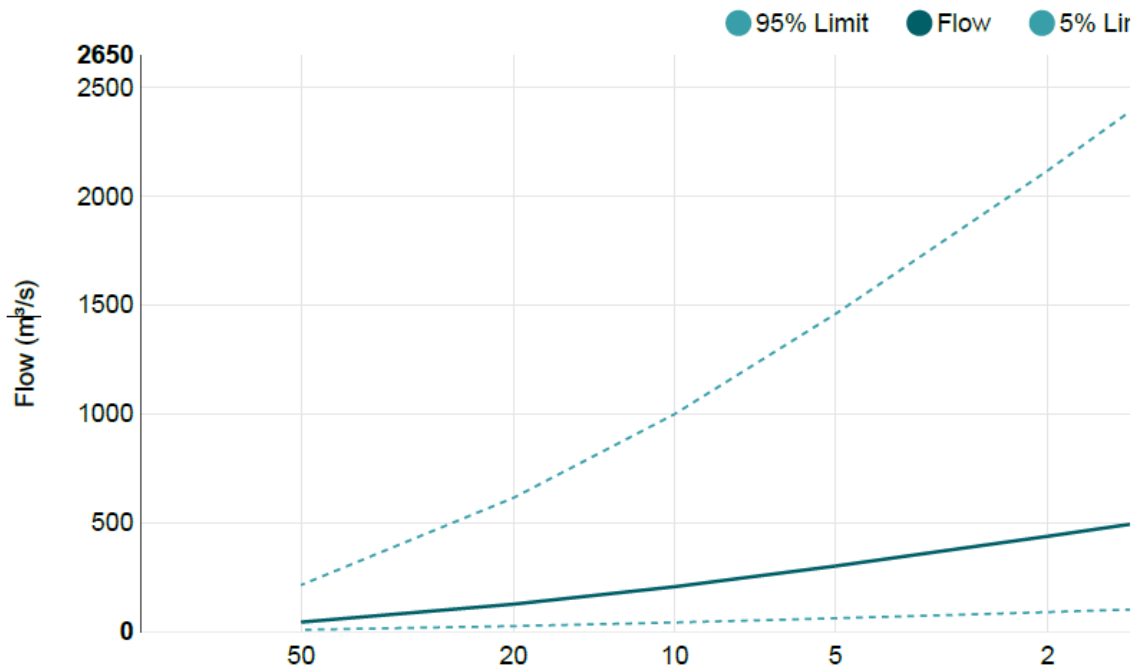
ENGINEERS AUSTRALIA (<http://www.engineersaustralia.org.au>)



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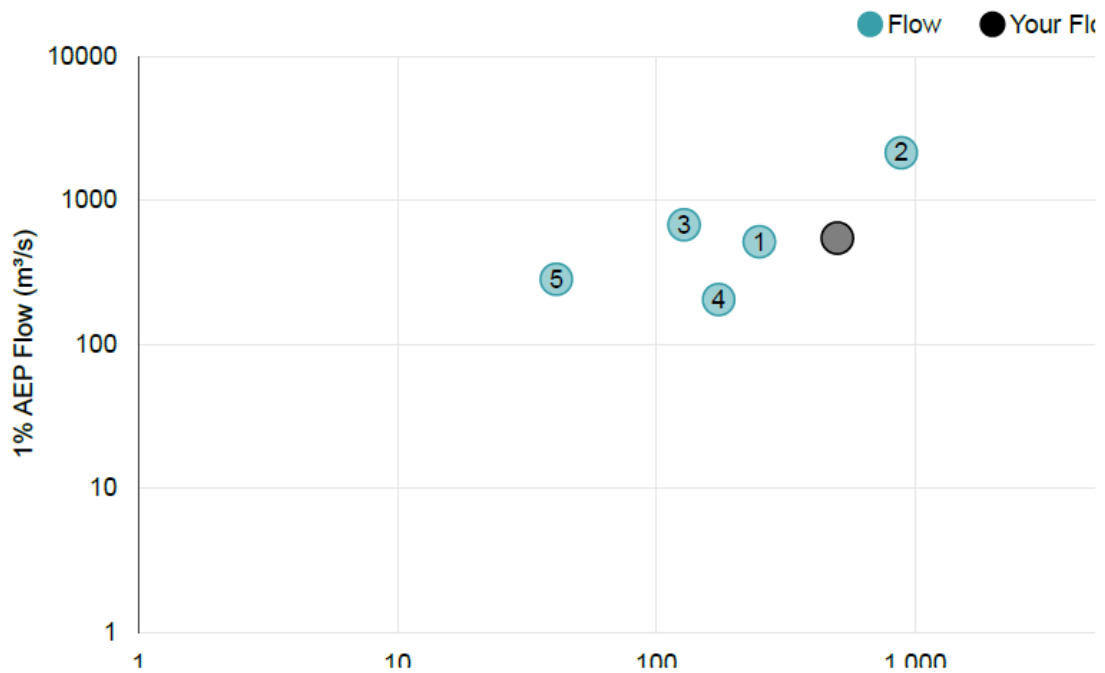
Results | Regional Flood Frequency Estimation Model



AEP (%)	Discharge (m³/s)	Lower Confidence Limit (5%) (m³/s)	Upper Confidence Limit (95%) (m³/s)
50	44.4	9.15	215
20	127	26.3	616
10	207	42.8	1000
5	302	62.3	1460
2	439	90.5	2120
1	547	113	2650

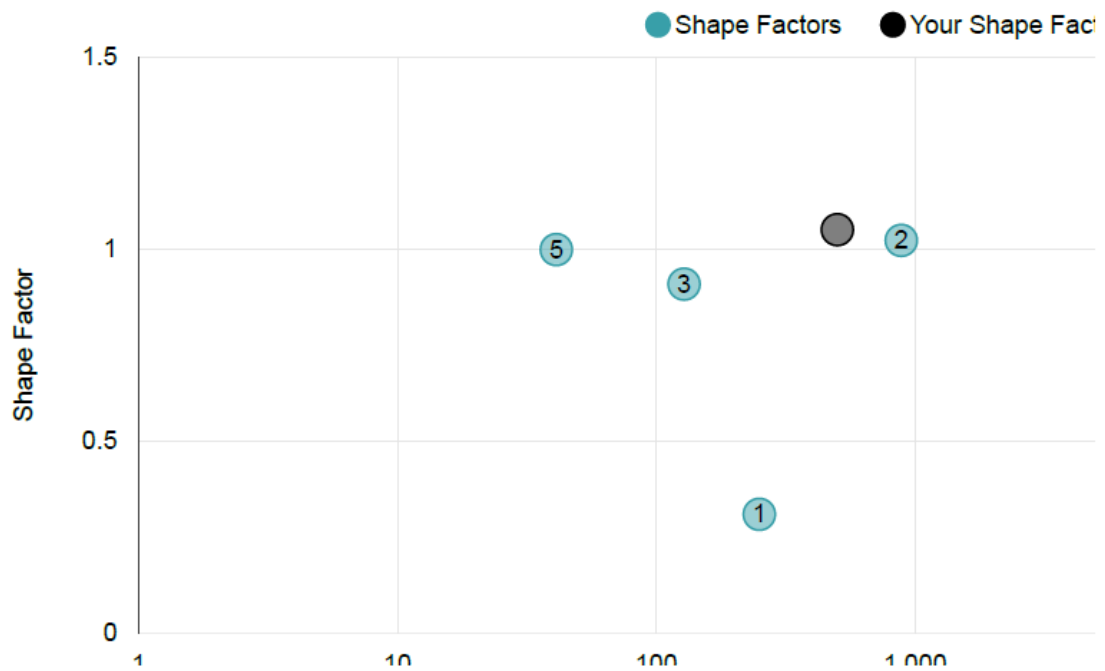


1% AEP Flow vs Catchment Area



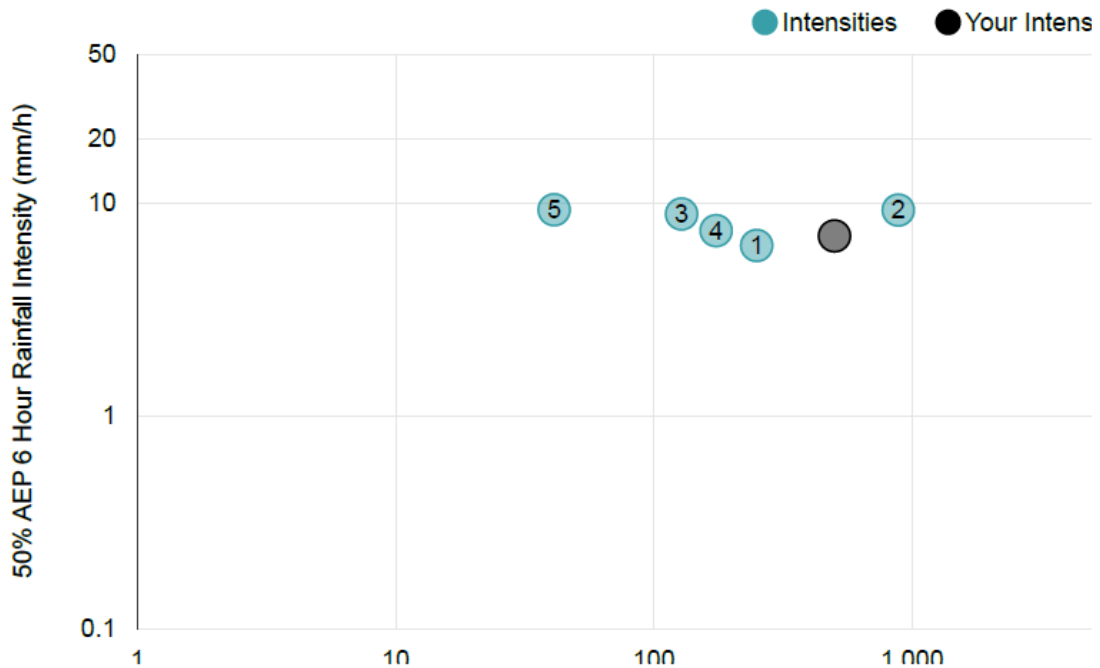
Shape Factor vs Catchment Area

Note: This region does not use shape factors

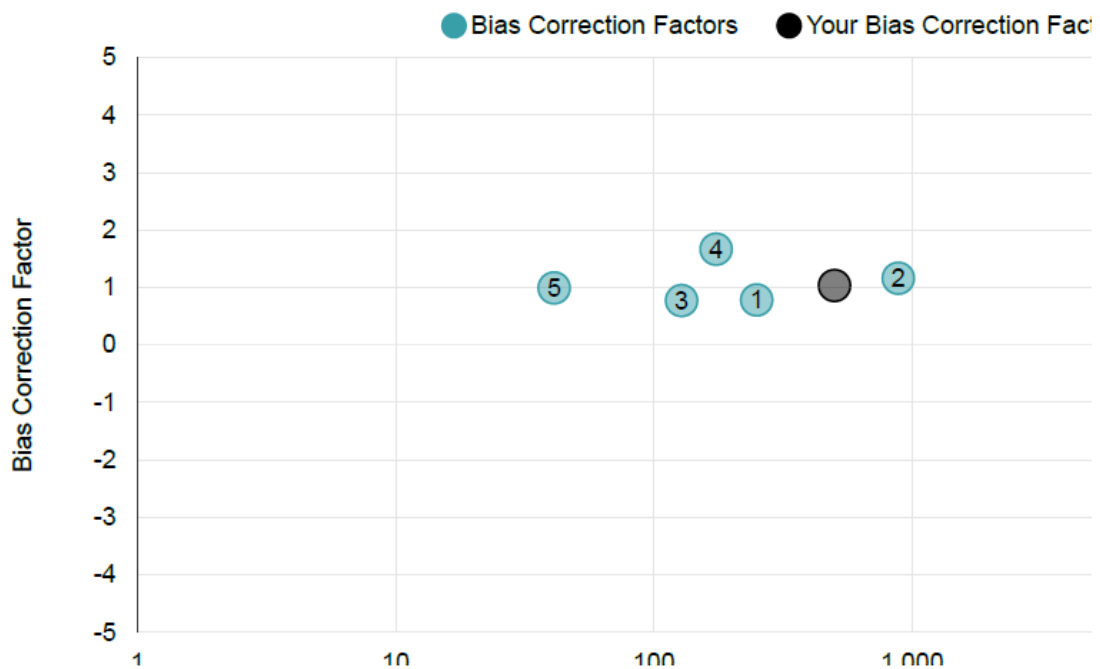




Intensity vs Catchment Area



Bias Correction Factor vs Catchment Area





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Input Data

Date/Time	2023-11-02 13:00
Catchment Name	RH West
Latitude (Outlet)	-23.193538
Longitude (Outlet)	119.43624
Latitude (Centroid)	-23.203987
Longitude (Centroid)	119.205482
Catchment Area (km ²)	501.0
Distance to Nearest Gauged Catchment (km)	195.87
50% AEP 6 Hour Rainfall Intensity (mm/h)	7.004188
2% AEP 6 Hour Rainfall Intensity (mm/h)	20.145661
Rainfall Intensity Source (User/Auto)	Auto
Region	Pilbara
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	1.05
Interpolation Method	Natural Neighbour
Bias Correction Value	1.034



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Method by Dr Ataur Rahman and Dr Khaled Haddad from Western Sydney University for the Australian Rainfall and Runoff Project. Full description of the project can be found at the project page (<http://arr.ga.gov.au/revision-projects/project-list/projects/project-5>) on the ARR website. Send any questions regarding the method or project here (<mailto:admin@arr-software.org>).



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BETA

Regional Flood Frequency Estimation Model



Australian Rainfall & Runoff

Release Version of the Regional Flood Frequency Estimation Model for the 4th edition of Australian Rainfall and Runoff.

Basic

Polygon

Input Data

Outlet Longitude (°)

119.438208

Outlet Latitude (°)

-23.228289

Centroid Longitude (°)

119.415034

Centroid Latitude (°)

-23.238399

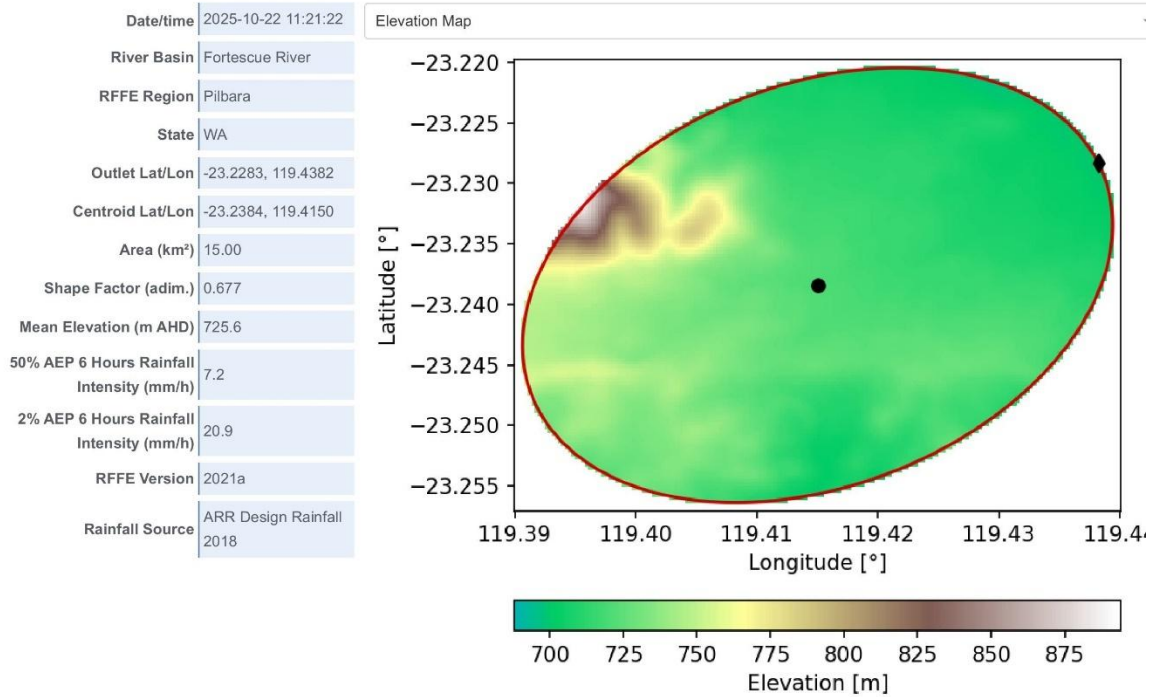
Catchment Area (km²)

15

RUN RFFE

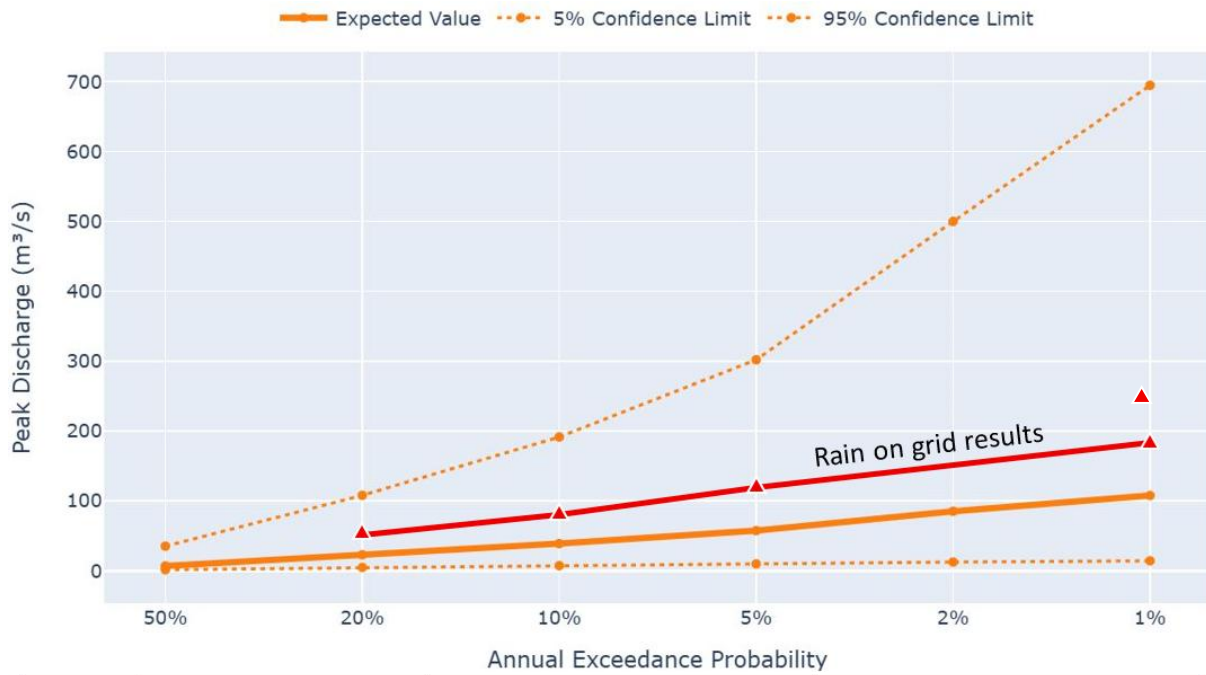


Catchment Properties



Estimated Flow Quantiles ?

Region	Model Type	Regression Type	Fitting Method	Predictors	Min Nearby Stations	Max Nearby Stations
6	Small Catchments [Recommended]	PRT	Mean GLS	Area km2, IFD 50% 6.0h, Soil Moisture Mean	Mean 50	Mean 50
			StDev OLS	Shape Factor, IFD 50% Tc, IFD 2% Tc	StDev 15	StDev 50
			Skew OLS	Elev Mean, IFD 50% 6.0h, IFD 2% 6.0h, Slope Mean	Skew -	Skew Full Region



AEP (%)	Expected Value (m³/s)	Lower Confidence Limit (m³/s)	Upper Confidence Limit (m³/s)
50%	6.81	1.38	35.14
20%	22.76	4.72	107.92
10%	38.76	7.23	191.32
5%	57.39	9.73	301.92
2%	85.07	12.39	499.91
1%	107.66	14.11	694.73

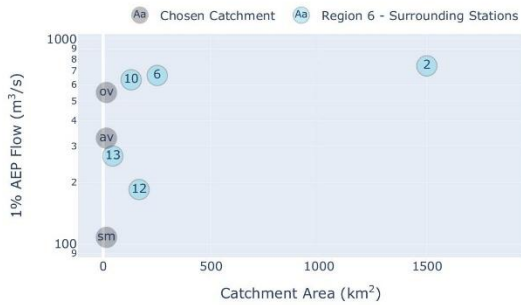


Predictors Data at 15 Closest Stations

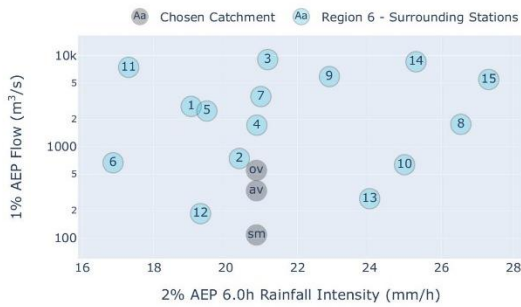
Select the flood's AEP



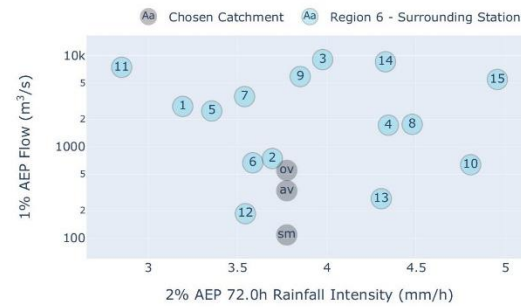
1% AEP Flow vs Catchment Area



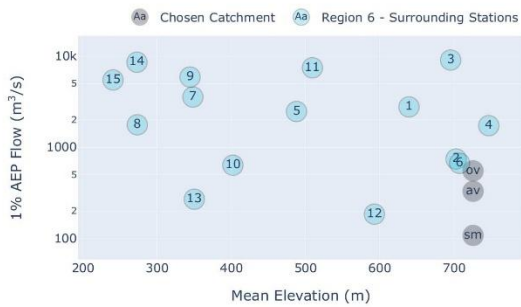
1% AEP Flow vs 2% AEP 6.0h Rainfall Intensity



1% AEP Flow vs 2% AEP 72.0h Rainfall Intensity



1% AEP Flow vs Mean Elevation



1% AEP Flow vs Mean Soil Moisture



Download RFFE Dataset

Method by Dr Ataur Rahman and Dr Khaled Haddad from Western Sydney University for the Australian Rainfall and Runoff Project. Full description of the project can be found at the [project page](#) on the ARR website. Send any questions regarding the method or project [here](#).





Appendix B. Depth, Velocity, and Afflux Maps

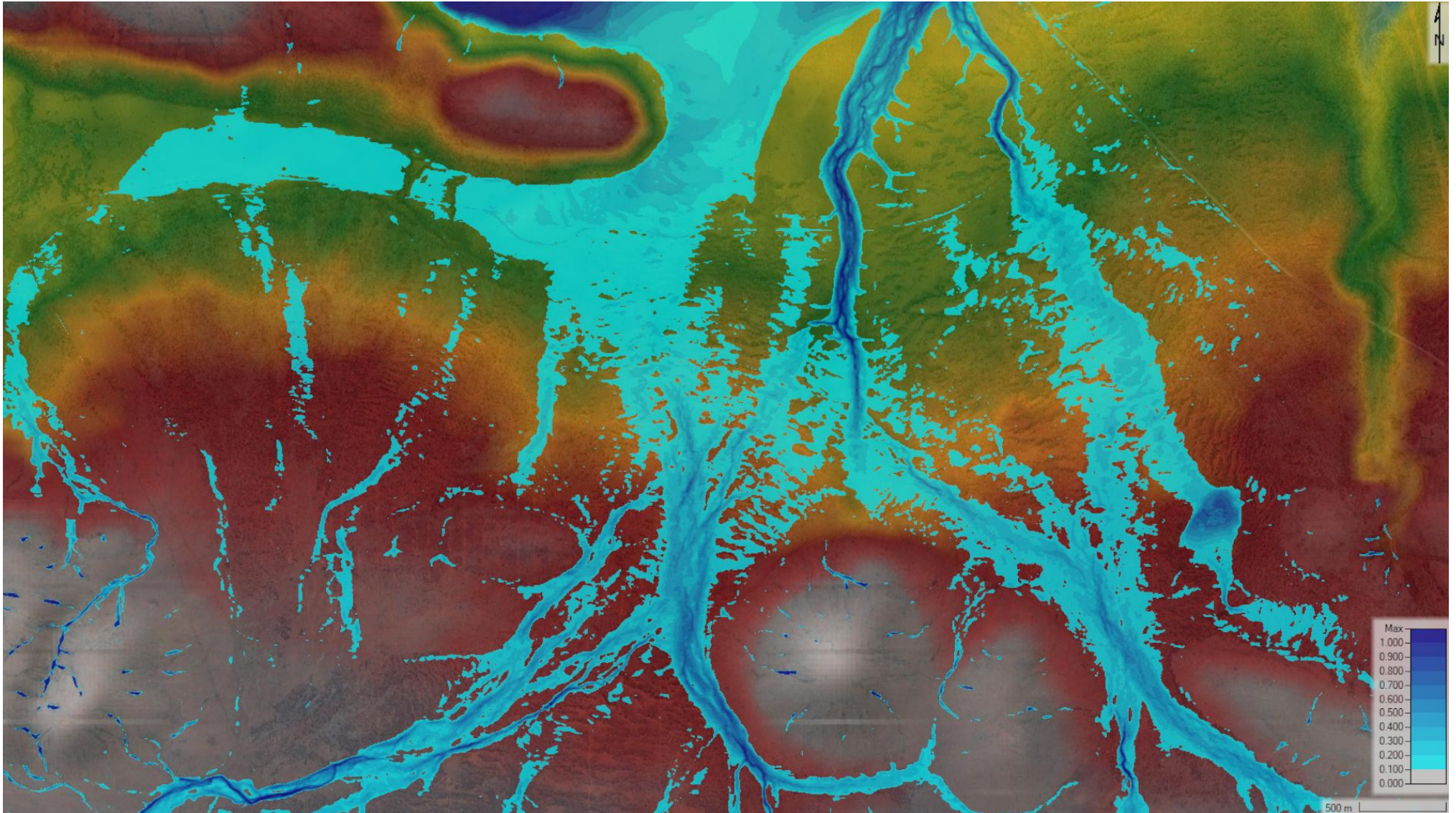


Figure B-1. 20% AEP baseline conditions maximum inundation depths (m) and extents

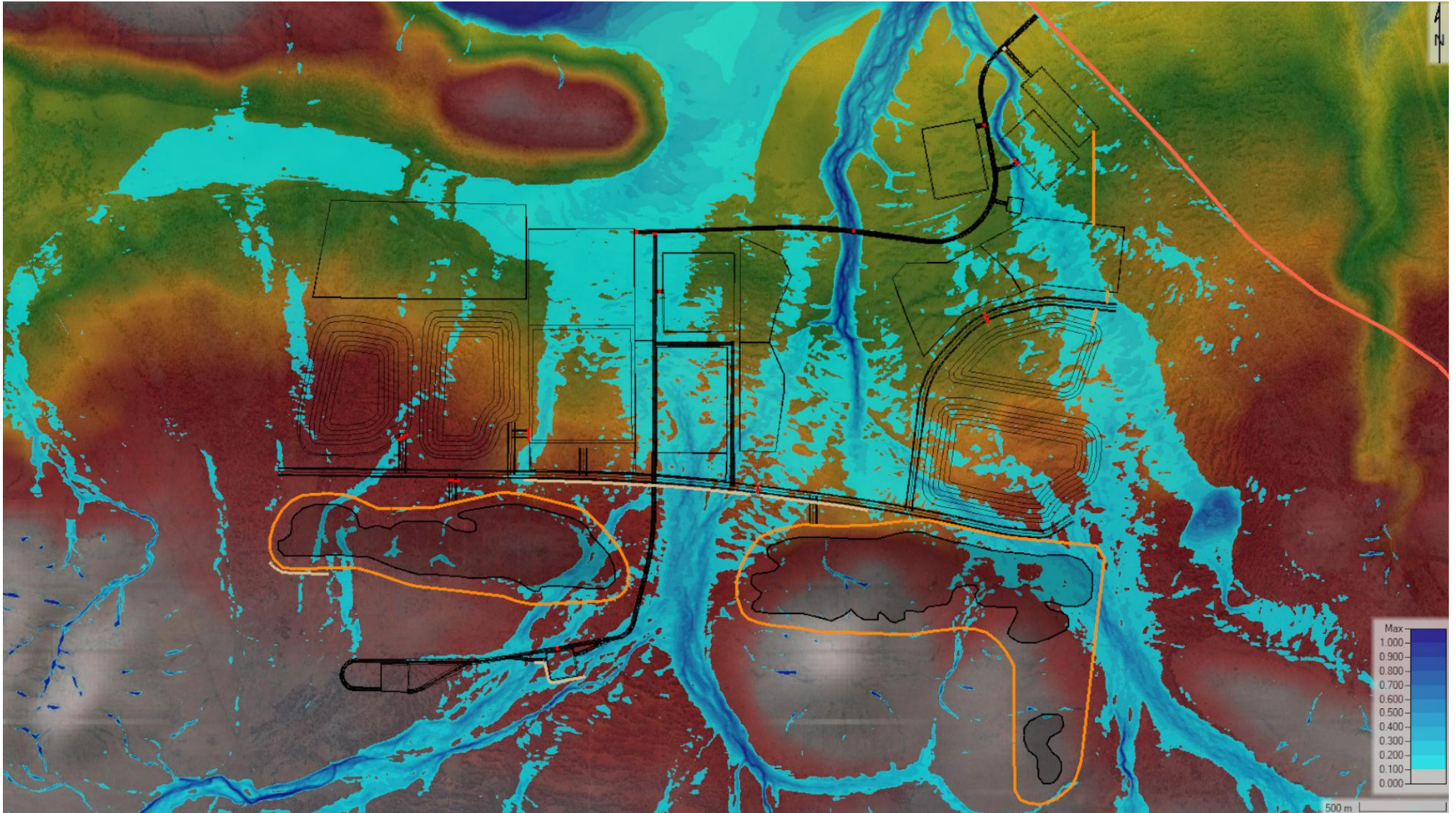


Figure B-2. 20% AEP baseline conditions maximum inundation depths (m) and extents with project overlay

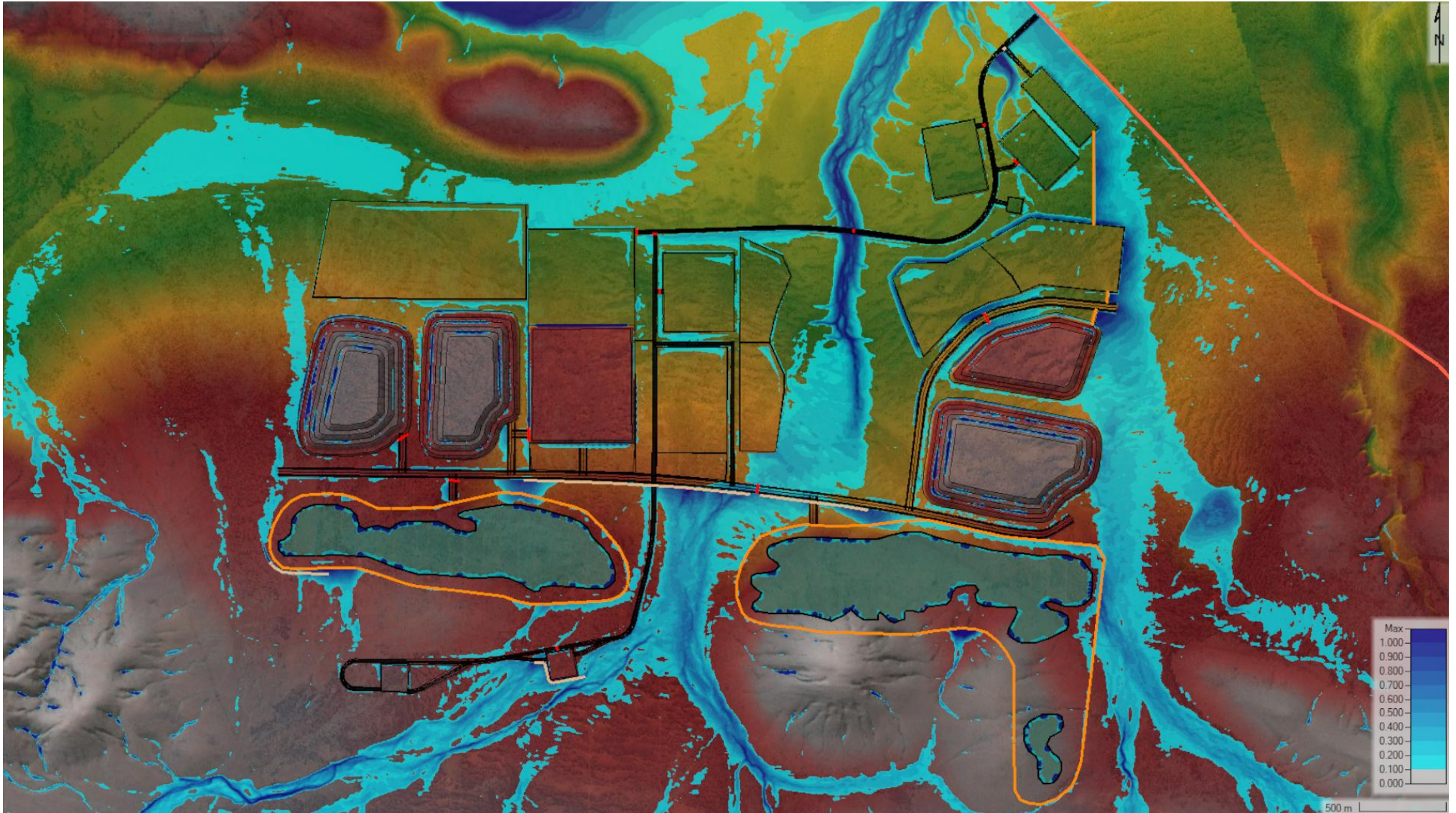


Figure B-3. 20% AEP project conditions maximum inundation depths (m) and extents



Figure B-4. 20% AEP project conditions maximum water surface elevation afflux (m)

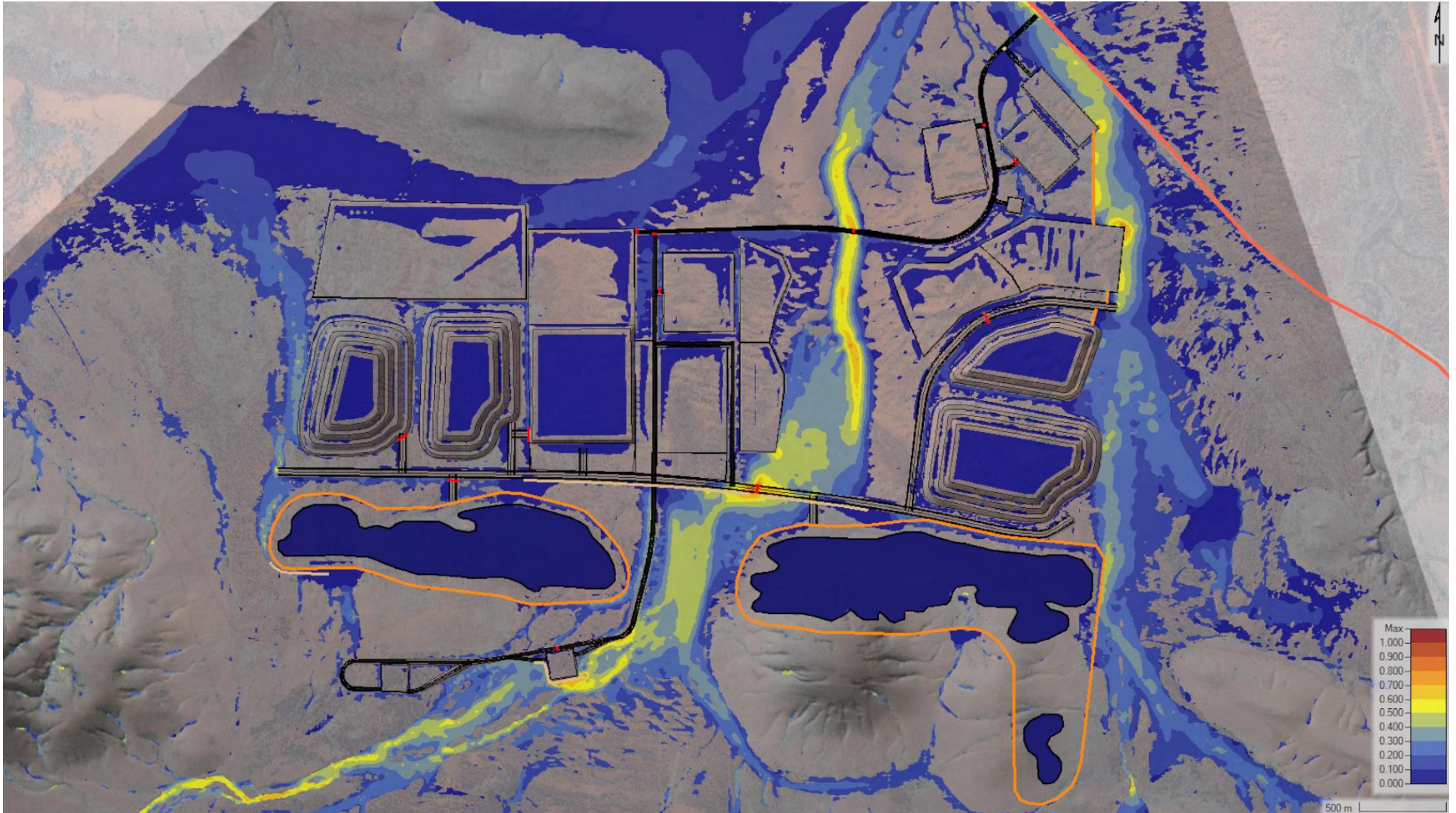


Figure B-5. 20% AEP project conditions maximum velocity (m/s)

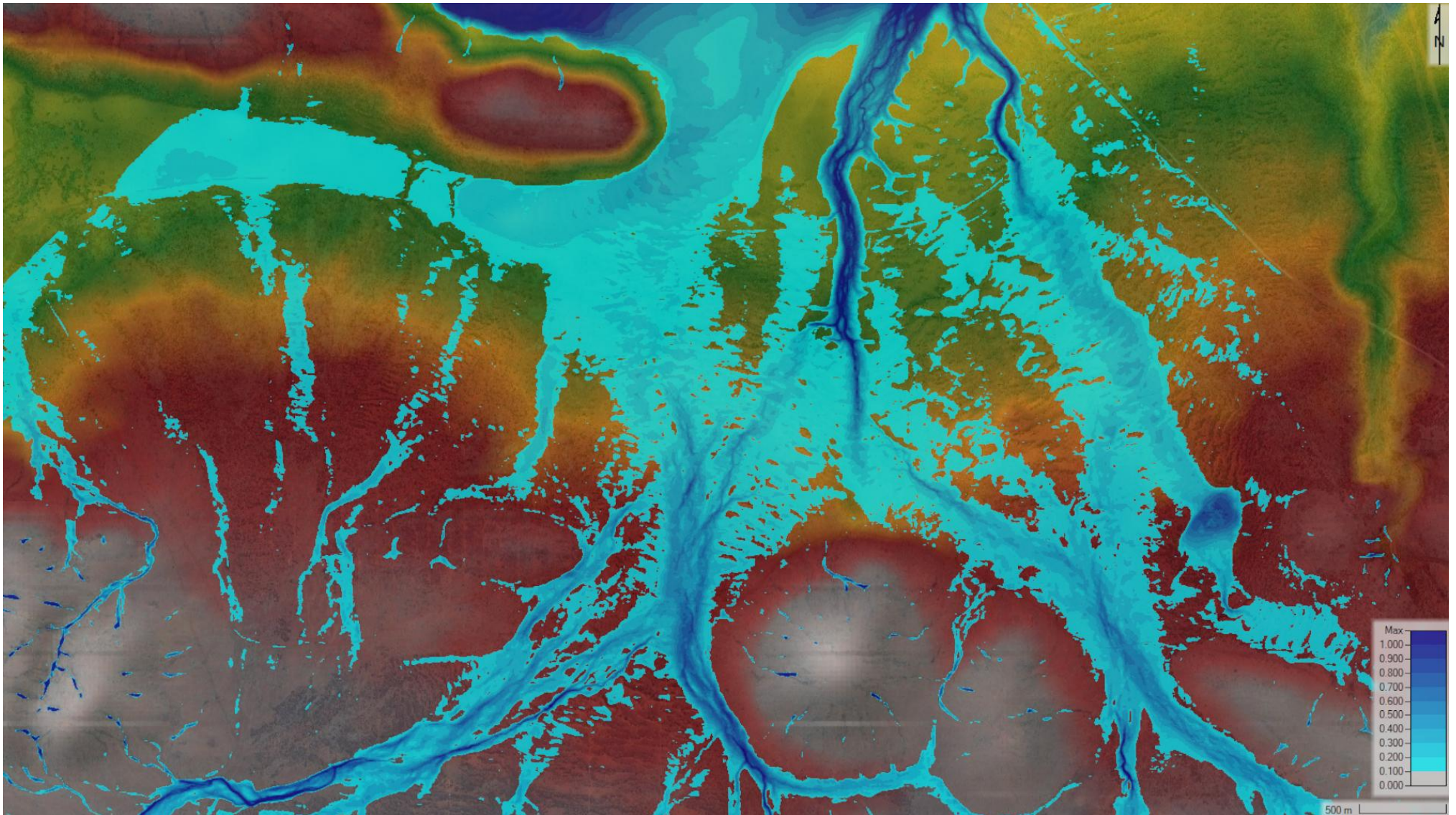


Figure B-6. 10% AEP baseline conditions maximum inundation depths (m) and extents

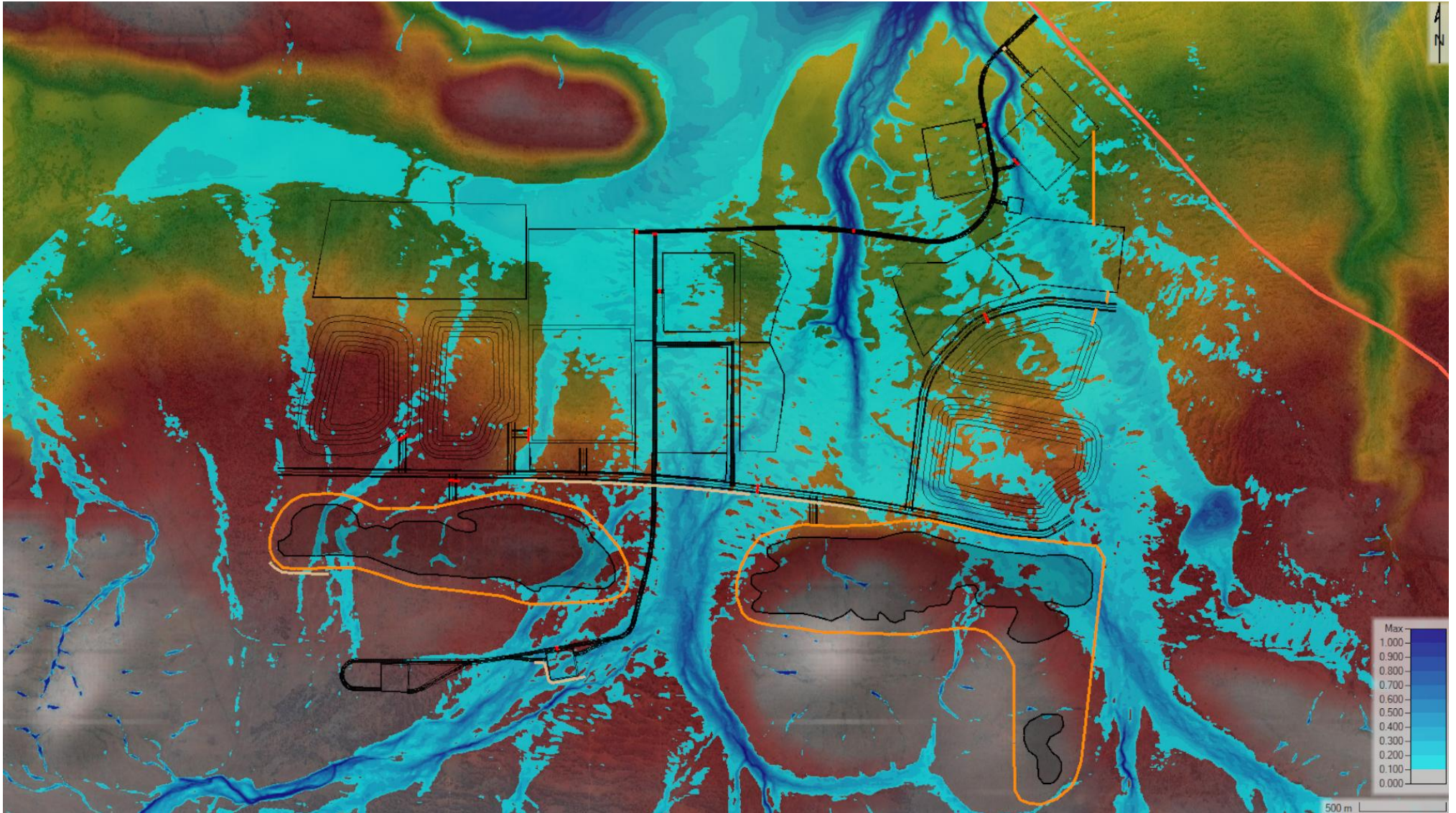


Figure B-7. 10% AEP baseline conditions maximum inundation depths (m) and extents with project overlay

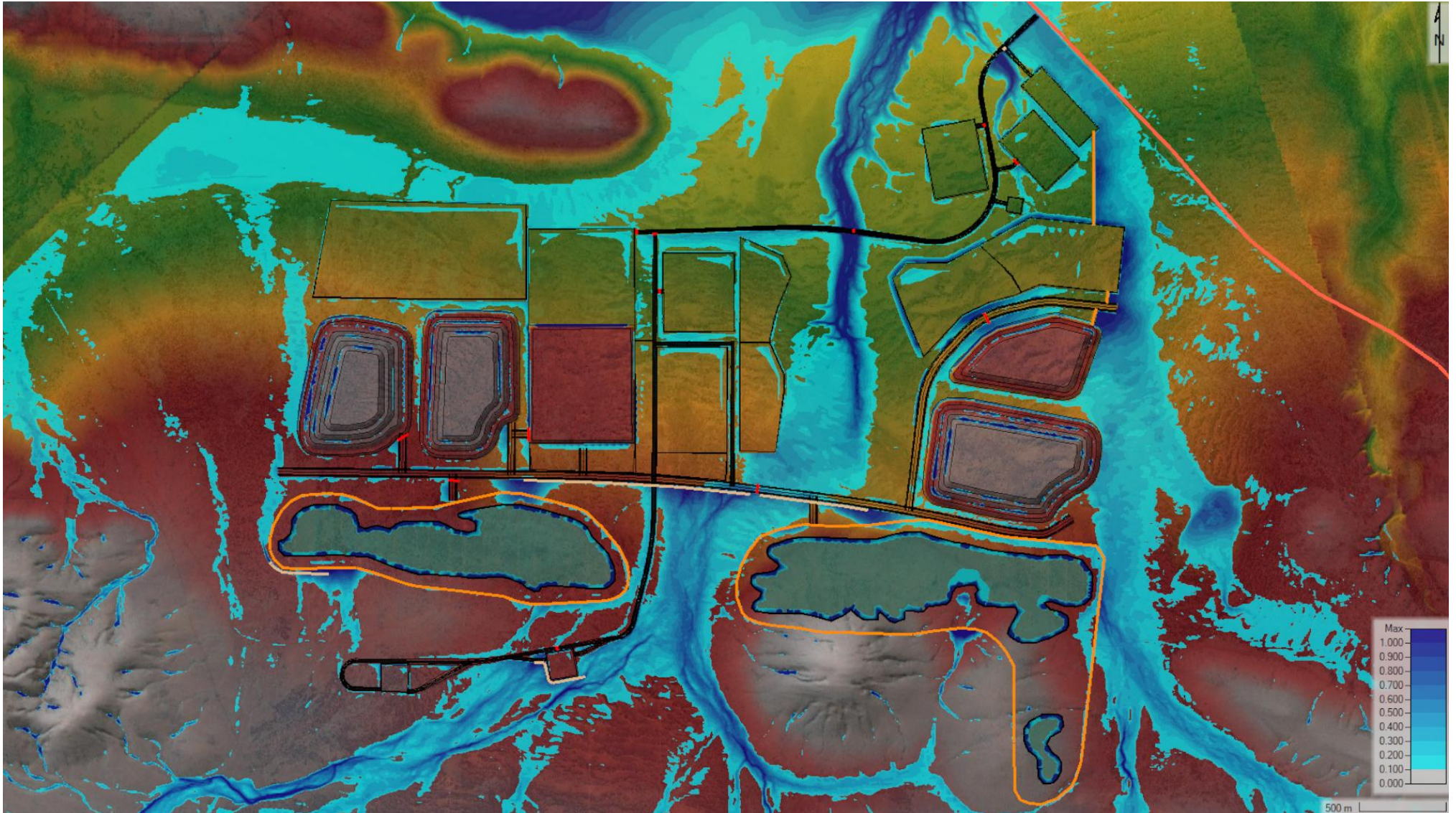


Figure B-8. 10% AEP project conditions maximum inundation depths (m) and extents

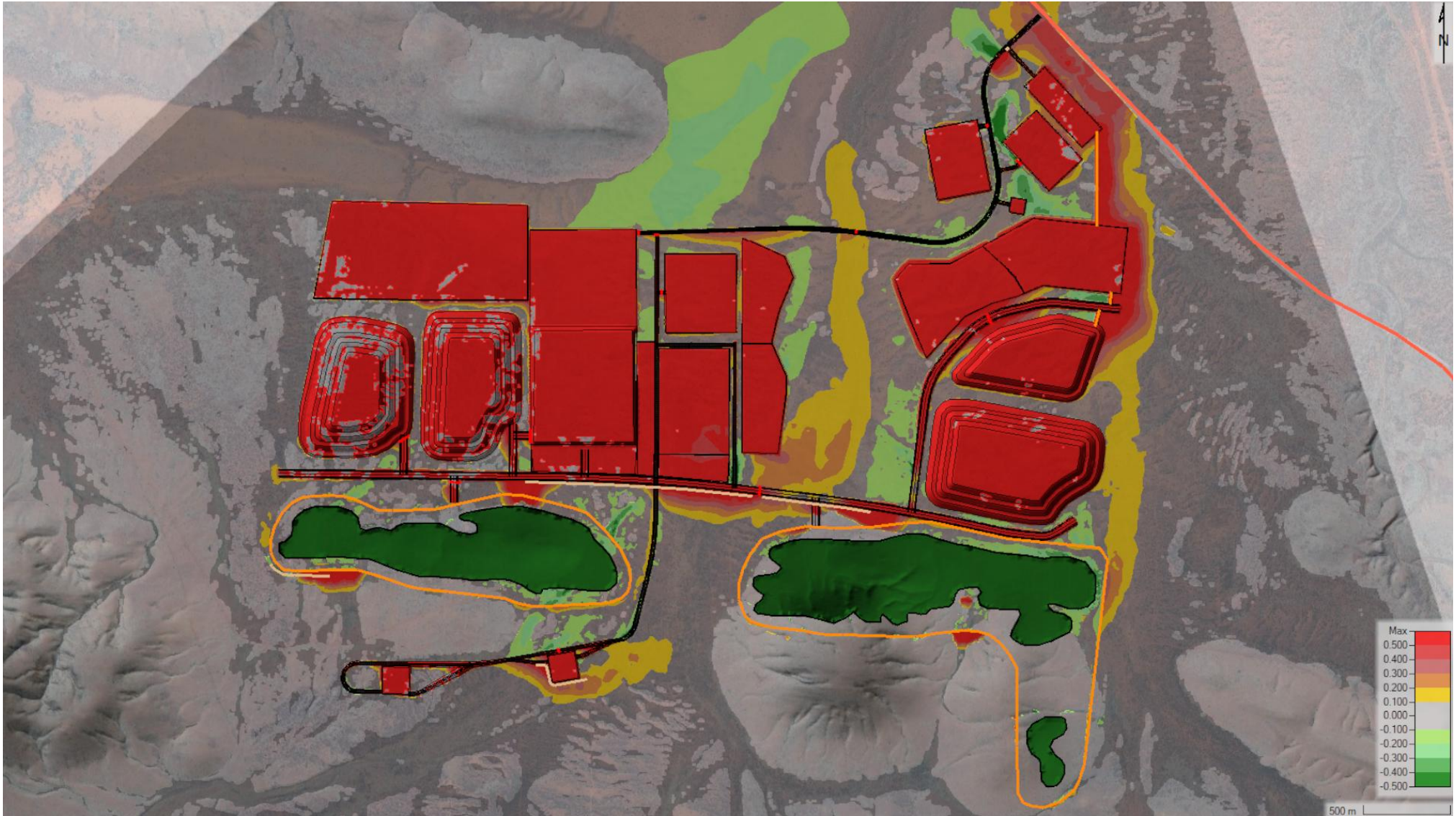


Figure B-9. 10% AEP project conditions maximum water surface elevation afflux (m)

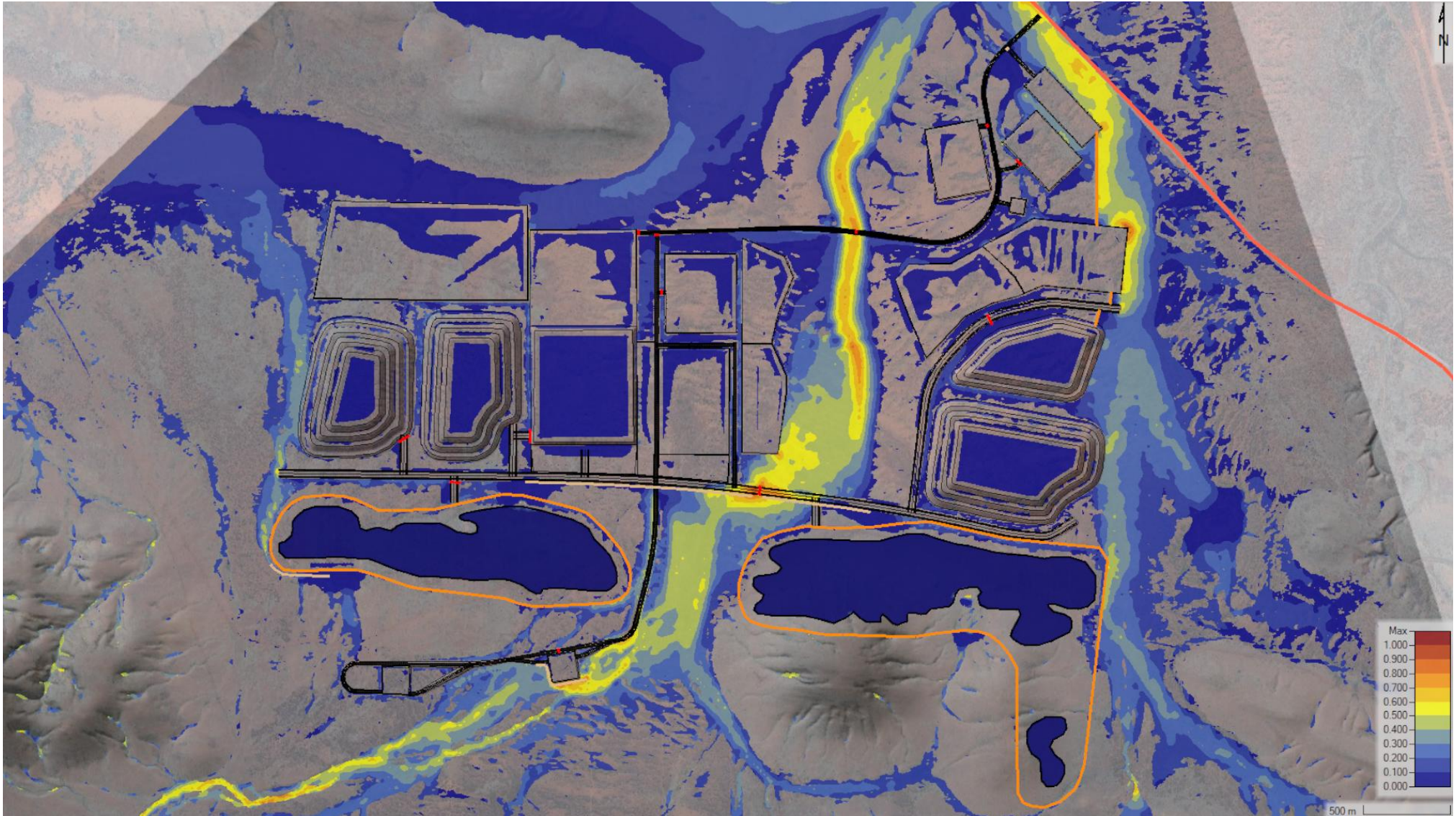


Figure B-10. 10% AEP project conditions maximum velocity (m/s)

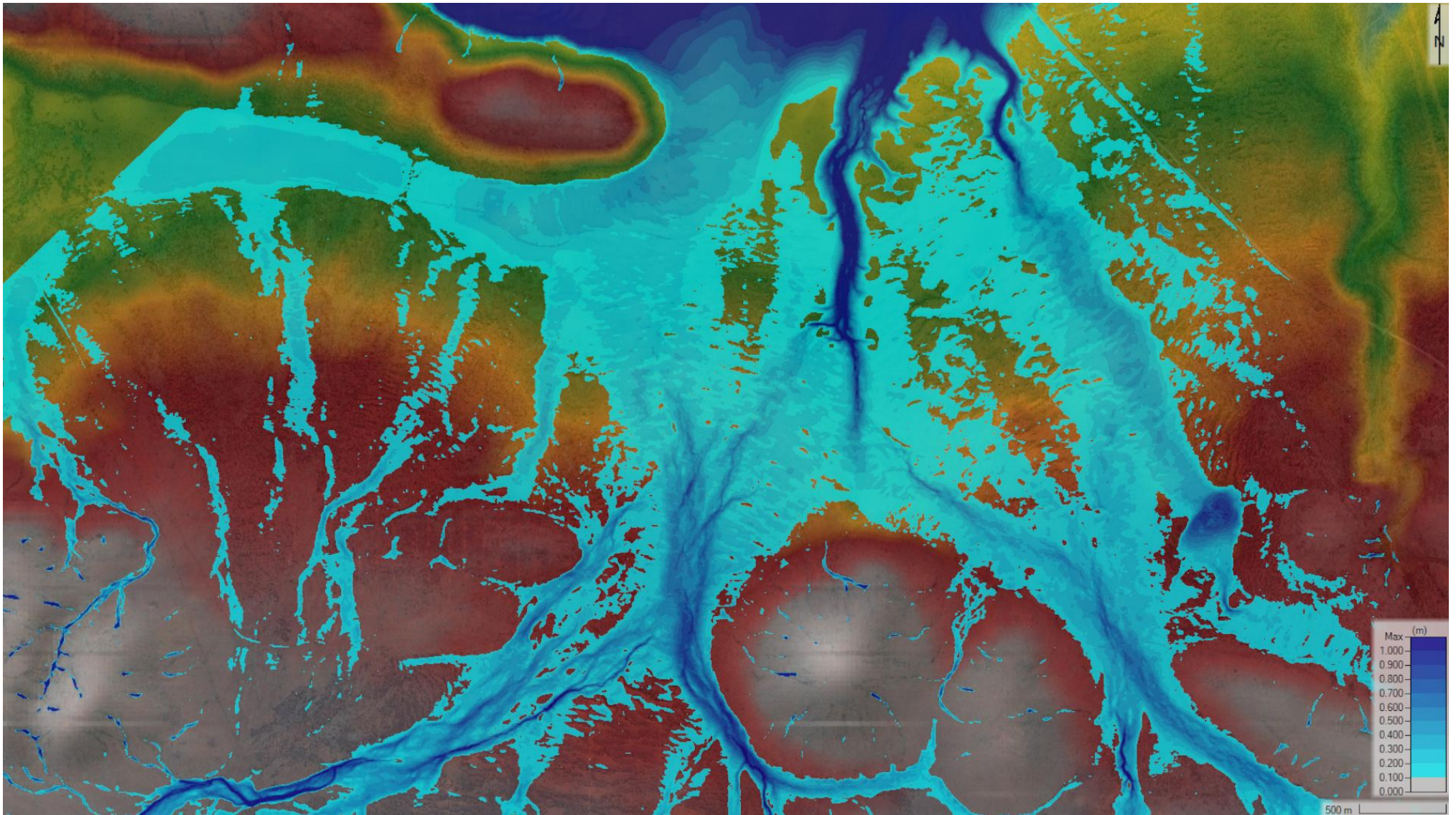


Figure B-11. 5% AEP baseline conditions maximum inundation depths (m) and extents

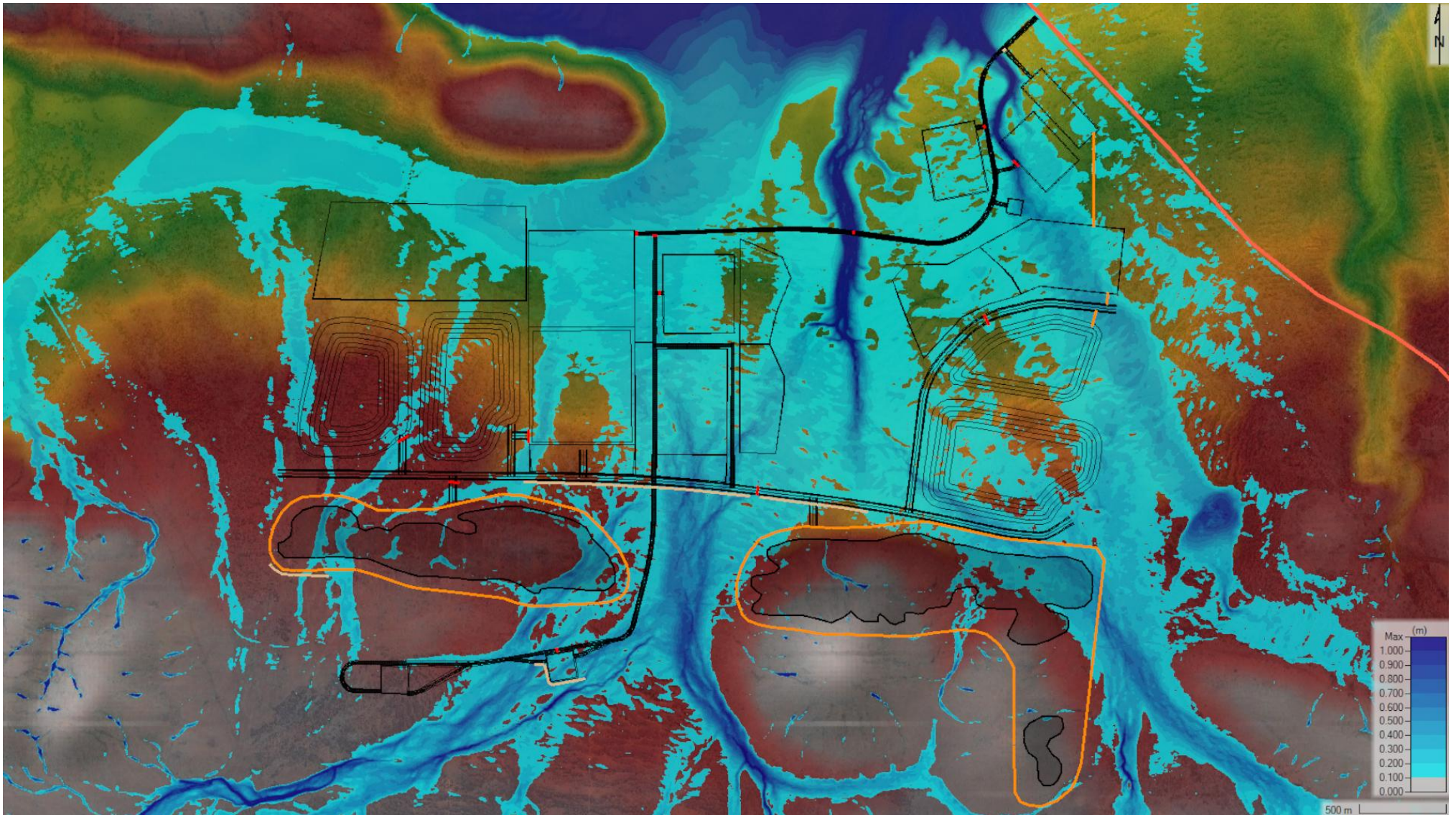


Figure B-12. 5% AEP baseline conditions maximum inundation depths (m) and extents with project overlay

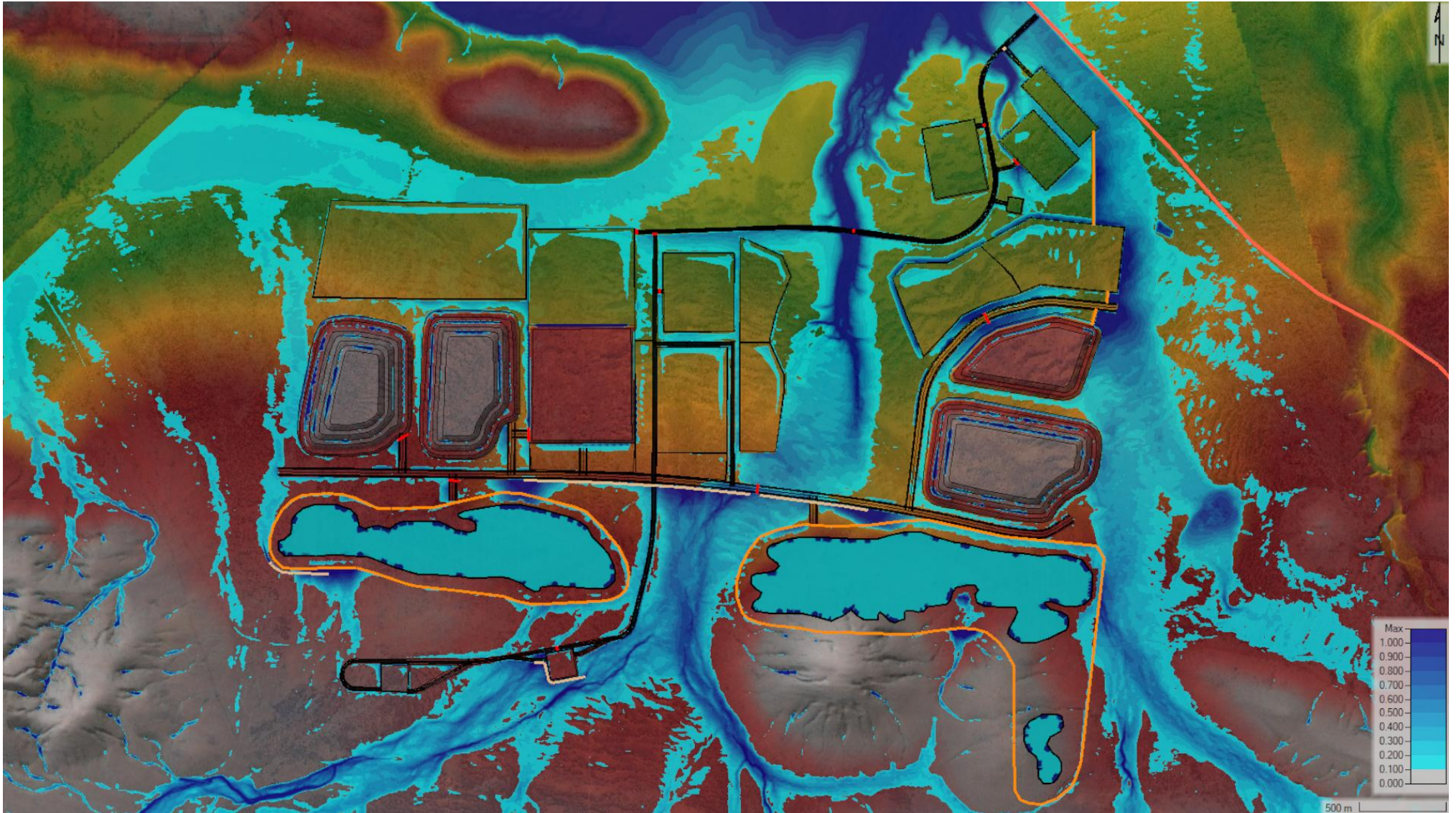


Figure B-13. 5% AEP project conditions maximum inundation depths (m) and extents

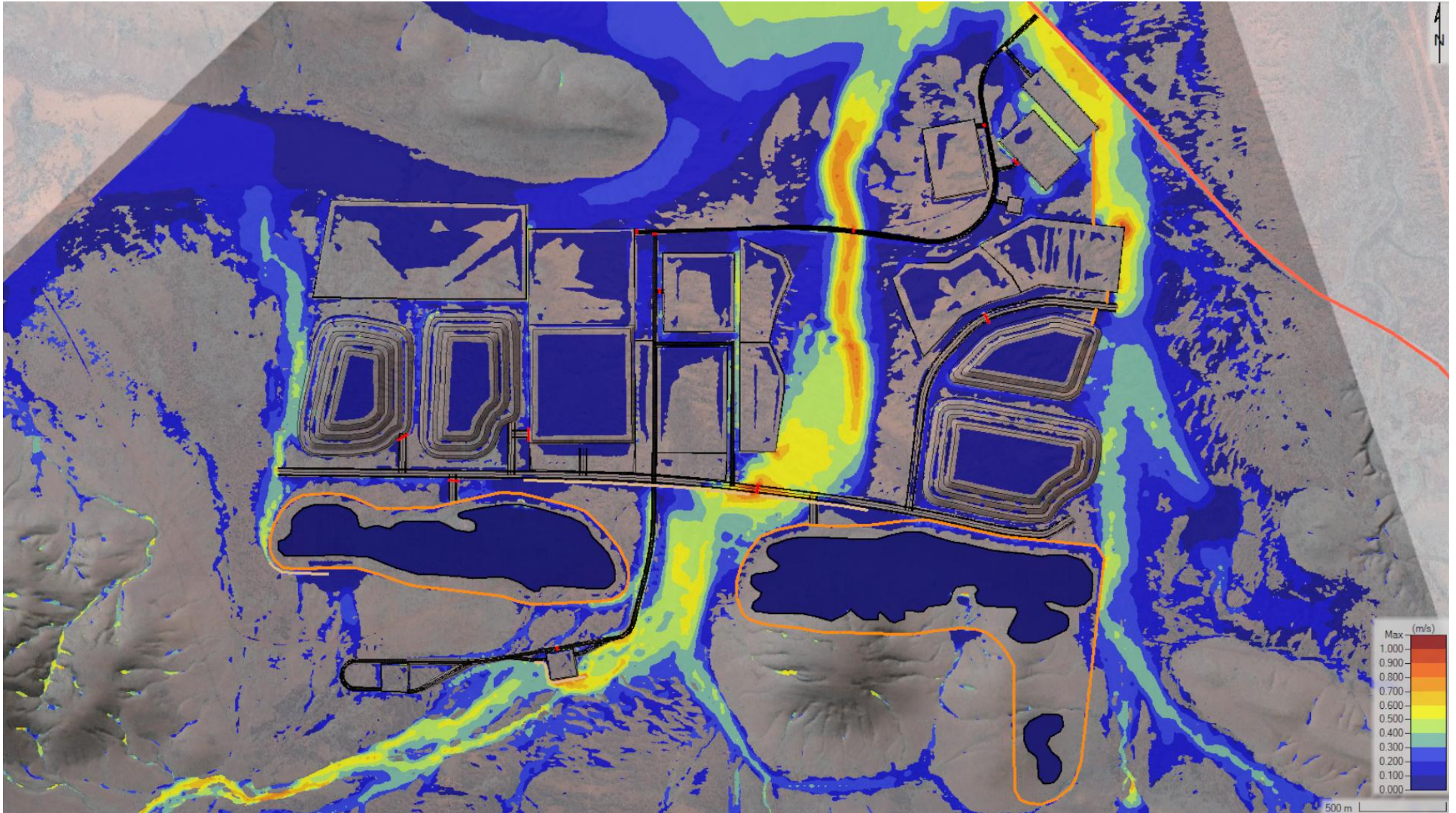


Figure B-14. 5% AEP project conditions maximum velocity (m/s)

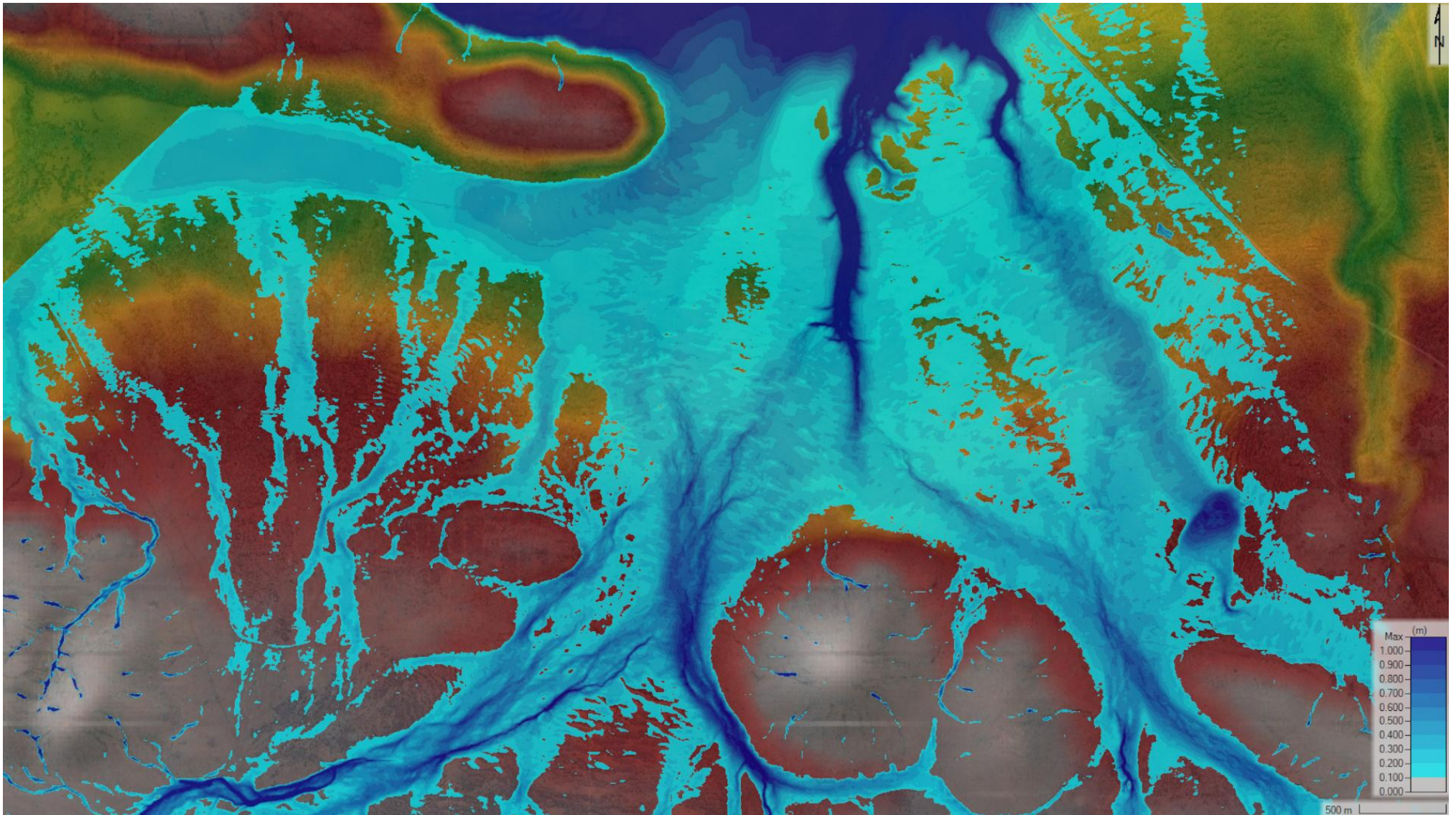


Figure B-15. 1% AEP baseline conditions maximum inundation depths (m) and extents

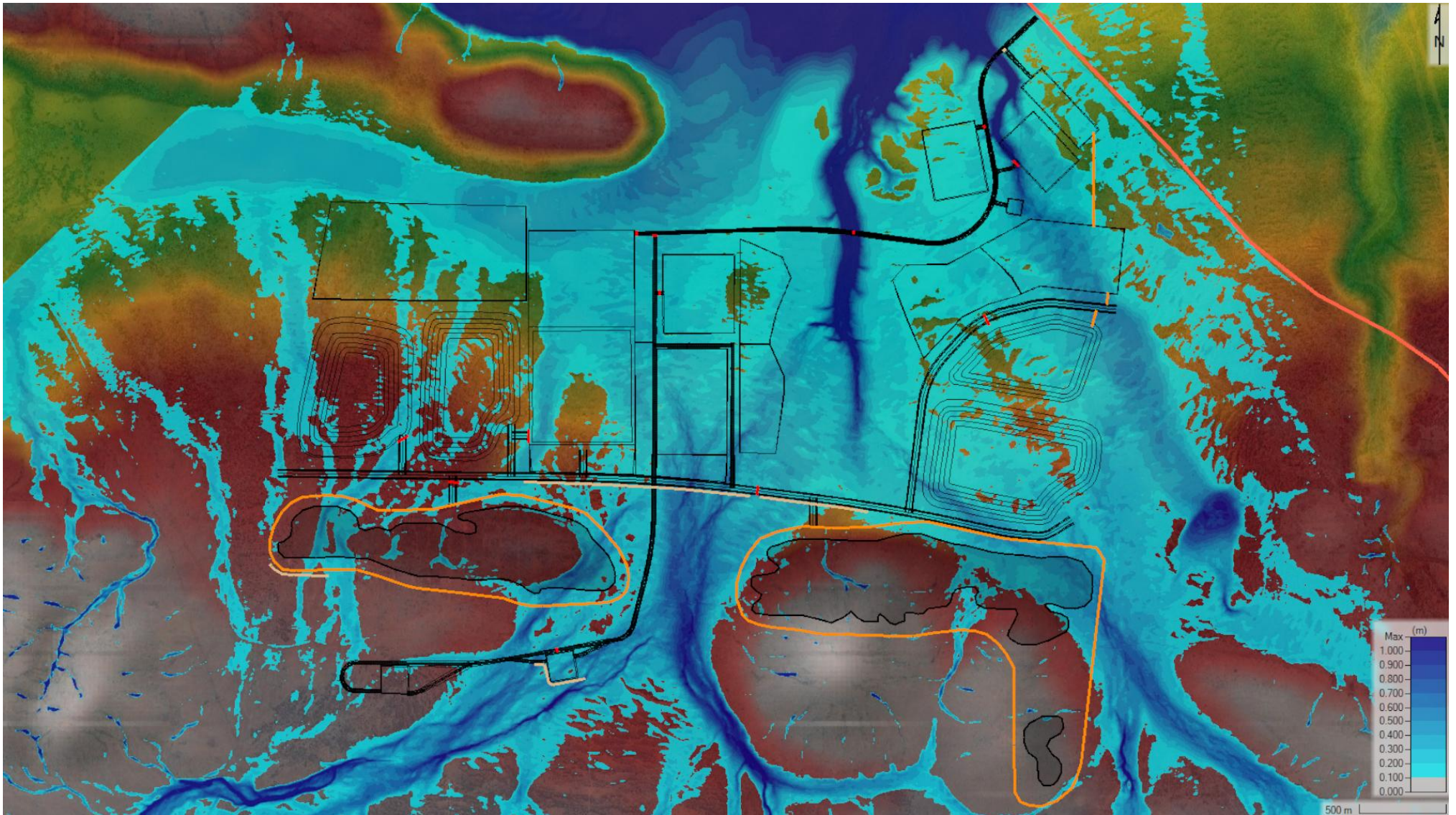


Figure B-16. 1% AEP baseline conditions maximum inundation depths (m) and extents with project overlay

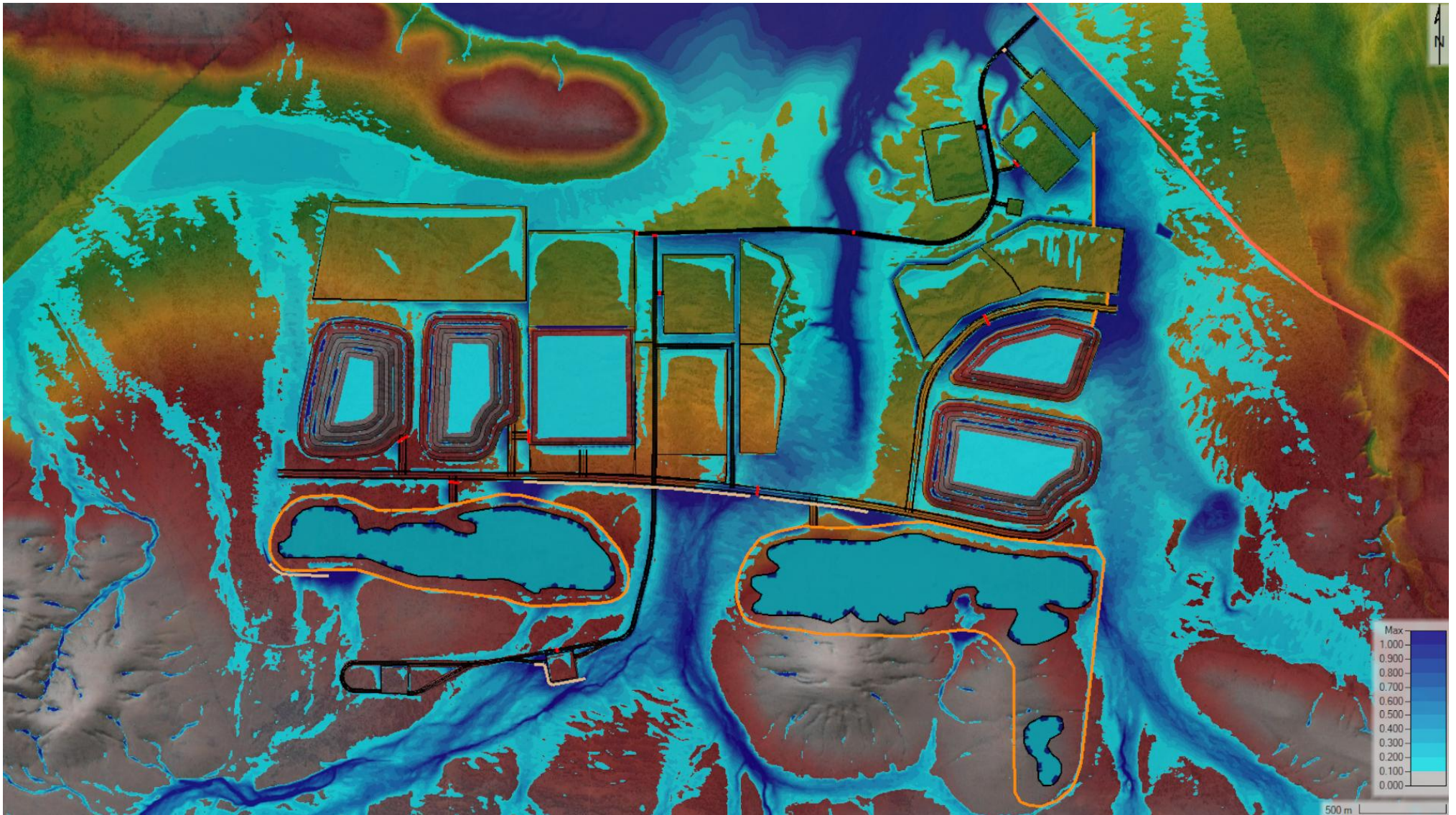


Figure B-17. 1% AEP project conditions maximum inundation depths (m) and extents

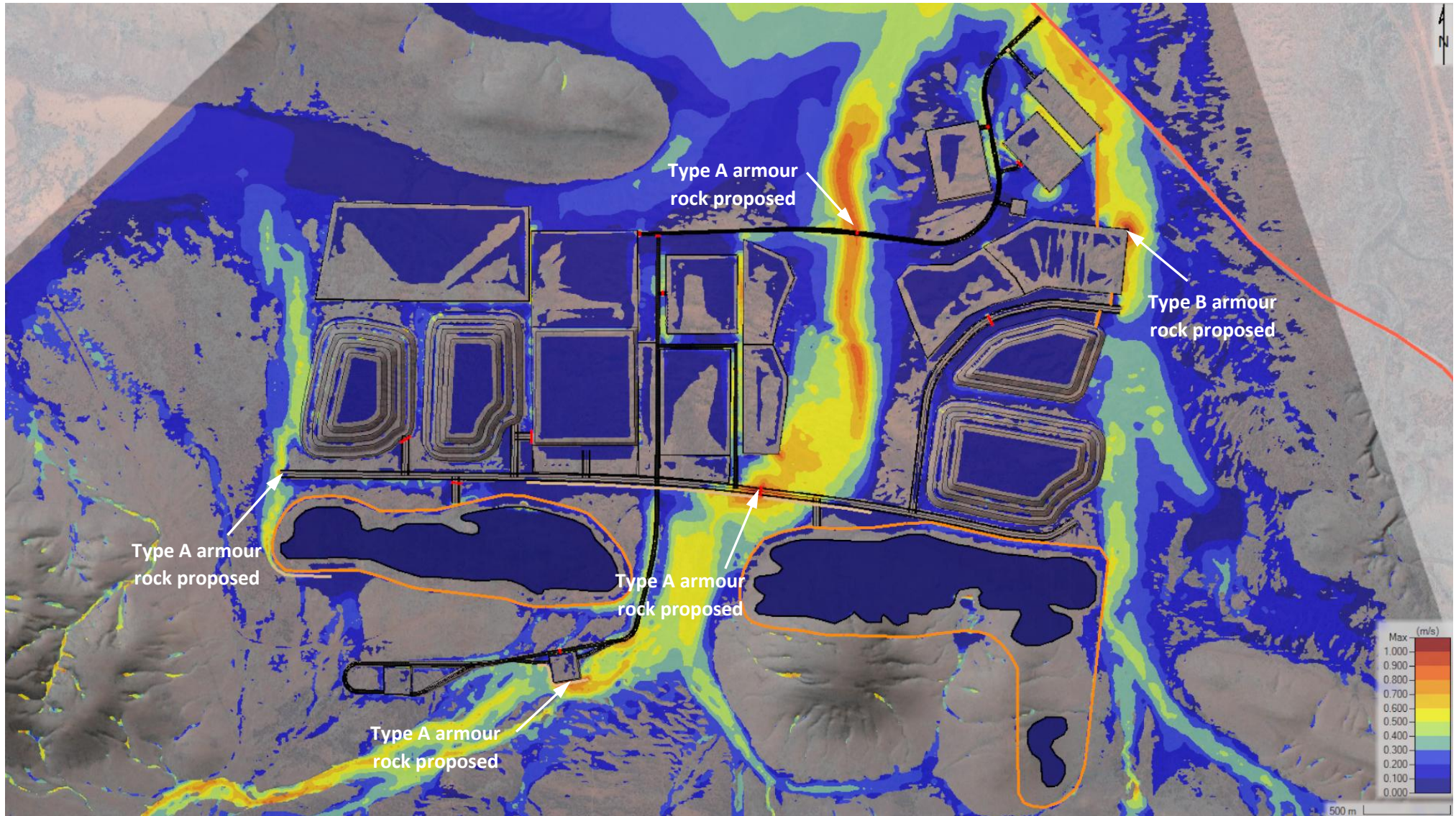


Figure B-18. 1% AEP project conditions maximum velocity (m/s)



Appendix C. Sensitivity Analyses

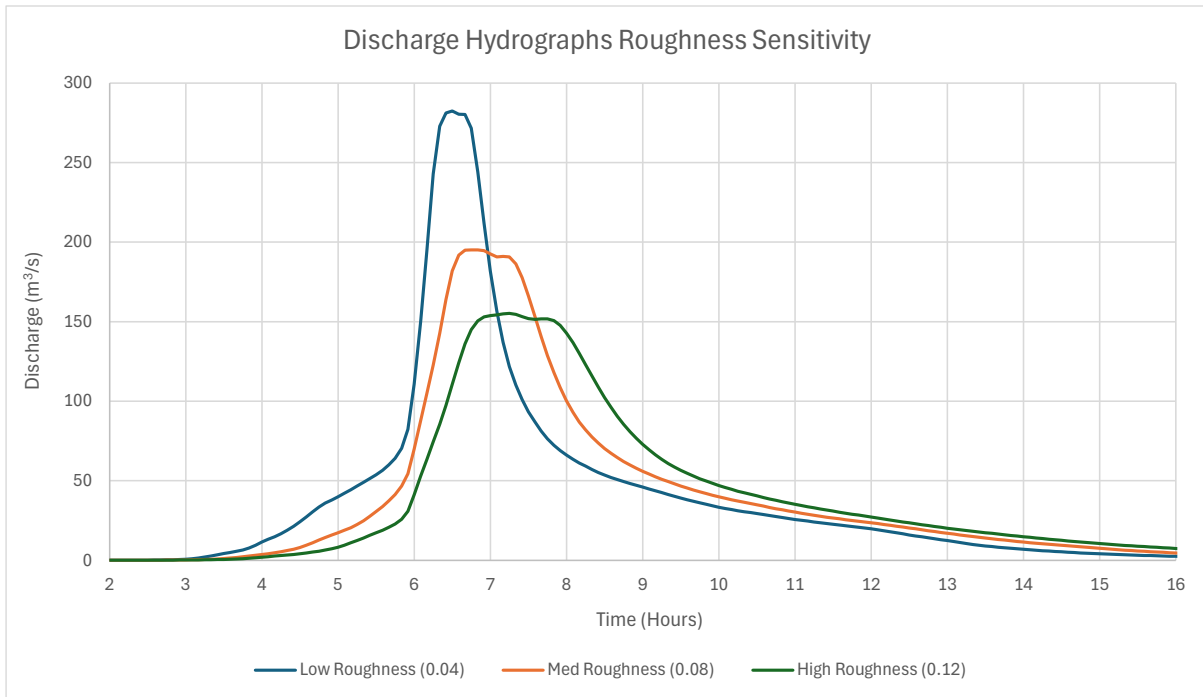


Figure C-1. Discharge hydrograph roughness sensitivity

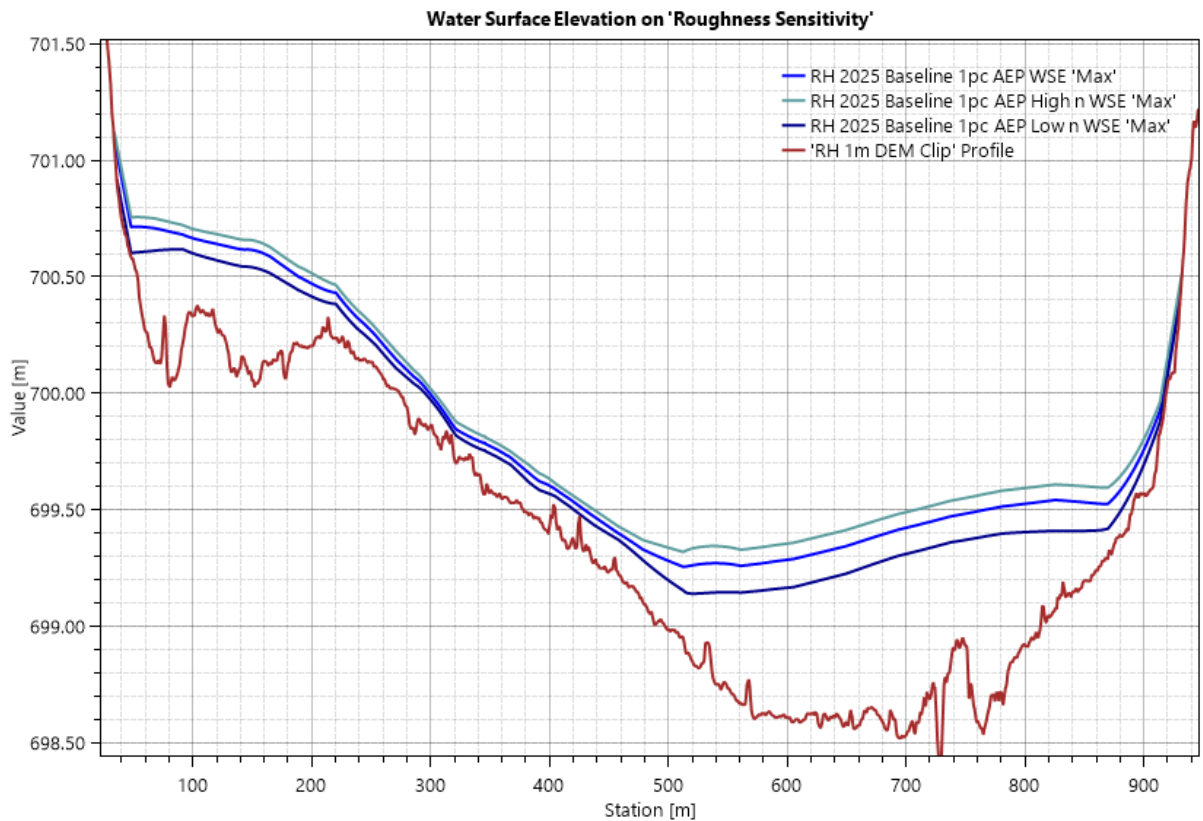


Figure C-2. Water surface elevation roughness sensitivity along upstream cross section

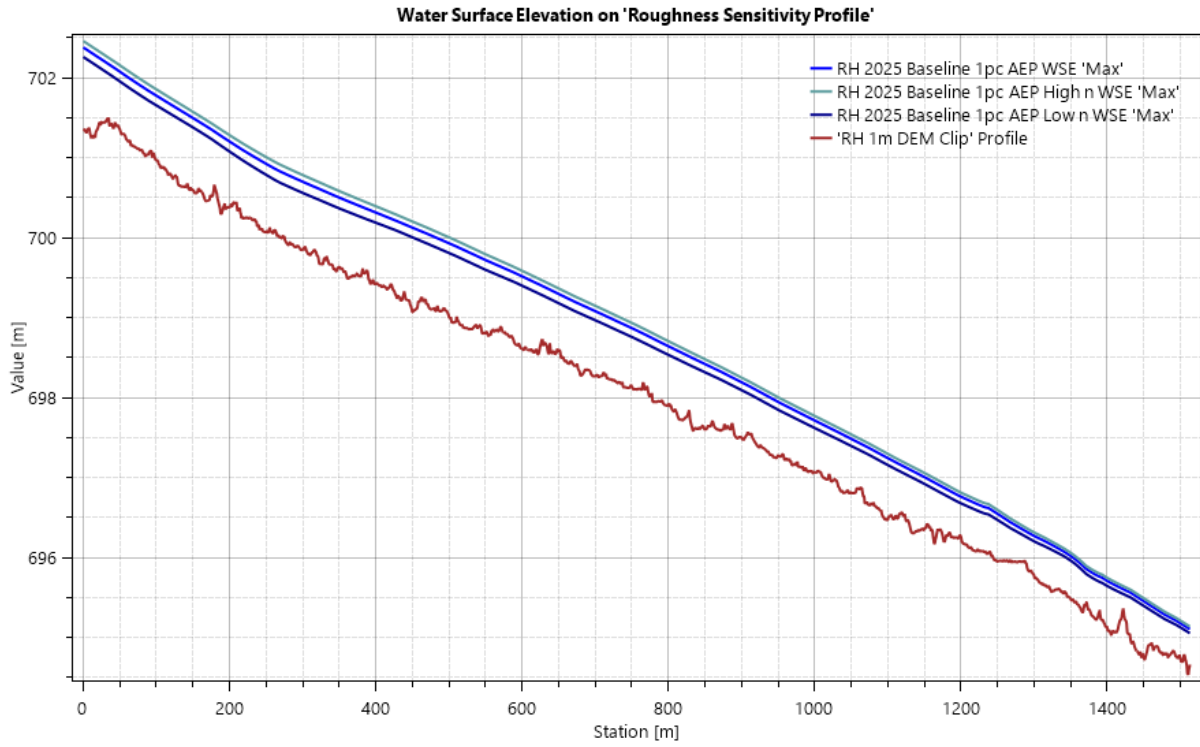


Figure C-3. Water surface elevation roughness sensitivity along longitudinal profile

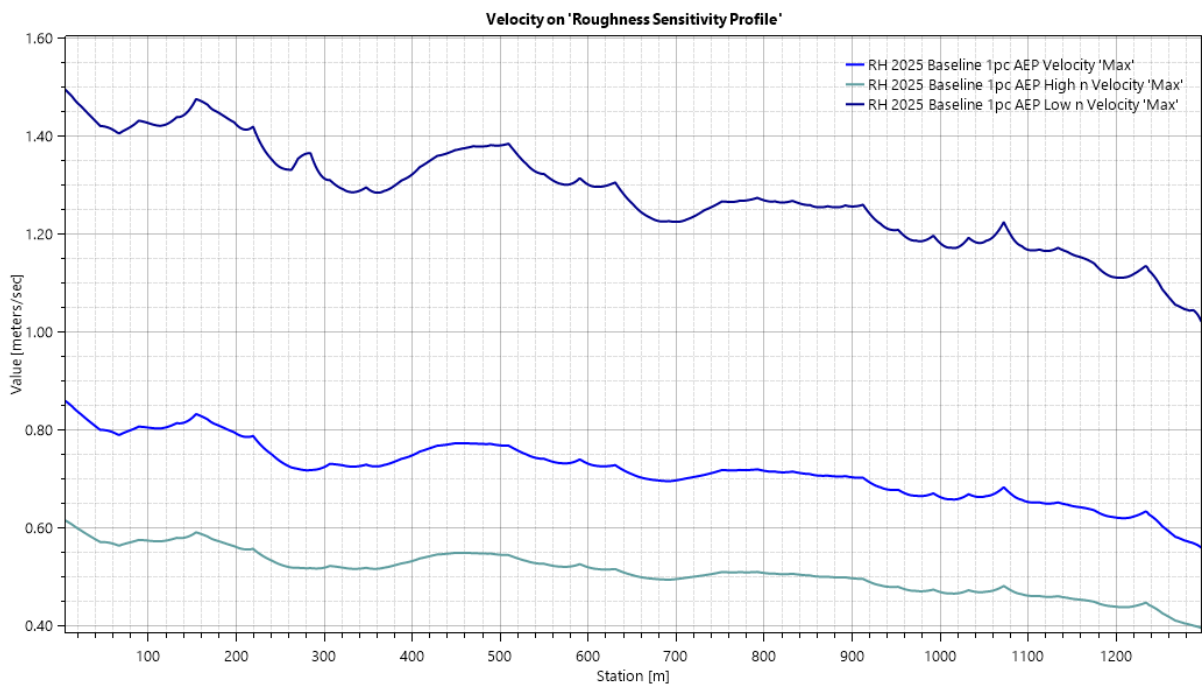


Figure C-4. Velocity roughness sensitivity along longitudinal profile