



Stormwater Management Plan

Karaka Road Plan Change

300-458 Karaka Road

Fisher & Paykel Healthcare Properties Ltd

Final

Document Control

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Executive Summary

Fisher & Paykel Healthcare Properties Ltd (F&P) has engaged Woods to prepare a Stormwater Management Plan (SMP) for a Structure Plan (Structure Plan) and Private Plan Change (Plan Change) for land zoned Future Urban and Rural – Mixed Rural, located at 300, 328, 350, 370, & 458 Karaka Road, Drury. The land is bound by State Highway 22 to the north, Oiroa Creek to the west and the railway network of the North Island Main Trunk (NIMT) Line to the south.

A Draft Stormwater Management Plan dated 12/04/2019 (revision 04C) was prepared for the Auckland Council Drury-Opāheke Structure Plan (2019) for the Future Urban Zone area, 'Drury-Opāheke Structure Plan Future Urban Zone Draft Stormwater Management Plan' by Mott Macdonald, (FUZ SMP). This Structure Plan is proposed in replacement of the Drury-Opāheke Structure Plan for this part of Drury West and the Plan Change will involve rezoning the portion of land zoned Future Urban and inside the Rural Urban Boundary to Business – Light Industry. The purpose of the Structure Plan and Plan Change is to facilitate the future development of a research & development and manufacturing campus to support the growth and expansion of Fisher & Paykel Healthcare. It is noted that whilst this SMP is applicable for the Plan Change area, it takes into consideration the wider Structure Plan area providing a holistic approach. The extents of the areas are shown in Figure 9 in Section 6 of this document.

The development is classified as a 'greenfield' development under Schedule 4 of Auckland Council's Regionwide Network Discharge Consent (NDC) and therefore requires a stormwater management plan to be compliant with NDC requirements. A list and subsequent descriptions of the relevant NDC requirements has been provided in Appendix B.

This report highlights how Schedule 4 of the NDC requirements have been met in the development of the SMP. It is noted this document is also in line with the wider FUZ SMP.

The overarching objectives of this SMP are to:

- Demonstrate how the proposed stormwater management meets the requirements of Schedule 4 of the Regionwide NDC;
- Support the PPC application, to rezone the Future Urban zoned area of the site to Business – Light Industry zone under the Auckland Unitary Plan - Operative in Part (AUP);
- Incorporate a water sensitive design approach that manages the impact of land use change from rural to urban;
- Retain stream networks, and protect and enhance riparian margins;
- Provide stormwater management standards for the proposed development and ensure stormwater runoff is to be conveyed in a safe manner to the receiving environment through the primary and secondary networks;
- Provide appropriate treatment for the receiving environment via stormwater quality treatment guidelines and avoidance of high contaminant yielding roof and cladding materials; and
- Identify flood risk areas and provide for development outside the 1% AEP floodplain without creating adverse flooding effects on properties upstream or downstream of the site.

Flood Management

As per Auckland Council GeoMaps, the site is located within two stormwater catchments, Oiroa Creek and Ngākōroa Stream. Approximately 72% of the site falls within Oiroa Creek catchment while the remaining 28% of the site falls within the Ngākōroa Stream catchment.

Woods requested the "Oira Creek and Ngakoroa Stream RFHA" model from Healthy Waters to assess flood effects that may arise (if any) from the PPC. The received model was refined to develop a flood model suitable undertaking the flooding assessment. In total, there were four flood model scenarios developed as part of the flood assessment:

-
- Scenario 1 - Pre-development
 - Scenario 2 - Post development without flood mitigation
 - Scenario 3 - Post development with pass forward
 - Scenario 4 - Post development with pass forward + diversion (preferred flood mitigation option)

All the model scenarios were simulated for 2-, 10-, and 100-year ARI (allowance for no climate change as well as a temperature increase of 2.1°C by 2090 and 3.8°C by 2110).

The flood modelling work undertaken demonstrated that Scenario 4 was the preferred flood management option and has been recommended for the PPC. This option has been modelled to enable flows to be passed forward in tandem with a full diversion of site area to Oiroa Stream. Whilst the flood modelling undertaken, allows for full diversion of flows to Oiroa Stream, in practice, existing base flows are sought to be maintained in a regime similar to existing conditions for smaller storm events (storm events less than 2-year ARI). This has been excluded from the assessment as smaller flows will be retained such that there will be no downstream flood effects as a result. Due to the small magnitude of these flows, they will also not materially impact the suitability of the preferred flood management option.

It is determined that the resulting water level and flooding extent from this flood management option is generally consistent with the existing flooding conditions. The water level difference plots indicate no change in flood hazards upstream or downstream as a result of the plan change and therefore the 'pass flows forward + diversion' is the recommended flood management strategy.

The recommended flood management strategy for the PPC area aligns with the general flood management of FUZ SMP for Drury West area which recommends passing flows forward for the downstream areas of the catchment. Additionally, the Waipupuke Private Plan Change or PC61 (now accepted), located directly downstream to the site have adopted the pass flows forward strategy. Furthermore, Healthy Waters have also supported the flood management strategy proposed for the PPC area.

Stormwater Management

A summary of the proposed stormwater management is outlined in Figure E1 below.

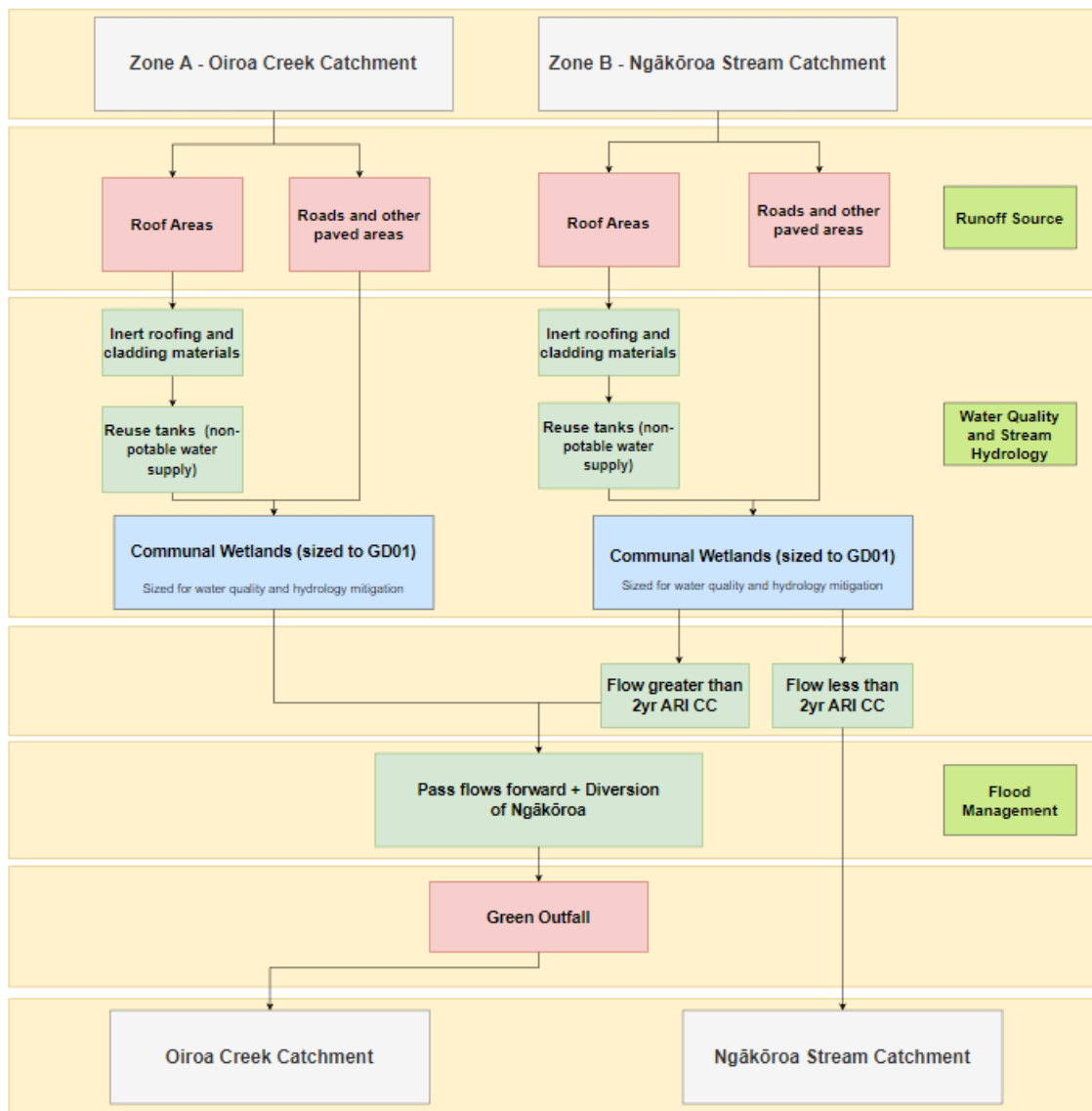


Figure E1: Summary of stormwater management

To meet the objectives of the SMP, NDC and the FUZ SMP, the following is proposed:

- The SMP proposes the following water quality treatment for all the impervious areas in the PPC area.
 - Wetlands will be provided to provide the water quality treatment for all the roads and paved impervious area. Wetlands have been selected as the best practicable option (BPO) due to their integrability with existing natural wetlands, ease of maintenance, and more effective whole of life costing. It is noted that additional measures such as provision of pre-treatment via a forebay or a proprietary device will also be provided.
 - Use of inert building and roofing material to avoid generation of high contaminants from buildings.
 - Use of green outfalls.
- SMAF-1 level stream hydrology mitigation is to be provided for the entire site. The stream hydrology strategy includes provision of retention of 5mm of rainfall depth and detention by storing and slowly releasing the collected water over more than 24-hours.
 - Wetlands have been proposed to collect and release the detention volume over more than 24-hours for all the impervious areas.

-
- To meet the retention requirements, re-use is proposed for roof runoff while for other areas, full detention will be applied and provided via wetlands.
 - If re-use cannot be achieved, full detention is to be provided via communal wetlands.
 - A stream erosion assessment has been undertaken using Auckland Council's Erosion Screening Tool. The results have indicated that the effects of land use as a result of the Plan Change are minimal. A detailed assessment maybe required once there is further detail available around the pipe network and discharge locations (i.e., outlets) to determine further impacts.
 - Conveyance of primary and secondary flows will be proposed as per the guidelines stated in Auckland Council's Stormwater Code of Practice, Ver 3, Jan 2022.

In conclusion, the SMP proposes an integrated stormwater management approach which aligns with the FUZ SMP as well as the requirement stated in NDC for a greenfield site and the AUP. The measures proposed in the SMP provides an overall positive impact to the environment and enhances stream health and downstream water quality.

1. Introduction

1.1. Background

Woods has been engaged by Fisher & Paykel Healthcare Properties Ltd (F&P) to provide stormwater input for a Structure Plan and Private Plan Change (PPC) application for a site located at 300, 328, 350, 370 and 458 Karaka Road (site). The site is located within the Drury-Opāheke Future Urban Zone and Rural – Mixed Rural zone under the Auckland Unitary Plan: Operative in Part (AUP).

The Structure Plan relates to the entire site. The PPC relates to the Future Urban zoned land only and proposes to rezone this land for Business - Light Industry zone.

There is noted to be a wider Drury-Opāheke Structure Plan Future Urban Zone Draft Stormwater Management Plan by Mott Macdonald dated 12 April 2019 rev. 04C, which provides a high-level stormwater management requirement for any development proposed in the Drury-Opāheke Structure Plan area (FUZ SMP). The PPC is noted to be within the Drury-West area of the Council's Drury-Opāheke Structure Plan.

The development is classified as a 'greenfield' development under Schedule 4 of Auckland Council's Regionwide Network Discharge Consent (NDC) and therefore requires a stormwater management plan to be compliant with the requirements laid out in the NDC and FUZ SMP.

This report outlines the stormwater management plan (SMP) for the proposed PPC, on behalf of F&P at the site, in line with the NDC requirements for a 'greenfield' site. The SMP is noted to be applicable for the Plan Change area, however, it takes into consideration the wider Structure Plan area providing a holistic approach for the entire site.

1.2. Purpose and objectives

The overall purpose of this SMP is to inform Auckland Council on how stormwater will be managed for the PPC area.

The report highlights how Schedule 4 of the NDC requirements have been met in the development of the SMP. It is also in line with the outcomes as outlined in the wider FUZ SMP.

The overarching objectives of this SMP are to:

- Demonstrate that the proposed stormwater management meets the requirements of Schedule 4 of the Regionwide NDC;
- Support the PPC request to rezone the Future Urban zoned area of the site to Business – Light Industry zone under the AUP to enable the development of a new Fisher & Paykel Healthcare campus in Drury West;
- To incorporate a water sensitive design approach that manages the impact of land use change from rural to urban;
- Retention of stream network, and protection and enhancement of riparian margins;
- Provide stormwater management standards for the proposed development and ensure stormwater runoff is to be conveyed in a safe manner to the receiving environment through the primary and secondary networks;
- Provide appropriate treatment for the receiving environment via stormwater quality treatment guidelines and avoidance of high contaminant yielding roof and cladding materials; and
- Identify flood risk areas and provide for development outside the 1% AEP floodplain without creating adverse flooding effects on properties upstream or downstream of the site.

2. Existing site appraisal

2.1. Summary of data sources and dates

A summary of key background information used in the development of the SMP is provided in Table 1.

Table 1: Summary of data sources

Existing site appraisal item	Source and date of data used
Topography	• LiDAR 2016
Geotechnical/ soil conditions	• Auckland Council Soil Maps
Existing stormwater network	• Auckland Council GeoMaps – Underground services (2018)
Existing hydrological features	• Auckland Council GeoMaps • Assessment of Ecological Effects undertaken by Bioresarches (30 May 2024, Final v1)
Stream, river, coastal erosion	• Auckland Council GeoMaps – Catchment and Hydrology: River names • Assessment of Ecological Effects undertaken by Bioresarches (30 May 2024, Final v1)
Flooding and flow paths	• Auckland Council GeoMaps
Ecological/ environmental areas	• Auckland Council GeoMaps – AUP management layers: Overlays – Natural Resources – Significant Ecological Areas (2016) • Assessment of Ecological Effects undertaken by Bioresarches (30 May 2024, Final v1)
Contaminated Land	• Preliminary Site Investigation (Ground Contamination) – Williamson Water & Land Advisory (August 2023, Rev. 2)
Cultural and heritage sites	• Archaeological Survey and Assessment of Effects – Archaeology Solutions Ltd (December 2023, Rev. 1)

2.2. Location and general information

The site is located in the Drury West area, comprising a total area of approximately 105ha. The updated Karaka Road Structure Plan encompasses the entire 105ha, with the PPC constituting 87.5ha of the total area. It is bounded by Karaka Road to the north, the North Island Main Trunk Railway Line to the south and Oiroa Creek to the west as can be seen in Figure 1.

The site is located within a predominantly rural area and currently has several buildings including 2 large greenhouses, two farmhouses, a trucking packing house and distribution centre, and 4 smaller sheds previously used for chickens. There are also several ponds and watercourses throughout the site.

The existing features of the site are shown in Figure 1. The current impervious coverage of the site has been estimated to be 15% from the impervious layer of Auckland Council's GeoMaps.

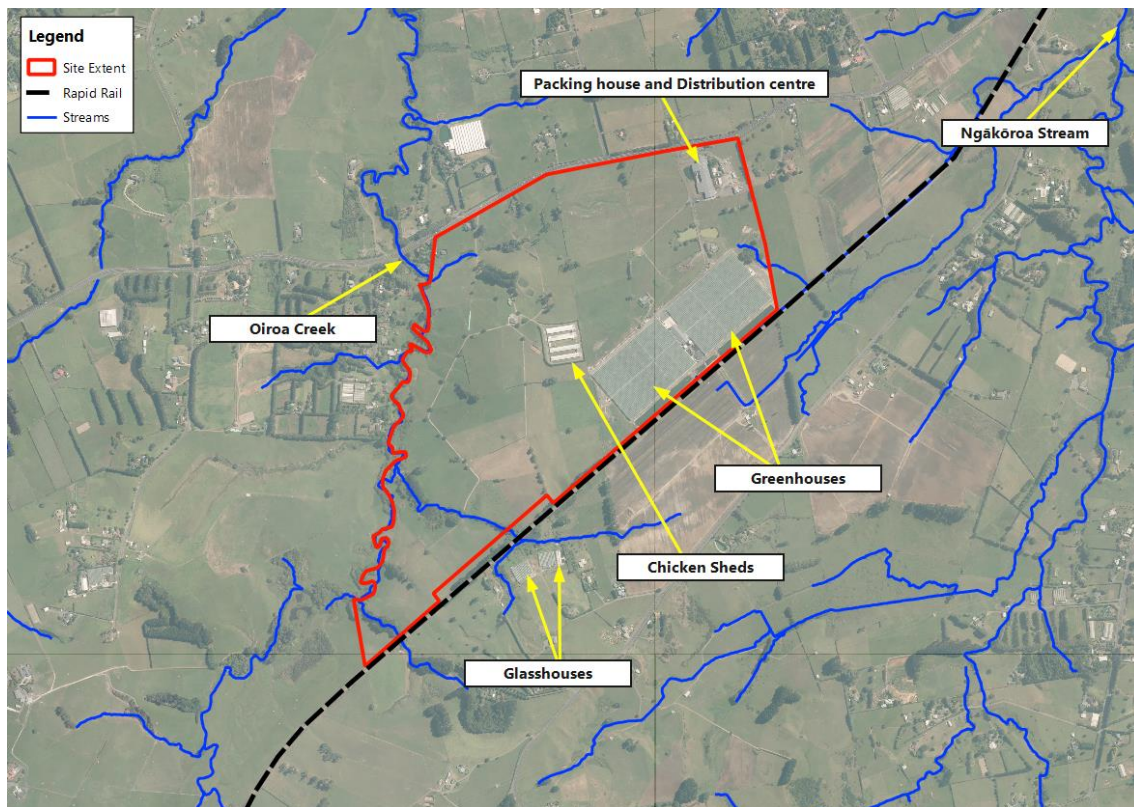


Figure 1: Existing site

2.3. Topography and existing catchments

The site is located within the lower Drury West stormwater management area as per the FUZ SMP which notes the topography across the lower Drury West catchment is generally of low elevation and has flat to gently undulating land.

The elevation within the site varies from 10 mRL to 30 mRL with a ridgeline through the site from northeast to southwest as can be seen in Figure 2.

The site is located within the Oiroa Creek and Ngākōroa Stream catchments. Approximately 72% (73.42 ha) drains to Oiroa Creek catchment with 28% of the site (28.58 ha) draining to Ngākōroa Stream catchment.

The location of the site in relation to the existing catchments is shown in Figure 2.

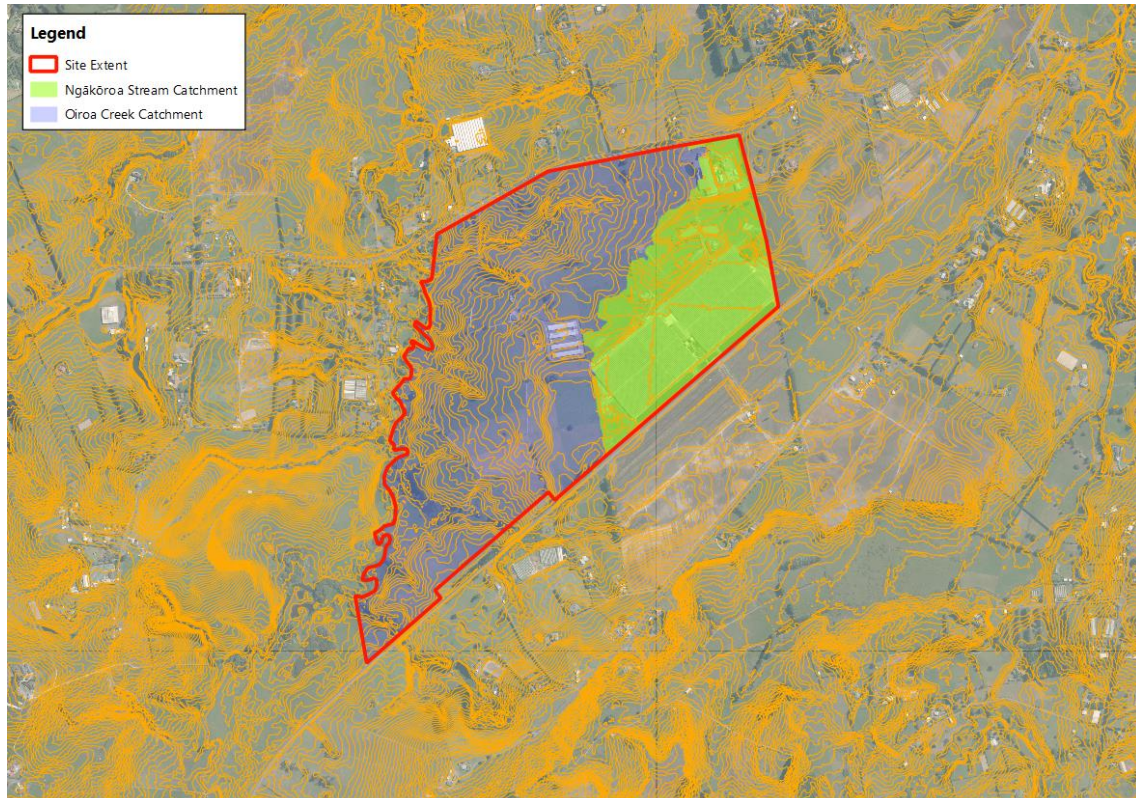


Figure 2: Existing topography and catchments (Source: Auckland Council GeoMaps)

2.4. Geology

Published geological maps for the area obtained from Auckland Council's soils layer indicate the underlying soil of the site is exclusively made up of alluvial soils (soil ID B) as shown in Figure 3. According to S-Maps online, the alluvial soils on the site vary in drainage capabilities, primarily falling within the range of moderate to poor drainage, with a predominant characteristic of imperfect drainage.

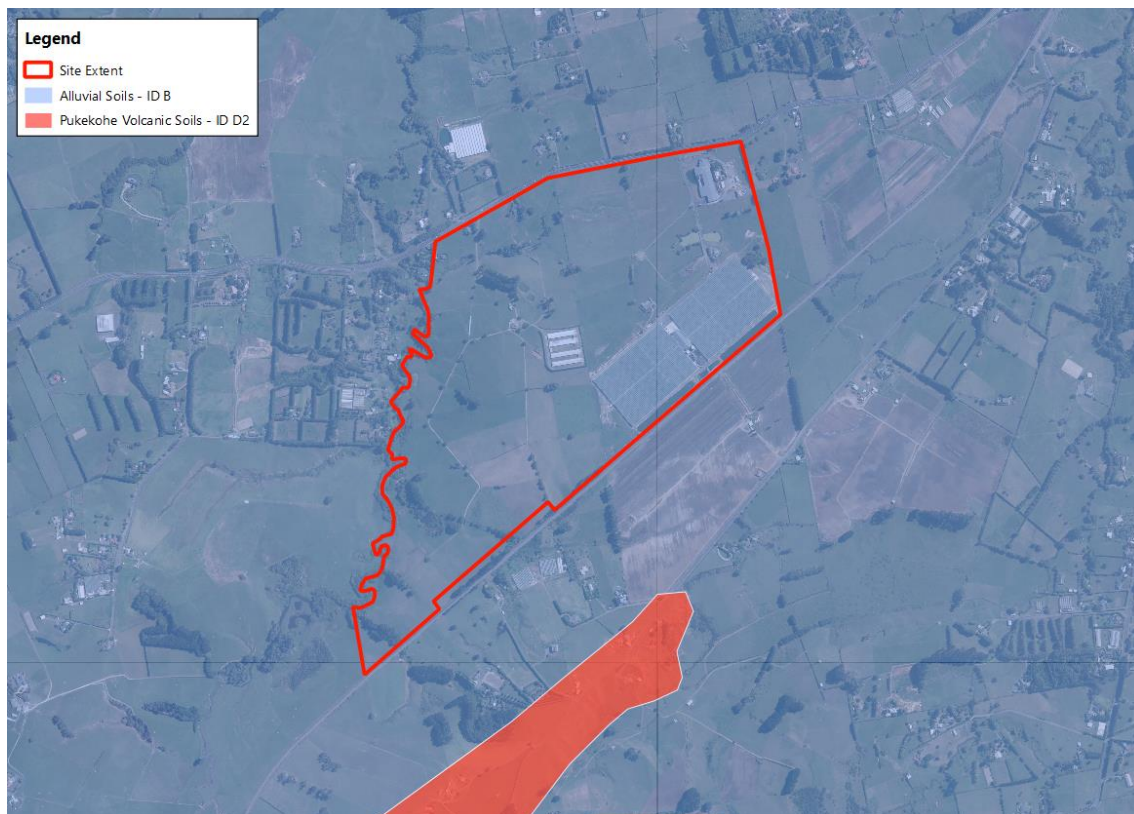


Figure 3: Geology (Source: Auckland Council Soil Maps)

2.5. Ecology/Biodiversity

An Ecological Effects Assessment (dated 30 May 2024 Final v1) has been undertaken by Biosearches for the proposed Structure Plan and PPC area. The report identifies numerous freshwater ecosystems, including permanent, intermittent, and ephemeral watercourses. Additionally, numerous natural wetlands have been identified throughout the site area. The existing ecological features are shown in Figure 4.

It is noted that the current ecological integrity of the identified freshwater ecosystems, including wetlands and ponds, are generally assessed as low to moderate value. They have the potential to support common native fish, but not provide high quality habitat for such fauna. One artificial pond has been identified as being very high value due to the likelihood of it being used by threatened dabchicks for breeding.

The terrestrial ecology values within the site range from moderate to high. These values are largely associated with potential habitats for native lizards, wetland birds, and long-tailed bats identified within or connected with the Oiroa Creek riparian vegetation.

More details on the ecological features of the site can be found in An Ecological Effects Assessment (dated 30 May 2024 Final v1) submitted with the PPC.

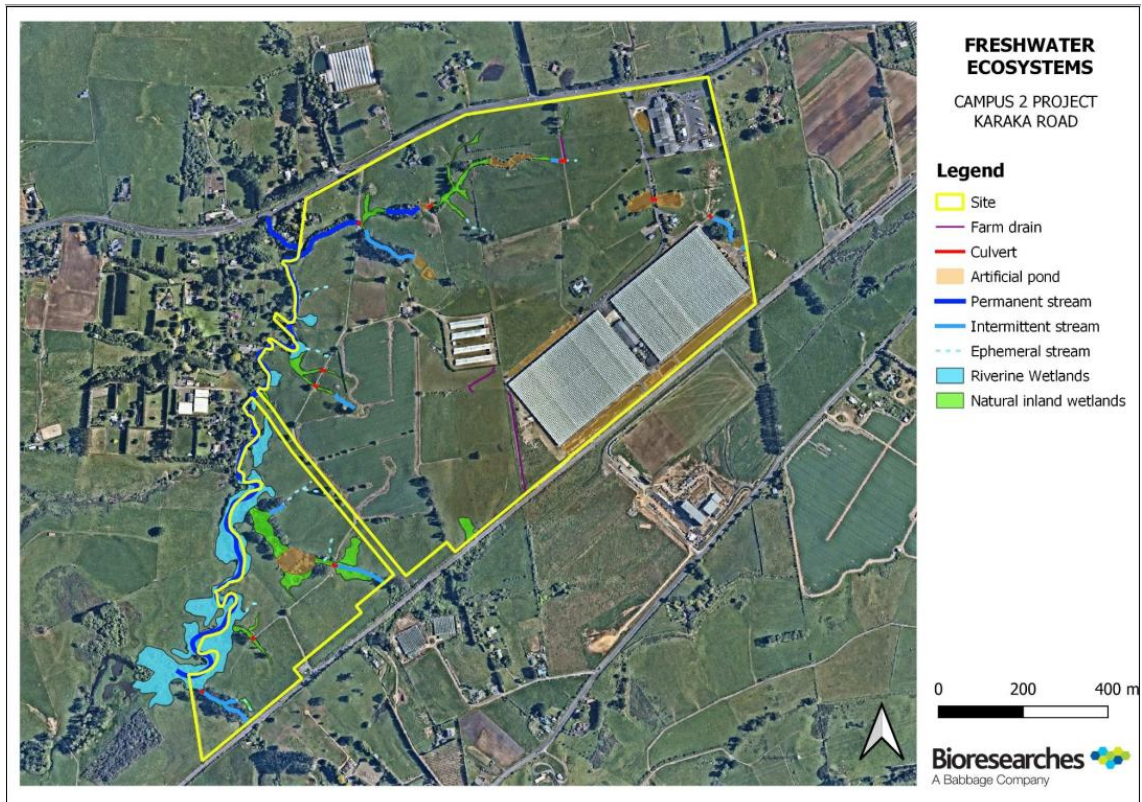


Figure 4: Map depicting localities of the classified watercourses (Source: Assessment of Ecological Effects undertaken by Bioresearches dated 30 May 2024 Final v1)

2.6. Existing drainage features and stormwater infrastructure

Auckland Council GeoMaps do not indicate any public stormwater networks located within the site. The existing stormwater network within the site is predominantly provided via existing watercourses and culverts.

There are currently several existing culverts upstream and downstream of the site as shown in Figure 5 below. Three concrete culverts (labelled 1-3 and 5) are located along the railway line as well as an existing culvert under Karaka Road (labelled 4).

Key information of the culverts are summarised below:

- Oiroa Creek traverses under the railway via Culvert 1 and traverses towards Culvert 4 along the western boundary of the site.
- Culverts 2 and 5 are located along the railway on the southern boundary of the site.
 - A portion of flows from the site discharges south underneath the railway (highlighted in Figure 5) and traverse north via Culvert 2 prior to discharges to the main Oiroa Creek along the western boundary of the site
- Oiroa Creek exits the site under Karaka Road via Culvert 4.
- Flows from the remainder of the site that discharges to Ngākōroa Stream traverse east and conveys via Culvert 3 under the before it discharges into the Ngākōroa Stream.

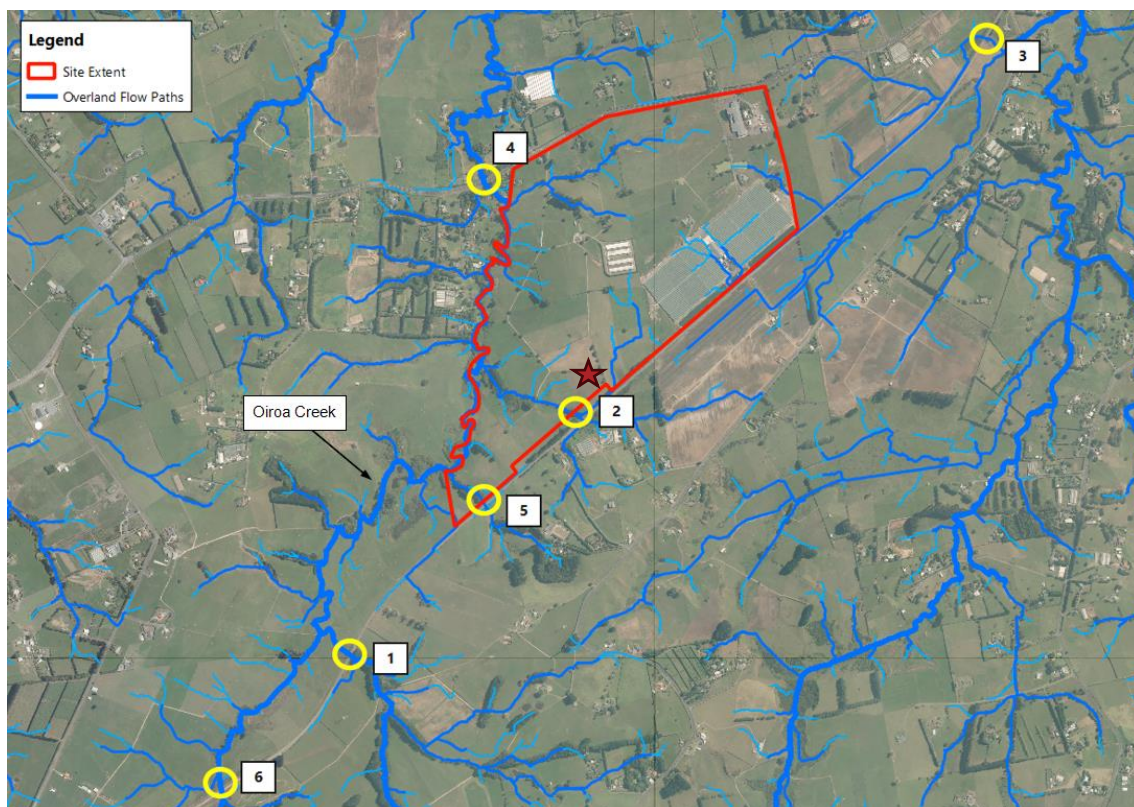


Figure 5: Existing stormwater infrastructure

A summary of the infrastructure data is summarised in Table 2 below. It is noted most assets have been surveyed while some of the asset data has been obtained from publicly available information.

Table 2: Summary of stormwater infrastructure

#	Asset type	Asset Owner	Diameter (mm)	Upstream invert level (m RL)	Downstream invert level (m RL)	Source of information
1	Culvert Box Railway	KiwiRail	2900 x 2500	15.6	12.38	Downstream invert level and diameter from Survey Information. Upstream invert level from MWH Oiroa Creek and Ngākōroa Stream RFHA
2	Culvert Circular Railway	KiwiRail	900	-	14.05	Downstream invert level and diameter from Survey Information. Upstream invert level from MWH Oiroa Creek and Ngākōroa Stream RFHA
3	Culvert Circular Railway	KiwiRail	750	8.5	7.32	Downstream invert level and diameter from Survey Information. Upstream invert level from MWH Oiroa Creek and Ngākōroa Stream RFHA
4	Twin Box Road Culvert	Auckland Council noted to be asset owner for inlet-outlet (as per AC GeoMaps)	3000 x 4000	5.5	5.4	Downstream invert level and diameter from Survey Information. Upstream invert level from MWH Oiroa Creek and Ngākōroa Stream RFHA
5	Culvert Circular Railway	KiwiRail	1050	-	-	All data sourced from AC GeoMaps
6	Culvert Circular Railway	KiwiRail	4600	-	-	All data sourced from AC GeoMaps

2.7. Receiving environment

As discussed in Section 2.3, there is an elevated ridge line within the site that divides and drains the site towards Oiroa Creek catchment (20.3 km²) and Ngākōroa Stream catchments (40.1km²). These catchments discharge into the Pahurehure Inlet of the Manukau Harbour (via Drury Creek), and lie above the Kaawa aquifer as can be seen in Figure 6 below.

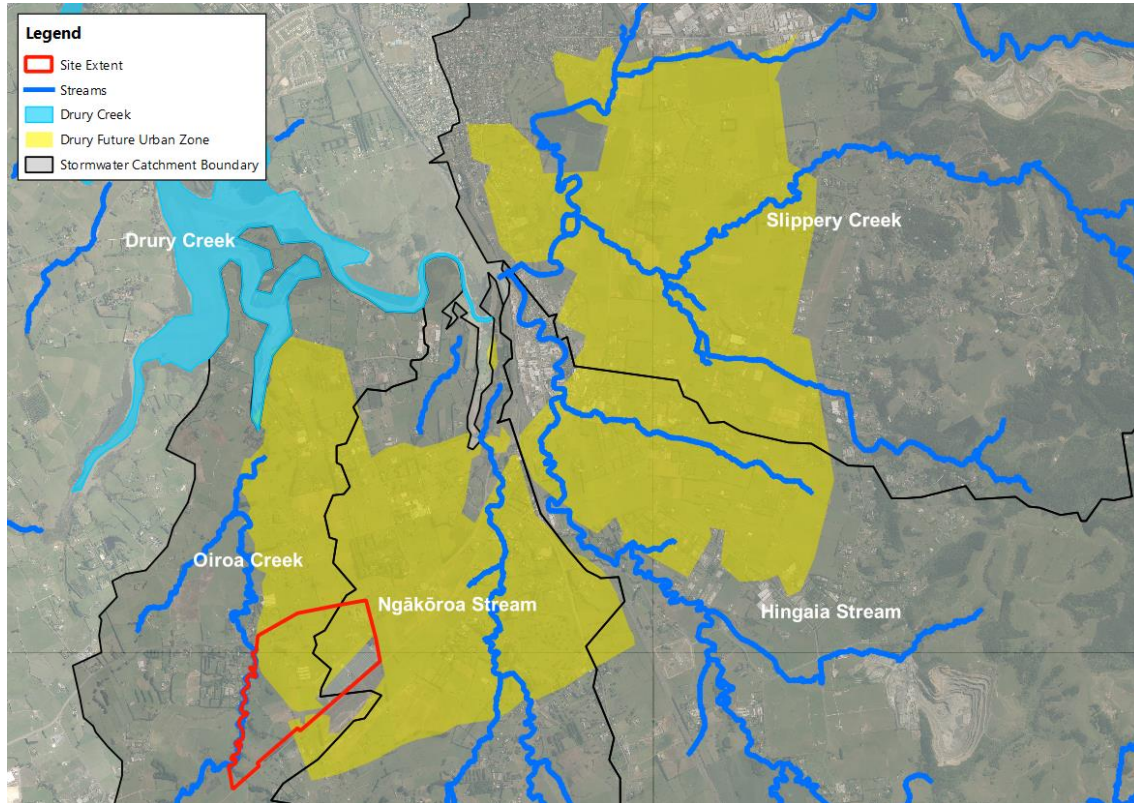


Figure 6: Drury-Opāheke Catchments (Source: FUZ SMP)

2.7.1. Oiroa Creek

Oiroa Creek and its tributaries make up a 61 km stream network and 20.3 km² catchment. As per the FUZ SMP, this creek reflects the physical characteristics of a highly modified agricultural catchment as it drains through rural and high-intensity agricultural land. The assessment addresses the stream's high E. Coli contamination, sparse riparian vegetation and low to moderate ecological value. The banks of the streams inletting into Oiroa Creek show evidence of having been widened, straightened and/or deepened.

2.7.2. Ngākōroa Stream

The Ngākōroa catchment has an area of 40.1 km² and is mainly rural. The Ngākōroa Stream is within a high-use stream management area and is threatened by high water take (uptake for irrigation and discharge for ecology and base flows). The FUZ SMP defines the catchment as highly modified with historical vegetation clearance; however, bank stability was assessed to be good. There is evidence of the stream channels having been modified, mostly via straightening. Online ponds, dams and low energy watercourses are present as well as several bridges and culverts that affect flooding. Significant Ecological Areas- Terrestrial, have been identified in this stream catchment, however, sit outside the site.

2.7.3. Drury Creek

The subject site discharges to the above local stream networks which subsequently discharge to Drury Creek. Approximately 25% of sediment and heavy metals deposit into Drury Creek from the upstream creeks. Drury Creek is identified as a Significant Ecological Area – Marine and comprises of intertidal, freshwater and

terrestrial habitats. Oiroa Creek discharges into Drury Creek via a major tidal inlet, therefore Drury Creek is influenced by coastal inundation.

2.7.4. Pahurehure Inlet

The Pahurehure Inlet is a sensitive low energy system, receiving fine sediment deposits from Drury Creek. Large-scale soil loss and erosion of cultivated land within the upstream Ngākōroa catchment results in significant sedimentation of this receiving environment. Parts of the Pahurehure Inlet are identified as marine Significant Ecological Area and the dominating soft, fine sediments settling out on the seabed detrimentally impact its ecological health (Mott MacDonald, 2019), resulting in it being ranked as 'unhealthy'. Extreme water levels of the inlet are caused by coastal inundation and tidal influences.

2.8. Flooding and overland flow paths

Auckland Council GeoMaps indicates several overland flow paths (OLFP) and associated flood plains within the site as can be seen in Figure 7.

As discussed in Section 2.7, the site discharges to two stormwater catchments, Oiroa Creek and Ngākōroa Stream catchments. Approximately 72% of the site falls within Oiroa Creek catchment while the remaining 28% of the site falls within the Ngākōroa Stream catchment.

As described in Section 2.6 of this report, runoff from the portion of the site located within Oiroa Creek catchment discharges by traversing westwards directly to the stream as well as southwards, towards the railway line from where the overland flow paths traverse back into the site and ultimately discharging to the Oiroa Creek. While the runoff from the site area forming part of Ngākōroa Stream catchment, traverses in south-east direction, discharging towards the upper tributaries of Ngākōroa Stream.

The published flood plain on GeoMaps has been produced in 2021 and is based on the Rapid Flood Hazard Assessment (Oiroa Creek and Ngākōroa Stream RFHA Model Build Report 2021). The flood assessment is noted to be undertaken based on Maximum Probable Development (MPD) 70% impervious and modelled using 2013 LiDAR.

Woods, as part of the development of the SMP, has undertaken flood modelling for the site. This is discussed further in Section 7 with a memorandum containing flood model build information included in Appendix A.

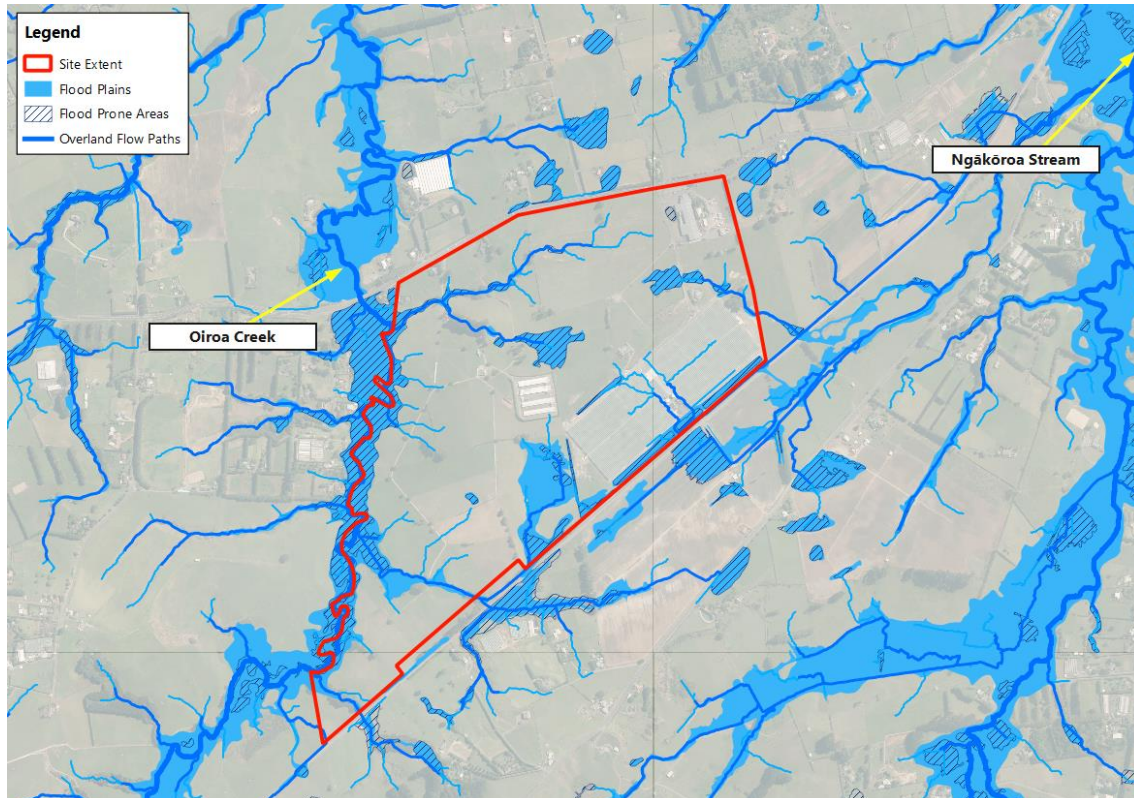


Figure 7: Overland flow paths and associated floodplain (Source: Auckland Council GeoMaps)

2.9. Coastal inundation

The majority of the runoff generated from the site discharges to the existing culvert (3.5m x 3.5m) located underneath the Karaka Road. This asset is located approximately 2km upstream of the ultimate discharge point (coastal estuary).

As can be seen in Figure 8, the Coastal Inundation (1% AEP) overlay from the AUP is indicated to begin past the bridge crossing. Therefore, it is assumed the site is not coastally influenced. However, Oiroa Creek is shown as being within a 1% AEP coastal inundation overlay which has been represented in the flood modelling undertaken for the preparation of the SMP.

The modelling assumptions are discussed in detail in the flood model build report (Appendix A).

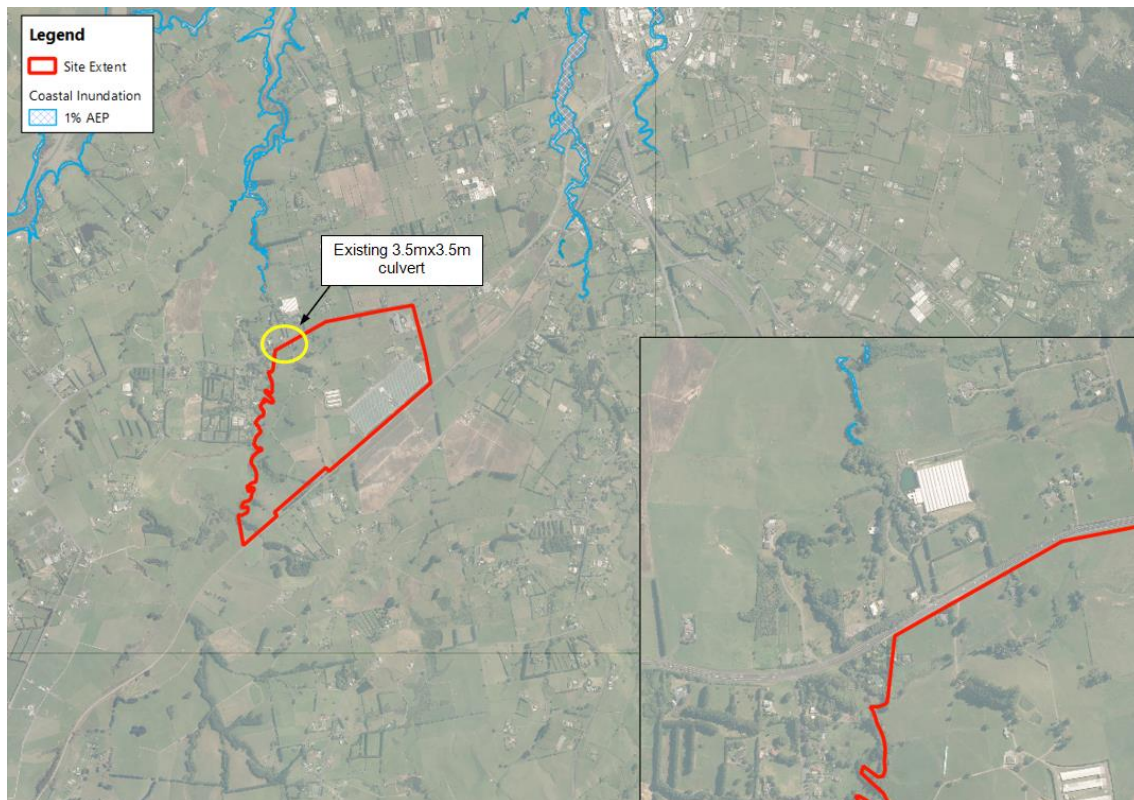


Figure 8: Coastal inundation (Source: Auckland Council GeoMaps)

2.10. Cultural and heritage sites

An archaeological investigation by Archaeology Solutions Limited has been undertaken for the PPC area. The report investigated cultural heritage features and potential risks within the area of the PPC. The study identifies the Oiroa Creek as high-risk area while the rest of the study area is considered to be low risk.

The report mentions that there are two previously recorded archaeological sites near the study area, but both relate to the railway and are contained within the railway corridor. There was no evidence of any archaeological sites recorded during the survey. However, the Oiroa Creek is a high risk to encounter archaeological sites during any earthworks.

There was also no evidence of historic cultural heritage, for example, European homesteads, etc. The oldest identified structure is from around 1930s/40s. The report mentions that any proposed earthworks within 100m buffer of Oiroa Creek should be first authorised by Heritage NZ Pouhere Taonga.

Further information on cultural and heritage sites can be found in the report 'Archaeological Survey and Assessment of Effects' submitted with the PPC.

2.11. Contaminated land

A Ground Contamination report has been prepared by Williamson Water & Land Advisory (WWLA0754 Revision 2, dated 29 August 2023) to determine the potential for contamination and planning implications for the PPC and future development earthworks. The key findings of the report are provided below

- The site has a history of farming and rural production uses.
- Several potential sources of contamination have been identified; however, the contaminants are present in highly localised areas and therefore not a risk to broader commercial/light industrial activities that will be undertaken on site.
- A further detailed assessment (DSI) will be undertaken to determine remediation and controls required for the development.

3. Development Summary and Planning Context

A review of the relevant stormwater guidelines and policies has been undertaken to determine the appropriate stormwater and flooding requirements to be adopted in the SMP for the PPC area.

The following documents have been reviewed:

- Auckland Unitary Plan – Operative in Part (AUP);
- Regionwide stormwater network discharge consent (NDC);
- Auckland Council’s Drury-Opāheke Structure Plan Future Urban Zone Management Plan – Draft Stormwater Management Plan (FUZ SMP), prepared by Mott Macdonald, Revision 04C;
- Water sensitive design (GD04); and
- National Policy Statement for Freshwater Management 2020 (NPS-FM).

A copy of this assessment can be found in Appendix B.

3.1. Technical guidance

The development approach for managing stormwater for the development is to adopt and align with policy E1.3 (10) in the AUP.

The purpose of this section is to communicate the minimum stormwater requirements for the development area. This includes regulatory, technical and design requirements that the stormwater management for the development must meet.

A summary of technical guidance documents used in this SMP is provided in Table 3.

Table 3: Guidance summary

Guidance document	Summary	Relevant for SMP
Regionwide stormwater network discharge consent (NDC)	RMA granted consent for managing and integrating land use, stormwater discharge and the region’s natural water assets to mitigate the impacts of climate change and flooding	Schedule 2 and Schedule 4 – greenfield development requirements - be complied with.
Auckland Unitary Plan – Operative in Part (AUP)	Covers policies regarding stormwater	Yes
Drury-Opāheke Structure Plan Future Urban Zone Draft Stormwater Management Plan (referred to as FUZ SMP)	The FUZ SMP has been prepared to support the Drury component of the structure plan South. It covers Drury West (Oiroa Creek and Ngākōroa Stream), Drury East (Hingaia Stream) and Opāheke (Slippery Creek).	Yes – provides guidance for the stormwater management strategy for Drury West catchments
Stormwater management devices in the Auckland Region – Guideline Document 2017/001 (GD01)	Technical guidance on design criteria for stormwater management devices	Yes – provides guidance for design of stormwater management devices
Guidelines for Stormwater Runoff Modelling in the Auckland Region – Technical Publication 108 (1999). Auckland Regional Council.	Guideline document for hydrology in Auckland Region	Yes – provides guidance on rainfall depths and hydrological assessment method

Guidance document	Summary	Relevant for SMP
Auckland Code of Practice: For Land Development and Subdivision (Chapter 4 - Stormwater) – Version 3.0 (January 2022). Auckland Council (SWCOP)	Provides minimum standards for the design and construction of public stormwater infrastructure for land development and subdivision	Yes – guidance to be followed
Auckland Council Stormwater Flood Modelling Specifications (2023) Auckland Council.	Technical specification document for stormwater flood modelling	Yes - Provides guidance for build of stormwater flood models
Water Sensitive Design for Stormwater – Guidance Document 2015/004 (March 2015) Auckland Council.	Guidance document for the application of Water Sensitive Design (WSD)	Yes - outlines the WSD approach for the site. WSD works alongside the urban design solution
National Policy Statement for Freshwater Management 2020 (NPS-FM)	Tool for managing and improving conditions of Auckland's freshwater and coastal systems	Yes - outlines strategic objectives to be considered.
National Policy Statement for Urban Development 2020	Provides national guidance on how cities are developed and respond to growth to enable improved housing affordability and community wellbeing	Yes - policies in this statement are applicable to this development which seeks intensification and urbanisation in the area. This has a direct bearing on how stormwater would have to be managed considering increased imperviousness on the site.
Auckland Plan 2050	Provides guidance on how Auckland is expected to grow and change in the next 30 years and states a development strategy	Yes – general guidance to be followed
NZS4404 – Land development and Subdivision infrastructure	Provides detail on stormwater management including WSD, flood risk management, freeboard allowance etc.	Yes - guidance to be followed
Auckland Water Strategy 2022-2050	Provides guidance on water strategy	Yes - outlines water strategy to be considered.

4. Mana whenua: Te Ao Māori and Mātauranga

4.1. Identification and incorporation of mana whenua values

At the time of writing this SMP, F&P has sent engagement correspondence to 18 iwi groups. Te Ākitai Waiohū, Ngaati Te Ata Waiohū, and Ngāti Tamaoho have confirmed an interest in being involved in the PPC. All three iwi groups took part in tours of the site and cultural values assessments have subsequently been completed for the proposed Structure Plan and PPC.

A summary of the discussions held in regard to stormwater is provided in Table 4.

Table 4: Summary of mana whenua engagement on stormwater matters

Date	Summary of Discussion
20/05/2024	- Hui with Ngaati te Ata Waiohū to discuss stormwater and ecology - Stormwater management and flood strategy of passing flows forward with diversion and retention of base flows to Ngākōroa is discussed
04/06/2024	- Hui with Ngāti Tamaoho - An overview of stormwater management approach and the overall flood strategy is provided - Passing flows forward approach is the preferred strategy given the site's location in the overall catchment. - Ngāti Tamaoho noted that they would seek clarification from Healthy Waters regarding the approach of passing flows forward.
02/07/2024	- Combined hui with Ngāti Tamaoho and Ngaati Te Ata Waiohū - An overview of stormwater management approach and the overall flood strategy is provided. - Reiteration of the fact that the pass flows forward approach is the preferred approach due to the location within the catchment. - The site is located within the downstream portions of the catchment. The proposed flood management strategy is therefore deemed to be the best most suitable for the awa and the overall catchment. - Discussion of model results which supports pass flows forward strategy and a brief discussion of the how the strategy is further supported by independent assessments including: - The FUZSMP, which confirms pass flows forward preferred for this part of the catchment (lower), and attenuation preferred for upper parts of the catchments – strategy. - Waipupuke Plan Change PC61 (now granted) which proposes pass flows forward as the suitable flood management strategy as well as an independent peer review undertaken which has supported this strategy during the plan change application process. - The reliability of the model results is challenged by Ngaati Te Ata Waiohū, who have differing views and do not support the strategy. - Delegates from Ngāti Tamaoho and Ngaati Te Ata Waiohū will seek independent stormwater review/advice to inform their respective Iwi

We understand that an additional hui was held between Ngāti Tamaoho, Ngaati Te Ata Waiohū and FPH in August 2024 to further discuss the Plan Change request including the stormwater approach for the site. The

Cultural Values Assessments which have been attached to the Plan Change request informs Ngāti Tamaoho's and Ngaati Te Ata Waiohua's positions on the Plan Change request and their recommendations.

Post lodgement of the PPC and the SMP, a hui was held on 23/10/2024 between Ngāti Tamaoho and FPH. It is our understanding that Ngāti Tamaoho did not proceed with obtaining independent advice on the stormwater strategy and a Memorandum of Understanding has been prepared and shared with Ngāti Tamaoho.

Appendix C provides a summary of the discussions relevant to stormwater by way of hui minutes.

5. Stakeholder Engagement

Engagement has been undertaken with various parties including KiwiRail, Waka Kotahi, Auckland Council, Auckland Transport, Watercare, Veolia, Local Boards and Ward Councillors. Community engagement has also been undertaken including a community drop-in day that was held on 10/02/2024. A consultation summary report is provided in the wider Plan Change report for reference.

Consultations in regard to stormwater is detailed in Table 5 with minutes provided in Appendix C.

Table 5: Summary of consultation with stakeholders

Date		Summary of discussion
21/05/2024	KiwiRail	- Meeting held with KiwiRail to go through the project and in particular on KiwiRail assets located along the railway that borders the FPH site - The proposed stormwater and flood management strategy should not increase the flows to the existing structures - Following the meeting, Woods have provided an overall design philosophy strategy (noting the detail around this to be undertaken during masterplanning) and share information on asset data
31/05/2024	Healthy Waters	- Meeting held with Healthy Waters following an issue of the Draft Stormwater Management Plan - Healthy Waters had reviewed the draft document and provided feedback. The version of the SMP getting submitted as part of the PPC lodgement to make amendments based on Healthy Waters review. - Healthy Waters noted they are generally happy with the stormwater management and flood strategy of passing flows forward - Healthy Waters noted their preference for the flood modelling to be updated to include a pre-development scenario based on ED i.e., existing impervious coverages, whilst no changes are anticipated to be undertaken for completeness. - This version of the SMP (V3) has been updated to include the ED simulations
25/02/2024	Healthy Waters	- Meeting held with Healthy Waters to discuss the Clause 23 response received post lodgement of the Final Stormwater Management Plan - This version of the SMP (V4) has been updated to reflect the responses. The main updates are summarised below: - A stream erosion assessment has been undertaken as requested by Healthy Waters. This is further detailed in Section 8.2.4 of this report and included in Appendix E. - Further detail provided regarding additional engagement undertaken with mana whenua post lodgement of the SMP - Further detail provided around flood modelling as requested by Healthy Waters
07/04/2025	Healthy Waters	- Meeting held with Healthy Waters team to discuss stream erosion assessment undertaken - The memorandum (Appendix E) and Section 8.2.4 has been updated to include requested items

It is noted that future consultation and engagement is planned and will continue on an ongoing basis as the PPC progresses.

6. Proposed Development

The Updated Karaka Road Structure Plan identifies the entire 105ha site as Business – Light Industry (Figure 9 below) and the PPC seeks to rezone approximately 87.5 ha of that site (the part of the site that is currently zoned Future Urban and located inside the Rural Urban Boundary) to Business - Light Industrial zone under the AUP (Figure 10 below).

Site specific ecological and archaeological assessments identify a number of features that are to be retained as part of the PPC. This includes the existing natural stream and wetland features located within the site that are proposed to be retained as part of PPC. This is as per the recommendation mentioned in the ecological assessment undertaken and discussed in Section 2.5 of this report. In addition to this, the ecological assessment recommends that a minimum 10m (but potentially up to 100m) buffer zone be provided around Oiroa Creek to avoid further degradation of the stream health.

At the time of this report, there was no masterplan prepared for the site and therefore, the impervious coverage for the site was conservatively assumed to be 80%.¹

Figure 9 shows the AUP zoning and proposed zoning for the site under the Structure Plan.

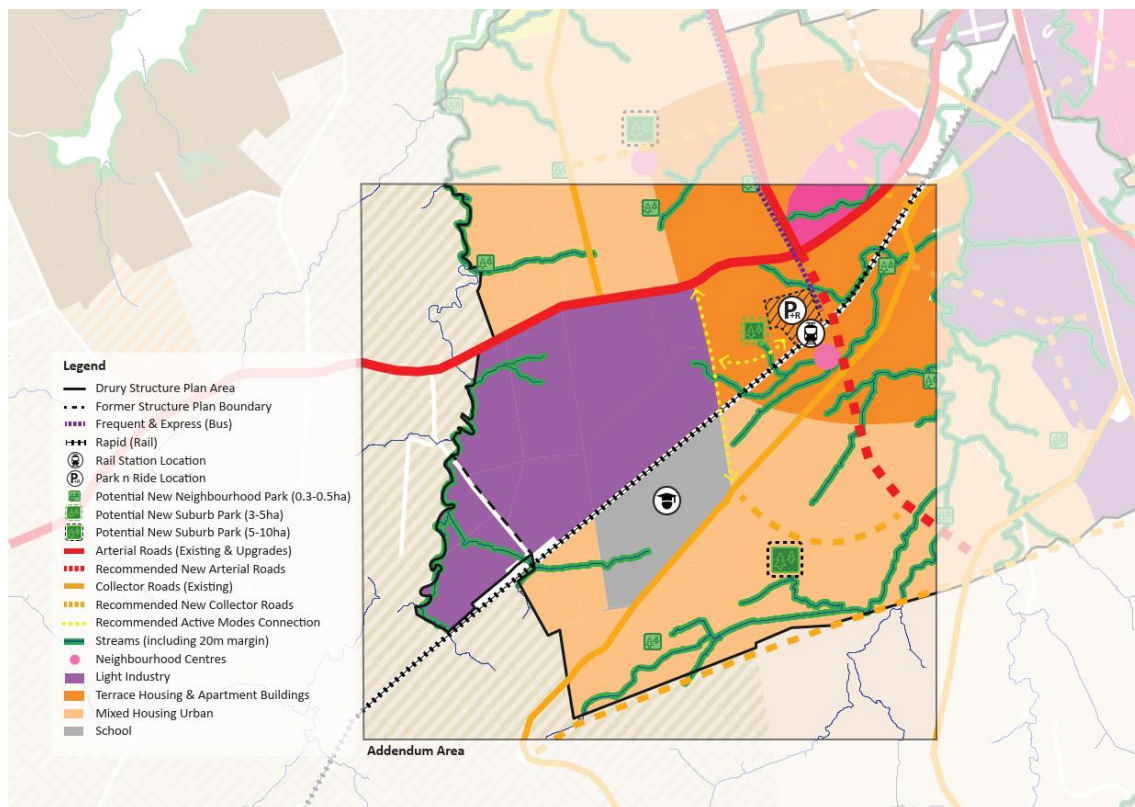


Figure 9: Proposed zoning for the Karaka Road Updated Structure Plan (Source: Barker & Associates Ltd)

Figure 10 shows the proposed rezoning of the Future Urban zoned land to Business - Light Industrial use under the PPC.

¹ An 80% impervious coverage has been used throughout this report for conservative modelling purposes only. It is noted that the impervious coverage of the site following the creation of a masterplan is likely to be less than 80% to achieve the campus feel to the site that F&P seeks.

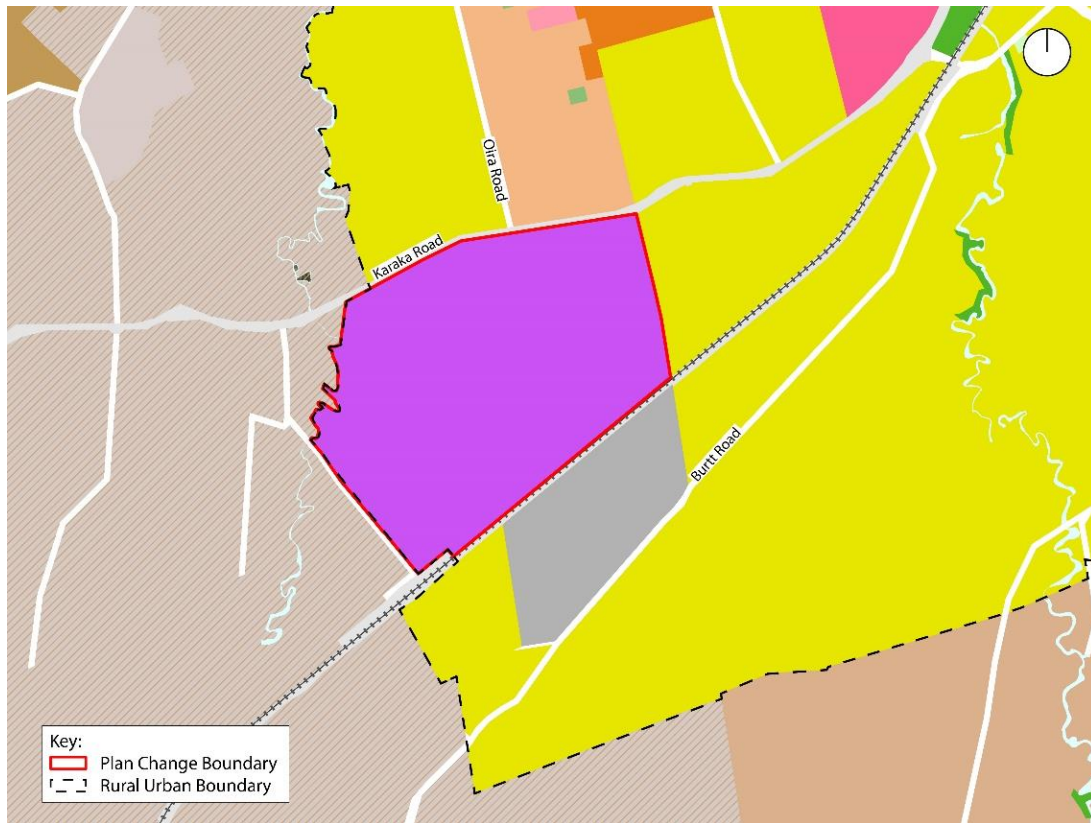


Figure 10: Proposed zoning under the Plan Change request to the part of the FPH site zoned FUZ (Source: Barker & Associated Ltd)

7. Flood management

Auckland Council GeoMaps indicates that approximately 23% of the site is covered by published floodplains. This flooding information is based on a rain on grid Rapid Flood Hazard Assessment (RFHA) undertaken by Stantec in 2021 as previously shown in Figure 7.

Woods have requested and received the “Oira Creek and Ngakoroa Stream RFHA” catchment model. This model has been used to assess the flood effects as a result of the proposed PPC (if any) and develop flood mitigation options to avoid or minimise/mitigate any change in the existing flooding conditions.

A flood model build memo (Appendix A) has been prepared which details all the updates made by Woods to the catchment model. The memo also details the model scenarios undertaken and key assumptions.

An 80% impervious coverage has been used throughout this report for modelling purposes and is deemed conservative for the post-development scenarios. The impervious coverage of the site following master planning is expected to be lower than 80% to achieve the campus feel to the site that F&P envisages.

7.1. Model scenarios

Four flood model scenarios have been undertaken as part of the flood assessment. This has been undertaken to understand the most suitable flood mitigation option for enabling the PPC.

A brief description of the modelled scenarios have been summarised in Table 6.

Table 6: Model scenario summary

#	Model scenario name	Description	Land use	Climate Change (°C)	ARI
1a	Pre-development	- This scenario was modelled to understand existing flood extents. - This scenario forms the basis for assessing future flood risk and suitability of flood management options	Existing Development (ED)	3.8°C, 2.1°C, No CC	100, 10, 2
1b			ED - for areas within the PPC extent. Maximum Probable Development (MPD) – all areas outside the PPC extent		
2	Post development without mitigation	- Model scenario allowing for imperviousness uplift as part of PPC without any flood management option - Catchment loading has allowed for storage within existing depressions located within the site	MPD	3.8°C, 2.1°C, No CC	100, 10, 2
3	Post development with pass forward	- Model scenario allowing for imperviousness uplift as part of PPC and allows for pass flows forward flood management option - Catchments have been loaded directly to the streams and therefore no storage allowed within the site to enable passing flows forward. - This is deemed conservative	MPD	3.8°C, 2.1°C, No CC	100, 10, 2
4a	Post development with pass forward + diversion	- Model scenario allowing for uplift of impervious area as proposed in PPC, and allows for pass flows forward + flow diversion as flood management option - This is deemed conservative as it doesn't allow for the proposed devices within the site	ED - for all areas outside the PPC extent MPD - for all areas within the PPC extent	3.8°C, 2.1°C, No CC	100, 10, 2
4b			MPD		

➤ **Pre-development (Scenario 1a and 1b)**

This scenario was modelled to understand existing flood extents and forms the basis for assessing future flood risk and flood management options. Two scenarios have been simulated as follows:

- 1a – Existing development (ED) impervious coverage for all areas within the model extent
- 1b – Existing development (ED) impervious coverage within PPC extent whereas for areas outside the PPC, the impervious coverage is assumed to be maximum probable development (MPD) as per AUP.

➤ **Post development without mitigation (Scenario 2)**

This model scenario was modelled to assess the flood effects on areas upstream and downstream of the development site as a result of the change in imperviousness with the proposed PPC. The modelling assumption for post development scenarios consider 80% impervious coverage within the development, which is a conservative approach. The impervious coverage of areas outside of the PPC have been based on MPD as per the AUP. Catchment loading within this scenario has allowed for the existing storage within the site.

➤ **Post development with pass forward (Scenario 3)**

This model scenario further builds on Scenario 2 and allows for flows generated within the PPC area to be passed forward. This scenario has been modelled to assess the flood effects on the basis post development flows are “passed forward” i.e. no attenuation. As per the FUZ SMP, the general flood management approach for Drury West area is to pass flows forward which is in line with the flood management option explored here. Local depressions within this area have been removed with secondary flows bypassing communal devices.

➤ **Post development with pass forward + diversion (Scenario 4 – Preferred Option)**

Further building on Scenario 3, Scenario 4 has been modelled to demonstrate the proposed option of passing flows forward along with diversion of site catchment area towards Oiroa Stream. Findings of Scenario 2 and Scenario 3 have been used to inform the catchment area diverted in this model scenario.

Two scenarios have been simulated for this option as follows:

- 4a – MPD impervious coverage within the development extent while the remaining model extent is assumed to be ED impervious coverage, and
- 4b – MPD impervious coverage for all areas within the model extent.

The model scenario implements the flood management strategy with the following measures:

- Diversion of the site area (28.58ha) which currently discharges to Ngākōroa Stream.
- It is noted that existing base flows are sought to be maintained in a regime similar to existing conditions for events such as the less than the 2yr event, this has been excluded from the assessment as this will not adversely impact the flood strategy.
- Diversion of the site area of 4.16ha which currently discharges towards the railway line at the southern end of the site.
- In total, this model scenario allows for diversion of 32.74ha of site area towards Oiroa Creek and passed forward.

Figure 11 shows the catchment delineation for Scenario 4.

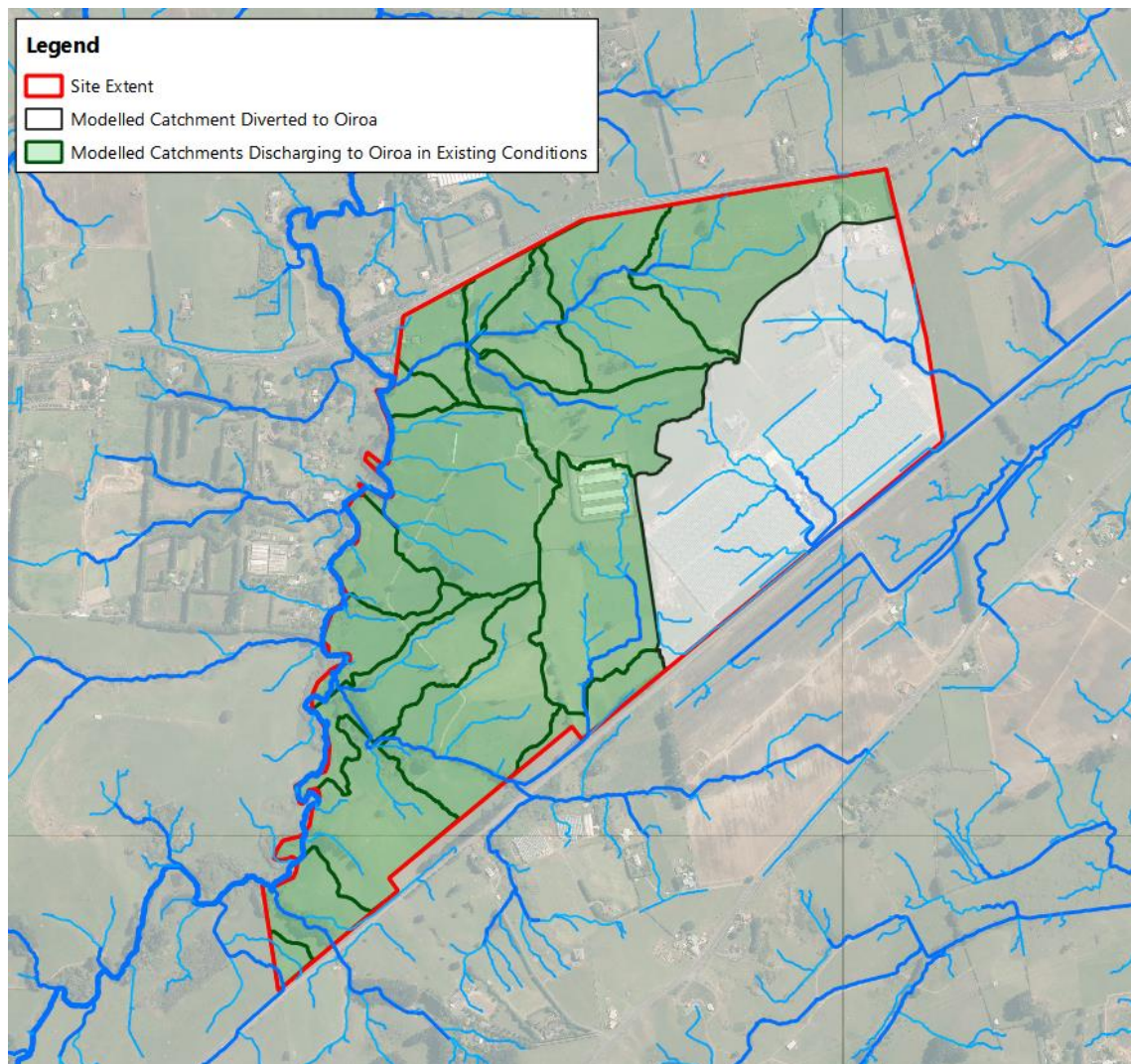


Figure 11: Catchment diversion for Scenario 4

Table 6 provides a summary of the pre-development (Scenario 1a and 1b) and post development pass flows forward + diversion (Scenario 4a and 4b – preferred option) model scenarios. This table provides a description of the key model assumptions and simulated rainfall events.

It is noted for the purpose of optioneering, Scenario 2 and Scenario 3 were also simulated and details are documented in the Model Build Report (provided in Appendix A).

7.2. Model results discussion

As stated in Section 7.1, the models have been simulated for no climate change, climate change considerations related to 2.1° temperature rise to 2090, as well as 3.8°C temperature rise to 2110 for 2, 10- and 100-year ARI storm events. The water level results of each post development model scenario were compared with the pre-development models to assess the differences in the water levels upstream and downstream of the site. This has guided the development of options to avoid or minimises/mitigates any change in the existing flooding as a result of development enabled by the PPC (if any).

This section discusses model results for the pre-development model scenario (Scenario 1a and 1b) and post development scenarios (Scenario 4a and 4b).

Model results and water level difference plots for all modelled scenarios including Scenario 2 and Scenario 3 have been included in Appendix D.

7.2.1. Pre-development Model Results (Scenario 1a and 1b)

Scenarios 1a and 1b has been simulated for all the storm events as stated in Table 6, however, for the purposes of the SMP, model results for storm events with allowance for 3.8°C future climate change factor have been provided in Figure 13 – Figure 17.

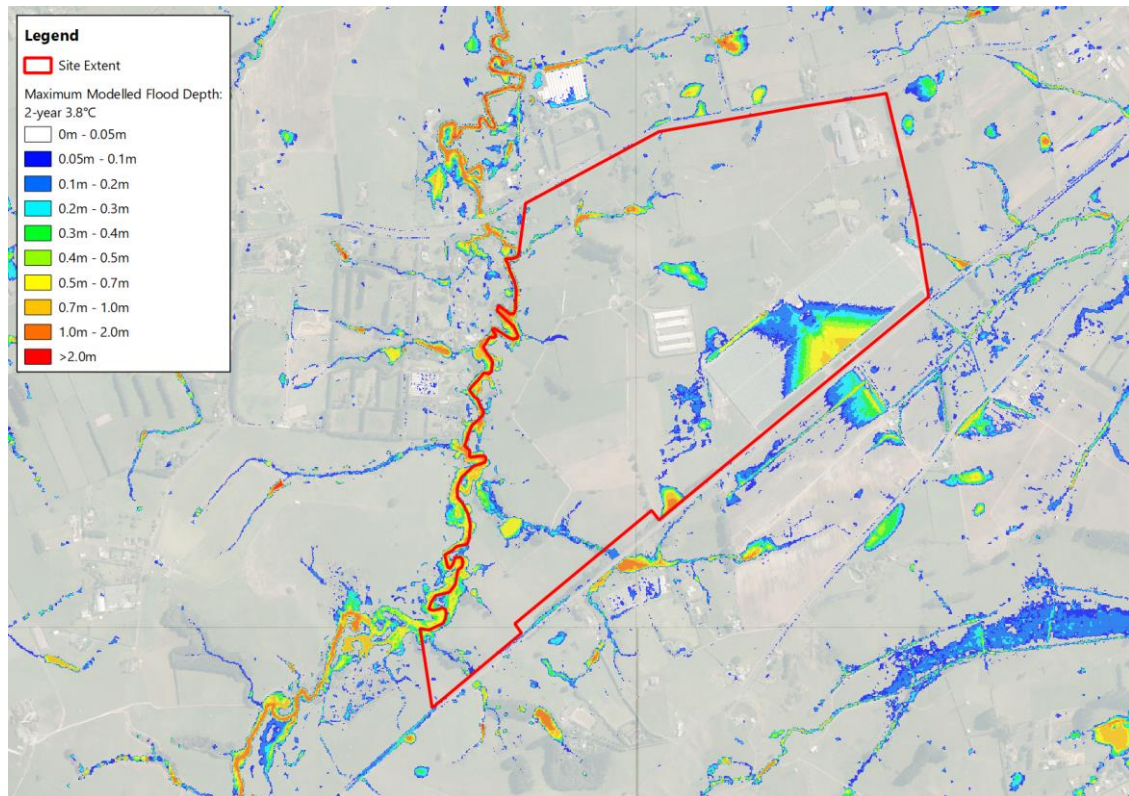


Figure 12: Scenario 1a - Maximum Modelled Flood Depth - Pre-development 2-year 3.8°C ARI (ED for entire model extent)

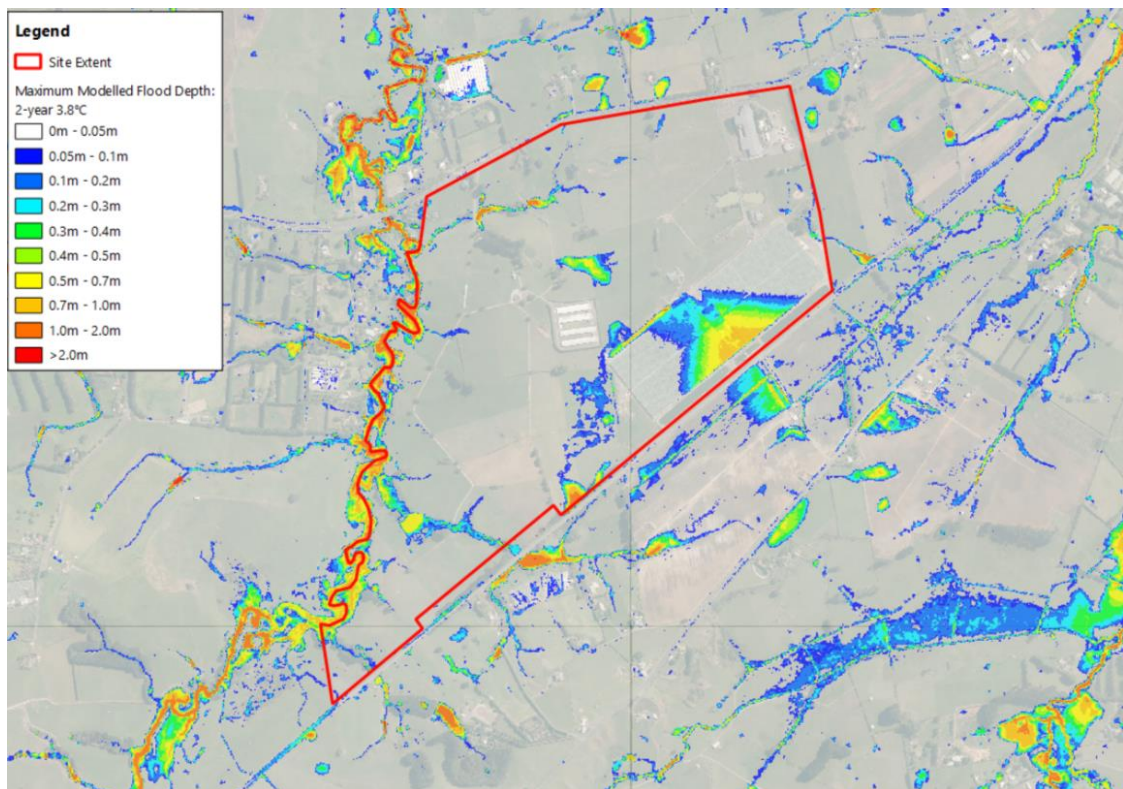


Figure 13: Scenario 1b - Maximum modelled flood depth - Pre-development 2-year 3.8°C ARI (ED within PPC and MPD for all model extent)

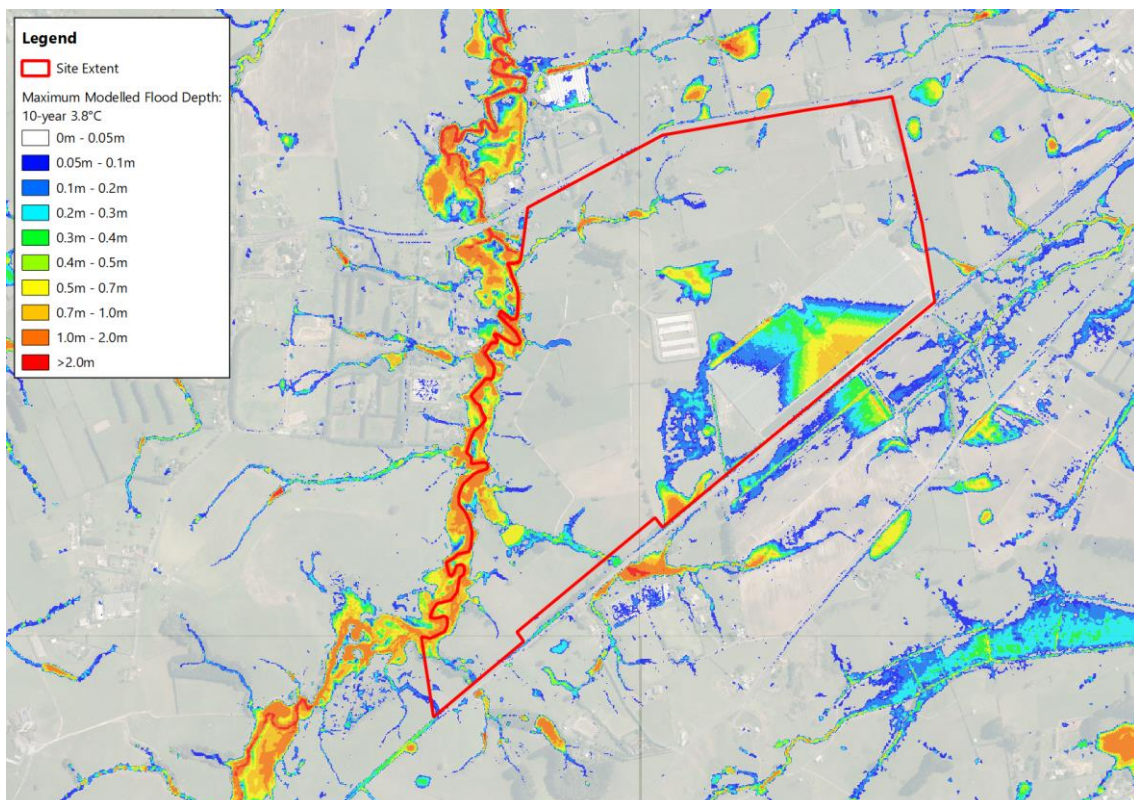


Figure 14: Scenario 1a - Maximum Modelled Flood Depth - Pre-development 10-year 3.8°C ARI (with ED for entire model extent)

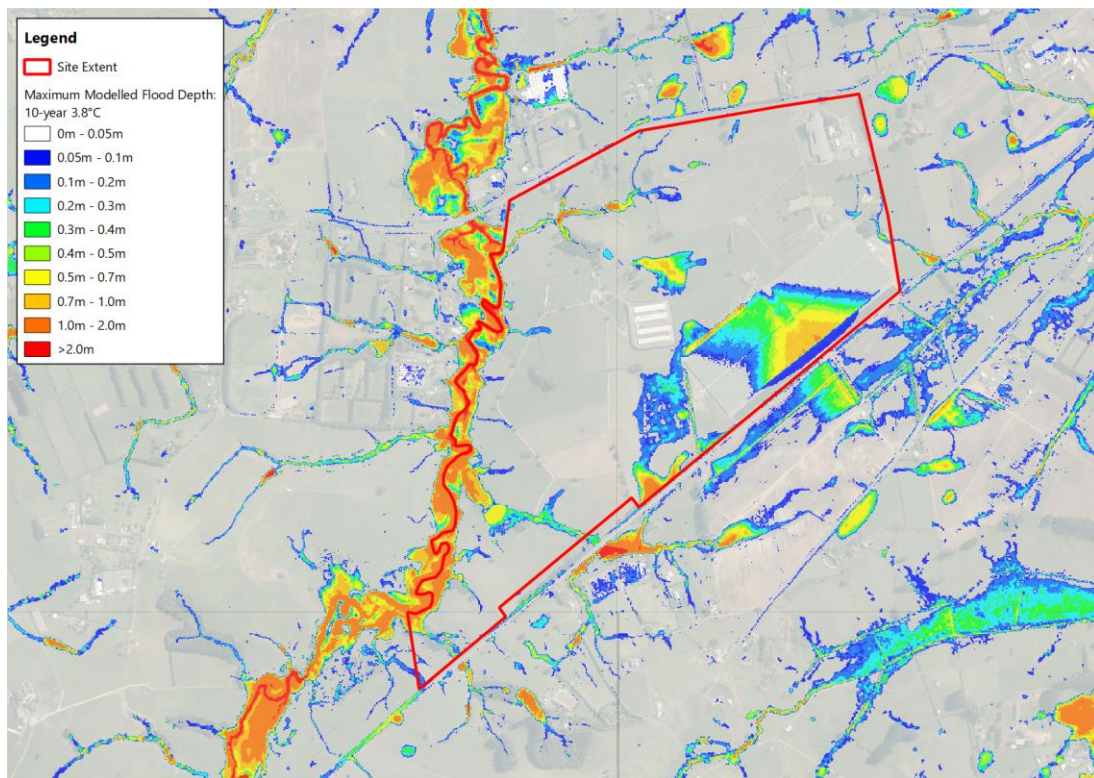


Figure 15: Scenario 1b - Maximum modelled flood depth - Pre-development 10-year 3.8°C ARI (with ED within PPC and MPD for all model extent)

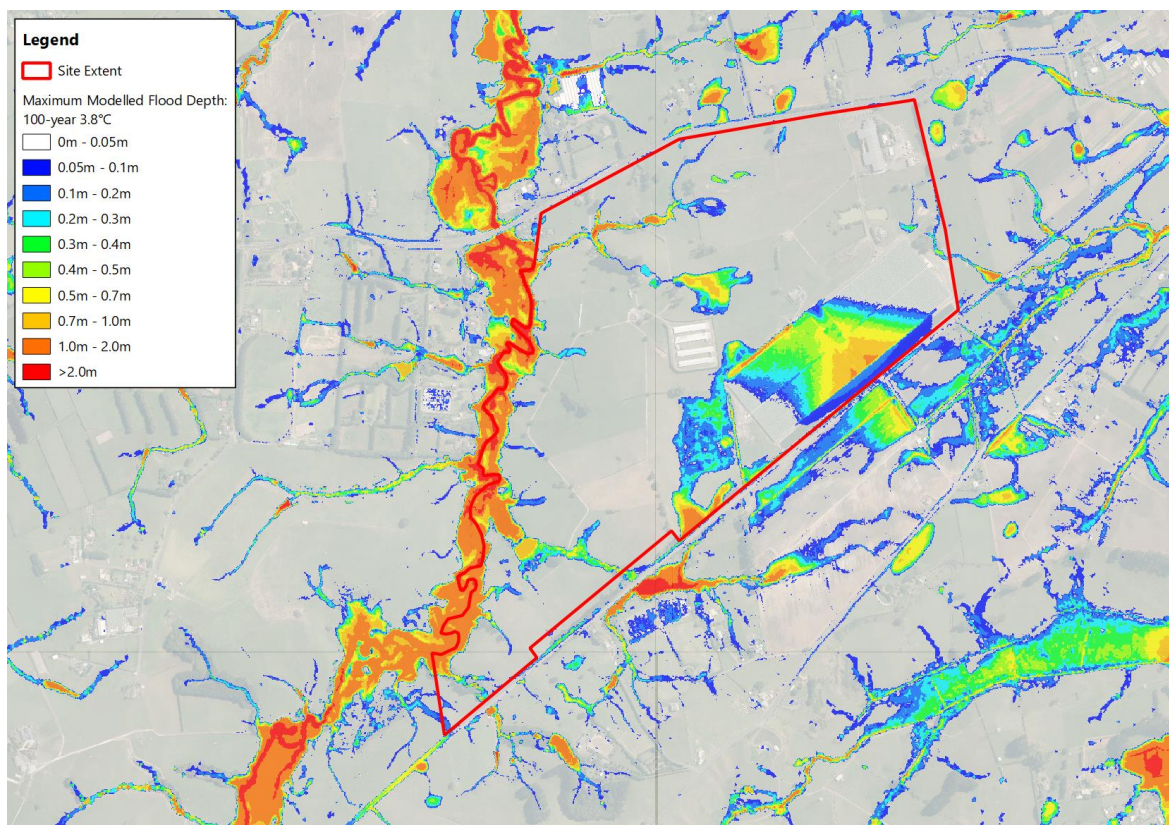


Figure 16: Scenario 1a - Maximum Modelled Flood Depth - Pre-development 100-year 3.8°C ARI (with ED for entire model extent)

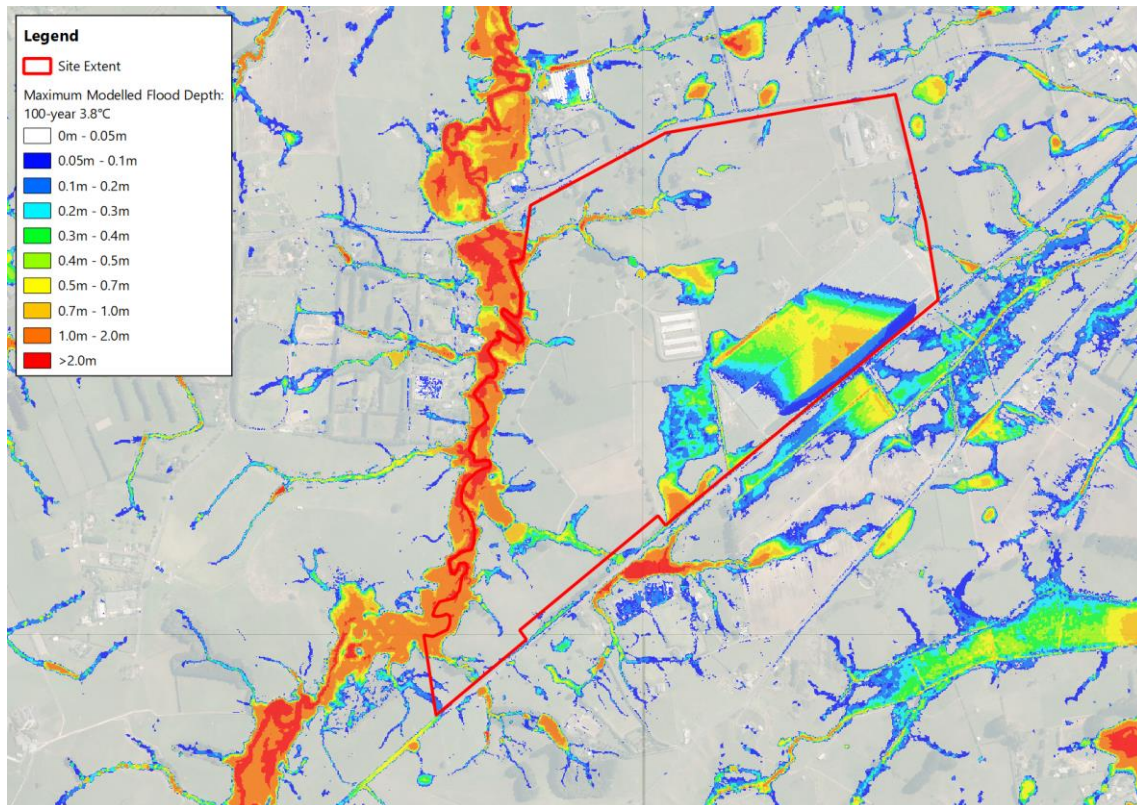


Figure 17: Scenario 1b - Maximum Modelled Flood Depth - Pre-development 100-year 3.8°C ARI (with ED within PPC and MPD for all model extent)

The following is concluded for simulated predevelopment model scenarios results:

- The flooding observed within the site, under ED conditions, is noted to be generally contained within natural streams/ riverine wetlands extents (identified in the ecological assessment by Biosearchers, refer to Section 2.5). The exception being around the southern portion of the site where flooding is observed around the existing building.

7.2.2. Post development (Scenario 2)

This model scenario builds on Scenario 1 with only changes in imperviousness with the proposed PPC area proposed. Figure 18 shows the afflux plot (water level differences) for post-development (Scenario 2) with the pre-development scenario (Scenario 1b) for 100-year ARI storm event (3.8°C climate change).



Figure 18: Afflux plot - Post development without flood mitigation (all areas MPD) minus Pre-development (PPC extent as ED and remaining model extent as MPD) (100-year 3.8°C)

The model results show that there are water level increases shown south of the PPC by the railway line and to the south-east in the tributary discharging to Ngākōroa Stream. The increases are due to the post-development model generating higher flows due to allowance for imperviousness uplift as per the PPC.

7.2.3. Post-development (Scenario 3)

This model scenario builds on Scenario 2 and allows for flows generated within the PPC area to be passed forward. Figure 19 shows the afflux plot (water level differences) for Post development with pass flows forward (Scenario 3) with the pre-development scenario (Scenario 1b) for 100-year ARI storm event (3.8°C climate change).

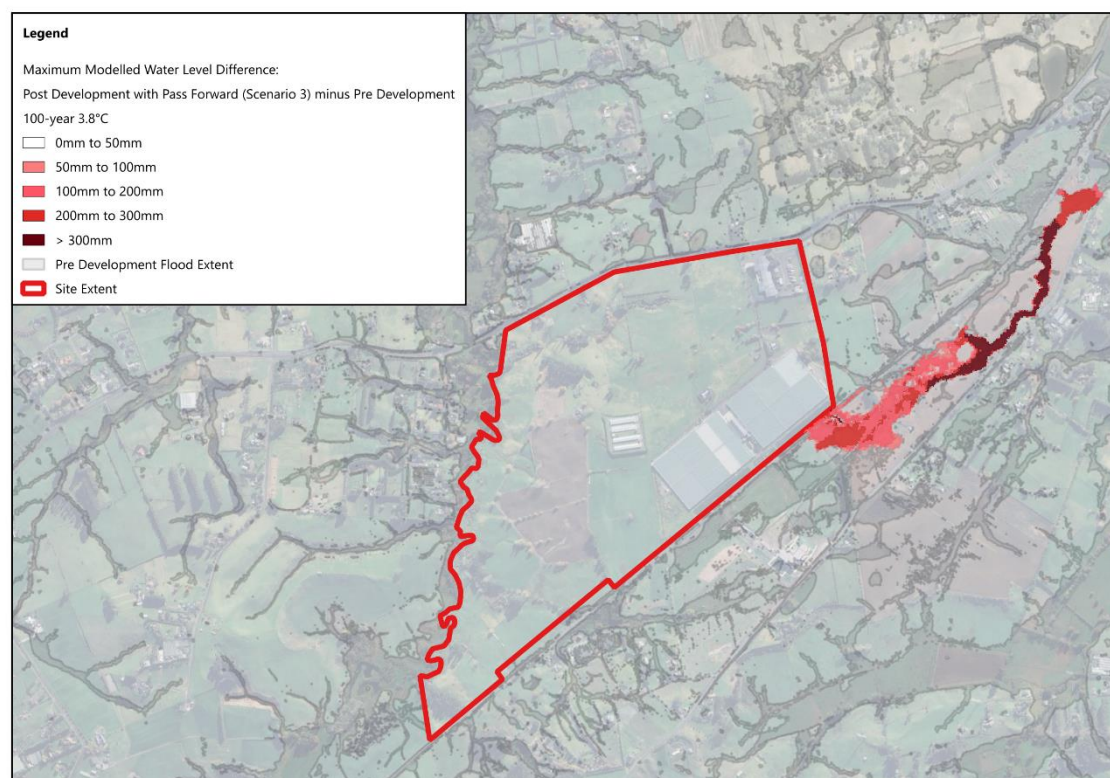


Figure 19: Afflux plot - Post development with pass forward (all areas MPD) minus Pre-development (PPC extent as ED and remaining model extent as MPD) (100-year 3.8°C)

The results indicate an increase in water levels downstream of the south-east side of the PPC, which is directly attributed to the flows being passed forward at this location with hydraulic structures limiting flows further downstream.

Figure 20 shows the afflux plot (water level differences) for Post development with pass flows forward (Scenario 3) with the Post development without mitigation (Scenario 2) for 100-year ARI storm event (3.8°C climate change).

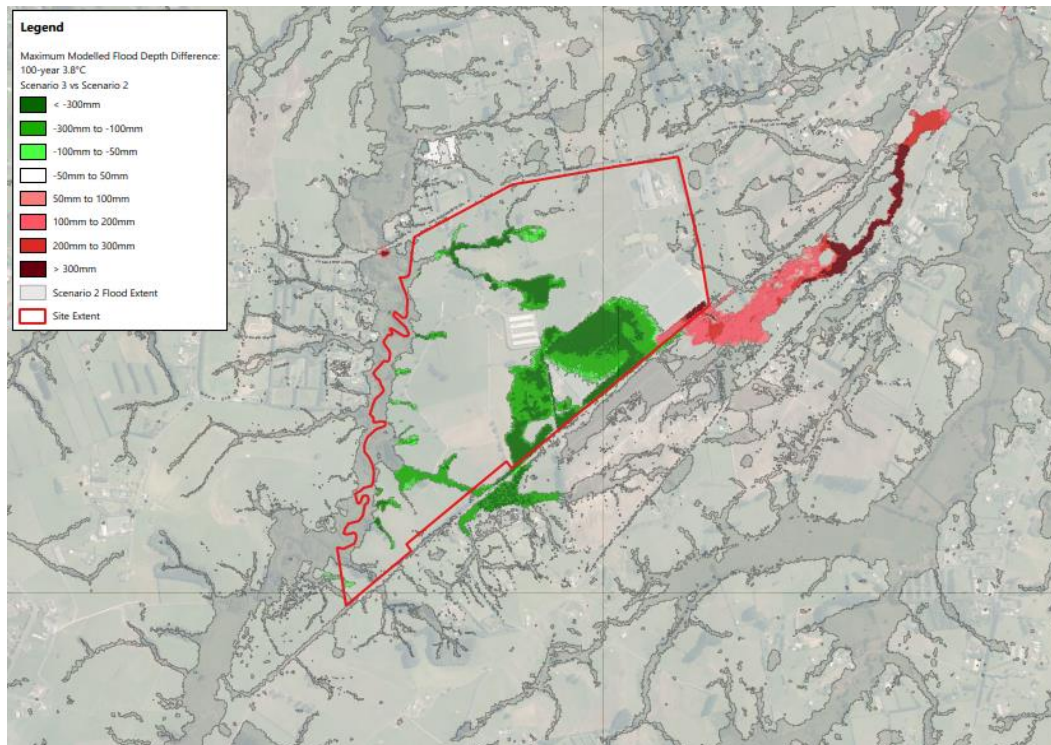


Figure 20: Afflux plot - Post development with pass forward (all areas MPD) minus Post development without flood mitigation (all areas MPD) (100-year 3.8°C)

The model results show a decrease in water levels downstream of the south-west side of the PPC, which is directly attributed to the flows being passed forward at this location.

The model results show a lesser increase in water levels downstream of the south-east side of the PPC, which is directly attributed to the flows being passed forward, and both scenarios allowed MPD cover within the PPC area.

Based on the model results, passing flows forward along with the diversion of site catchment area towards Oiroa Stream was considered.

7.2.5. Post development with flood mitigation – (Scenario 4a and 4b) model results

For the purposes of this report, the model results discussion only includes the water level difference plot (afflux plot) with the pre-development model scenarios (Scenario 1a and 1b). The afflux plot shows the change in flooding (if any) as a result of the PPC and the implemented flood management strategy.

Figure 18 – Figure 23 show the afflux plots (water level differences) for Scenario 4 with Scenario 1. While undertaking the assessment, comparisons were made for all the modelled scenarios as stated in Table 6, however for the purposes of the SMP, the figures and discussion has only been presented for storm events with allowance for 3.8°C climate change factor. It is noted that the findings of the comparisons is consistent between all storm events and any recommendations made in the SMP will be applicable for all the storm events.

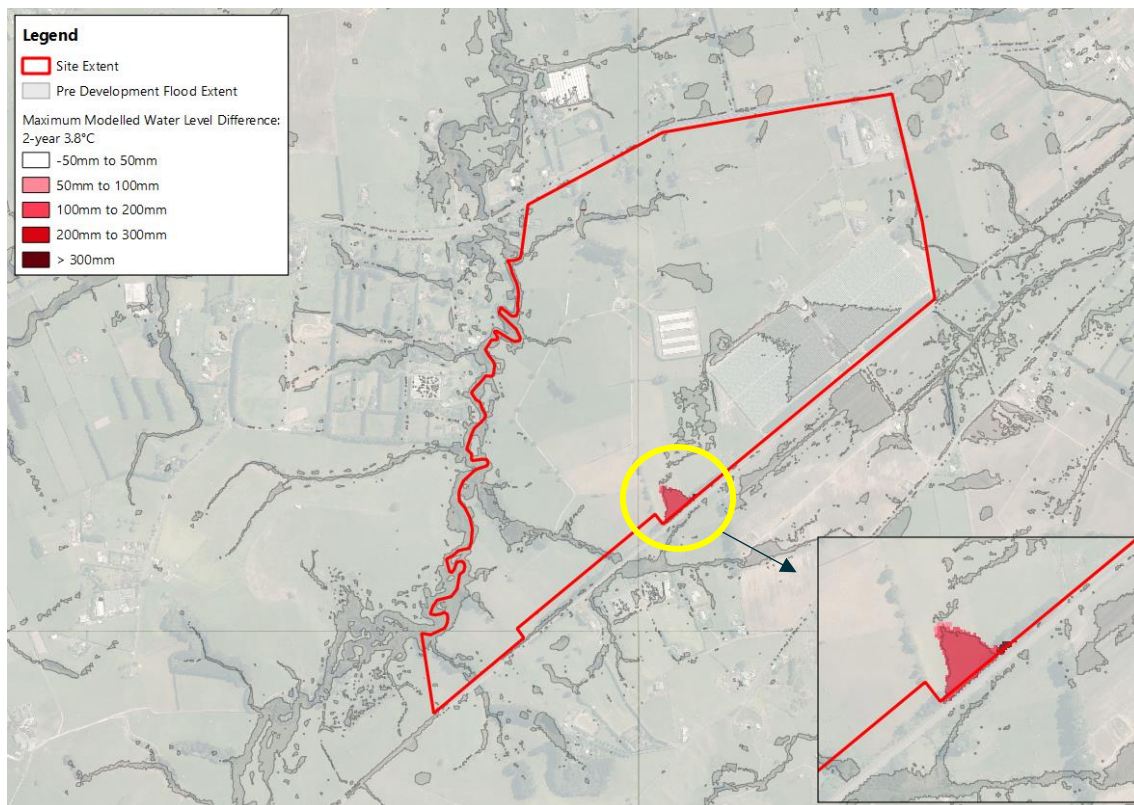


Figure 21: Afflux plot - Scenario 4a (PPC extent as MPD, remaining model extent as ED) minus Scenario 1a (all areas within model extent as ED) for 2-year 3.8°C

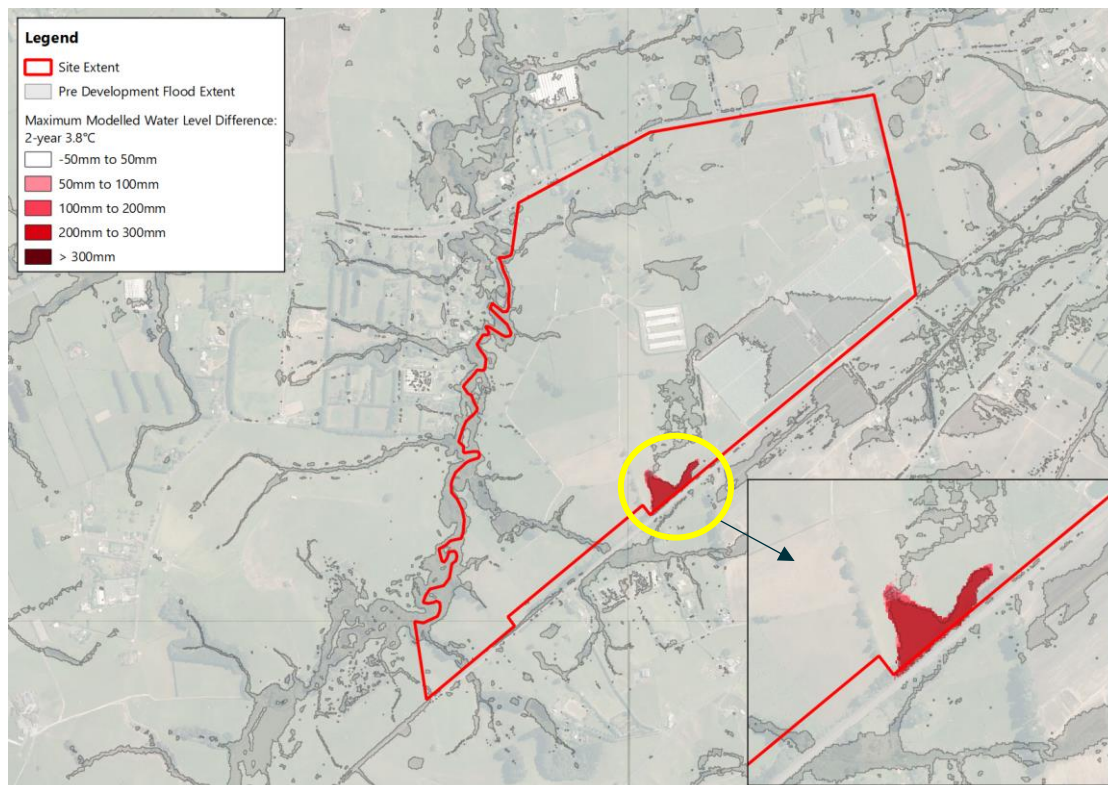


Figure 22: Afflux plot - Scenario 4b (all areas within model extent as MPD) minus Scenario 1b (PPC extent as ED and remaining model extent as MPD) for 2-year 3.8°C

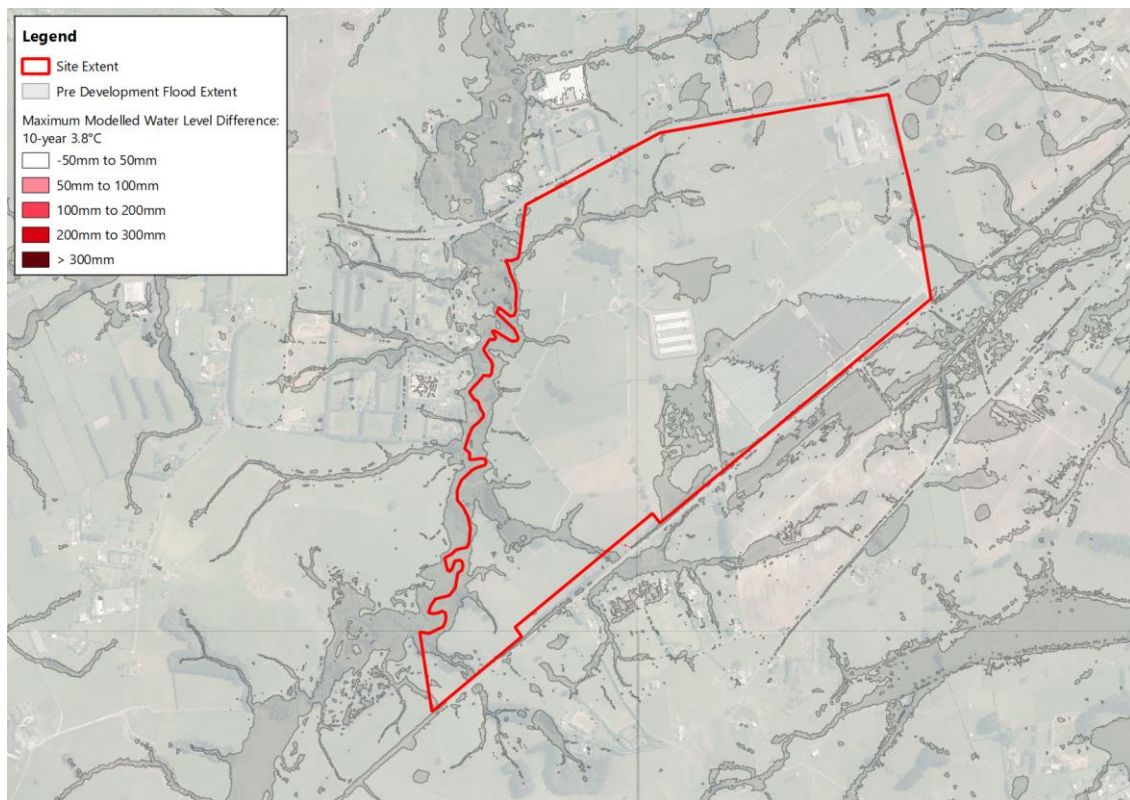


Figure 23: Afflux Plot - Scenario 4a (PPC extent as MPD, remaining model extent as ED) minus Scenario 1a (all areas within model extent as ED) for 10-year 3.8°C

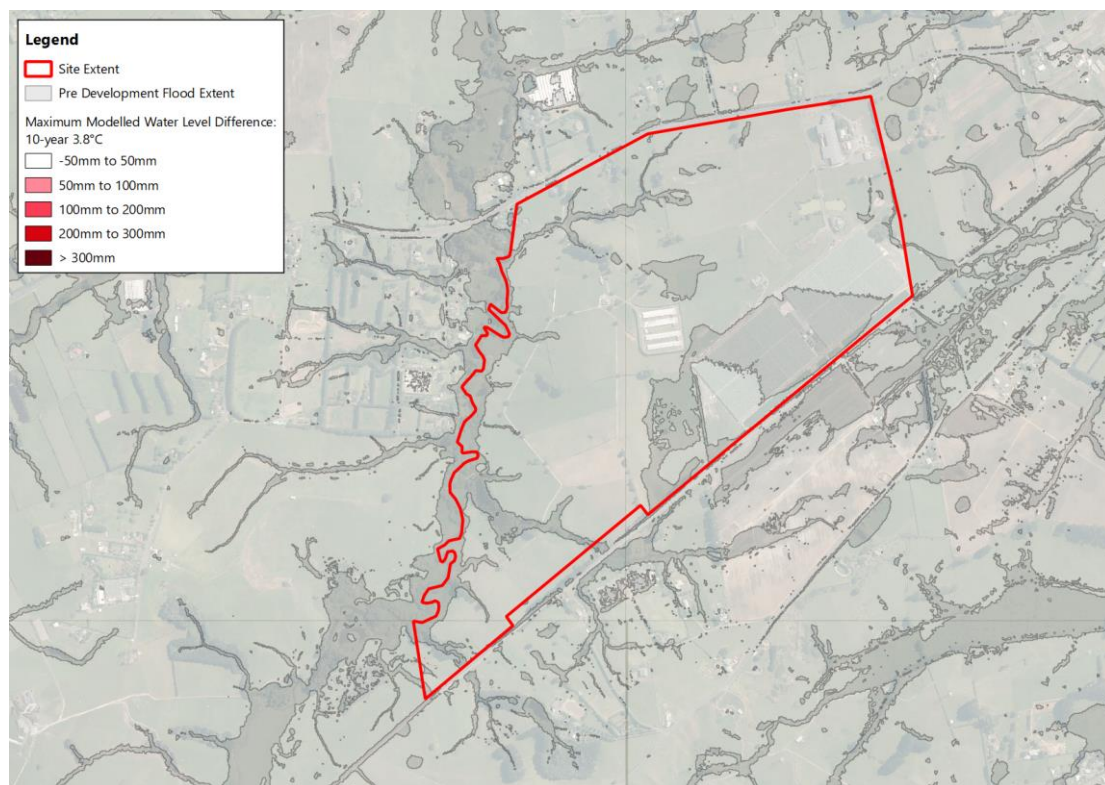


Figure 24: Afflux plot - Scenario 4b (all areas within model extent as MPD) minus Scenario 1b (PPC extent as ED and remaining model extent as MPD) for 10-year 3.8°C

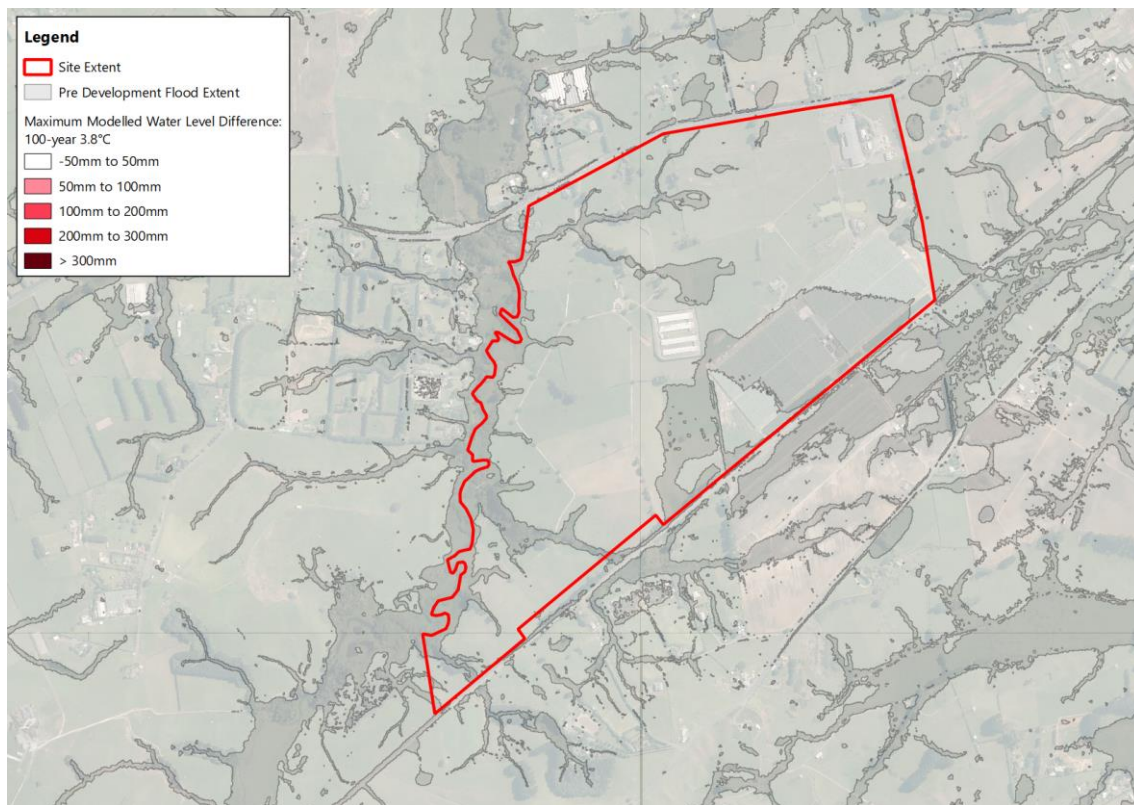


Figure 25: Afflux Plot - Scenario 4a (PPC extent as MPD, remaining model extent as ED) minus Scenario 1a (all areas within model extent as ED) for 100-year 3.8°C

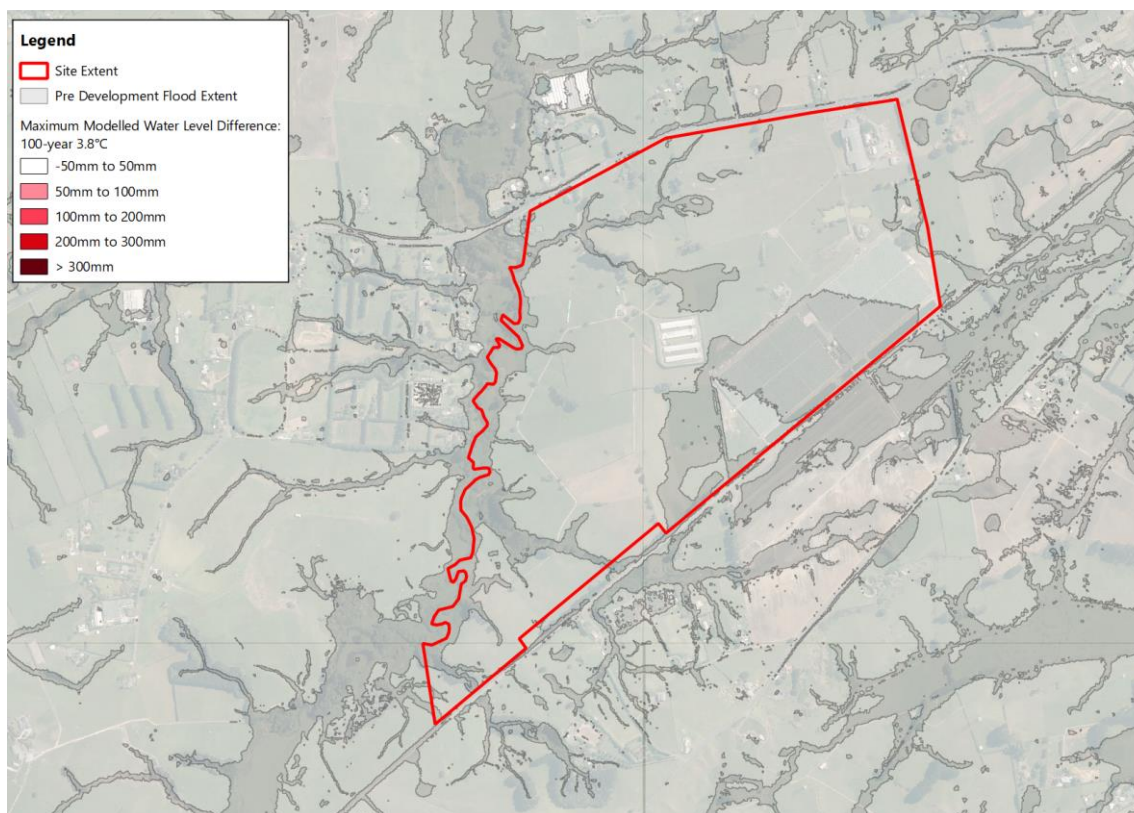


Figure 26: Afflux plot - Scenario 4b (all areas within model extent as MPD) minus Scenario 1b (PPC extent as ED and remaining model extent as MPD) for 100-year 3.8°C

The following can be determined from afflux plots:

2-year ARI (inclusive of 3.8°C climate change)

- There is a small locally depressed area towards the south of the PPC where flood increase is observed (highlighted in yellow – Figure 21 and 22).
 - When considering all areas as MPD, as highlighted in Figure 22, the maximum flood depth increase is approximately 215mm, with the pre-development flood depth approximately 1.2m around the area. Much of the increase is within the plan change area, however, a small section of the flood increase is observed on the channel present adjacent to the railway line.
 - This increase results from the greater discharge flowing into the existing topography. During the earthworks stage of the development, changes to the landform within the site will mitigate this increase. This will be addressed during the detail design stage.
 - Based on the above, the water level difference plots indicate no change in flood hazards upstream or downstream of the PPC area as a result of the plan change.

10-year ARI (inclusive of 3.8°C climate change)

- No increases in flooding are observed, upstream or downstream, as a result of the recommended flood management strategy i.e. Pass flows forward + diversion (Scenario 4b).

100-year ARI (inclusive of 3.8°C climate change)

- No increases in flooding are observed, upstream or downstream, as a result of the recommended flood management strategy i.e. Pass flows forward + diversion (Scenario 4b).

It is concluded that as the water levels and flood extents are generally similar between the post development and pre-development model scenario (Scenario 1b). Pass flows forward + diversion (Scenario 4b) is the recommended flood management strategy for the PPC.

7.3. Discussion on suitability of pass flows forward strategy for the PPC

Due to the location of the site within the downstream portion of the Drury West catchment, pass flows forward is the preferred flood strategy. The pass flows forward strategy discharges peak runoff from the site downstream, prior to the peak water level reaching in the Oiroa Stream, which occurs much later during a storm event. If flow attenuation is pursued, there is potential for the peak runoff from the site to coincide with peak water level in Oiroa Stream at the same time which may result in increase of water level downstream of PPC and further exacerbate flooding. For this reason, the pass flow forward strategy is preferred over attenuation.

It is noted that the pass flows forward strategy is the recommended for the downstream portion of the Drury West catchment by:

- Auckland Councils SMP for the Opāheke – Drury Structure Plan, which confirms pass flows forward is preferred for downstream portion of the catchment. Attenuation is recommended for the upstream portion of the catchment.
- The stormwater management plan prepared for the Waipupuke Private Plan Change (PC61), by Tonkin + Taylor, Revision E, dated 16/12/2020, also recommends the pass flows forward strategy for the Waipupuke site, which is located immediately downstream of the site. It is noted that PC61 has now been approved.
 - As per the 'Hearing Report' for PC61, dated 06/10/2021, under 'Section 9 – Assessment of Effects on the Environment, Stormwater', an independent peer review undertaken by Tektus, key point regarding the flood management strategy was:

"The general management approach for passing forward large storm event flows is considered appropriate. The peak flows generated as a result of development within the

Waipupuke Precinct will discharge to downstream receiving environments faster than upstream peak flows. Detention or attenuation of peak flows has the potential to worsen downstream flooding by synchronising the release of delayed discharges with the upstream peak flow"

- As discussed in Section 5 of the SMP, Healthy Waters supports the pass flows forward strategy due to the location of the site within the downstream portion of the Drury West catchment.

8. Stormwater management

This section discusses the proposed stormwater management approach for the PPC. The SMP is proposed to align with requirements stated under Schedule 4 of the NDC and FUZ SMP. Where it is not, this section demonstrates why the proposed option is the BPO for the development.

It should be noted that the stormwater management strategy mentioned below has been proposed to be consistent with the flood management strategy stated in Section 6 of this report.

8.1. Proposed stormwater management

The development area discharges to two catchments as discussed in Section 2.3 of this report. A summary of the proposed stormwater management for two areas is shown in Figure 24 with details provided in subsequent sections.

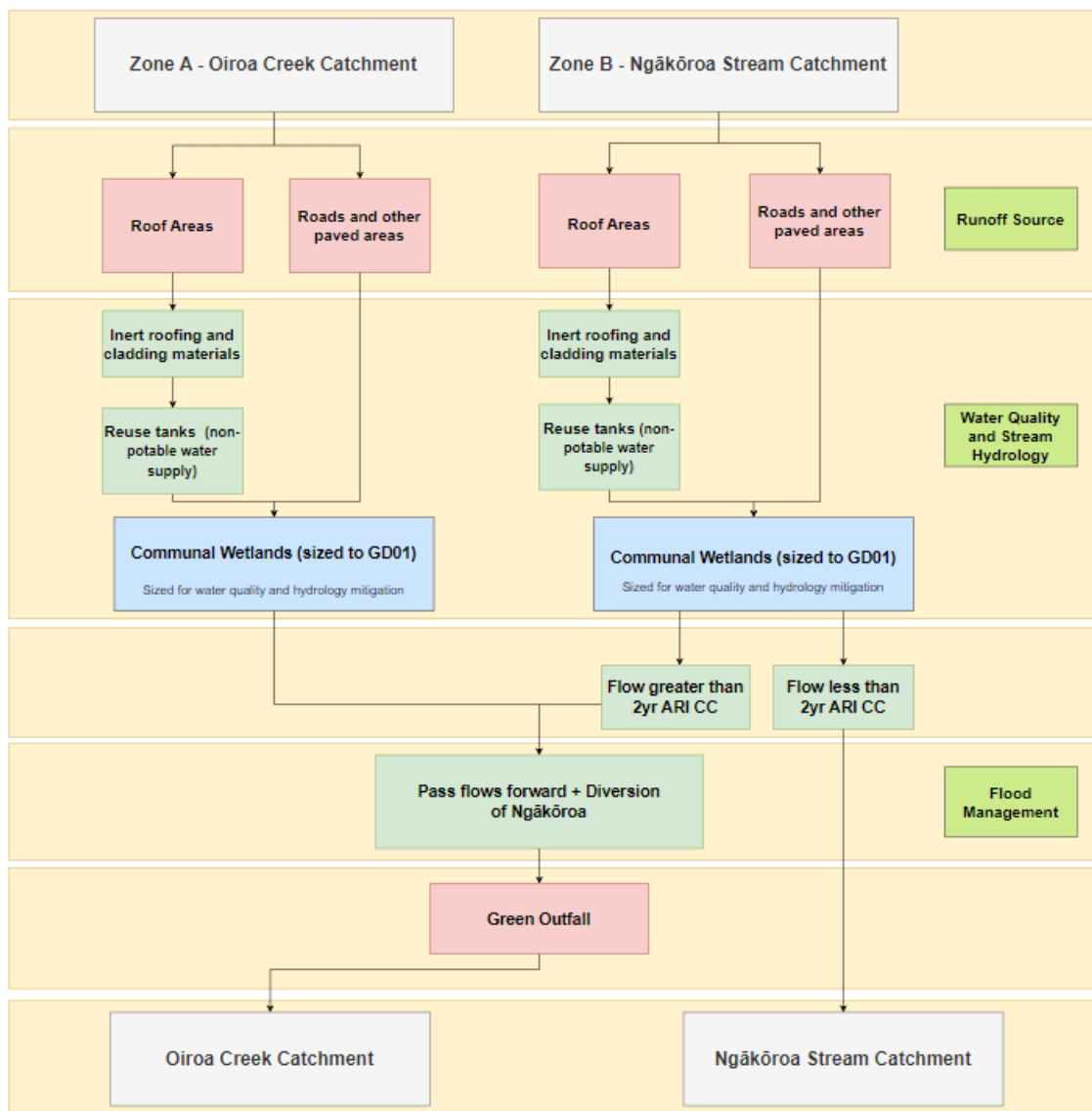


Figure 27: Summary of stormwater management

8.1.1. Water Quality

Schedule 4 of the NDC requires treatment of all impervious areas to be accomplished using a water quality device designed in accordance with GD01/TP 10 for the relevant contaminants.

Various devices were considered to provide water quality requirements. This included all the devices recommended in GD01 such as bioretention devices including wetlands, raingardens and swales. While assessing the suitability of devices, consideration has been given to freshwater values, integration with natural systems, lifecycle costing/maintenance and performance.

Based on this, wetlands are proposed for meeting water quality treatment requirements due to the following:

1. The site has an existing system of natural wetlands and streams (Figure 4). Providing wetlands on-site will allow for better integration with the overall existing freshwater systems. This also aligns with water sensitive design as it mimics natural systems.
2. Wetlands are more cost effective to maintain in long term as opposed to use of smaller fragmented bio-retention devices which rely on filtration media that needs replacement. Wetlands have longer term maintenance cycles.

All the proposed constructed wetlands will receive pre-treated runoff from either a forebay or a proprietary device (GPT) for pre-treatment. This is to be finalised in the later detailed design stages.

8.1.2. Proposed water quality management for impervious areas

8.1.2.1. Roads and paved areas

- It is proposed that all the paved areas and roads forming part of the PPC will be treated via large communal wetlands, in accordance with the GD01 design standards.
- All the paved areas and roads will be connected to a stormwater network from where the flows will be conveyed to the proposed large communal wetlands.
- Prior to discharge to the wetlands, the runoff will be treated via a forebay or a proprietary device for pre-treatment.

8.1.2.2. Roofs

- Use of non-contaminant generating inert material is proposed for roofs and cladding.
- Re use tanks which is considered to be BPO for meeting treatment of roofed areas.
- If reuse demands are not met, it is noted the roofed areas also discharge to the communal wetlands which provides treatment, in accordance with GD01 design standards.

The FUZ SMP also recommends the use of green outfalls when discharging to streams to help mitigate thermal pollution and erosion. The use of green outfall structures is proposed to be adopted for this SMP.

8.2. Stream Hydrology

The PPC site discharges to a stream environment. Therefore, as per the NDC, stream hydrology requirements need to be provided for the 95th percentile storm event.

Stream hydrology is proposed to be implemented throughout the PPC area. This is to mitigate any increased stormwater runoff volume associated with the development of new impervious surfaces for storm events up to and including the 95th percentile storm event.

The design parameters for each hydrological mitigation objective are provided in Table 7 below.

Table 7: Hydrology mitigation

	Rainfall Depth (mm)
Retention	5.0
Detention	19.4
95 th Percentile (Total)	24.4

8.2.1. Detention

Detention will be provided by storage of the calculated detention volume in a storage device with provision for an appropriately sized orifice which releases the collected detention volume for more than 24 hours.

Detention on site for all areas will be achieved via the following method:

- Use of large communal wetlands for all the impervious areas.
- Where it is not possible for an area to drain to a communal wetland, at source detention is to be provided.

8.2.2. Retention

It is proposed that retention of at least 5mm of rainfall depth will be provided for the PPC area. Retention requirements can be achieved through multiple ways. Table E10.6.3.1.1, item (2) of the AUP stipulates a hierarchy of the methods to achieve retention, these are noted below:

- Re-use – Rainwater re-use can be provided for purposes such as non-potable water supply, garden/crop irrigation or toilet flushing. Re-use might not be appropriate if untreated runoff is collected from paved areas. Re-use is noted to be the preferred method for meeting retention requirements.
- Infiltration – Retention via infiltration will depend on whether the soil infiltration rate is more than 2mm/hour. A Geotechnical Engineer will be consulted for this during the detail design stages. Retention requirement can be achieved via infiltration using:
 - Bio-retention devices such as large communal wetlands.
- If none of the above can be achieved on site, retention can be taken up by the detention volume to be provided via the communal wetlands.

8.2.3. Proposed hydrology mitigation for all areas

8.2.3.1. Roofs

- Detention to be provided via communal wetlands
- Retention or re-use will be proposed for roofs via underground or above ground tanks. This volume of water will be used for all non-potable uses.
- If reuse demands are not met, it is noted the roofed areas also discharge to the communal wetlands which provides hydrology mitigation.

8.2.3.2. Paved areas and roads

- Full detention will be applied to the runoff discharging from paved areas and roads via communal wetlands.

8.2.4. Stream Erosion

As requested by Healthy Waters, a stream erosion assessment has been undertaken by Woods for Oiroa Creek, focusing on the stream reach adjacent to the PPC area. A memorandum containing details around the methodology and results is included in Appendix E, with a summary provided below.

The stream erosion assessment has been considered for the following scenarios:

- Scenario 1a – Existing development
- Scenario 4a – Existing development for all areas outside the PPC extent and MPD within the PPC extent

The analysis has been undertaken using Auckland Council's Erosion Screening Tool. Several cross sections have been analysed across Oiroa Creek around the PPC area, including immediately adjacent to where the site is discharging to. The results of Scenario 1a indicates that there is already active erosion within Oiroa Creek, around PPC area. These areas appear to be similar to information that has already been provided by Healthy Waters i.e., the watercourse assessment. There are locations identified which are actively eroding, particularly, cross-section 1 and the hotspots identified in GCD analysis which may be more sensitive to flow increase.

The increase in flows, and susceptibility to erosion, as a result of change in land use associated with the PPC, Scenario 4a, is minimal and therefore mitigation currently proposed in terms of SMAF is considered appropriate.

8.2.5. Addendum

Following the submission of the stream erosion assessment, a follow-up meeting was held with Healthy Waters where further information was requested, including the addition of a toolbox. It is important to note that the proposed plan change is not exacerbating the erosional effects in Oiroa Creek.

A detailed stream erosion assessment will be required to be undertaken for any application for land modification, subdivision or development within 100m of the Oiroa awa (Creek) at the resource consent stage, including the identification and provision of any appropriate mitigation measures, if required (Refer to Special Information Requirement IX.9(7)). While the methodology for the detailed assessment has not been devised, it is expected that it will make use of suitable methods to evaluate stream erosion and further complement it with visual and geomorphic assessments.

Refer to the memo in Appendix E for further information.

8.3. Wetland sizing

As discussed in the sections above, the water quality treatment and hydrology mitigation requirements for the PPC are proposed to be met via communal wetlands. It is noted that the wetlands have been sized to accommodate all of the development area, in accordance with GD01.

It is to be noted that multiple natural streams and wetlands have been identified on-site. Post-development sub-catchments have been delineated indicatively based on the location of existing natural wetlands. The natural stream and wetland features will be retained, and the proposed wetlands will be positioned to support the functionality of the existing natural wetlands. It is noted this assessment is s indicative only and subject to change based on the masterplan and proposed development.

A high-level wetland sizing has been undertaken in accordance with GD01 guidelines. The key assumptions for the wetland design are summarised in Table 8 with the associated catchment area, water quality volume, permanent water volume, detention volume and indicative size of each wetland summarised in Table 10. The supporting calculations are included in Appendix F.

An indicative layout of the wetlands is shown in Figure 25. As mentioned above, this is indicative and is subject to change based on comprehensive master planning and the proposed development of the site. It is noted that all the volume requirements stated in Table 10 will be met.

The post-development sub-catchments and associated wetland sizing are to be further refined during the resource consent and detailed design.

Table 8: Design assumption

	Assumptions
--	-------------

Rainfall Depth (90th Percentile)	25.0mm
Rainfall Depth (95th Percentile)	33.0mm
Average wetland depth	2.5m
Average permanent water depth	1.0m
Live storage depth	1.0m
Length-to-width ratio	1V:3H
Internal wetland slope – below Permanent Water Level (PWL)	1V:4H
Safety bench	3.0m 1V:10H
Internal wetland slope – above PWL	1V:3H

Table 9: Wetland Design Parameters

Catchment ID	Contributing Catchment Area (ha)	Required Water Quality Volume (m^3)	Required Permanent Water Volume (m^3) ^{1*}	Total Required Hydrology Mitigation Volume (m^3) ^{2*}	Indicative Device Size Area (ha)
1	5.4	894	447	1054	0.26
2	2.8	471	235	555	0.17
3	5.5	913	456	1076	0.26
4	36.8	6100	3050	7187	1.41
5	13.3	2204	1102	2596	0.57
6	12.4	2061	1030	2428	0.54
7	6.1	1015	508	1196	0.29
8	11.2	1858	929	2189	0.49
9	7.3	1213	607	1429	0.34
10	2.8	470	235	554	0.17
11	1.4	224	112	264	0.12

1* - The required permanent water volume is half the required water quality volume as additional hydrology mitigation volume is provided in the wetlands. This is as per GD01.

2* - The total required hydrology mitigation volume includes the required retention and detention volume. It is however noted all the required hydrology mitigation volume will be provided as detention.

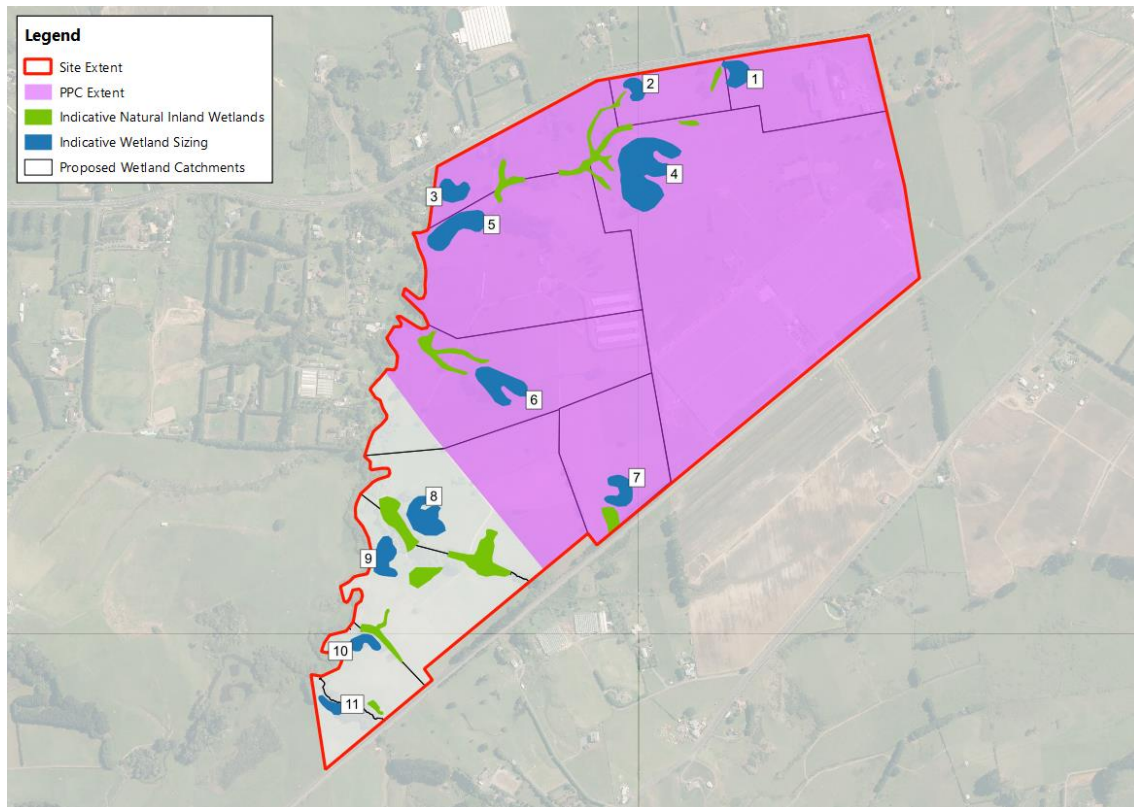


Figure 28: Indicative locations of wetlands - Structure Plan area

8.4. Flooding 10 percent AEP event

With regards to downstream network capacity, as per the flood modelling undertaken, the existing dual culverts located under Karaka Road (Culvert X) has sufficient capacity to convey post-development flow from upstream MPD catchment for 10-year 3.8°C ARI storm event.

There is currently no piped stormwater network within the site. The proposed stormwater network will be designed to accommodate a 10-year ARI storm event, in accordance with the current Auckland Council Stormwater Code of Practice V3, Jan 2022.

8.5. Flooding 1 percent AEP event (Habitable floors)

Flood and habitable floors are to be developed with adequate freeboards to be provided in accordance with the current Auckland Council Stormwater Code of Practice V3, Jan 2022, and the Building Code.

8.6. Overland flow path and floodplain management

Secondary flow events greater than a 10-year ARI storm event and up to a 100-year ARI storm will be conveyed along road corridor, conveyance channels and green spaces as overland flow paths. Overland flow path alignments will be dependent on the overall built environment and should maintain existing discharge locations where possible.

The proposed overland flow path management will meet the following design criteria:

- Overland flow paths will be designed with sufficient capacity to accommodate the 100-year ARI storm event for the MPD, inclusive of 3.8°C climate change, for resilience purposes.
- They will be unobstructed, with capacity to safely convey runoff through the development.
- Over land flows will follow either road reserves or dedicated green areas. All flow paths are proposed to be located within the site and not over private properties without easement or other approval by Auckland Council.

8.7. Hydraulic connectivity

The primary stormwater runoff is to be conveyed through the stormwater network. The conveyance of secondary stormwater runoff is proposed through road corridors and conveyance channels.

8.8. Asset ownership

As the PPC is within privately owned land, all the assets proposed within the development extent are to be in private ownership.

8.9. Ongoing maintenance requirements

Maintenance requirements are to be addressed at Resource Consent.

Maintenance and operation manuals for the proposed stormwater management devices are to be provided to Auckland Council for approval as part of the future resource consent applications. As all the devices proposed with the PPC are proposed to be privately owned, maintenance for private treatment devices and other proposed infrastructure such as pipes, manholes and other management devices will be the sole responsibility of the owner.

This PPC does not propose any new assets that will need to be publicly vested in the future. It is expected existing publicly owned assets will be maintained by the respective agencies currently holding the ownership.

8.10. Implementation of stormwater network and devices

Stormwater devices and the network will remain in private ownership with the intended user of this SMP being F&P.

The implementation of the stormwater network, stormwater management devices (wetlands, re-use tanks etc.) and the diversion proposed for food mitigation are to be addressed at appropriate consenting stages. Once adequate details on the proposed development are available, a staging assessment is recommended to be undertaken at consenting stages that will identify the triggers for the various stormwater measures. This will address the stormwater and flood effects of the Plan Change area and ensure the stormwater strategy is implemented appropriately.

It is expected that downstream stormwater infrastructure will be in place prior to connection of any impervious/ hard stand areas.

9. Departures from regulatory or design codes

The stormwater management approach proposed for the PPC satisfies the regulatory and design codes standards in the NDC and AUP chapter E8.

10. Conclusion

Fisher & Paykel Healthcare Properties Ltd (F&P) has engaged Woods to prepare a Stormwater Management Plan (SMP) for a Structure Plan and subsequent Private Plan Change (PPC) application for a site located at 300, 328, 350, 370 and 458 Karaka Road. The site is located within the Drury-Opāheke Future Urban Zone and Rural – Mixed Rural zone, as identified under the Auckland Unitary Plan: Operative in Part (AUP). It is proposed to be rezoned for Business - Light Industrial use.

The development is classified as a 'greenfield' development under Schedule 4 of Auckland Council's Regionwide Network Discharge Consent (NDC) and therefore requires a stormwater management plan to comply with NDC requirements. There is noted to be a wider Drury-Opāheke Structure Plan Future Urban Zone Draft Stormwater Management Plan (FUZ SMP) by Mott Macdonald dated 12 April 2019 rev. 04C, which provides a high-level requirement for any development proposed in the Drury-Opāheke Structure Plan area.

The SMP's primary purpose is to guide Auckland Council on stormwater management in the Drury-Opāheke Structure Plan area and direct future developers regarding stormwater management provisions. It addresses Schedule 4 of the Network Discharge Consent and aims to meet several objectives, including water-sensitive design, stream network retention, stormwater management standards, water quality treatment, and flood risk assessment.

As per Auckland Council's GeoMaps, the site is within an existing floodplain and therefore flood modelling was conducted for no climate change, 2.1° and 3.8°C future climate change scenarios for 2-, 10-, and 100-year ARI storm events. Model comparisons between Post Development and Predevelopment scenarios were also conducted to determine the potential flood effects arising from the PPC (if any) and assess a suitable flood mitigation option.

The flood modelling work undertaken demonstrates that Post development with flood mitigation – pass forward + diversion (Scenario 4) was the preferred flood management option and is recommended for the PPC. This option enables flows to be passed forward in tandem with diversion of site area to Oiroa Stream. The resulting water level and flooding extent from this flood management option is generally consistent with the existing flooding conditions. The water level difference plots indicate no change in flood hazards upstream or downstream of the PPC area as a result of the plan change.

The recommended flood management strategy for the PPC area aligns with the general flood management of FUZ SMP for Drury West area which recommends passing flows forward for the downstream areas of the catchment. Additionally, the Waipupuke Private Plan Change or PC61 (now accepted), located directly downstream to the site have adopted the pass flows forward strategy. Furthermore, Healthy Waters have also supported the flood management strategy proposed for the PPC area.

The PPC is considered as a 'greenfield' site, and therefore the following has been proposed to meet the stormwater management objectives of a Greenfields site as per the NDC:

- The SMP proposes the water quality treatment for all the impervious area in the PPC area.
 - Wetlands will provide water quality treatment for all the roads and paved impervious areas. Wetlands have been selected as BPO due to their integrability with existing natural wetlands, ease of maintenance, and more effective whole of life costing. It is noted that additional measures such as provision of pre-treatment via a forebay or a proprietary device will also be provided.
 - The SMP proposes use of inert building and roofing material to avoid generation of high contaminants from buildings.
 - The SMP also proposes use of green outfalls.
- As the PPC discharges to a stream, SMAF-1 level stream hydrology mitigation is to be provided for the entire site. The stream hydrology strategy includes provision of retention of 5mm of rainfall depth and detention by storing and slowly releasing the collected water over more than 24-hours.
 - Wetlands have been proposed to collect and release the detention volume over more than 24-hours for all the impervious areas.

-
- To meet the retention requirements, re-use is proposed for roof runoff while for other areas, full detention will be applied and provided via wetlands.
 - A stream erosion assessment has been undertaken using Auckland Council's Erosion Screening Tool. The results have indicated that the effects of land use as a result of the Plan Change are minimal. It is noted a detailed assessment A detailed assessment maybe required once there is further detail available around the pipe network and discharge locations discharge locations (i.e., outlets) to determine further impacts.
 - Conveyance of primary and secondary flows will be proposed as per the guidelines stated in Auckland Council's Stormwater Code of Practice, Ver 3, Jan 2022.

In summary, the objectives of the AUP and Schedule 4 of the NDC are satisfied by the stormwater approach described within this SMP, and any adverse effects related to stormwater and flooding will be avoided, remedied, and mitigated. The measures proposed in the SMP provides an overall positive impact to the environment and enhances stream health and downstream water quality.

Overall, there are no significant impediments with respect to stormwater.

APPENDICES

APPENDIX A – FLOOD MODEL BUILD



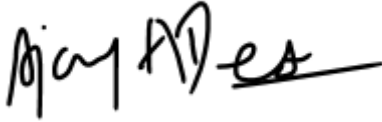
Stormwater Model Build

Karaka Road Plan Change

300-458 Karaka Road
Fisher & Paykel Healthcare Properties Ltd

Final

Document Control

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1. Introduction

Fisher & Paykel Healthcare Properties Ltd (F&P) has engaged Woods to prepare a Stormwater Management Plan (SMP) to support a Structure Plan and subsequent Private Plan Change (PPC) application for a site located at 300-458 Karaka Road. The site is located within the Drury-Opāheke Future Urban Zone and Rural – Mixed as identified under the Auckland Unitary Plan: Operative in Part (AUP). It is proposed to be rezoned for light industrial use.

Auckland Council GeoMaps shows that approximately 23% of the site is covered by published floodplains. This flooding information is based on a rain on grid Rapid Flood Hazard Assessment (RFHA) undertaken by Stantec in 2021. Upon request from Healthy Waters (HWs), Woods received the Ngākōroa catchment model (July 2019) RFHA model.

This flood modelling undertaken has been used to assess the flood effects as a result of the proposed PPC (if any) and flood mitigation options to avoid or minimise/mitigate any change in the existing flooding conditions.

This flood model build memorandum has been prepared to provide all the updates made to the Ngākōroa catchment model (July 2019) RFHA model. The memo also details the model scenarios undertaken and key assumptions. The hydrological and hydraulic parameters undertaken for the flood modelling (discussed in this report) are in line with the information provided in:

- Oiroa Creek and Ngākōroa Stream RFHA model build report, from Stantec (commissioned by Auckland Council), rev no. 3 dated October 2017.
- Oiroa-Ngākōroa RFHA Spatial Rainfall Zones Modelling, from AECOM, dated 15/07/2019.
- Oiroa-Ngākōroa Creek RFHA model updates memo, from AECOM, dated 26/09/2019.

2. Background

The site is located at 300-458 Karaka Road which is within the lower Drury West stormwater management area as per the FUZ SMP, comprising a total area of approximately 102ha. It is bounded by Karaka Road to the north, the North Island Main Trunk Railway Line to the south and Oiroa Creek to the west.

The site is located within a predominantly rural area which currently has several buildings including 2 large greenhouses and 4 smaller greenhouses. There are also several ponds and watercourses throughout the site. The current impervious coverage of the site is estimated at 15% from the impervious layer of Auckland Council's GeoMaps.

Figure 1 shows the site location.

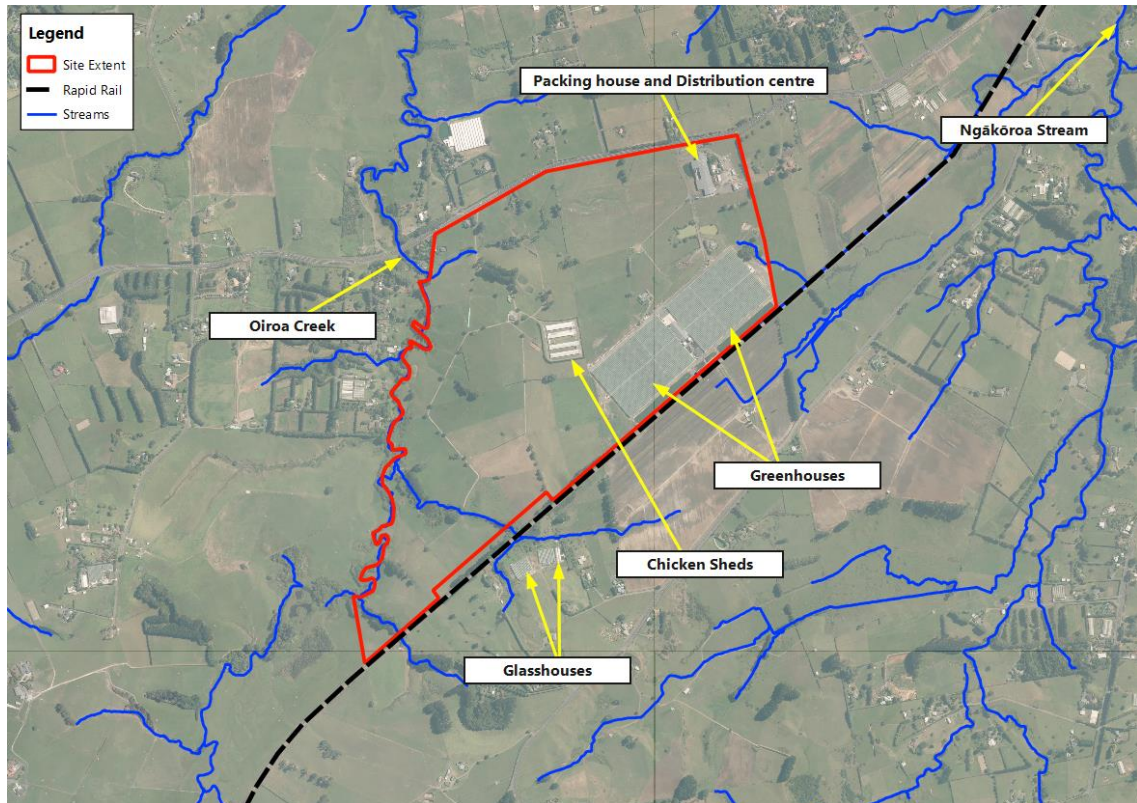


Figure 1. Site location

3. Model Parameters Overview

Upon request from Healthy Waters, Woods received the following flood model:

- Oira Creek and Ngakoroa Stream RFHA 1D-2D coupled catchment model (July 2019) which uses a rain-on-grid approach. The model uses a maximum probable development (MPD) impervious coverage and has been built using InfoWorks ICM modelling package.

To develop the base models, the model received was updated to InfoWorks ICM v2021.7.1, extended to include the stormwater network around the project site extent, and included further updates. Table 1 provides a summary of the changes undertaken to generate the base pre- and post- development models.

Table 1. Summary of model changes

Item	Information	Model scenario specific changes
Hydrology Updates		
Subcatchments	There are 17 subcatchments in the model. Subcatchments have only been included to represent areas within the development extent. Areas outside the development extent utilise Rain-on-grid methodology.	Pre-development scenarios 17 subcatchments delineated within the development extent. Subcatchments delineated based on existing contours and OLFPs (as per AC GeoMaps). Post development scenarios: 17 subcatchments delineated within the proposed development extent. Subcatchments delineated based on proposed flood mitigation option (discussed in the later sections of this memo).
Rain-on-grid (variable rainfall zones)	The areas outside the development extent utilise rain-on-grid with spatially varying rainfall zones.	Pre- and post-development scenarios Rain-on-grid approach used for areas outside the development extent is consistent between Pre- and Post development scenarios.
Rainfall	The model scenarios have been simulated for 24-hour existing rainfall as per TP108 guidelines. Additionally, the model scenarios have been simulated for no climate change, 2.1°C and 3.8°C future climate change.	Pre- and post-development scenarios All pre- and post-development model (preferred option) scenarios have been simulated for 2, 10- and 100-year ARI with existing rainfall (no climate change) and future rainfall (inclusive of 2.1°C and 3.8°C climate change).
Imperviousness	Imperviousness has been included based on the model scenarios. Existing impervious coverage has been calculated based on the impervious layer shown on AC GeoMaps. Maximum Probable Development (MPD) impervious coverage is based on AUP zoning. For Plan Change, a constant 80% imperviousness has been assumed which is considered conservative.	Pre-development and post development scenario As per the purpose of the model scenario

Item	Information	Model scenario specific changes
Hydrological parameters	The subcatchments (representing development area) have been modelled with hydrological parameters as per TP108 document. Hydrology for the rainfall zones remain consistent with Oiroa Creek and Ngākōroa Stream modelling documentation mentioned in Section 1 of this report.	Pre- and post-development scenario No changes.
Topography		
Topography	The RFHA model received by Woods from Healthy Waters uses LiDAR 2013 DEM. This was updated to LiDAR 2016.	Pre- and post-development scenario No changes.
Roughness		
Roughness and surface	Roughness modelled as per Oiroa Creek and Ngākōroa Stream modelling documentation mentioned in Section 1 of this memorandum.	Pre-development scenarios: Roughness modelled for building footprints and road layers with a Manning's (n) of 1 and 0.05, respectively as per the values adopted in the Healthy Waters RFHA Oira Creek and Ngakaroa model build report. Post development scenarios: At this stage, there is no proposed design available and therefore roughness is unchanged from pre-development model.
Boundary Conditions		
Water Levels	Three time-series Inflow boundary conditions included. A constant MHWS level of 3.3m RL included as downstream boundary condition.	Pre- and post-development scenario No changes.

4. Hydrological Model

4.1. Modelled Catchment Parameters

Majority of the flood model uses spatially varying rainfall zones except for the area within the development extent. Area within the development site have been represented with 17 sub-catchments. The modelled subcatchments have been delineated using the LiDAR 2016 topographical information.

The subcatchments have been modelled following the guidelines outlined in the ARC Technical Publication No. 108 document (TP108). The key assumptions are listed below:

- A standard 24-hour temporal rainfall pattern, having peak rainfall intensity at mid-duration. Shorter duration rainfall bursts with a range of durations from 10 minutes to 24 hours are nested within the 24-hour temporal pattern. Climate change has been estimated in accordance with the guideline provided by Auckland Council's Stormwater Code of Practice v3 for 2.1°C future climate change. Additionally, rainfall profiles were created for future climate change of 3.8°C.
- Runoff depth calculated using SCS (Soil Conservation Services) rainfall-runoff curves, with curve numbers determined from the soil classification mentioned in TP108.
- The time of concentration was estimated using the equation provided in TP108.

Figure 2 shows the subcatchments delineation and Table 2 provides areas of each sub-catchment.

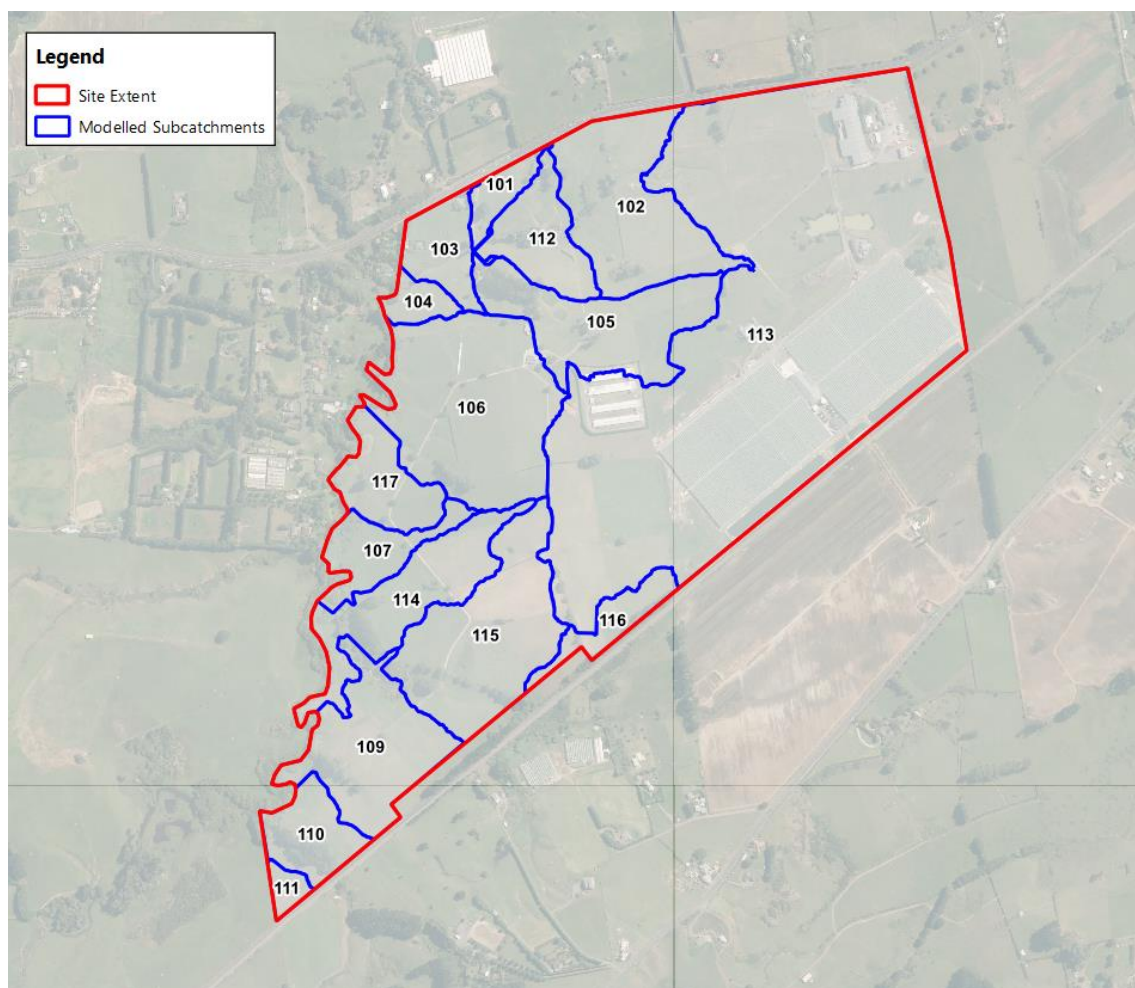


Figure 2: Sub-catchment delineation

Table 2: Sub-catchment areas

ID	Area (ha)
101	1.06
102	7.12
103	2.21
104	0.96
105	6.01
106	10.12
107	2.42
109	5.79
110	2.43
111	0.53
112	3.07
113	46.39
114	4.85
115	7.82
116	1.58
117	2.76

4.1.1. Time of concentration

A time of concentration (Tc) of 10 minutes has been used for all subcatchments within the site.

4.1.2. Initial abstraction

The amendments within the development area are as follows:

- Impervious areas were given a 0 mm initial abstraction, and pervious areas were given a 5 mm initial abstraction.

4.1.3. Curve number

The amendments within the development area are as follows:

- A Curve Number (CN) of 98 was used for impervious areas, and for the pervious areas a CN value of 74 was used.

4.2. Rainfall Zones

The Ngākōroa RFHA model uses a rain-on-grid approach with five spatially varying rainfall zones. There is another rainfall zone (zone 6) for the site. As the site has been modelled with delineated catchment approach (discussed in Section 4.1), there are no losses applied to this rainfall zone. Zone 6 has been discussed in Section 4.1.

The hydrological modelling for the rainfall zones undertaken for the flood assessment discussed here remains consistent with the HWs Ngākōroa RFHA model approach. TP108 rainfall contours were used to calculate additional unit hydrographs for different rainfall events. The losses within the rainfall zones have been applied based on the impervious coverage assumption i.e. MPD or ED, depending on the model scenario.

Table 3 shows the hydrological parameters for the five rainfall zones. Figure 3 shows the location and extent of the rainfall zones.

Table 3: Hydrological parameters for Rainfall Zones

Zones	1	2	3	4	5
Impervious Coverage (MPD as per AUP)	26.2%	21.6%	42.0%	60.9%	25.1%
Impervious Coverage (ED)	3.6%	6.4%	6.7%	17.2%	4.9%
Pervious CN	58.2	54.8	57.1	74.2	49.4
Weighted CN	68.6	64.1	74.3	88.7	61.6
la	3.7	3.9	2.9	2.0	3.7

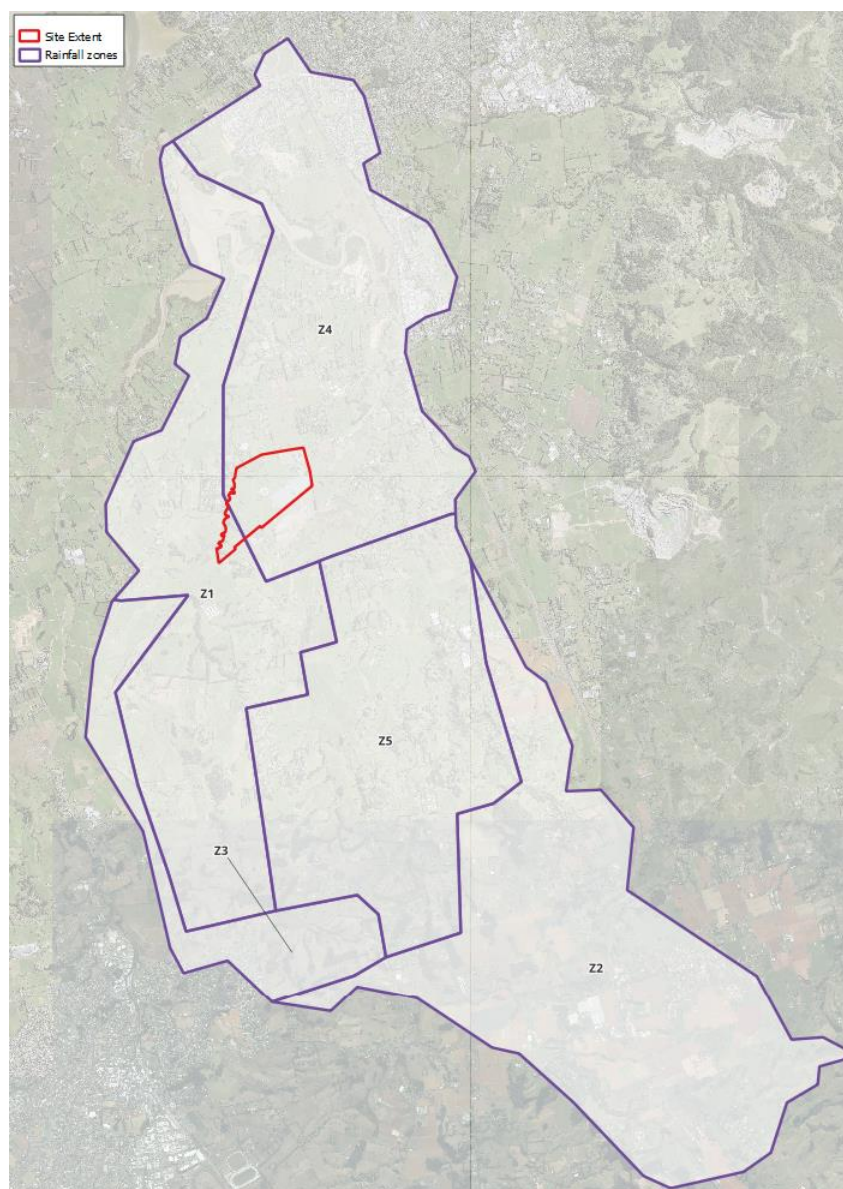


Figure 3: Rainfall Zones

5. Land Use

The MPD impervious coverages are based on AUP whereas ED imperviousness is based on existing impervious layer. Similarly, the impervious coverage within the PPC extent depends on the purpose of the model scenario. Section 9 discusses the impervious coverage assumption for modelled scenarios.

The impervious coverage has been calculated based on the following:

- ED impervious coverage is calculated from the impervious layer information shown in AC GeoMaps.
- The PPC proposes a light industrial zone over the site extent. Conservatively, an assumption of 80% impervious coverage has been assumed for the site area in all the post development model scenarios.
- MPD impervious coverage has been calculated as per the information provided in the AUP.

Figure 4: Existing development impervious coverage shows the existing development impervious coverage of the development site. Figure 5 shows the proposed PPC zoning, however conservatively, 80% impervious coverage has been assumed for site area for all Post Development scenarios.

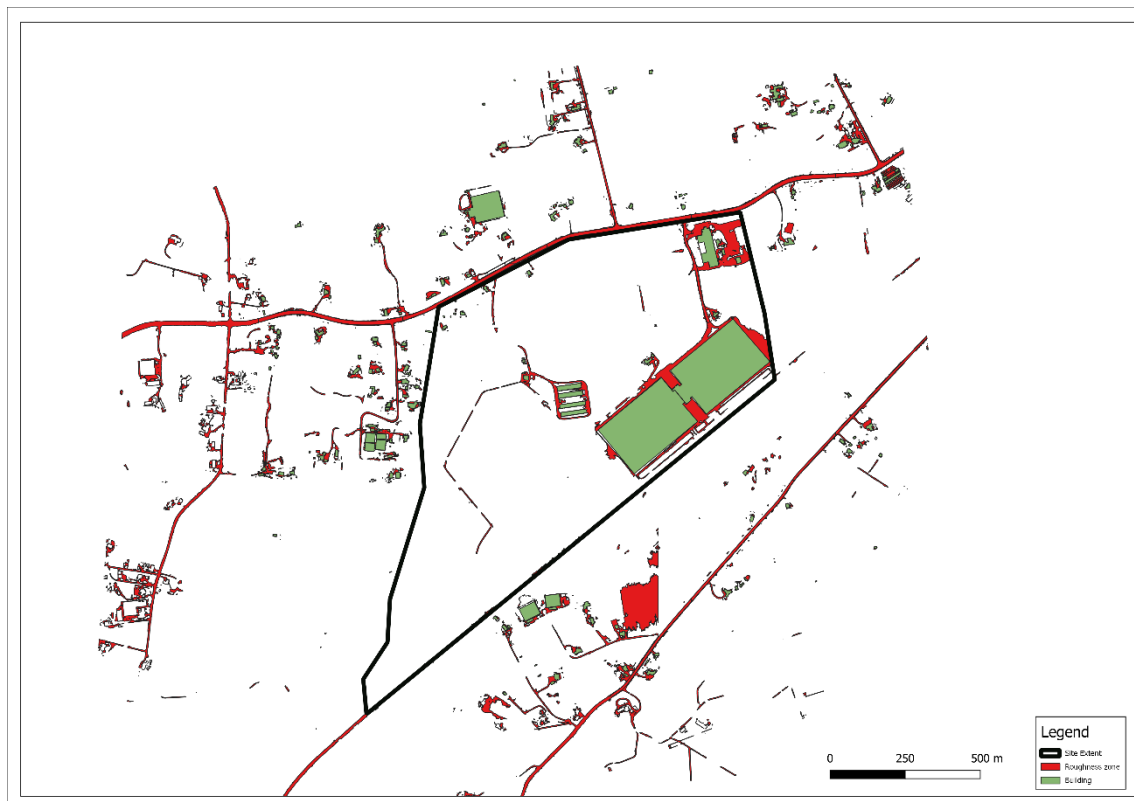


Figure 4: Existing development impervious coverage

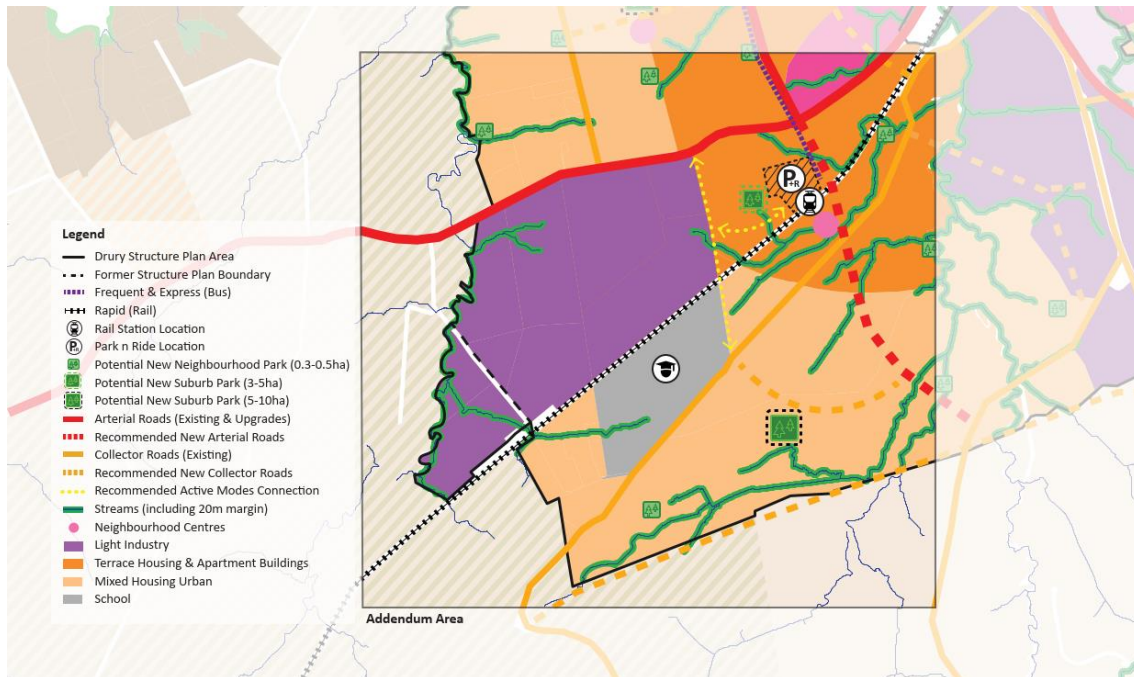


Figure 5: AUP zoning and proposed zoning for PPC

6. Terrain Data

Site survey and LiDAR 2016 DEM data has been used to update the terrain surface in the model for the predevelopment scenarios. Changes for post development scenarios are detailed in subsequent sections. The existing site topography is shown in Figure 6.



Figure 6: Site terrain (LiDAR 2016)

7. Hydraulic Model

The hydraulic elements were based on the provided Ngākōroa model. Changes to the hydraulic model were made to include with the existing additional network for Karaka Road based on survey and LiDAR information.

7.1. 1D Model

7.1.1. 1D culverts

The flood models include several 1D culverts around the development site. A summary of this has been provided in Table 4 which shows the upstream and downstream invert levels, size/diameter and the source of information used. Figure 7 shows the location of these culverts.

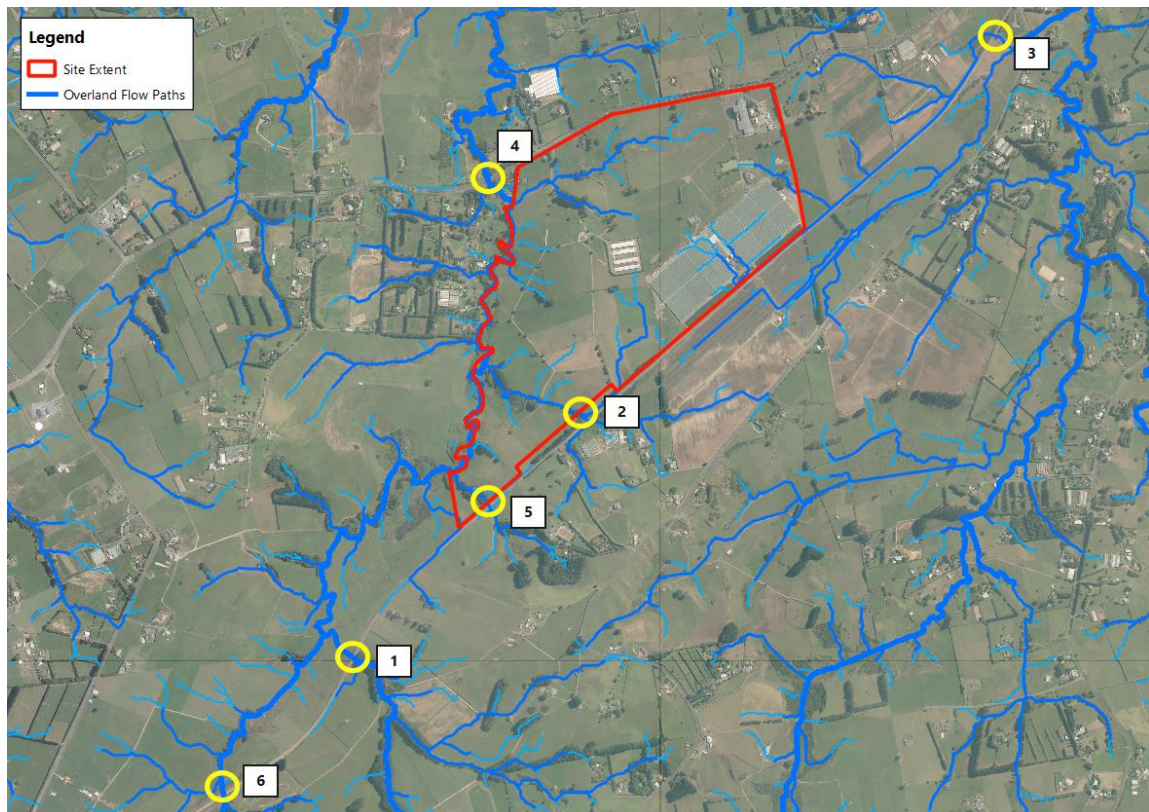


Figure 7: Existing Infrastructure

Table 4: Summary of Infrastructure

#	Asset type	Asset Owner	Diameter (mm)	Upstream invert level (m RL)	Downstream invert level (m RL)	Source of information
1	Culvert Box Railway	KiwiRail	2900 x 2500	15.6	12.38	Downstream invert level and diameter from Survey Information Upstream invert level from MWH Oiroa Creek and Ngākōroa Stream RFHA
2	Culvert Circular Railway	KiwiRail	900	-	14.05	Downstream invert level and diameter from Survey Information Upstream invert level from MWH Oiroa Creek and Ngākōroa Stream RFHA
3	Culvert Circular Railway	KiwiRail	750	8.5	7.32	Downstream invert level and diameter from Survey Information Upstream invert level from MWH Oiroa Creek and Ngākōroa Stream RFHA
4	Twin Box Road Culvert	Auckland Council noted to be asset owner for inlet-outlet as per AC GeoMaps	3000 x 4000	5.5	5.4	Downstream invert level and diameter from Survey Information Upstream invert level from MWH Oiroa Creek and Ngākōroa Stream RFHA
5	Culvert Circular Railway	KiwiRail	1050	-	-	All data sourced from AC GeoMaps
6	Culvert Circular Railway	KiwiRail	4600	-	-	All data sourced from AC GeoMaps

7.1.2. 1D losses

The 1D losses have not been changed and retained as per the Oiroa Creek and Ngākōroa Stream RFHA flood model.

7.2. 2D Model

7.2.1. 2D Zone

A 2D zone with a flexible mesh approach was created using the terrain data from LiDAR 2016. The mesh resolution was retained as per the catchment model to a maximum triangle area of 80m^2 and a minimum triangle area of 25m^2 .

7.2.2. Mesh Zone

There are 25 mesh zones included in the model extent that provides higher resolution around the flood prone areas and the site. Figure 8 shows the mesh zones included in the model and Table 5 provides minimum and maximum triangle area for each mesh zone.

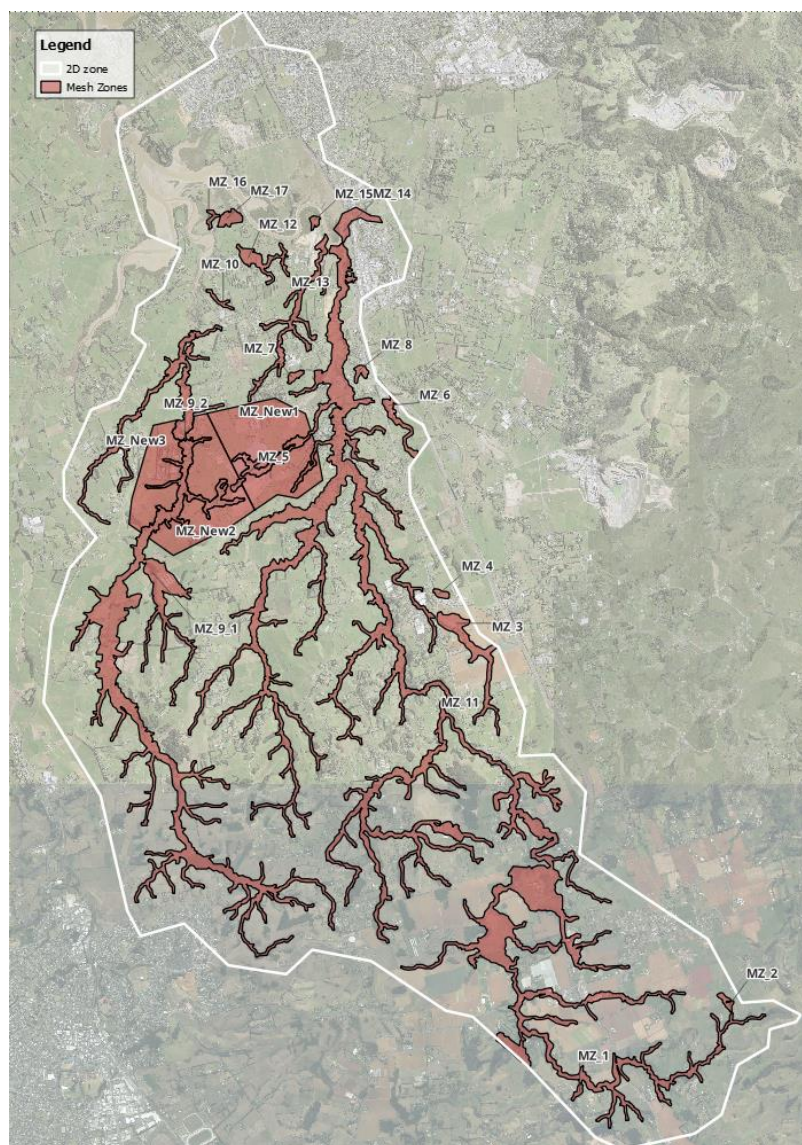


Figure 8: Mesh Zones

Table 5: Mesh Zone Summary

Mesh Zone ID	Area (ha)	Function	Maximum Triangle Area (m ²)	Minimum Triangle Area (m ²)
MZ_New1	143.76	Detailed resolution within site	4	1
MZ_New2	112.67		4	1
MZ_New3	69.58		4	1
MZ_1	1.71	Detailed resolution within flooded areas	10	5
MZ_10	2.42		10	5
MZ_11	653.72		10	5
MZ_12	12.41		10	5
MZ_13	27.74		10	5
MZ_14	1.83		10	5
MZ_15	1.91		10	5
MZ_16	2.05		10	5
MZ_17	5.73		10	5
MZ_2	2.58		10	5
MZ_3	24.99		10	5
MZ_4	2.09		10	5
MZ_5	1.74		10	5
MZ_6	8.93		10	5
MZ_7	2.34		10	5
MZ_8	2.94		10	5
MZ_9_1	306.55		10	5
MZ_9_2	0.071		10	5
MZ_9_3	0.005	Define levels around inlet and outlet structures	1000	900
MZ_9_4	0.007		1000	900
MZ_9_5	0.007		1000	900
MZ_9_6	0.007		1000	900

7.2.3. 2D Roughness

Manning's 'n' values have been used to represent the 2D roughness of different areas. Table 6 shows the value used for different areas. All the modelled roughness is as per the information provided in RFHA Oiroa Creek and Ngākōroa Model Build report.

Table 6: 2D Roughness

Surface type	Manning's 'n' value
Buildings	1
Roads and other impervious area	0.05
Remaining model extent	0.1

8. Boundary Conditions

8.1. Inflow Boundary Conditions

There are three inflow boundary conditions applied to the flood models. The inflow boundary conditions include flow discharging from Whangapouri Creek, Slippery Creek and Norrie Bridge.

Figure 9 shows the locations of the inflow boundary conditions applied to the flood model. Appendix A provides all the information used to represent the inflow boundary conditions.

8.2. Downstream Boundary Condition

The final discharge point for all the runoff generated in the model is identified to be the Manukau Harbour and therefore a constant MHWS level of 3.3m RL has been used to represent the downstream boundary condition. The downstream boundary condition allows for 1m of sea level rise as per the guidelines provided in AUP:OiP.

Figure 9 shows the locations of the downstream boundary condition applied to the flood model.

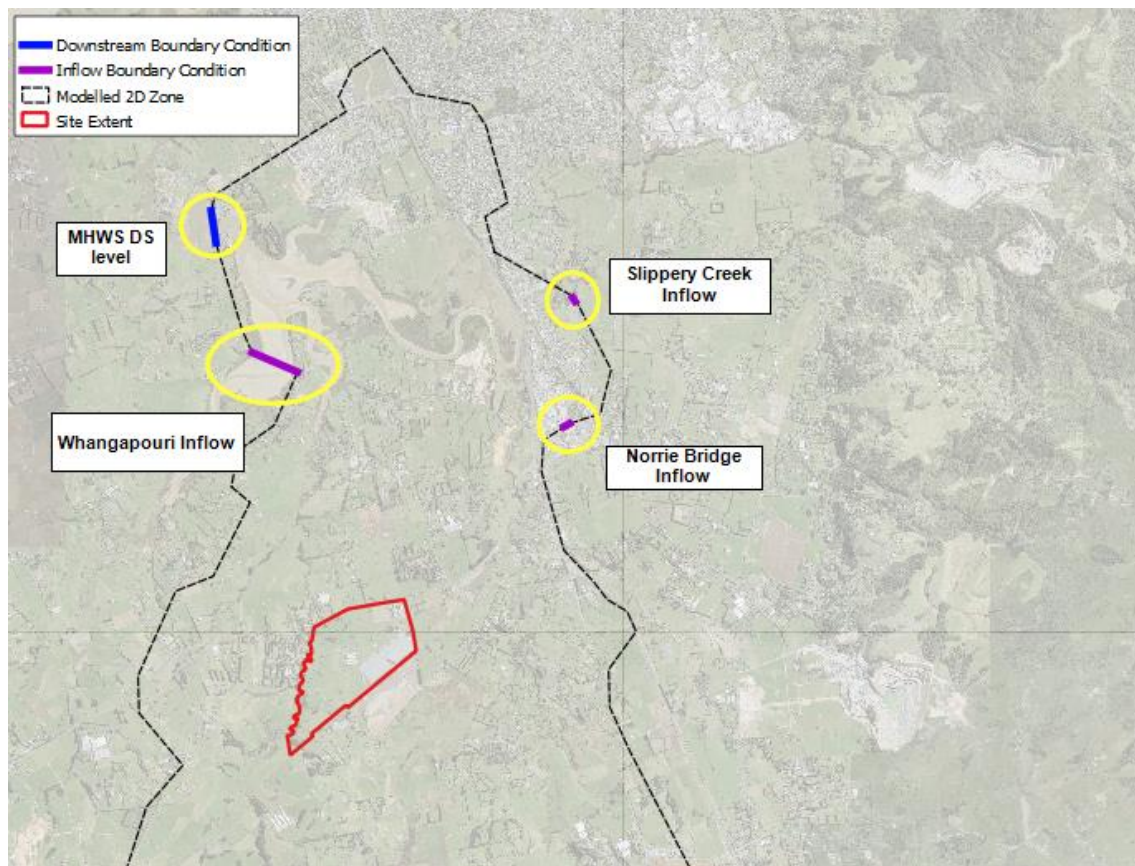


Figure 9: Boundary conditions

9. Modelled Scenarios

➤ **Pre-development (Scenario 1a and 1b)**

This scenario was modelled to understand existing flood extents and forms the basis for assessing future flood risk and flood management options. Two scenarios have been simulated as follows:

- 1a – Existing development (ED) impervious coverage for all areas within the model extent
- 1b – Existing development (ED) impervious coverage within PPC extent whereas for areas outside the PPC, the impervious coverage is assumed to be maximum probable development (MPD) as per AUP.

➤ **Post development without mitigation (Scenario 2)**

This model scenario was modelled to assess the flood effects on areas upstream and downstream of the development site as a result of the change in imperviousness with the proposed PPC. The modelling assumption for post development scenarios consider 80% impervious coverage within the development, which is a conservative approach. The impervious coverage of areas outside of the PPC have been based on MPD as per the AUP. Catchment loading within this scenario has allowed for the existing storage within the site.

➤ **Post development with pass forward (Scenario 3)**

This model scenario further builds on Scenario 2 and allows for flows generated within the PPC area to be passed forward. This scenario has been modelled to assess the flood effects on the basis post development flows are “passed forward” i.e. no attenuation. As per the FUZ SMP, the general flood management approach for Drury West area is to pass flows forward which is in line with the flood management option explored here. Local depressions within this area have been removed with secondary flows bypassing communal devices.

➤ **Post development with pass forward + diversion (Scenario 4 – Preferred Option)**

Further building on Scenario 3, Scenario 4 has been modelled to demonstrate the proposed option of passing flows forward along with diversion of site catchment area towards Oiroa Stream. Findings of Scenario 2 and Scenario 3 have been used to inform the catchment area diverted in this model scenario.

Two scenarios have been simulated for this option as follows:

- 4a – MPD impervious coverage within the development extent while the remaining model extent is assumed to be ED impervious coverage, and
- 4b – MPD impervious coverage for all areas within the model extent.

The model scenario implements the flood management strategy with the following measures:

- Diversion of the site area (28.58ha) which currently discharges to Ngākōroa Stream.
- It is noted that existing base flows are sought to be maintained in a regime similar to existing conditions for events such as the less than the 2yr event, this has been excluded from the assessment as this will not adversely impact the flood strategy.
- Diversion of the site area of 4.16ha which currently discharges towards the railway line at the southern end of the site.
- In total, this model scenario allows for diversion of 32.74ha of site area towards Oiroa Creek and passed forward.

Figure 10 shows the catchment delineation for the Scenario 4. A brief description of the modelled scenarios have been summarised in Table 7.

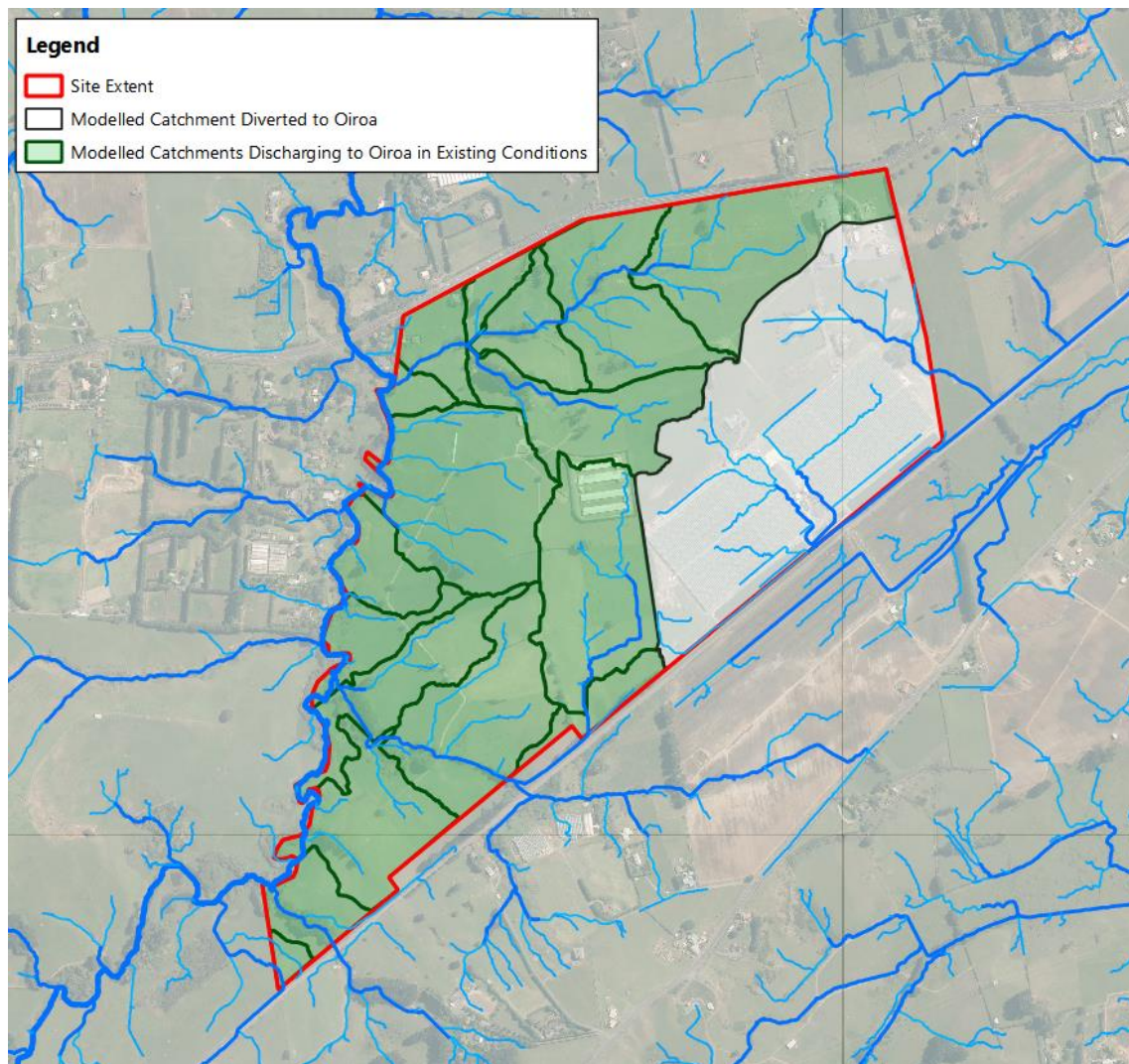


Figure 10: Catchment diversion for Scenario 4

Table 7 provides a summary of the model scenarios. The information presented in the table provides a detailed description of the key scenarios and model assumptions.

Table 7: Modelled scenarios

#	Model scenario name	Description	Land use	Climate Change (°C)	ARI
1a	Pre-development	- This scenario was modelled to understand existing flood extents. - This scenario forms the basis for assessing future flood risk and suitability of flood management options	Existing Development (ED)	3.8°C, 2.1°C, No CC	100, 10, 2
1b			ED - for areas within the PPC extent. Maximum Probable Development (MPD) – all areas outside the PPC extent		
2	Post development without mitigation	- Model scenario allowing for imperviousness uplift as part of PPC without any flood management option - Catchment loading has allowed for storage within existing depressions located within the site	MPD	3.8°C, 2.1°C, No CC	100, 10, 2
3	Post development with pass forward	- Model scenario allowing for imperviousness uplift as part of PPC and allows for pass flows forward flood management option - Catchments have been loaded directly to the streams and therefore no storage allowed within the site to enable passing flows forward. - This is deemed conservative	MPD	3.8°C, 2.1°C, No CC	100, 10, 2
4a	Post development with pass forward + diversion	- Model scenario allowing for uplift of impervious area as proposed in PPC, and allows for pass flows forward + flow diversion as flood management option - This is deemed conservative as it doesn't allow for the proposed devices within the site	ED - for all areas outside the PPC extent MPD - for all areas within the PPC extent	3.8°C, 2.1°C, No CC	100, 10, 2
4b			MPD		

9.1. Model Results

As stated in Table 7, the models have been simulated for no climate change, climate change considerations related to 2.1° temperature rise to 2090 as well as 3.8°C temperature rise to 2110 for 2, 10- and 100-year ARI storm events. The water level results of each post development model scenario were compared with the pre-development model to assess the differences in the water levels upstream and downstream of the site. This guided the optioneering assessment to obtain a suitable flood management option which avoids or minimises/mitigates any change in the existing flooding (if any) as a result of the PPC.

For purposes of the memorandum, results of the 2-year, 10-year and 100-year inclusive of 3.8°C climate change have been presented and discussed as this is considered conservative.

9.1.1. Pre-development Model Results (Scenario 1a and 1b)

Figure 11 to Figure 16 show the flood model results for Pre-development 2, 10 and 100-year 3.8°C ARI storm event.

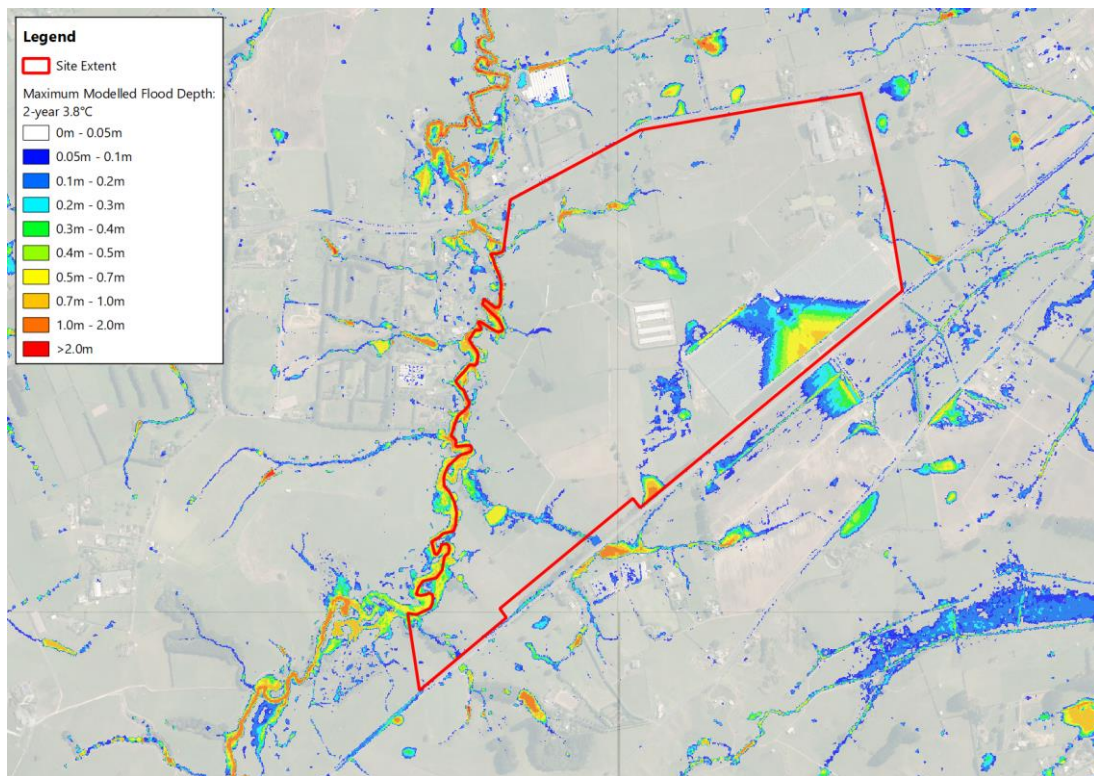


Figure 11: Scenario 1a - Maximum Modelled Flood Depth - Pre-development 2-year 3.8°C ARI (with ED for entire model extent)

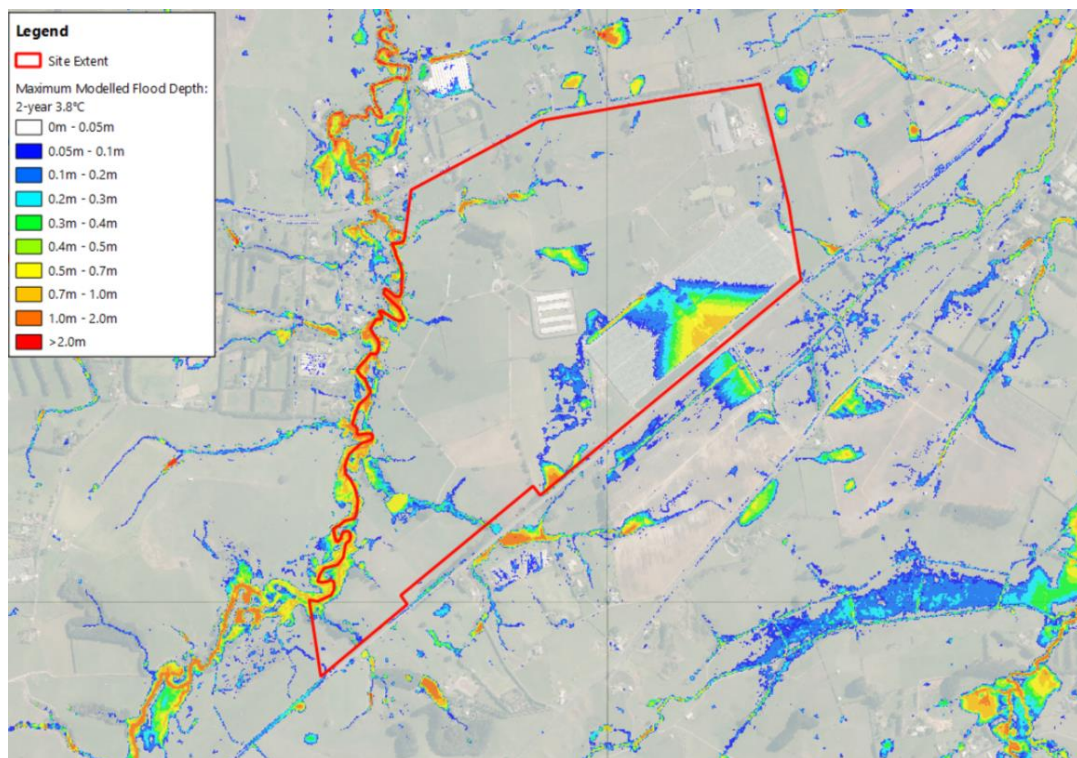


Figure 12: Scenario 1b - Maximum modelled flood depth - Pre-development 2-year 3.8°C ARI (with ED within PPC and MPD for all model extent)

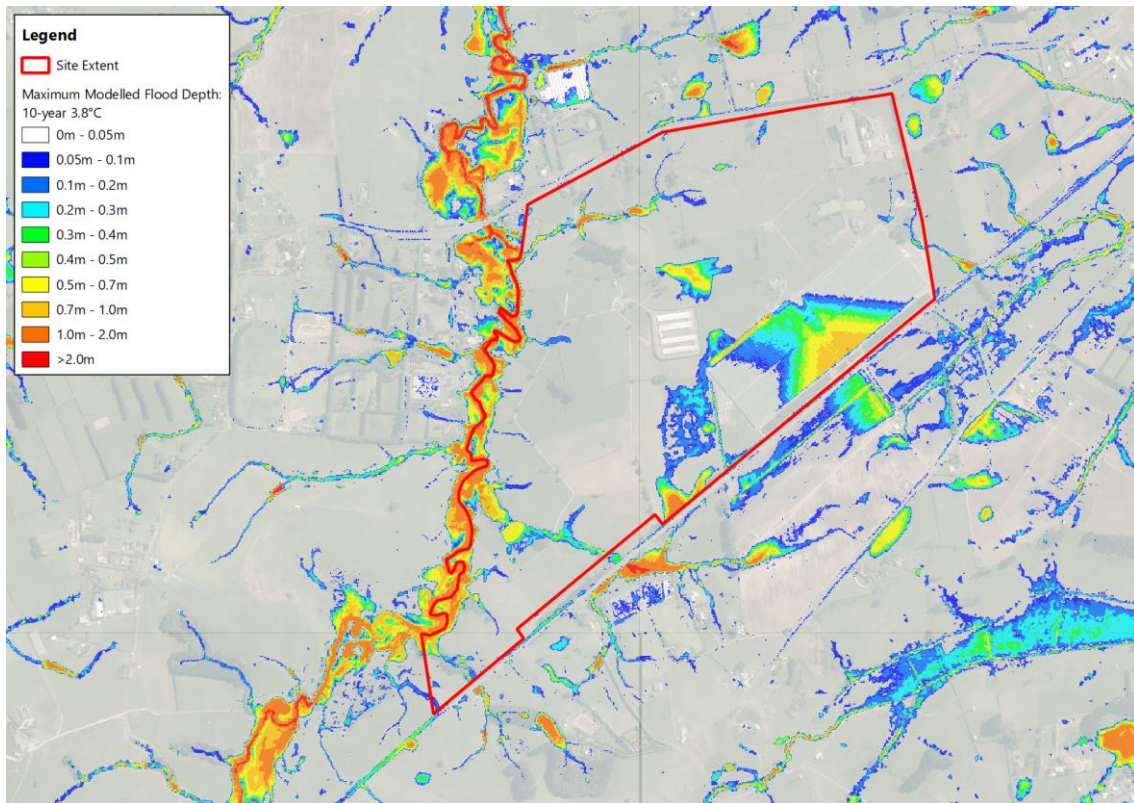


Figure 13: Scenario 1a - Maximum Modelled Flood Depth - Pre-development 10-year 3.8°C ARI (with ED for entire model extent)

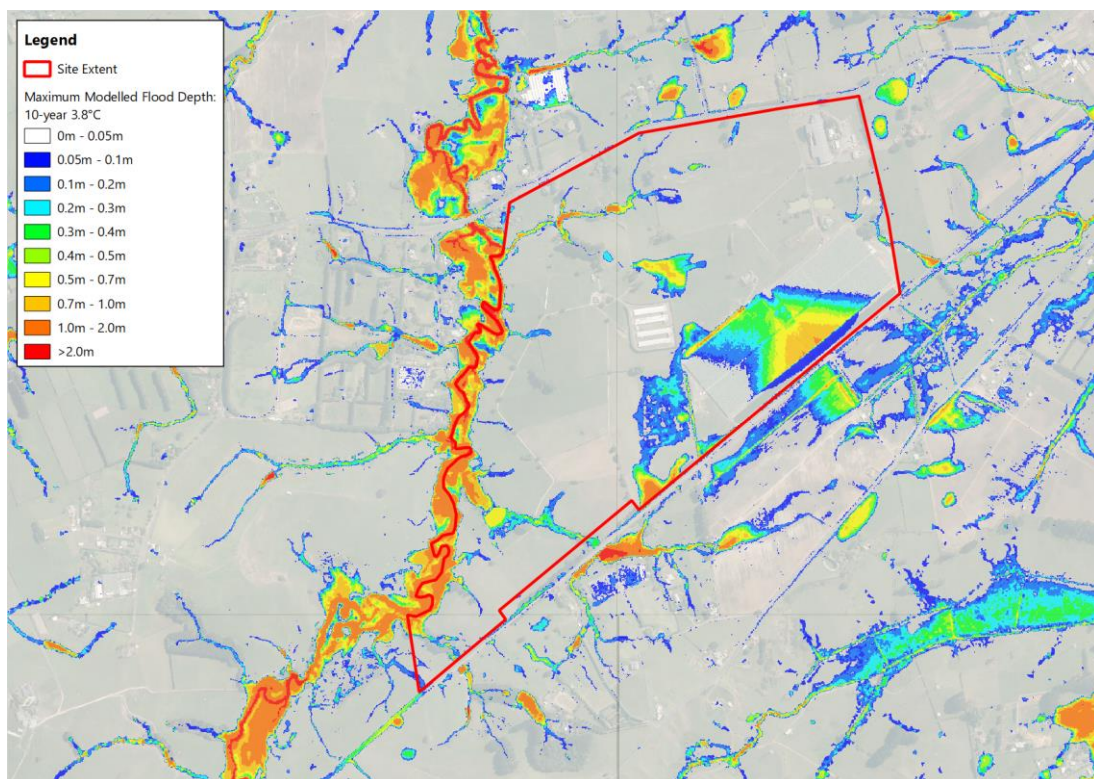


Figure 14: Scenario 1b - Maximum modelled flood depth - Pre-development 10-year 3.8°C ARI (with ED within PPC and MPD for all model extent)

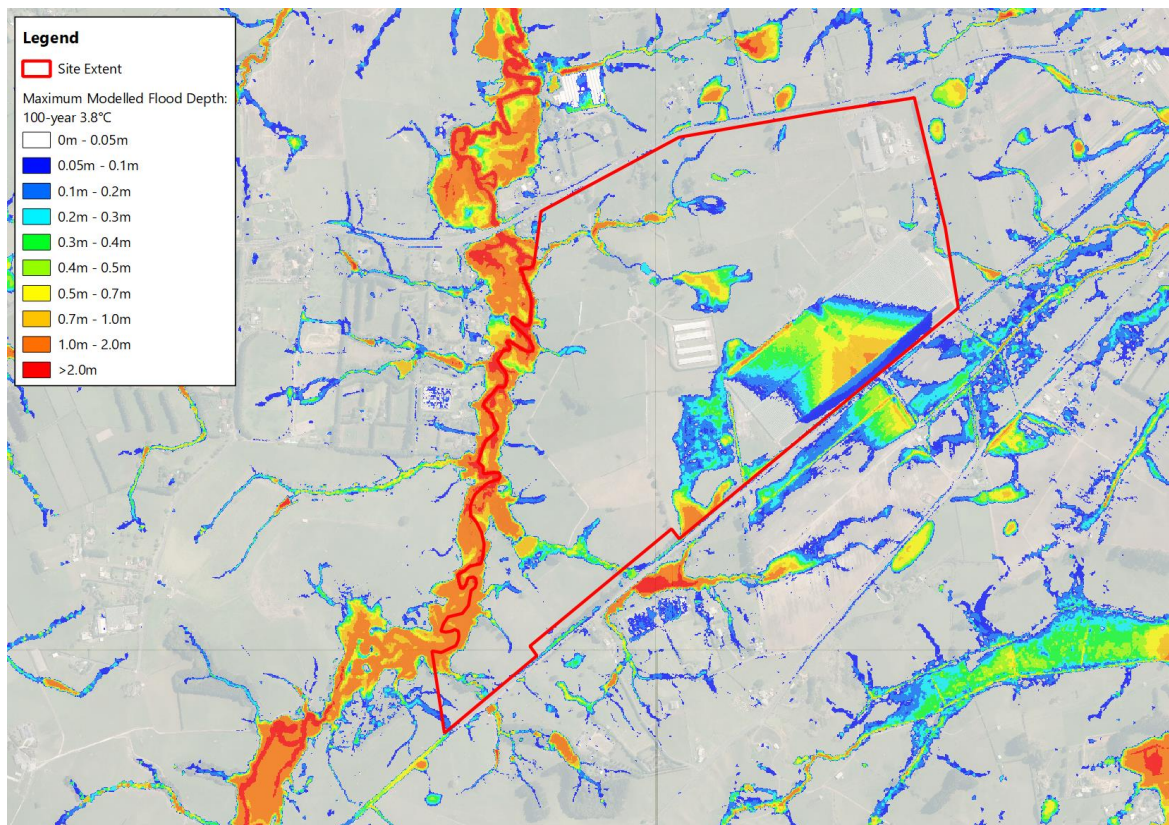


Figure 15: Scenario 1a - Maximum Modelled Flood Depth - Pre-development 100-year 3.8°C ARI (with ED for entire model extent)

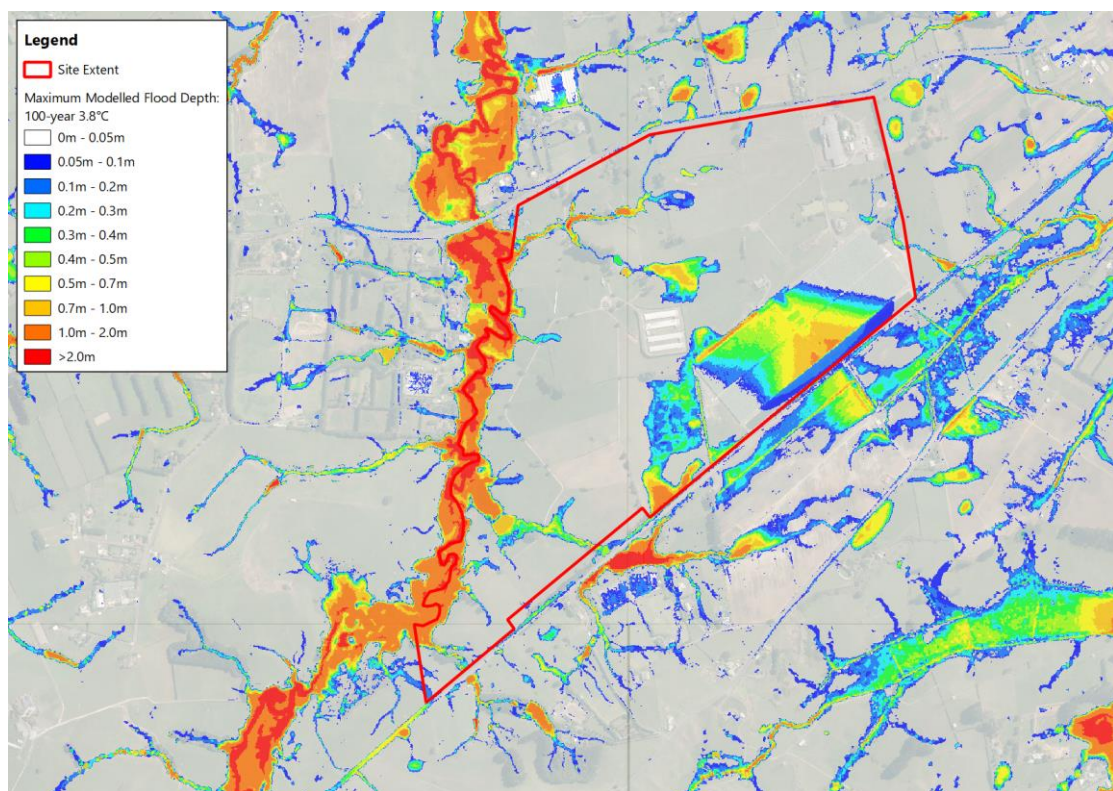


Figure 16: Scenario 1b - Maximum Modelled Flood Depth - Pre-development 100-year 3.8°C ARI (with ED within PPC and MPD for all model extent)

The following conclusions can be made for the 2, 10-year and 100-year 3.8°C ARI storm event simulations undertaken the Pre-development model scenario:

- The flooding expected within the site under existing conditions is noted as being generally contained within natural streams/ riverine wetlands wetland extents as identified in the ecological assessment by the consultants, Bioresarches.

9.1.2. Post development model results

For the purposes of this report, the post development model results discussion only includes the water level difference plot (afflux plot) of Scenario 2 and 3 with the pre-development model scenario (Scenario 1b) for 100-year ARI (+3.8°C) storm event, however, all relevant comparisons between Scenario 4 and Scenario 1 have been included. The afflux plot shows the change in flooding as a result of the PPC (if any) and the implemented flood mitigation strategy.

9.1.2.1. Post development without flood mitigation (Scenario 2)

Figure 17 shows the afflux plot (water level differences) for post-development (Scenario 2) with the pre-development scenario (Scenario 1b) for 100-year ARI storm event (3.8°C climate change).

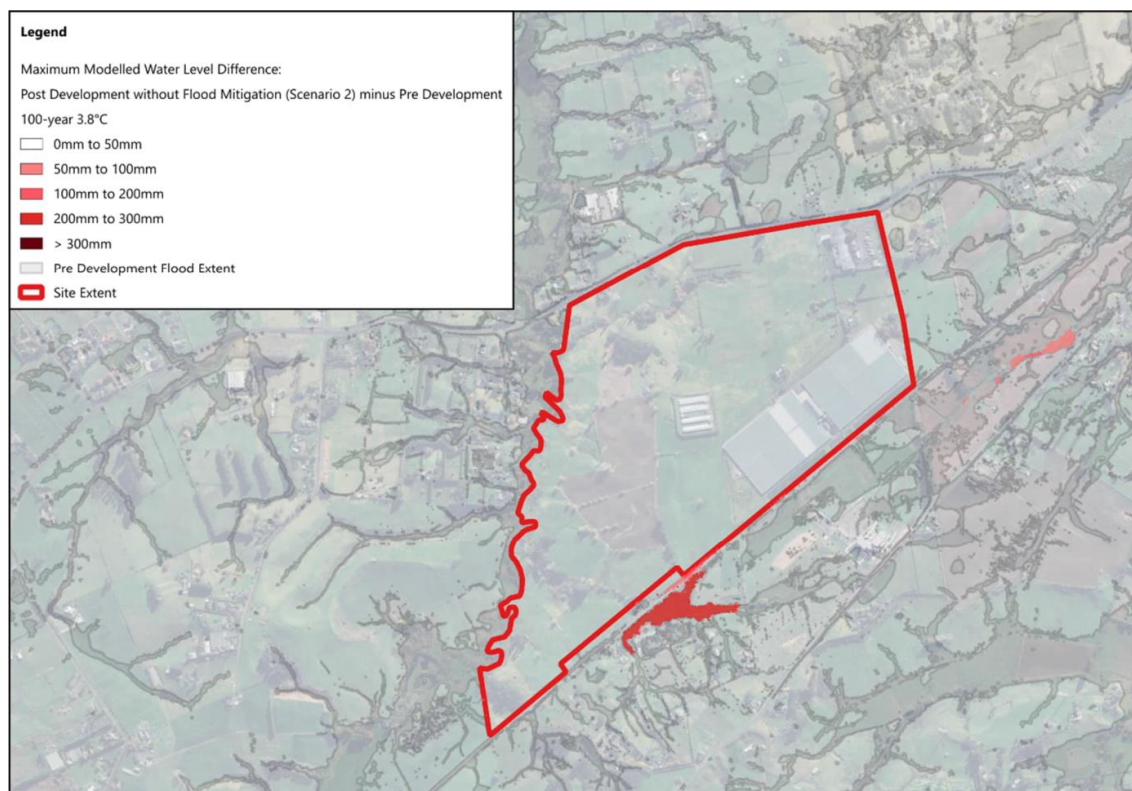


Figure 17: Afflux plot - Post development without flood mitigation (all areas MPD) minus Pre-development (PPC extent as ED and remaining model extent as MPD) (100-year 3.8°C)

The model results show that there are water level increases shown south of the PPC by the railway line and to the south-east in the tributary discharging to Ngākōroa Stream. The increases are due to the post-development model generating higher flows due to allowance for imperviousness uplift as per the PPC.

9.1.2.2. Post development with pass forward (Scenario 3)

Figure 18 shows the afflux plot (water level differences) for Post development with pass flows forward (Scenario 3) with the pre-development scenario (Scenario 1b) for 100-year ARI storm event (3.8°C climate change).

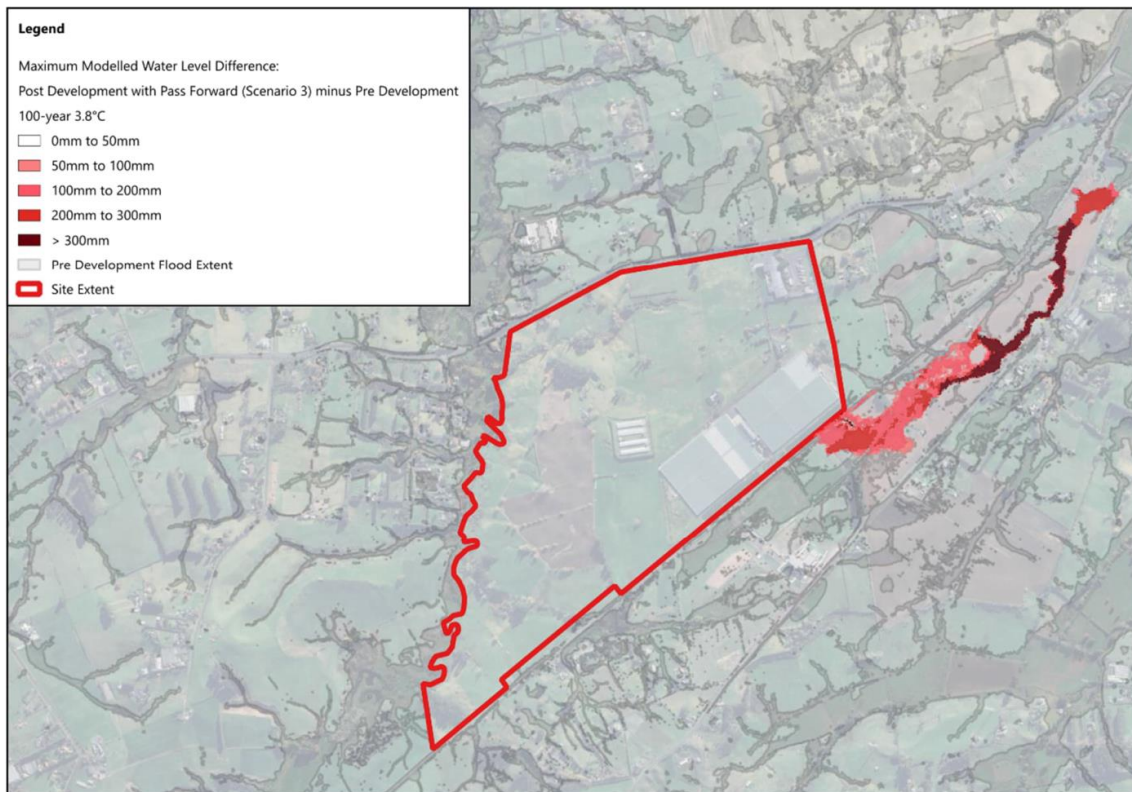


Figure 18: Afflux plot - Post development with pass forward (all areas MPD) minus Pre-development (PPC extent as ED and remaining model extent as MPD) (100-year 3.8°C)

The results indicate an increase in water levels downstream of the south-east side of the PPC, which is directly attributed to the flows being passed forward at this location with hydraulic structures limiting flows further downstream.

9.1.2.3. Post development with flood mitigation – pass forward + diversion (Scenario 4a and 4b)

This model scenario allows for the diversion of the catchment areas within the PPC. The diversion of the catchment has been informed from the Scenarios 2 & 3 model results.

This scenario has been modelled to assess the option of passing flows forward along with diversion of site catchment area towards Oiroa Stream. This model scenario allows for complete diversion of the site area which currently discharges to Ngākōroa Stream. This is noted to be a diversion of 28.58ha of site area.

Figure 19 – Figure 24, show the afflux plots (water level differences) for Post development with flood mitigation – pass forward + diversion (Scenario 4a and 4b) with the pre-development scenarios (Scenario 1a and 1b) for 2, 10- and 100-year ARI storm event (3.8°C climate change).

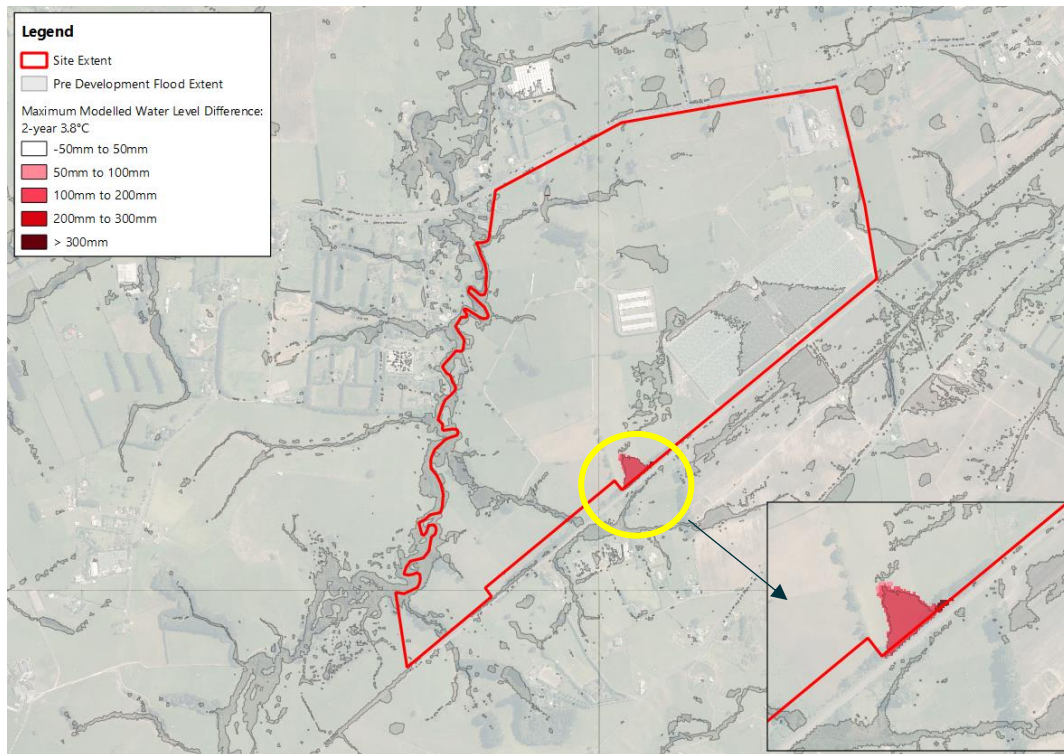


Figure 19: Afflux plot - Scenario 4a (PPC extent as MPD, remaining model extent as ED) minus Scenario 1a (all areas within model extent as ED) for 2-year 3.8°C

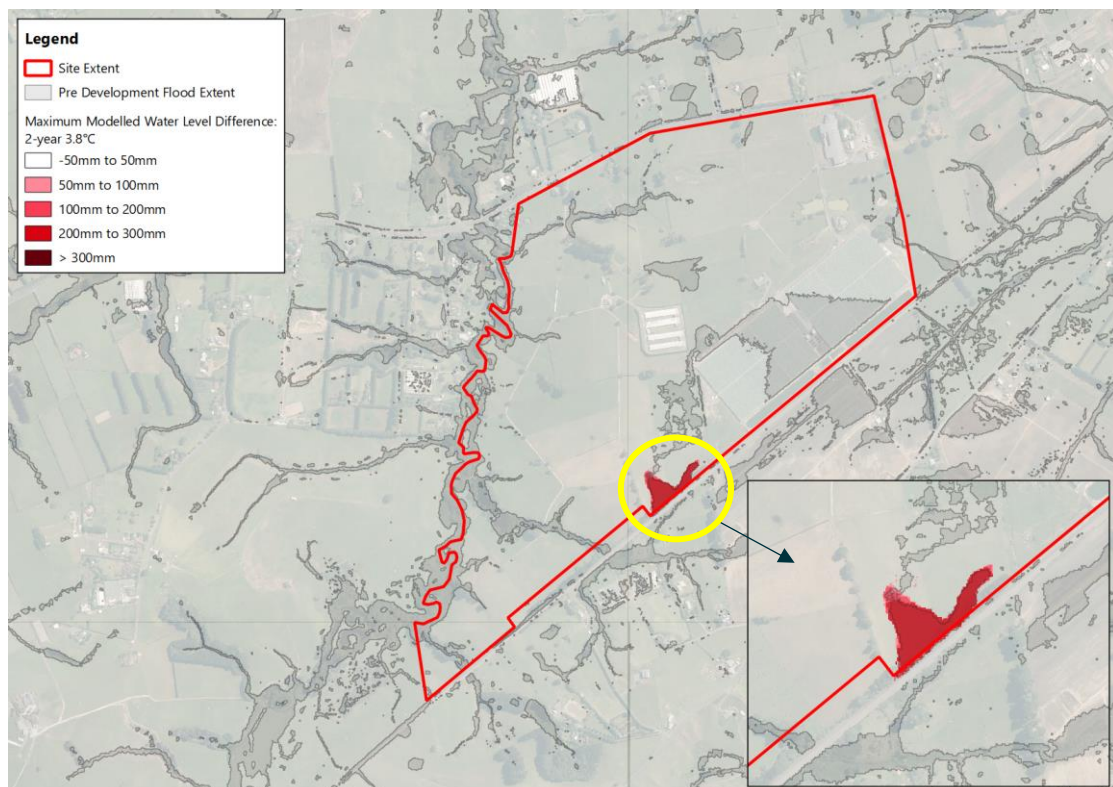


Figure 20: Afflux plot - Scenario 4b (all areas within model extent as MPD) minus Scenario 1b (PPC extent as ED and remaining model extent as MPD) for 2-year 3.8°C

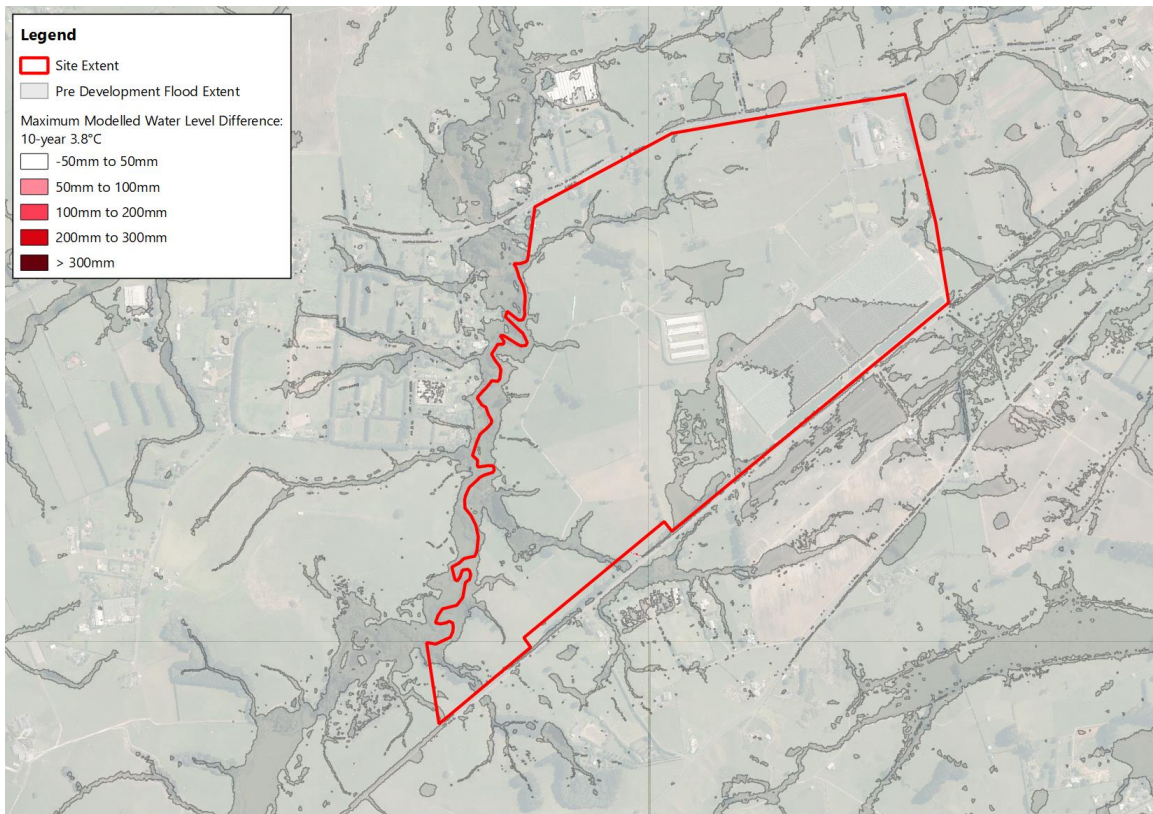


Figure 21: Afflux Plot - Scenario 4a (PPC extent as MPD, remaining model extent as ED) minus Scenario 1a (all areas within model extent as ED) for 10-year 3.8°C

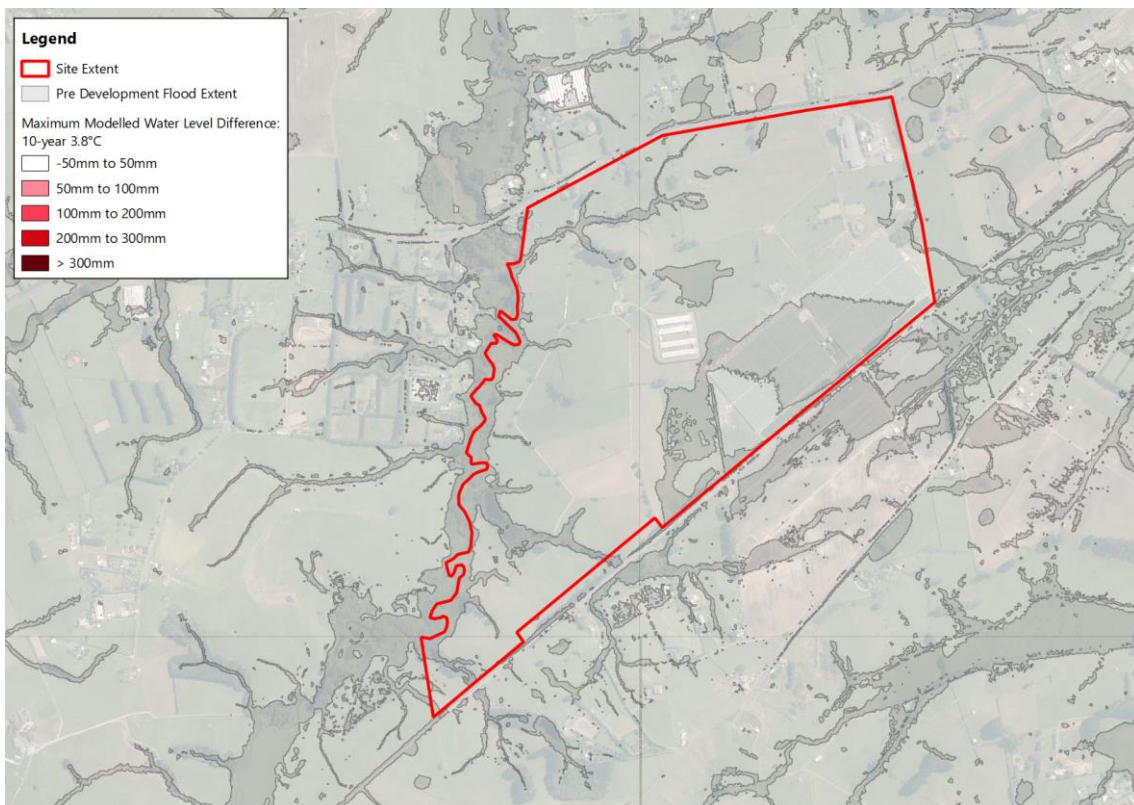


Figure 22: Afflux plot - Scenario 4b (all areas within model extent as MPD) minus Scenario 1b (PPC extent as ED and remaining model extent as MPD) for 10-year 3.8°C

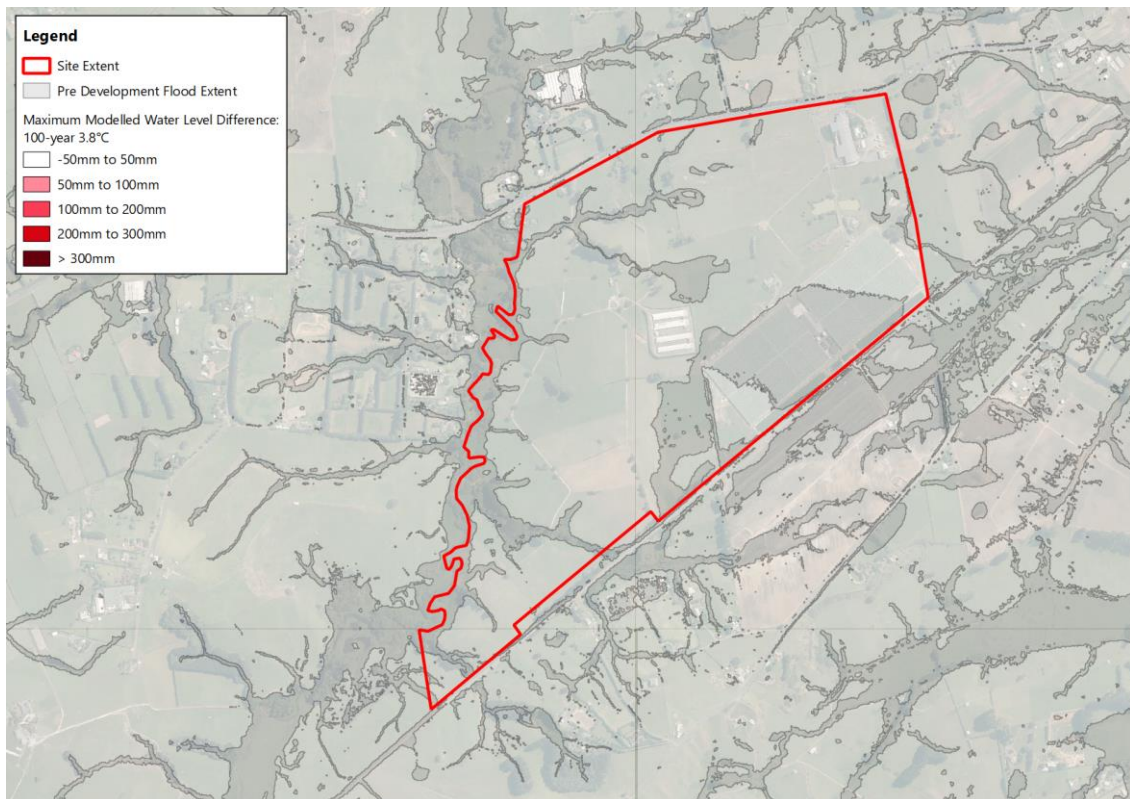


Figure 23: Afflux Plot - Scenario 4b (PPC extent as MPD, remaining model extent as ED) minus Scenario 1b (all areas within model extent as ED) for 100-year 3.8°C

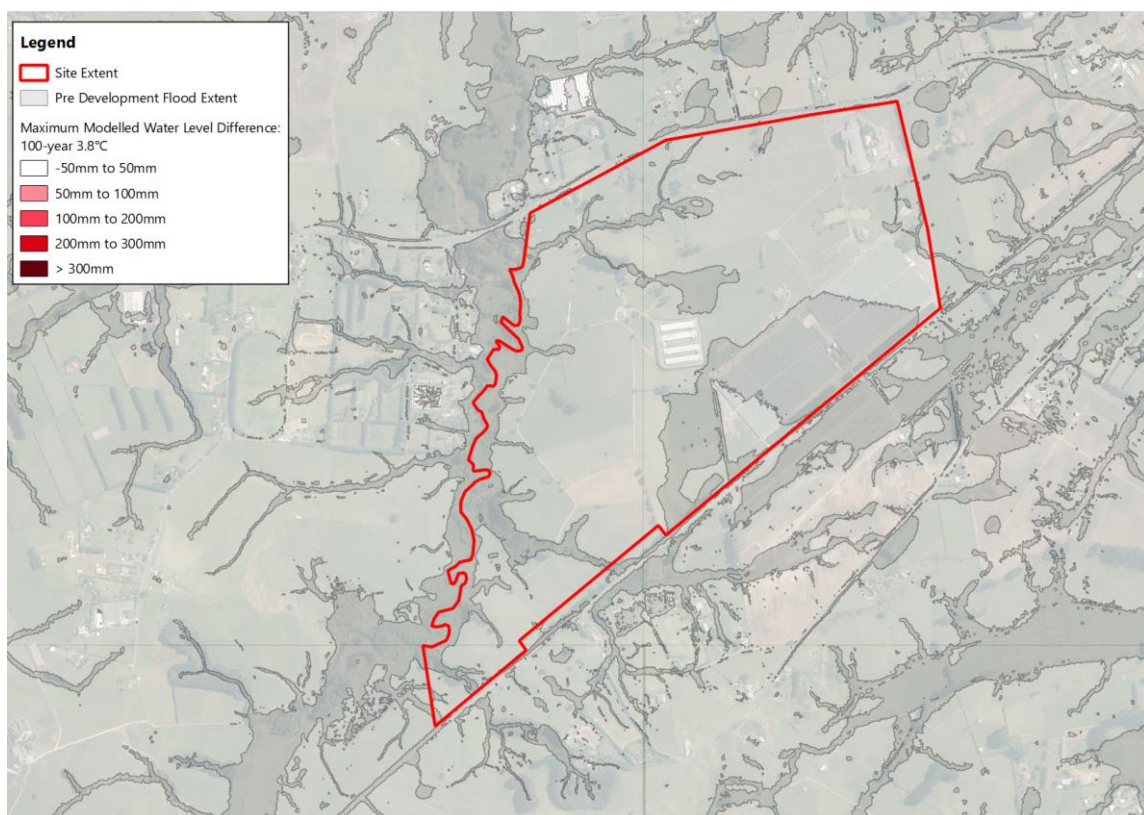


Figure 24: Afflux plot - Scenario 4b (all areas within model extent as MPD) minus Scenario 1b (PPC extent as ED and remaining model extent as MPD) for 100-year 3.8°C

The following can be determined from water level difference plots:

2-year ARI (inclusive of 3.8°C climate change)

- There is a small locally depressed area towards the south of the PPC where flood increase is expected (highlighted in Figure 20)
 - When considering all areas as MPD, as highlighted in figure 20, the maximum flood depth increase is approximately 215mm, with the pre-development flood depth approximately 1.2m around the area. Much of the increase is within the plan change area, however, a small section of the flood increase is observed on the channel present adjacent to the railway line.
 - This increase results from the greater discharge flowing into the existing topography. During the earthworks stage of the development, changes to the landform within the site will mitigate this increase. This will be addressed during the detail design stage.
 - Based on the above, this flood increase is determined to have less than minor flood effects on areas outside the PPC.

10-year ARI (inclusive of 3.8°C climate change)

- No increases in flooding are observed, upstream or downstream, as a result of the recommended flood management strategy i.e. Pass flows forward + diversion (Scenario 4b).

100-year ARI (inclusive of 3.8°C climate change)

- No increases in flooding are observed, upstream or downstream, as a result of the recommended flood management strategy i.e. Pass flows forward + diversion (Scenario 4b).

It is concluded that as the water levels and flood extents are generally similar between the post development and pre-development model scenario (Scenario 1b). Pass flows forward + diversion (Scenario 4b) is the recommended flood management strategy for the PPC.

10. Limitations and Assumptions

The following assumptions and limitations are noted:

- This model has been prepared to provide guidance on the flood assessment undertaken in support of the PPC. The findings of the model and the flood assessment should only be considered for applicable for the following scope:
 - This model has been used to assess the flood effects as a result of the proposed PPC (if any) and potential flood mitigation options to avoid or minimise/mitigate any change in the existing flooding conditionss
- The runoff flows calculated by the hydrological model are loaded in the hydraulic model at specified nodes inside the two-dimensional model extents (structured mesh). Inside the two-dimensional model extents, water can flow in all directions from the loading node. The extents of the flow paths may vary based on the location of the loading node, the elevation of the two-dimensional grid cells (from LiDAR data) and other model assumptions. The location of the loading determines the origin of the overland flow path.
- No sedimentation or blockage has been allowed for in any watercourses or culverts.
- Modelling process relies on a range of assumptions and simplifications and may be subject to errors and inaccuracies. The compounding effects of the uncertainties in the TP108 rainfall model (ARC, 1999), the uncertainties in the LiDAR data and the uncertainties in hydraulic parameters such as roughness could result in the water level varying from the mapped levels.
- The LiDAR data has an absolute vertical accuracy of +/- 0.10m. Deviations in vertical accuracy can occur in areas of dense vegetation. Below water, ground levels are not reliably represented in the LiDAR data. As a result of the water level variability, the flood extent may vary from that shown on the plans. This can have a compounding effect with other uncertainties.
- There is no measured flow data considered in this assessment; therefore, it is not possible to validate the peak water levels or flows.

11. Conclusions

Woods have undertaken a flood assessment to support the proposed PPC application at 300-458 Karaka Road using the Ngākōroa catchment model (July 2019) RFHA model received from Healthy Waters.

The flood model build report provides details regarding the parameters and assumptions used to update the Healthy Waters Ngākōroa RFHA model. As part of the flood assessment, there were four scenarios modelled. All the scenarios were simulated for 2, 10, 100-year ARI storm event with allowance for no climate change as well as a temperature increase of 2.1°C by 2090 and 3.8°C by 2110.

The flood modelling work undertaken demonstrates that Post development with flood mitigation – pass forward + diversion (Scenario 4) was the preferred flood management option and is recommended for the PPC. This option enables flows to be passed forward in tandem with diversion of site area to Oiroa Stream. The resulting water level and flooding extent from this flood management option is generally consistent with the existing flooding conditions. There are no areas upstream and downstream of the development site that are identified to be impacted from the PPC and therefore the 'pass flows forward + diversion' flood management option is recommended. As per the FUZ SMP, the general flood management approach for Drury West area is to pass flows forward which is in line with the flood management option recommended in this SMP.

APPENDICES

Appendix A - Inflow Boundary Conditions

Time	Inflow_Whangapouri	Inflow_NorrieBridge	Inflow_SlipperyCreek
1/01/2017 0:00	0.248	0.1	0.498
1/01/2017 0:02	0.407	0.1	0.498
1/01/2017 0:04	0.579	0.1	0.498
1/01/2017 0:06	0.743	0.1	0.497
1/01/2017 0:08	0.904	0.1	0.497
1/01/2017 0:10	1.025	0.1	0.498
1/01/2017 0:12	1.099	0.1	0.499
1/01/2017 0:14	1.188	0.1	0.498
1/01/2017 0:16	1.295	0.1	0.499
1/01/2017 0:18	1.418	0.1	0.5
1/01/2017 0:20	1.534	0.1	0.499
1/01/2017 0:22	1.603	0.1	0.496
1/01/2017 0:24	1.609	0.1	0.497
1/01/2017 0:26	1.638	0.1	0.497
1/01/2017 0:28	1.651	0.1	0.498
1/01/2017 0:30	1.596	0.1	0.497
1/01/2017 0:32	1.577	0.1	0.499
1/01/2017 0:34	1.572	0.1	0.499
1/01/2017 0:36	1.551	0.1	0.5
1/01/2017 0:38	1.545	0.1	0.5
1/01/2017 0:40	1.565	0.1	0.501
1/01/2017 0:42	1.598	0.1	0.503
1/01/2017 0:44	1.648	0.1	0.505
1/01/2017 0:46	1.702	0.1	0.506
1/01/2017 0:48	1.764	0.1	0.507
1/01/2017 0:50	1.848	0.1	0.509
1/01/2017 0:52	1.907	0.1	0.51
1/01/2017 0:54	1.907	0.1	0.511
1/01/2017 0:56	1.89	0.1	0.511
1/01/2017 0:58	1.882	0.1	0.511
1/01/2017 1:00	1.876	0.1	0.512
1/01/2017 1:02	1.889	0.1	0.512
1/01/2017 1:04	1.929	0.1	0.513
1/01/2017 1:06	1.965	0.1	0.514
1/01/2017 1:08	1.991	0.1	0.514
1/01/2017 1:10	1.995	0.1	0.514
1/01/2017 1:12	1.981	0.1	0.513
1/01/2017 1:14	1.995	0.1	0.515
1/01/2017 1:16	2.03	0.1	0.515
1/01/2017 1:18	2.077	0.1	0.514
1/01/2017 1:20	2.152	0.1	0.515
1/01/2017 1:22	2.215	0.1	0.516
1/01/2017 1:24	2.239	0.1	0.516
1/01/2017 1:26	2.225	0.1	0.517
1/01/2017 1:28	2.177	0.1	0.52
1/01/2017 1:30	2.114	0.1	0.522
1/01/2017 1:32	2.049	0.1	0.523
1/01/2017 1:34	1.978	0.189	0.524
1/01/2017 1:36	1.876	0.619	0.525
1/01/2017 1:38	1.767	1.061	0.526
1/01/2017 1:40	1.647	1.056	0.527
1/01/2017 1:42	1.506	1.04	0.528
1/01/2017 1:44	1.403	0.39	0.53
1/01/2017 1:46	1.344	0.546	0.532
1/01/2017 1:48	1.311	0.785	0.533
1/01/2017 1:50	1.315	1.03	0.534
1/01/2017 1:52	1.327	1.149	0.536
1/01/2017 1:54	1.332	1.186	0.536
1/01/2017 1:56	1.339	1.212	0.536
1/01/2017 1:58	1.35	1.179	0.537
1/01/2017 2:00	1.358	1.223	0.539
1/01/2017 2:02	1.386	1.342	0.54
1/01/2017 2:04	1.435	1.469	0.541
1/01/2017 2:06	1.465	1.539	0.543
1/01/2017 2:08	1.482	1.481	0.544
1/01/2017 2:10	1.478	1.482	0.545
1/01/2017 2:12	1.415	1.47	0.546
1/01/2017 2:14	1.325	1.495	0.547
1/01/2017 2:16	1.238	1.504	0.548

1/01/2017 2:18	1.16	1.476	0.549
1/01/2017 2:20	1.104	1.407	0.55
1/01/2017 2:22	1.071	1.403	0.552
1/01/2017 2:24	1.038	1.467	0.553
1/01/2017 2:26	1.002	1.505	0.556
1/01/2017 2:28	0.972	1.543	0.558
1/01/2017 2:30	0.938	1.573	0.561
1/01/2017 2:32	0.913	1.638	0.564
1/01/2017 2:34	0.912	1.708	0.566
1/01/2017 2:36	0.912	1.758	0.569
1/01/2017 2:38	0.91	1.782	0.571
1/01/2017 2:40	0.914	1.841	0.574
1/01/2017 2:42	0.916	1.903	0.577
1/01/2017 2:44	0.918	1.956	0.58
1/01/2017 2:46	0.931	2.004	0.583
1/01/2017 2:48	0.952	2.04	0.586
1/01/2017 2:50	0.973	2.052	0.589
1/01/2017 2:52	0.991	2.086	0.591
1/01/2017 2:54	1	2.141	0.593
1/01/2017 2:56	1.006	2.206	0.595
1/01/2017 2:58	1.028	2.276	0.597
1/01/2017 3:00	1.064	2.363	0.6
1/01/2017 3:02	1.125	2.448	0.602
1/01/2017 3:04	1.212	2.528	0.605
1/01/2017 3:06	1.309	2.616	0.608
1/01/2017 3:08	1.396	2.708	0.611
1/01/2017 3:10	1.46	2.79	0.614
1/01/2017 3:12	1.495	2.869	0.617
1/01/2017 3:14	1.509	2.953	0.62
1/01/2017 3:16	1.52	3.039	0.624
1/01/2017 3:18	1.532	3.123	0.627
1/01/2017 3:20	1.546	3.2	0.631
1/01/2017 3:22	1.563	3.272	0.634
1/01/2017 3:24	1.563	3.343	0.638
1/01/2017 3:26	1.544	3.411	0.642
1/01/2017 3:28	1.516	3.472	0.646
1/01/2017 3:30	1.476	3.533	0.65
1/01/2017 3:32	1.448	3.61	0.654
1/01/2017 3:34	1.445	3.684	0.658
1/01/2017 3:36	1.467	3.753	0.663
1/01/2017 3:38	1.511	3.817	0.667
1/01/2017 3:40	1.569	3.88	0.67
1/01/2017 3:42	1.631	3.937	0.674
1/01/2017 3:44	1.692	3.999	0.679
1/01/2017 3:46	1.762	4.061	0.684
1/01/2017 3:48	1.832	4.113	0.689
1/01/2017 3:50	1.899	4.161	0.693
1/01/2017 3:52	1.965	4.216	0.698
1/01/2017 3:54	2.01	4.271	0.702
1/01/2017 3:56	2.035	4.323	0.707
1/01/2017 3:58	2.043	4.375	0.711
1/01/2017 4:00	2.033	4.429	0.716
1/01/2017 4:02	2.017	4.479	0.721
1/01/2017 4:04	2.003	4.527	0.727
1/01/2017 4:06	1.988	4.572	0.732
1/01/2017 4:08	1.964	4.607	0.738
1/01/2017 4:10	1.935	4.639	0.743
1/01/2017 4:12	1.897	4.675	0.748
1/01/2017 4:14	1.851	4.712	0.754
1/01/2017 4:16	1.815	4.751	0.76
1/01/2017 4:18	1.79	4.79	0.766
1/01/2017 4:20	1.773	4.826	0.771
1/01/2017 4:22	1.77	4.862	0.777
1/01/2017 4:24	1.768	4.885	0.784
1/01/2017 4:26	1.758	4.907	0.79
1/01/2017 4:28	1.737	4.934	0.796
1/01/2017 4:30	1.708	4.967	0.803
1/01/2017 4:32	1.672	5.004	0.809
1/01/2017 4:34	1.642	5.043	0.816
1/01/2017 4:36	1.62	5.083	0.822

1/01/2017 4:38	1.597	5.124	0.828
1/01/2017 4:40	1.578	5.166	0.834
1/01/2017 4:42	1.56	5.207	0.84
1/01/2017 4:44	1.54	5.248	0.846
1/01/2017 4:46	1.525	5.288	0.852
1/01/2017 4:48	1.519	5.33	0.858
1/01/2017 4:50	1.52	5.376	0.864
1/01/2017 4:52	1.525	5.422	0.87
1/01/2017 4:54	1.529	5.47	0.876
1/01/2017 4:56	1.527	5.519	0.882
1/01/2017 4:58	1.516	5.567	0.888
1/01/2017 5:00	1.5	5.617	0.894
1/01/2017 5:02	1.482	5.668	0.9
1/01/2017 5:04	1.465	5.716	0.907
1/01/2017 5:06	1.445	5.765	0.913
1/01/2017 5:08	1.417	5.817	0.92
1/01/2017 5:10	1.378	5.869	0.926
1/01/2017 5:12	1.324	5.922	0.933
1/01/2017 5:14	1.263	5.975	0.94
1/01/2017 5:16	1.204	6.032	0.946
1/01/2017 5:18	1.155	6.092	0.952
1/01/2017 5:20	1.125	6.161	0.959
1/01/2017 5:22	1.114	6.233	0.966
1/01/2017 5:24	1.118	6.309	0.972
1/01/2017 5:26	1.128	6.388	0.979
1/01/2017 5:28	1.142	6.471	0.986
1/01/2017 5:30	1.158	6.558	0.993
1/01/2017 5:32	1.177	6.653	0.999
1/01/2017 5:34	1.207	6.753	1.006
1/01/2017 5:36	1.247	6.856	1.013
1/01/2017 5:38	1.293	6.956	1.02
1/01/2017 5:40	1.34	7.053	1.027
1/01/2017 5:42	1.382	7.147	1.034
1/01/2017 5:44	1.413	7.239	1.041
1/01/2017 5:46	1.432	7.331	1.048
1/01/2017 5:48	1.444	7.414	1.055
1/01/2017 5:50	1.45	7.506	1.063
1/01/2017 5:52	1.454	7.602	1.07
1/01/2017 5:54	1.46	7.703	1.078
1/01/2017 5:56	1.463	7.812	1.086
1/01/2017 5:58	1.466	7.929	1.094
1/01/2017 6:00	1.472	8.034	1.102
1/01/2017 6:02	1.643	8.177	1.111
1/01/2017 6:04	1.835	8.342	1.12
1/01/2017 6:06	2.021	8.514	1.128
1/01/2017 6:08	2.206	8.703	1.137
1/01/2017 6:10	2.341	8.912	1.146
1/01/2017 6:12	2.416	9.116	1.154
1/01/2017 6:14	2.503	9.301	1.163
1/01/2017 6:16	2.61	9.495	1.171
1/01/2017 6:18	2.74	9.681	1.181
1/01/2017 6:20	2.867	9.863	1.189
1/01/2017 6:22	2.94	10.054	1.195
1/01/2017 6:24	2.942	10.242	1.204
1/01/2017 6:26	2.965	10.396	1.212
1/01/2017 6:28	2.966	10.528	1.221
1/01/2017 6:30	2.882	10.677	1.229
1/01/2017 6:32	2.841	10.799	1.239
1/01/2017 6:34	2.829	10.913	1.248
1/01/2017 6:36	2.81	11.016	1.257
1/01/2017 6:38	2.82	11.146	1.267
1/01/2017 6:40	2.865	11.297	1.277
1/01/2017 6:42	2.928	11.459	1.288
1/01/2017 6:44	3.001	11.641	1.3
1/01/2017 6:46	3.072	11.832	1.311
1/01/2017 6:48	3.147	12.024	1.323
1/01/2017 6:50	3.248	12.216	1.335
1/01/2017 6:52	3.322	12.406	1.348
1/01/2017 6:54	3.327	12.573	1.36
1/01/2017 6:56	3.307	12.717	1.372

1/01/2017 6:58	3.292	12.872	1.385
1/01/2017 7:00	3.273	13.035	1.399
1/01/2017 7:02	3.27	13.2	1.413
1/01/2017 7:04	3.3	13.303	1.428
1/01/2017 7:06	3.332	13.399	1.444
1/01/2017 7:08	3.36	13.515	1.459
1/01/2017 7:10	3.367	13.663	1.476
1/01/2017 7:12	3.36	13.83	1.492
1/01/2017 7:14	3.386	14.011	1.511
1/01/2017 7:16	3.439	14.201	1.529
1/01/2017 7:18	3.51	14.358	1.547
1/01/2017 7:20	3.62	14.513	1.566
1/01/2017 7:22	3.727	14.667	1.587
1/01/2017 7:24	3.796	14.784	1.608
1/01/2017 7:26	3.824	14.898	1.629
1/01/2017 7:28	3.813	14.983	1.653
1/01/2017 7:30	3.78	15.053	1.676
1/01/2017 7:32	3.739	15.164	1.7
1/01/2017 7:34	3.69	15.311	1.724
1/01/2017 7:36	3.612	15.48	1.749
1/01/2017 7:38	3.53	15.627	1.774
1/01/2017 7:40	3.442	15.757	1.801
1/01/2017 7:42	3.332	15.904	1.828
1/01/2017 7:44	3.256	16.061	1.856
1/01/2017 7:46	3.219	16.231	1.885
1/01/2017 7:48	3.204	16.417	1.917
1/01/2017 7:50	3.224	16.619	1.948
1/01/2017 7:52	3.26	16.832	1.981
1/01/2017 7:54	3.291	17.045	2.013
1/01/2017 7:56	3.33	17.209	2.046
1/01/2017 7:58	3.374	17.38	2.079
1/01/2017 8:00	3.41	17.549	2.113
1/01/2017 8:02	3.459	17.702	2.147
1/01/2017 8:04	3.525	17.852	2.182
1/01/2017 8:06	3.57	18.01	2.216
1/01/2017 8:08	3.6	18.155	2.253
1/01/2017 8:10	3.613	18.279	2.29
1/01/2017 8:12	3.571	18.396	2.328
1/01/2017 8:14	3.504	18.52	2.367
1/01/2017 8:16	3.442	18.613	2.405
1/01/2017 8:18	3.39	18.664	2.444
1/01/2017 8:20	3.362	18.746	2.484
1/01/2017 8:22	3.36	18.862	2.525
1/01/2017 8:24	3.361	18.999	2.567
1/01/2017 8:26	3.362	19.146	2.61
1/01/2017 8:28	3.37	19.285	2.654
1/01/2017 8:30	3.373	19.45	2.698
1/01/2017 8:32	3.382	19.641	2.744
1/01/2017 8:34	3.413	19.856	2.791
1/01/2017 8:36	3.446	20.063	2.84
1/01/2017 8:38	3.475	20.235	2.889
1/01/2017 8:40	3.507	20.438	2.941
1/01/2017 8:42	3.533	20.636	2.994
1/01/2017 8:44	3.549	20.812	3.05
1/01/2017 8:46	3.566	20.985	3.11
1/01/2017 8:48	3.581	21.167	3.173
1/01/2017 8:50	3.593	21.362	3.238
1/01/2017 8:52	3.603	21.569	3.305
1/01/2017 8:54	3.61	21.761	3.375
1/01/2017 8:56	3.619	21.936	3.448
1/01/2017 8:58	3.643	22.065	3.525
1/01/2017 9:00	3.676	22.084	3.604
1/01/2017 9:02	3.809	22.134	3.686
1/01/2017 9:04	3.964	22.254	3.771
1/01/2017 9:06	4.118	22.412	3.859
1/01/2017 9:08	4.264	22.54	3.948
1/01/2017 9:10	4.371	22.71	4.04
1/01/2017 9:12	4.431	22.921	4.132
1/01/2017 9:14	4.486	23.171	4.224
1/01/2017 9:16	4.547	23.457	4.316

1/01/2017 9:18	4.614	23.768	4.41
1/01/2017 9:20	4.676	24.05	4.504
1/01/2017 9:22	4.71	24.316	4.599
1/01/2017 9:24	4.697	24.584	4.699
1/01/2017 9:26	4.683	24.799	4.799
1/01/2017 9:28	4.654	24.995	4.897
1/01/2017 9:30	4.578	25.195	4.993
1/01/2017 9:32	4.536	25.393	5.088
1/01/2017 9:34	4.529	25.552	5.183
1/01/2017 9:36	4.534	25.665	5.276
1/01/2017 9:38	4.57	25.635	5.367
1/01/2017 9:40	4.633	25.699	5.456
1/01/2017 9:42	4.708	25.848	5.549
1/01/2017 9:44	4.786	26.065	5.643
1/01/2017 9:46	4.871	26.323	5.735
1/01/2017 9:48	4.961	26.512	5.823
1/01/2017 9:50	5.065	26.703	5.909
1/01/2017 9:52	5.161	26.908	5.993
1/01/2017 9:54	5.221	27.134	6.075
1/01/2017 9:56	5.265	27.384	6.16
1/01/2017 9:58	5.306	27.666	6.245
1/01/2017 10:00	5.332	27.893	6.328
1/01/2017 10:02	5.53	28.172	6.409
1/01/2017 10:04	5.757	28.502	6.49
1/01/2017 10:06	5.97	28.864	6.57
1/01/2017 10:08	6.168	29.244	6.649
1/01/2017 10:10	6.305	29.451	6.73
1/01/2017 10:12	6.378	29.374	6.811
1/01/2017 10:14	6.478	29.413	6.891
1/01/2017 10:16	6.61	29.541	6.97
1/01/2017 10:18	6.766	29.755	7.049
1/01/2017 10:20	6.934	30.045	7.128
1/01/2017 10:22	7.047	30.4	7.208
1/01/2017 10:24	7.078	30.708	7.293
1/01/2017 10:26	7.111	31.047	7.38
1/01/2017 10:28	7.111	31.445	7.465
1/01/2017 10:30	7.019	31.817	7.55
1/01/2017 10:32	6.973	32.113	7.635
1/01/2017 10:34	6.955	32.392	7.721
1/01/2017 10:36	6.928	32.629	7.809
1/01/2017 10:38	6.934	32.839	7.902
1/01/2017 10:40	6.965	32.955	7.997
1/01/2017 10:42	7.003	32.929	8.091
1/01/2017 10:44	7.063	33.012	8.185
1/01/2017 10:46	7.134	33.212	8.281
1/01/2017 10:48	7.218	33.459	8.376
1/01/2017 10:50	7.345	33.723	8.474
1/01/2017 10:52	7.465	34.054	8.578
1/01/2017 10:54	7.536	34.376	8.682
1/01/2017 10:56	7.599	34.685	8.786
1/01/2017 10:58	7.664	35.024	8.89
1/01/2017 11:00	7.709	35.383	8.994
1/01/2017 11:02	8.081	35.742	9.106
1/01/2017 11:04	8.504	36.178	9.219
1/01/2017 11:06	8.892	36.592	9.333
1/01/2017 11:08	9.258	36.858	9.446
1/01/2017 11:10	9.508	36.934	9.56
1/01/2017 11:12	9.625	37.177	9.68
1/01/2017 11:14	9.779	37.593	9.804
1/01/2017 11:16	9.98	38.104	9.928
1/01/2017 11:18	10.215	38.688	10.053
1/01/2017 11:20	10.474	39.197	10.181
1/01/2017 11:22	10.644	39.785	10.316
1/01/2017 11:24	10.677	40.446	10.454
1/01/2017 11:26	10.717	40.889	10.594
1/01/2017 11:28	10.703	41.025	10.737
1/01/2017 11:30	10.546	41.104	10.888
1/01/2017 11:32	11.114	41.514	11.044
1/01/2017 11:34	11.785	42.238	11.202
1/01/2017 11:36	12.398	43.021	11.368

1/01/2017 11:38	13.048	44.03	11.54
1/01/2017 11:40	13.547	44.797	11.718
1/01/2017 11:42	14.223	45.047	11.903
1/01/2017 11:44	14.999	45.27	12.096
1/01/2017 11:46	15.854	46.127	12.292
1/01/2017 11:48	16.755	47.421	12.492
1/01/2017 11:50	17.598	48.781	12.695
1/01/2017 11:52	19.631	49.183	12.907
1/01/2017 11:54	21.485	49.836	13.121
1/01/2017 11:56	23.237	51.539	13.344
1/01/2017 11:58	24.814	53.222	13.578
1/01/2017 12:00	25.666	53.692	13.821
1/01/2017 12:02	29.029	55.828	14.081
1/01/2017 12:04	32.629	57.777	14.355
1/01/2017 12:06	36.078	58.394	14.651
1/01/2017 12:08	39.429	60.847	14.972
1/01/2017 12:10	41.769	62.718	15.319
1/01/2017 12:12	38.985	63.543	15.687
1/01/2017 12:14	35.924	65.064	16.078
1/01/2017 12:16	33.618	67.466	16.491
1/01/2017 12:18	31.483	68.606	16.924
1/01/2017 12:20	30.161	69.006	17.384
1/01/2017 12:22	29.13	70.32	17.92
1/01/2017 12:24	27.221	72.158	18.482
1/01/2017 12:26	25.027	72.975	19.055
1/01/2017 12:28	22.489	73.841	19.642
1/01/2017 12:30	19.989	74.113	20.26
1/01/2017 12:32	18.738	75.38	20.908
1/01/2017 12:34	18.862	76.883	21.574
1/01/2017 12:36	19.201	77.855	22.262
1/01/2017 12:38	20.303	78.87	22.975
1/01/2017 12:40	22.271	79.303	23.783
1/01/2017 12:42	23.774	80.845	24.867
1/01/2017 12:44	25.095	82.921	26.121
1/01/2017 12:46	26.486	84.538	27.382
1/01/2017 12:48	27.692	85.484	28.692
1/01/2017 12:50	28.843	87.975	30.07
1/01/2017 12:52	29.794	89.734	31.602
1/01/2017 12:54	30.455	91.088	33.194
1/01/2017 12:56	30.884	93.473	34.848
1/01/2017 12:58	31.031	96.433	36.578
1/01/2017 13:00	30.935	97.918	38.357
1/01/2017 13:02	30.324	101.533	40.17
1/01/2017 13:04	29.722	102.792	42.01
1/01/2017 13:06	29.124	105.432	43.864
1/01/2017 13:08	28.559	107.485	45.738
1/01/2017 13:10	28.079	111.168	47.659
1/01/2017 13:12	27.683	113.063	49.676
1/01/2017 13:14	27.263	116.89	51.841
1/01/2017 13:16	26.828	118.804	54.142
1/01/2017 13:18	26.433	122.353	56.601
1/01/2017 13:20	26.172	124.908	59.237
1/01/2017 13:22	26.103	127.906	62.071
1/01/2017 13:24	26.198	131.365	65.057
1/01/2017 13:26	26.373	134.199	68.197
1/01/2017 13:28	26.624	138.521	71.45
1/01/2017 13:30	26.896	140.83	74.726
1/01/2017 13:32	27.131	145.478	77.996
1/01/2017 13:34	27.332	147.61	81.238
1/01/2017 13:36	27.518	152.21	84.46
1/01/2017 13:38	27.695	153.781	87.676
1/01/2017 13:40	27.853	156.941	90.897
1/01/2017 13:42	27.953	160.863	94.137
1/01/2017 13:44	27.994	165.42	97.39
1/01/2017 13:46	27.97	167.982	100.636
1/01/2017 13:48	27.876	167.044	103.849
1/01/2017 13:50	27.724	168.009	106.991
1/01/2017 13:52	27.545	176.897	109.936
1/01/2017 13:54	27.35	178.662	112.719
1/01/2017 13:56	27.143	186.906	115.372

1/01/2017 13:58	26.927	187.437	117.861
1/01/2017 14:00	26.716	183.773	120.176
1/01/2017 14:02	26.31	188.936	122.309
1/01/2017 14:04	25.903	185.734	124.246
1/01/2017 14:06	25.523	196.556	125.986
1/01/2017 14:08	25.163	194.594	127.523
1/01/2017 14:10	24.875	193.85	128.898
1/01/2017 14:12	24.649	209.67	130.081
1/01/2017 14:14	24.412	209.547	131.067
1/01/2017 14:16	24.171	223.599	131.858
1/01/2017 14:18	23.924	222.377	132.465
1/01/2017 14:20	23.688	221.191	132.889
1/01/2017 14:22	23.5	230.631	133.139
1/01/2017 14:24	23.357	229.173	133.227
1/01/2017 14:26	23.231	238.781	133.164
1/01/2017 14:28	23.129	237.654	132.962
1/01/2017 14:30	23.034	235.644	132.648
1/01/2017 14:32	22.927	244.581	132.246
1/01/2017 14:34	22.824	241.377	131.772
1/01/2017 14:36	22.735	249.787	131.235
1/01/2017 14:38	22.656	245.47	130.625
1/01/2017 14:40	22.599	241.579	129.937
1/01/2017 14:42	22.558	251.965	129.172
1/01/2017 14:44	22.534	249.47	128.332
1/01/2017 14:46	22.529	259.253	127.408
1/01/2017 14:48	22.544	255.733	126.391
1/01/2017 14:50	22.582	253.252	125.301
1/01/2017 14:52	22.647	260.892	124.146
1/01/2017 14:54	22.737	258.831	122.95
1/01/2017 14:56	22.85	267.144	121.726
1/01/2017 14:58	22.986	265.692	120.484
1/01/2017 15:00	23.143	266.683	119.225
1/01/2017 15:02	23.141	275.214	117.961
1/01/2017 15:04	23.153	275.031	116.691
1/01/2017 15:06	23.211	281.578	115.404
1/01/2017 15:08	23.311	281.824	114.103
1/01/2017 15:10	23.502	281.32	112.779
1/01/2017 15:12	23.771	288.41	111.425
1/01/2017 15:14	24.049	287.895	110.033
1/01/2017 15:16	24.346	293.381	108.595
1/01/2017 15:18	24.655	292.487	107.125
1/01/2017 15:20	24.999	292.334	105.618
1/01/2017 15:22	25.407	299.136	104.09
1/01/2017 15:24	25.855	299.017	102.542
1/01/2017 15:26	26.326	302.14	100.985
1/01/2017 15:28	26.826	301.96	99.433
1/01/2017 15:30	27.325	301.512	97.893
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1/01/2017 15:34	28.303	303.665	94.884
1/01/2017 15:36	28.795	305.602	93.442
1/01/2017 15:38	29.293	305.755	92.039
1/01/2017 15:40	29.799	305.864	90.672
1/01/2017 15:42	30.308	307.849	89.336
1/01/2017 15:44	30.809	307.835	88.032
1/01/2017 15:46	31.32	309.252	86.759
1/01/2017 15:48	31.848	309.125	85.512
1/01/2017 15:50	32.4	309.086	84.292
1/01/2017 15:52	32.98	310.05	83.095
1/01/2017 15:54	33.577	309.983	81.924
1/01/2017 15:56	34.183	310.246	80.78
1/01/2017 15:58	34.799	310.115	79.659
1/01/2017 16:00	35.407	309.983	78.558
1/01/2017 16:02	36.007	309.579	77.476
1/01/2017 16:04	36.594	309.459	76.41
1/01/2017 16:06	37.167	308.985	75.362
1/01/2017 16:08	37.728	308.851	74.332
1/01/2017 16:10	38.277	308.678	73.319
1/01/2017 16:12	38.817	307.674	72.324
1/01/2017 16:14	39.351	307.491	71.347
1/01/2017 16:16	39.883	306.271	70.389

1/01/2017 16:18	40.419	306.031	69.449
1/01/2017 16:20	40.954	305.828	68.527
1/01/2017 16:22	41.486	304.22	67.624
1/01/2017 16:24	42.015	304.008	66.739
1/01/2017 16:26	42.539	302.23	65.872
1/01/2017 16:28	43.06	302.108	65.025
1/01/2017 16:30	43.578	302.003	64.2
1/01/2017 16:32	44.102	299.976	63.393
1/01/2017 16:34	44.628	299.873	62.605
1/01/2017 16:36	45.153	297.718	61.834
1/01/2017 16:38	45.677	297.641	61.081
1/01/2017 16:40	46.203	297.571	60.343
1/01/2017 16:42	46.729	295.356	59.619
1/01/2017 16:44	47.254	295.291	58.91
1/01/2017 16:46	47.779	292.938	58.216
1/01/2017 16:48	48.303	292.875	57.536
1/01/2017 16:50	48.825	292.83	56.87
1/01/2017 16:52	49.342	290.223	56.215
1/01/2017 16:54	49.854	290.216	55.572
1/01/2017 16:56	50.362	287.418	54.941
1/01/2017 16:58	50.864	287.44	54.321
1/01/2017 17:00	51.359	287.55	53.713
1/01/2017 17:02	51.848	284.413	53.116
1/01/2017 17:04	52.332	284.487	52.53
1/01/2017 17:06	52.81	281.49	51.953
1/01/2017 17:08	53.283	281.556	51.387
1/01/2017 17:10	53.75	281.636	50.83
1/01/2017 17:12	54.212	278.168	50.283
1/01/2017 17:14	54.669	278.023	49.743
1/01/2017 17:16	55.121	274.957	49.21
1/01/2017 17:18	55.569	275.167	48.684
1/01/2017 17:20	56.015	275.341	48.165
1/01/2017 17:22	56.46	271.588	47.652
1/01/2017 17:24	56.905	271.668	47.145
1/01/2017 17:26	57.35	267.43	46.647
1/01/2017 17:28	57.797	267.977	46.158
1/01/2017 17:30	58.244	268.302	45.679
1/01/2017 17:32	58.692	264.531	45.208
1/01/2017 17:34	59.137	265.007	44.747
1/01/2017 17:36	59.579	260.417	44.295
1/01/2017 17:38	60.017	260.687	43.852
1/01/2017 17:40	60.451	260.947	43.418
1/01/2017 17:42	60.88	256.754	42.991
1/01/2017 17:44	61.307	257.458	42.573
1/01/2017 17:46	61.736	252.987	42.165
1/01/2017 17:48	62.164	253.771	41.767
1/01/2017 17:50	62.591	254.312	41.378
1/01/2017 17:52	63.012	249.126	40.998
1/01/2017 17:54	63.428	248.918	40.627
1/01/2017 17:56	63.838	247.13	40.265
1/01/2017 17:58	64.241	248.22	39.912
1/01/2017 18:00	64.637	249.097	39.57
1/01/2017 18:02	64.88	244.301	39.236
1/01/2017 18:04	65.116	245.479	38.912
1/01/2017 18:06	65.367	240.608	38.595
1/01/2017 18:08	65.628	241.947	38.288
1/01/2017 18:10	65.931	243.241	37.988
1/01/2017 18:12	66.261	238.72	37.701
1/01/2017 18:14	66.567	240.089	37.423
1/01/2017 18:16	66.863	235.877	37.155
1/01/2017 18:18	67.141	237.272	36.895
1/01/2017 18:20	67.422	238.007	36.643
1/01/2017 18:22	67.719	232.253	36.399
1/01/2017 18:24	68.023	232.756	36.164
1/01/2017 18:26	68.325	227.497	35.936
1/01/2017 18:28	68.622	226.336	35.717
1/01/2017 18:30	68.905	226.843	35.508
1/01/2017 18:32	69.168	221.762	35.308
1/01/2017 18:34	69.42	222.422	35.114
1/01/2017 18:36	69.657	217.221	34.927

1/01/2017 18:38	69.883	217.356	34.747
1/01/2017 18:40	70.098	217.719	34.572
1/01/2017 18:42	70.301	212.28	34.402
1/01/2017 18:44	70.491	213.025	34.238
1/01/2017 18:46	70.667	208.463	34.078
1/01/2017 18:48	70.83	208.584	33.922
1/01/2017 18:50	70.982	209.321	33.771
1/01/2017 18:52	71.124	203.746	33.623
1/01/2017 18:54	71.256	203.902	33.481
1/01/2017 18:56	71.378	197.935	33.343
1/01/2017 18:58	71.491	199.721	33.206
1/01/2017 19:00	71.595	200.136	33.071
1/01/2017 19:02	71.69	196.989	32.937
1/01/2017 19:04	71.777	196.444	32.805
1/01/2017 19:06	71.856	190.986	32.673
1/01/2017 19:08	71.928	190.485	32.543
1/01/2017 19:10	71.991	190.457	32.413
1/01/2017 19:12	72.046	185.967	32.284
1/01/2017 19:14	72.093	185.752	32.154
1/01/2017 19:16	72.132	181.618	32.024
1/01/2017 19:18	72.163	181.07	31.893
1/01/2017 19:20	72.188	181.078	31.761
1/01/2017 19:22	72.208	177.234	31.627
1/01/2017 19:24	72.222	177.59	31.494
1/01/2017 19:26	72.231	173.498	31.358
1/01/2017 19:28	72.235	173.759	31.22
1/01/2017 19:30	72.236	174.218	31.079
1/01/2017 19:32	72.232	170.729	30.936
1/01/2017 19:34	72.224	171.331	30.791
1/01/2017 19:36	72.212	167.547	30.644
1/01/2017 19:38	72.194	168.264	30.494
1/01/2017 19:40	72.17	169.344	30.342
1/01/2017 19:42	72.139	166.292	30.187
1/01/2017 19:44	72.102	167.559	30.03
1/01/2017 19:46	72.058	164.55	29.871
1/01/2017 19:48	72.01	165.795	29.713
1/01/2017 19:50	71.957	167.114	29.554
1/01/2017 19:52	71.899	164.477	29.394
1/01/2017 19:54	71.835	165.795	29.232
1/01/2017 19:56	71.765	162.841	29.068
1/01/2017 19:58	71.688	164.966	28.902
1/01/2017 20:00	71.607	165.274	28.733
1/01/2017 20:02	71.52	160.066	28.562
1/01/2017 20:04	71.43	159.663	28.388
1/01/2017 20:06	71.337	155.45	28.213
1/01/2017 20:08	71.241	155.159	28.037
1/01/2017 20:10	71.142	154.664	27.861
1/01/2017 20:12	71.04	150.782	27.689
1/01/2017 20:14	70.936	150.48	27.516
1/01/2017 20:16	70.831	148.214	27.341
1/01/2017 20:18	70.724	147.9	27.165
1/01/2017 20:20	70.614	147.662	26.988
1/01/2017 20:22	70.5	145.694	26.809
1/01/2017 20:24	70.382	145.739	26.631
1/01/2017 20:26	70.262	144.263	26.451
1/01/2017 20:28	70.141	144.599	26.273
1/01/2017 20:30	70.018	144.661	26.095
1/01/2017 20:32	69.895	142.567	25.923
1/01/2017 20:34	69.77	139.938	25.753
1/01/2017 20:36	69.643	136.952	25.583
1/01/2017 20:38	69.514	135.382	25.411
1/01/2017 20:40	69.384	134.617	25.24
1/01/2017 20:42	69.252	133.136	25.069
1/01/2017 20:44	69.117	132.211	24.899
1/01/2017 20:46	68.979	130.901	24.73
1/01/2017 20:48	68.837	130.176	24.562
1/01/2017 20:50	68.689	129.323	24.396
1/01/2017 20:52	68.536	127.708	24.231
1/01/2017 20:54	68.378	125.878	24.074
1/01/2017 20:56	68.214	124.051	23.918

1/01/2017 20:58	68.046	123.331	23.76
1/01/2017 21:00	67.873	122.195	23.602
1/01/2017 21:02	67.696	120.884	23.443
1/01/2017 21:04	67.517	118.942	23.284
1/01/2017 21:06	67.335	117.705	23.127
1/01/2017 21:08	67.149	117.228	22.971
1/01/2017 21:10	66.961	116.182	22.816
1/01/2017 21:12	66.768	115.093	22.663
1/01/2017 21:14	66.57	113.413	22.51
1/01/2017 21:16	66.37	112.329	22.368
1/01/2017 21:18	66.172	111.718	22.227
1/01/2017 21:20	65.978	110.999	22.085
1/01/2017 21:22	65.787	109.866	21.942
1/01/2017 21:24	65.597	108.717	21.799
1/01/2017 21:26	65.407	107.417	21.657
1/01/2017 21:28	65.215	106.64	21.516
1/01/2017 21:30	65.02	105.96	21.376
1/01/2017 21:32	64.823	105.164	21.238
1/01/2017 21:34	64.622	103.849	21.1
1/01/2017 21:36	64.417	103.004	20.963
1/01/2017 21:38	64.213	101.993	20.828
1/01/2017 21:40	64.013	101.281	20.708
1/01/2017 21:42	63.81	100.597	20.586
1/01/2017 21:44	63.605	100.074	20.464
1/01/2017 21:46	63.396	98.871	20.344
1/01/2017 21:48	63.181	98.025	20.226
1/01/2017 21:50	62.961	97.525	20.112
1/01/2017 21:52	62.733	96.661	19.999
1/01/2017 21:54	62.496	95.933	19.889
1/01/2017 21:56	62.25	95.38	19.781
1/01/2017 21:58	61.999	94.765	19.675
1/01/2017 22:00	61.741	93.743	19.571
1/01/2017 22:02	61.478	93.051	19.47
1/01/2017 22:04	61.209	92.68	19.37
1/01/2017 22:06	60.935	92.171	19.284
1/01/2017 22:08	60.657	91.491	19.197
1/01/2017 22:10	60.373	90.975	19.111
1/01/2017 22:12	60.084	90.516	19.026
1/01/2017 22:14	59.789	89.782	18.943
1/01/2017 22:16	59.487	88.992	18.863
1/01/2017 22:18	59.178	88.497	18.786
1/01/2017 22:20	58.866	88.203	18.71
1/01/2017 22:22	58.556	87.956	18.637
1/01/2017 22:24	58.252	87.51	18.565
1/01/2017 22:26	57.953	87.054	18.495
1/01/2017 22:28	57.664	86.397	18.427
1/01/2017 22:30	57.377	85.304	18.36
1/01/2017 22:32	57.09	84.615	18.296
1/01/2017 22:34	56.801	84.175	18.234
1/01/2017 22:36	56.509	83.887	18.184
1/01/2017 22:38	56.213	83.656	18.133
1/01/2017 22:40	55.914	83.479	18.082
1/01/2017 22:42	55.611	83.427	18.031
1/01/2017 22:44	55.305	82.668	17.982
1/01/2017 22:46	54.995	82.106	17.935
1/01/2017 22:48	54.674	81.469	17.888
1/01/2017 22:50	54.343	80.731	17.844
1/01/2017 22:52	54.008	80.388	17.8
1/01/2017 22:54	53.672	79.966	17.759
1/01/2017 22:56	53.338	79.742	17.718
1/01/2017 22:58	53.009	79.539	17.68
1/01/2017 23:00	52.685	79.38	17.651
1/01/2017 23:02	52.365	79.313	17.623
1/01/2017 23:04	52.048	79.334	17.595
1/01/2017 23:06	51.735	78.583	17.567
1/01/2017 23:08	51.424	77.938	17.539
1/01/2017 23:10	51.116	77.508	17.511
1/01/2017 23:12	50.819	76.872	17.485
1/01/2017 23:14	50.522	76.487	17.459
1/01/2017 23:16	50.229	76.074	17.433

1/01/2017 23:18	49.941	75.779	17.409
1/01/2017 23:20	49.657	75.464	17.385
1/01/2017 23:22	49.375	75.237	17.361
1/01/2017 23:24	49.097	75.097	17.339
1/01/2017 23:26	48.82	75.013	17.317
1/01/2017 23:28	48.544	74.938	17.296
1/01/2017 23:30	48.272	74.526	17.276
1/01/2017 23:32	48.001	73.961	17.256
1/01/2017 23:34	47.728	73.564	17.237
1/01/2017 23:36	47.455	73.077	17.219
1/01/2017 23:38	47.18	72.657	17.202
1/01/2017 23:40	46.905	72.31	17.185
1/01/2017 23:42	46.629	71.967	17.169
1/01/2017 23:44	46.355	71.619	17.154
1/01/2017 23:46	46.082	71.341	17.139
1/01/2017 23:48	45.81	71.173	17.125
1/01/2017 23:50	45.538	71.071	17.112
1/01/2017 23:52	45.266	70.982	17.099
1/01/2017 23:54	44.993	70.898	17.086
1/01/2017 23:56	44.721	70.785	17.075
1/01/2017 23:58	44.448	70.245	17.063
2/01/2017 0:00	44.175	69.893	17.052

APPENDIX B – DEVELOPMENT AND PLANNING CONTEXT

Regional Policy Statement

Section B2: Urban Growth and Form

Section B2 of the AUP sets out objectives and policies to address issues associated with urban growth and form in dealing with Auckland's growing population which increases demand for housing, employment, business, infrastructure, social facilities, and services. The growth needs to be provided in a way that addresses the following:

1. enhancing the quality of life for individuals and communities;
2. supporting integrated planning of land use, infrastructure and development;
3. optimising the efficient use of the existing urban area;
4. encouraging the efficient use of existing social facilities and provides for new social facilities;
5. enabling provision and use of infrastructure in a way that is efficient, effective and timely;
6. maintaining and enhancing the quality of the environment, both natural and built;
7. maintaining opportunities for rural production; and
8. enabling Mana Whenua to participate and their culture and values to be recognised and provided for.

The development of this SMP, through a collaborative effort with various stakeholders, will address the relevant issues on the list to ensure a viable outcome for urban growth and form.

Section B7: Natural Resources

Section B7 of the AUP recognises that the combination of urban growth and past land, coastal and freshwater management practices have:

1. placed increasing pressure on land and water resources including habitats and biodiversity;
2. reduced air quality; and
3. increased demand for mineral resources.

The pressures on natural resources need to be managed not only for environmental well-being but also for social, economic, and cultural well-being.

In addressing these, this section has laid out objectives and policies for:

- Indigenous biodiversity
- Freshwater systems
- Coastal water, freshwater, and geothermal water and
- Air

Section B10: Environmental Risk

Section B10 of the AUP sets policies, objectives to address environmental risk issues covering the following:

- Natural hazards and climate change
- Hazardous substances
- Contaminated land and
- Genetically modified organisms

Auckland wide provisions

The general AUP policies for management of stormwater and flooding are covered in Section E – Auckland wide rules, namely:

-
- Section E1 – Water quality and integrated management.
 - Section E8 – Diversion and discharge.
 - Section E36 – Natural hazards and flooding.

Policy 9 in Section E1 (Policy E1.3.9) sets out the following policies for management of stormwater runoff from redevelopment of existing urban areas:

- Minimise or mitigate new adverse effects of stormwater runoff; and where practicable progressively reduce existing adverse effects of stormwater runoff, on freshwater systems, freshwater and coastal waters during intensification and redevelopment of existing urban areas by all the following:
 - Requiring measures to reduce contaminants, particularly from high contaminate-generating car parks and high use roads;
 - Requiring measures to reduce the discharge of gross stormwater pollutants;
 - Requiring measures to be adopted to reduce the peak flow rate and volume of stormwater flows:
 - Within sites identified in the Stormwater Management Area – Flow 1 and Flow 2 Control (as shown on the planning maps)
 - Where development exceeds the maximum impervious area for the relevant zone; or
 - From areas of impervious surface where discharges may give rise to flooding or adversely affect rivers and streams;
 - Taking an integrated stormwater management approach for large-scale and comprehensive redevelopment and intensification (refer to Policy E1.3.10) and encourage the restoration of freshwater systems where practicable; and
 - Ensuring intensification is supported by appropriate stormwater infrastructure, including natural assets that are utilised for stormwater conveyance and overland flow paths.

The other relevant policies from Section E1 are summarised briefly below:

- Discharges must avoid contamination that will have an adverse effect on the life supporting capacity of freshwater (Policy E1.3.4).
- Discharges must avoid contamination that will have an adverse effect on health of people and communities (Policy E1.3.5).
- An integrated stormwater management approach (Policy E1.3.10) must have regard to all of the following:
 - The nature and scale of the development and practical and cost considerations.
 - The location and design of site and infrastructure to protect significant site features and minimise effects on receiving environments.
 - The nature and sensitivity of receiving environments.
 - Reducing stormwater flows and contaminants at source.
 - The use and enhancement of natural hydrological features and green infrastructure where practicable.
 - Manage contaminants in stormwater runoff from high contaminant generating carparks (> 30 cars) and high use roads (>5000 vehicles per day) to minimise adverse effects on water and sediment quality (Policy E1.3.12).
 - Require Stormwater quality or flow management to be achieved on-site unless there is a downstream communal device (Policy E1.3.13).

-
- Adopt the best practicable option to minimise the adverse effects of stormwater discharges (Policy E1.3.14).

Section E8 provisions are broadly divided into two groups. Stormwater runoff from impervious areas is either:

- diverted and directed to a stormwater network or the combined sewer network; or
- diverted and discharged to land, water or the coastal marine area.

The rules in this section regulate the diversion and discharge of stormwater runoff from impervious areas into or onto land or into water or into the coastal marine area pursuant to sections 14 and 15 of the Resource Management Act 1991.

Section E36 sets out the policies relating to management of natural hazards and flooding. The relevant policies are summarised briefly below:

- Avoid locating buildings in the 100yr ARI floodplain (Policy E36.3.17).
- Earthworks within the 100yr ARI floodplain should not permanently reduce floodplain conveyance or exacerbate flooding experienced by other sites upstream or downstream (Policy E36.3.20).
- Ensure all development in the 100yr floodplain does not increase adverse effects or increased flood depths and velocities to other properties upstream or downstream of the site (Policy E36.3.21).
- Required the storage and containment of hazardous substances in floodplains so that the integrity of the storage method will not be compromised in a flood event (Policy E36.3.22).
- Provide for flood mitigation measures which reduce flood-related effects and provide for the reconstruction of culverts and bridges where those measures do not create or exacerbate flooding upstream or downstream or otherwise increase flood hazards (Policy E36.3.23).
- Enable the planting and retention of vegetation cover to enhance amenity values, green linkages and ecological values in floodplains as long as it does not create or exacerbate flooding upstream or downstream or otherwise increase flood hazards (Policy E36.3.24).
- When considering mitigation of flood hazards where buildings are located in floodplains, promote measures such as use of water-resistant materials and flood-proof utility connections to increase resilience to flood damage (Policy E36.3.25).
- Construct accessways, including private roads, so that flood hazard risks are not increased (Policy E36.3.26).
- Enable the construction and maintenance of flood mitigation works to reduce flood risks to people, property, infrastructure and the environment (Policy E36.3.27).
- Take into account any authorised earthworks or drainage infrastructure which avoids, remedies or mitigates flood hazards when assessing proposed subdivision, use or development (Policy E36.3.28).
- Maintain the function and capacity of overland flow paths to convey stormwater runoff safely and without damage to the receiving environment (Policy E36.3.29) and Policy E36.3.30).

Regionwide stormwater network discharge consent

The regionwide stormwater NDC is a tool for managing and integrating land use, stormwater discharge and the region's natural water assets to mitigate the impacts of climate change and flooding.

Schedule 2

Schedule 2 of the NDC sets out the objectives and outcomes for discharge of stormwater within the Auckland region. The key objectives of Schedule 2 are:

- Safe Communities – Reduce risk to people, property, and infrastructure.

-
- Healthy and Connected Waterways that Provide for Te Mauri O Te Wai – Enhance value of streams, groundwater and coastal water and restore te mauri o te wai.
 - Support Growth – Provide quality stormwater infrastructure through water sensitive design.
 - Collaborative Outcomes - Engage stakeholders to achieve best practicable stormwater outcomes.
 - Prioritised Investment – maximise benefits by targeting best practicable outcomes.
 - Efficient Business – Deliver stormwater systems through robust systems, practices and processes.

The key outcomes of Schedule 2 are:

- Manage erosion effects caused by discharges from the public stormwater infrastructure (Assets O1.2)
- Improve existing assets by taking opportunities from redevelopment where they arise (Assets O1.3)
- Integrate water sensitive design into new and major re-development (Growth O2.2)
- Enable effective land use and stormwater management planning and co-operation between developers and infrastructure providers (Growth O2.3)
- Avoid the increase of existing flooding or creation of new flooding of habitable floors as a result of urban development and intensification (Flooding O3.1)
- Reduce existing flood risk by taking opportunities from redevelopment where they arise (Flooding O3.2)
- Enhance urban streams and waterways by working collaboratively with key stakeholders such as Mana Whenua, Local Boards, Community Groups and the development community to take opportunities where they arise (Stream Health O4.2)
- Collaborate with Council departments and CCOs that have key role delivering positive stormwater outcomes (Common to all Issues O8.1)
- Establish effective mechanisms for mana whenua to be appropriately engaged in stormwater management (Common to all Issues O8.2)

Schedule 4

Schedule 4 of the regionwide NDC outlines development requirements for greenfield developments within Auckland.

The requirements for water quality are as follows:

- Treatment of 100% impervious areas by a water quality device designed in accordance with GD01 for relevant contaminants.

For discharges to a stream via a public network outside of a stormwater management area – flow (SMAF):

- Achieve equivalent hydrology (infiltration, runoff volume, peak flow) to pre-development (grassed state) levels:
 - Provide retention (volume reduction) of a minimum of 5mm runoff depth for all impervious areas; and
 - Provide detention (temporary storage) with a draindown period of 24 hours for the difference between the pre-development (grassed state) and post-development runoff volumes from the 95th percentile, 24-hour rainfall event minus the retention volume for all impervious areas.

The requirements around property/ pipe capacity in the 10% AEP event are as follows:

- Ensure that there is sufficient capacity within the pipe network downstream of the connection point to cater for the stormwater runoff associated with the development in a 10% AEP event including incorporating flows from contributing catchments at maximum probable development.

Methods of ensuring sufficient capacity in the downstream pipe network include any one of the following:

- Demonstrating sufficient capacity is available including flows from the catchment (at maximum probable development) draining to the relevant pipe network in the 10% AEP event);
- Attenuating and reducing stormwater flows and volume on-site such that there is no increase in peak flow in a 10% AEP event from the site compared to that prior to the new development. Note that any devices associated with this option will also require an operation and maintenance plan to ensure the long-term efficacy of such a system;
- Upgrading the relevant pipe network to a size that can cater for the additional flows from the development in the 10% AEP event (taking into account existing flows from the contributing catchment); or
- Upgrading the relevant pipe network to a size that is larger than would otherwise be required to cater for the 10% AEP event for the development, due to the need to cater for flows from the contributing catchment at maximum probable development, subject to a fair and proportionate funding agreement with Healthy Waters.

The requirements around buildings in the 100yr ARI event are as follows:

- To development in accordance with SWCOP (V3 – January 2022).

If the above requirements on water quality, stream hydrology and flooding cannot be met, then an alternative level of mitigation determined through a SMP that:

- Applies an Integrated Stormwater Management Approach
- Meets the NDC Objectives and Outcomes in Schedule 2
- Is the BPO for the given project.

The site is classified as a greenfield site under the Regionwide stormwater network discharge consent (NDC), and thus requirements under Schedule 4 apply.

The requirements under the NDC are as follows:

Water quality

- Treatment of all impervious areas by a water quality device designed in accordance with GD01/TP10 for relevant contaminants.

Stream Hydrology

The site is not located within, but is adjacent, to a Stormwater Management Area Flow 1 (SMAF 1) area and discharges to a stream. Therefore, the following is required:

- Achieve equivalent hydrology (infiltration, runoff volume, peak flow) to pre-development (grassed state) levels:
 - Provide retention (volume reduction) of a minimum of 5mm runoff depth for all impervious surfaces; and
 - Provide detention (temporary storage) with a drain down period of 24 hours for the difference between pre-development (grassed state) and post-development runoff volumes from the 95th percentile, 24-hour rainfall event minus the retention volume for all impervious areas.

Flooding – Property/ pipe capacity 10% AEP event

- Ensure sufficient capacity in downstream network

As there are currently no piped stormwater network within the PPC area, the proposed network will be designed in accordance with Auckland Council Stormwater Code of Practice.

Flooding – Buildings 1% AEP event

- To be developed to Auckland Council Stormwater Code of Practice

If the above requirements on water quality, stream hydrology and flooding cannot be met, then an alternative level of mitigation can be determined through a SMP that:

- Applies an Integrated Stormwater Management Approach
- Meets the NDC Objectives and Outcomes in Schedule 2
- Is the BPO for the given project.

A summary of future urban development connection requirements for Greenfields can be seen in Figure B1 below.

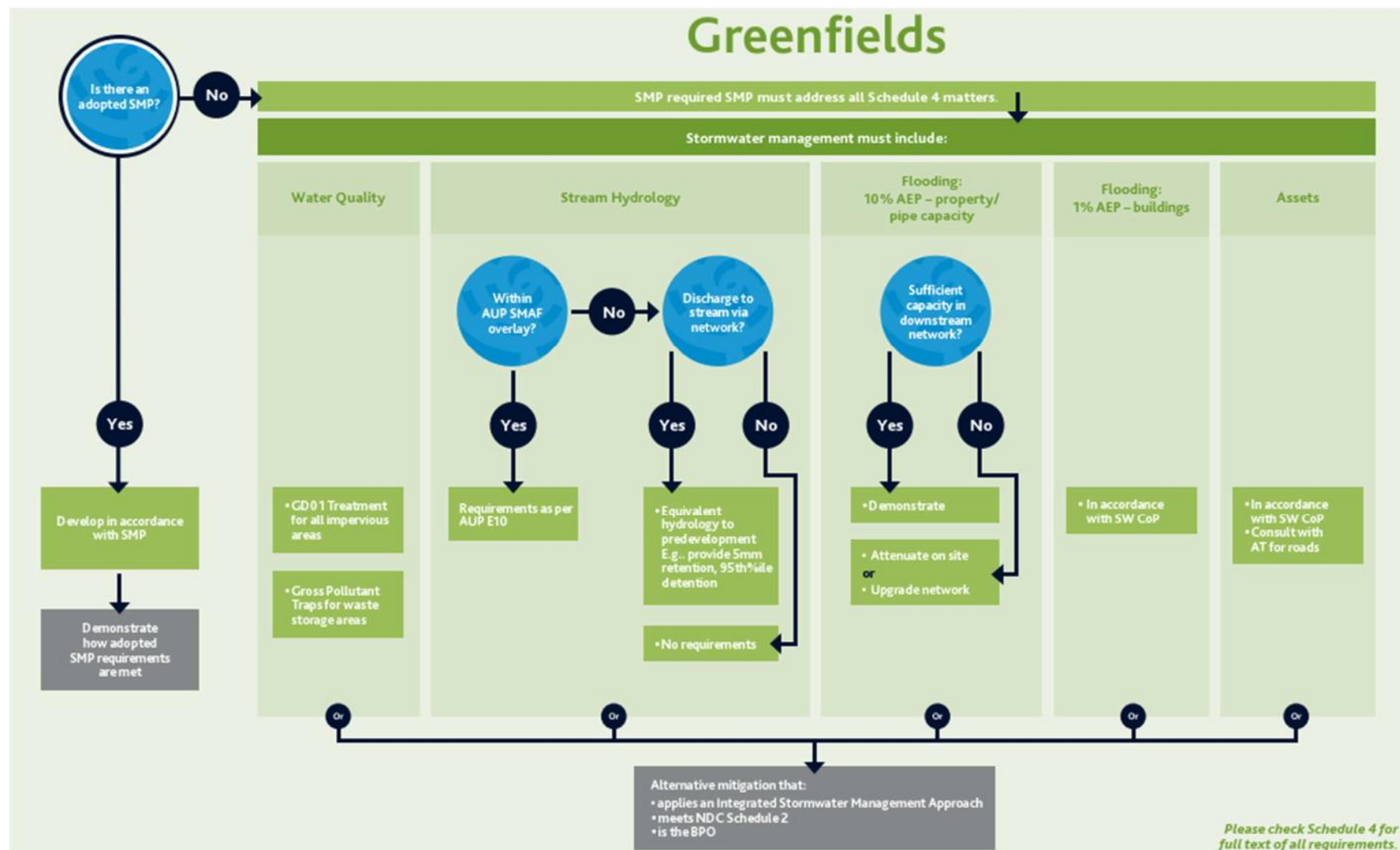


Figure B1: Greenfields Connection Requirements (Auckland Council Regionwide stormwater network discharge consent)

Opāheke – Drury Stormwater Management Plan – Preliminary Plan

The Opāheke -Drury Structure Plan area covers the Future Urban Zone (FUZ) areas around Drury Township and area south of Papakura and north of Pukekohe.

The Opāheke – Drury Stormwater Management Plan (FUZ SMP) has been prepared to support the Drury component of the Structure Plan South. The FUZ SMP covers three stormwater management areas: Drury West (Oiroa Creek and Ngākōroa Stream), Drury East (Hingaia Stream) and Opāheke (Slipper Creek).

The details regarding the stormwater management approach provided below are relevant to the Drury West, where the site is located.

1. Management approach mentioned in WSD (GD04) is considered to be the best practice for this region.
2. Flood management mitigation:
 - a. Adequate floodplain allowance – This indicated as route where conveyance and storage functions must be provided. The cumulative effects of development on these areas must be considered.
 - b. 1% AEP floodplain must be kept free of structures and development.
 - c. Developments to consider potential effects of climate change and MPD in the surrounding catchment in accordance with SWCOP.
 - d. Existing floodplain should be maintained.
3. Hydrology mitigation approach – All development must ensure pre-development hydrology for the wider catchment area is maintained. SMAF-1 is considered to provide good stormwater outcome.
4. Stream and Wetland management
 - a. Protection and enhancement of permanent and intermittent streams and wetlands during Greenfields development is required by AUP(OiP).
 - b. Riparian planting is to be progressively restored or enhanced to a minimum of 10m either side of the watercourse or wetland. The riparian margin width should be assessed by an ecologist to determine if an amended width is required.
 - c. Construction of erosion protection measures where erosion is currently an issue. Green infrastructure and soft engineering approaches should be considered in preference to engineered protection works.
 - d. Diffuse flows from smaller distributed stormwater outlets to the receiving environment better mimic natural drainage paths and reduce the risk of erosion that can result from single large point discharges.

Water sensitive design (GDo4)

GD04 is a guidance document by Auckland Council which introduces principles and objectives for Water Sensitive Design (WSD). These include inter-disciplinary design approach, using at-source stormwater management practices to mimic natural systems and protect functions of natural ecosystems. WSD approaches focus on reducing or eliminating stormwater runoff generation through source control and utilising natural systems and processes to manage stormwater quantity and quality effects. The objectives include:

- Reducing stormwater runoff - reduce stormwater runoff volume and peak flow to predevelopment levels.
- Managing stormwater quality - manage stormwater quality to avoid adverse environmental effects.

-
- Minimising soil disturbance - minimise sediment in stormwater runoff, especially during construction, and protect site soil resources from modification.
 - Promoting ecosystem health - promote the health of regional ecosystems and their associated environmental services through the management of stormwater at the catchment and site scale.
 - Delivering best practice - deliver best practice urban design and broader community outcomes as part of stormwater management delivery.
 - Maximising return on investment - achieve maximum value from stormwater management through the consideration of a broad range of benefits.

National Policy Statement of Freshwater Management 2020

The National Policy Statement of Freshwater Management 2020 (NPS-FM) came into effect in September 2020 and provides local authorities with direction on how to manage freshwater under the Resource Management Act 1991. The NPSFM is a first step to improve freshwater management at a national level. The previous NPS-FM released in 2014 and revised in 2017, set out some key requirements to manage freshwater resources. These include but not limited to the following:

- 'Consider and recognise' Te Mana o te Wai in freshwater management.
- Identify and reflect tangata whenua values and interests in the management of freshwater and in decision-making around freshwater planning.
- Safeguard freshwater's life-supporting capacity, ecosystem processes, and indigenous species
- Maintain or improve the overall quality of freshwater within a freshwater management unit but improve it where people recreate so that it is suitable for primary contact more often.
- Follow a specific process - the national objectives framework - for identifying the values that tangata whenua and communities have for water; use a specified set of water quality measures (called attributes) to set freshwater objectives to achieve those values; then set water quality and quantity limits on resource use (e.g., how much water can be taken or how much of a contaminant can be discharged) to meet the freshwater objectives over time and ensure they continue to be met.
- Protect the significant values of wetlands and outstanding freshwater bodies.
- Take an integrated approach to managing land use, freshwater and coastal water.

The 2020 version expanded on these requirements to include the following:

- Manage freshwater in a way that 'gives effect' to Te Mana o te Wai:
 - Through involving tangata whenua.
 - Working with tangata whenua and communities to set out long-term visions in the regional policy statement.
 - Prioritising the health and wellbeing of water bodies, then the essential needs of people, followed by other uses.
- Improve degraded water bodies and maintain or improve all others using bottom lines defined in the NPS.
- An expanded national objectives framework:
 - Two additional values - threatened species and mahinga kai - join ecosystem health and human health for recreation, as compulsory values.
 - Councils must develop plan objectives that describe the environmental outcome sought for all values (including an objective for each of the five individual components of ecosystem health)

-
- New attributes, aimed specifically at providing for ecosystem health, include fish index of biotic integrity (IBI), sediment, macroinvertebrates (MCI and QMCI), dissolved oxygen, ecosystem metabolism and submerged plants in lakes; councils will have to develop action plans and/or set limits on resource use to achieve these attributes.
 - Tougher national bottom lines for the ammonia and nitrate toxicity attributes to protect 95% of species from toxic effects (up from 80%)
 - No national bottom lines for dissolved inorganic nitrogen (DIN) or dissolved reactive phosphorus (DRP) (as consulted on) but there is a requirement to manage these attributes as they relate to periphyton and other ecosystem health attributes, and to provide for the health of downstream ecosystems.
 - Avoid any further loss or degradation of wetlands and streams, map existing wetlands and encourage their restoration.
 - Identify and work towards target outcomes for fish abundance, diversity and passage and address in-stream barriers to fish passage over time.
 - Set an aquatic life objective for fish and address in-stream barriers to fish passage over time.
 - Monitor and report annually on freshwater (including the data used); publish a synthesis report every five years containing a single ecosystem health score and respond to any deterioration.

APPENDIX C – SUMMARY OF ENGAGEMENT

Project: Karaka Road Plan Change – Ngāti te Ata hui – Stormwater and Ecology

Date: 20 May 2024

Time: 4:00-4:45pm

Location: Online via MS Teams

Attendees:

Name	Role/Organisation
Karl Flavell (KF)	Ngāti te Ata Waiohū
Matt Comery (MC)	Fisher & Paykel Healthcare
James Hui (JH)	Fisher & Paykel Healthcare
Pranil Wadan (PW)	Woods
Bidara Pathirage (BP)	Woods
Chris Wedding (CW)	BioResearches
Christel DuPreez (CD)	BioResearches
Nick Roberts (NR)	Barker & Associates
Cosette Pearson (CP)	Barker & Associates
Mary Wood (MW)	GHD

Item	Detail	Action
1	Stormwater Management Overview PW provided overview of Stormwater Management Plan prepared for the site (including the draft flood modelling and stormwater strategy) – refer to PowerPoint slides included as Attachment 1. PW covered off the extent that the SMP has been provided for, explaining the difference between the Structure Plan area and the Plan Change area, noting that the SMP has been prepared for the entire Structure Plan area extent, however may just apply to the Plan Change area, given that portion of the site is the only area subject to the Plan Change application currently being prepared. The Structure Plan area covers two separate catchments, those being the Ngākōroa catchment and the Oiroa catchment.	
2	Existing Culverts PW provided an overview of the existing culverts surrounding the Fisher & Paykel Healthcare site, including a number of which are under KiwiRail control (and located within the railway line	

	designation boundary. One of the outlets is an overflow of existing irrigation that glasshouses use. Structure 4 culvert which runs under SH22 is a Waka Kotahi owned asset.	
3	Stormwater Management Strategy PW provided an overview of the three parts that make up the broad stormwater strategy for the site, those being water quality (how this is managed), stream hydrology (retention / detention aspect) and the SMAF-1 standards requirement across the site and Flood management.	
4	Indicative Wetland Locations PW provided an overview of the indicative locations of the wetlands that may be required across the site and potential locations of where these could be located. PW did emphasise that these are shown as indicative only, for the purpose of illustrating potential locations and sizes, however these locations and sizes will be further refined and subject to change through the masterplanning process and as more detailed design is undertaken. KF queried whether all 'indicative wetlands' are proposed to be used for stormwater treatment, which PW confirmed would be the case.	
5	Site Locality and Flood Strategy PW provided an overview of the site's locality in the wider stream catchment context, noting that the site is located in the lower portion of the receiving environment / catchment. Given the sites location, the preferred flooding strategy is to pass flows forward, given that if you did attenuate this may coincide with peak flows from upstream of the site, resulting in an increased flooding impact, exacerbating the effects. PW concluded that letting the flows pass forward is the preferred option for the site, from a flooding effects perspective. PW provided more detailed overview of this to ensure that all understood the flood strategy.	
6	Flood Modelling PW noted that the no climate change, 2.1- and 3.8-degrees scenarios have been modelled, to ensure future resilience testing., as well as an extremely conservative 100% impervious surface area. The different scenarios modelled were; pre-development, 100% post – development, post development with pass flows forward and post development with pass flows forward and diversions in place. PW covered off the flood results on two separate plots – the first showing the post development flood depths, and the second showing the water level difference which would illustrate any flooding effects or impact of the proposed stormwater approach – of which, no additional flooding effects showed up.	

7

Ecology – Terrestrial

CW provided an overview of the terrestrial ecology of the site, as per the first half of the PowerPoint presentation slides included as **Attachment 2**.

CW noted that the first step on the ecological assessment was a desktop assessment (broad overview of the site, the bank landscape nature of the site), the second stage was a more detailed ecological assessment including monitoring and site walkover.

Vegetation

CW provided an overview of the vegetation on site – there is not a lot of native vegetation present, there is a strong presence of exotic vegetation, in particular along the Oiroa awa.

Indigenous Birds and Pekapeka (Long tailed Bats)

The birds observed on-site were common native bird species (common of those often found in the surrounding landscape) as well as some threatened weweia (dabchicks) associated with the ponds close to the Oiroa and the artificial ponds associated with the glasshouses.

CW noted that dabchicks do perform well in urban environments and on stormwater ponds / infrastructure therefore the current proposal for the site will protect the dabchick's habitat.

Pekapeka – surveys were initially undertaken close to the green corridor which picked up two passes, followed by an expanded survey across the wider site area which picked up 11 additional passes. Majority of activity recorded was associated with the green corridor along the Oiroa awa, with some activity recorded further out from the green corridor. No activity recorded relates to a *high* number of passes, and no evidence of roosting on-site was recorded.

CW did note that the activity recorded was not considered high, and additional pekapeka (bat) monitoring and surveys will be undertaken in the coming season to get a better understanding of how the pekapeka are using the area.

KF noted that CW should reach out to EcoQuest who are doing a lot of pekapeka (bat) monitoring and surveys and may be looking at this information from a more regional scale – which is important to understand. CW confirmed that they are sharing data through an online database, however not working with EcoQuest as of yet.

KF queried how much information sharing goes on in this space, KF is aware of a number of groups undertaking bat monitoring in the

	area and it is important to see the site in the wider context not from an isolated perspective. CW agreed, and noted that given they are a highly mobile species (not roosting for more than 2-3 days in one place) a regional scale survey would be a complex and costly experience, however agreed that more information sharing does need to occur. <i>Native Lizards</i> CW confirmed that while no native lizards were picked up on site, this is not to mean that there aren't any there. KF confirmed that they will be there, and that they will likely be aligned along the important green corridor along the western boundary that is to be protected (riparian margin of the Oiroa awa). CW confirmed a precautionary approach, given they are highly likely present on-site.	
8	Ecology – Freshwater features and wetlands CD provided an overview of the freshwater features on site (including wetlands), as per the second half of the PowerPoint presentation included as Attachment 2. CD noted that the main freshwater feature of the site is the Oiroa awa which runs along the southwester boundary. CD noted it is a lovely habitat for native fish species, and although none were recorded on-site, they have been recorded in the broader catchment, and therefore will likely pass through the site. CD noted that the vegetation along the Oiroa was not great, dominated by exotic species. The Oiroa tributary in the southwestern portion, combined with the Oiroa awa have moderate ecological value. CD provided a summary of natural inland wetlands, riverine wetlands associated with the awa, as well as artificial ponds located on-site. KF questioned what the artificial ponds were constructed for – noting that they are located around the glasshouses and therefore were likely associated with sediment control retention or detention, or used for irrigation purposes. KF queried whether there is an opportunity to naturalise and enhance the artificial ponds, and would be interested to understand the ecological integrity of the ponds – would be nice to know what is in them. KF recommended an exercise is undertaken to understand what is in the artificial ponds on-site.	
9.	Portion of Site zoned Rural – Mixed Rural Zone	

	KF queried what the strategic plan for the bottom quadrant (that being the portion of the site that is located outside of the Rural Urban Boundary and is zoned Rural – Mixed Rural zone) is? MC confirmed that this portion of the site will not be included within the Plan Change request to rezone the land for development, as it is not part of Fisher & Paykel’s short or even medium-term plans for development of the site. MC did note however that it could be built on in the future. KF noted that this section of the site protected for conservation purposes could be a legacy and considered a jewel for the region if protected as a conservation park. All agreed there are lots of existing opportunities across the site, in particular associated with the Oria awa for conservation and enhancement.	
10.	Next Steps KF is very keen to have a direct korero with MC and JR (FPH) over some kai, and be involved on an ongoing basis through all stages of master planning and plan change.	MC to arrange time between KF and JR to have further discussions.

Project: Karaka Road Plan Change – Fisher & Paykel Healthcare and KiwiRail Stormwater discussion

Date: 21 May 2024

Time: 2:30-3:30pm

Location: Online via MS Teams

Attendees:

Name	Role/Organisation
Karla Avila (KA)	KiwiRail
Bingling Mei (BM)	KiwiRail
Ross Kaufusi (RK)	KiwiRail
Pranil Wadan (PW)	Woods
Bidara Pathirage (BP)	Woods
Matt Comery (MC)	Fisher & Paykel Healthcare
James Hui (JH)	Fisher & Paykel Healthcare
Mary Wood (MW)	GHD
Cosette Pearson (CP)	Barker & Associates

Item	Detail	Action
1	PW shared a PowerPoint presentation, noting that the focus of this meeting will be particularly on KiwiRail assets, where the Fisher & Paykel Healthcare site borders with the railway line and the strategy proposed around those assets.	
2	CP provided a high-level overview of the proposed Structure Plan and Plan Change request for the site, providing all meeting attendees with context to what is proposed and what work has been undertaken to date, noting this work has been prepared to support a Private Plan Change request to rezone ~86.5ha of the site from Future urban zone to a Business – Light Industry zone.	
3	PW identified the existing stormwater structures adjacent to the site. The slides have been included as Attachment 1. The culverts at numbers 2, 3 and 5 are all KiwiRail assets. The red star has been identified at a location where there is overflow associated with the artificial ponds on the site, which are associated with irrigation and the glasshouses. Noting Structure 4 north of the site is a Waka Kotahi asset under SH22.	

4	Flooding Strategy PW provided an overview of the proposed development and the strategy to managing flooding. PW confirmed that no discharge of additional flows through the existing structures are proposed, the proposal looks to discharge through the structures based on what is already there. PW confirmed the strategies (pass flows forward with no impacts) for the two different catchments which apply to the site (Ngākōroa and Oiroa).	
5	Flood Modelling PW noted that the no climate change, 2.1- and 3.8-degrees scenarios have been modelled, to ensure future resilience testing, as well as an extremely conservative 100% impervious surface area.	
6	PW confirmed that there will be no additional flows through any of the existing KiwiRail structures. PW also spoke to the plot in Attachment 1 which shows the modelled flood depths plus a water level difference plot, which confirms there is no difference as a result of development. PW noted that there are some differences around the boundary of the site at the 10-year event, however this is not significant and this will be mitigated through the development process (noting that the 100% impervious surface that has been modelled will not be the case – more likely to be ~80% impervious surface).	
7	KiwiRail sought confirmation that there was no increase in flows to existing structures, to what is currently the case – PW confirmed this is correct.	
8	RK queried whether the assessment has been made in collaboration with the Drury Railway station team. PW noted that while this hasn't been done to date, the flows will need to be allowed for anyway (maintain base flows into current streams to discharge into the existing stream network). MC and JH both clarified that FPH have engaged in numerous conversations with KiwiRail over the past 18 months.	
9	KiwiRail queried how the pre-development flows into the KiwiRail culvert were calculated? PW clarified that based upon the proposal to divert, the flows are to be significantly less than what is currently being received at these culverts.	
10	KA noted that there appeared to be some discrepancies between the information in the SMP and the KiwiRail database on the sizes of the KiwiRail culverts. PW noted that the sizing was pulled from a mixture of surveying work, GeoMaps data as well as KiwiRail information.	

	All agreed that it would be useful to share information on the sizing of the culverts to ensure that all are working off the same (correct) data – especially where the culverts have been surveyed. PW and KA will share information between themselves to ensure consistency and accuracy.	PW and KA to share culvert sizing information.
11	BM requested a summary of the design philosophy (and the data around this) – back to pre-development for each culvert – to provide better clarity and so that KiwiRail can form an informed position. PW noted that a lot of this information is within the SMP, but confirmed he would circulate more information on the design philosophy. PW also noted the work undertaken is to assist with the Plan Change and therefore hard to provide exact data or numbers around flows as that would depend on the masterplanning. PW also clarified that maintaining flows is to maintain ecological values of the waterways.	PW / BP to provide summary of design philosophy.
12	KiwiRail queried the indicate wetland locations (in particular #7 in Attachment 1). PW clarified that there are very indicative (subject to change and refinement) and are dependent on the master planning process that has just commenced.	
13	RK noted the active modes corridor and four-track proposal. CP confirmed that we are in discussions with Andrew Swan re active mode connections and will work with KiwiRail on an ongoing basis – FPH will not preclude for a future active modes connection between the site and the Ngākōroa train station, however FPH do not own the land between the station and the eastern boundary of the FPH site. RK noted that as part of the four-tracking, KiwiRail will likely need to extend the culverts, and MC clarified that this will likely be ahead of development on the FPH site.	
14	Next Steps: Culvert Sizing Information - PW and KA to share culvert sizing information to ensure accuracy. Summary of Design Philosophy - PW / BP to provide a summary of the design philosophy (including calculations).	

Minutes

Project: Fisher & Paykel Healthcare Plan Change + Healthy Waters Meeting

Date: 31 May 2024

Time: 2:00-3:00pm

Location: Online via MS Teams

Attendees:

Name	Role/Organisation
Preetika Sing (PS)	Healthy Waters (Auckland Council)
Brooke Waterson (BW)	Healthy Waters (Auckland Council)
Danny Curtis (DC)	Healthy Waters (Auckland Council)
Lee Te (LT)	Healthy Waters (Auckland Council)
Pranil Wadan (PW)	Woods
Bidara Pathirage (BP)	Woods
Kobe Daniel (KD)	Woods
James Hui (JH)	Fisher & Paykel Healthcare
Cosette Pearson (CP)	Barker & Associates

Item	Detail	Action
1	Meeting started with a round of introductions	
2	General PW provided an overview of the stormwater management and flooding strategy for the site (Plan Change area), noting that the SMP has been pre-issued for comments. PW noted that the SMP is being updated based on a revised 80% impervious surface (conservative figure, and a standard for maximum building coverage will also be proposed as part of the Plan Change).	
3	Stream Erosion BW requested a copy of Bioresearches ecological assessment, and was interested in gaining a better understanding of the stream erosion assessment. PW confirmed that the commentary around stream erosion was more based upon observations of the existing stream banks and vegetation, PW also confirmed that he was happy to circulate the final ecological assessment.	PW to circulate final Ecological assessment for BW review.

	BW noted it would be helpful to go out and walkover the site, CP confirmed B&A happy to facilitate this with FPH and Healthy Waters staff.	BW to advise of preferred date for site visit and CP to facilitate access to the site.
4	Stormwater Management & Flooding – SMP review DC noted that he has undertaken a review of the pre-circulated SMP and is generally very happy with it. DC noted he was originally unclear on the two different areas (Structure Plan + Plan Change areas) however PW's earlier general overview has clarified this. DC noted mana whenua engagement important for the SMP being adopted by Auckland Council into the NDC – CP clarified that further mana whenua engagement had occurred following draft SMP, and will be ongoing throughout the duration of this project. DC noted the flow chart that sets out the proposed stormwater management strategy was very helpful in understanding the SMP and strategy, and requested this be included into the SMP. DC queried roof area and the required treatment. If re-use is not provided, where does the treatment come from – flow chart helpful for explaining the treatment train approach and hence to be included into SMP. PW clarified that if re-use is not achievable, all stormwater gets drained into the wetlands and treated – DC confirmed happy with this approach. Wetland sizing – confirmed that wetlands have been sized both for detention and retention. This needs to be clarified in the flow chart also. A smaller wetland in the proposal is queried – PW confirmed that the strategy proposes a shift to size for wetlands rather than large communal rain gardens due to feedback from Drury east developments. However, during detail design, the devices can be amended to be large raingardens if the wetland sizing is inadequate.	
5	Ownership & Maintenance PW confirmed that all stormwater management devices are private will be held in ownership of FPH and will be maintained by FPH – no stormwater devices to be vested with Auckland Council.	
6	Flooding Habitable floors are classed as commercial given the proposed zoning and use is for Business (Light Industry zone). DC noted he was unclear on the pre-development scenario and what this scenario is presenting. DC noted that he agrees with PW on the point that the site is extremely low down in the catchment, and passing flows forward is the most appropriate flood strategy given to location within the	

	wider catchment and to ensure flood flows from upper reaches of the catchment don't coincide with release of flows from this site, and noted that these results are believable. However, DC did request that pre-development scenario will need to be ED levels rather than MPD (undeveloped). DC has requested updated modelling undertaken to show pre-development scenario based on ED (existing impervious) rather than MPD. PW confirmed that this modelling has been done, and will provide this post-lodgement (w/c 10 June 2024).	PW to circulate modelling results post-lodgement based on pre-development scenario being MPD rather than ED.
7	Amendments to SMP reviewed DC noted a number of errors and amendments required to the SMP prior to lodgement, including duplication of a Figure (13 a copy of Figure 12), and run-ff depths added to a Table in section 8.2 (among other minor mark-ups). DC agreed to circulate his review comments of the SMP immediately following the meeting to help PW and BP with updating the SMP based on discussions.	

Project: Fisher & Paykel Healthcare Plan Change – Ngāti Tamaoho hui – stormwater management and provisions

Date: 4 June 2024

Time: 10:00-11:00am

Location: Online via MS Teams

Attendees:

Name	Role/Organisation
Edith Tuhimata (ET)	Ngāti Tamaoho
Lucie Rutherford (LR)	Ngāti Tamaoho
Dennis Kirkwood (DK)	Ngāti Tamaoho
Beau White (BW)	Ngāti Tamaoho
Matt Comery (MC)	Fisher & Paykel Healthcare
Katie Wright (KW)	Fisher & Paykel Healthcare
James Hui (JH)	Fisher & Paykel Healthcare
Pranil Wadan (PW)	Woods
Cosette Pearson (CP)	Barker & Associates
Nick Roberts (NR)	Barker & Associates

Item	Detail	Action
1	ET opened the hui with a karakia.	
2	LR noted that a preferred name for the Plan Change / Precinct has been agreed between Ngaati Te Ata Waiohua and Ngāti Tamaoho which is 'Oiroa'.	B&A team to circulate preferred name to all three mana whenua involved in this project for comment.
3	PW provided an overview of the stormwater management approach, and spoke to the overall stormwater and flood management strategy as per the slides included at Attachment 1 .	
4	Existing Farm ponds LR queried whether the existing farm ponds will be utilised as part of the stormwater management on-site. PW confirmed that the old farm ponds are not proposed to be used as part of the stormwater management. LR noted that regardless of whether the old farms ponds are being filled in, desludging and decontamination of the ponds will be required, and additional contamination assessment needs to be	

	undertaken to determine what is at the bottom of these ponds and what will be required to undertake decontamination.	
5	Pass Flows forward approach LR queried what Auckland Councils Healthy Waters department's view is of the proposed pass flows forward strategy. PW provided detail overview of how the pass flows forward strategy is preferred due to the site's location in the overall catchment (very low (in the bottom 20%)) of the overall catchment. PW clarified that the team has met with Healthy Waters and Healthy Waters are supportive of the proposed stormwater management strategy put forward through the SMP and as part of this PC application. The proposed approach is also consistent with the wider SMP prepared for the Councils Drury-Opāheke Structure Plan (2019) which proposed pass flows forward for this site. PW confirmed that there are no greater impacts as a result of FPH development pushing flows downstream (no flood effects increased), as it means that water is not held back and released at the same time as the rest of the catchment flows down, and means that water is in and out of the site quickly, before flows coincide with flows from the upper reaches of the catchment, avoiding an exacerbated and coincided flooding impact. LR noted that she would need to clarify Councils view on this approach. While LR noted that the expectation would be attenuation, PW clarified that attenuation in this location would likely result in flood impacts and given the sites location flows should be passed forward to ensure flooding is not exacerbated. PW also provided overview of the strategy both from a water quality (multi stage treatment train approach) and pass flows forward to catchment flows from a flooding strategy.	
6	Proposed Provisions NR provided an overview of the proposed provisions, in particular those relating to the stormwater management, man whenua values, riparian planting, maximum impervious surface and the archaeological alter layer (full set of draft provisions included as Attachment 2).	

	Amendments to the Informing Iwi Standard (to reference Te Waiohū), the archaeological alert layer reference and the naming of the Oiroa awa in the Riparian Planting standard were discussed and made during the hui. NR confirmed that the provisions are the beginning from a working with mana whenua perspective, and FPH will involve mana whenua through all stages of masterplanning of the site. BW queried who undertook the archaeological assessment. CP confirmed it was Hans-Dieter Bader and will circulate the archaeology report prepare in support of the Plan Change (refer Attachment 3). NR also confirmed that the stormwater management approach is similar to what has been agreed as BPO approach in other Drury greenfield PCs – LR confirmed it is helpful having consistent specialists involved who support a consistent approach across the area.	
7	Water Quality Monitoring LR noted that it is important for mana whenua to undertake pre-works water quality testing to understanding the baseline, MC and NR agreed this was good idea and would be facilitated, noting that works are not due to commence on the site for a number of years yet.	
8	Riparian Planting ET queried who will be doing the planting along the waterways. MC noted that it will take a long time to plant as there is over 3km of waterways across the site – LR noted it is important that all iwi are in agreement before planting taken too much further forward, and when people are working close to the waterways (including planting) they need to have some cultural understanding. Nic Bishop from FPH sustainability team is preparing a strategy document focused on best practice and making sure FPH are doing things on-site correctly, this will include planting plans and management of water.	
9	Ngāti Tamaoho CVA NR queried when we can anticipate to receive Ngāti Tamaoho's CVA, noting that we will be lodging the Plan Change request with Auckland Council this Friday 7 June. DK expressed that some internal korero will need to be undertaken following this hui before it can be finalised, and ET noted that this would be picked up immediately, and a CVA will aim to be finalised in the next couple of days.	ET and DK finalising CVA prior to lodgement of PC request on Friday 7 June.
10	ET closed the hui with a Karakia.	

Minutes of the Hui between Fisher & Paykel Healthcare and Ngāti Tamaoho

Held on FRIDAY 23 AUGUST 2024, Ngāti Tamaoho offices, commencing at 2:00PM.

Present: Matekino Marshall (MM)
Edith Tuhimata (ET)
Lucie Rutherford (LR, online)
Jonti Rhodes (JR)

Matt Comery (MC)
Nic Bishop (NB)
Veronica Matheson (VM)

MINUTES

Karakia: Matekino Marshall.

MM opened the hui and stated that Ngāti Tamaoho was committed to developing a relationship with F&P Healthcare and doing that through conversation.

MM said it would be good to formalise our approach, so we have some guidance when we reach a stalemate.

JR agreed and reiterated F&P’s approach to this development including mana whenua.

CULTURAL VALUES ASSESMENT

ET said the treatment of stormwater is very important to Ngāti Tamaoho due to this development being in two catchments. MM agreed and said he supported the Ngāti Tamaoho environment team in matters where they felt strongly.

LR said that it wasn’t until the Waipupuke development was lodged that the Council did not support pass flow forward approach to stormwater treatment.

MC stated that full modelling on the Waipupuke development was not done and that land was set aside for attenuation *if* it was

needed. F&P has done full modelling and our specialists have advised that Balu would have come to the same conclusion (that pass flow forward was the best solution) when full modelling for Waipupuke was completed.

However, MC also stated that F&P did not have a preference on either strategy and wanted to take a best for awa approach. If attenuation is shown to be best for awa, F&P will adopt that solution.

JR and ET asked LR if a second opinion or independent assessment with a specialist of her choice would provide assurance. LR agreed that it would and recommended Mark Lewis.

Action: MC to confirm with LR the approach for an independent assessment of stormwater treatment and facilitate .

LR said that the bar should be set that there is no more of an impact on the stream post-development, than there is pre-development.

NB said that part of the opportunity is to improve the flow of the Oiroa Stream where it is poor, improve water quality and get the awa back to a better state. He said it was complex to meet a high bar of no additional impact without first understanding what is best for the awa, the impact of climate change over the next 40 years, and the impact of flow from higher up the catchment.

JR stated that to meet that bar, it was F&P’s responsibility to put controls in place to ensure no more of an impact occurred post development. He asked that Ngāti Tamaoho provide advice on how they would measure “no further impact post developmmnet”.

LR, ET and MM agreed to make the following amendment to the Cultural Values Assessment, with an additional secondary paragraph as suggested by JR:

“[Ngāti Tamaoho] are not opposed providing there is no more impact post-development than pre-development, particularly in stormwater quantity discharge from the site.

Ngāti Tamaoho and Fisher & Paykel Healthcare agree to a mutual commitment to co-develop solutions to ensure that the awa achieves and maintains a healthy state.”

PARTNERSHIP AGREEMENT

MM reiterated that Ngāti Tamaoho is committed to a relationship with F&P and wants to see it work but that he would also back his team who are dedicated to meeting the needs of Tamaoho.

MM said the best way to resolve issues is through kōrero/discussion.

He asked that these fundamentals be captured as founding or guiding principles to keep us together as partners going forward.

ET suggested that this acts as a living document as the relationship grows and can endure as people leave and our grandchildren take up the work around the table.

ET said her wish list for the partnership includes:

- Understanding on-site water treatment so that they can be adopted on marae
- Funding for charcoal treatment to improve water quality
- Identifying another space for a plant nursery within 5-10 years.

NB stated that it is important to have clarity between each other about what “environmental impact” means and how it is defined.

He added that it would be good to reference a framework for water quality in our agreement together.

LR said that differences in opinion existed in all relationships, and it was important to find a way to meet in the middle.

Action: VM to begin drafting Guiding Principles for the relationship between Ngāti Tamaoho and F&P Healthcare going forward. Share with this group by mid-September 2024 pending the next hui.

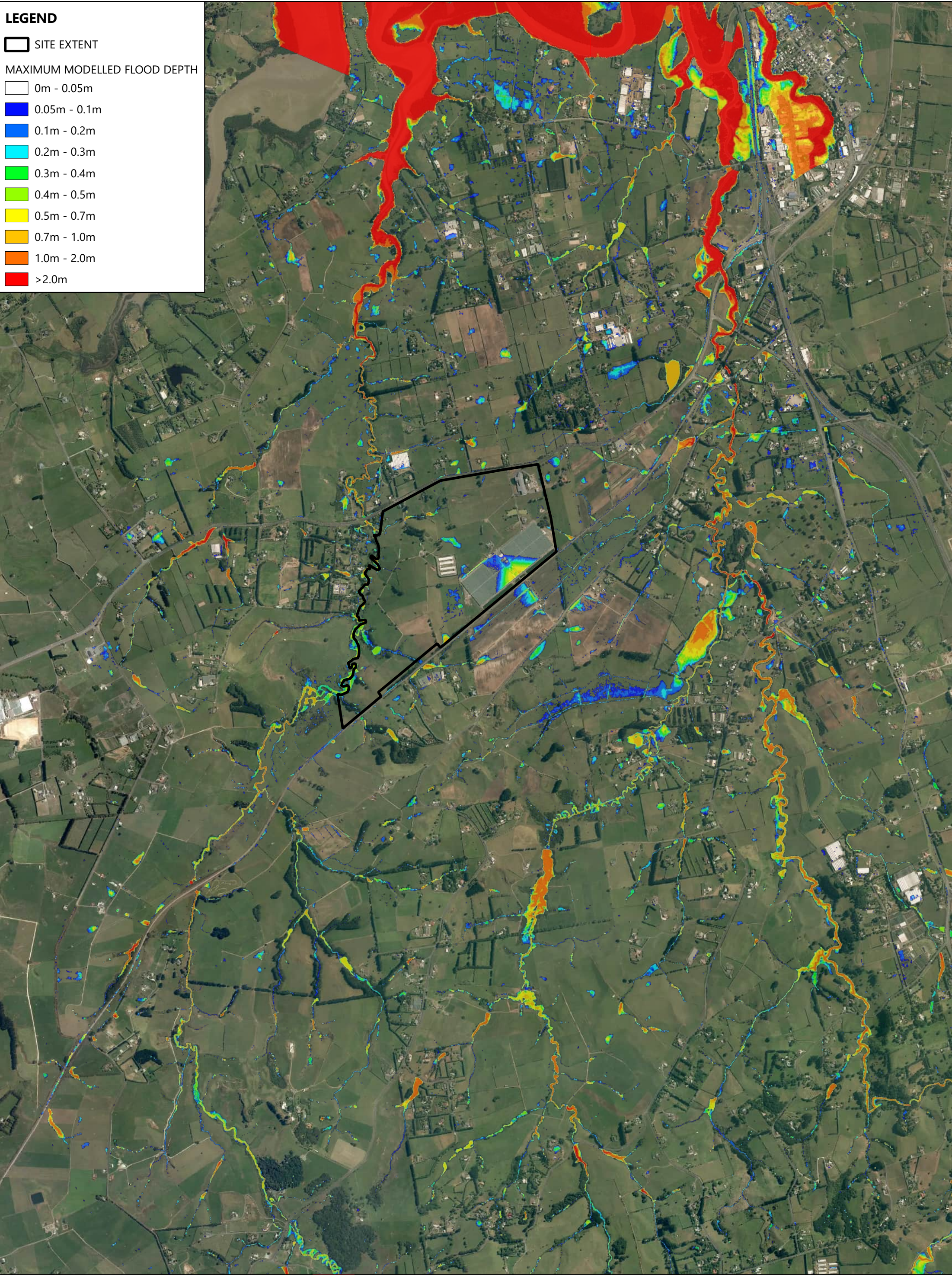
Karakia: Matekino Marshall.

NEXT MEETING

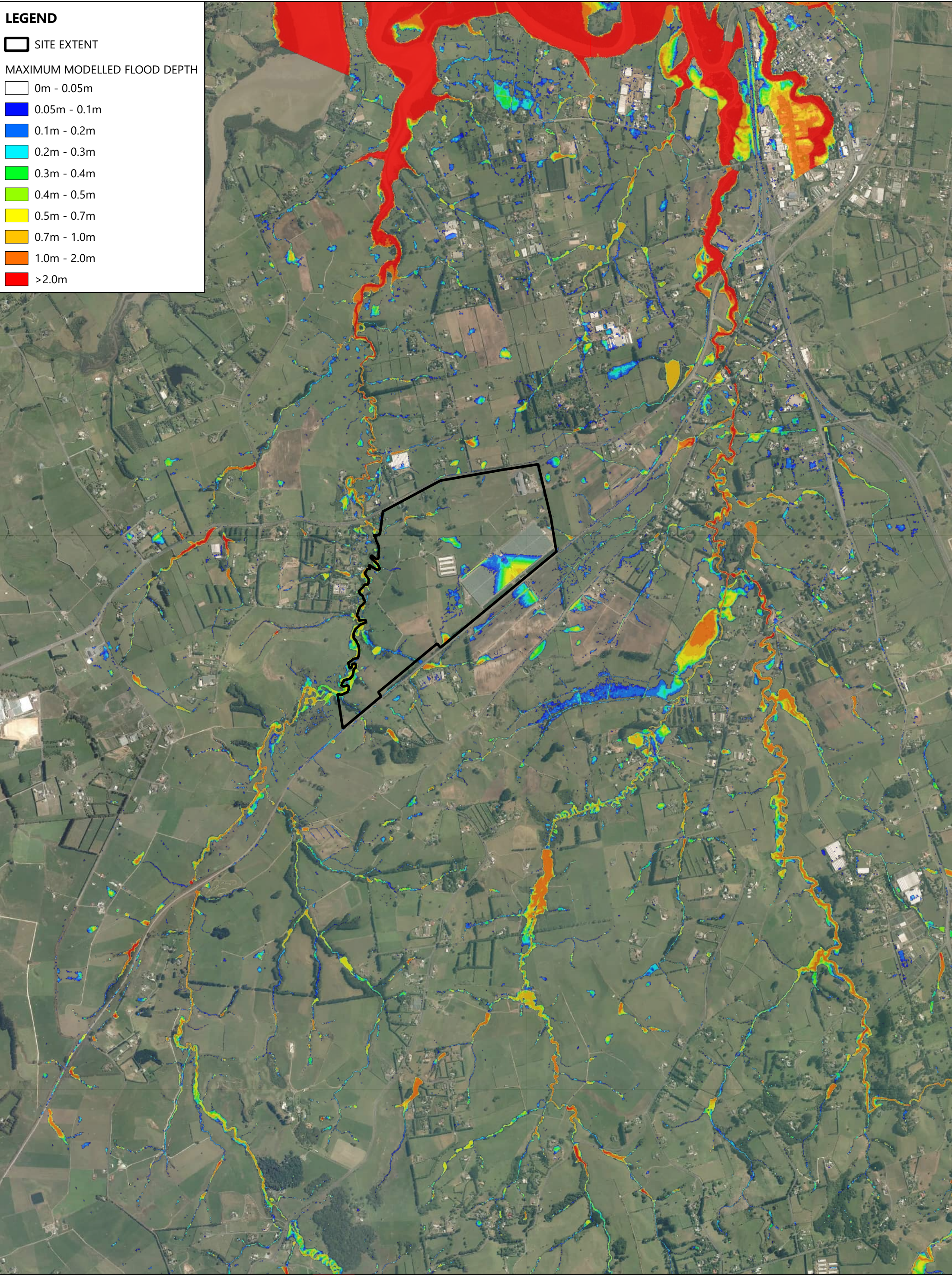
Next hui TBC.

Hui scheduled for Tuesday 3 September with Ngāti Tamaoho Settlement Trust Board members and F&P / F&P Foundation representatives will be rescheduled to a later date.

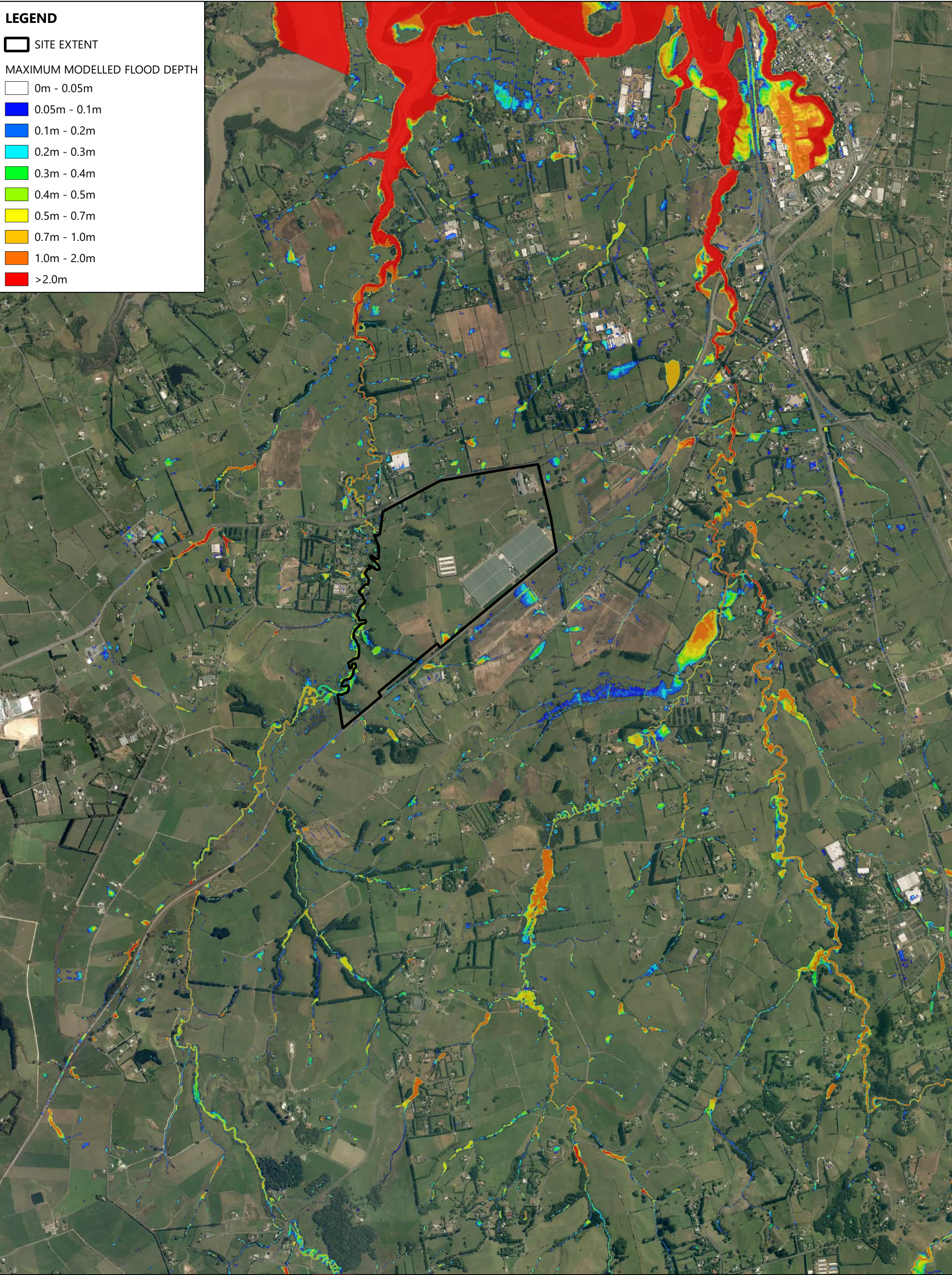
APPENDIX D – FLOOD MODEL RESULTS (DEPTH PLOTS AND AFFLUX)



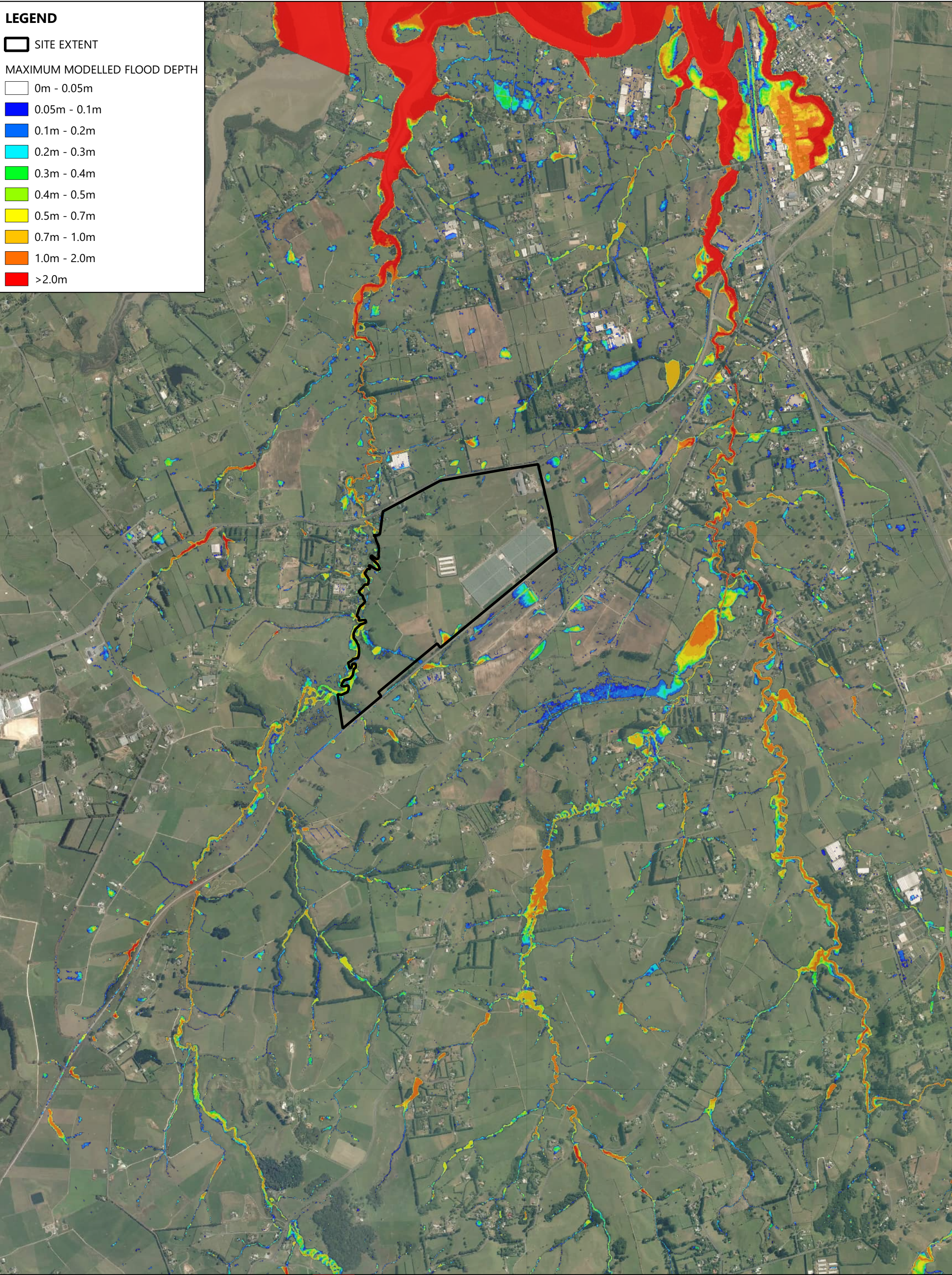
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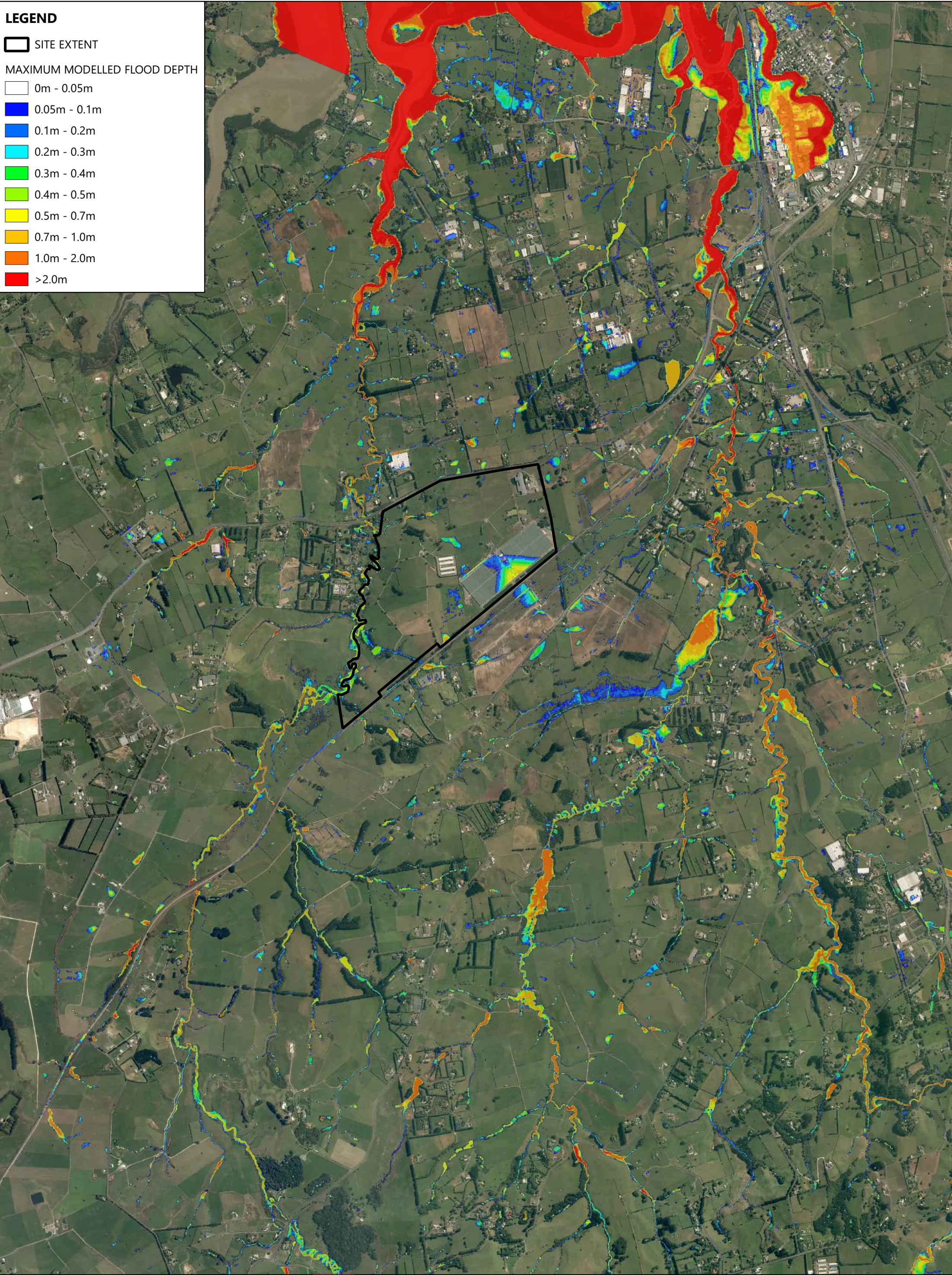


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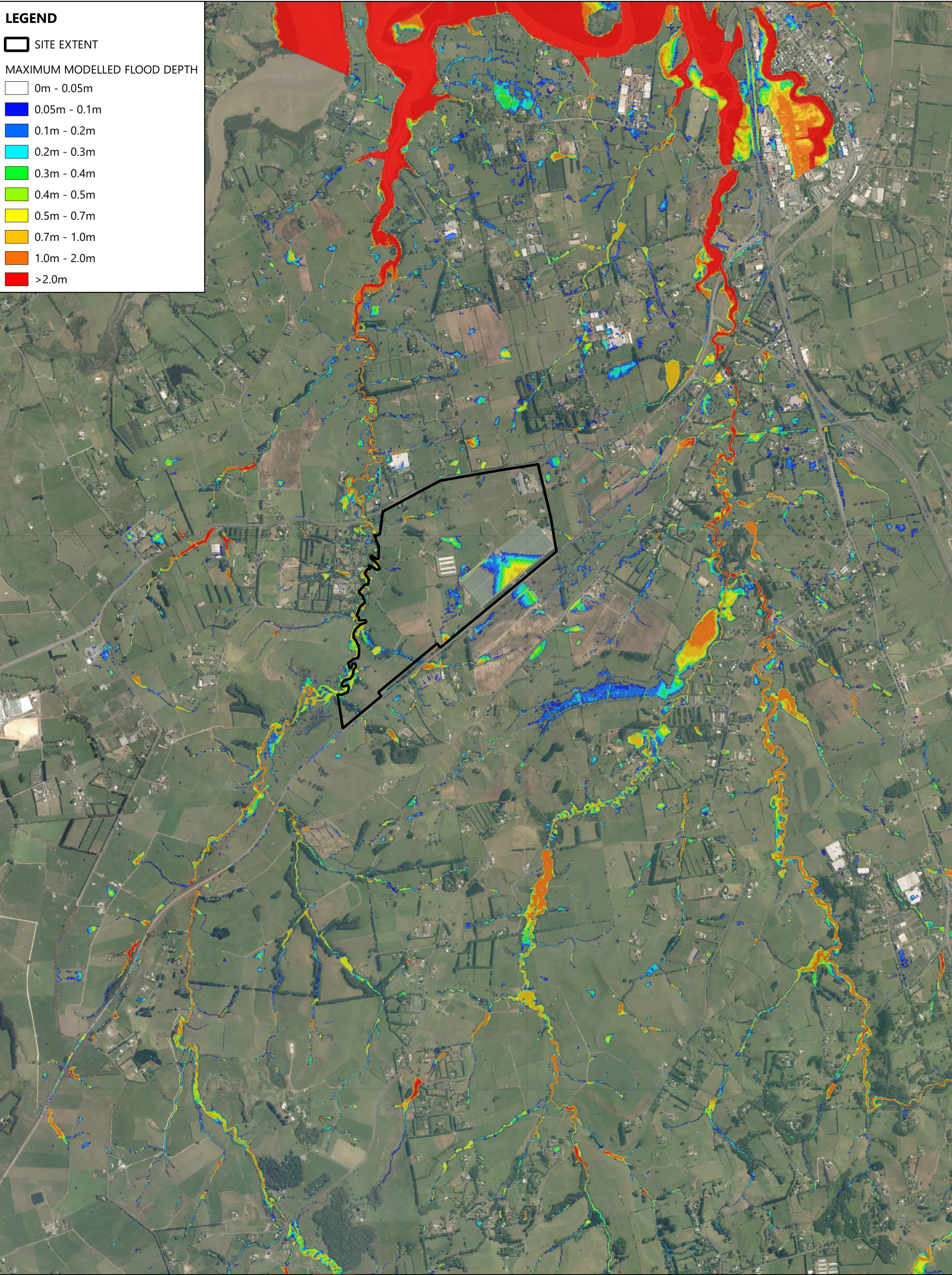


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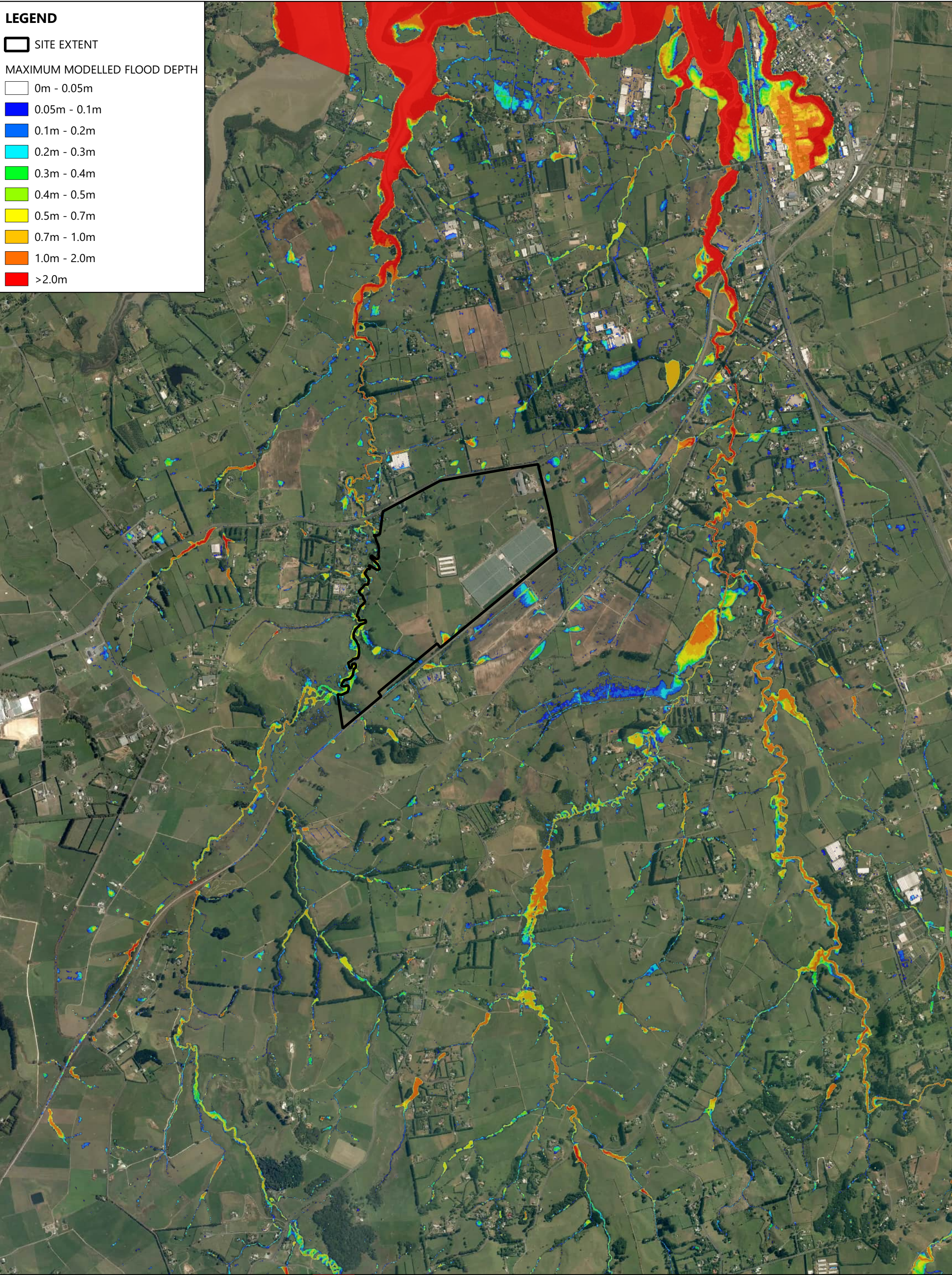
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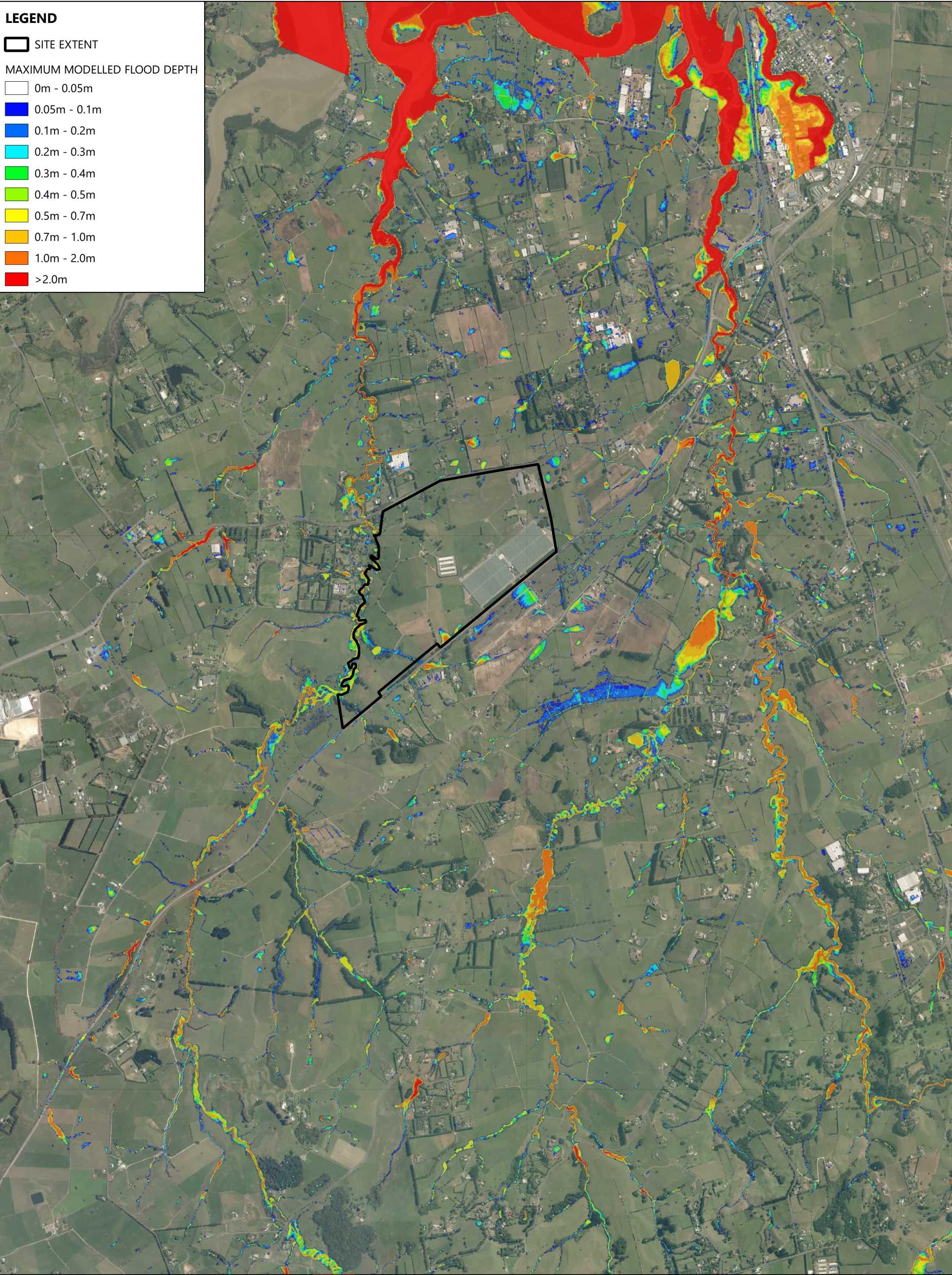
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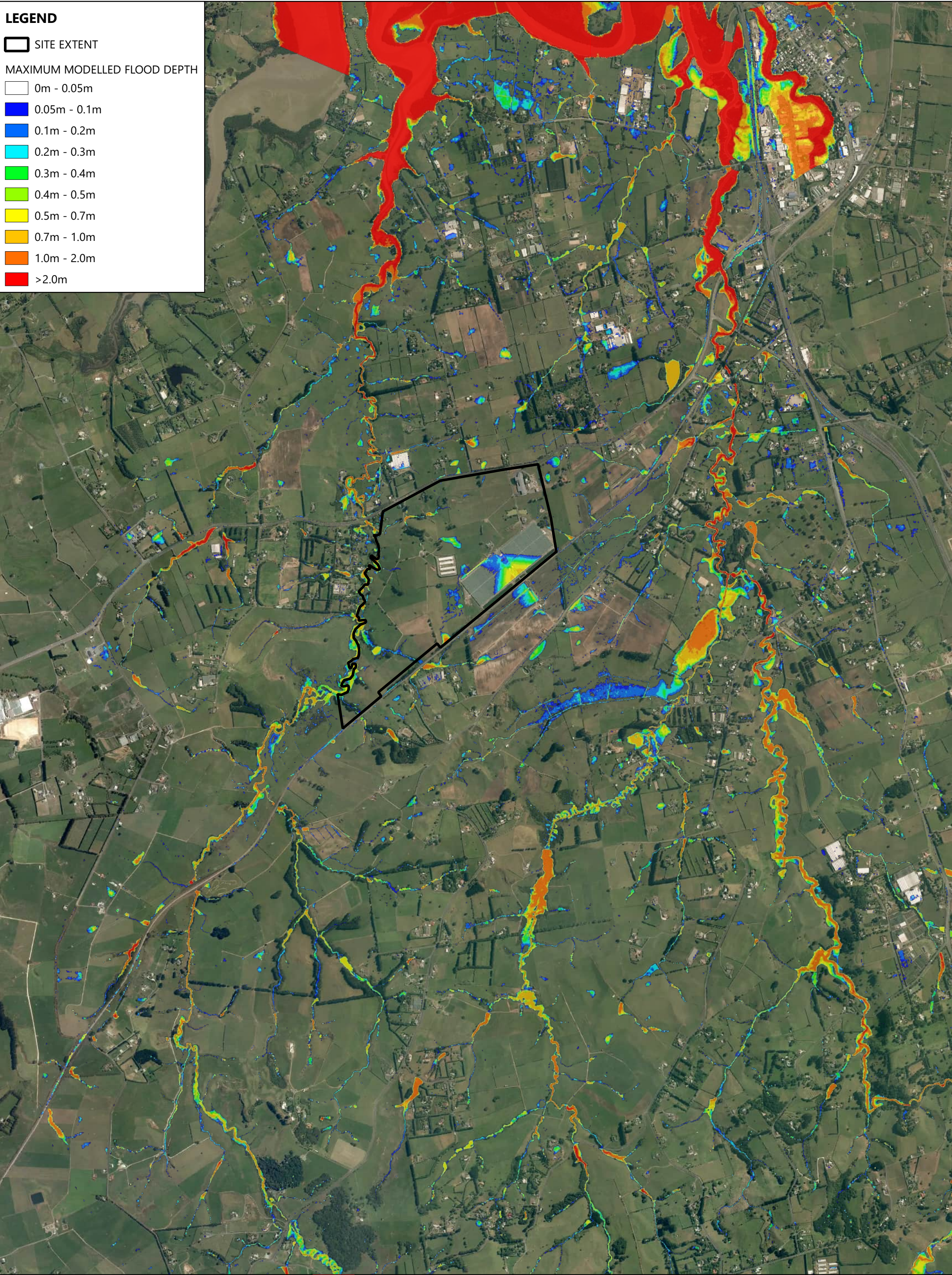


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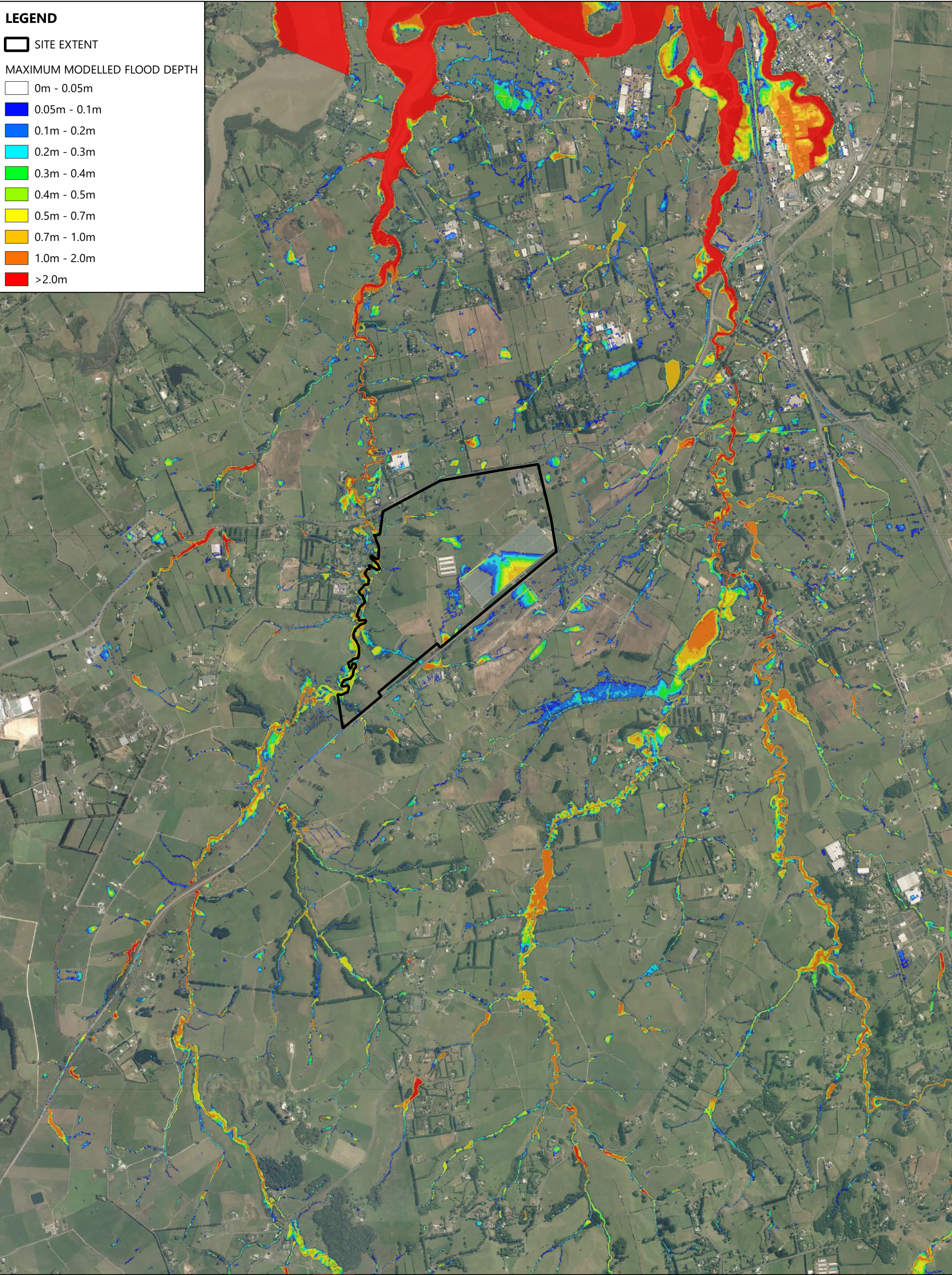
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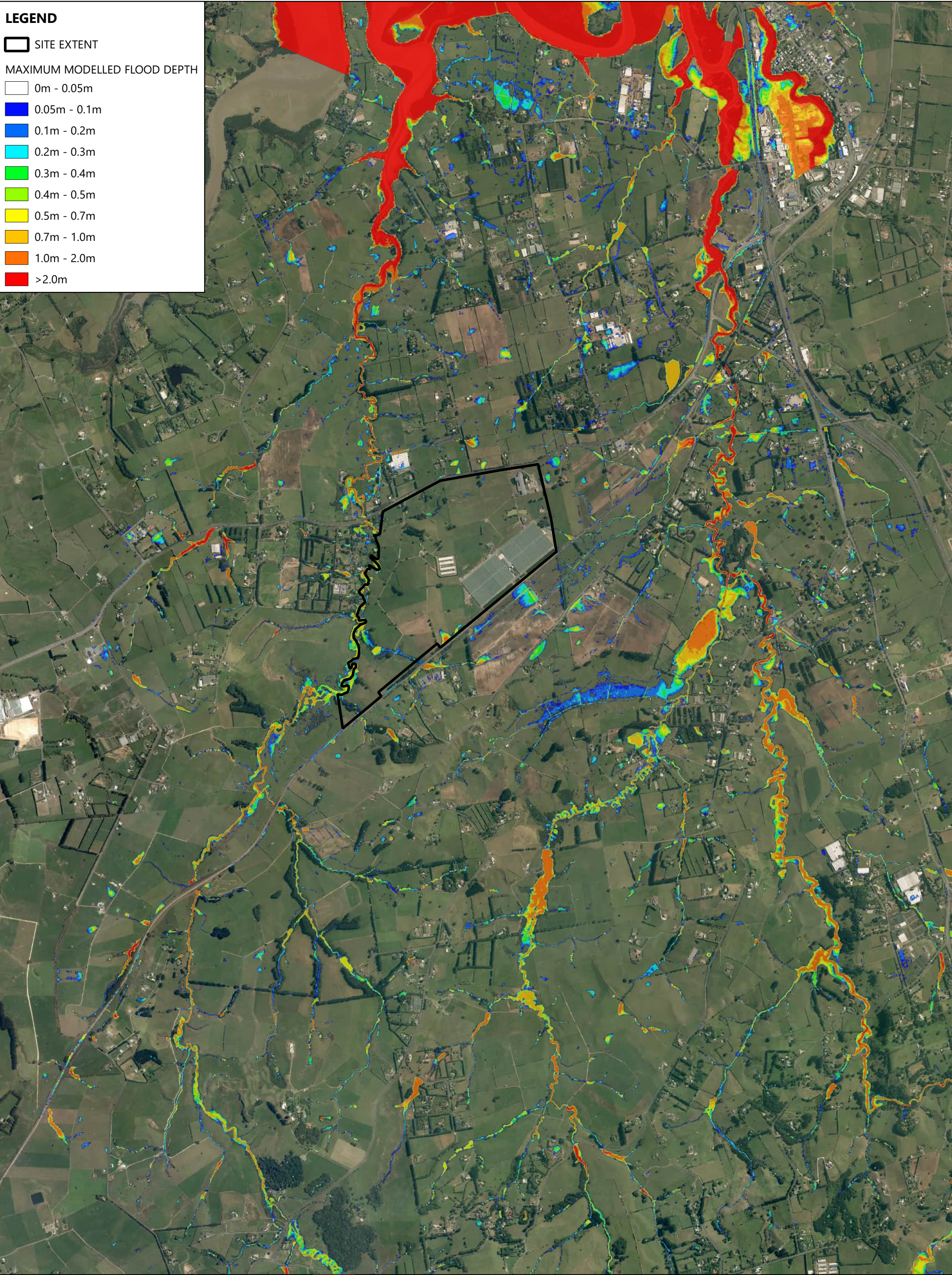
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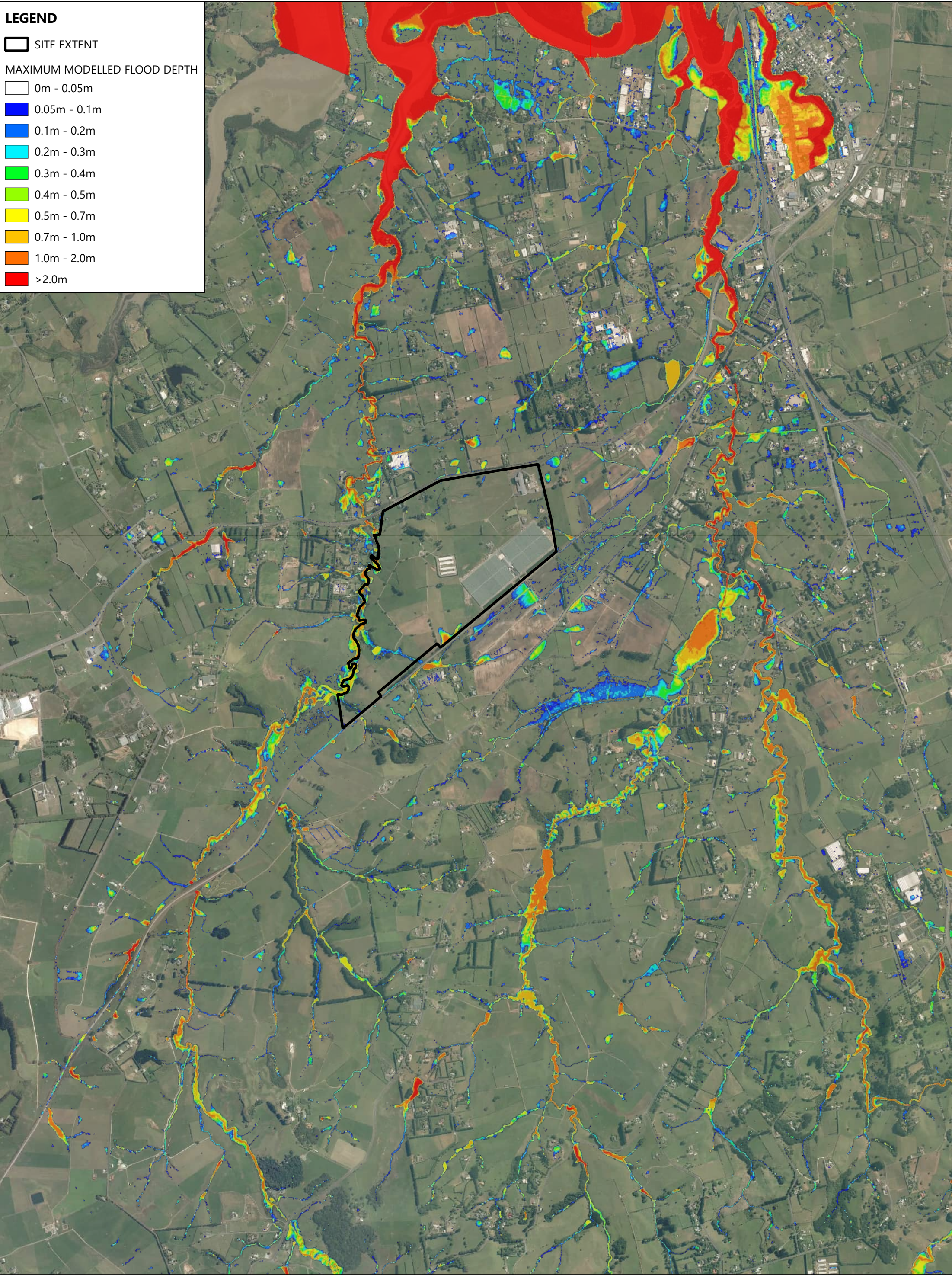
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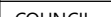
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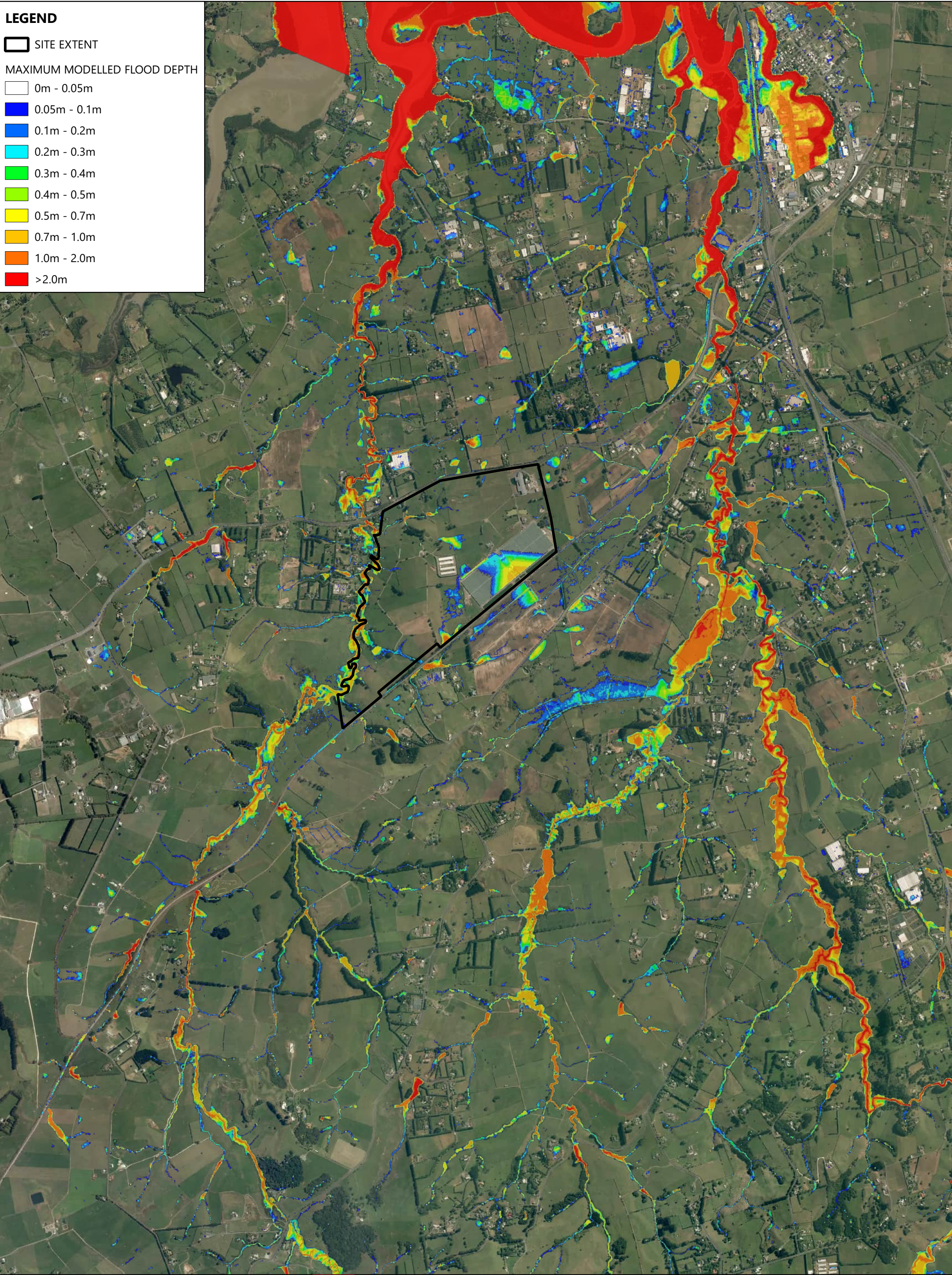
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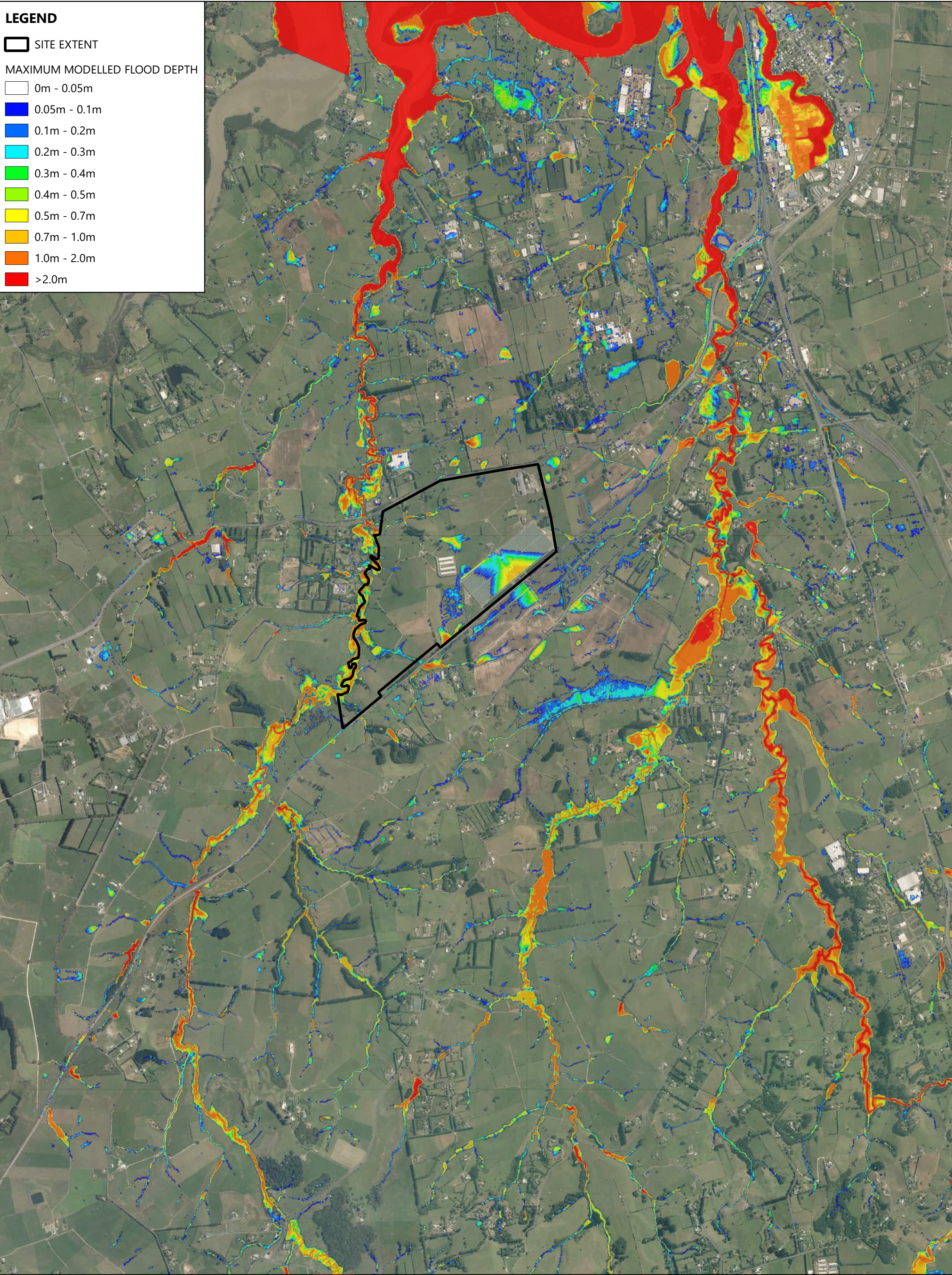
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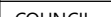
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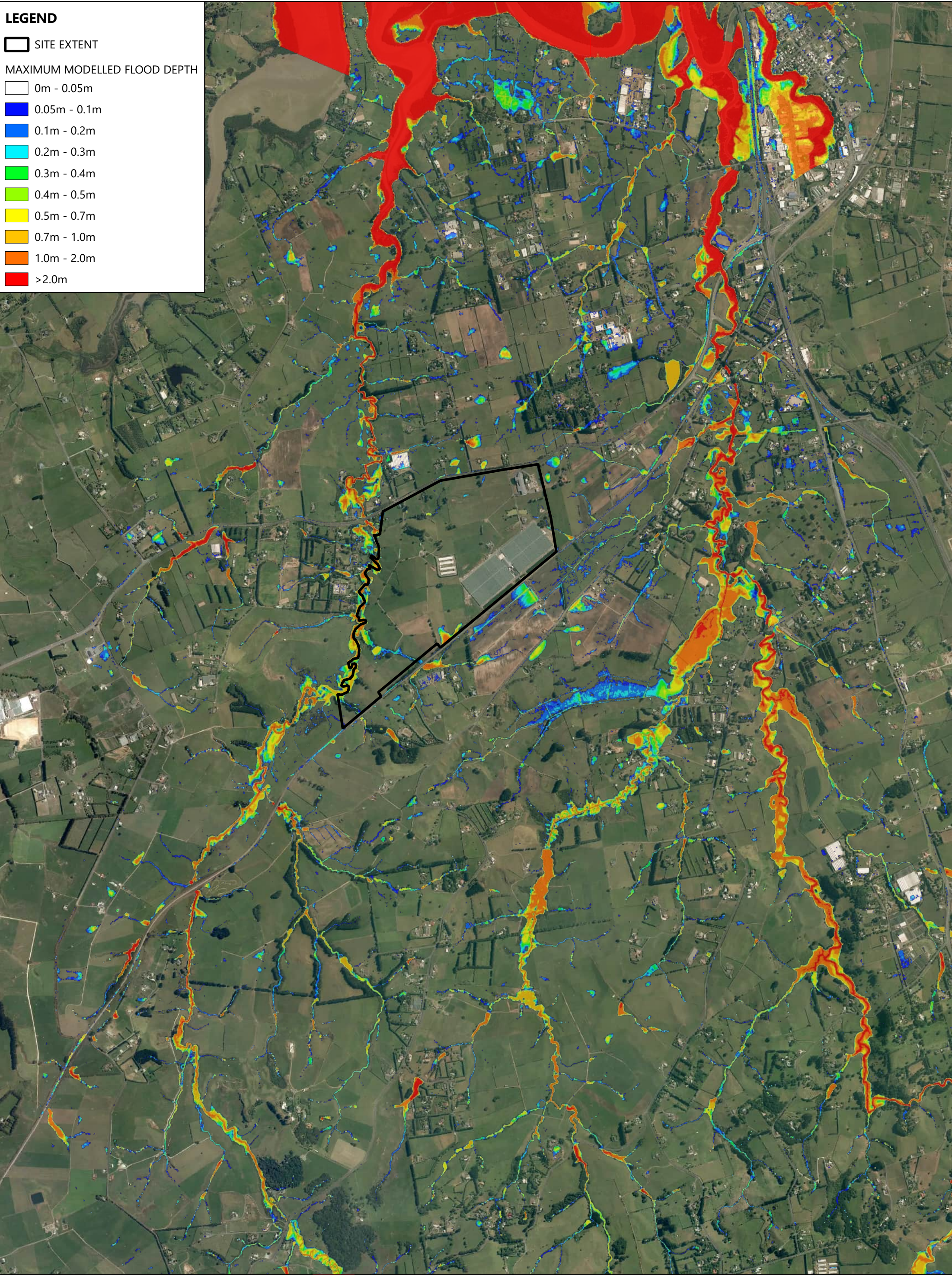
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0.5m - 0.7m

0.7m - 1.0m

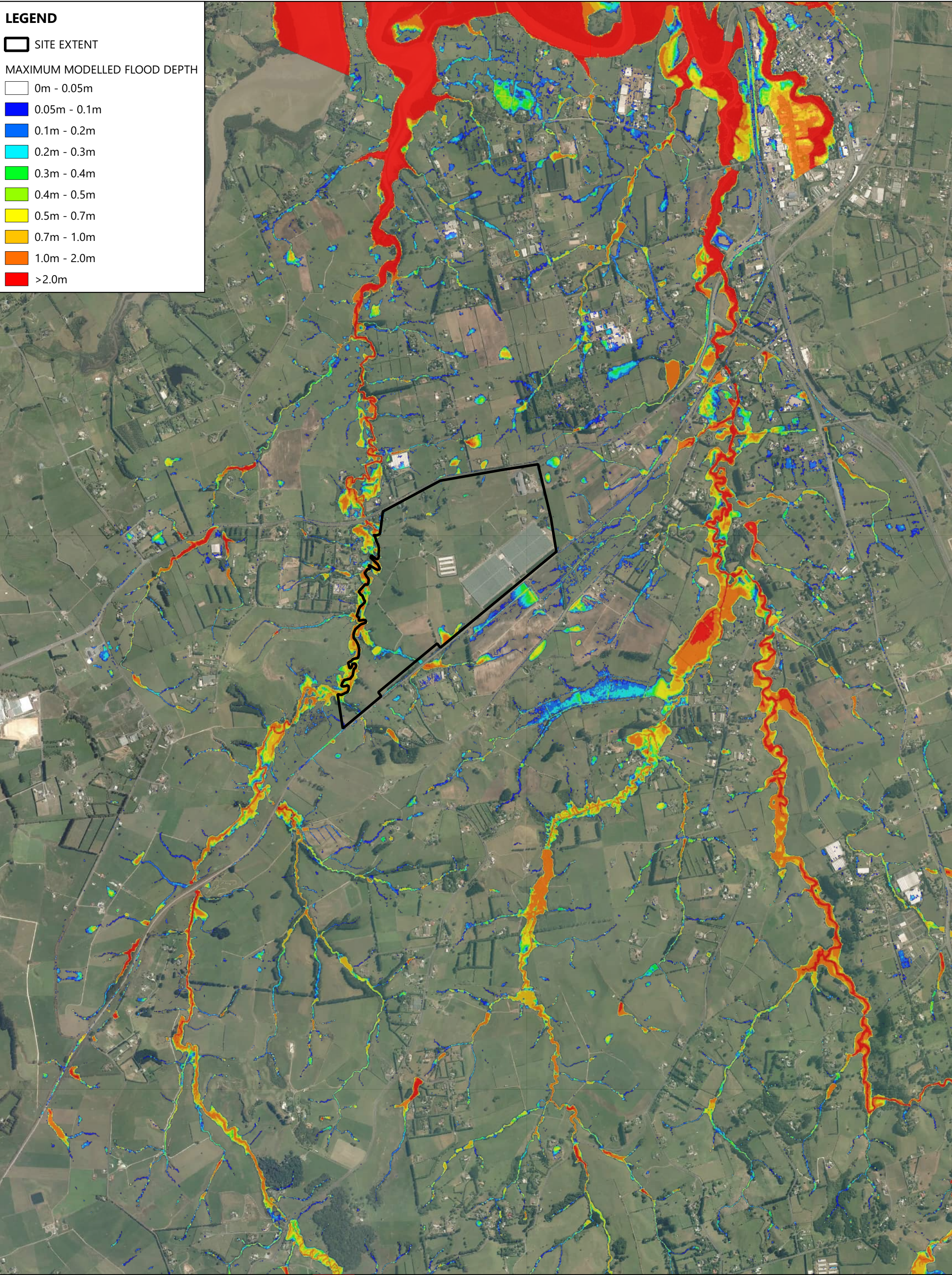
1.0m - 2.0m

>2.0m

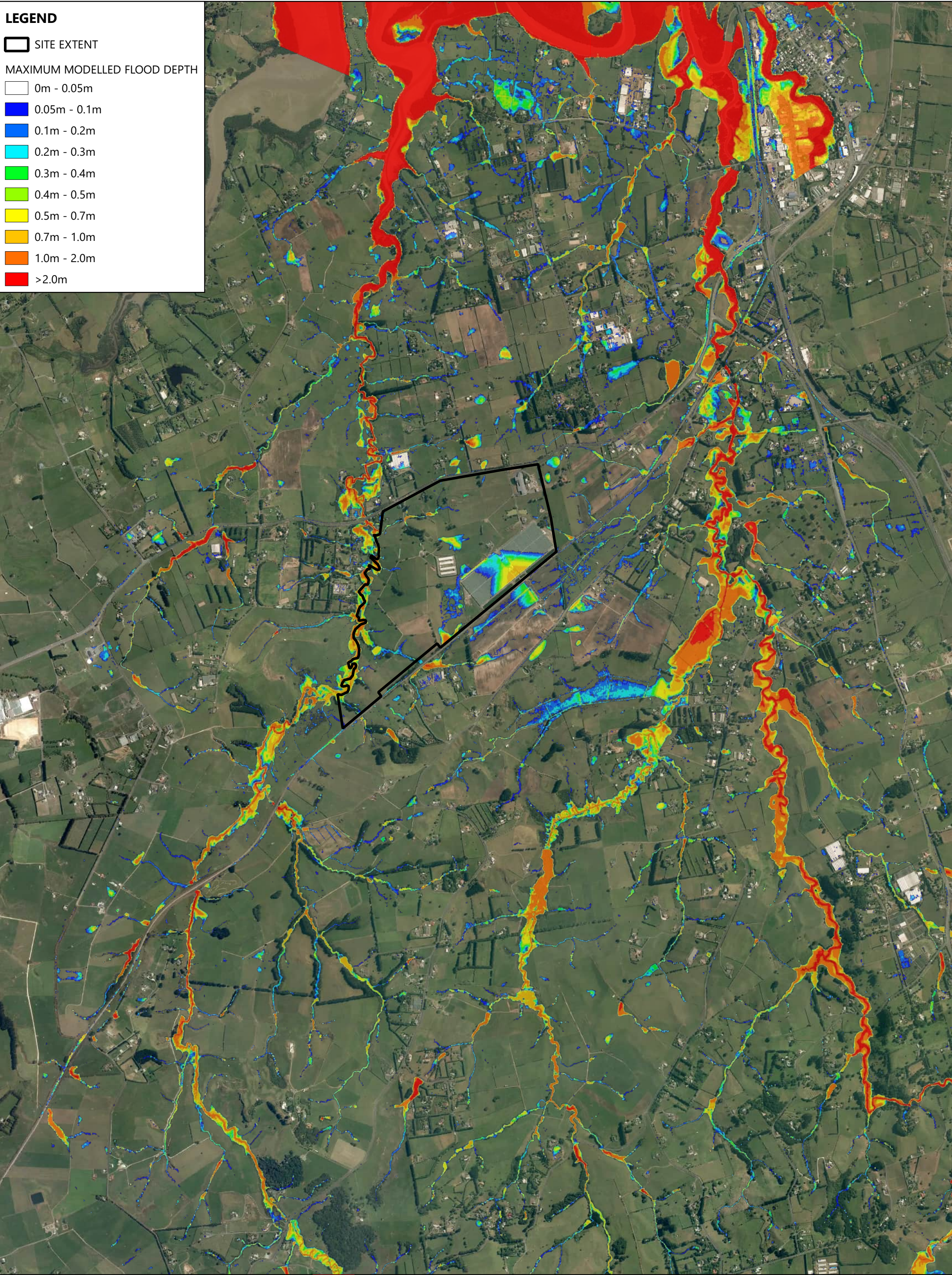
REVISION DETAILS					INT	DATE	SURVEYED	-	LEVEL 1 8 NUGENT ST GRAFTON AUCKLAND 1061	WOODS EST.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4A - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 10-YEAR WITH NO CLIMATE CHANGE ALLOWANCE				STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS										SCALE	NTS	1.0
-	-	-	-	DRAWN	KD										COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS										DWG NO	SHEET 1 OF 1	
				APPROVED					WOODS.CO.NZ								

 SITE EXTENT

	0m - 0.05m
	0.05m - 0.1m
	0.1m - 0.2m
	0.2m - 0.3m
	0.3m - 0.4m
	0.4m - 0.5m
	0.5m - 0.7m
	0.7m - 1.0m
	1.0m - 2.0m
	>2.0m



REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8	 WOODS ESTD 1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4B - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 10-YEAR WITH NO CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS	NUGENT ST				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD	GRAFTON				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS	AUCKLAND				DWG NO	SHEET 1 OF 1	
				APPROVED		WOODS.CO.N						



LEGEND

SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

0m - 0.05m

0.05m - 0.1m

0.1m - 0.2m

0.2m - 0.3m

0.3m - 0.4m

0.4m - 0.5m

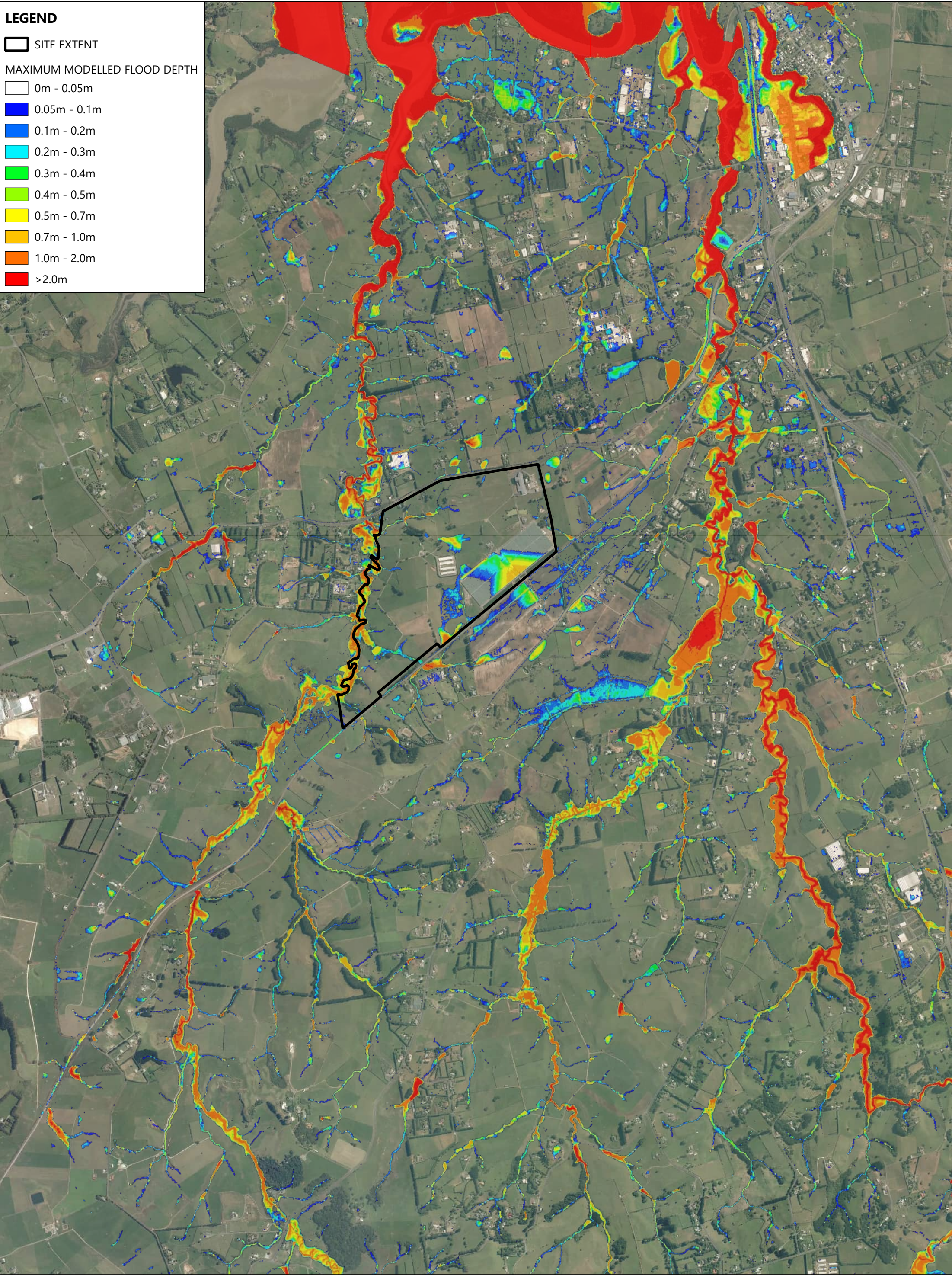
0.5m - 0.7m

0.7m - 1.0m

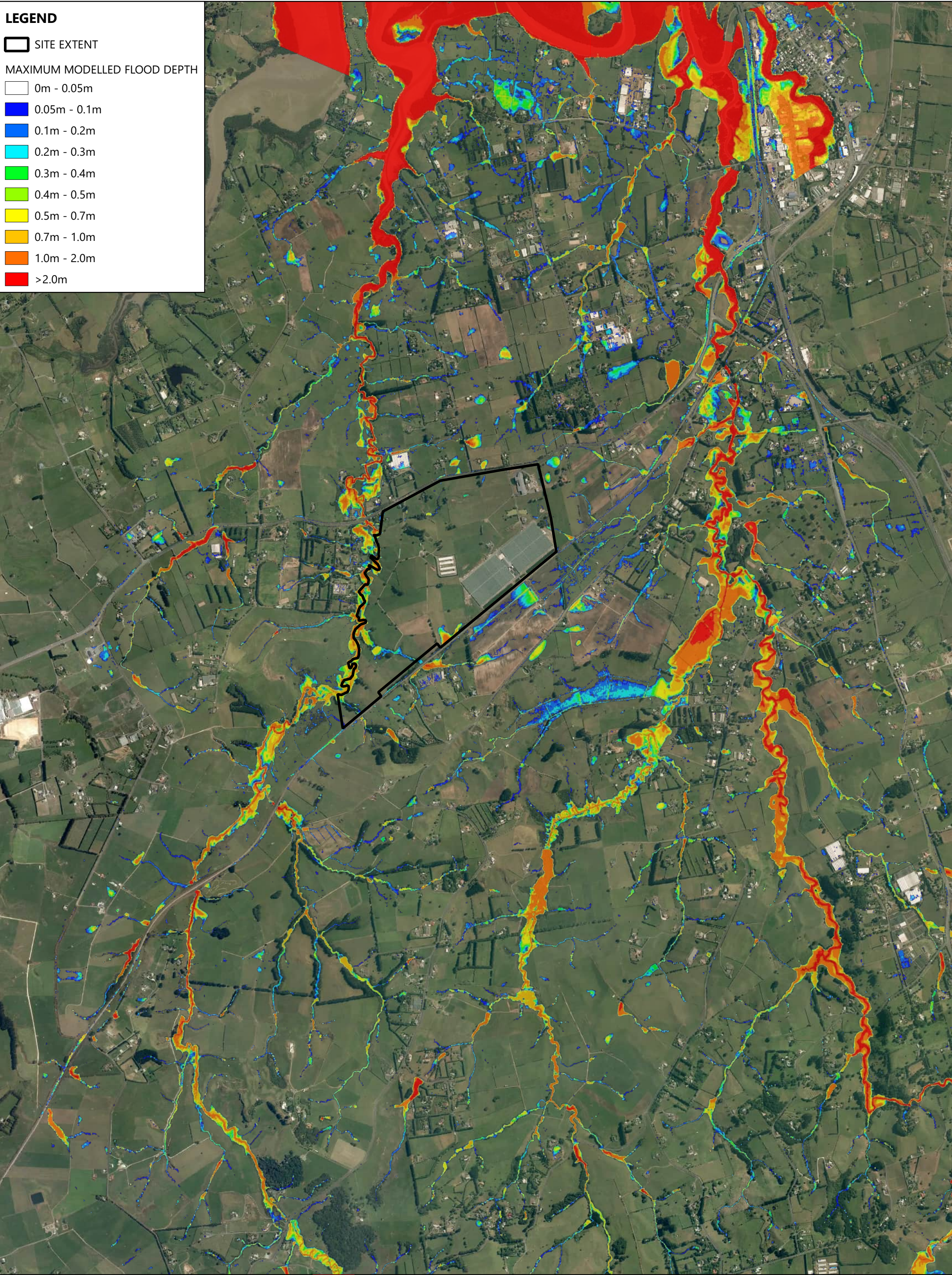
1.0m - 2.0m

>2.0m

REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8		P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 1A - PRE DEVELOPMENT 10-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS	NUGENT ST				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD	GRAFTON				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS	AUCKLAND						
				APPROVED		1061						
						WOODS.CO.NZ						



REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8		P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 1B - PRE DEVELOPMENT 10-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS	NUGENT ST				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD	GRAFTON				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS	AUCKLAND				DWG NO	SHEET 1 OF 1	
				APPROVED		1061						
						WOODS.CO.N						



LEGEND

SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

0m - 0.05m

0.05m - 0.1m

0.1m - 0.2m

0.2m - 0.3m

0.3m - 0.4m

0.4m - 0.5m

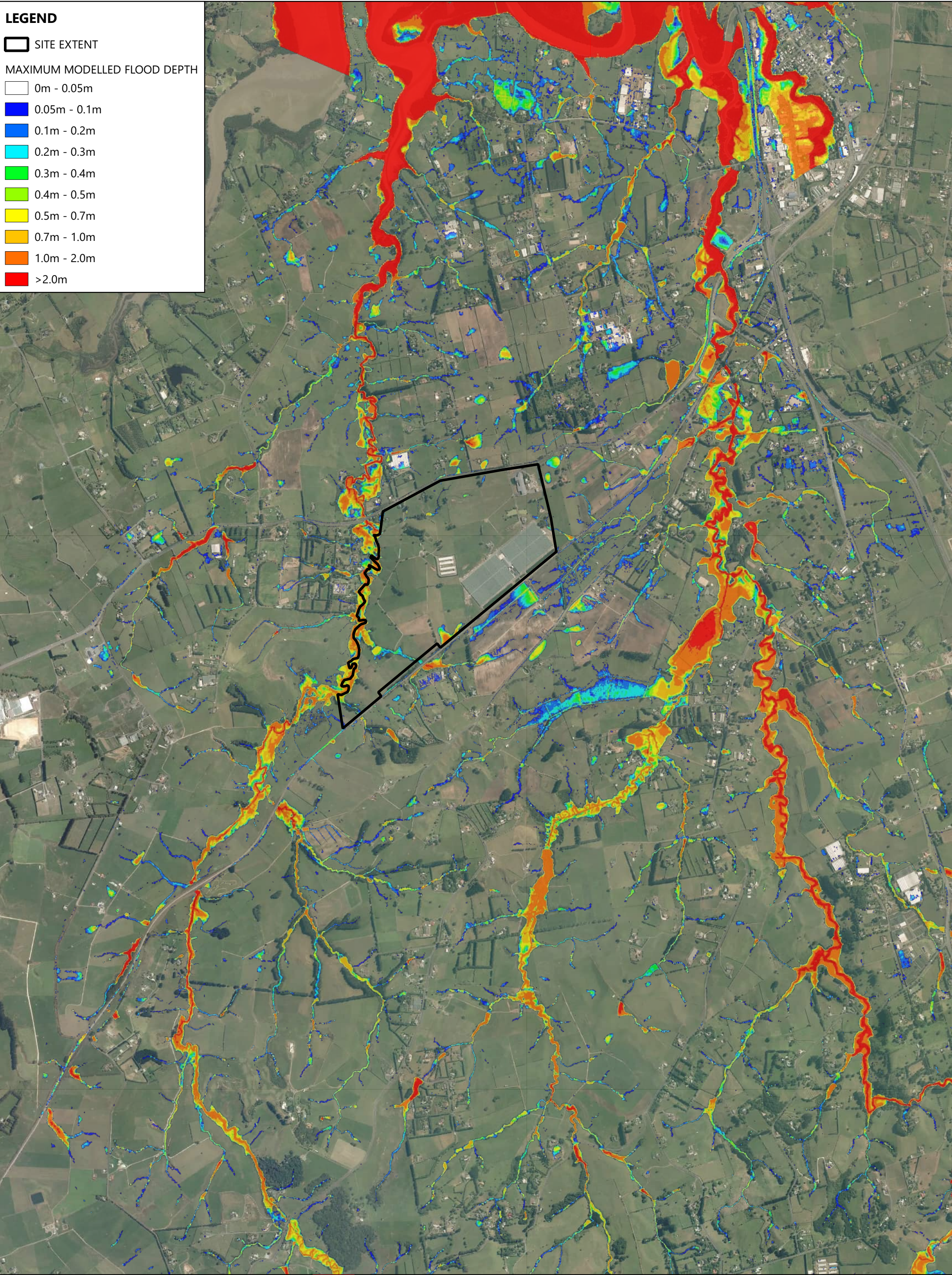
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0.7m - 1.0m

1.0m - 2.0m

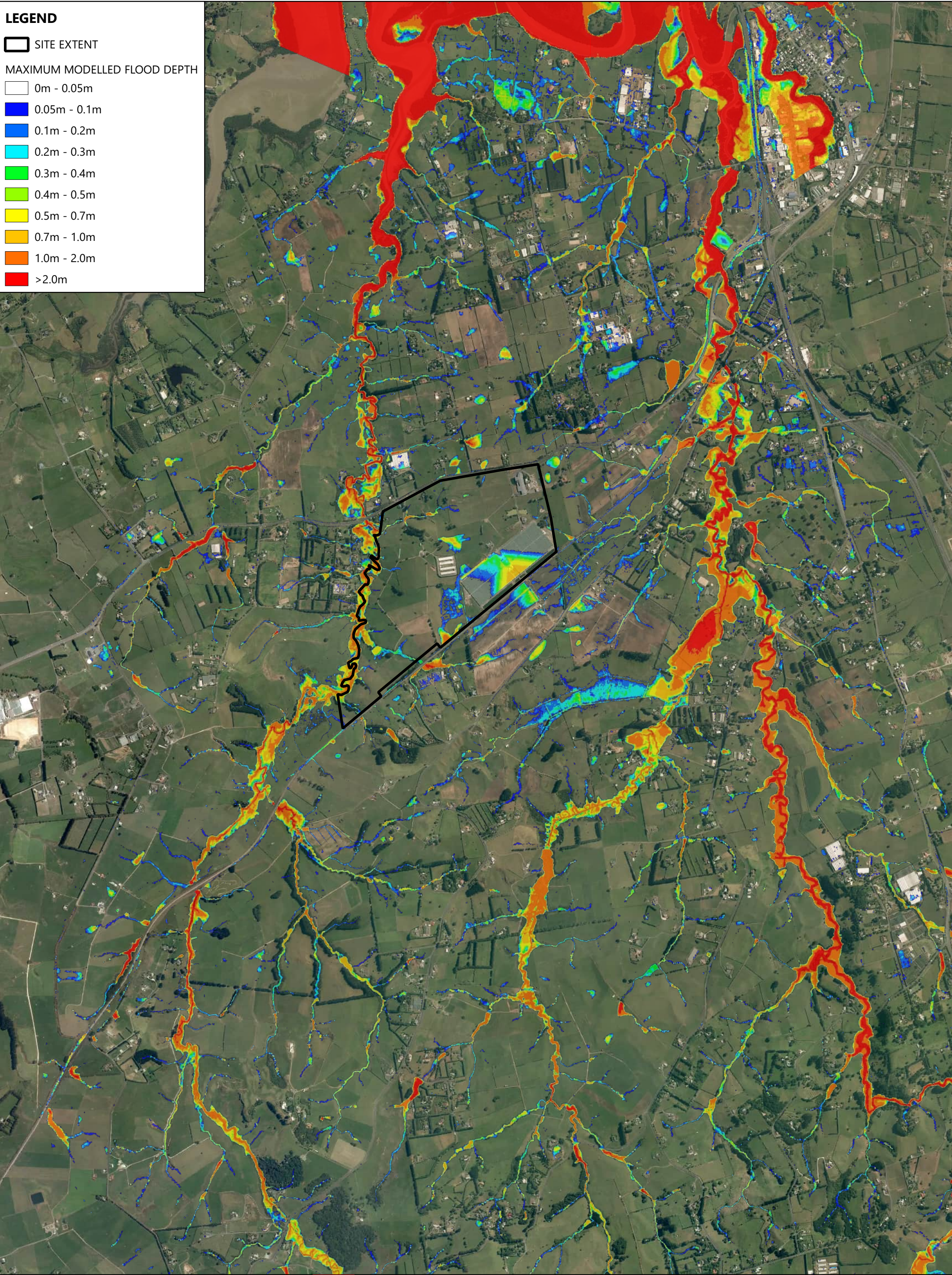
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REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8 NUGENT ST GRAFTON AUCKLAND 1061 WOODS.CO.NZ	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4A - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 10-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV	
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				SCALE	NTS	1.0	
-	-	-	-	DRAWN	KD				COUNCIL	AUCKLAND COUNCIL		
-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1		
				APPROVED								

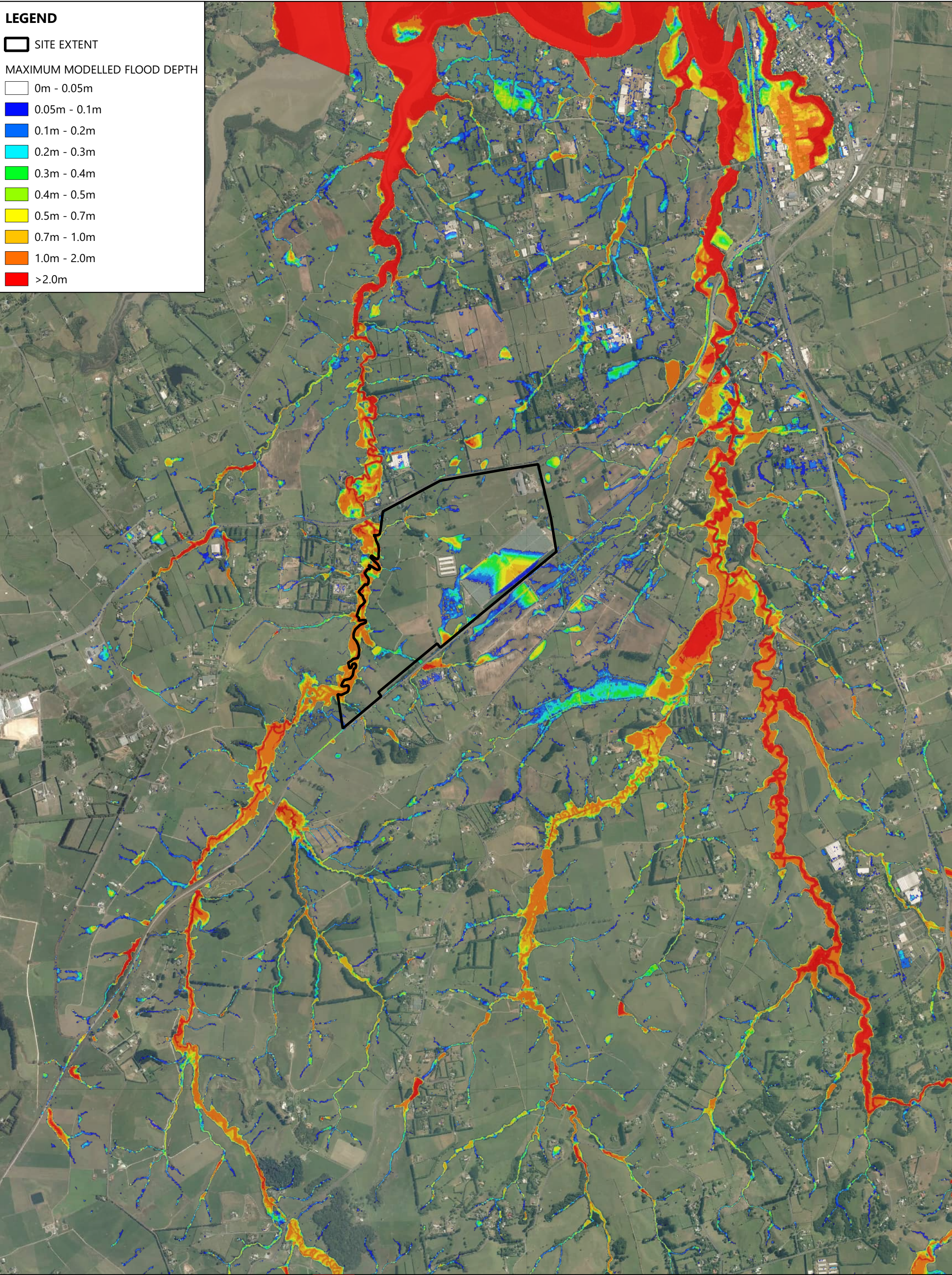


REVISION DETAILS		INT	DATE	SURVEYED	-	 WOODS EST.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4B - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 10-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV	
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				SCALE	NTS	1.0	
-	-	-	-	DRAWN	KD				COUNCIL	AUCKLAND COUNCIL		
-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1		
				APPROVED								

	0m - 0.05m
	0.05m - 0.1m
	0.1m - 0.2m
	0.2m - 0.3m
	0.3m - 0.4m
	0.4m - 0.5m
	0.5m - 0.7m
	0.7m - 1.0m
	1.0m - 2.0m
	>2.0m



REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8	 WOODS EST. 1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 1A - PRE DEVELOPMENT 10-YEAR WITH 3.8°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS	NUGENT ST				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD	GRAFTON				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS	AUCKLAND						
				APPROVED		1061						
						WOODS.CO.NZ				DWG NO	SHEET 1 OF 1	



LEGEND

SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

0m - 0.05m

0.05m - 0.1m

0.1m - 0.2m

0.2m - 0.3m

0.3m - 0.4m

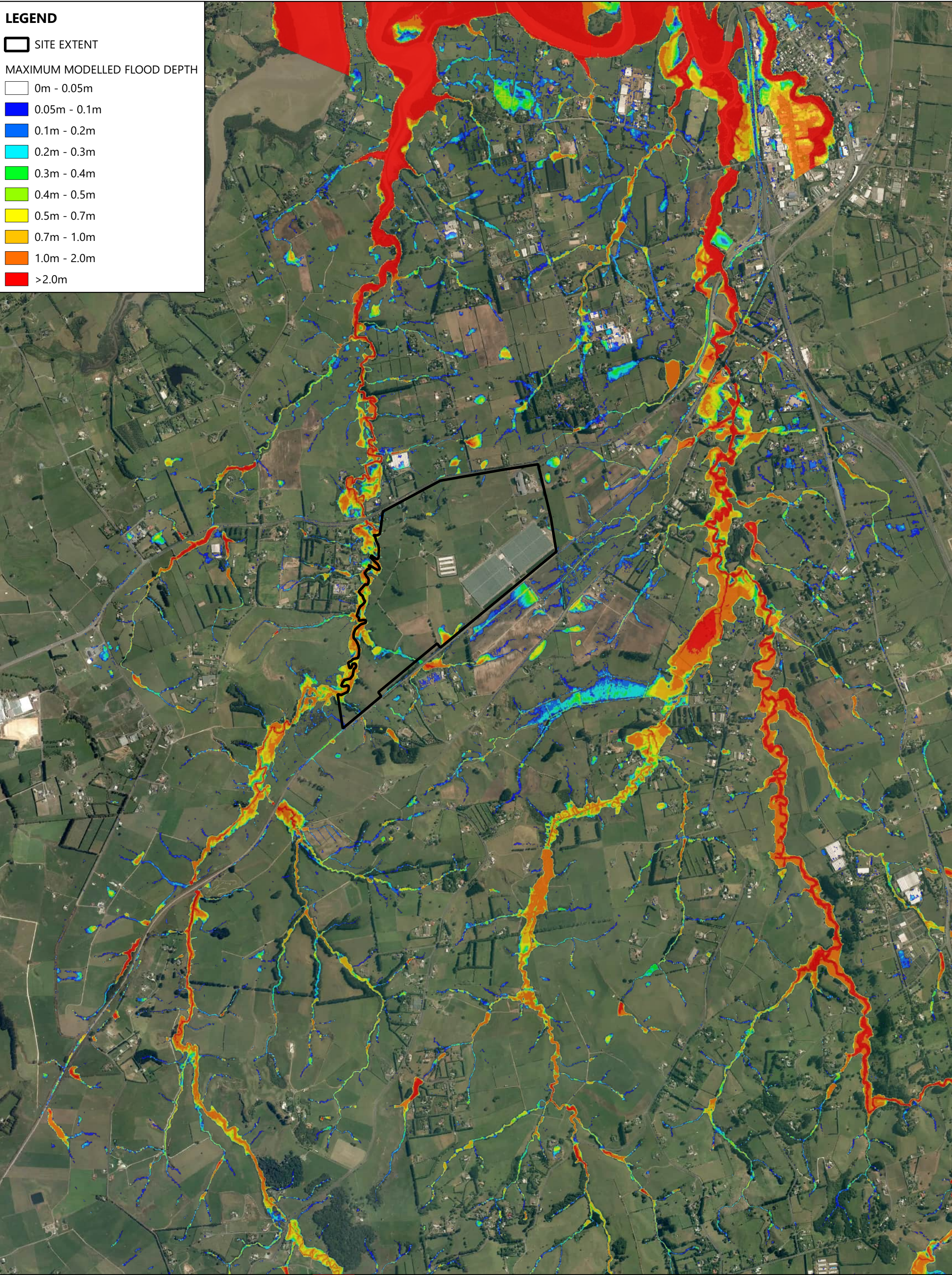
0.4m - 0.5m

0.5m - 0.7m

0.7m - 1.0m

1.0m - 2.0m

>2.0m



LEGEND

SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

0m - 0.05m

0.05m - 0.1m

0.1m - 0.2m

0.2m - 0.3m

0.3m - 0.4m

0.4m - 0.5m

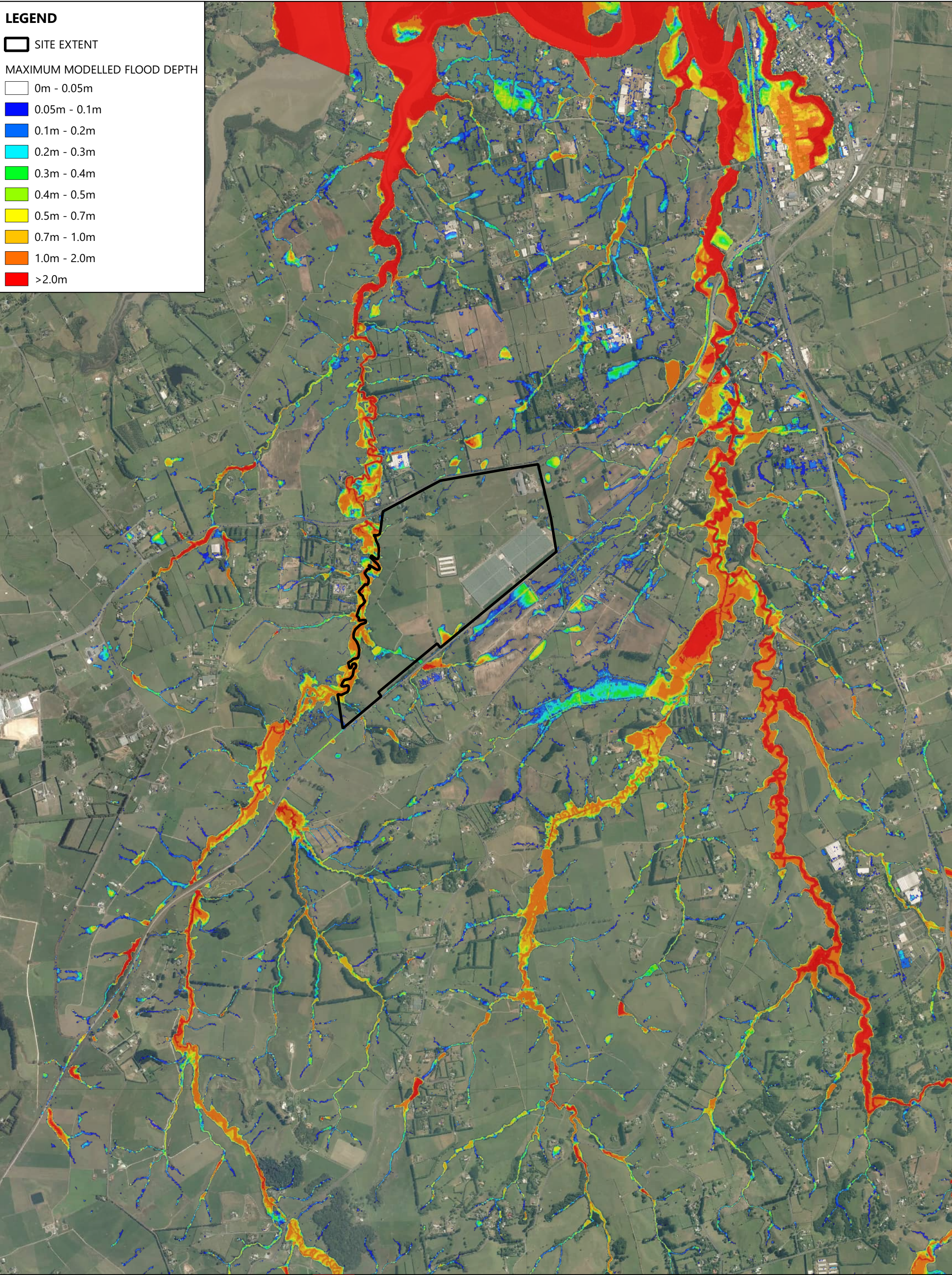
0.5m - 0.7m

0.7m - 1.0m

1.0m - 2.0m

>2.0m

REVISION DETAILS		INT	DATE	SURVEYED	-	 WOODS EST. 1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4A - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 10-YEAR WITH 3.8°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1	
				APPROVED					WOODS.CO.NZ		



LEGEND

SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

0m - 0.05m

0.05m - 0.1m

0.1m - 0.2m

0.2m - 0.3m

0.3m - 0.4m

0.4m - 0.5m

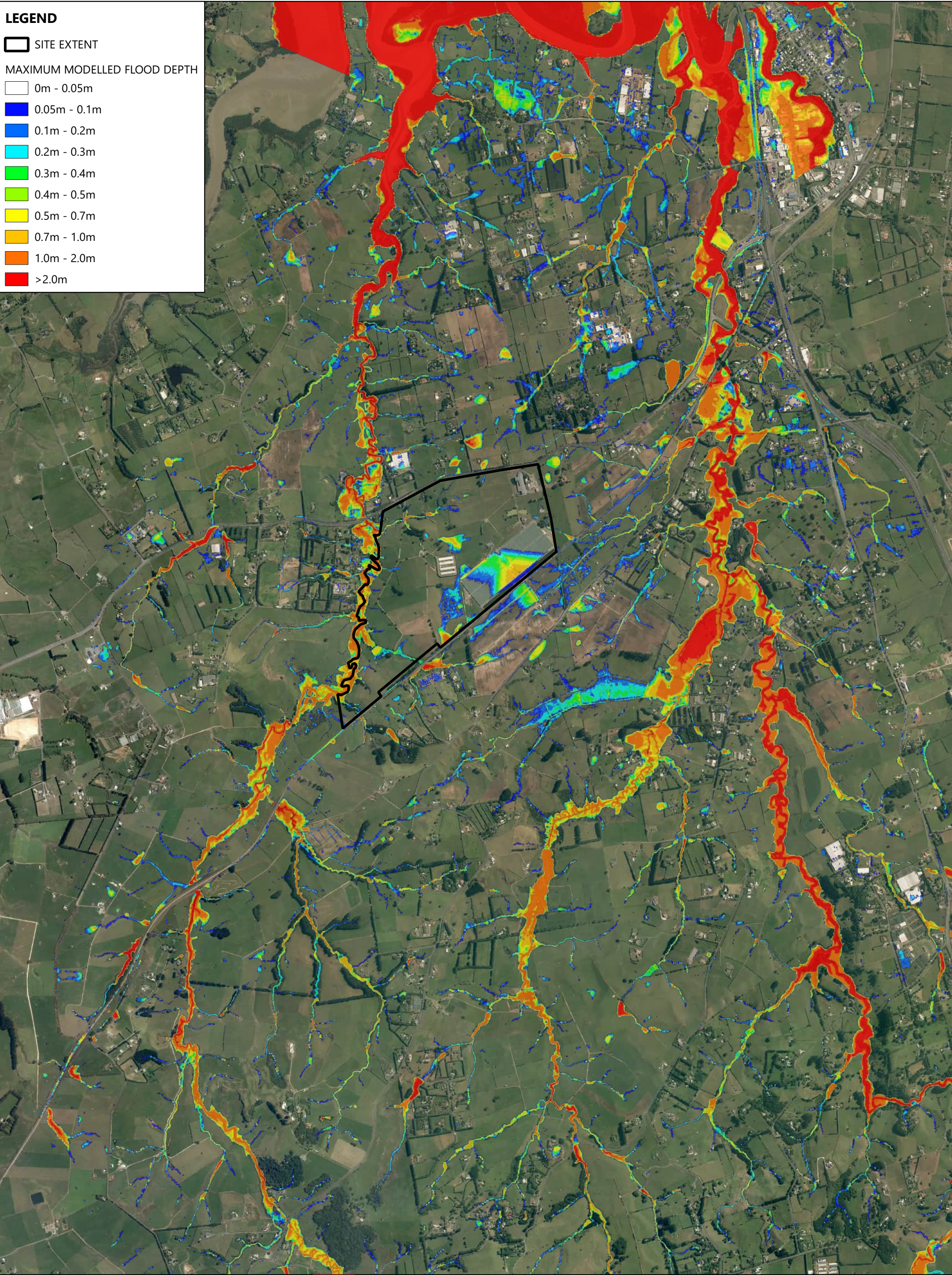
0.5m - 0.7m

0.7m - 1.0m

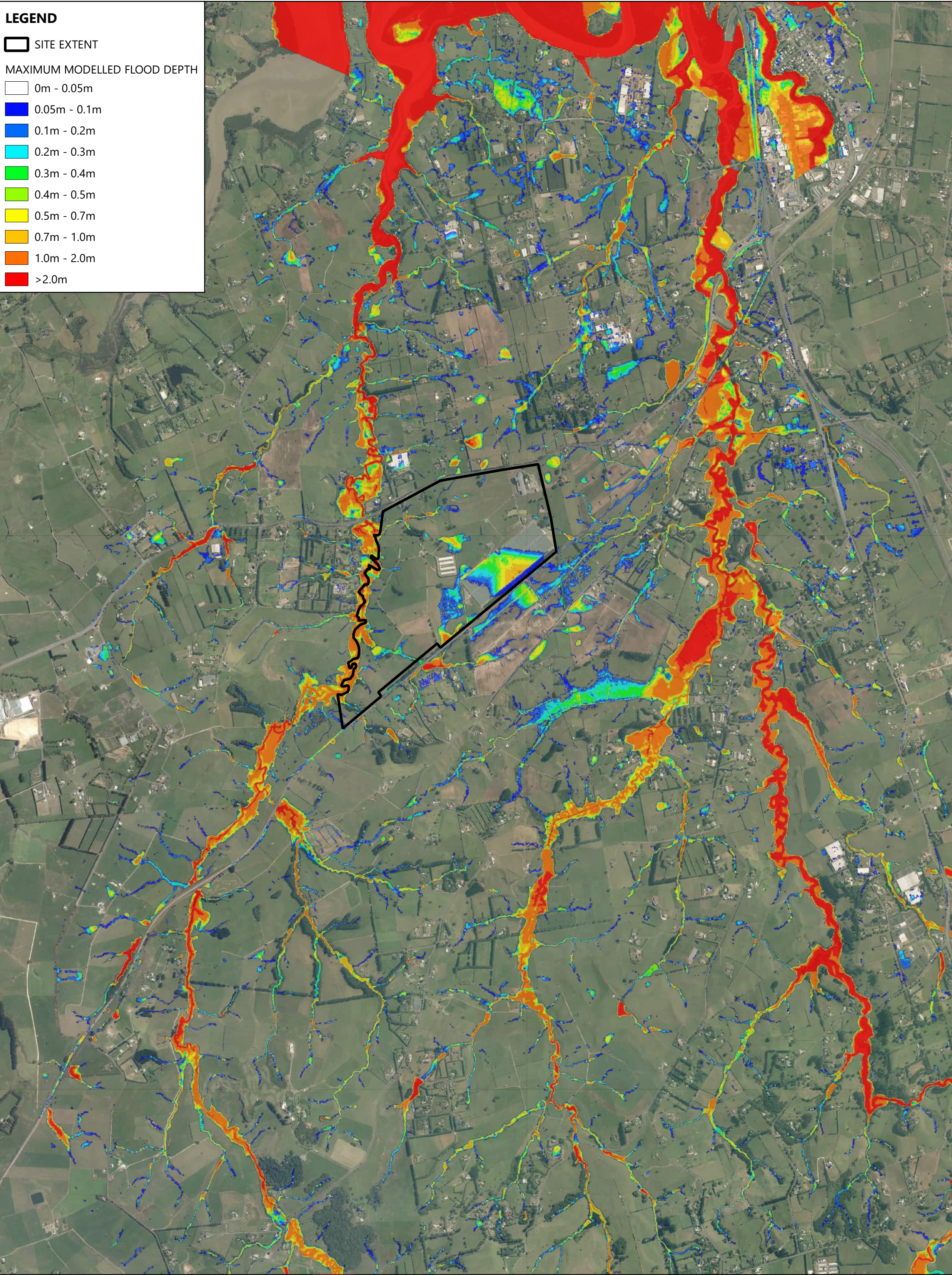
1.0m - 2.0m

>2.0m

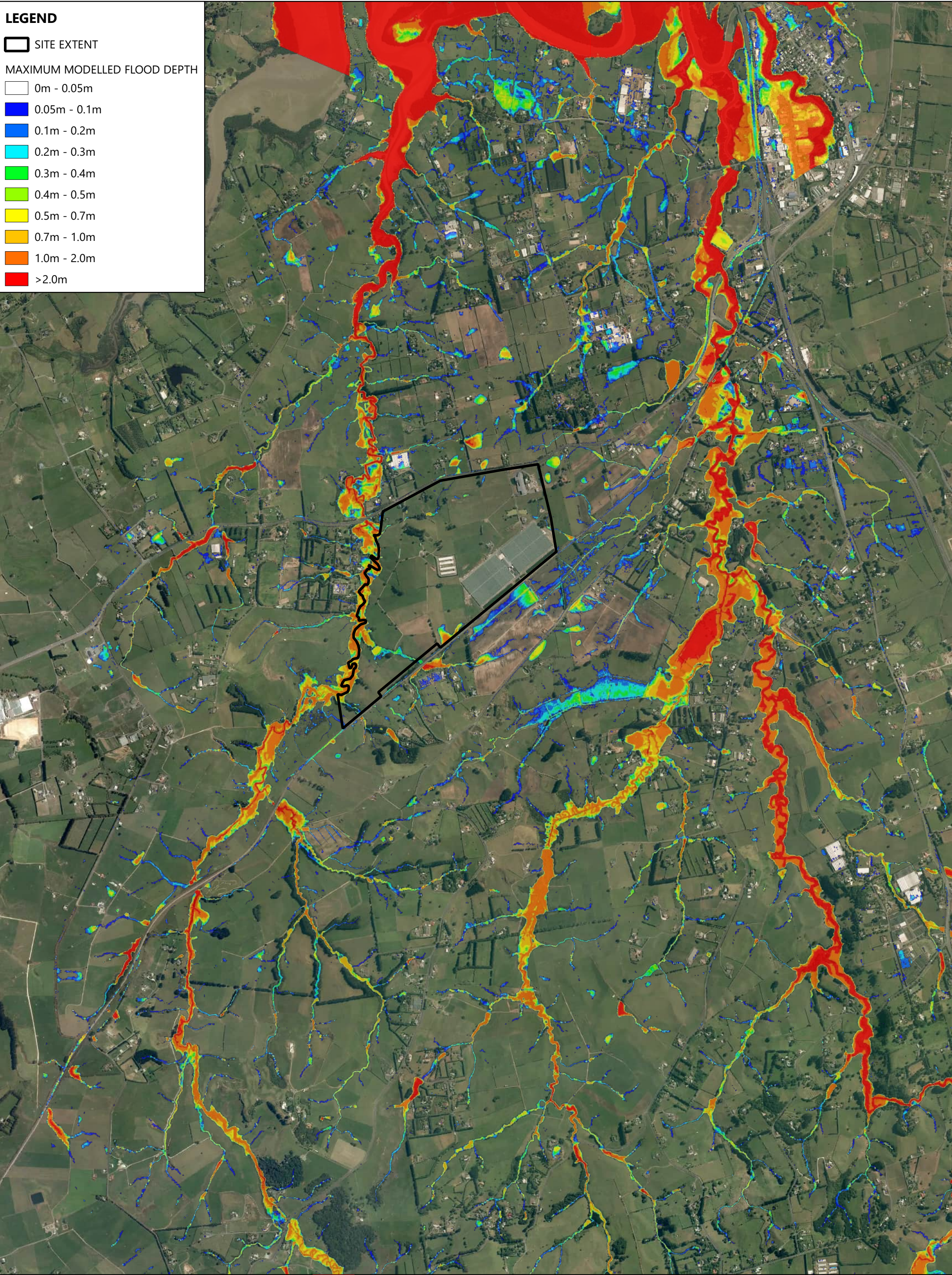
REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8 NUGENT ST GRAFTON AUCKLAND 1061  WOODS EST.1970 WOODS.CO.N	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4B - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 10-YEAR WITH 3.8°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1	
				APPROVED							



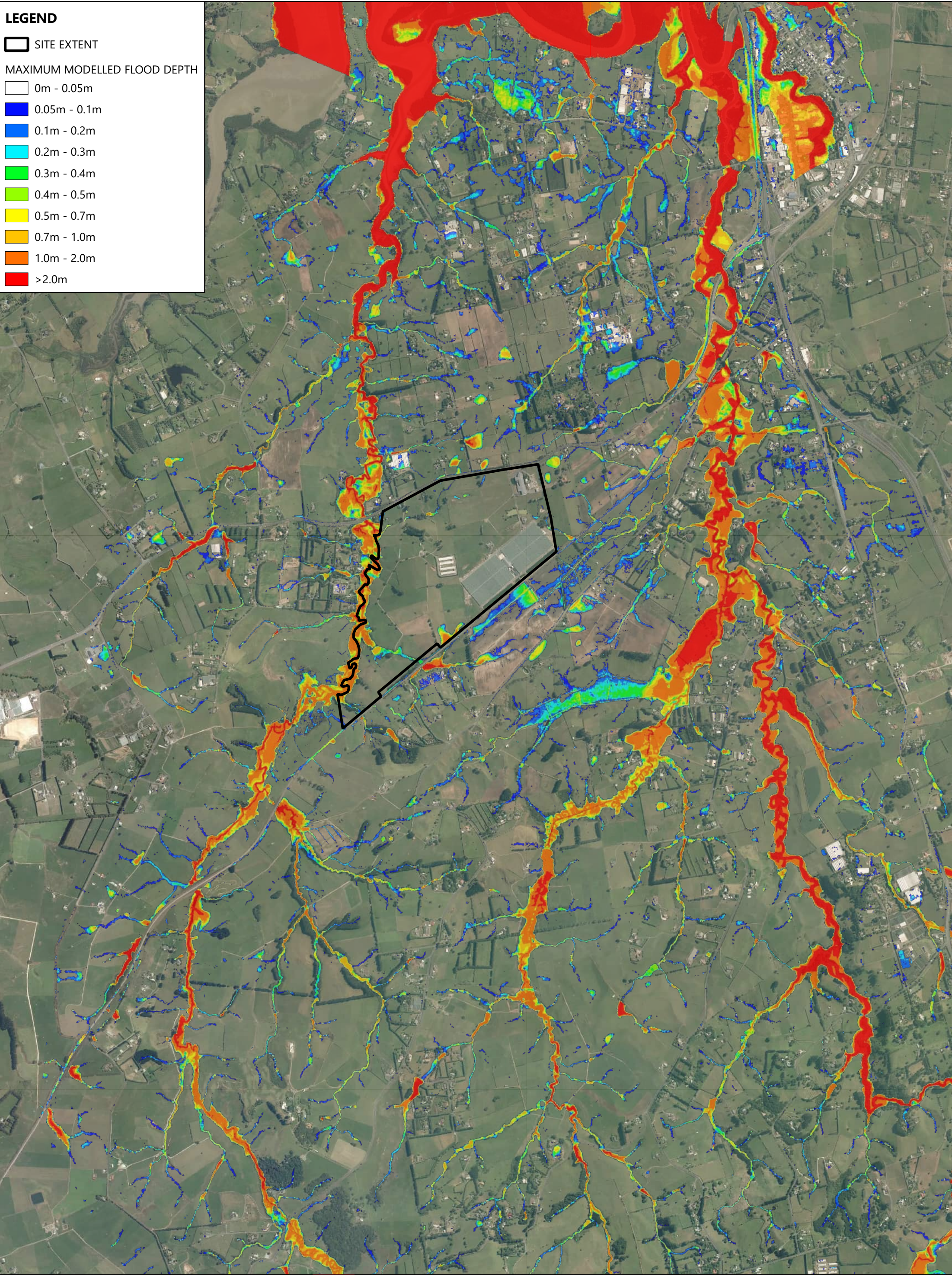
REVISION DETAILS		INT	DATE	SURVEYED	-	 WOODS EST.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 1A - PRE DEVELOPMENT 100-YEAR WITH NO CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1	
				APPROVED					WOODS.CO.NZ		



REVISION DETAILS					INT	DATE	SURVEYED	-	LEVEL 1 8		P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 1B - PRE DEVELOPMENT 100-YEAR WITH NO CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				NUGENT ST				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD				GRAFTON				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS				1061				DWG NO	SHEET 1 OF 1	
				APPROVED					WOODS.CO.N						



REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8 NUGENT ST GRAFTON AUCKLAND 1061		P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4A - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 100-YEAR WITH NO CLIMATE CHANGE ALLOWANCE			STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS						SCALE	NTS	1.0
-	-	-	-	DRAWN	KD						COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS						DWG NO	SHEET 1 OF 1	
				APPROVED		WOODS.CO.NZ							



LEGEND

SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

0m - 0.05m

0.05m - 0.1m

0.1m - 0.2m

0.2m - 0.3m

0.3m - 0.4m

0.4m - 0.5m

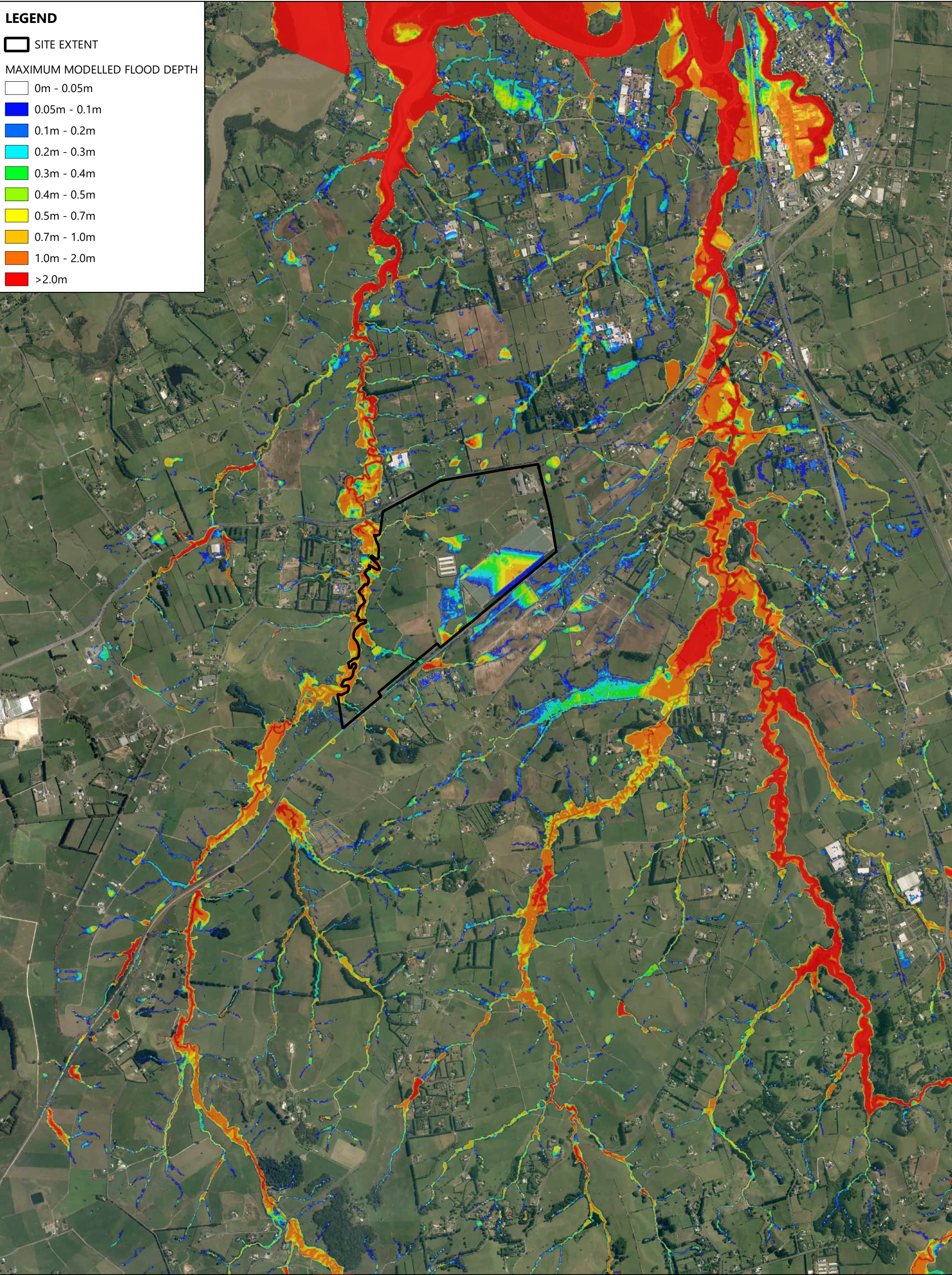
0.5m - 0.7m

0.7m - 1.0m

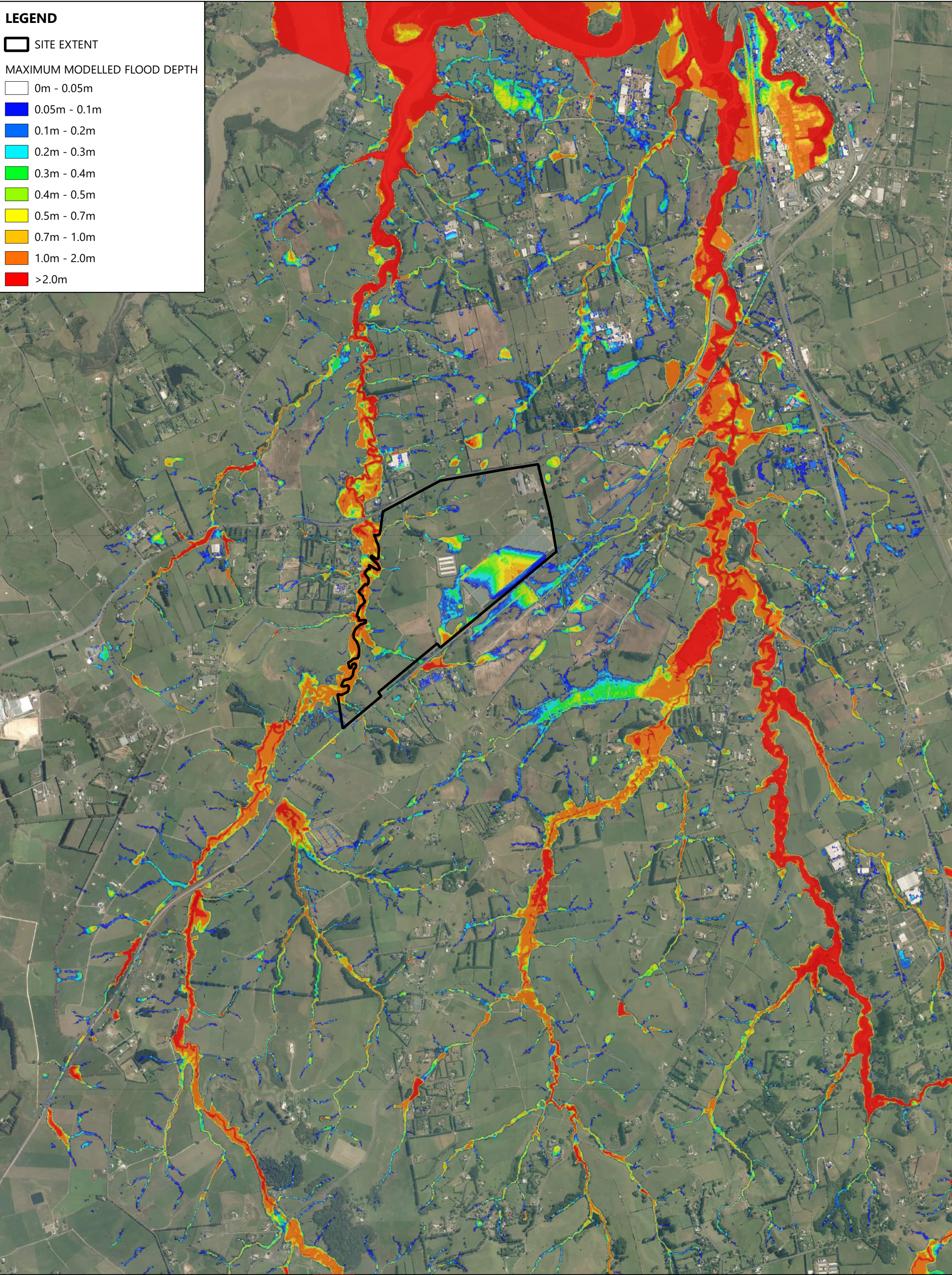
1.0m - 2.0m

>2.0m

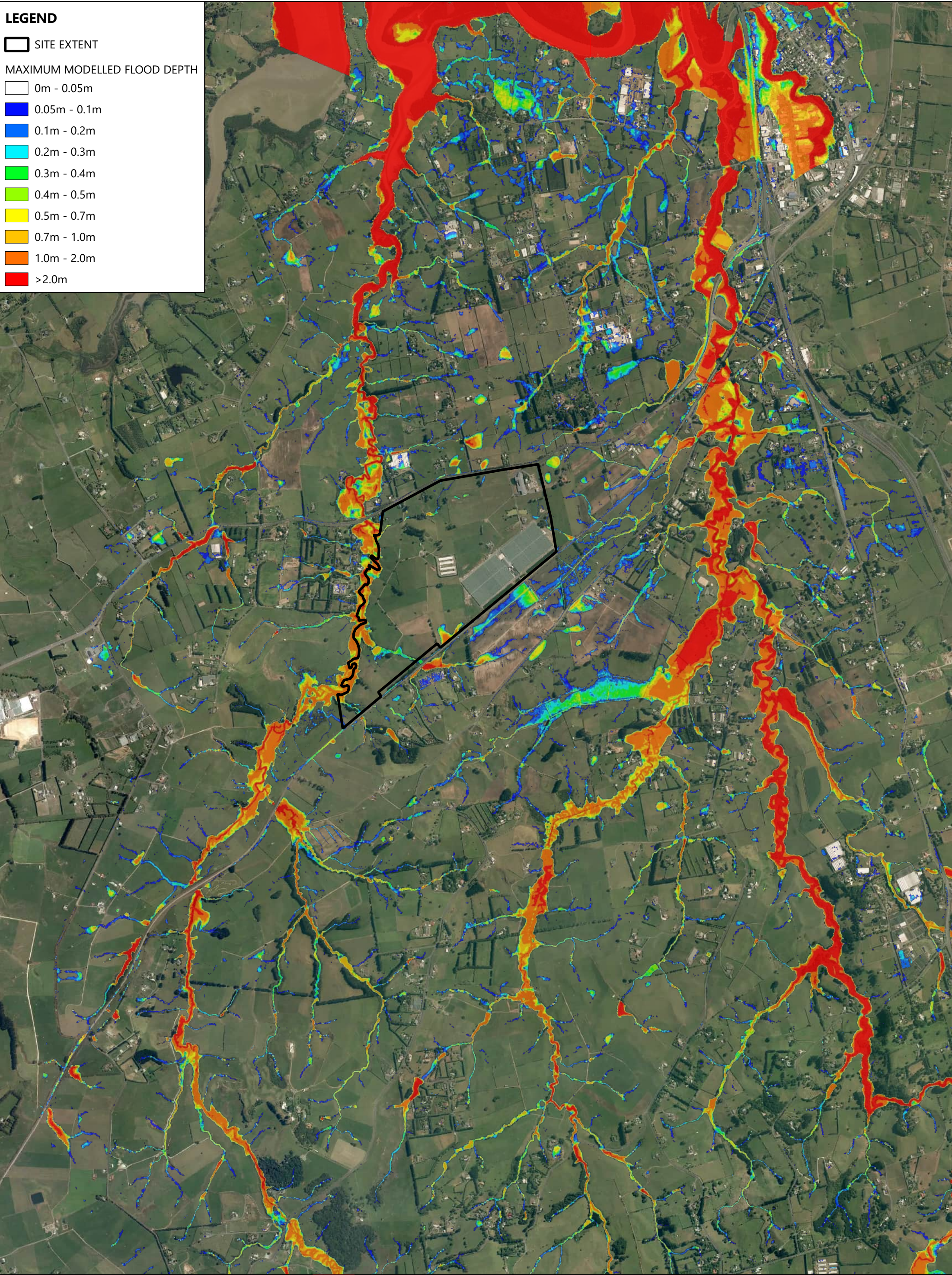
REVISION DETAILS		INT	DATE	SURVEYED	-	 WOODS EST.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4B - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 100-YEAR WITH NO CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1	
				APPROVED					WOODS.CO.N		



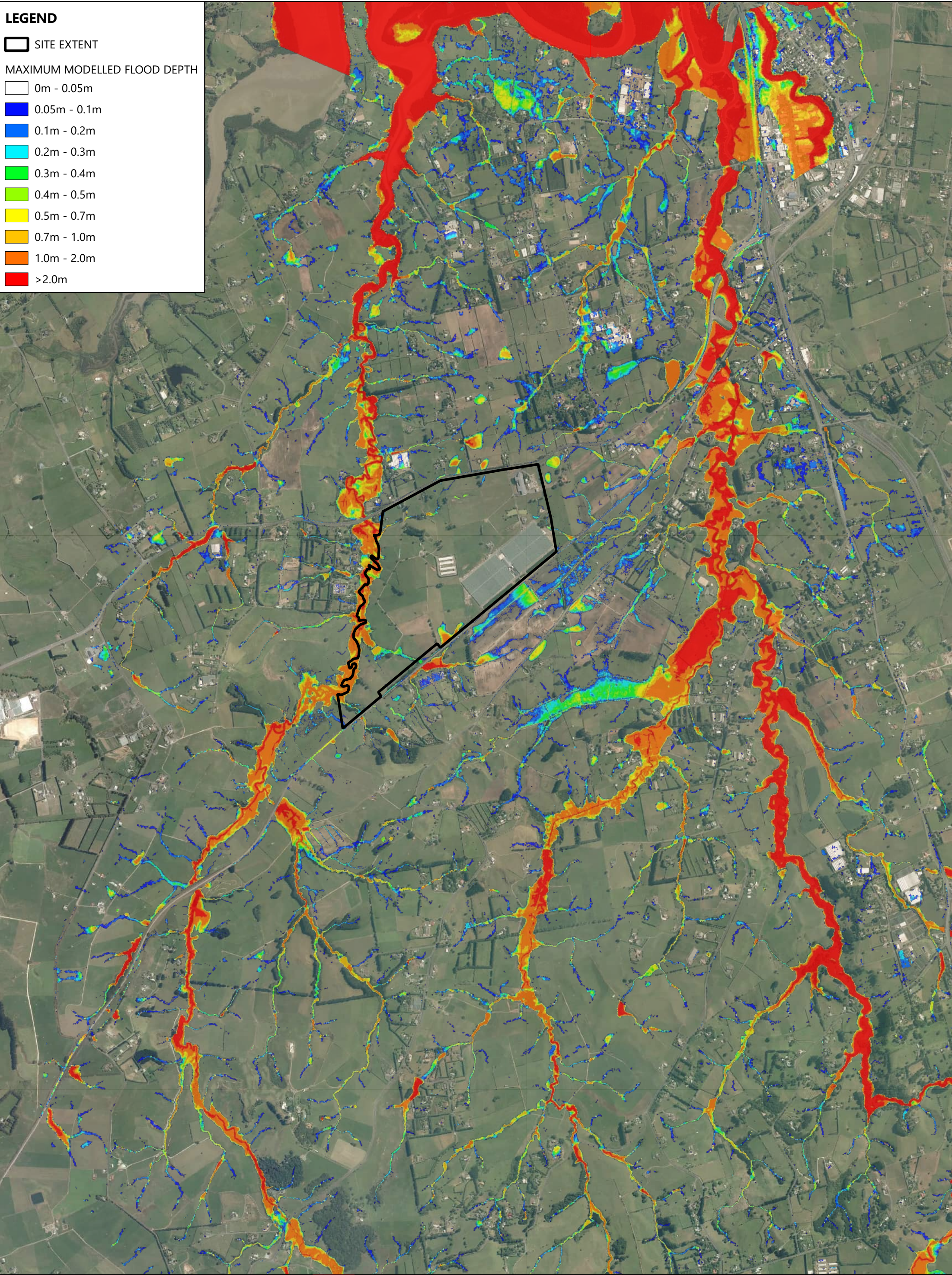
REVISION DETAILS		INT	DATE	SURVEYED	-	 WOODS EST. 1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 1A - PRE DEVELOPMENT 100-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1	
				APPROVED					WOODS.CO.NZ		



REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8 NUGENT ST GRAFTON AUCKLAND 1061	 WOODS EST.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 1B - PRE DEVELOPMENT 100-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE			STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS						SCALE	NTS	1.0
-	-	-	-	DRAWN	KD						COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS						DWG NO	SHEET 1 OF 1	
				APPROVED		WOODS.CO.N							



REVISION DETAILS		INT	DATE	SURVEYED	-	 WOODS EST.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4A - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 100-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1	
				APPROVED					WOODS.CO.NZ		



LEGEND

 SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

 0m - 0.05m

 0.05m - 0.1m

 0.1m - 0.2m

 0.2m - 0.3m

 0.3m - 0.4m

 0.4m - 0.5m

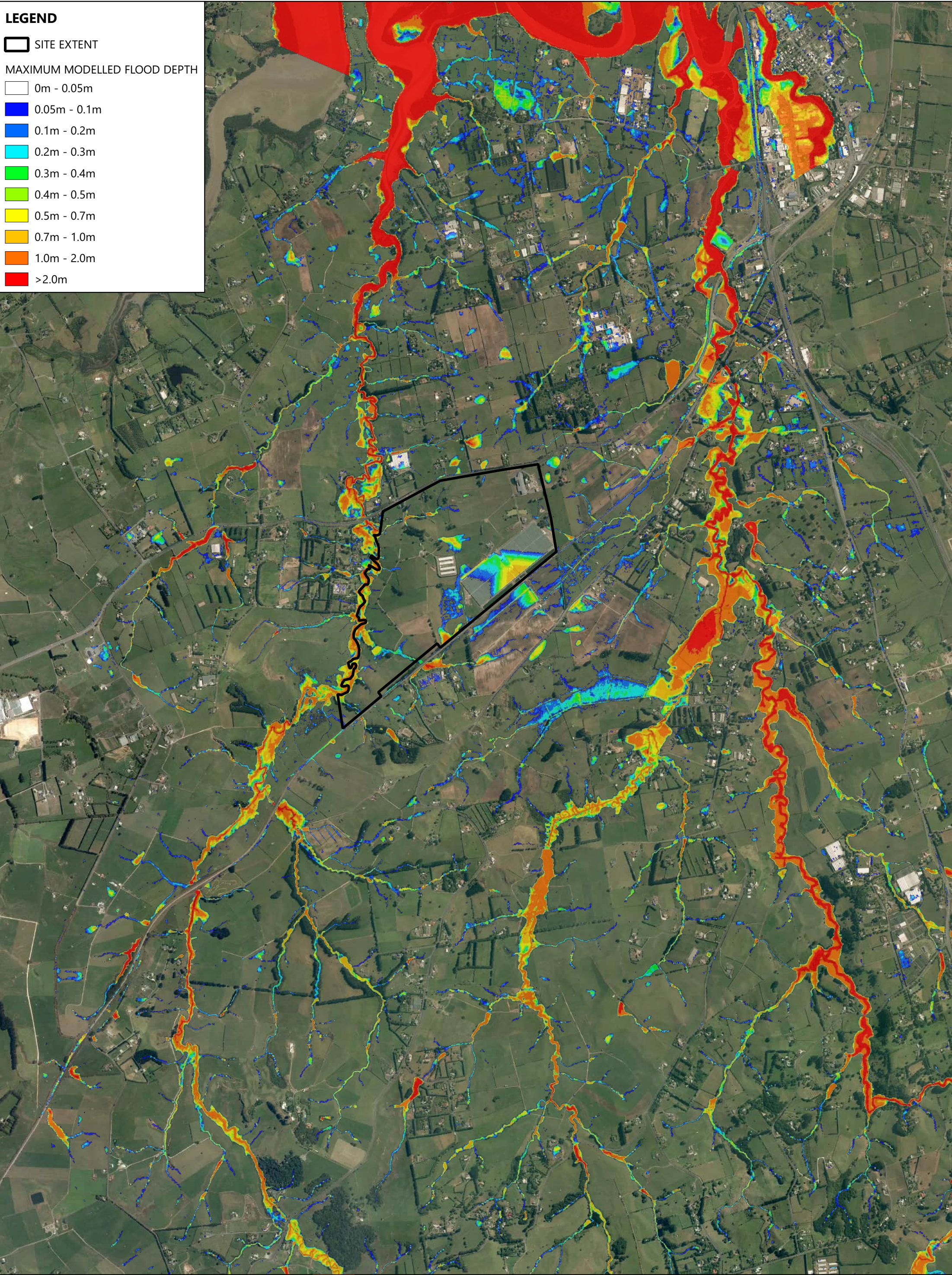
 0.5m - 0.7m

 0.7m - 1.0m

 1.0m - 2.0m

 >2.0m

REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8 NUGENT ST GRAFTON AUCKLAND 1061  WOODS.CO.N	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4B - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 100-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV	
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				SCALE	NTS	1.0	
-	-	-	-	DRAWN	KD				COUNCIL	AUCKLAND COUNCIL		
-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1		
				APPROVED								



LEGEND

SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

0m - 0.05m

0.05m - 0.1m

0.1m - 0.2m

0.2m - 0.3m

0.3m - 0.4m

0.4m - 0.5m

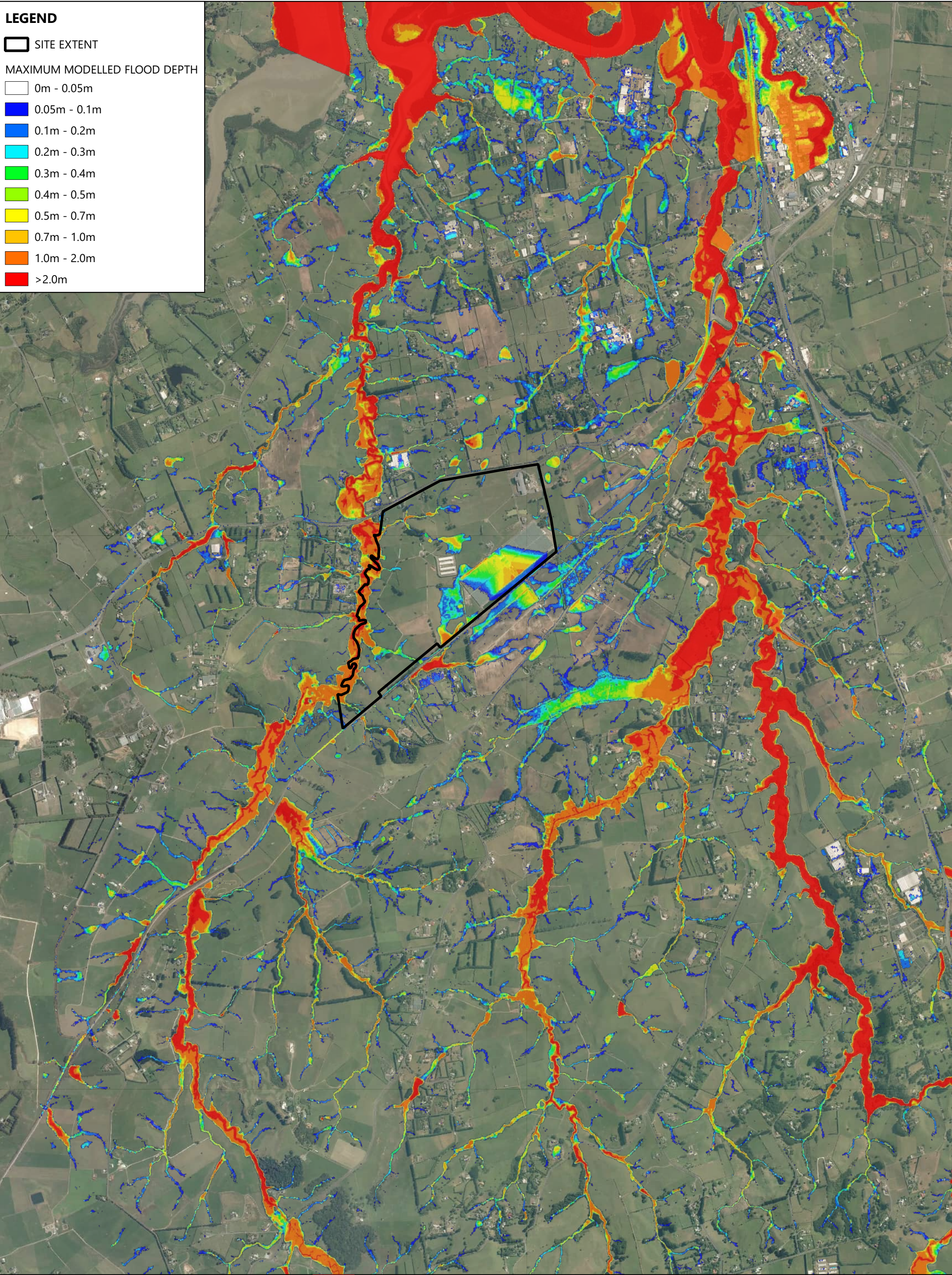
0.5m - 0.7m

0.7m - 1.0m

1.0m - 2.0m

>2.0m

REVISION DETAILS					INT	DATE	SURVEYED	-	LEVEL 1 8		P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 1A - PRE DEVELOPMENT 100-YEAR WITH 3.8°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				LEVEL 1 8				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD				NUGENT ST				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS				GRAFTON				DWG NO	SHEET 1 OF 1	
				APPROVED					AUCKLAND 1061						
									WOODS.CO.NZ						



LEGEND

SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

0m - 0.05m

0.05m - 0.1m

0.1m - 0.2m

0.2m - 0.3m

0.3m - 0.4m

0.4m - 0.5m

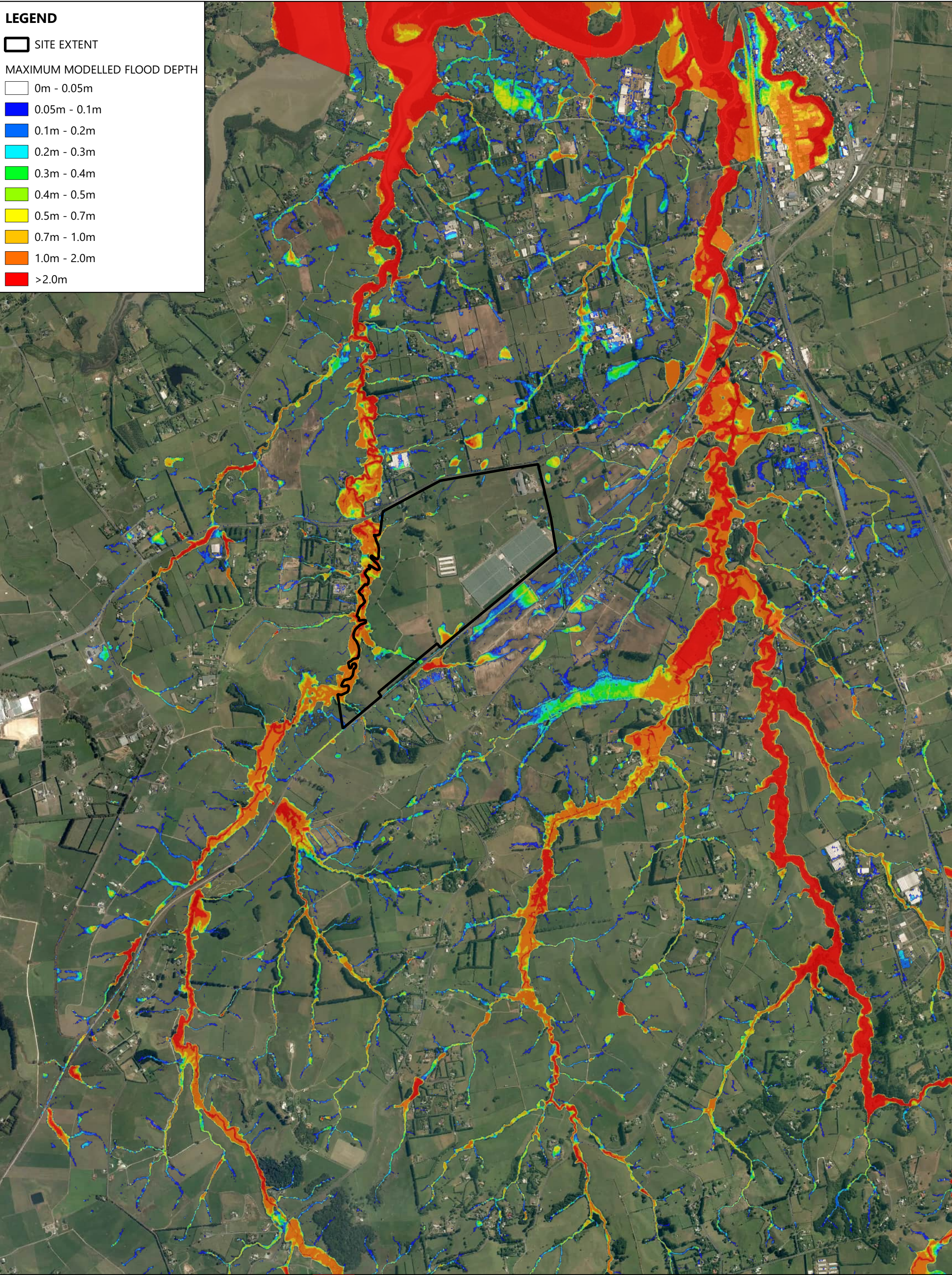
0.5m - 0.7m

0.7m - 1.0m

1.0m - 2.0m

>2.0m

REVISION DETAILS		INT	DATE	SURVEYED	-	 WOODS EST.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 1B - PRE DEVELOPMENT 100-YEAR WITH 3.8°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1	
				APPROVED					WOODS.CO.N		



LEGEND

SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

0m - 0.05m

0.05m - 0.1m

0.1m - 0.2m

0.2m - 0.3m

0.3m - 0.4m

0.4m - 0.5m

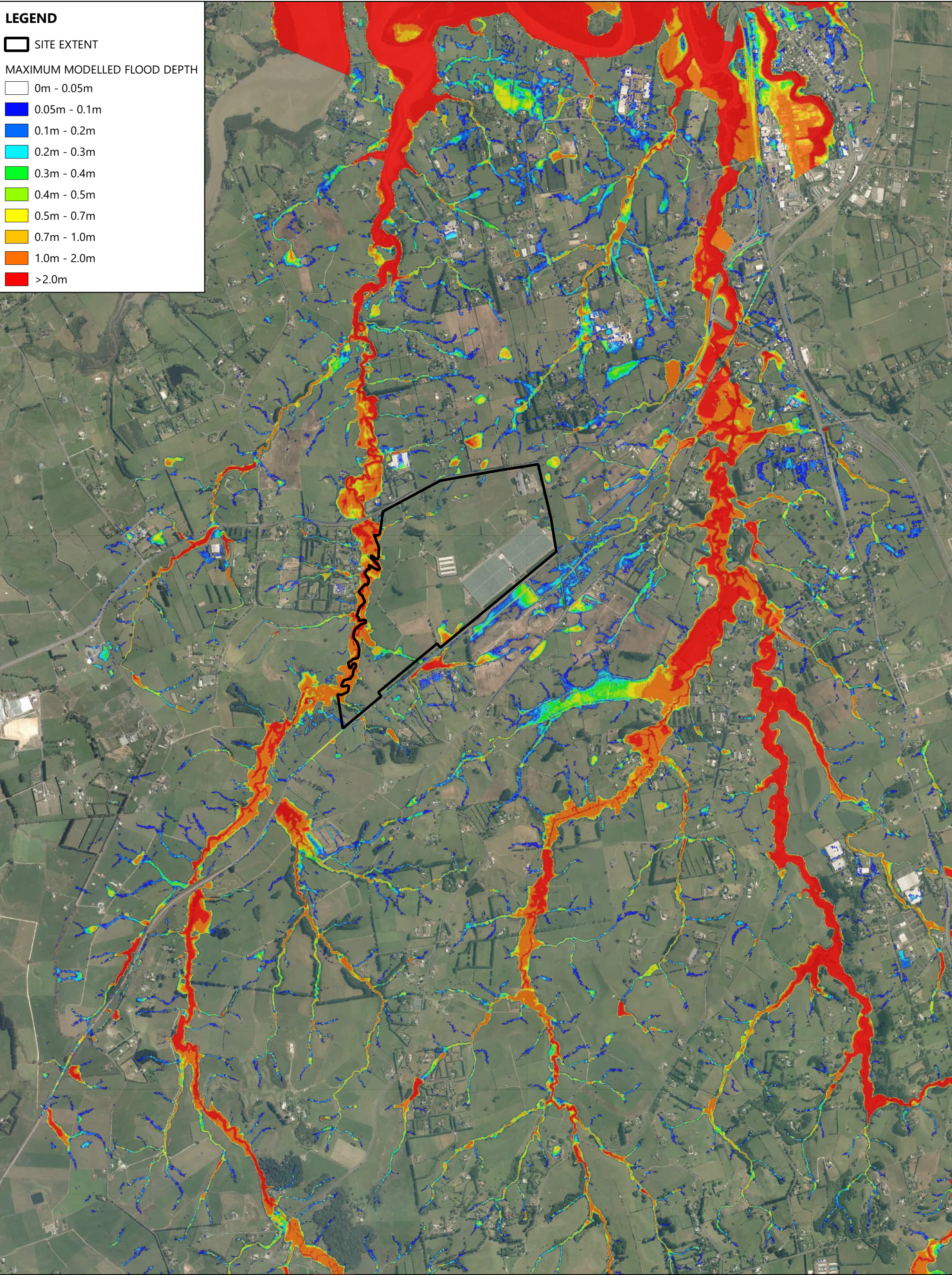
0.5m - 0.7m

0.7m - 1.0m

1.0m - 2.0m

>2.0m

REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8	 WOODS EST.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4A - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 100-YEAR WITH 3.8°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
1.0	FOR INFORMATION	-	19/09/2024	MODELLED	SS	NUGENT ST				SCALE	NTS	1.0
-	-	-	-	DRAWN	KD	GRAFTON				COUNCIL	AUCKLAND COUNCIL	
-	-	-	-	CHECKED	SS	AUCKLAND				DWG NO	SHEET 1 OF 1	
				APPROVED		1061						
							WOODS.CO.NZ					



LEGEND

SITE EXTENT

MAXIMUM MODELLED FLOOD DEPTH

0m - 0.05m

0.05m - 0.1m

0.1m - 0.2m

0.2m - 0.3m

0.3m - 0.4m

0.4m - 0.5m

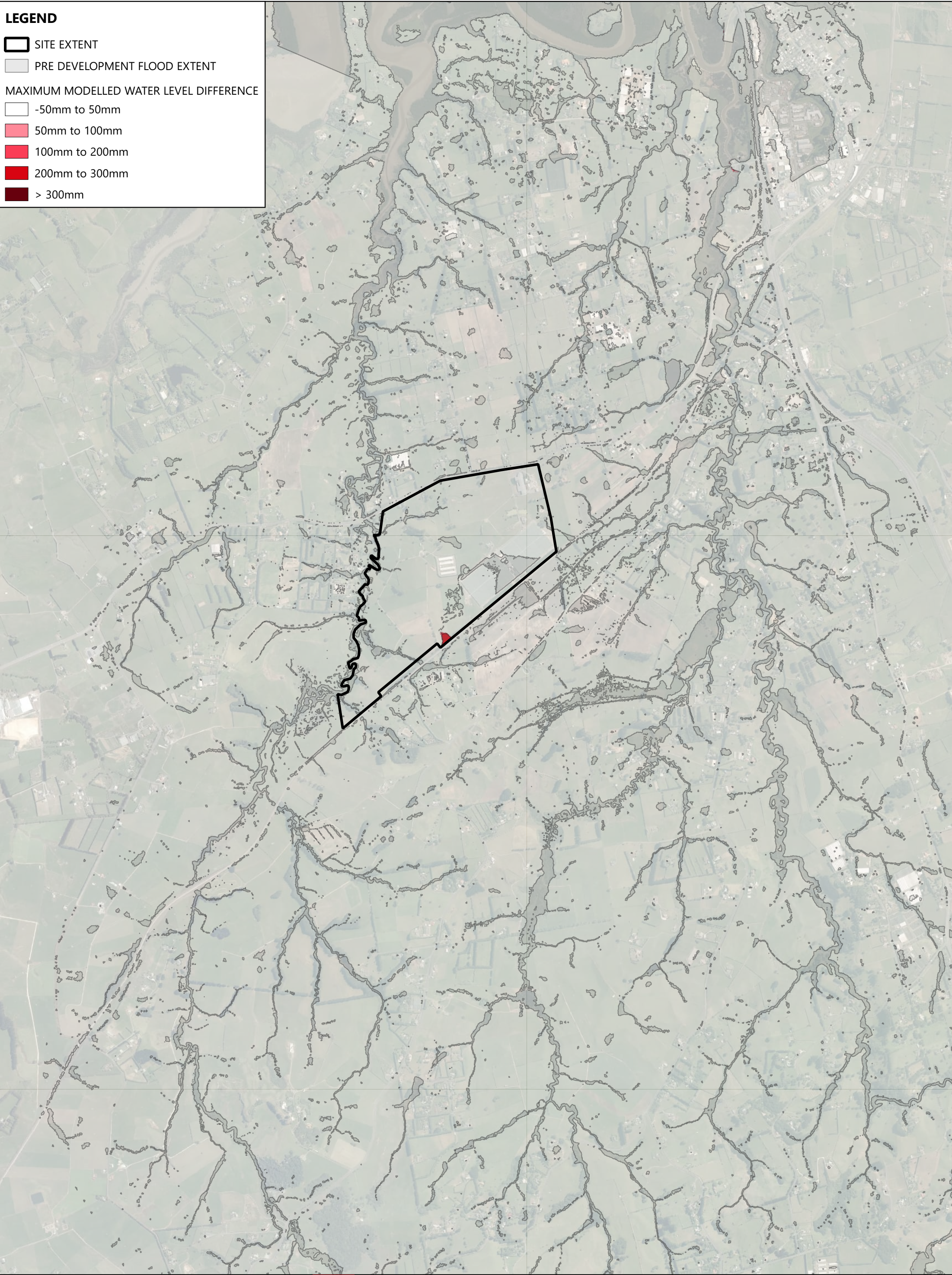
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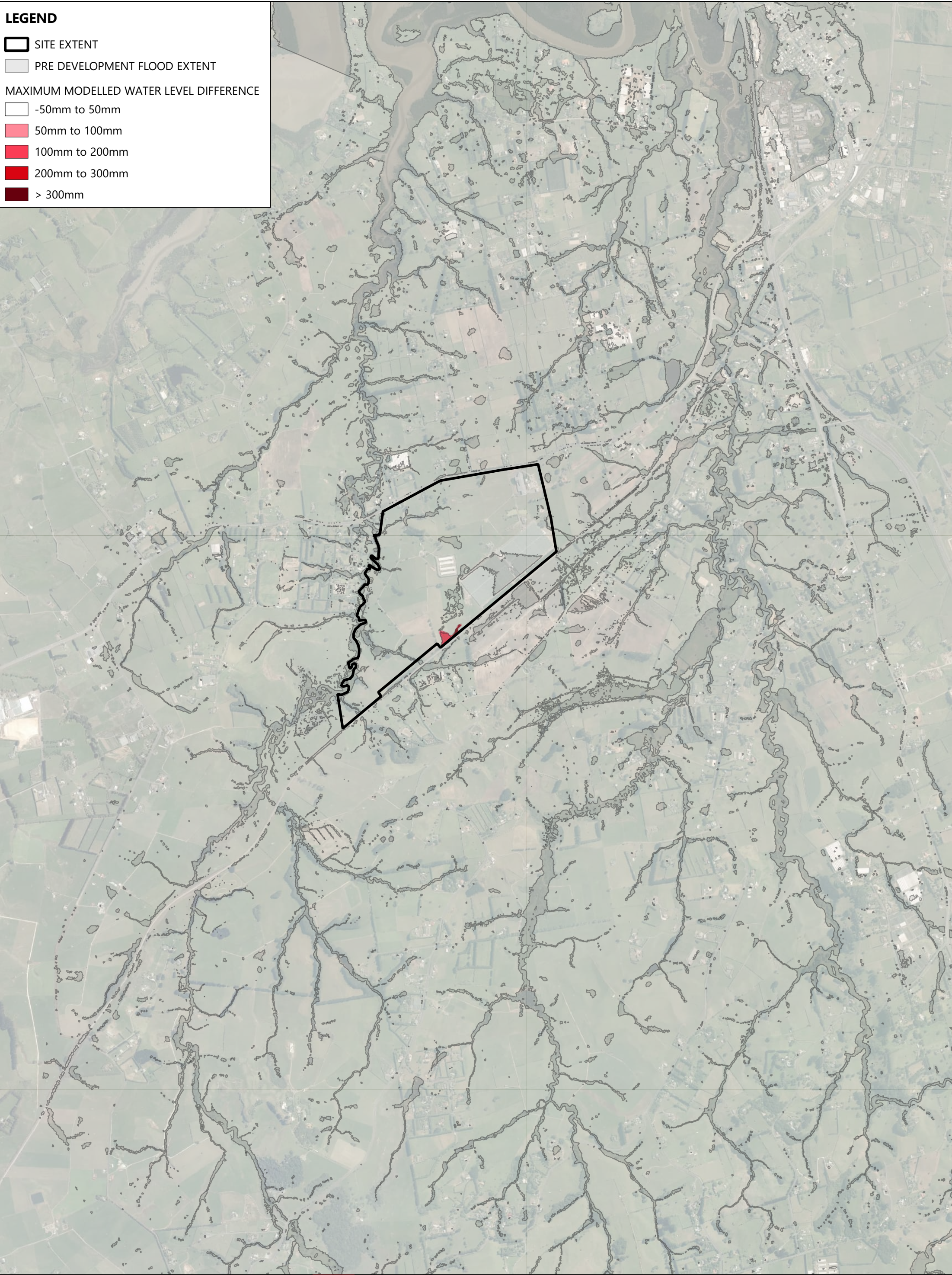
0.7m - 1.0m

1.0m - 2.0m

>2.0m

REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8 NUGENT ST GRAFTON AUCKLAND 1061  WOODS EST.1970 WOODS.CO.N	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED FLOOD DEPTH: SCENARIO 4B - POST DEVELOPMENT WITH FLOOD MITIGATION - PASS FORWARD + DIVERSION 100-YEAR WITH 3.8°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
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-	-	-	-	CHECKED	SS				DWG NO	SHEET 1 OF 1	
				APPROVED							





LEGEND

SITE EXTENT

PRE DEVELOPMENT FLOOD EXTENT

MAXIMUM MODELLED WATER LEVEL DIFFERENCE

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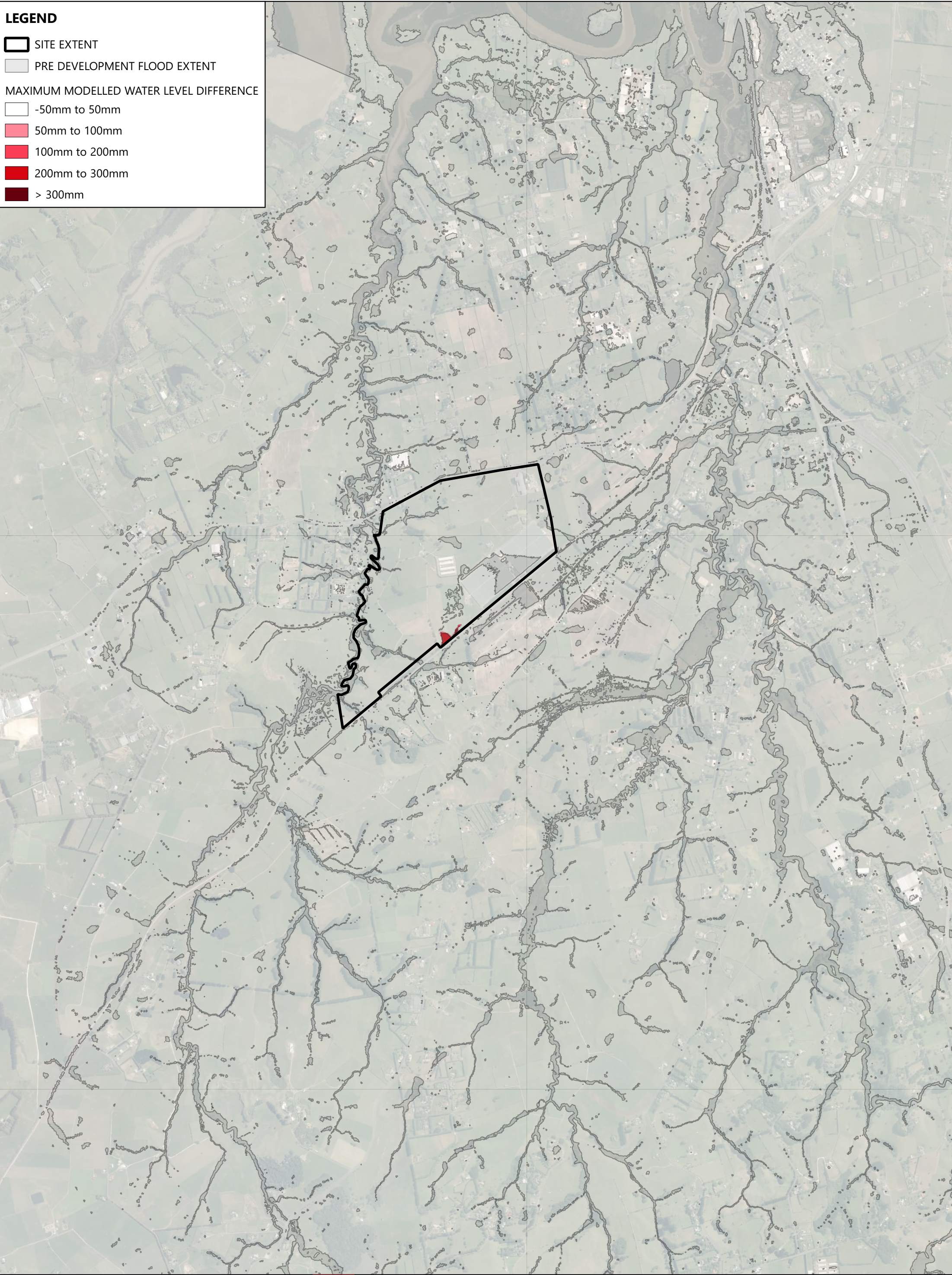
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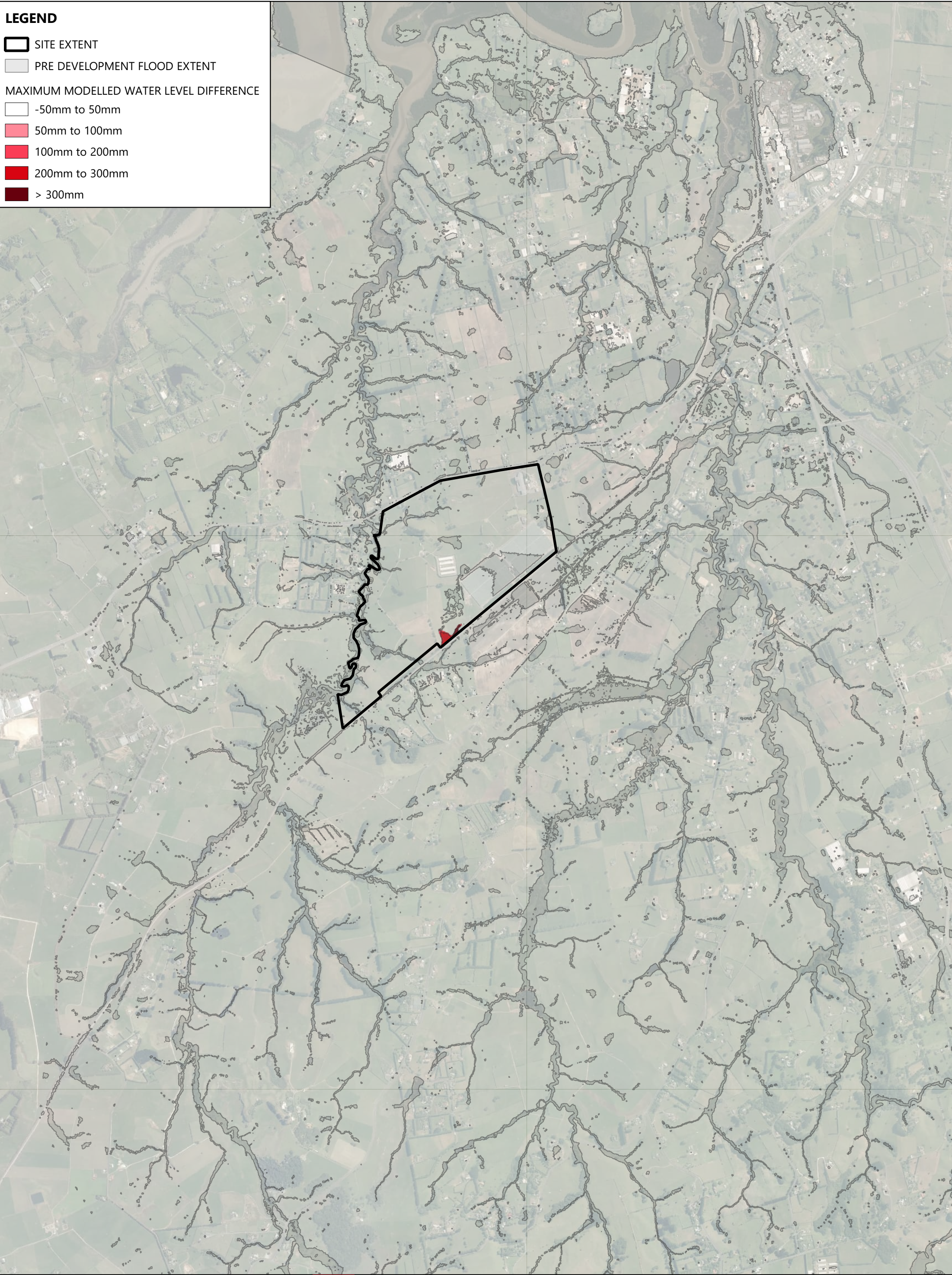
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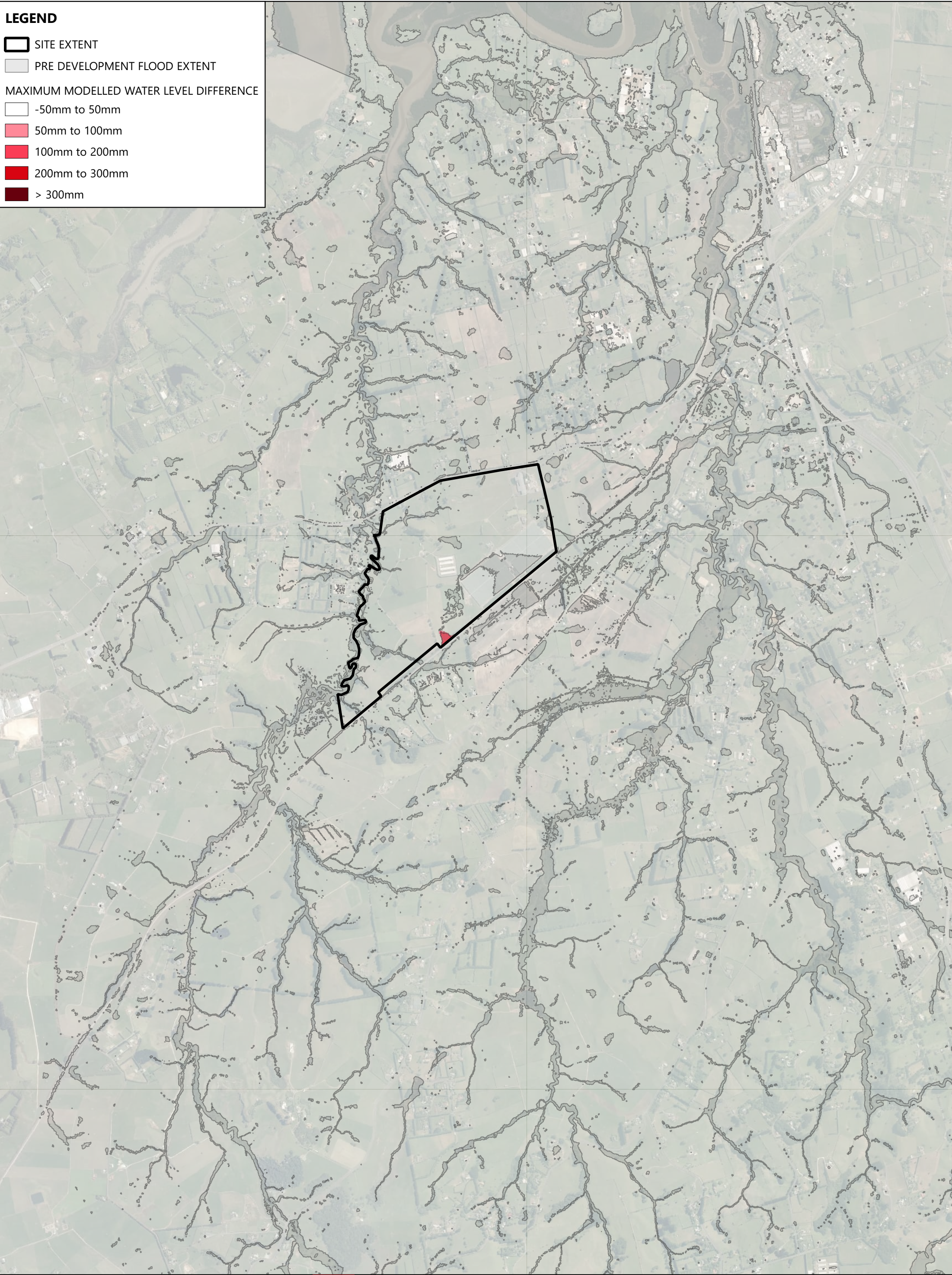
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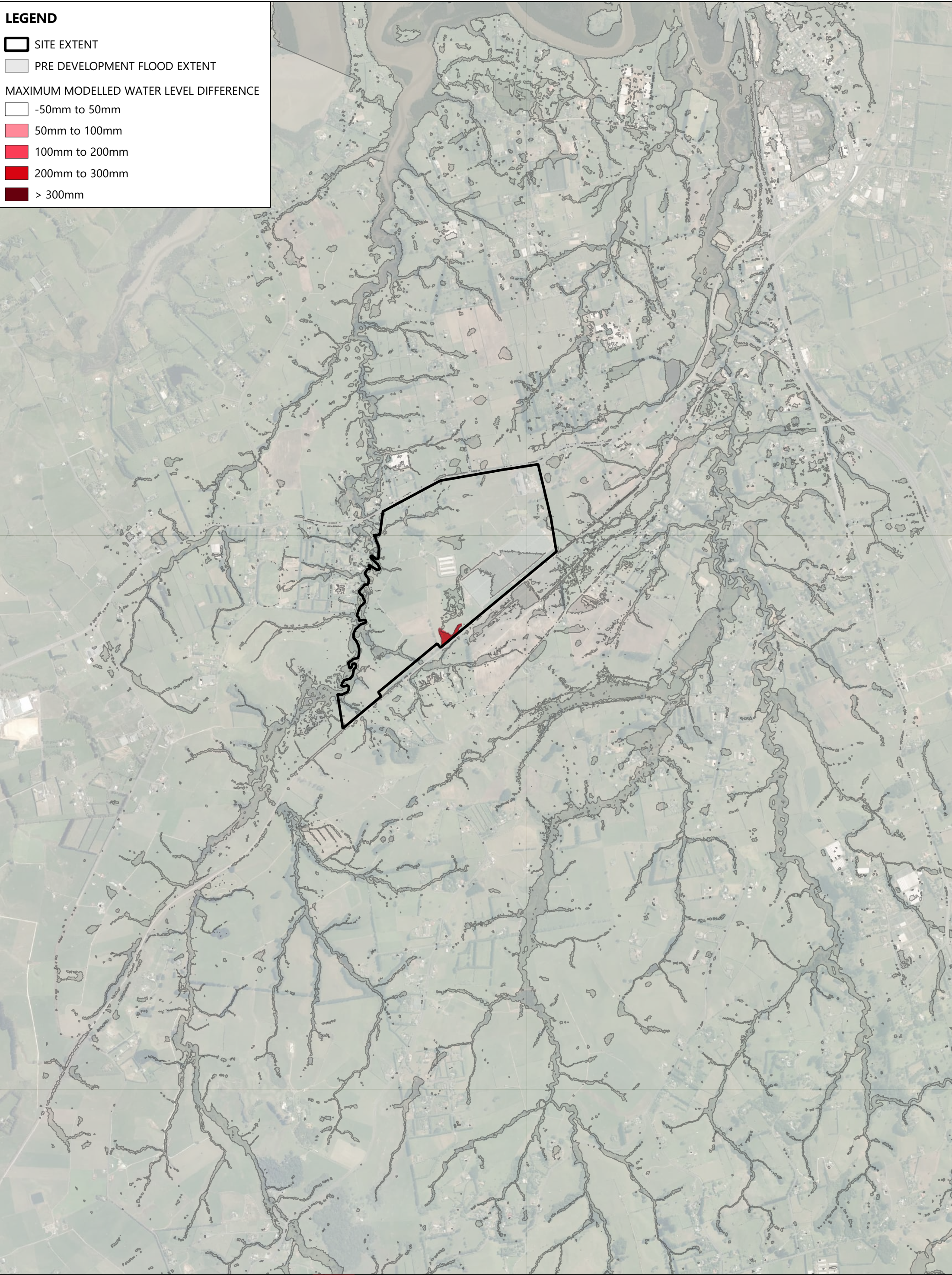


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				APPROVED		WOODS.CO.NZ						

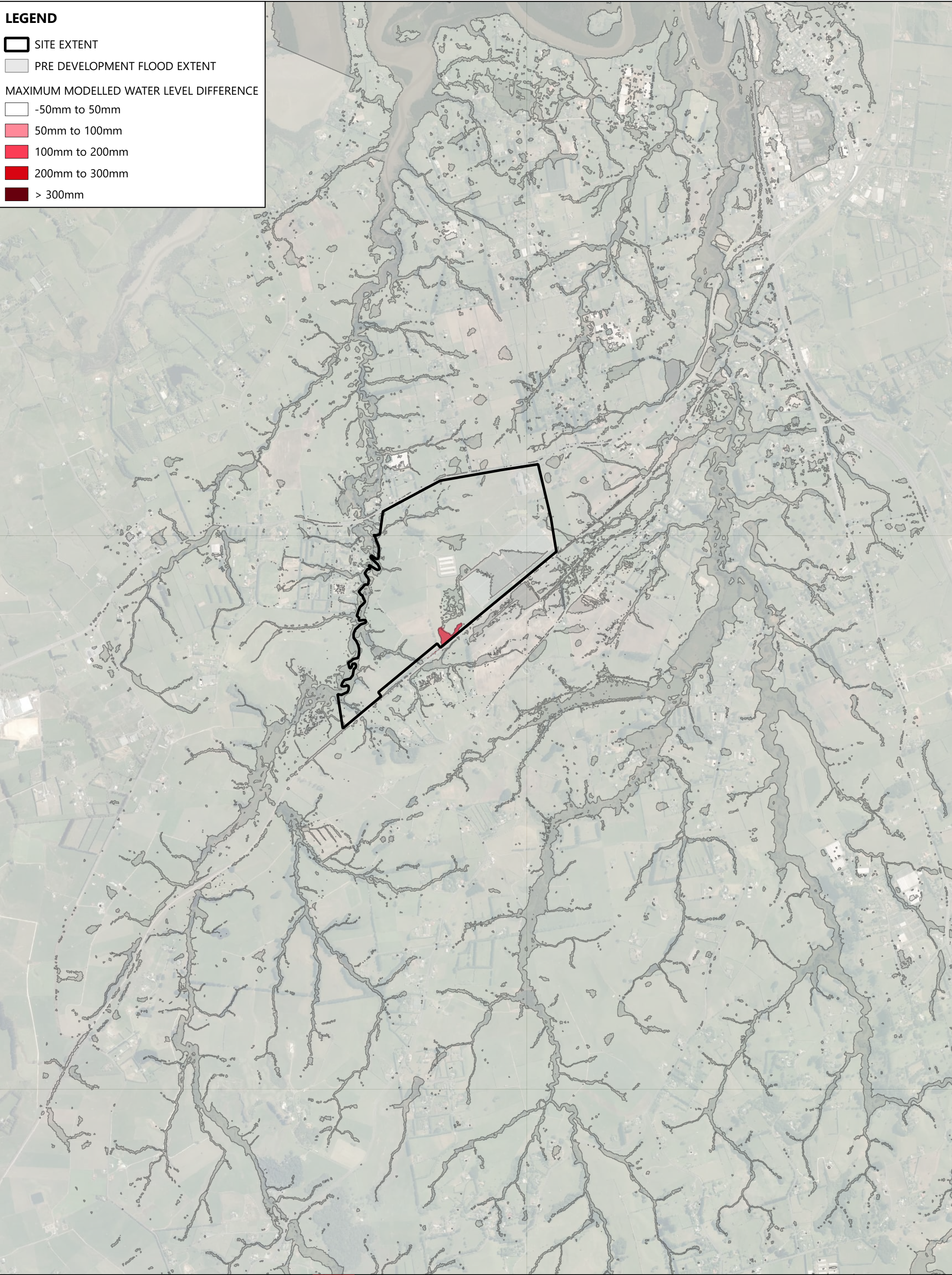


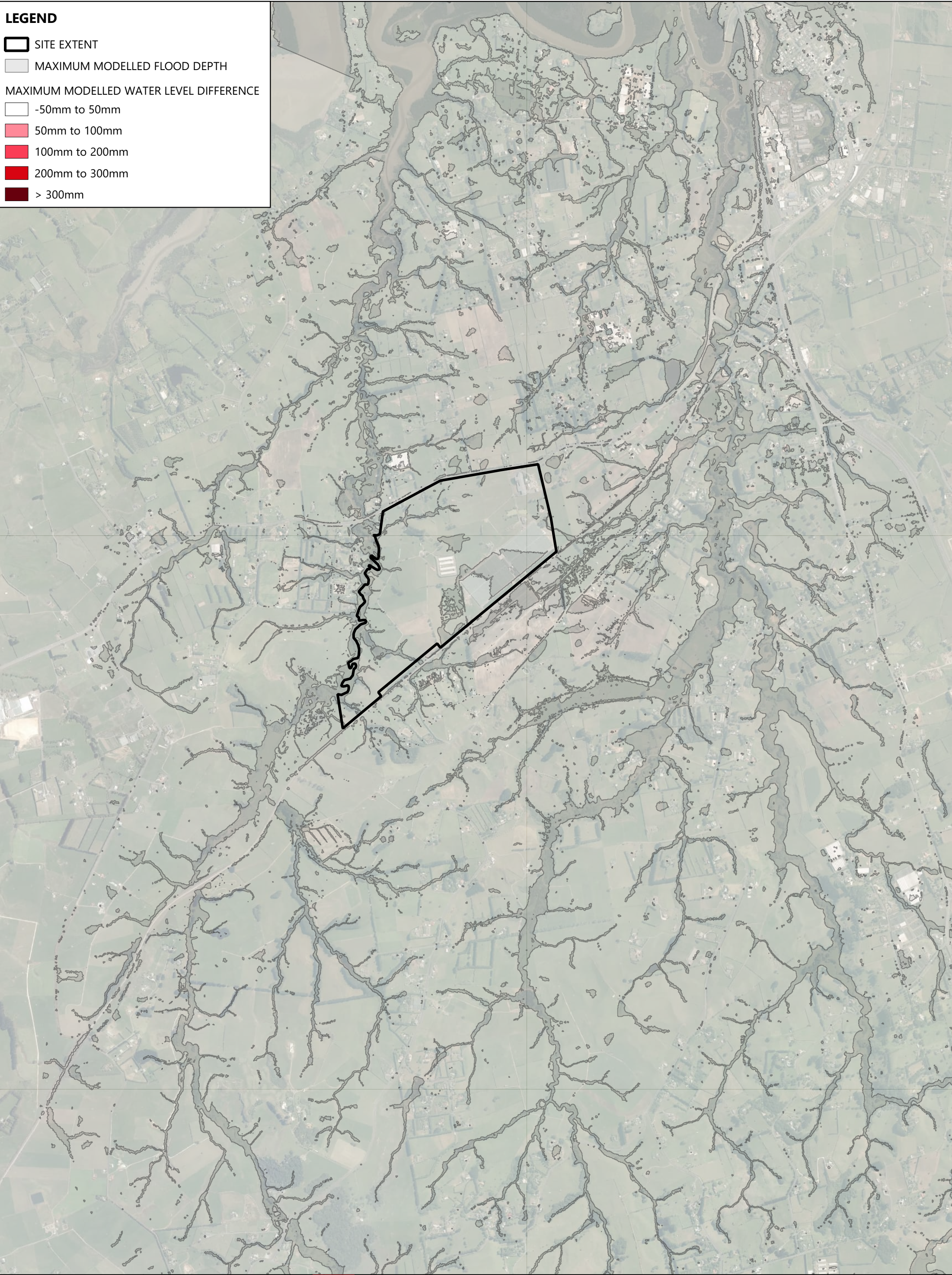
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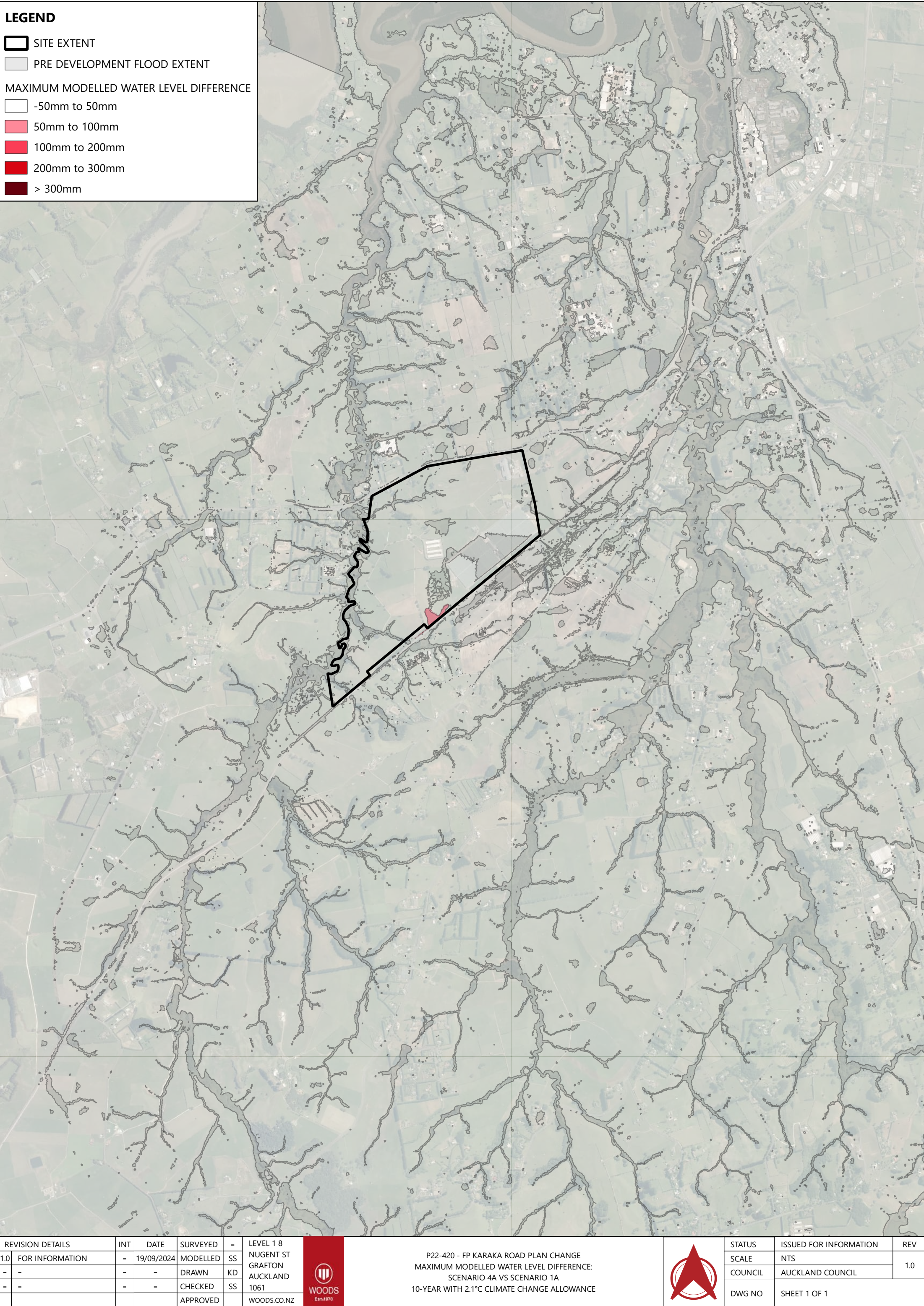


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REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8 NUGENT ST GRAFTON AUCKLAND 1061  WOODS.CO.N	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED WATER LEVEL DIFFERENCE: SCENARIO 4B VS SCENARIO 1B 10-YEAR WITH NO CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
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SITE EXTENT

PRE DEVELOPMENT FLOOD EXTENT

MAXIMUM MODELLED WATER LEVEL DIFFERENCE

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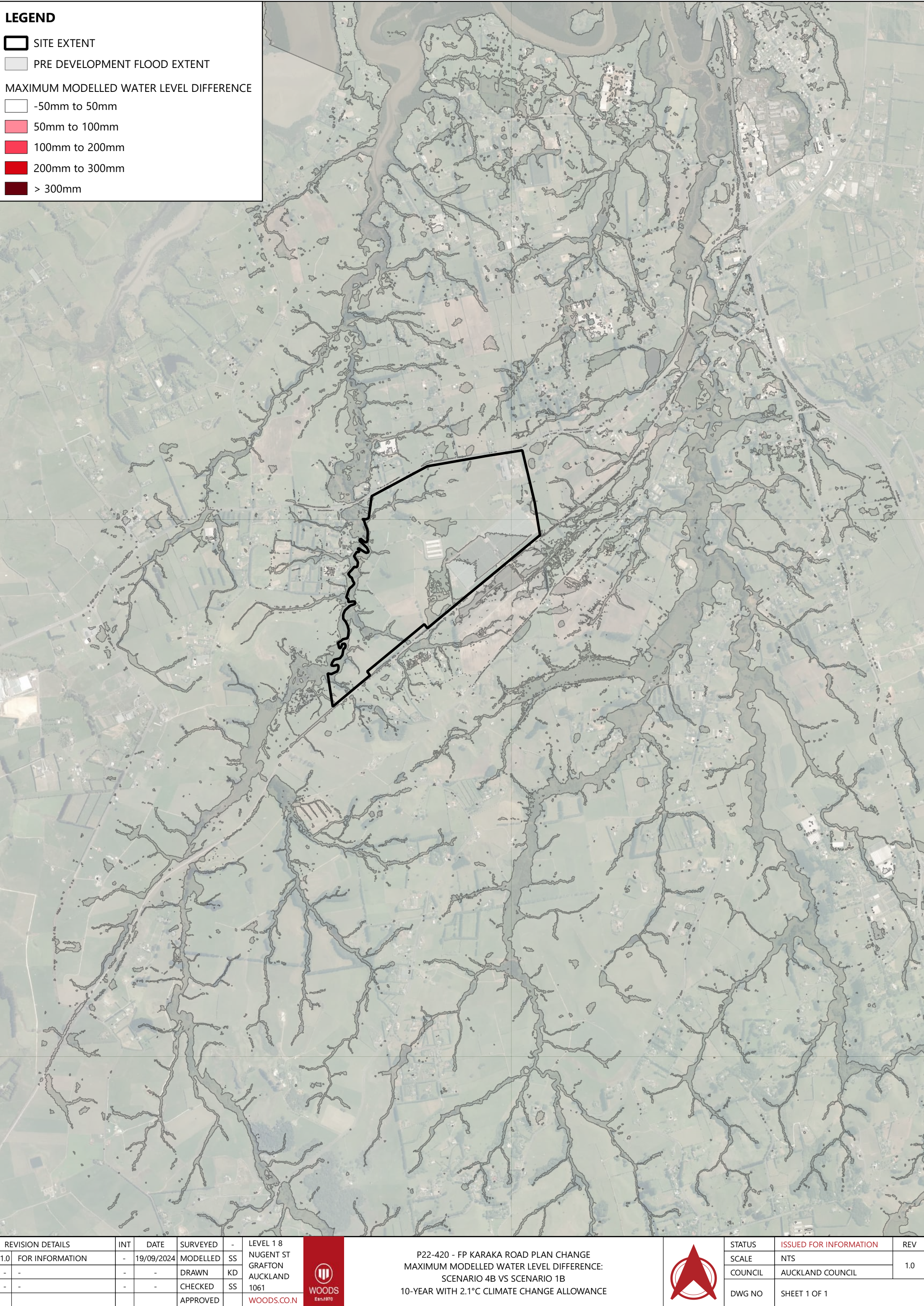
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100mm to 200mm

200mm to 300mm

> 300mm

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				APPROVED		WOODS.CO.NZ						



SITE EXTENT

PRE DEVELOPMENT FLOOD EXTENT

MAXIMUM MODELLED WATER LEVEL DIFFERENCE

-50mm to 50mm

50mm to 100mm

100mm to 200mm

200mm to 300mm

> 300mm

REVISION DETAILS		INT	DATE	SURVEYED	-
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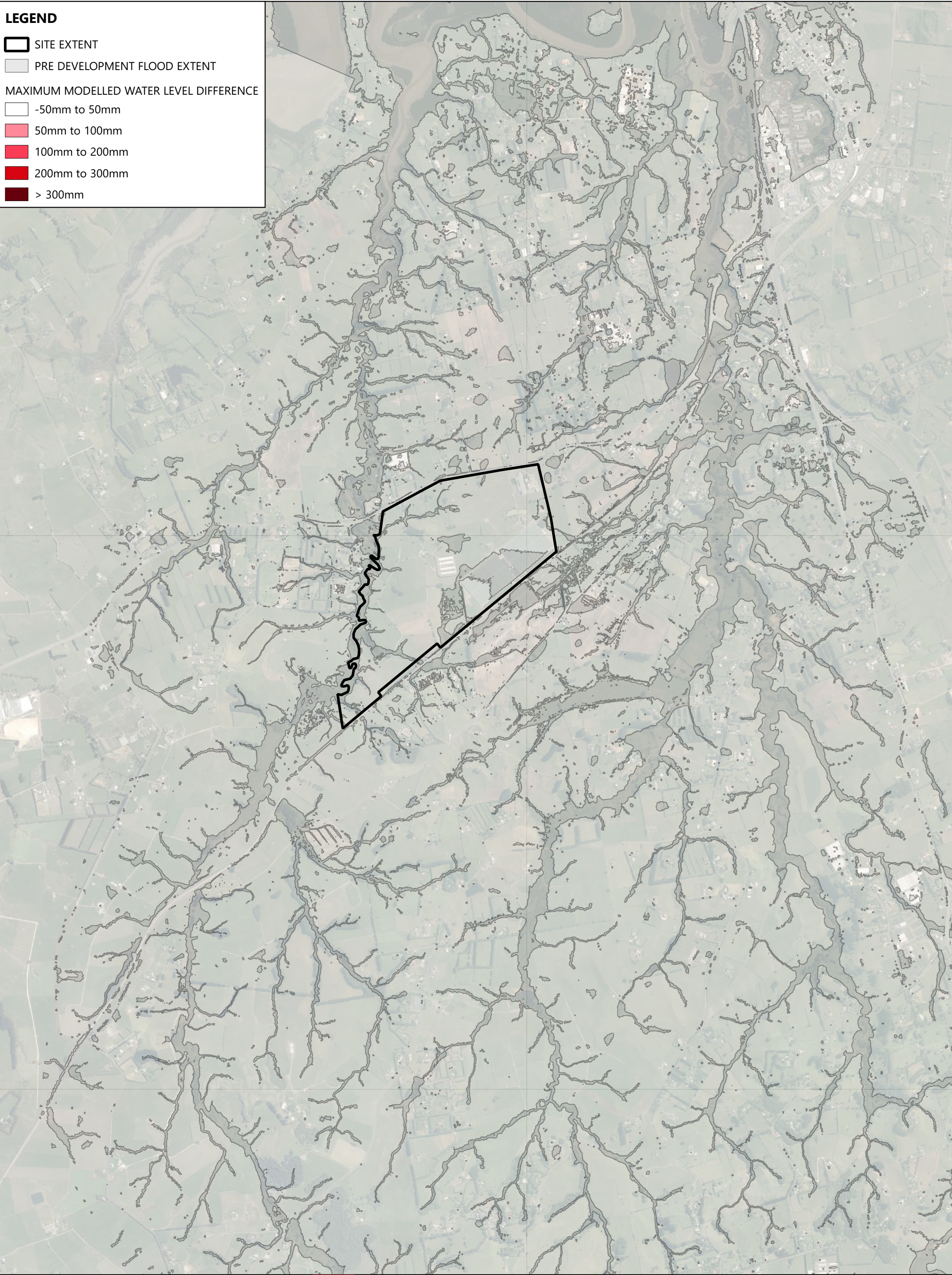
LEVEL 1 B
NUGENT ST
GRAFTON
AUCKLAND
1061



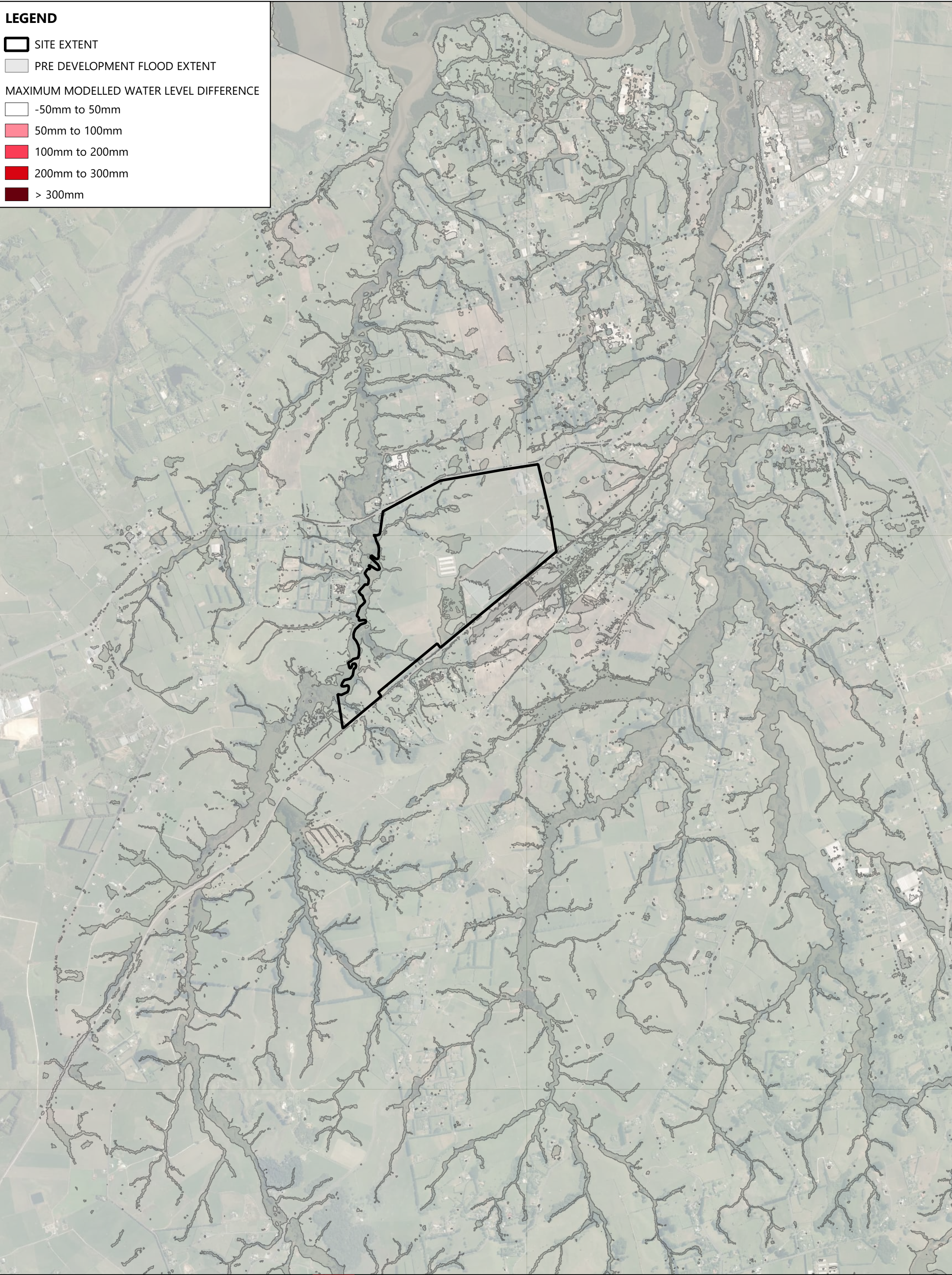
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MAXIMUM MODELLED WATER LEVEL DIFFERENCE:
SCENARIO 4B VS SCENARIO 1B
10-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE



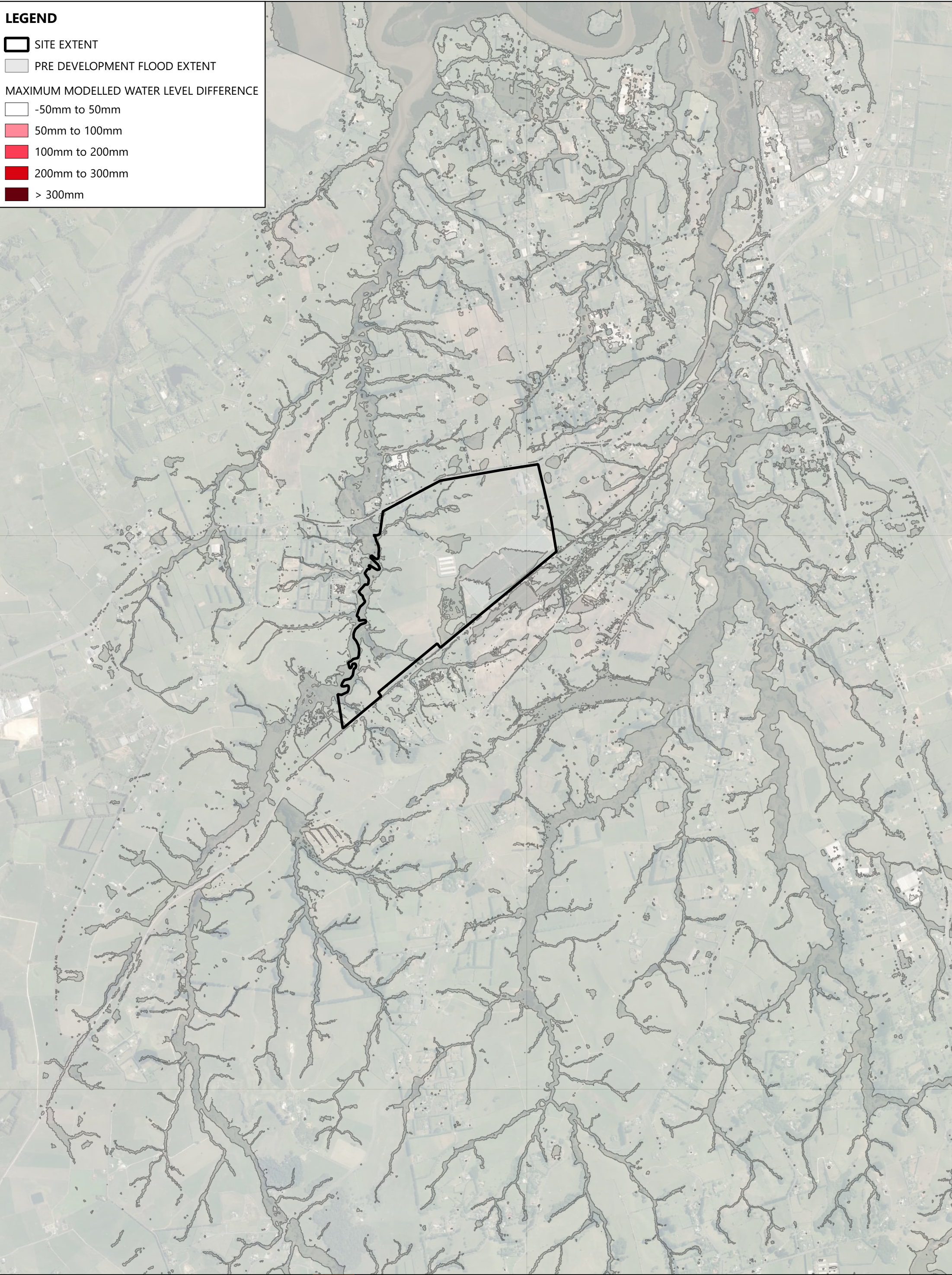
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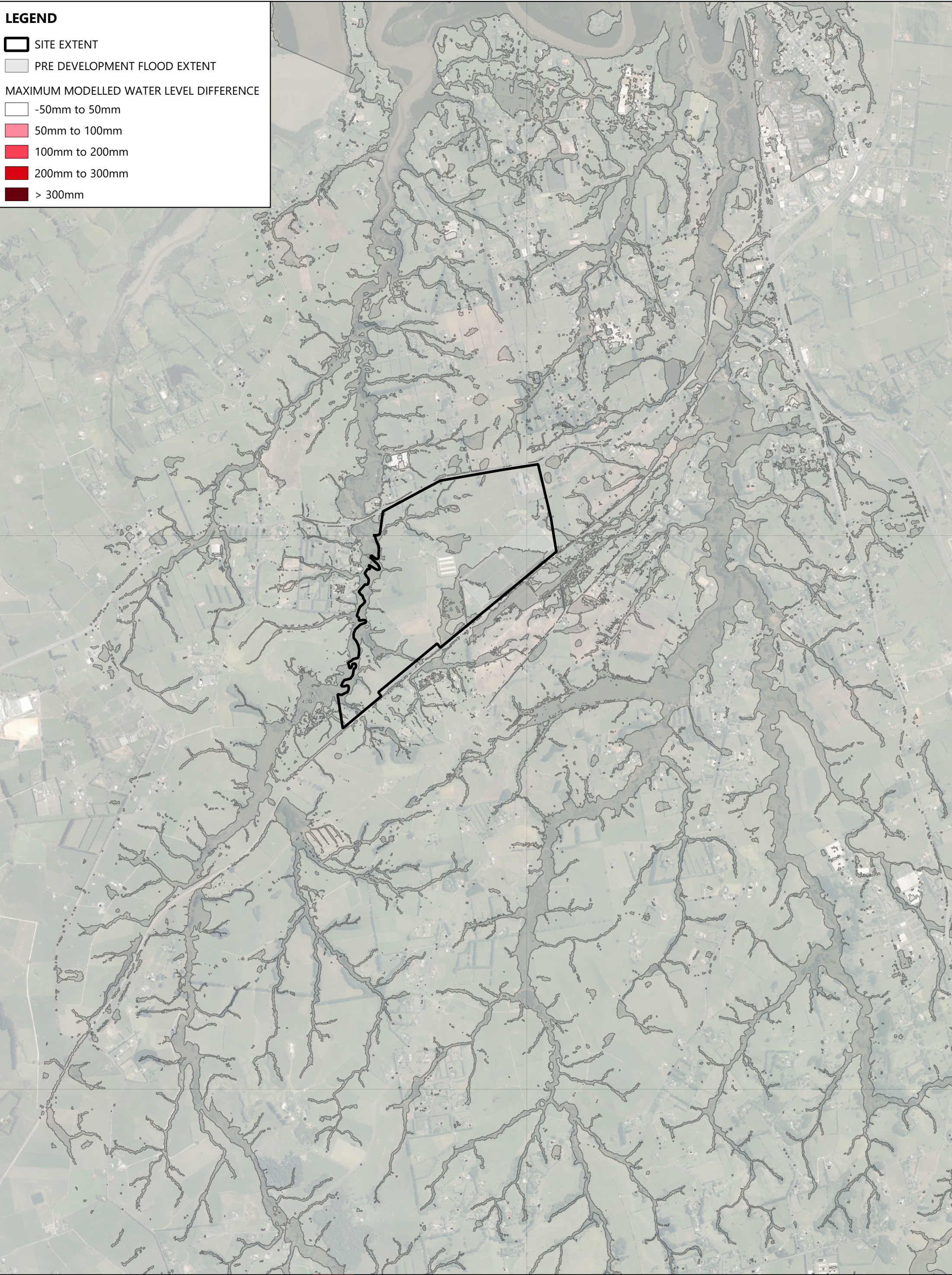
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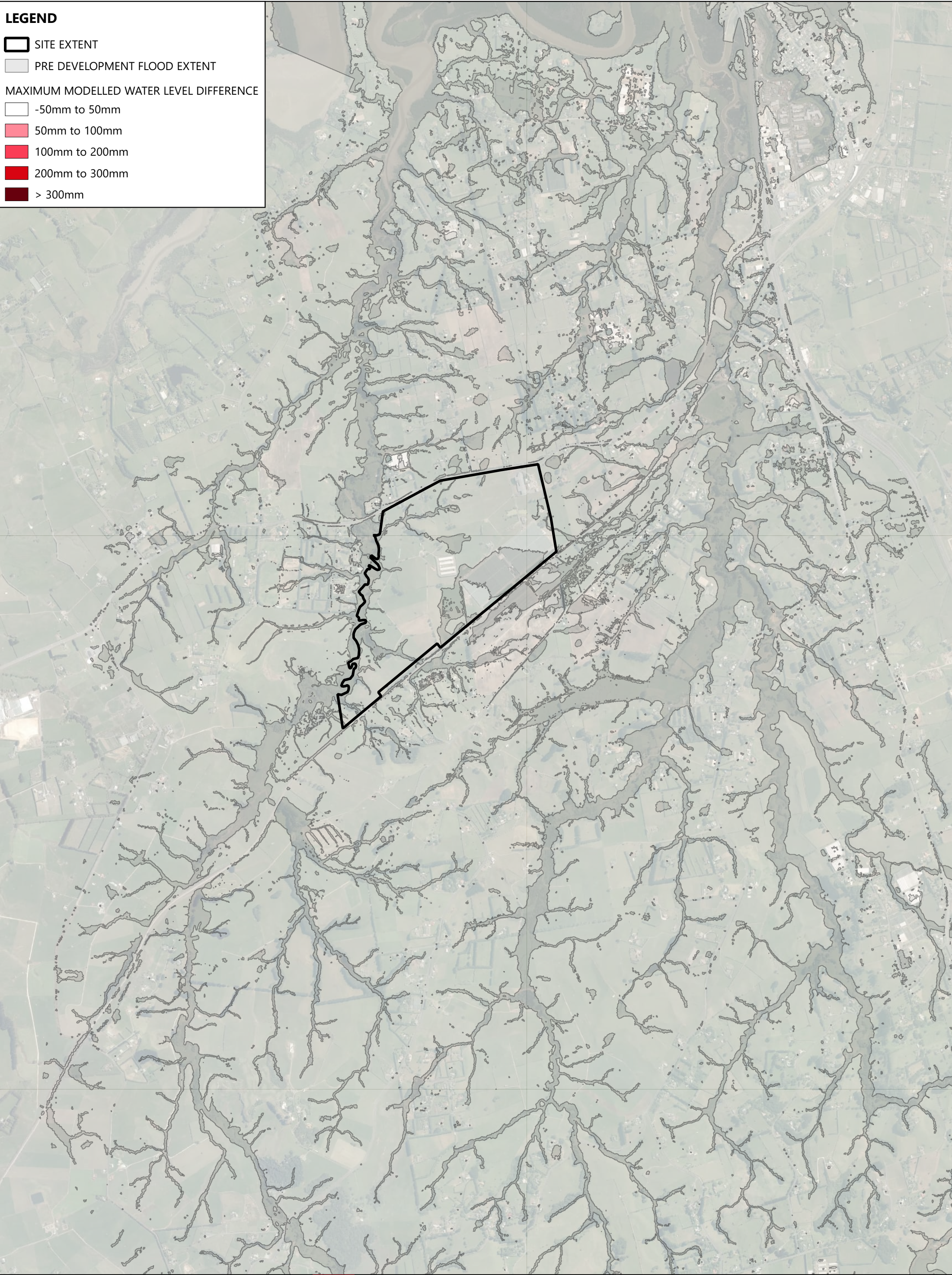
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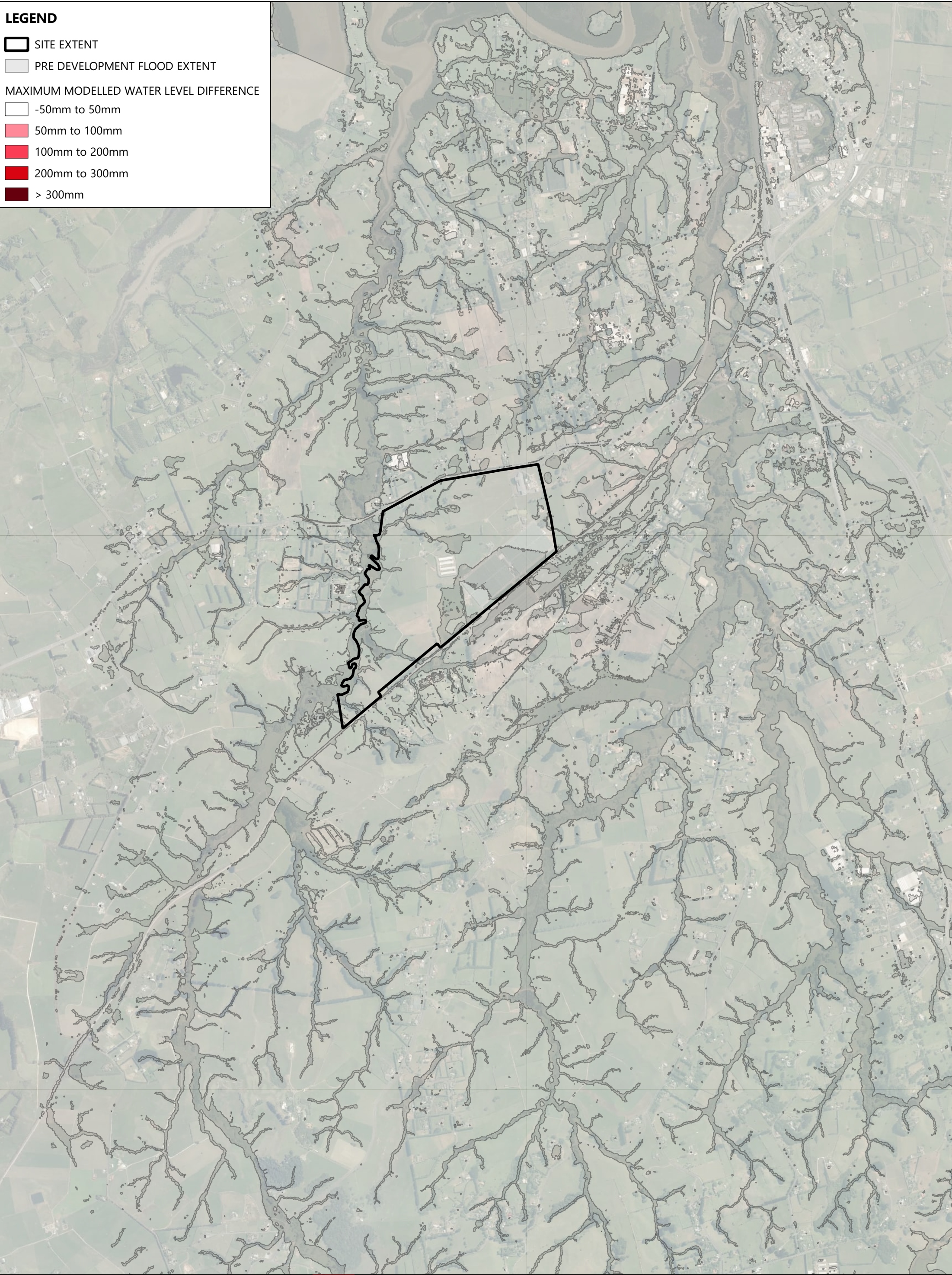
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						WOODS.CO.NZ						



REVISION DETAILS		INT	DATE	SURVEYED	-	 WOODS EST.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED WATER LEVEL DIFFERENCE: SCENARIO 4B VS SCENARIO 1B 100-YEAR WITH NO CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
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REVISION DETAILS		INT	DATE	SURVEYED	-	WOODS Est.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED WATER LEVEL DIFFERENCE: SCENARIO 4A VS SCENARIO 1A 100-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
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REVISION DETAILS		INT	DATE	SURVEYED	-	LEVEL 1 8	 WOODS EST.1970	P22-420 - FP KARAKA ROAD PLAN CHANGE MAXIMUM MODELLED WATER LEVEL DIFFERENCE: SCENARIO 4B VS SCENARIO 1B 100-YEAR WITH 2.1°C CLIMATE CHANGE ALLOWANCE		STATUS	ISSUED FOR INFORMATION	REV
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						WOODS.CO.N						

SITE EXTENT

PRE DEVELOPMENT FLOOD EXTENT

MAXIMUM MODELLED WATER LEVEL DIFFERENCE

-50mm to 50mm

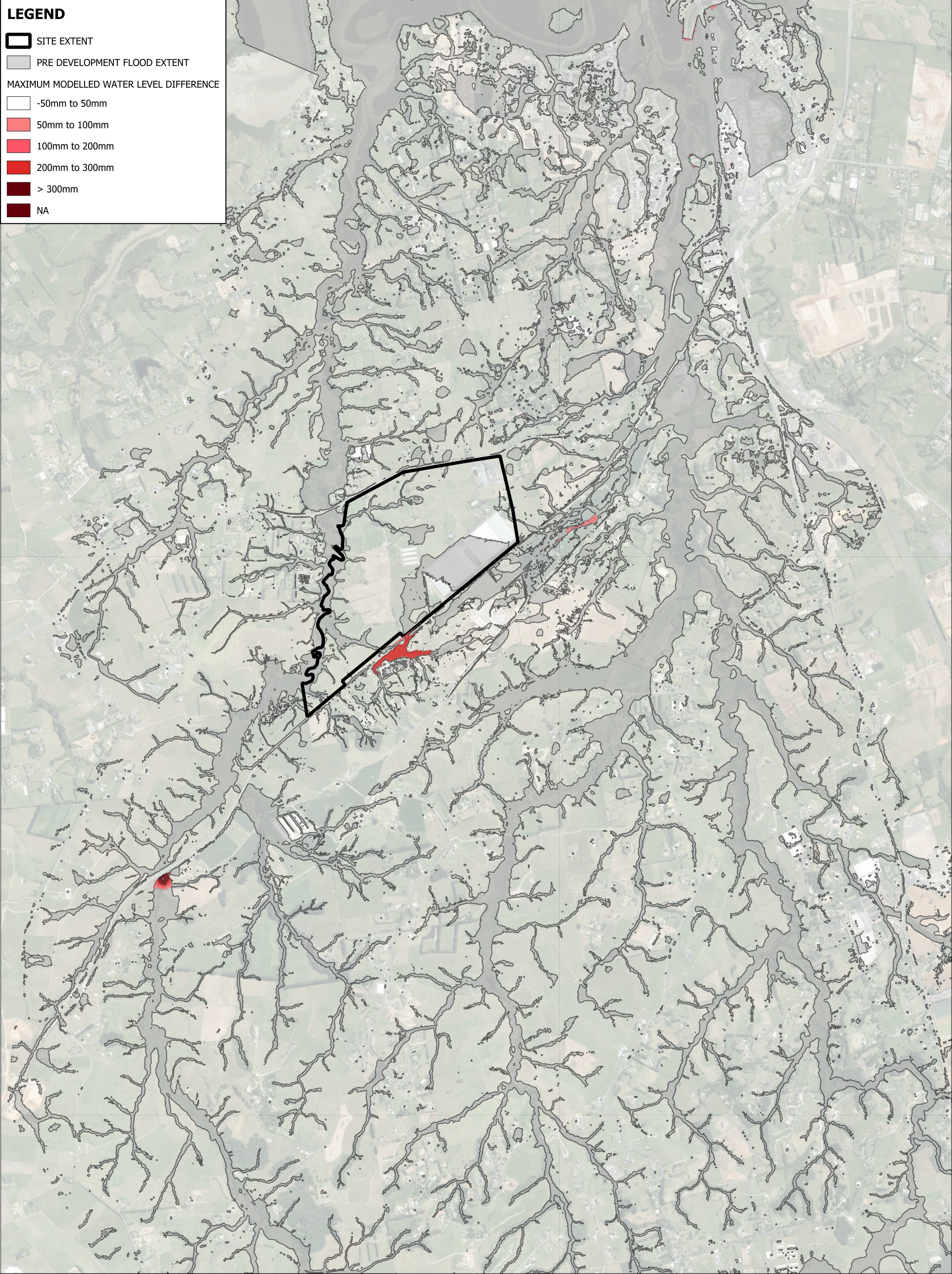
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100mm to 200mm

200mm to 300mm

> 300mm

NA



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						WOODS.CO.NZ								

SITE EXTENT

PRE DEVELOPMENT FLOOD EXTENT

MAXIMUM MODELLED WATER LEVEL DIFFERENCE

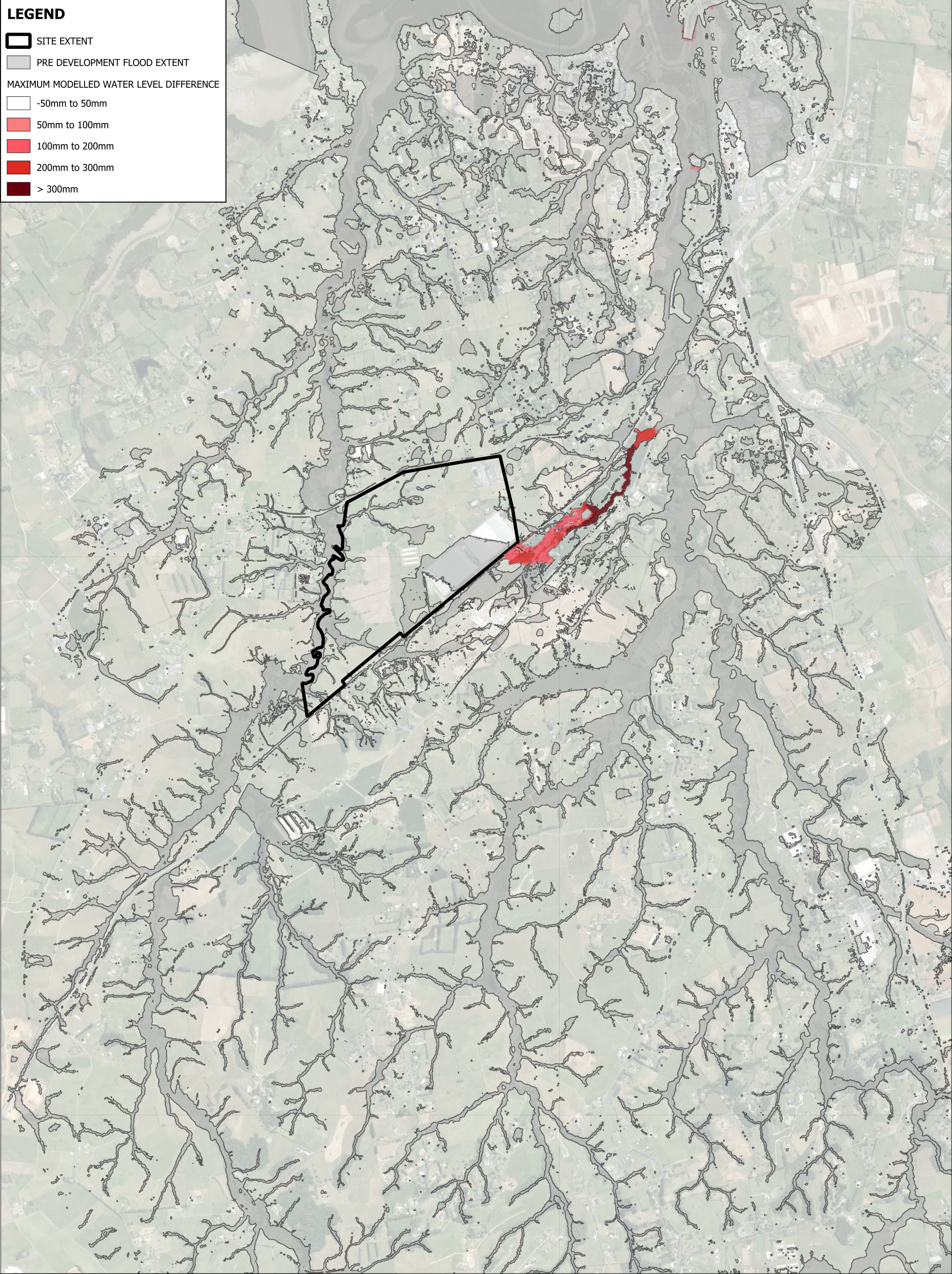
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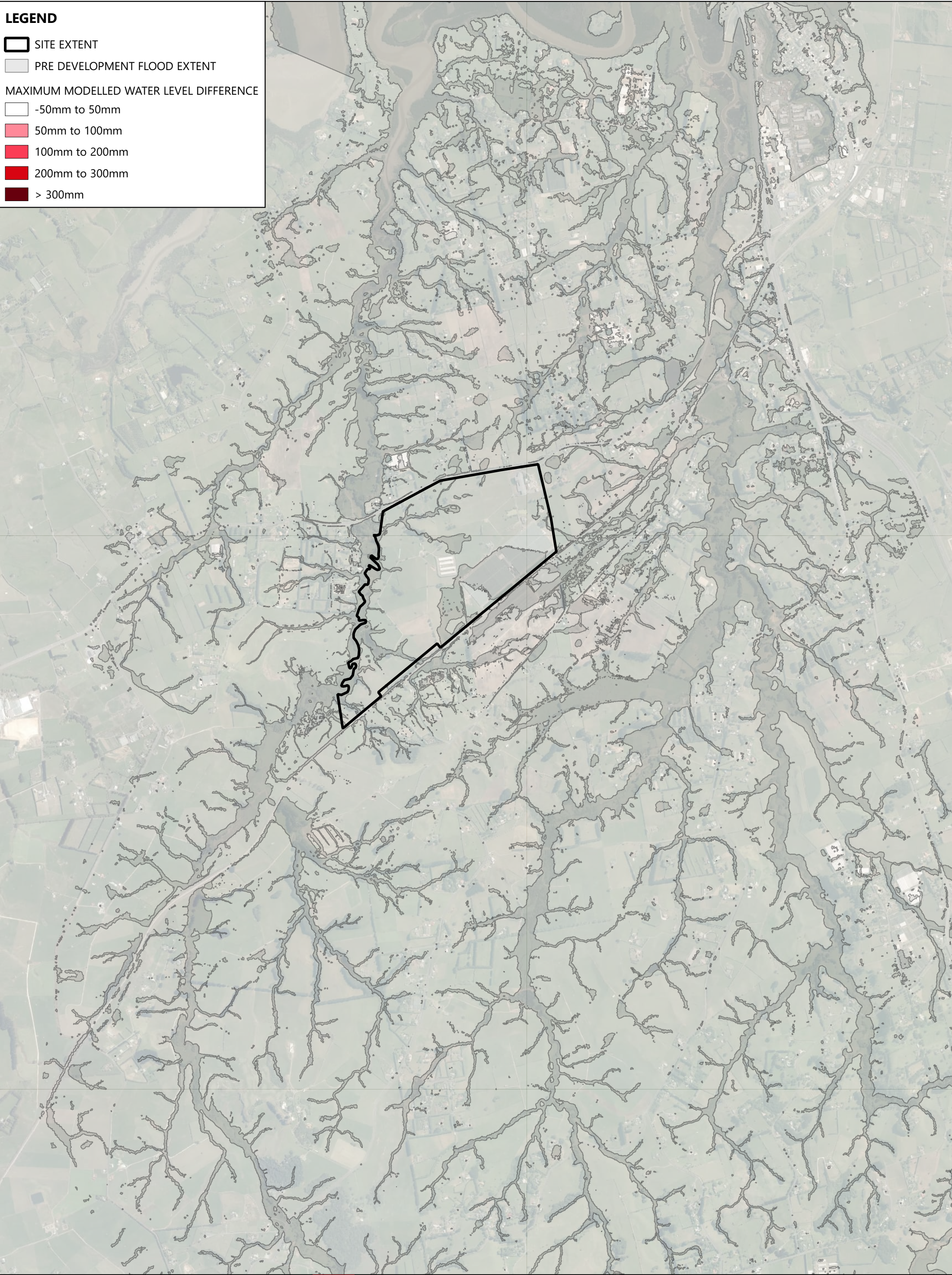
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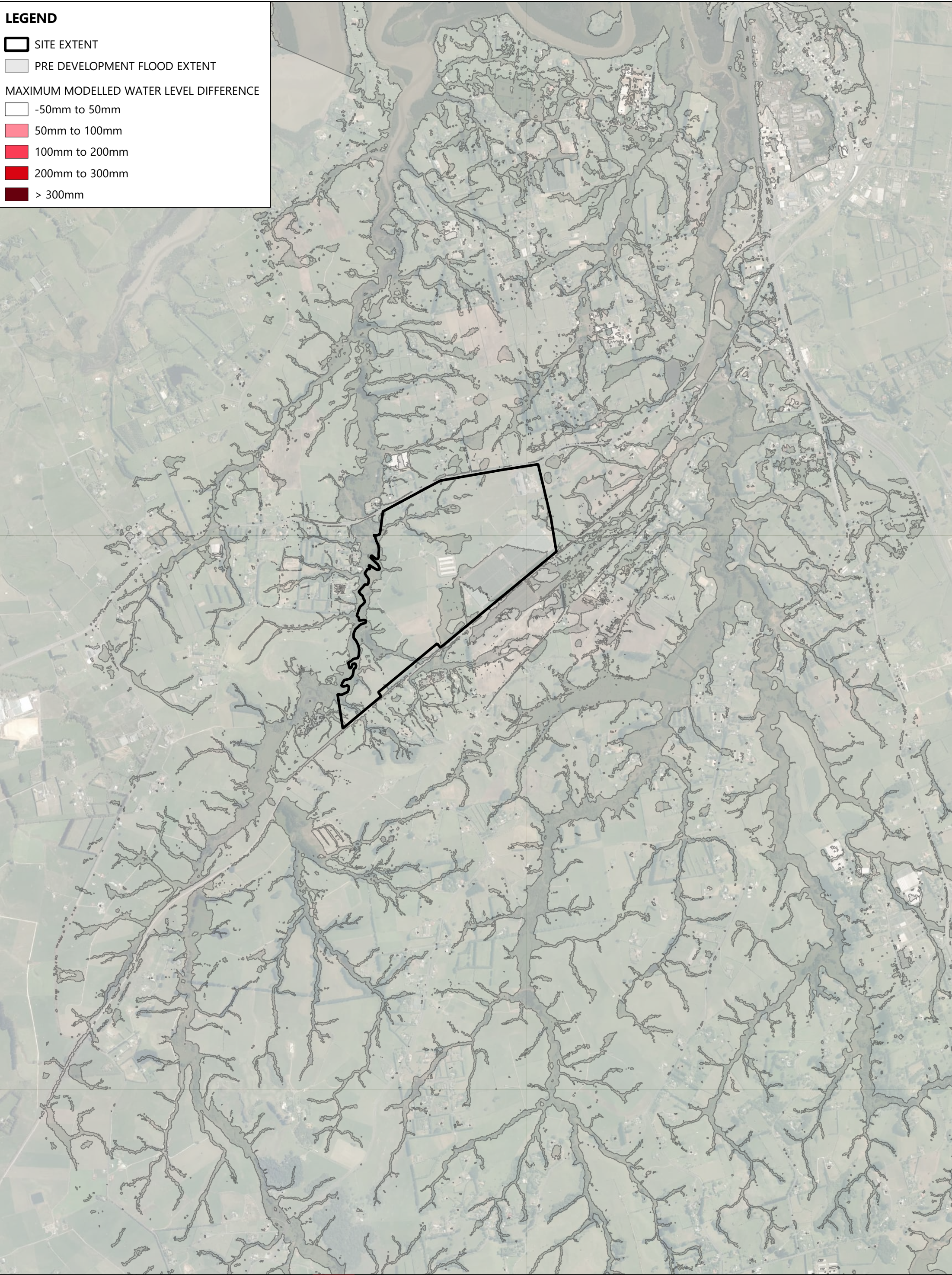
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				APPROVED							

APPENDIX E – STREAM EROSION ASSESSMENT

To

Auckland Council

From

Woods

Shakti Singh – 3 Waters Engineer

Danny Baucke – Geomorphologist and geospatial specialist

Reviewers:

Boniface Kinnear – Senior Associate Engineer

Pranil Wadan – Technical Director

W-REF: P22-420 FP Karaka Road Plan Change

19 June 2025

Karaka Road Plan Change - Stream Erosion Assessment Version 2

1. Introduction

Fisher & Paykel Healthcare Properties Ltd (F&P) has engaged Woods to provide expertise regarding stormwater for a Structure Plan and Private Plan Change (PPC) for land zoned Future Urban and Rural – Mixed Rural, located at 300, 328, 350, 370, & 458 Karaka Road, Drury (Figure 1). The development is classified as a 'greenfield' development under Schedule 4 of Auckland Council's Regionwide Network Discharge Consent (NDC) and therefore requires a stormwater management plan (SMP).

Figure 1 shows the extent of the site and the proposed Plan Change.

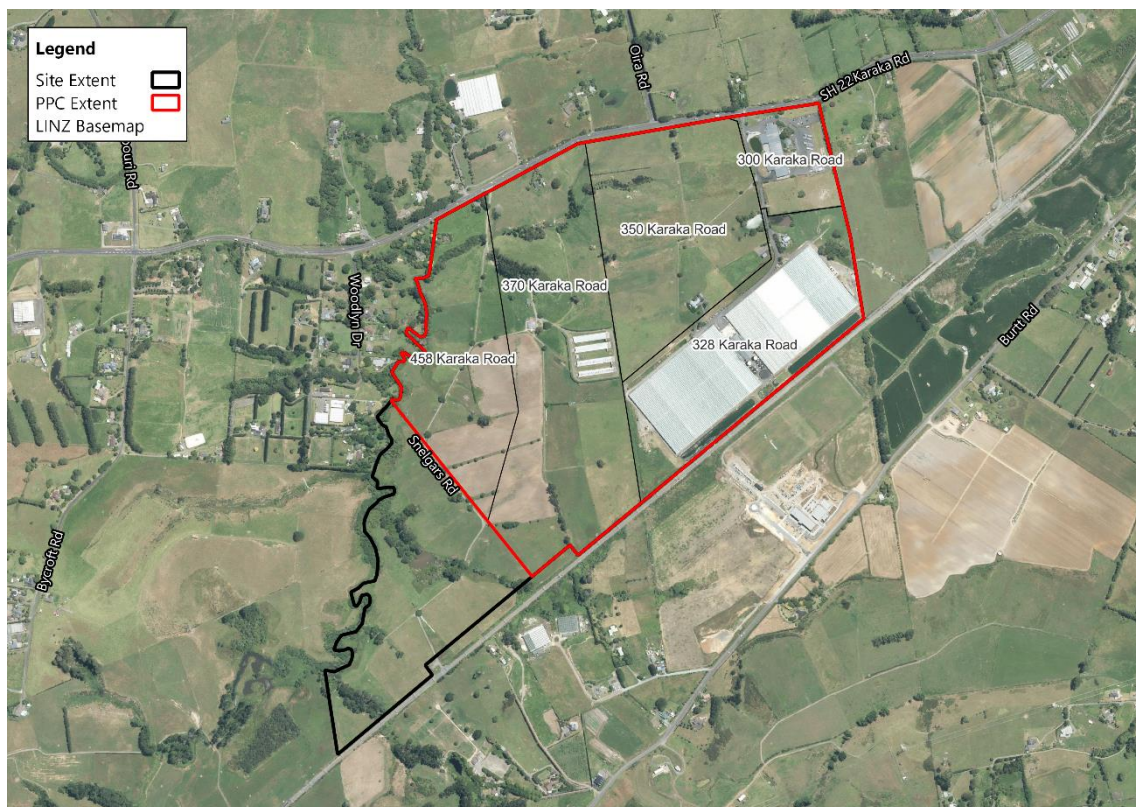


Figure 1: Site and plan change extent

After lodgement of the Plan Change and the SMP, a Clause 23 was issued by Auckland Council. Subsequently, a stream erosion assessment was undertaken by Woods for Oiroa Creek along the western boundary to where the PC area discharges. The assessment utilised the Healthy Waters' Erosion Screening Tool (EST) and was submitted to same for review. On April 7, 2025, Healthy Water and Woods had a meeting to discuss the results from the assessment (i.e., Version 1 of this current document). Additional queries were received in a second iteration of the Clause 23 request. This version (version 2) of the document builds on the previous version and expands on the responses. Both sets of Clause 23 queries are summarised below:

Clause 23 request:

Item SW2:

Executive Summary, Stormwater Management, pg. 7. Stated that,

"As per the FUZ SMP, the ecologists engaged by the applicant (Bioresearches) were consulted and have confirmed that the proposed stormwater management strategy in this SMP will mitigate any stream erosion which may occur post development."

Please clarify where in the report by Bioresearches (May 2024) this is stated. What assessment was used to determine this?

Item SW4:

- *What are the current conditions of the stream. Has a geomorphic assessment of its current state been carried out?*
- *What are the effects of the change in land use on stream erosion? Please provide further information on what management options can be used to manage any adverse effects.*

Clause 23 request (2):

Item SW 2

The following items need to be clarified:

- *whether the results provided are based on the EST results for pre and post development changes,*
- *whether the proposed mitigation will sufficiently manage the existing state of the stream.*
- *include the missing excess shear tables and graphs*
- *provide assessment of the existing state of the stream based on the EST.*

The EST results reflect pre-and-post-development scenarios. The EST was applied at five cross sections of Oiroa Creek (as shown on Figure 3). The results from the stream erosion assessment tool were used to assess the existing erosion potential of the stream, evaluate effects of climate change, and compare the change in the risk of erosion potential on Oiroa Creek as result of the proposed plan change (if any).

The assessment uses inputs from a flood model and makes use of a pre-development scenario (**Scenario 1a**) and plan change scenario (**Scenario 4a**), as discussed in the *SMP*. These were undertaken for 2-, 10- and 100-year ARI storm events (with and without climate change for 3.8°C future temperature increases by 2110 for all events).

In addition to the desktop studies, Woods recently undertook an additional site visit on 05/05/2025 to visually assess areas along the stream that may be susceptible to erosion and assess the existing state of the stream. During the site visit, a drone was used to capture high-definition images of the streams where walkover was not possible. A geomorphic change detection analysis was also undertaken to quantify vertical changes in elevation over time and identify patterns of erosion and deposition within the stream corridor from two periods 2016 and 2024, using LiDAR. This is discussed further in Section 3 of this memo.

2. Visual assessment

A 2 km reach of a low-energy, meandering portion of the stream was assessed on pastoral land adjacent the PC area. The stream appeared to be in a stable geomorphic state, showing natural features, minimal human

modification, and a well-established riparian corridor. Some of the key geomorphic and hydrological observations made during the site visit are included in Table 1.

Table 1: Visual assessment of Oiroa Creek

Observation	Visuals
The stream displays a passive meandering planform with alternating step-pool, riffle, and run sequences, providing good hydraulic diversity.	
The bed is composed mainly of fine silts and mud, with no evidence of bed armouring.	
Although in-channel bars were limited, there was a presence of some sandy, vegetated bars with tree growth, suggesting historic lateral migration and deposition during high flow events.	

Certain areas of the stream were at bank full stage at the time of observation and appears well connected to adjacent floodplains.	
No signs of bank instability were present; banks were intact with no slumping, undercutting, or active erosion.	
Lush wetlands with standing water bodies are present adjacent to the stream in the upper extent of the reach, contributing to floodplain connectivity, groundwater recharge, and potential habitat diversity.	

A culvert road crossing exists downstream of the extent.	
A well-developed riparian corridor spans most of the assessed reach, ranging from 5 to 15 metres wide on either side.	
Vegetation includes a mix of native and exotic species, with some breaks in coverage, especially on elevated banks or where pasture encroaches.	

There is no evidence of stock access to the stream, fencing runs parallel to the channel for the length of the reach. No evidence of significant human modifications (e.g., straightening, reinforcements, or diversions) was observed within the reach itself, though there may be some minor influence from the adjacent residential area, likely with limited impact on the stream's geomorphic character.	
The surrounding land is primarily pastoral, but there were no visible sources of active erosion, such as gullies, runoff points, or sediment plumes entering the stream.	

3. Geomorphic change detection analysis

This assessment includes a Geomorphic Change Detection (GCD) analysis using the GCD software developed by Dr. Joe Wheaton and collaborators¹. The assessment has been undertaken for the Oiroa Creek and within the extent of the site. The software performs spatial differencing between two Digital Elevation Models (DEMs), in this case, LiDAR-derived surfaces from 2016 and 2024 to quantify vertical changes in elevation over time and identify patterns of erosion and deposition within the stream corridor.

The analysis applies a Level of Detection (LOD) threshold of ± 0.1 m, which means only changes greater than ± 0.1 m in vertical elevation is considered statistically significant and mapped as either erosion (negative change) or deposition (positive change). This threshold accounts for spatial uncertainty in the LiDAR datasets and avoids misinterpreting noise or minor surface changes as geomorphic activity (i.e. indicates meaningful geomorphic change).

Streams are inherently dynamic systems and naturally undergo periods of erosion and deposition. However, the results from this GCD analysis suggest that:

- This stream is currently in a relatively stable geomorphic condition, with limited significant change over the assessed period. This indicates a state of dynamic equilibrium, where erosional and depositional processes are generally balanced.
- One exception is a localised zone of incision (red hotspot) at the northern part of the Plan Change area near the culvert under SH22, and at the southern end of the stream reach, near the culvert under the railway line (identified as Area 1 and Area 2 in Figure 2). These features likely reflect channel incision where the flow exits / enters the culverts and re-establishes its natural stream form potentially due to increased flow energy or hydraulic discontinuity at the culvert outlets.

- Another area identified (Area 3 in Figure 2) appears to be a localized zone of incision caused by a stream tributary joining Oiroa Creek; however, further investigation is needed for accurate analysis.

Results from the analysis have been summarised in Table 2. Figure 2 shows the spatial overview of the geomorphic change detection analysis.

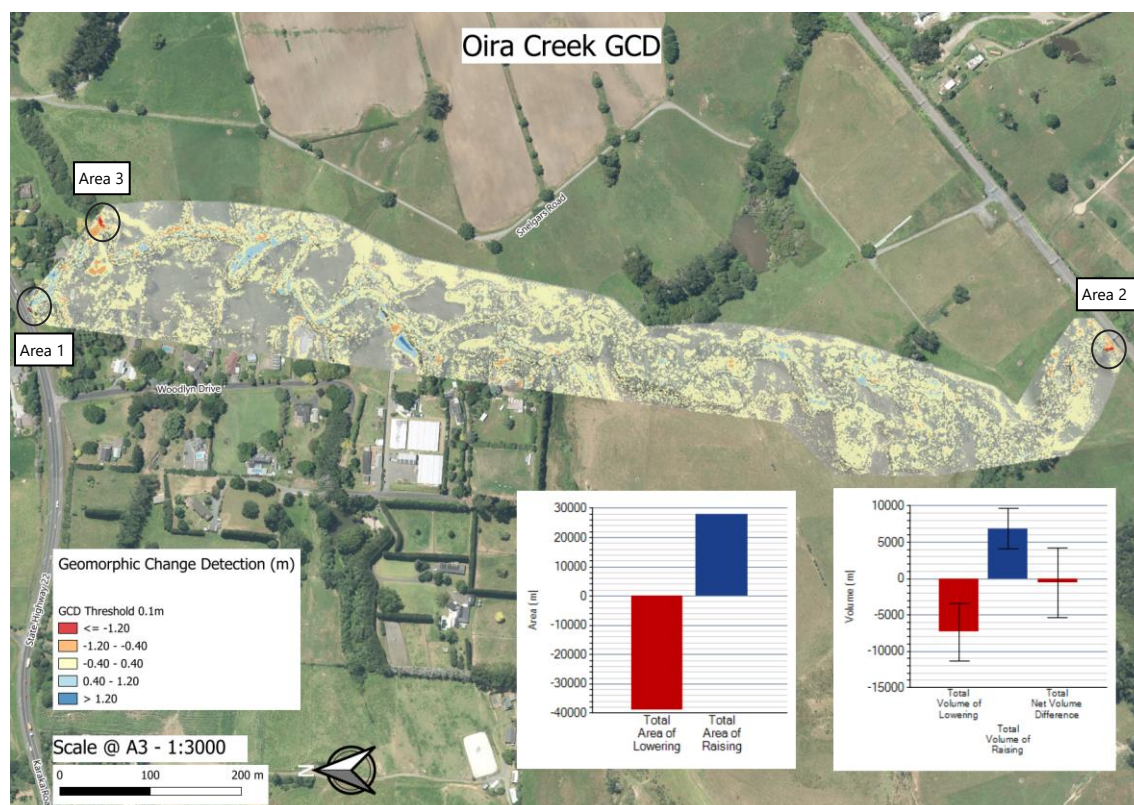


Figure 2: Geomorphic change detection analysis

Table 2: Summary of GCD

Total area of lowering (m ²)	Total area of raising (m ²)	Change (m ²)
38938	28010	10928
Total volume lowering (m ³)	Total volume raising (m ³)	Change (m ³)
-7387	6837	-550

¹Accounting for uncertainty in DEMs from repeat topographic surveys: improved sediment budgets, Joseph M. Wheaton, James Brasington, Stephen E. Darby, David A. Sear

4. Modelling and Erosion Screening Tool

4.1. Assessment locations

Stream erosion risk assessment was carried out at five locations along the Oiroa Creek relevant to the Fisher & Paykel Healthcare Plan Change area using the Auckland Council Erosion Screening Tool (EST) as previously mentioned. One cross section is located upstream of the site, two located adjacent to the plan change, and two more located downstream of the plan change area. The locations of the cross sections along the Oiroa Creek were selected with consideration for the meandering of the stream, confluence points of tributaries, and site development extent.

The stream profile information is based on the LiDAR 2016 topographical information. Appendix 1 shows all the stream profiles used for carrying out the assessment.

Figure 3 shows the locations of the cross sections used for the assessment.

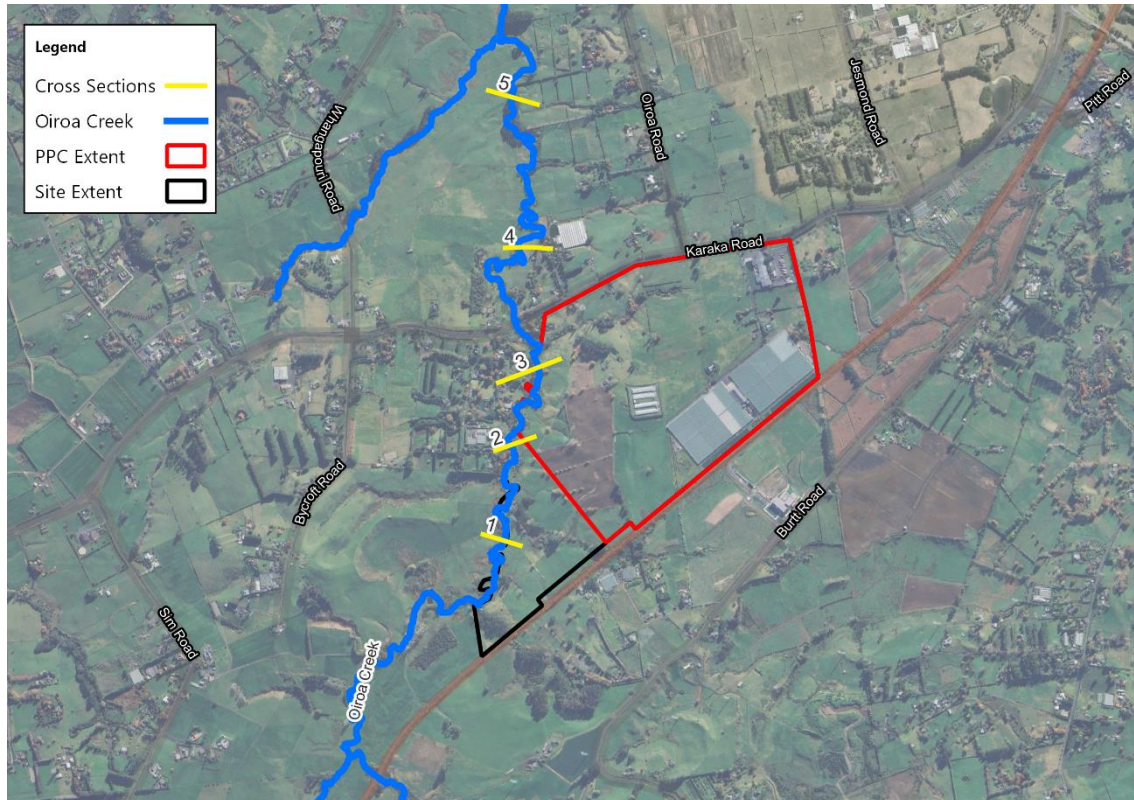


Figure 3: Oiroa Creek assessment locations

4.2. Hydrographs

The stream erosion assessment makes use of hydrographs generated from the flood modelling carried out for the proposed plan change application. This allows for a more accurate assessment than a simpler approach of using TP108 calculations. Details regarding the flood models have been included in the 'Stormwater Model Build', prepared by Woods, version *Final*, dated 20/09/2024.

The hydrographs have been extracted for Scenarios 1a and Scenario 4a, for 2-, 10- and 100-year ARI storm events (with and without climate change for 3.8°C future temperature increases by 2110 for all events).

The SMP provides details of all modelled scenarios, however, a summary of this is provided in Table 3. The hydrographs were extracted for each simulated time step (10min) for both scenarios. The extracted hydrograph information has been included in Appendix 3.

The 2-year ARI storm event is considered the most relevant frequency for the assessment as the 2-year ARI flood event strongly influences the geomorphology of the stream².

²Auckland's Approach to the Stream Erosion Problem, by Josh Irvine (WSP), Nick Brown (Auckland Council), Scott Speed (Auckland Council), Andrew Simon (Cardno), 2019.

Table 3: Model scenarios used for assessments

#	Scenario name	Land use	Climate Change (°C)	ARI	Purpose
Scenario 1a	Pre-development	Existing Development (ED)	3.8°C and no CC	2, 10, 100	This scenario was modelled to understand existing flood extents. This scenario forms the basis for assessing future flood risk and suitability of flood management options
Scenario 4a	Post development with pass forward + diversion	ED - for all areas outside the PPC extent MPD - for all areas within the PPC extent	3.8°C and no CC	2, 10, 100	Model scenario allowing for uplift of impervious area as proposed in the PPC, and allows for pass flows forward + flow diversion as flood management option, consistent with the stormwater management approach set out in the SMP

4.3. Erosion Screening Tool

Healthy Waters provided Woods with the Erosion Screening Tool (EST), version 2024.2 which has been used to undertake the erosion assessment. In summary, the tool calculates excess shear stress for each time step in a storm event which is then grouped into four thresholds, including, no erosion predicted (green), some erosion predicted (yellow), active erosion predicted (orange), and rapid erosion predicted (red).

Table 4 summarises the thresholds provided by Auckland Council. The stream profile information (discussed in Section 4.1) and hydrographs (discussed in Section 4.2) were input in the EST to calculate the excess shear thresholds for each scenario in all storm events. The results from the tool were used to assess the existing erosional potential of the stream, evaluate effects of climate change, and compare the change in the risk of erosion potential on Oiroa Creek as result of the proposed plan change (if any).

It is noted that the EST assessment undertaken does not allow for consideration of any SMAF mitigation, such as is proposed in the SMP for the proposed plan change. Therefore, it provides a conservative assessment of evaluating future erosion risk.

Table 4: Auckland Council Erosion Risk Thresholds

Threshold	Excess Shear	Description
Green	< 1.0	Indicates no erosion predicted to occur
Yellow	> 1.0 < 2.0	Indicates the potential for some erosion of the channel
Orange	> 2.0 < 10.0	Indicates the potential for channel to be mobile, (likely active erosion)
Red	> 10.0	Indicates potential rapid rates of erosion and incision of channel

4.3.1. Watercourse assessment

Healthy Waters provided Woods with shapefile data containing the results of a watercourse assessment conducted to evaluate the current extent of erosion in the watercourses near the plan change area. The shapefiles were provided for the true left and the true right banks of watercourses including Oiroa Creek. The results were grouped into five categories i.e. <20%, 20-40%, 40-60%, >60% and none.

The results for the Oiroa Creek indicate that most of the current erosional extent of the left and right banks fall within the lowest category i.e. <20%. Figure 4 and Figure 5 below show the information included in the shapefiles for Oiroa Creek and include the location of the cross sections used for this assessment.

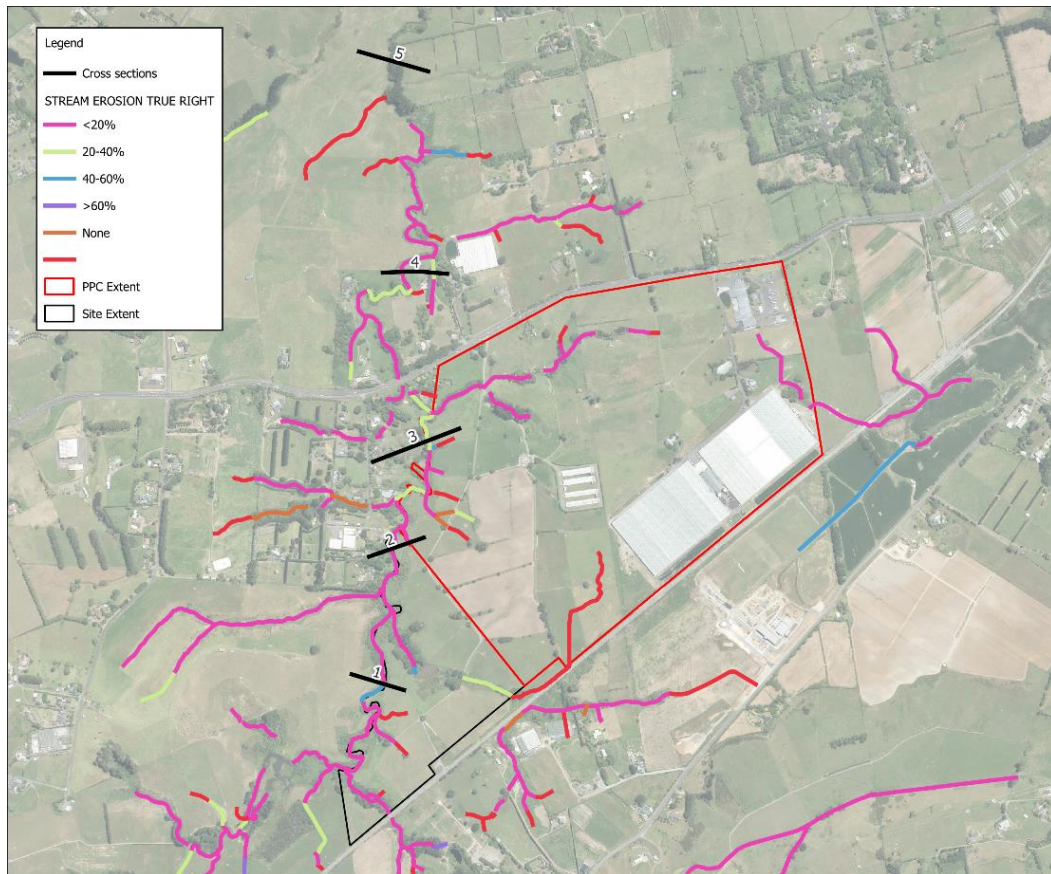


Figure 4: Watercourse assessment (true right)

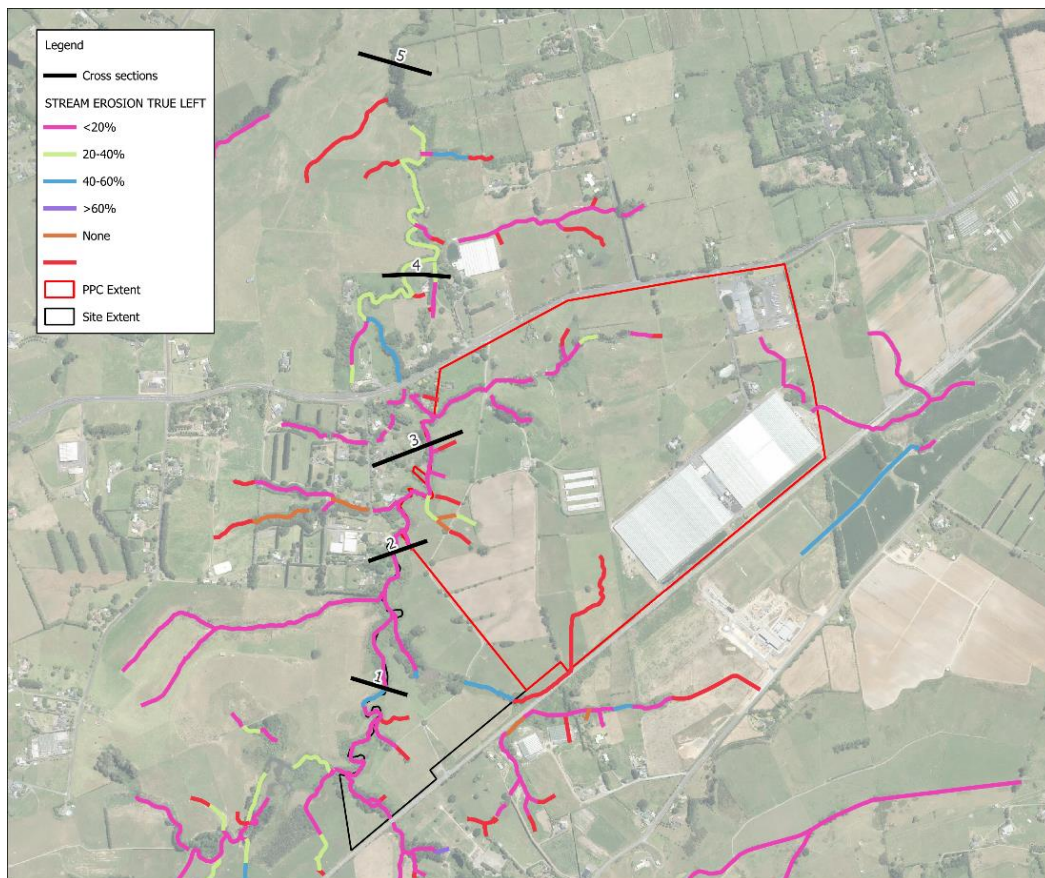


Figure 5: Watercourse assessment (true left)

4.4. Critical Shear Stress

A critical shear stress of 32.6Pa for the site has been adopted, as per the project geotechnical engineer ([CMW Geosciences](#)) recommendation. CMW Geosciences' recommendation is based on the findings from the following assessment:

- 'Response to Auckland Council Further Information Request on Stormwater Matters for Drury East - Stream Erosion Risk Assessment for Hingaia Catchment', prepared by T+T and Woods, dated 06/04/2020

Woods' correspondence with CMW's Geosciences regarding the appropriate critical shear stress is included in Appendix 2.

5. Results and discussion

5.1. Erosion potential

A total of 5 cross sections have been assessed using the EST. The calculated excess shear stress for all cross sections have been categorised into one of the four erosion risk thresholds as discussed previously.

Figure 6 to Figure 10 provides the summarised from the EST assessment. Discussion regarding the results for each cross section have been provided below. Appendix 4 contains all EST outputs for each cross section.

Stream cross section 1

- Results for Scenario 1a show that the existing potential of stream erosion majorly falls within the 'no erosion' and 'active erosion' threshold category across all storm events.
- The comparison between the scenarios show that the effects of the plan change have negligible impact on the stream cross section as the maximum increase is noted to be 2.1% in the 'some erosion' threshold category for the 2-year ARI storm event without climate change.
- The effects of climate change show minor exacerbation of the erosion potential as the increase between no climate change and 3.8° future climate change is between 1% - 3%.

	XS-1	NO CC						Change		
		Scenario 1a			Scenario 4a					
		2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR
XS-1 NO CC	Peak Flow (m3/s)	2.7	11.4	28.7	2.7	11.5	28.7	0.0	0.0	0.0
	<1 (min)	760	650	530	730	640	520			
	>1 & <2 (min)	30	50	70	60	60	70			
	>2 & <10 (min)	650	740	840	650	740	850			
	>10 (min)	0	0	0	0	0	0			
	<1 (min)	53%	45%	37%	51%	44%	36%	-2.1%	-0.7%	-0.7%
	>1 & <2 (min)	2%	3%	5%	4%	4%	5%	2.1%	0.7%	0.0%
	>2 & <10 (min)	45%	51%	58%	45%	51%	59%	0.0%	0.0%	0.7%
	>10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%
	XS-1	3.8°C						Change		
		Scenario 1a			Scenario 4a					
		2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR
XS-1 3.8CC	Peak Flow (m3/s)	4.9	22.0	52.3	5.0	22.0	52.2	0.0	0.0	-0.2
	<1 (min)	730	620	520	710	610	510			
	>1 & <2 (min)	30	60	60	40	60	70			
	>2 & <10 (min)	680	760	860	690	770	860			
	>10 (min)	0	0	0	0	0	0			
	<1 (min)	51%	43%	36%	49%	42%	35%	-1.4%	-0.7%	-0.7%
	>1 & <2 (min)	2%	4%	4%	3%	4%	5%	0.7%	0.0%	0.7%
	>2 & <10 (min)	47%	53%	60%	48%	53%	60%	0.7%	0.7%	0.0%
	>10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%

Figure 6: Excess shear exceedance table for XS-1 (no CC and 3.8°C)

Stream cross section 2

- Results for Scenario 1a show that the existing potential of stream erosion majorly falls within the 'no erosion' threshold category during a 2-year ARI storm event, while for 10- and 100-year ARI storm event, the results are approximately equally split between the 'no erosion' or 'some erosion' threshold category.
- The comparison between the scenarios show that the effects of the plan change have negligible impact on the stream cross section as the maximum increase is noted to be 0.7% across all storm events.
- The effects of climate change are most noticeable in the 2-year ARI storm event (approximately 30% increase in erosion potential from 'no erosion' threshold to 'some erosion' threshold).

	XS-2	NO CC						Change		
		Scenario 1a			Scenario 4a					
		2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR
XS-2 NO CC	Peak Flow (m3/s)	3.2	12.6	30.9	3.2	12.7	31.0	0.0	0.0	0.0
	<1 (min)	1440	800	710	1440	790	720			
	>1 & <2 (min)	0	640	730	0	650	720			
	>2 & <10 (min)	0	0	0	0	0	0			
	>10 (min)	0	0	0	0	0	0			
	<1 (min)	100%	56%	49%	100%	55%	50%	0.0%	-0.7%	0.7%
	>1 & <2 (min)	0%	44%	51%	0%	45%	50%	0.0%	0.7%	-0.7%
	>2 & <10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%
	>10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%

	XS-2	3.8°C						Change		
		Scenario 1a			Scenario 4a					
		2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR
XS-2 3.8CC	Peak Flow (m3/s)	5.6	23.8	56.2	5.7	23.7	55.9	0.0	-0.2	-0.3
	<1 (min)	1020	740	720	1010	730	720			
	>1 & <2 (min)	420	700	720	430	710	720			
	>2 & <10 (min)	0	0	0	0	0	0			
	>10 (min)	0	0	0	0	0	0			
	<1 (min)	71%	51%	50%	70%	51%	50%	-0.7%	-0.7%	0.0%
	>1 & <2 (min)	29%	49%	50%	30%	49%	50%	0.7%	0.7%	0.0%
	>2 & <10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%
	>10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%

Figure 7: Excess shear exceedance table for XS-2 (no CC and 3.8°C)

Stream cross section 3

- Results for Scenario 1a show that existing potential of stream erosion during,
 - 2-year ARI storm event falls completely within 'no erosion' threshold.
 - 10-year ARI storm event falls roughly evenly between 'no erosion' and 'some erosion' threshold.
 - 100-year ARI storm event falls roughly 50% within 'no erosion' threshold, 33% within 'some erosion' threshold, and 20% within 'active erosion' threshold.
- The comparison between the scenarios show that the effects of the plan change cause,
 - no increase in erosion potential in the 2-year ARI storm event,
 - roughly 2% increase for the no climate change scenario during the 10- and 100-year ARI storm event which is considered to be negligible.
 - approximately 7% and 4% in the 'active erosion' threshold during 10- and 100-year ARI storm event with allowance for 3.8° future climate change. However, the increase is inferred to be accentuated by the effects of climate change.
- The effects of climate change are not noticed for the 2-year ARI storm event, however, results for the 10- and 100-year ARI storm event show that the increase in erosion potential is between 11%-14%.

	XS-3	NO CC						Change		
		Scenario 1a			Scenario 4a			2-YEAR	10-YEAR	100-YEAR
		2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR			
XS3 NO CC	Peak Flow (m3/s)	3.0	12.1	31.1	3.2	12.5	32.0	0.2	0.4	0.9
	<1 (min)	1440	840	730	1440	810	700			
	>1 & <2 (min)	0	600	470	0	630	470			
	>2 & <10 (min)	0	0	240	0	0	270			
	>10 (min)	0	0	0	0	0	0			
	<1 (min)	100%	58%	51%	100%	56%	49%	0.0%	-2.1%	-2.1%
	>1 & <2 (min)	0%	42%	33%	0%	44%	33%	0.0%	2.1%	0.0%
	>2 & <10 (min)	0%	0%	17%	0%	0%	19%	0.0%	0.0%	2.1%
	>10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%
	XS-3	3.8°C						Change		
		Scenario 1a			Scenario 4a			2-YEAR	10-YEAR	100-YEAR
		2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR			
XS-3 3.8CC	Peak Flow (m3/s)	5.3	23.7	56.8	5.6	24.1	57.6	0.3	0.5	0.8
	<1 (min)	1440	760	730	1440	710	700			
	>1 & <2 (min)	0	680	300	0	630	270			
	>2 & <10 (min)	0	0	410	0	100	470			
	>10 (min)	0	0	0	0	0	0			
	<1 (min)	100%	53%	51%	100%	49%	49%	0.0%	-3.5%	-2.1%
	>1 & <2 (min)	0%	47%	21%	0%	44%	19%	0.0%	-3.5%	-2.1%
	>2 & <10 (min)	0%	0%	28%	0%	7%	33%	0.0%	6.9%	4.2%
	>10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%

Figure 8: Excess shear exceedance table for XS-3 (no CC and 3.8°C)

Stream cross section 4

- Results for Scenario 1a show that the existing potential of stream erosion are distributed between the 'no erosion', 'some erosion', and 'active erosion' threshold category across all storm events.
- The comparison between the scenarios show that the effects of the plan change have some increases in the 2-year ARI storm event as the increase is approximately 11%. The 10- and 100-year ARI storm events show minor increases (up to 2%).
 - It is noted that the increase in the 2-year ARI storm event can be mitigated by implementation of SMAF provisions as stated in the SMP.
- The effects of climate change are most noticeable in the 2-year ARI storm event (approximately 8% increase in erosion potential from 'no erosion' threshold to 'some erosion' threshold). Remaining storm events show marginal increases (less than 2%).

	XS-4	NO CC						Change		
		Scenario 1a			Scenario 4a					
		2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR
XS-4 NO CC	Peak Flow (m3/s)	3.7	13.9	32.5	3.9	14.3	33.2	0.2	0.4	0.7
	<1 (min)	730	660	530	700	530	420			
	>1 & <2 (min)	180	70	150	50	170	190			
	>2 & <10 (min)	530	710	760	690	740	830			
	>10 (min)	0	0	0	0	0	0			
	<1 (min)	51%	46%	37%	49%	37%	29%	-2.1%	-9.0%	-7.6%
	>1 & <2 (min)	13%	5%	10%	3%	12%	13%	-9.0%	6.9%	2.8%
	>2 & <10 (min)	37%	49%	53%	48%	51%	58%	11.1%	2.1%	4.9%
	>10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%
	XS-4	3.8°C						Change		
		Scenario 1a			Scenario 4a					
		2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR
XS-4 3.8CC	Peak Flow (m3/s)	6.3	25.4	57.6	6.6	25.9	58.1	0.3	0.4	0.5
	<1 (min)	720	620	510	670	500	410			
	>1 & <2 (min)	70	100	150	60	170	170			
	>2 & <10 (min)	650	720	780	710	770	860			
	>10 (min)	0	0	0	0	0	0			
	<1 (min)	50%	43%	35%	47%	35%	28%	-3.5%	-8.3%	-6.9%
	>1 & <2 (min)	5%	7%	10%	4%	12%	12%	-0.7%	4.9%	1.4%
	>2 & <10 (min)	45%	50%	54%	49%	53%	60%	4.2%	3.5%	5.6%
	>10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%

Figure 9: Excess shear exceedance table for XS-4 (no CC and 3.8°C)

Stream cross section 5

- Results for Scenario 1a show that the existing potential of stream erosion are majorly distributed 'no erosion' and 'active erosion' threshold category. Roughly 10% of the results fall within the 'some erosion' threshold category.
- The comparison between the scenarios show that the effects of the plan change have some increases in the 2-year ARI storm event as the increase is approximately 11%. The 10- and 100-year ARI storm events show minor increases (up to 3%).
 - It is noted that the increase in the 2-year ARI storm event can be mitigated by implementation of SMAF provisions as stated in the SMP.
- The effects of climate change show minor exacerbation of the erosion potential as the increase between no climate change and 3.8° future climate change is no more than 2%.

	XS-5	NO CC						Change		
		Scenario 1a			Scenario 4a					
		2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR
XS-5 NO CC	Peak Flow (m3/s)	3.1	12.7	31.6	3.3	13.1	32.3	0.2	0.4	0.7
	<1 (min)	670	570	430	660	530	410			
	>1 & <2 (min)	270	130	250	110	170	230			
	>2 & <10 (min)	470	730	760	640	730	800			
	>10 (min)	0	0	0	0	0	0			
	<1 (min)	47%	40%	30%	46%	37%	28%	-0.7%	-2.8%	-1.4%
	>1 & <2 (min)	19%	9%	17%	8%	12%	16%	-11.1%	2.8%	-1.4%
	>2 & <10 (min)	33%	51%	53%	44%	51%	56%	11.8%	0.0%	2.8%
	>10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%
	XS-5	3.8°C						Change		
		Scenario 1a			Scenario 4a					
		2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR	2-YEAR	10-YEAR	100-YEAR
XS-5 3.8CC	Peak Flow (m3/s)	5.5	24.3	56.7	5.9	24.8	57.3	0.3	0.5	0.6
	<1 (min)	660	570	450	650	530	430			
	>1 & <2 (min)	240	130	240	110	170	230			
	>2 & <10 (min)	510	730	750	650	730	780			
	>10 (min)	0	0	0	0	0	0			
	<1 (min)	46%	40%	31%	45%	37%	30%	-0.7%	-2.8%	-1.4%
	>1 & <2 (min)	17%	9%	17%	8%	12%	16%	-9.0%	2.8%	-0.7%
	>2 & <10 (min)	35%	51%	52%	45%	51%	54%	9.7%	0.0%	2.1%
	>10 (min)	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%

Figure 10: Excess shear exceedance table for XS-5 (no CC and 3.8°C)

6. Limitations

Stream erosion is an inherently natural geomorphic process. Based on the findings from the assessment (pre mitigation) we consider that the minimal change in erosion risk that would result from the proposed plan change is acceptable.

Furthermore, there are limitations to the tool including that it does not account for other operational matters such as removal of stock (which can degrade banks) from the existing land. In reality, the removal of stock from the stream margins to make way for development is likely to positively impact (ie reduce) erosion of the stream bank. We are advised that FPH has already fenced a number of areas of the creek off from grazing paddocks that were previously unfenced, which may already be having a positive effect on erosion. Variability of soil stream profile characteristics (e.g., Manning's and soil cohesiveness) can also skew the results.

We therefore recommend that more detailed analyses is carried out during the relevant consenting / detailed design stage, post plan change.

7. Addendum

From the Clause 23 requests and meetings with Healthy Waters, additional clarifications of how stream erosion management will be achieved was requested. It was suggested that the information provided (as part of the overall stormwater management) should identify the existing erosion hotspots, provide targeted measures to improve stream condition, as well as manage effects of climate change.

At the plan change stage, it is noted that there isn't adequate information regarding the location of stormwater outfalls and development staging, which are key requirements to evaluate the impacts of future development and provide targeted erosion mitigation measures. A detailed stream erosion assessment will be required to be undertaken for any application for land modification, subdivision or development within 100m of the Oiroa awa (Creek) at the resource consent stage, including the identification and provision of any appropriate mitigation measures, if required (Refer to Special Information Requirement IX.9(7)). While the methodology for the detailed assessment has not been devised, it is expected that it will make use of suitable methods to evaluate stream erosion and further complement it with visual and geomorphic assessments.

Furthermore, a stream erosion mitigation measure toolbox has been developed exploring various approaches that could be adopted to address erosional hotspots. It is important to note that the proposed plan change is not exacerbating the erosional effects in Oiroa Creek.

The toolbox has been sourced from the document, named, *Technical Guidelines for Waterway Management*, prepared by Victoria State Government, Australia. The measures in the toolbox can be implemented as standalone measures or used in varying combinations once detailed investigation and design has been undertaken at future resource consenting stage.

The toolbox has been included as Appendix 5 to this memorandum.

8. Conclusion

A stream erosion assessment has been undertaken by Woods to provide a response to the requests raised by Healthy Waters' as part of Clause 23, for the proposed plan change located at 300, 328, 350, 370, & 458 Karaka Road, Drury.

The assessment was undertaken using the Erosion Screening Tool (provided by Healthy Waters), to evaluate the existing erosional conditions of Oiroa Creek, assess the effects of future climate change and compare the effects of change in potential for erosion that may be caused by proposed plan change (if any). The assessment uses inputs from a flood model and uses model Scenario 1a (predevelopment) and Scenario 4a (post development) as described in the SMP. The assessment has been undertaken for 2-, 10- and 100-year ARI storm events with allowance for no climate change (no CC) and 3.8°C future climate change (3.8°C). The assessment has been further complemented by visual inspections and geomorphic change detection analysis (GCD).

The following observations were made from the visual inspection:

- No signs of bank instability were present
- Lush wetlands with standing water bodies are present adjacent to the stream
- A well-developed riparian corridor spans most of the assessed reach, ranging from 5 to 15 metres wide on either side.
- Vegetation includes a mix of native and exotic species
- There is no evidence of stock access to the stream
- No evidence of significant human modifications
- The surrounding land is primarily pastoral, but there were no visible sources of active erosion

Furthermore, the GCD analysis concluded that:

- This stream is currently in a relatively stable geomorphic condition, with limited significant change over the assessed period. This indicates a state of dynamic equilibrium, where erosional and depositional processes are generally balanced.

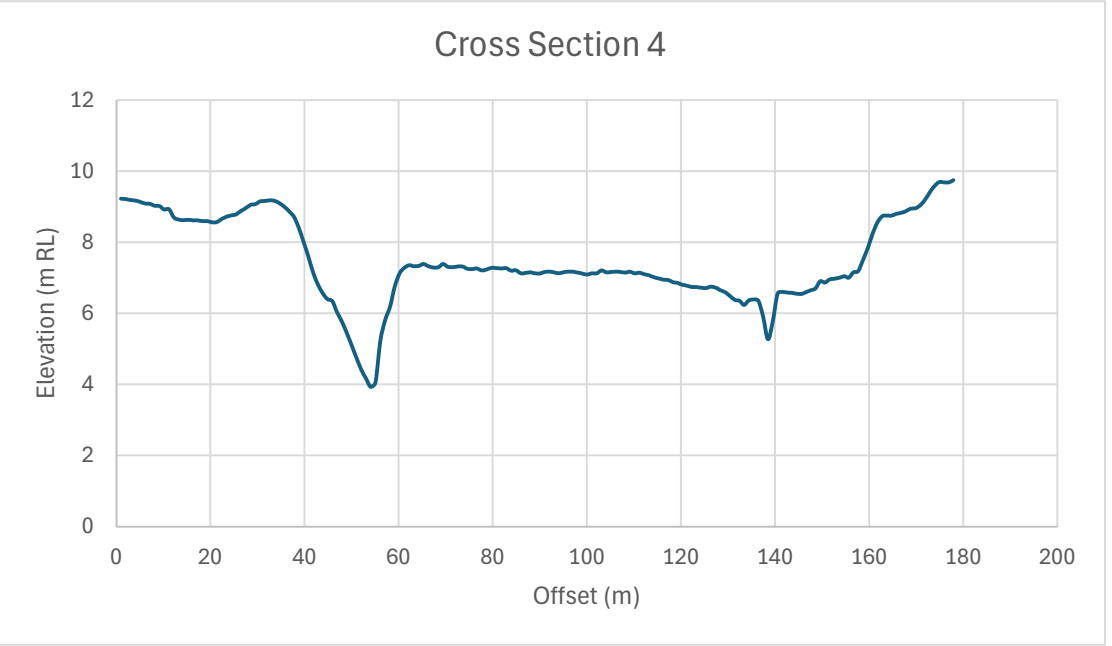
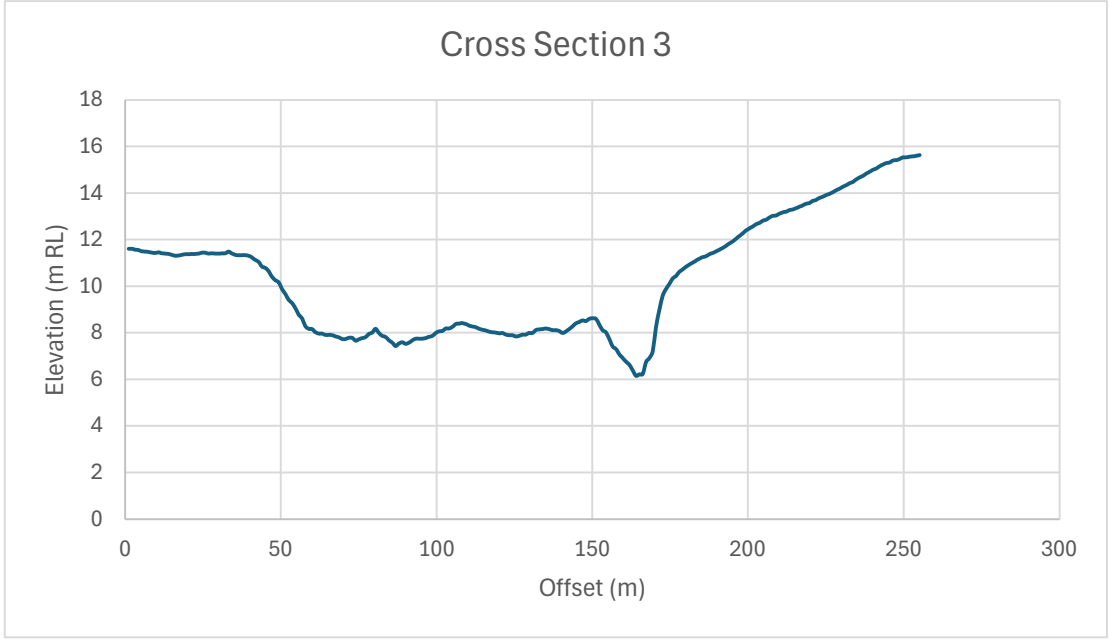
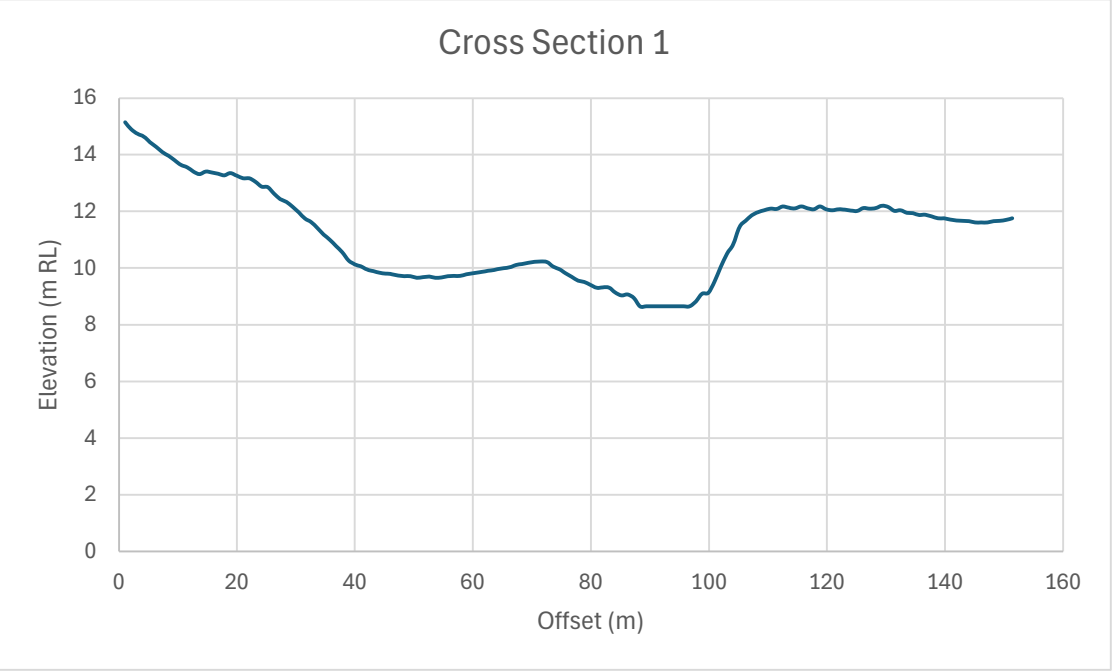
The EST assessment was undertaken at five cross section locations. The results for each cross section have been discussed in the memo, and a summary of the findings is outlined below.

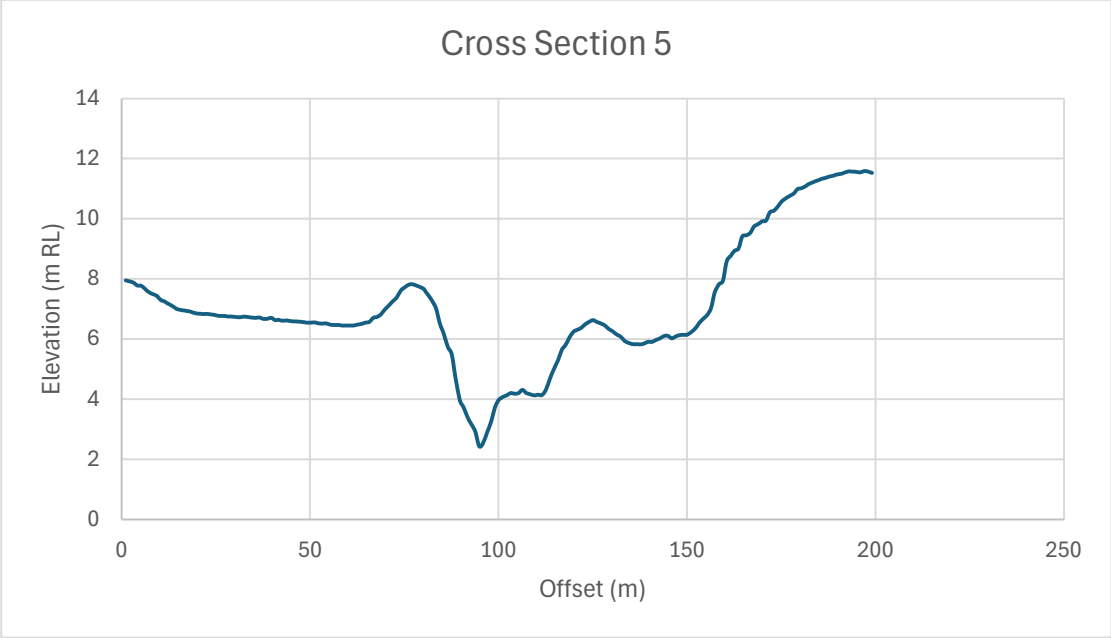
- Generally, the results for Scenario 1a showed that the computed timesteps were within the '*no erosion*' and '*active erosion*' thresholds. This means that the erosion potential of the stream in the existing conditions can be more pronounced as the storm events become more intensified.
- The comparison of results between Scenario 1a and Scenario 4a generally showed negligible change. Two cross sections show considerable increase in the '*active erosion*' threshold for the 2-year ARI event however, this is expected to be mitigation with the implementation of SMAF provisions as stated in the SMP.
- The effects of the climate change vary depending on the cross section; however, the results show that climate change can cause further erosion in the future.

In summary, the comprehensive assessment—including the visual inspections, and geomorphic change detection analysis—demonstrates that Oiroa Creek is currently in a stable geomorphic state, with minimal evidence of significant erosional activity under current conditions. However, there are locations identified which are actively eroding, particularly, cross-section 1 and the hotspots identified in GCD analysis which may be more sensitive to flow increase.

The comparative analysis of pre- and post-development scenarios indicates that any potential increase in stream erosion risk associated with the plan change is negligible, with SMAF mitigation being considered appropriate. A detailed analysis is proposed to be undertaken at consenting stage as project details such as network and outfall locations are confirmed.

Appendix 1 – Stream cross section profiles





Appendix 2 – Email communication with CMW

Shakti Singh

To: Bidara Pathirage; Chantelle Potbury; Boniface Kinnear; Jasmin Moll
Cc: Pranil Wadan
Subject: RE: Fisher & Paykel Healthcare Plan Change - Clause 23 Request #AKL2022-0214

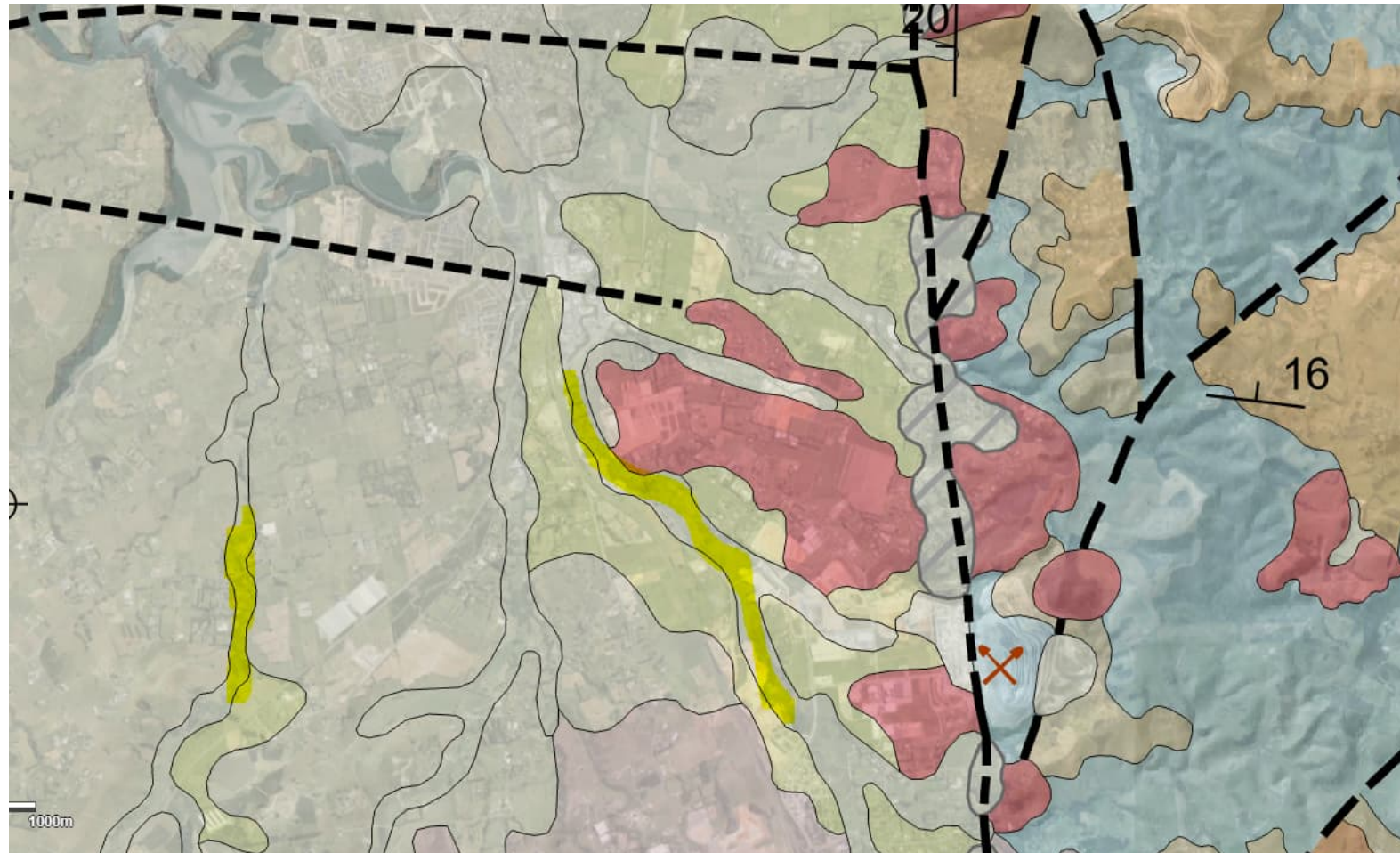
From: Melissa Campbell <MelissaC@cmwgeo.com>
Sent: Monday, 17 March 2025 1:49 pm
To: Bidara Pathirage <bidara.pathirage@woods.co.nz>
Cc: Chris Ritchie <chrisr@cmwgeo.com>
Subject: RE: Fisher & Paykel Healthcare Plan Change - Clause 23 Request #AKL2022-0214

Hi Bidara,

I've been sent a stream erosion risk assessment memo for the Hingaia Catchment, written by Woods in 2020 for Drury East, (Ref 1003297) as a reference for this query.

I think its directly applicable and the same assumptions made in this document could be applied to the Oira Creek.

GNS 1:250k geology mapping (<https://data.gns.cri.nz/geology/>) shows the same unit is present in both the Hingaia Creek and Oira Creek (highlighted in the snip below). This is the (relatively newly described) Holocene river deposits of Takaanini Formation – variably sorted non-marine gravel, sand, and mud deposits.



Without any more specific information available I would recommend adopting the same assumptions as those in the report above, that is, to use a median CSS of 32.6Pa.

Hope this helps.

Kind regards, Melissa

Melissa Campbell | Senior Engineering Geologist

Phone: +64 (0) 9 414 4632 Mobile: +64 (0) 27 583 8777 Email: MelissaC@cmwgeo.com
Website: www.cmwgeosciences.com



From: Bidara Pathirage <bidara.pathirage@woods.co.nz>
Sent: Monday, 17 March 2025 12:51 pm
To: Melissa Campbell <MelissaC@cmwgeo.com>
Subject: RE: Fisher & Paykel Healthcare Plan Change - Clause 23 Request

Hi Melissa,

Yes please if you could, similar to what you did for Milldale for us?

Thanks,
Bidara



Bidara Pathirage | BE(Hons), CPEng, CMEngNZ
Senior Associate Engineer - 3 Waters
Water Infrastructure & Planning
☎ +64 9 308 9229

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From: Melissa Campbell <MelissaC@cmwgeo.com>
Sent: Monday, 17 March 2025 10:29 am
To: Bidara Pathirage <bidara.pathirage@woods.co.nz>
Subject: RE: Fisher & Paykel Healthcare Plan Change - Clause 23 Request

Hi Bidara,

Sorry I've only just got to this – do you still need input from us? I can try to find some relevant info and provide a recommendation, but as before, its not normally something we address.

Kind regards, Melissa

Melissa Campbell | Senior Engineering Geologist

Phone: +64 (0) 9 414 4632 Mobile: +64 (0) 27 583 8777 Email: MelissaC@cmwgeo.com
Website: www.cmwgeosciences.com



From: Bidara Pathirage <bidara.pathirage@woods.co.nz>
Sent: Tuesday, 11 March 2025 7:38 am
To: Melissa Campbell <MelissaC@cmwgeo.com>
Cc: Shakti Singh <shakti.singh@woods.co.nz>; Pranil Wadan <pranil.wadan@woods.co.nz>; Cosette Pearson <CosetteP@barker.co.nz>; James Hui <James.Hui@fphcare.co.nz>
Subject: FW: Fisher & Paykel Healthcare Plan Change - Clause 23 Request

Hi Melissa,

Hope you are well.

We have had a request from HWs to undertake a stream erosion assessment for Oiroa Creek at FPH site including understanding the existing baseline condition. Similar to what we undertook for Milldale North Plan Change, are you able to provide us with the critical shear stress? Happy to have a quick chat first if that helps.

Thanks,
Bidara



Bidara Pathirage | BE(Hons), CPEng, CMEngNZ

Senior Associate Engineer - 3 Waters
Water Infrastructure & Planning

+64 9 308 9229

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From: Bidara Pathirage
Sent: Wednesday, 26 February 2025 1:39 pm
To: Mark Delaney <mark.delaney@viridis.co.nz>
Cc: Boniface Kinnear <Boniface.Kinnear@woods.co.nz>; Cosette Pearson <CosetteP@barker.co.nz>; James Hui <James.Hui@fphcare.co.nz>; Pranil Wadan <pranil.wadan@woods.co.nz>
Subject: FW: Fisher & Paykel Healthcare Plan Change - Clause 23 Request

Hi Mark,

Hope you are well.

Just getting in touch regarding the Cl 23 request for FPH Plan Change queries regarding stream erosion – we had a meeting to discuss with HWs yesterday and their preference is for us to do a stream erosion assessment including understanding the existing baseline condition of the stream.

Understand from talking to the team you are going out to site next week – do you have any time this week (either tomorrow afternoon or Friday morning) to have a quick meeting to discuss the queries and strategy on the best way to undertake the assessment?

Thanks,
Bidara

From: Cosette Pearson <CosetteP@barker.co.nz>
Sent: Monday, 13 January 2025 11:04 am
To: James Hui <James.Hui@fphcare.co.nz>; Pranil Wadan <pranil.wadan@woods.co.nz>; Bidara Pathirage <bidara.pathirage@woods.co.nz>
Cc: Kasey Zhai <KaseyZ@barker.co.nz>; Mark Delaney <mark.delaney@viridis.co.nz>; Amanda Naude <amanda.naude@viridis.co.nz>
Subject: RE: Fisher & Paykel Healthcare Plan Change - Clause 23 Request

Morning Bidara and Pranil,

I hope you both had lovely summer breaks!
Following on from James’ email below confirming that FPH are happy to proceed with the work required to respond to the Clause 23 requests from Auckland Council relating to stormwater / flooding, would you be able to please prepare a draft response by Monday 3 February?

I also just wanted to let you know that FPH have engaged Viridis for this next stage of the Plan Change (post-lodgement phase) including responding to the ecological Clause 23 requests.
Based on this, where coordination with ecology is required to respond to the RFIs, please contact Mark and Amanda (copied into this email as FYI).
If you have any questions as you work through the requests please just give me a bell, happy to discuss 😊

Cheers!

Ngā mihi | Kind regards,

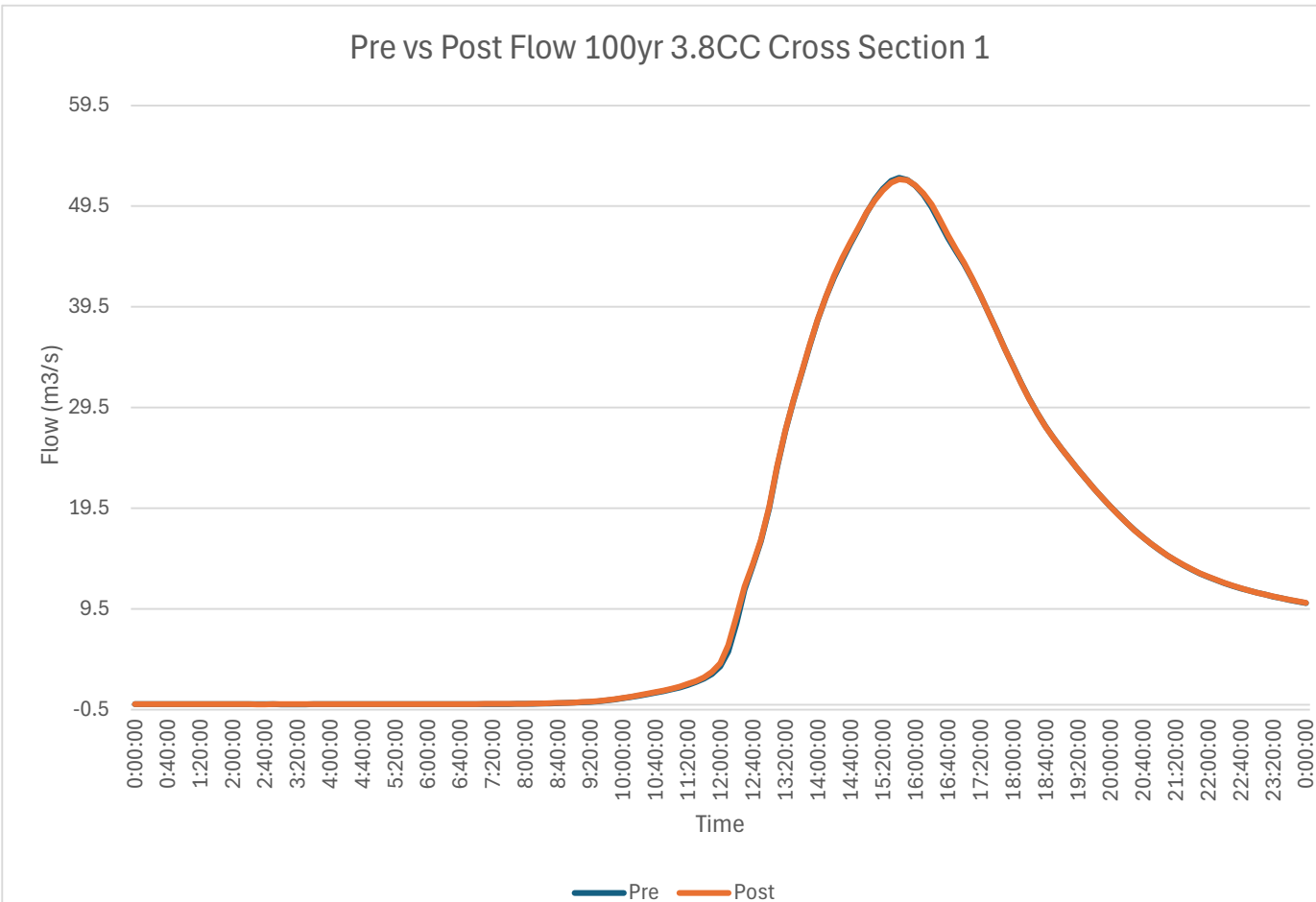
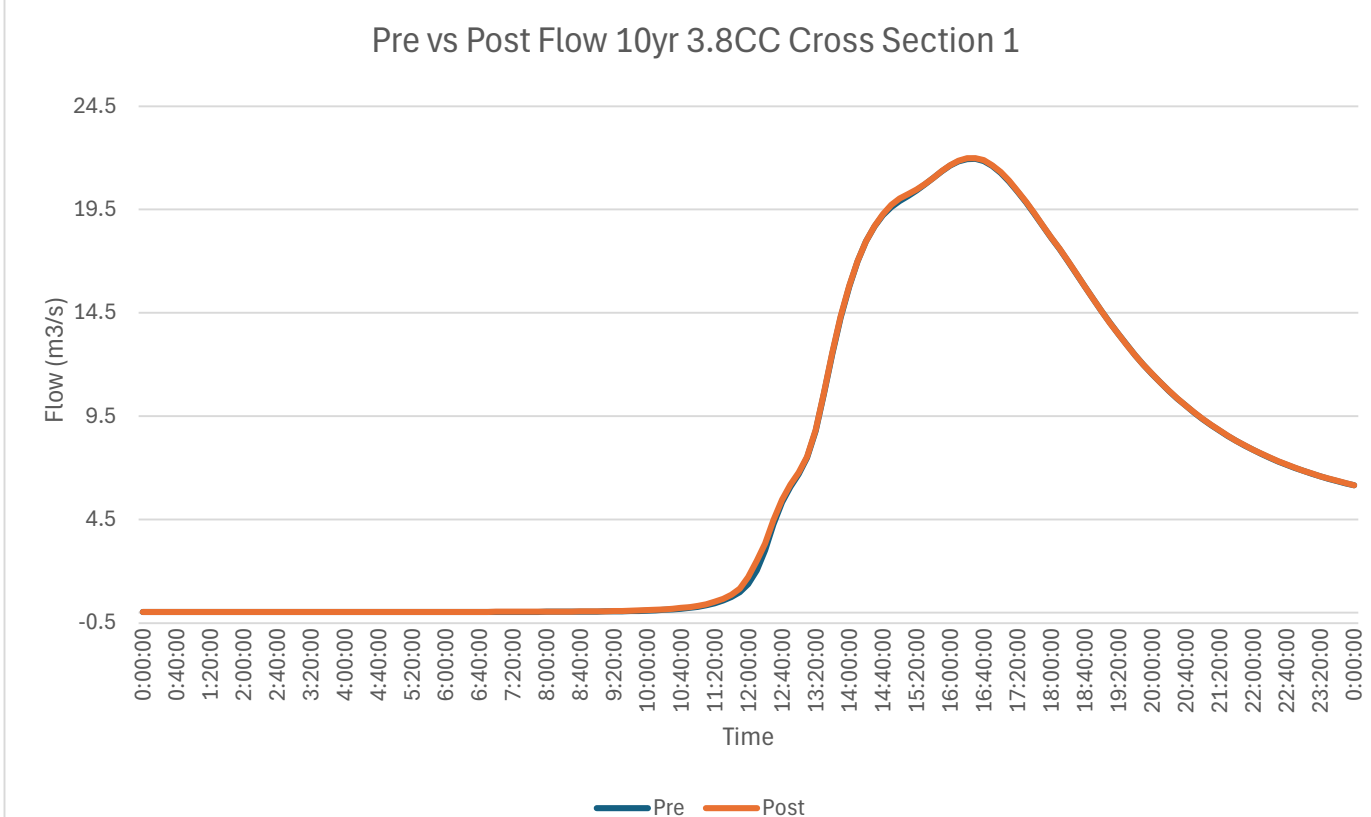
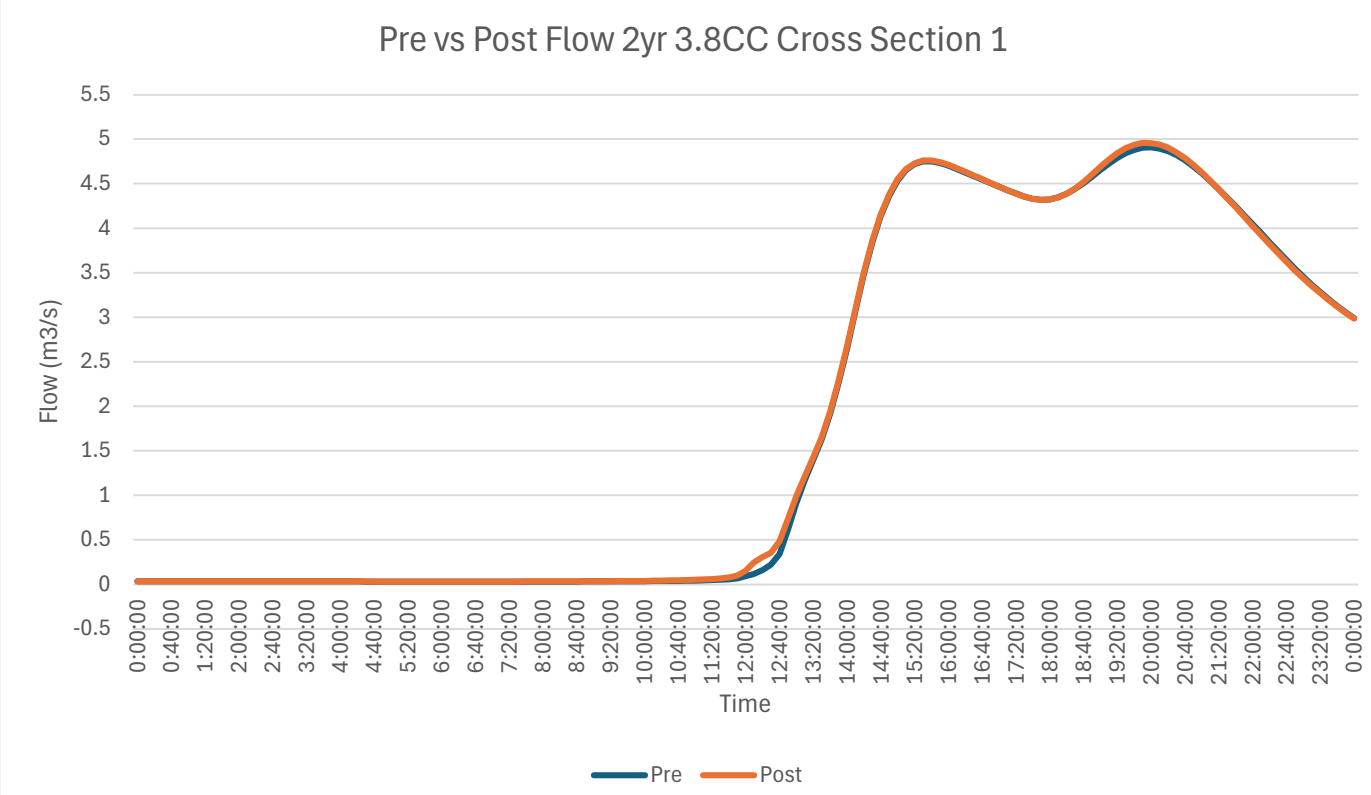
COSETTE PEARSON
Associate
021 250 5055
CosetteP@barker.co.nz

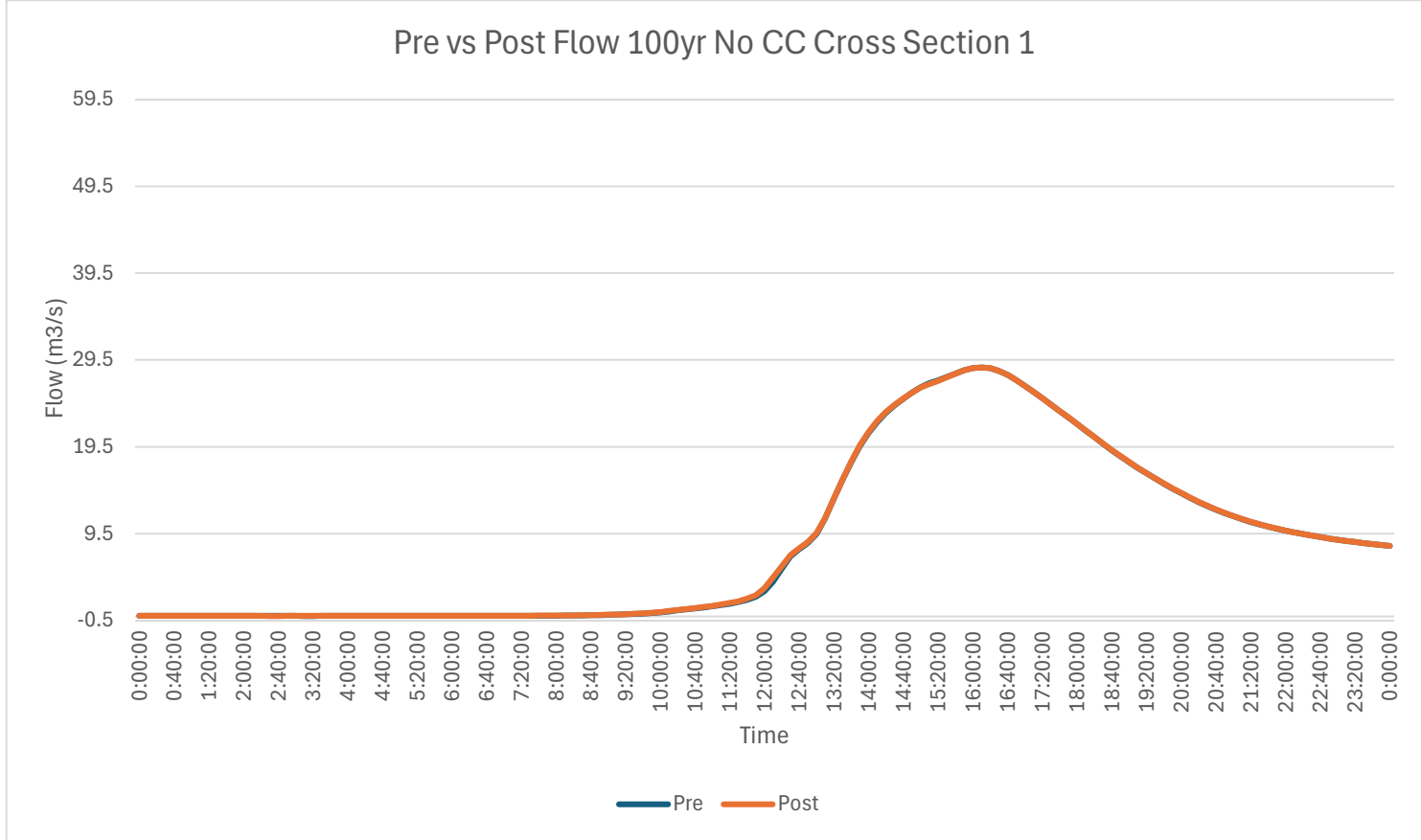
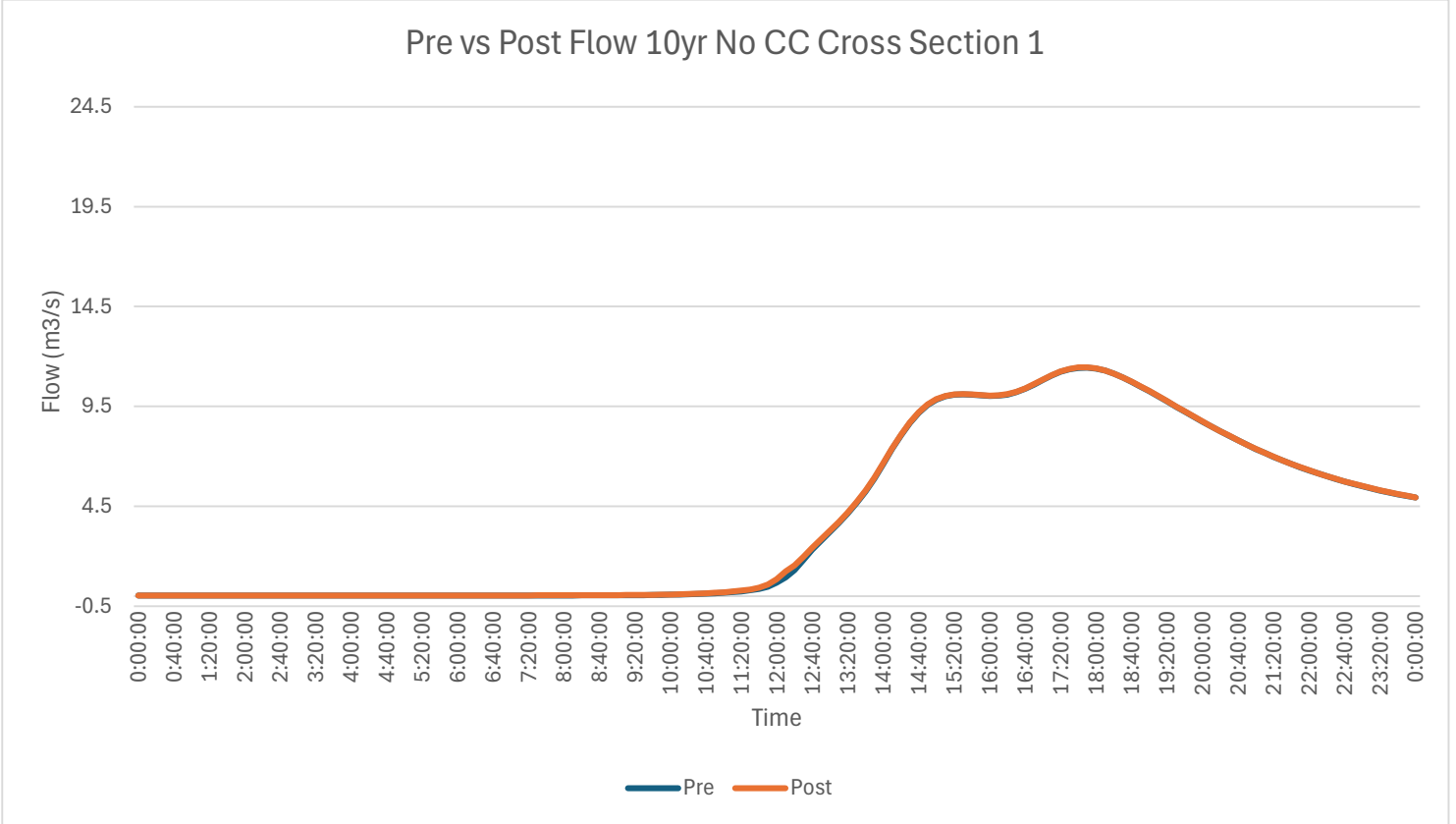
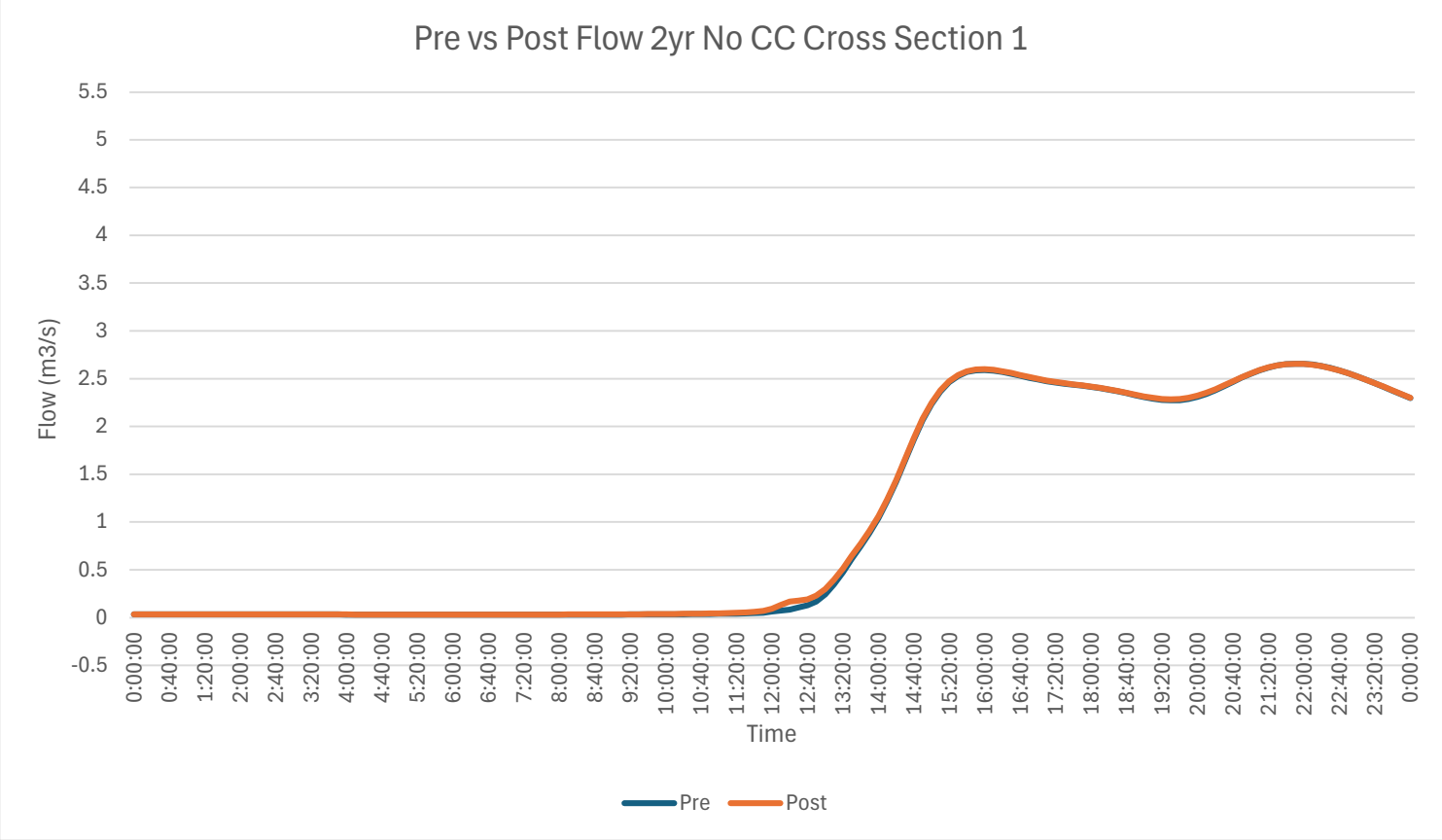


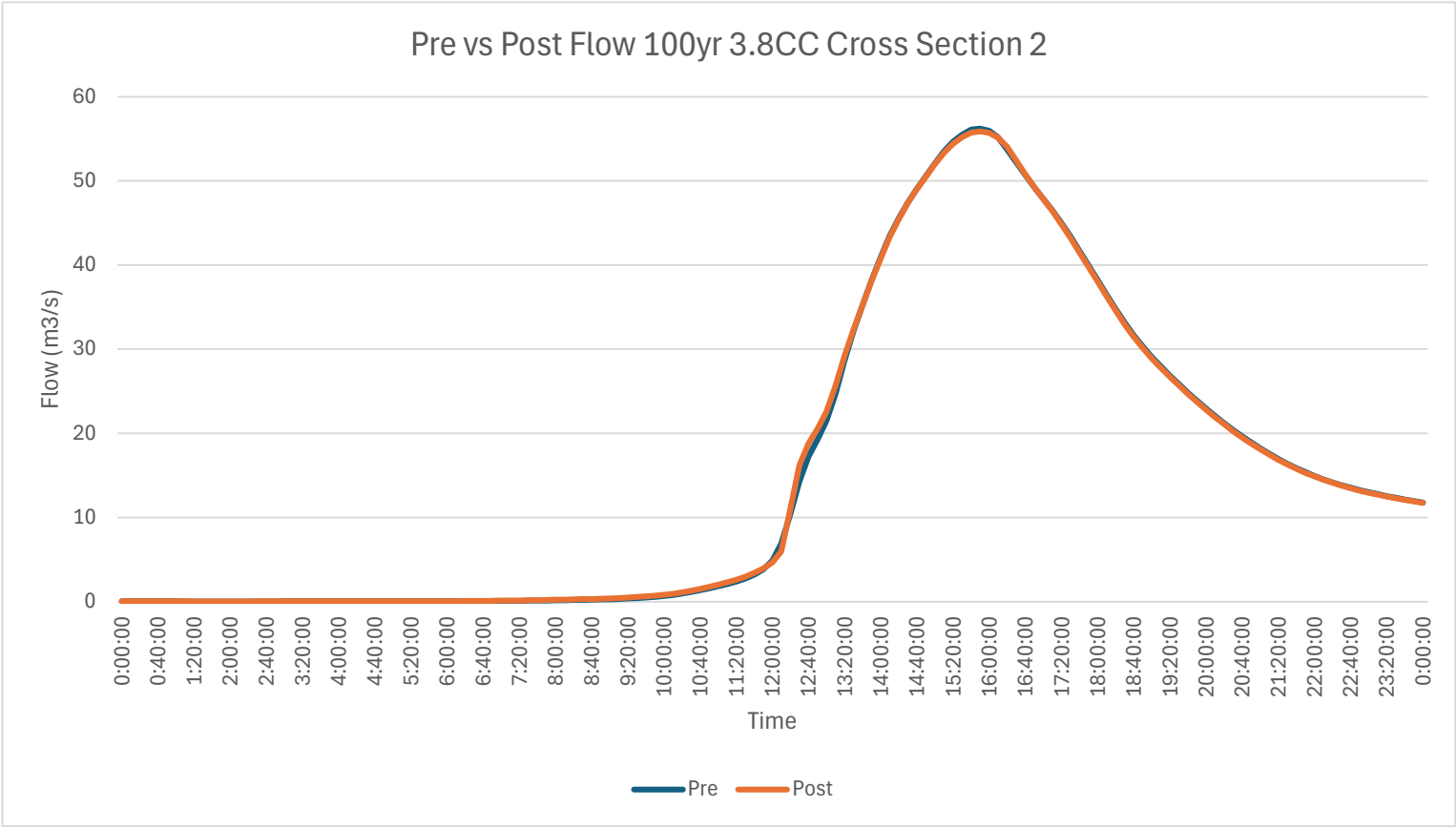
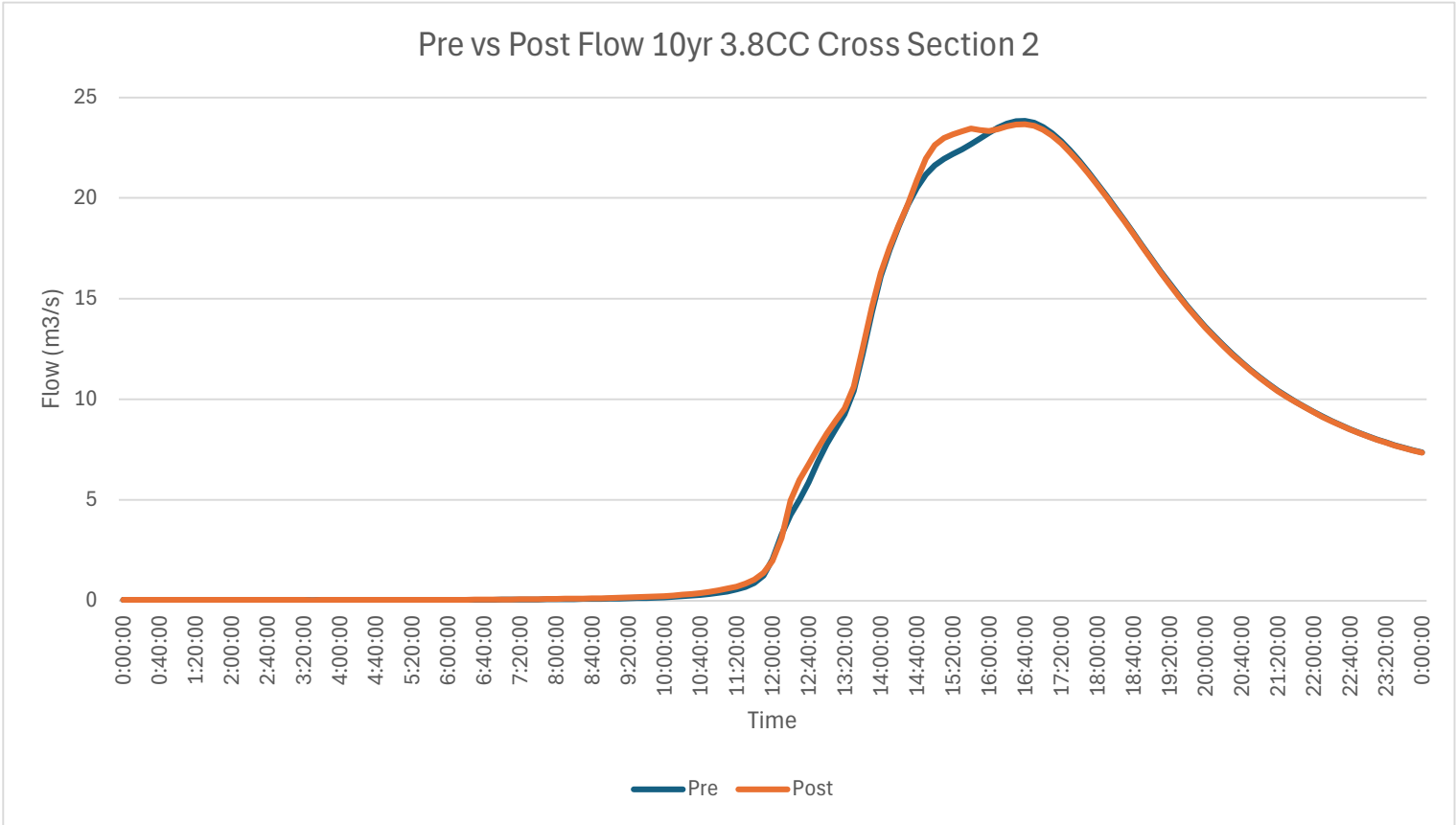
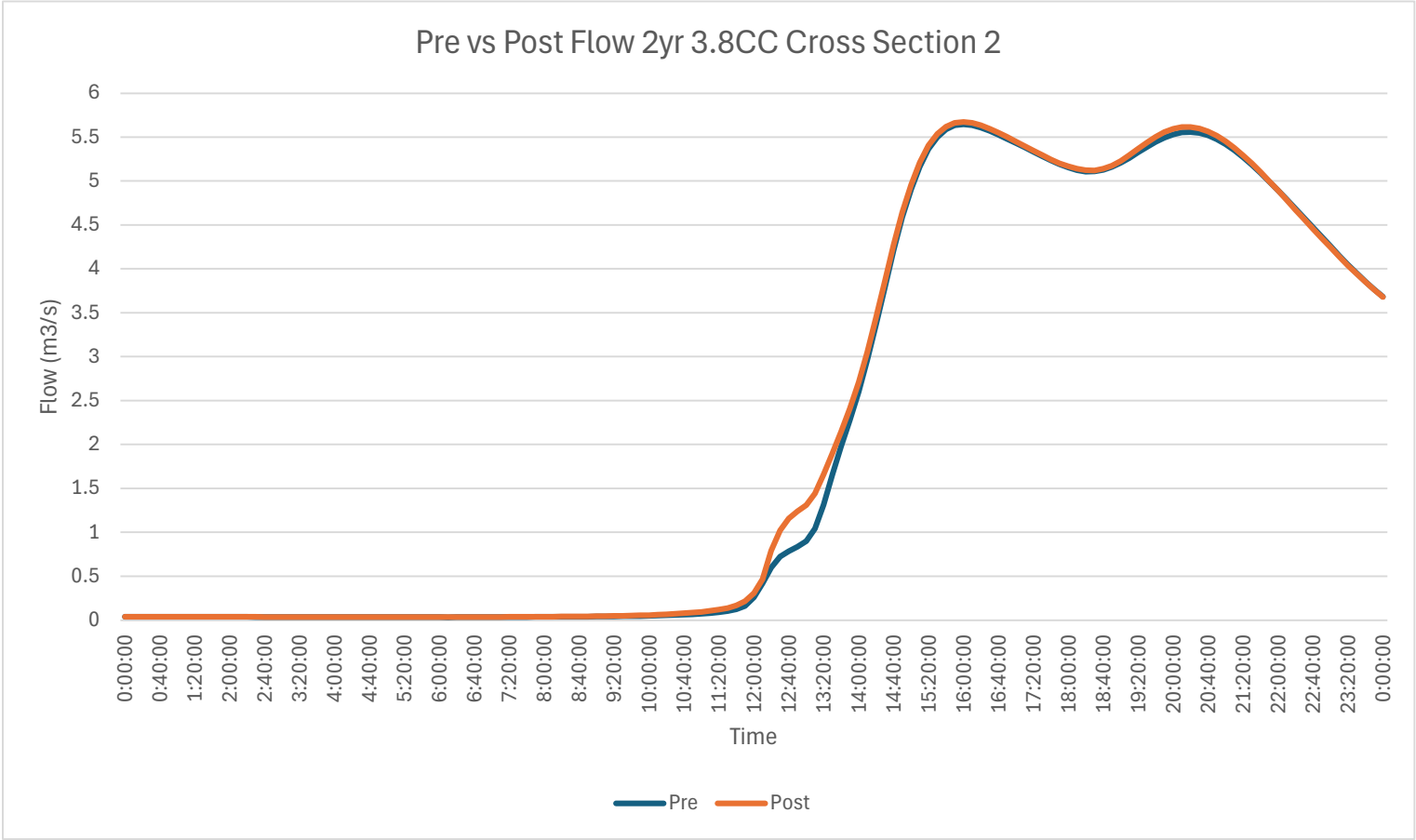
barker.co.nz

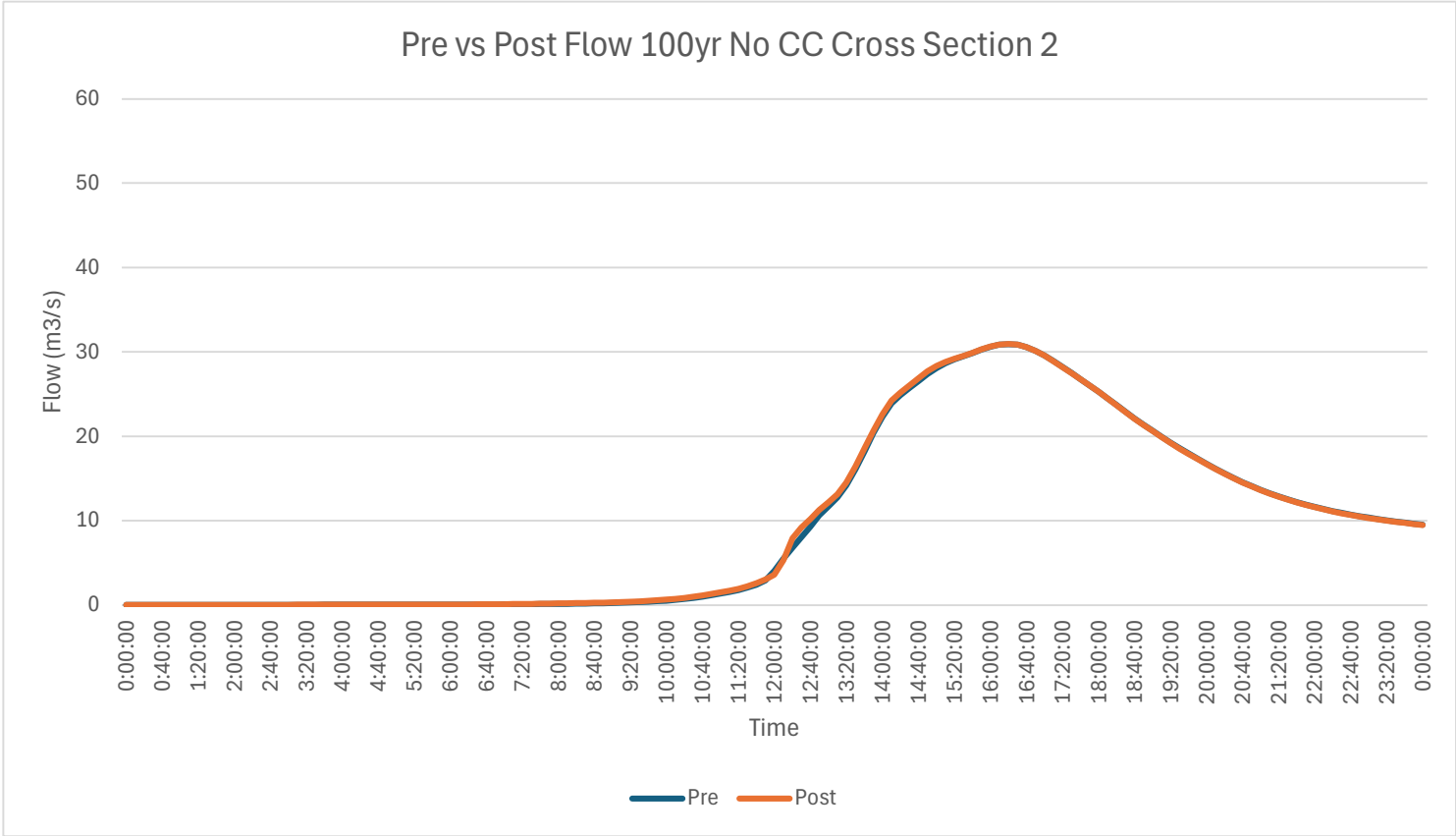
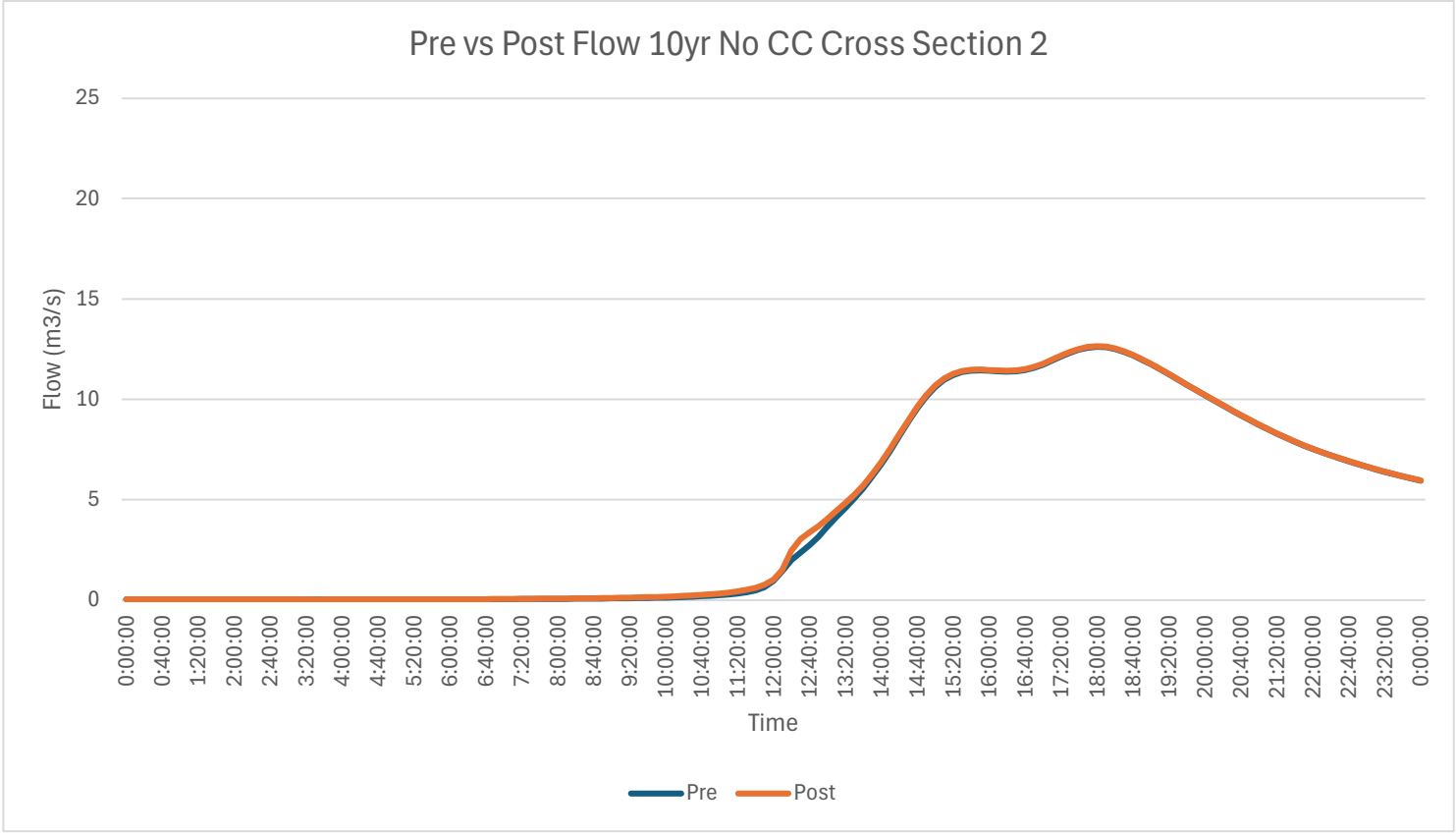
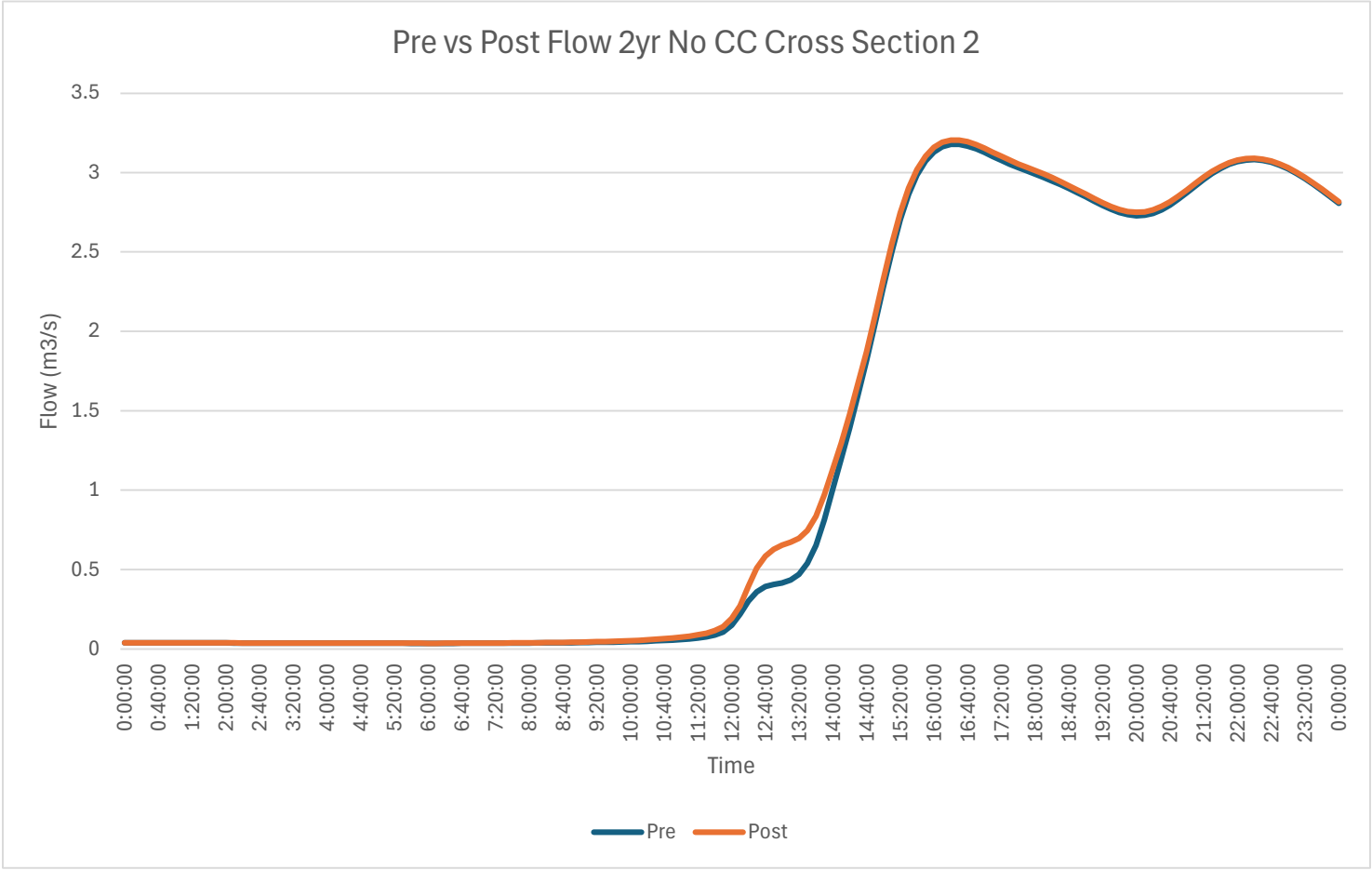
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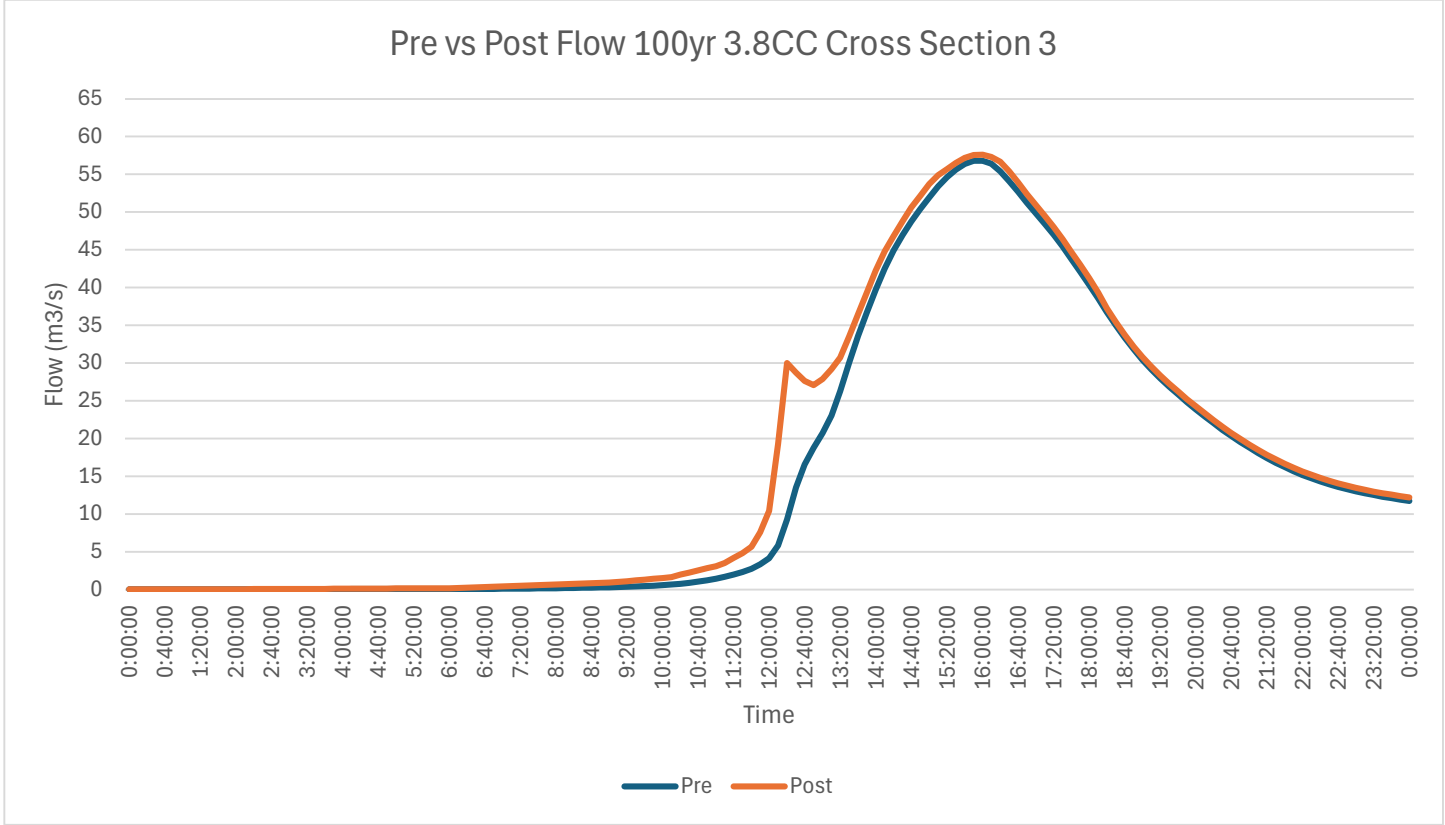
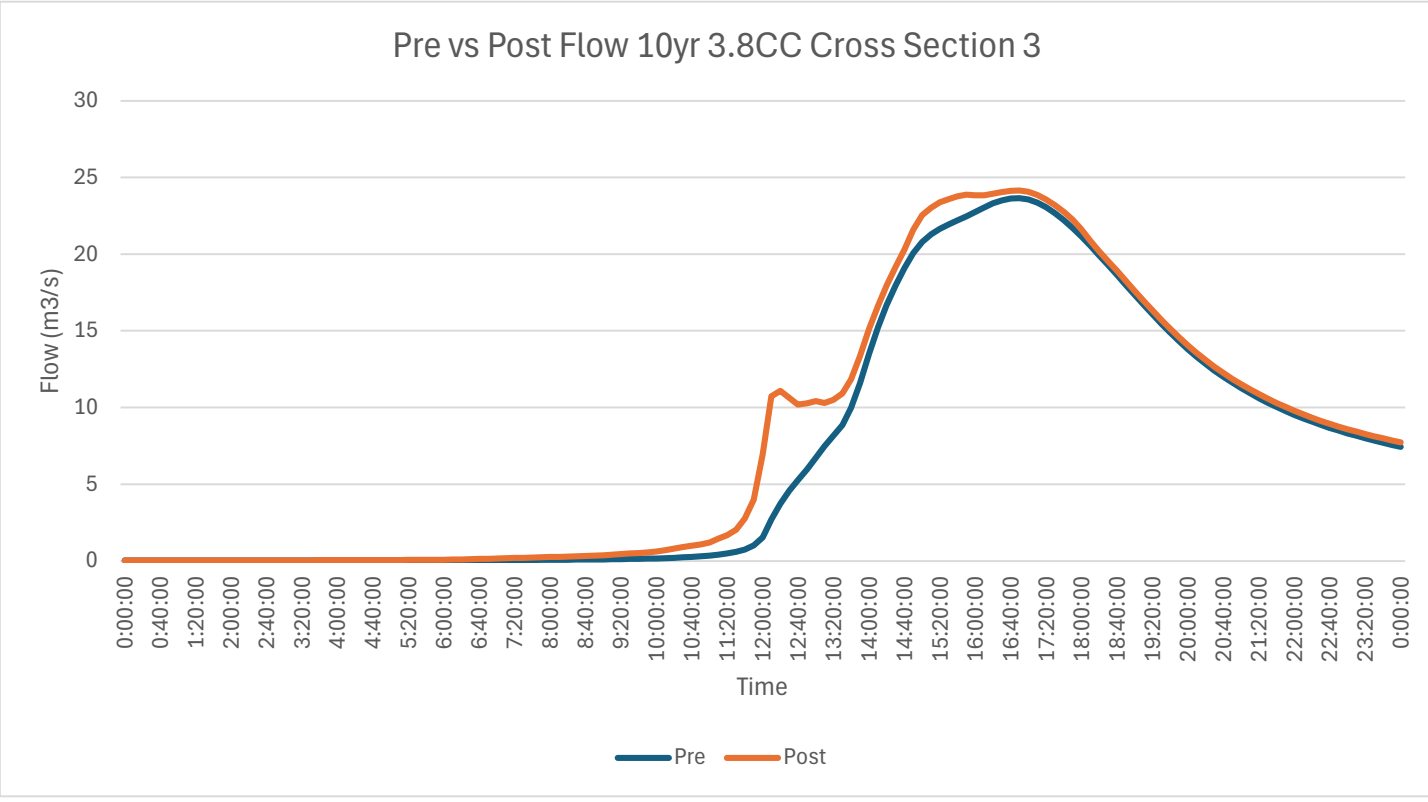
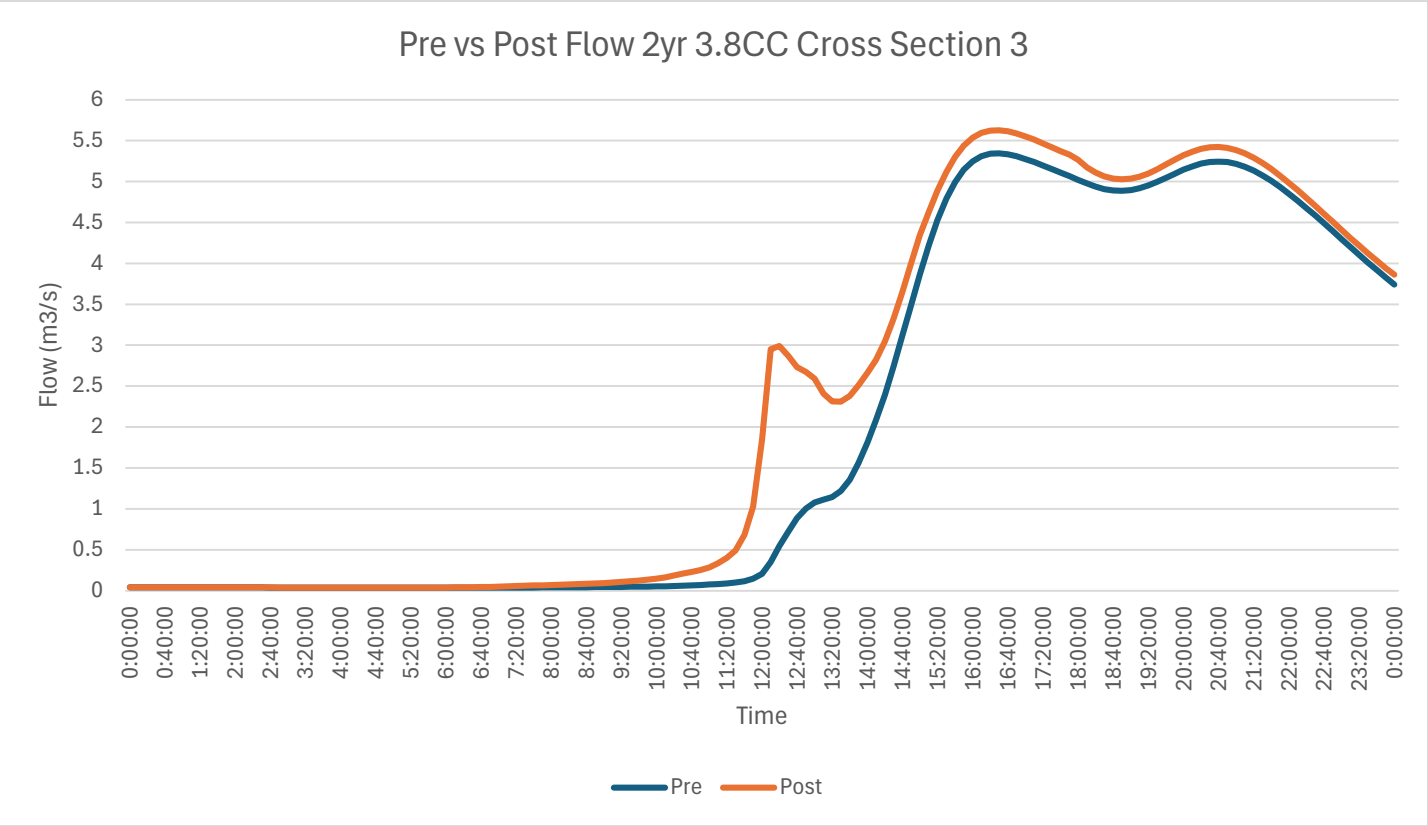
Appendix 3 – Extracted Hydrographs

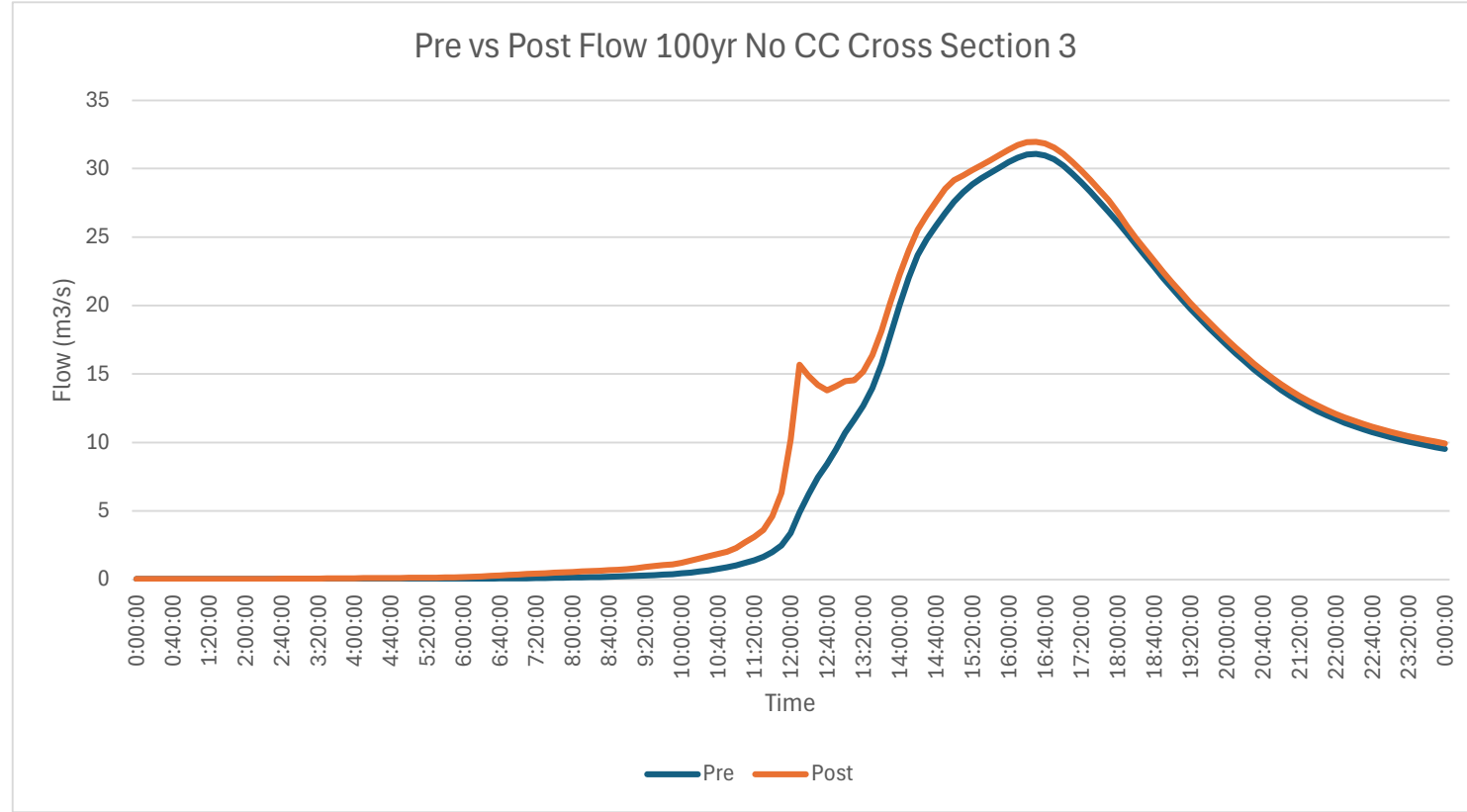
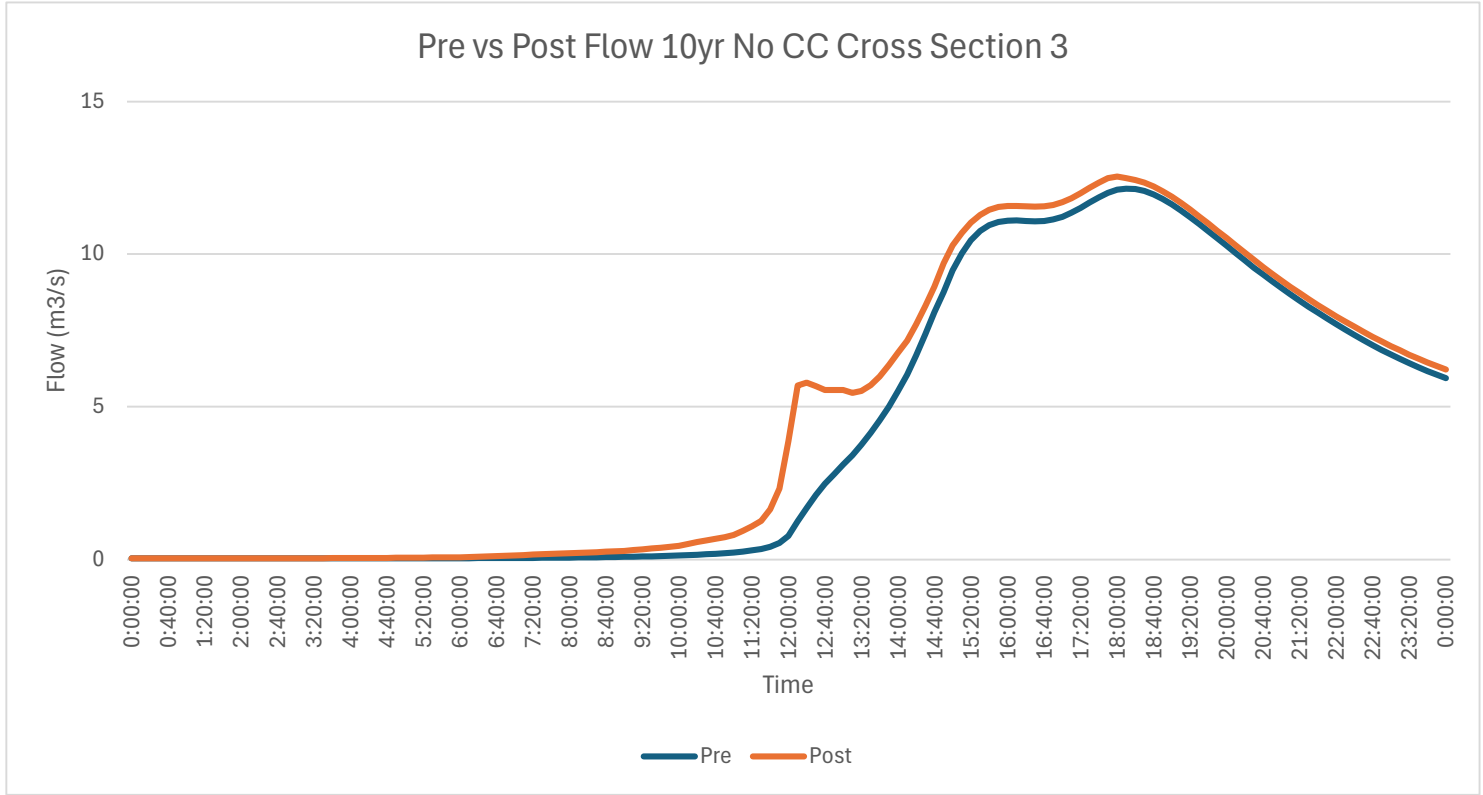
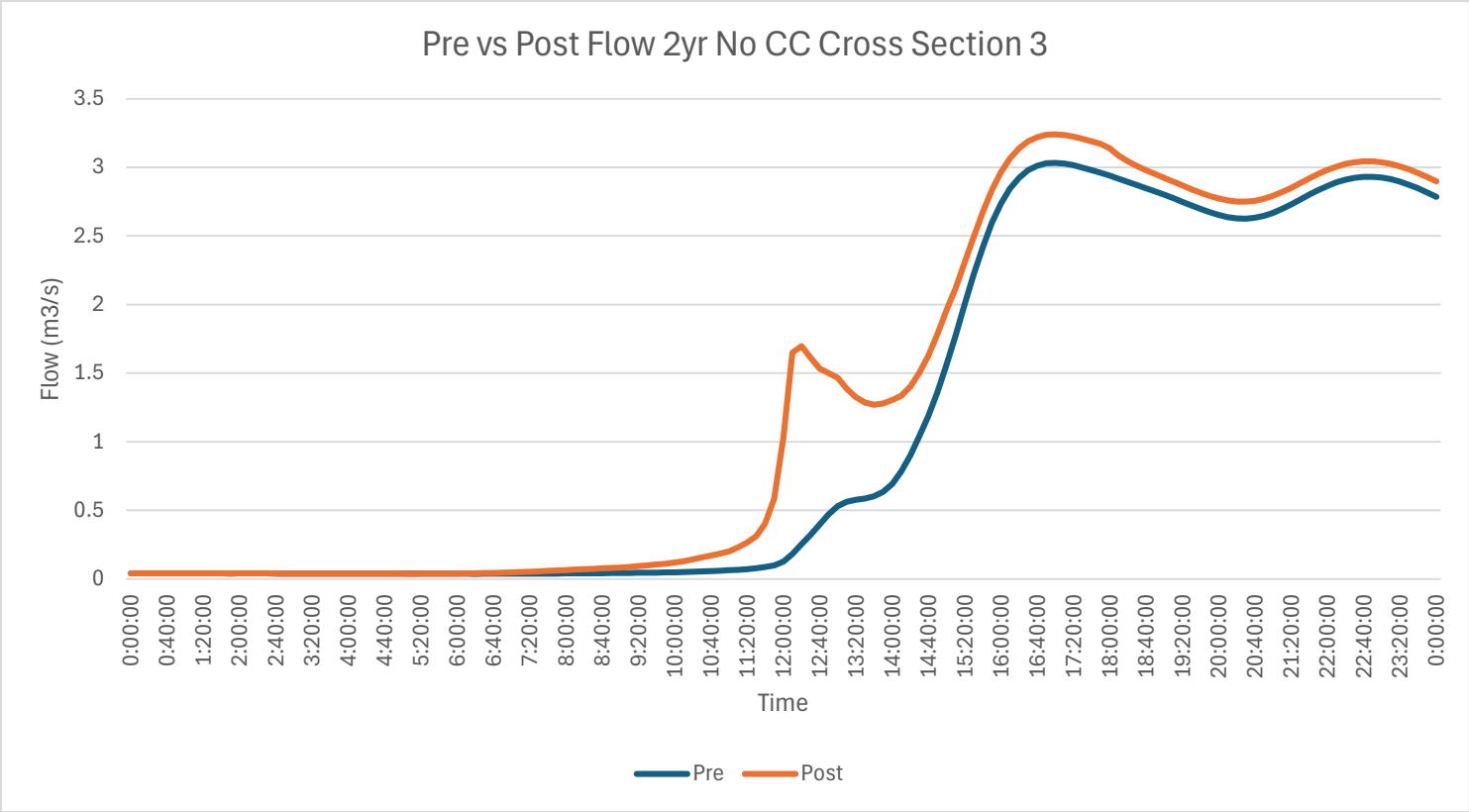


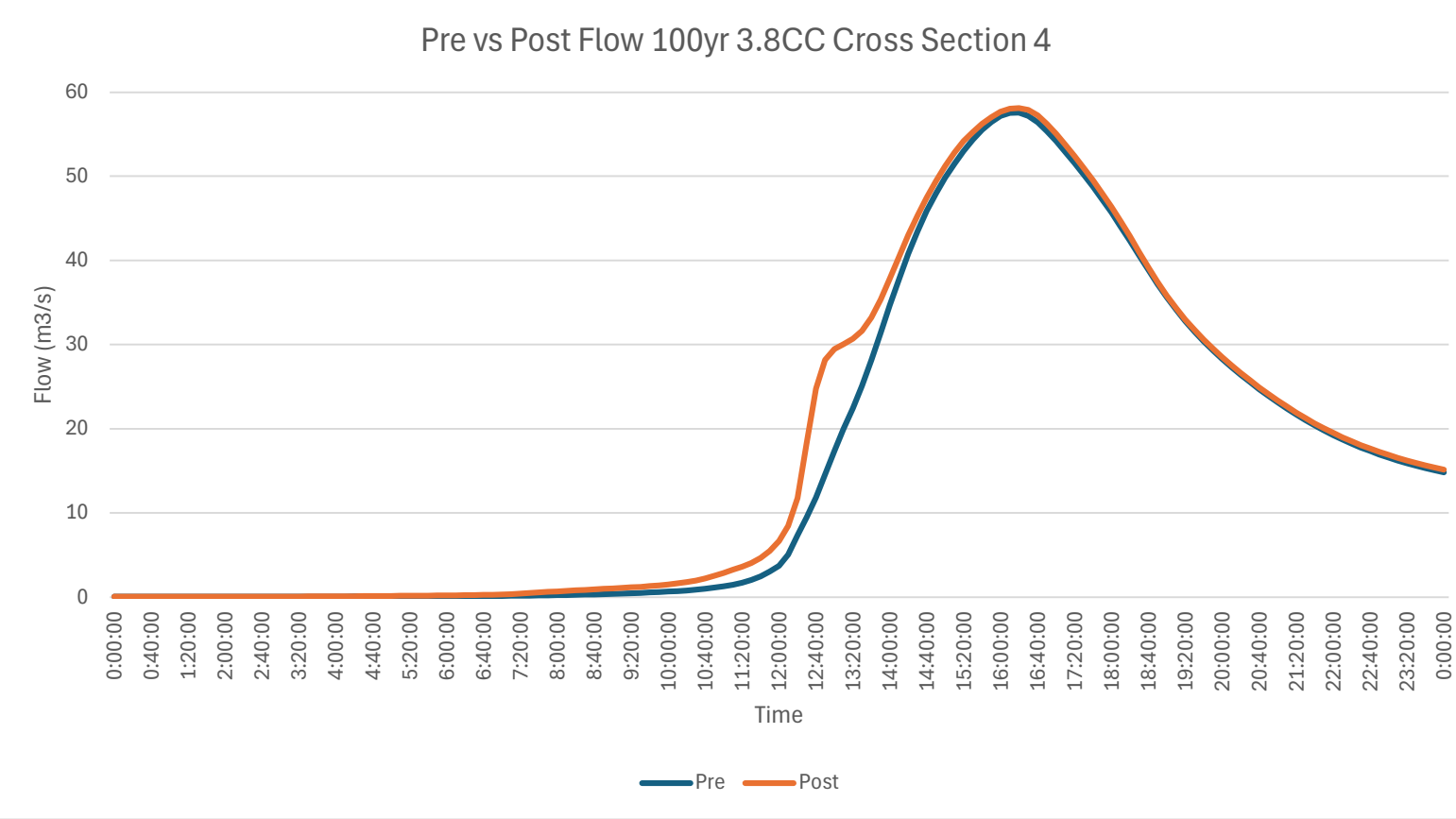
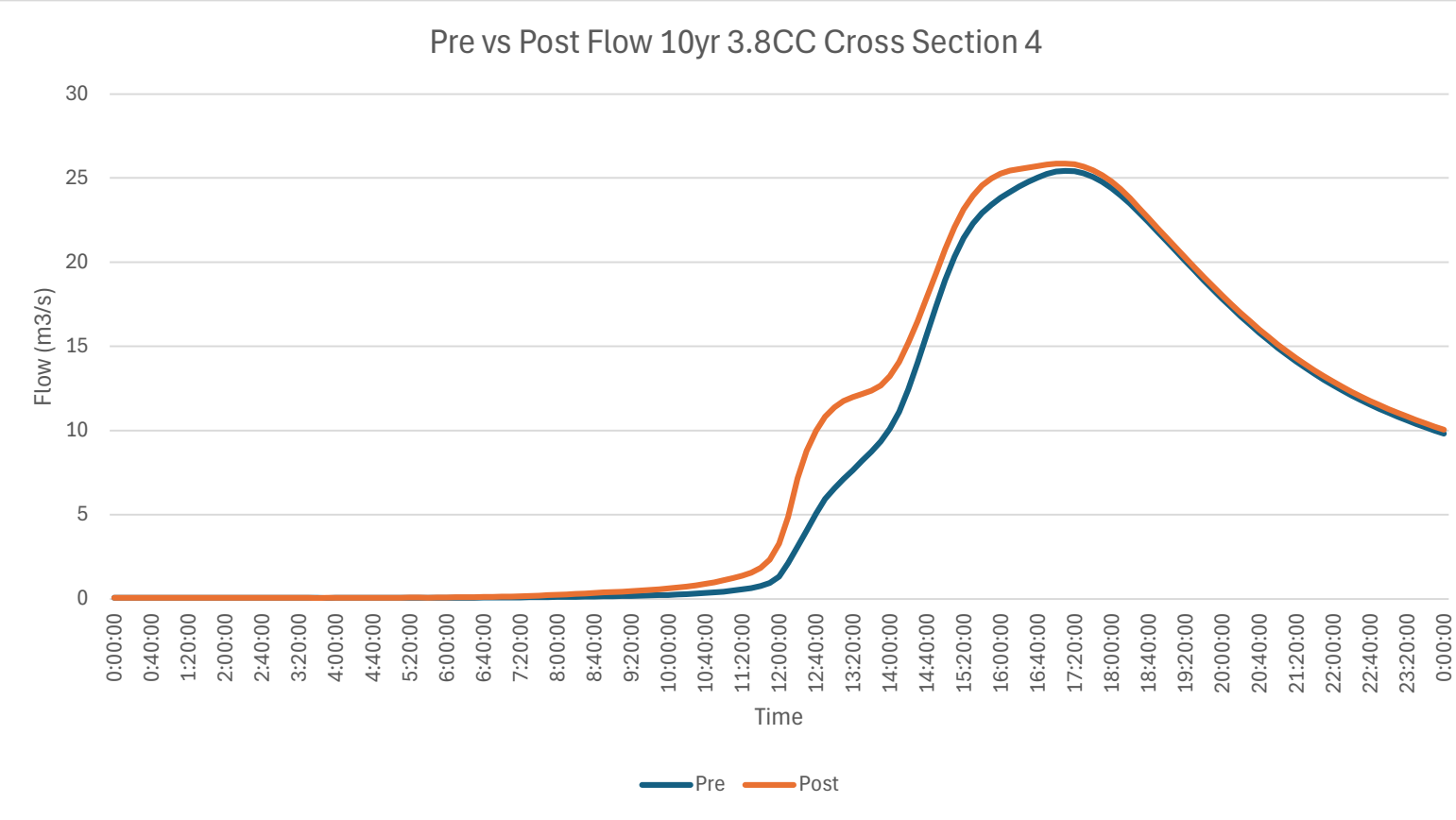
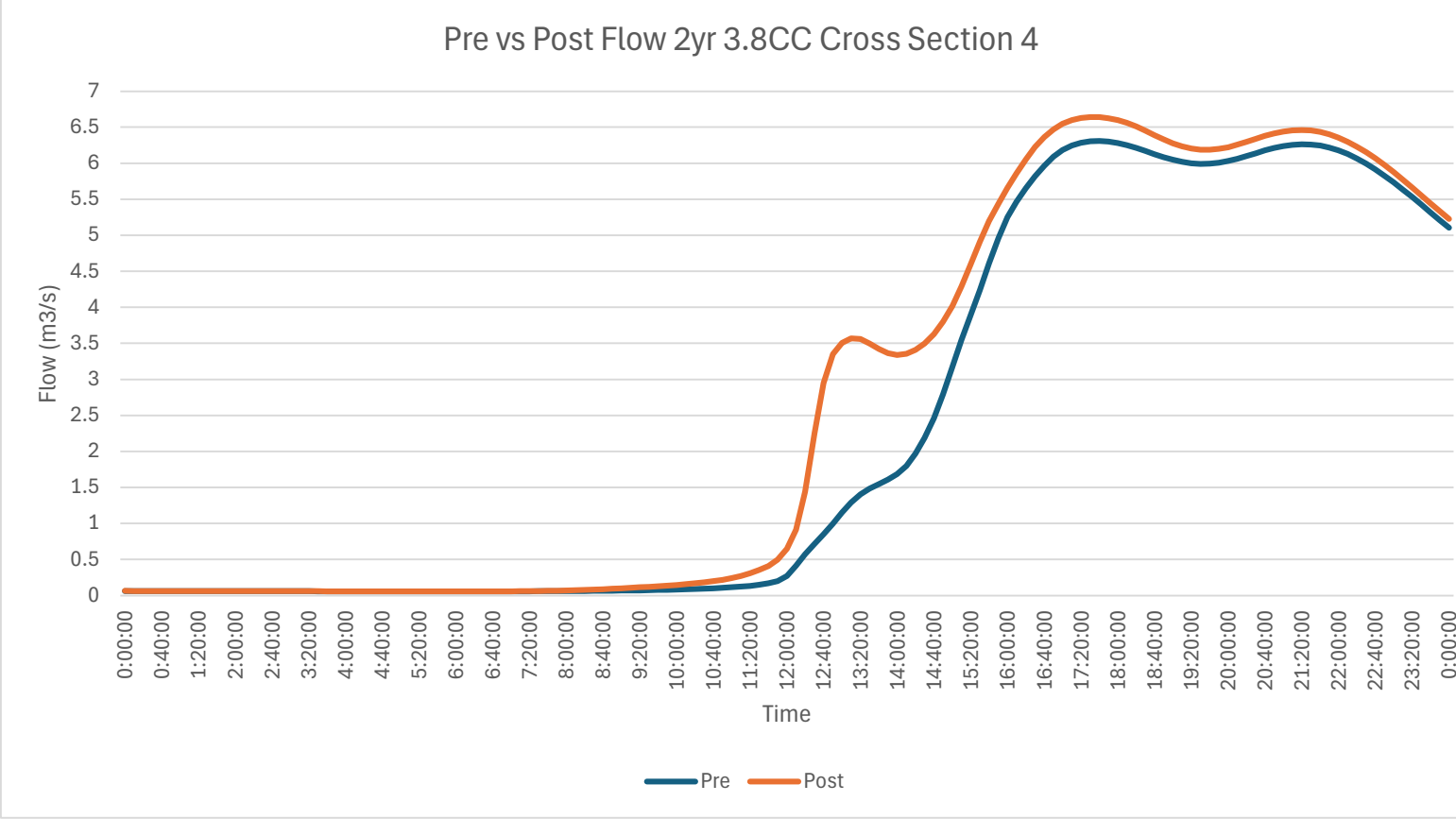


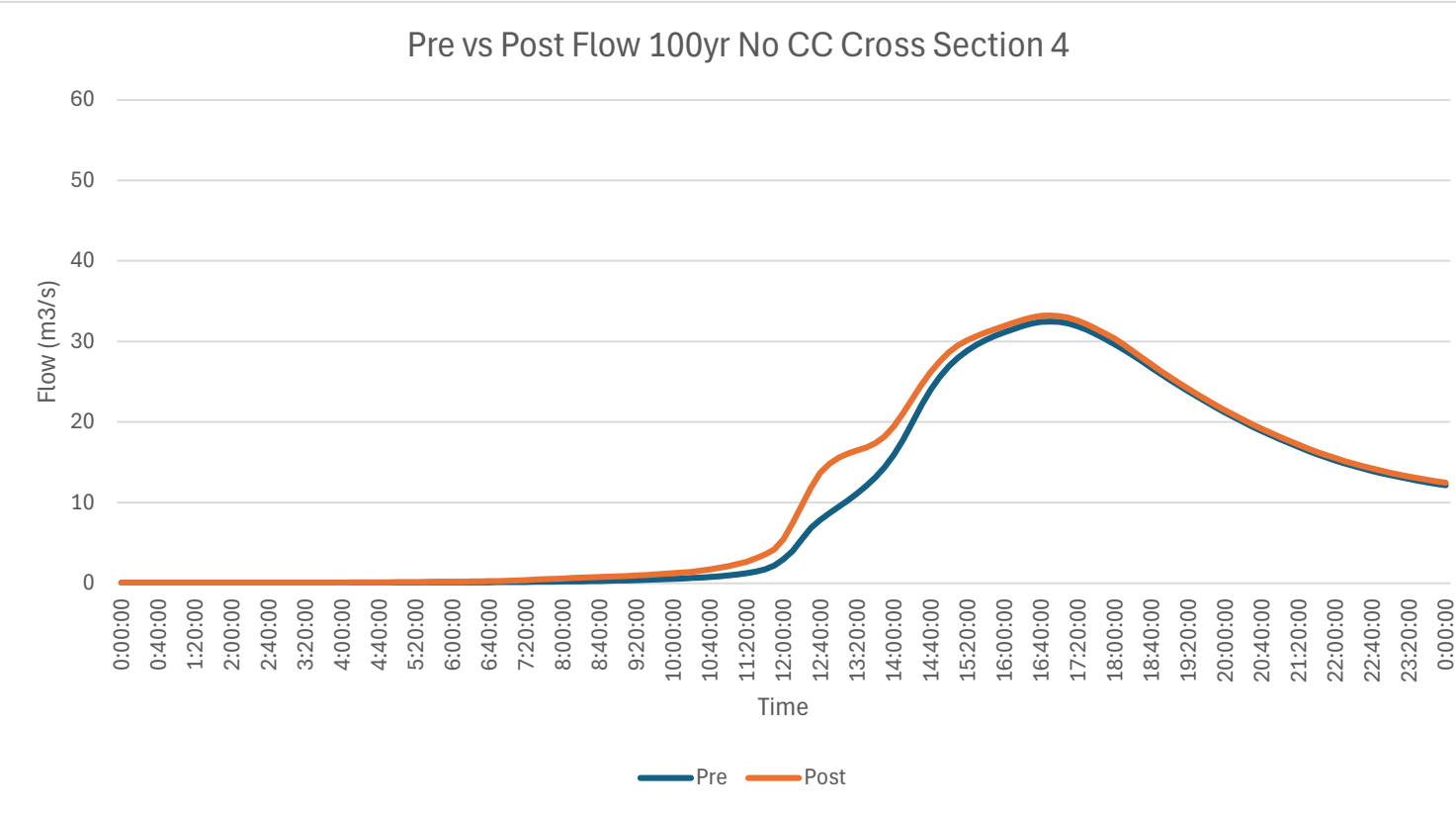
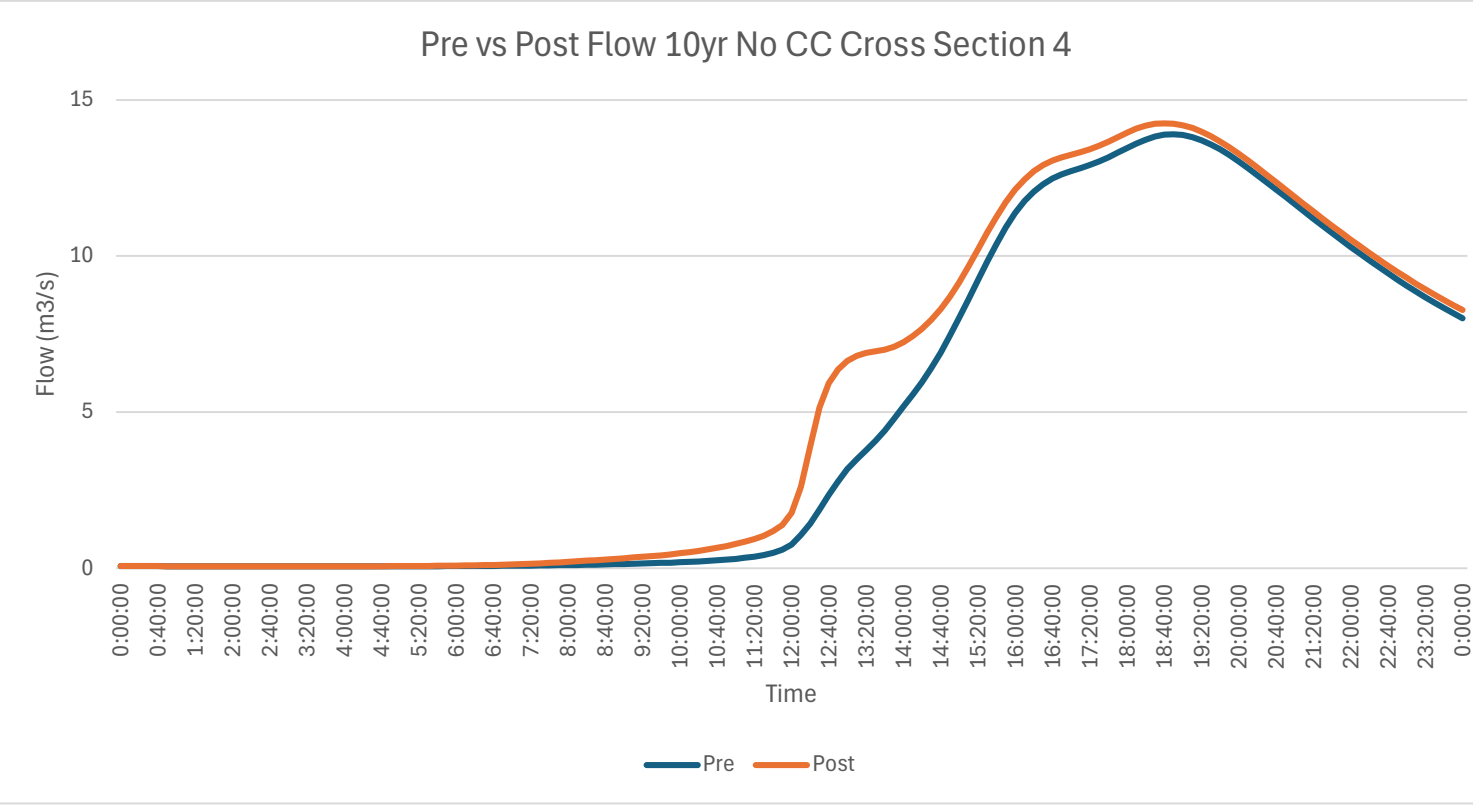
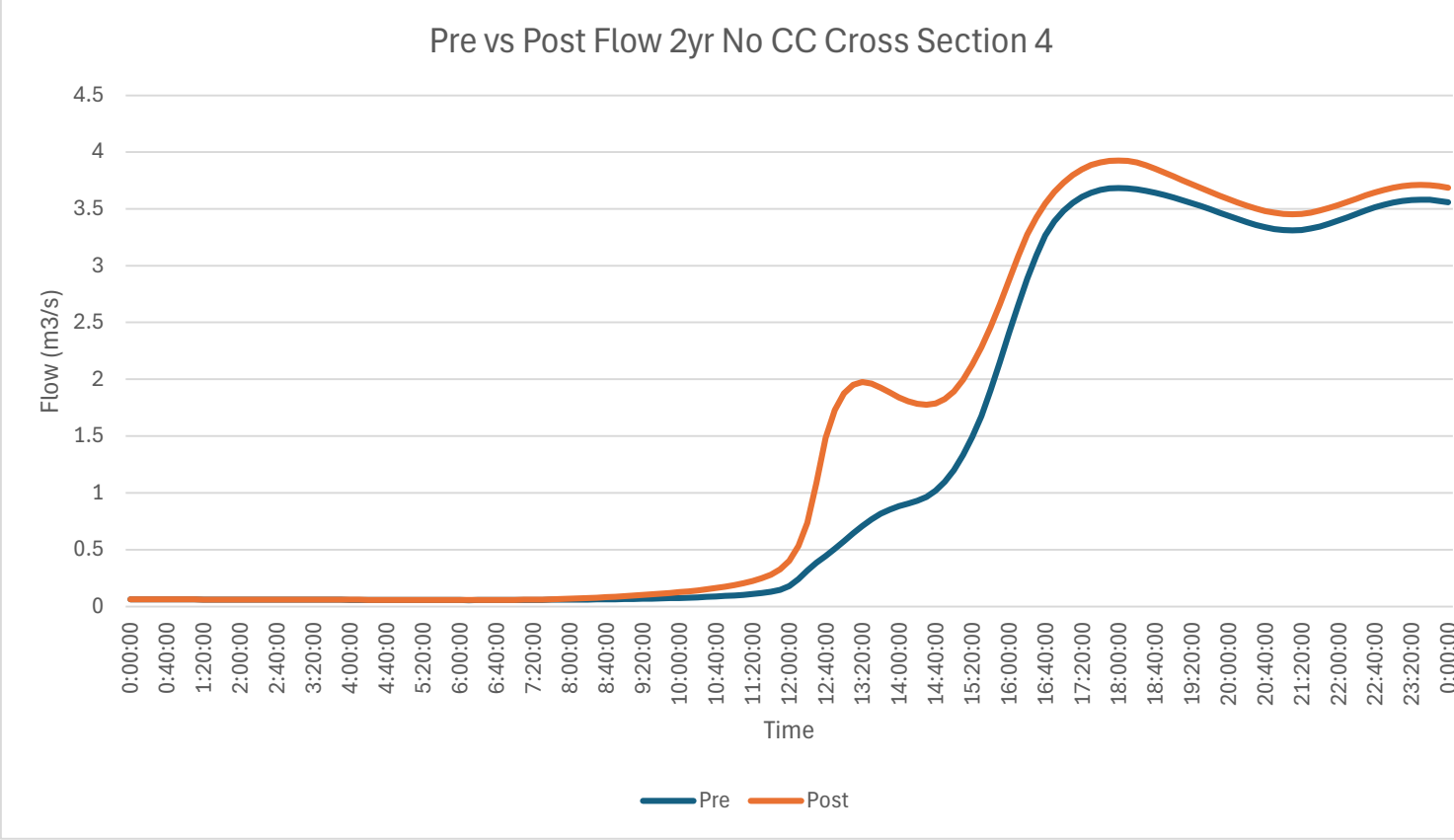


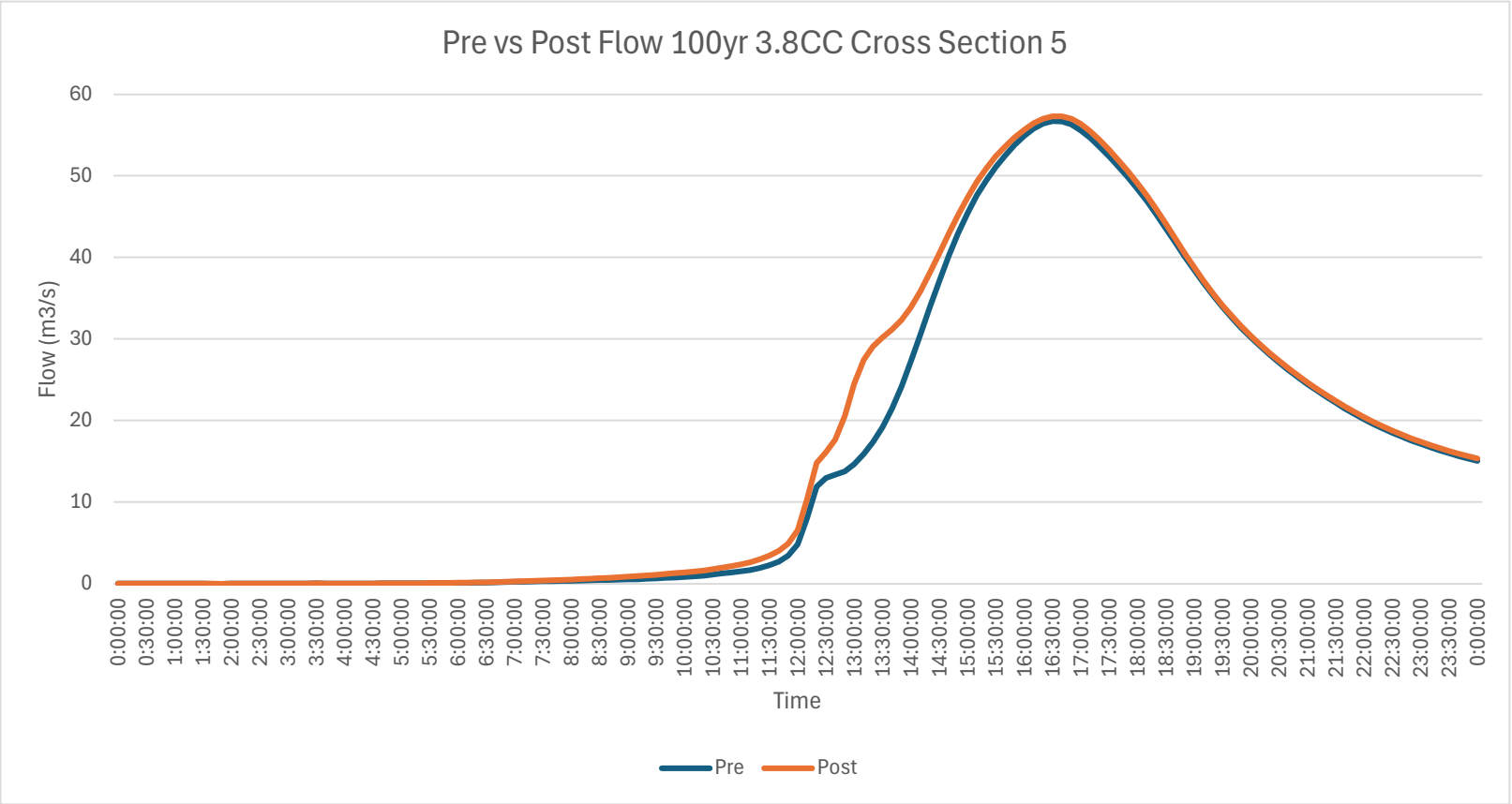
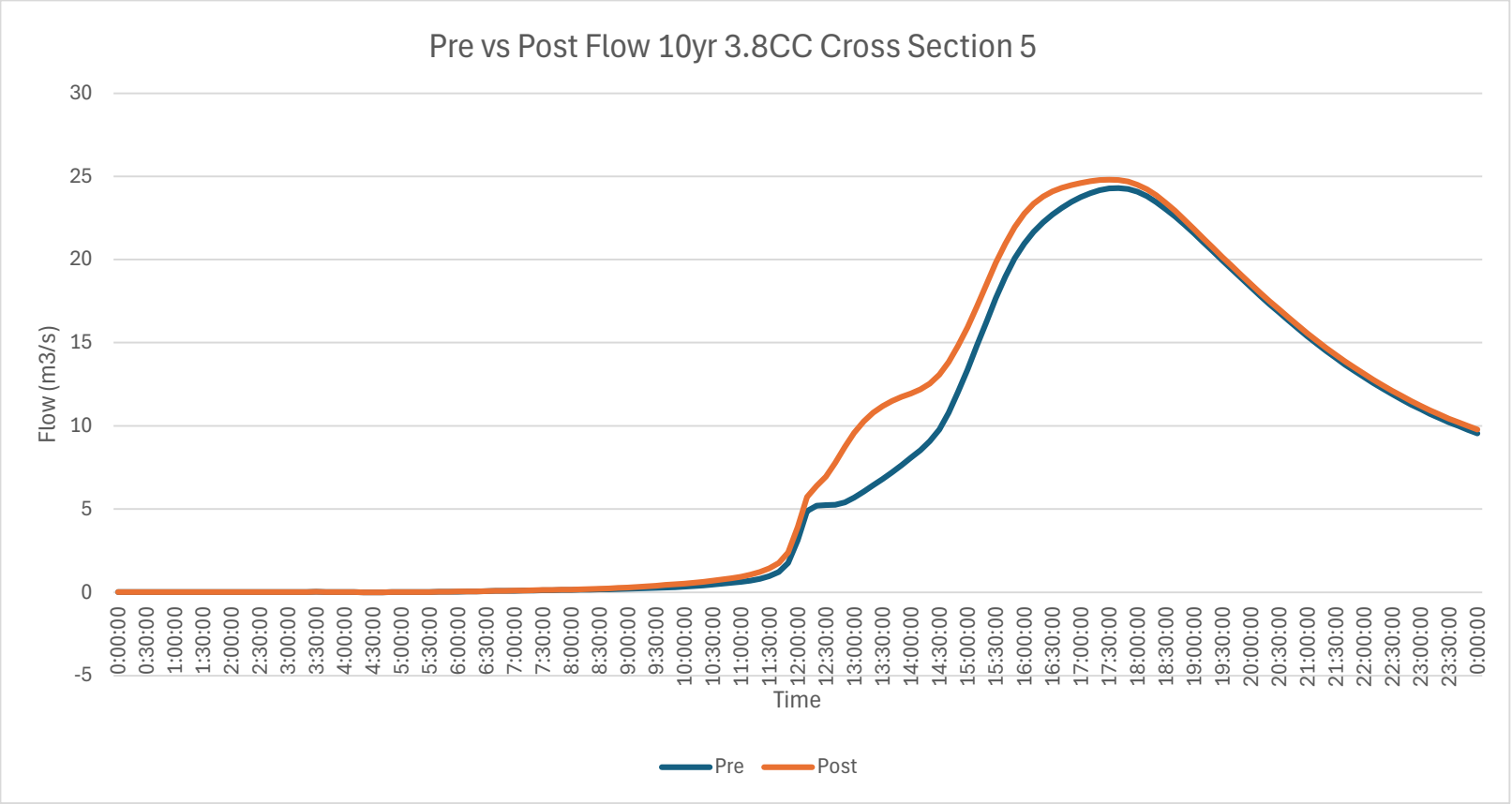
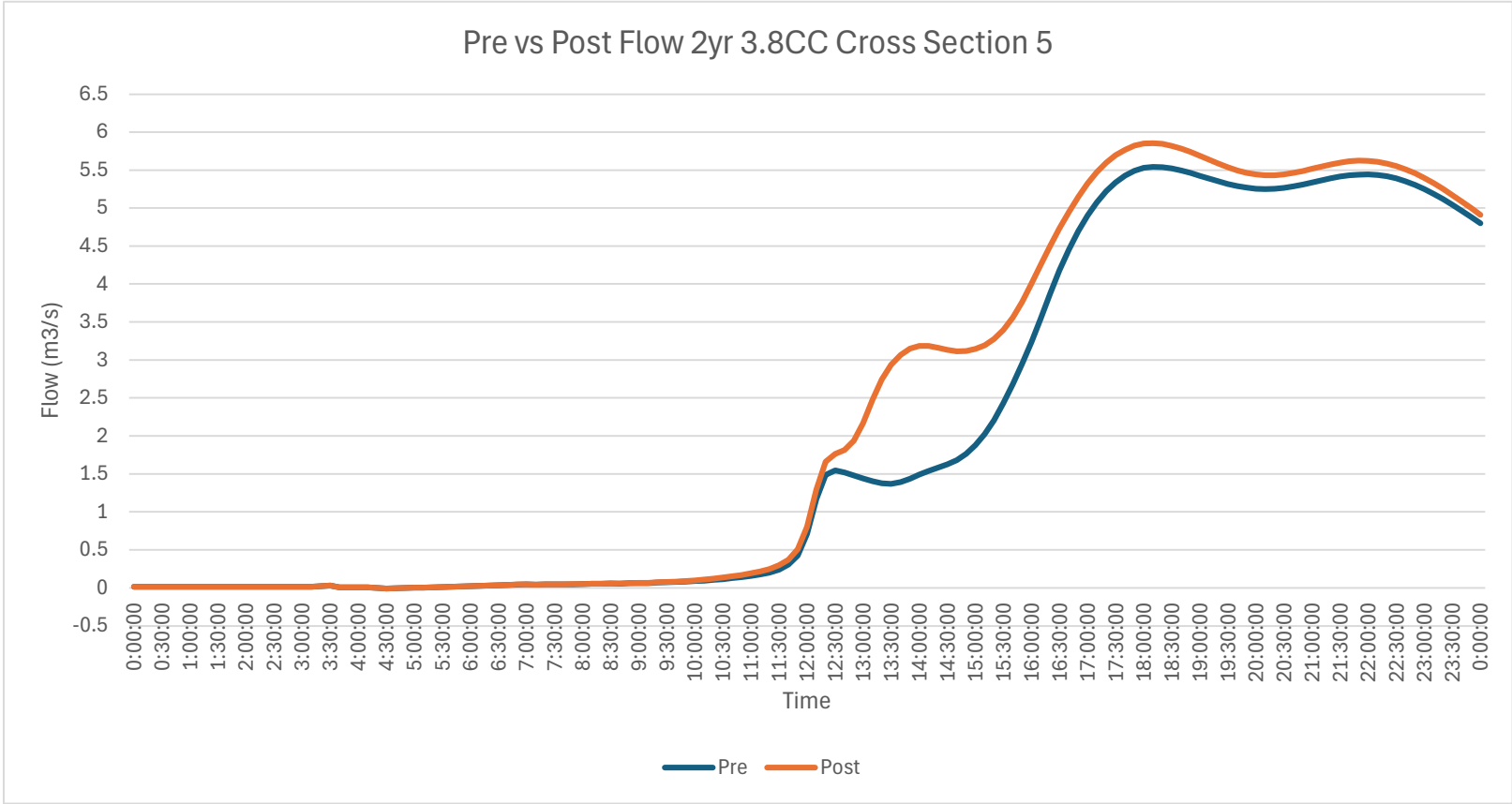


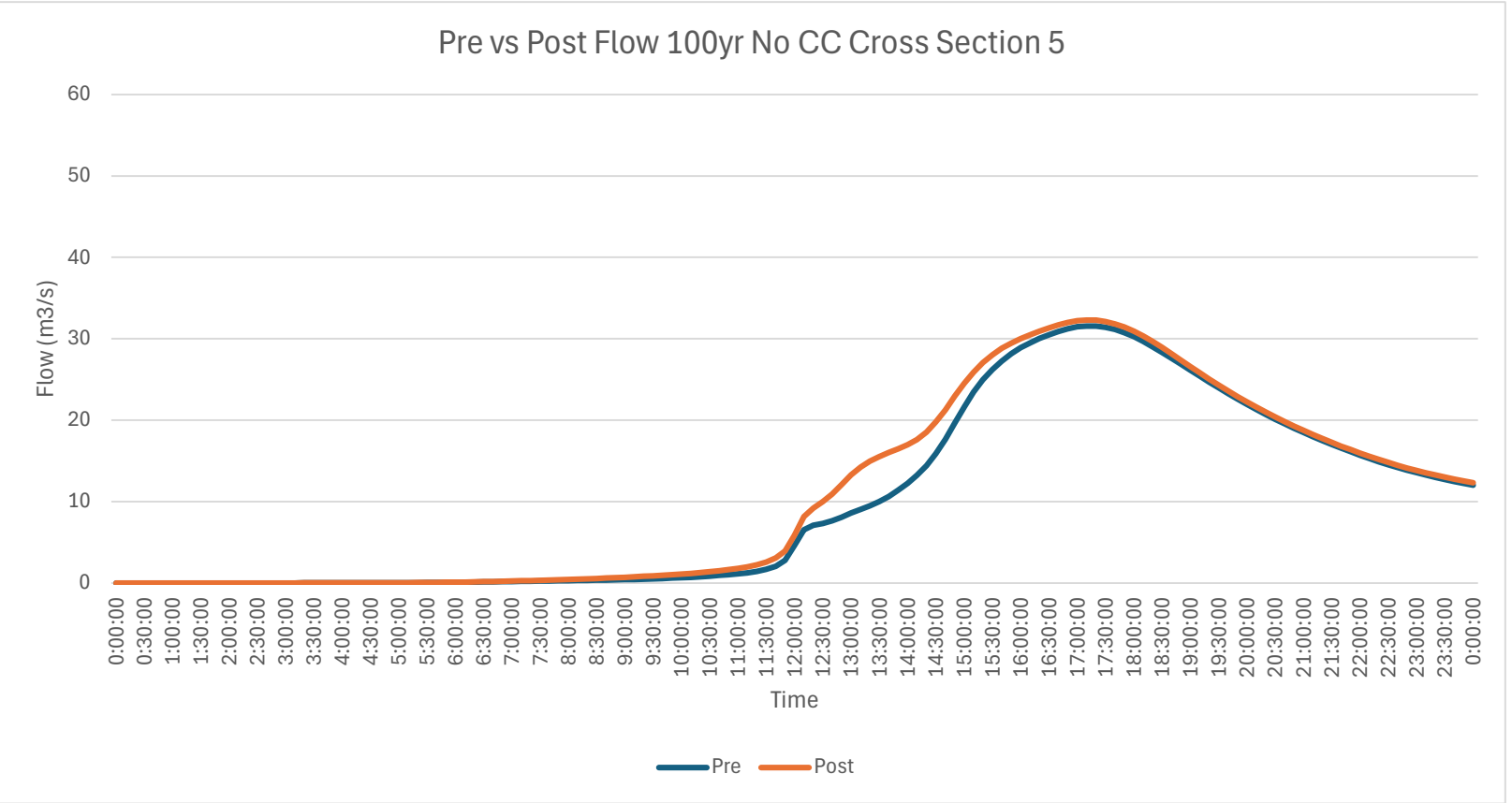
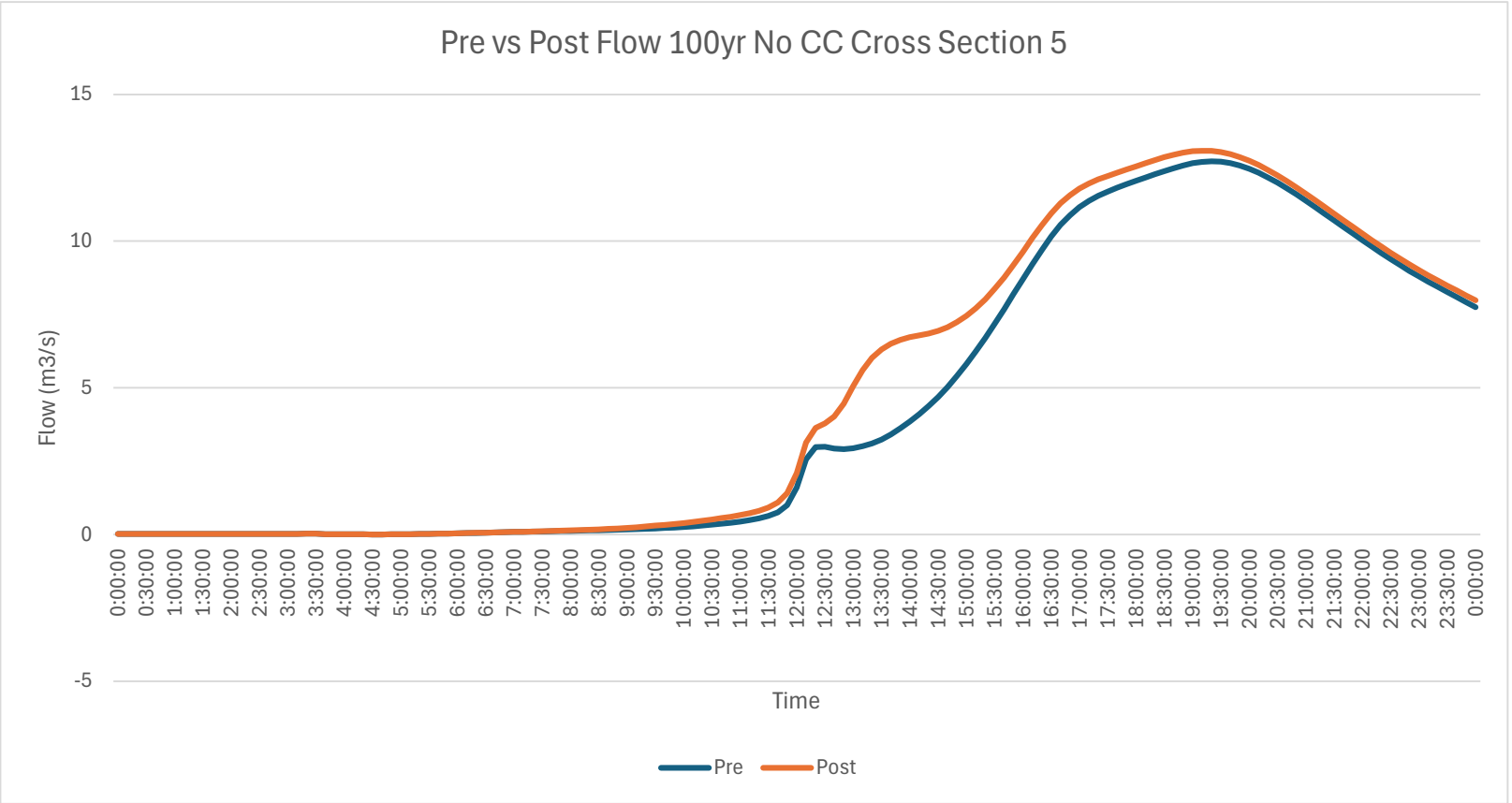
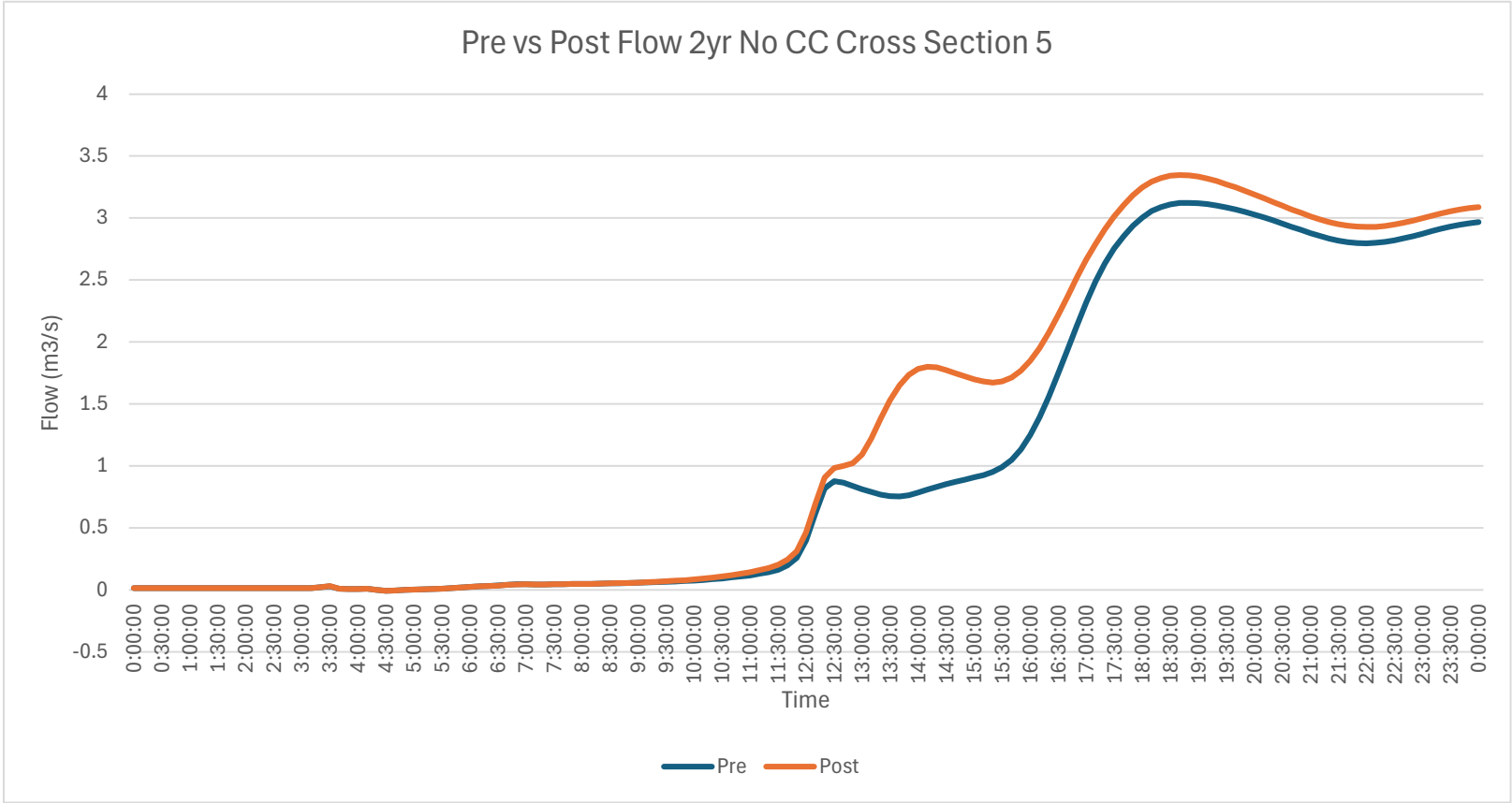




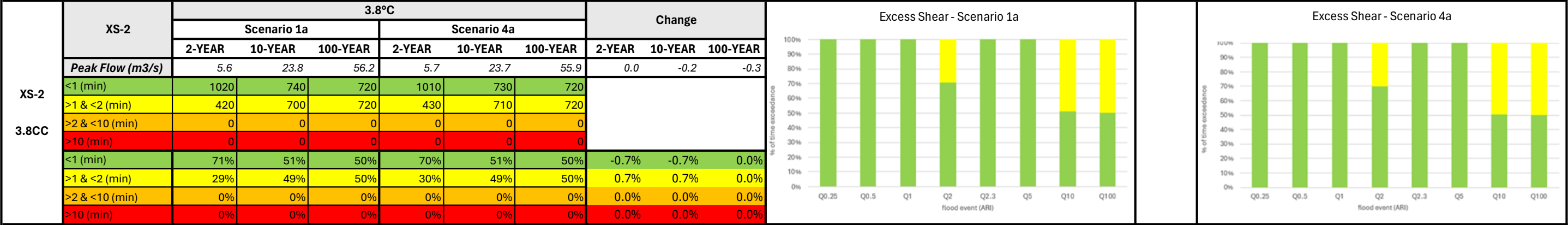
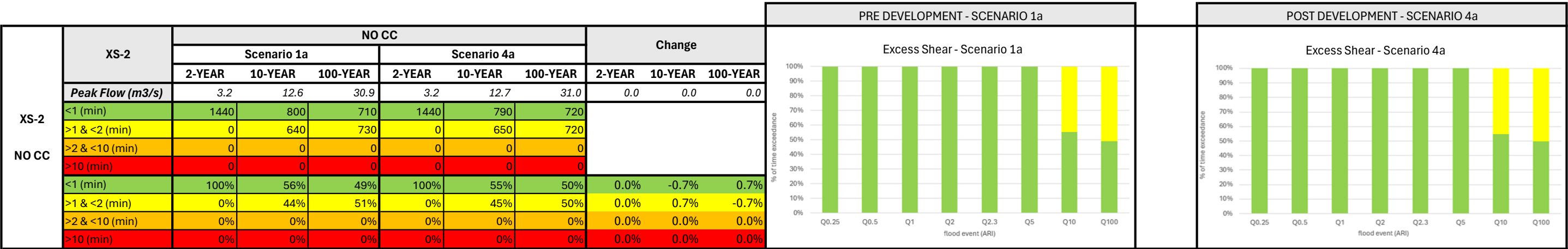
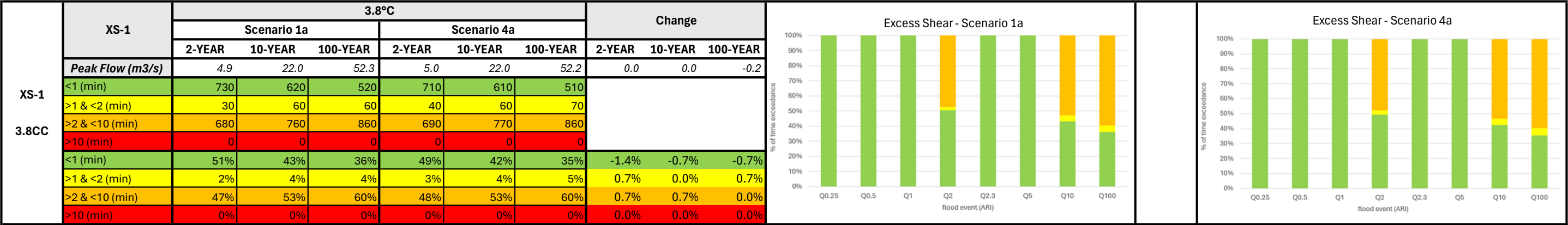
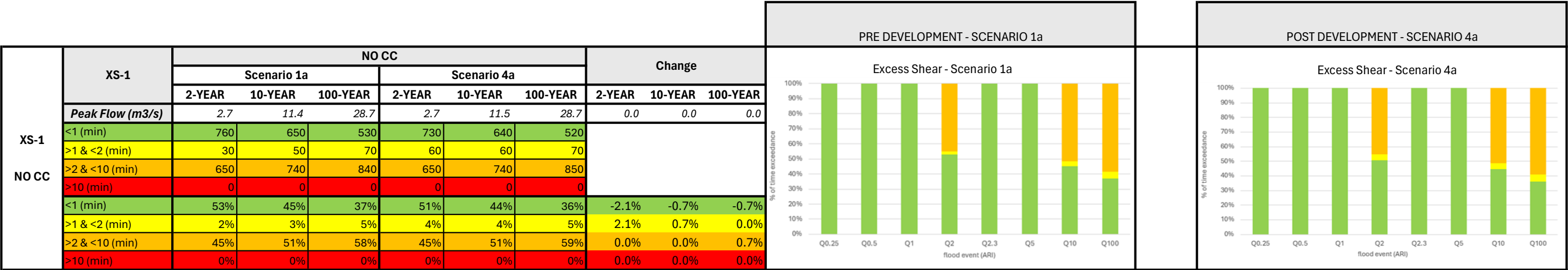


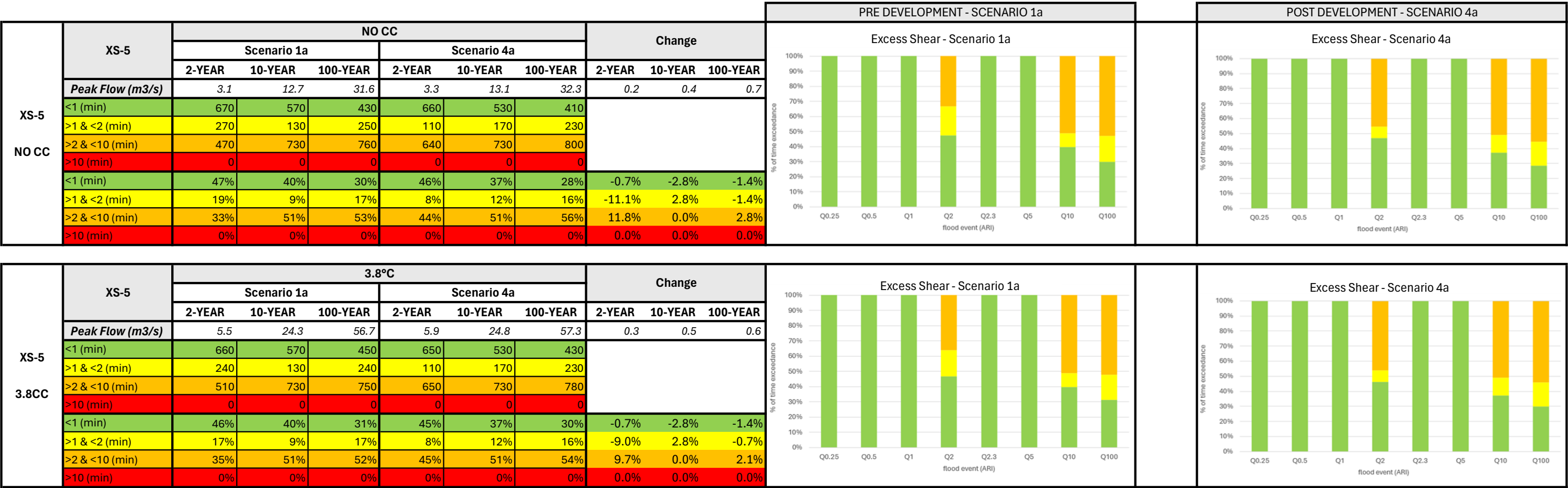






Appendix 4 – EST outputs





Cross-section 1 - No climate change

Erosion screening tool outputs

Test project

Input summary							
Catchment parameters							
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
		ED+C	ED+CC	PD+C	PD+CC	PD+C+M	PD+CC+M
Total Area (km²)	A	0.00	0.00	0.00	0.00		
Perviousness		0.00	0.00	0.00	0.00		
Pervious Area (km²)		0.00	0.00	0.00	0.00		
Impervious Area (km²)		0.00	0.00	0.00	0.00		
Channelisation Factor	C	0	0	0	0		
Catchment Length (km)	L	0.00	0.00	0.00	0.00		
Catchment Slope (m/m)	Sc	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Curve Numbers							
Soil Type	S	0	0	0	0		
Pervious Areas	CN	0	0	0	0		
Impervious Areas	CN	98	98	98	98		
Weighted	CN	98.0	98.0	98.0	98.0		
TP108							
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Soil Storage (mm)	S	5	5	5	5		
Time of Concentration (hr)	t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Time to Peak (hr)	t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
P24 Rainfall Depth (mm)							
3 month ARI*		0	0	0	0	0	0
6 month ARI		0	0	0	0	0	0
1 year ARI		0	0	0	0	0	0
2 year ARI		0	0	0	0	0	0
2.3 year ARI		0	0	0	0	0	0
5 year ARI		0	0	0	0	0	0
10 year ARI		0	0	0	0	0	0
100 year ARI		0	0	0	0	0	0

* 3 month ARI estimated rainfall does not fits well in regression calculation, not recommend to use.

Results - TP108 Peak Flow Analysis								
ARI (yr)	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 2 ED+CC								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 3 PD+C								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 4 PD+CC								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 5 PD+C+M								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 6 PD+CC+M								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff

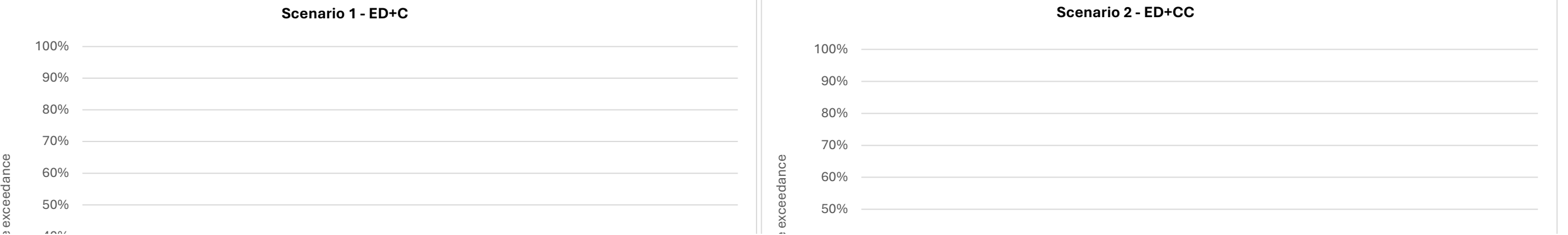
#N/A

Results - Bank Full Channel Identification	
Approximate channel width (m)	11.91
Bank full water depth (m)	#N/A
Bank full flow (m³/s)	#N/A
Bank full flow excess shear	#N/A
Annual fullest flow as represented by the mean annual flood (m³/s)	0.00
Annual fullest flow as represented by the mean annual flood excess shear	0.0

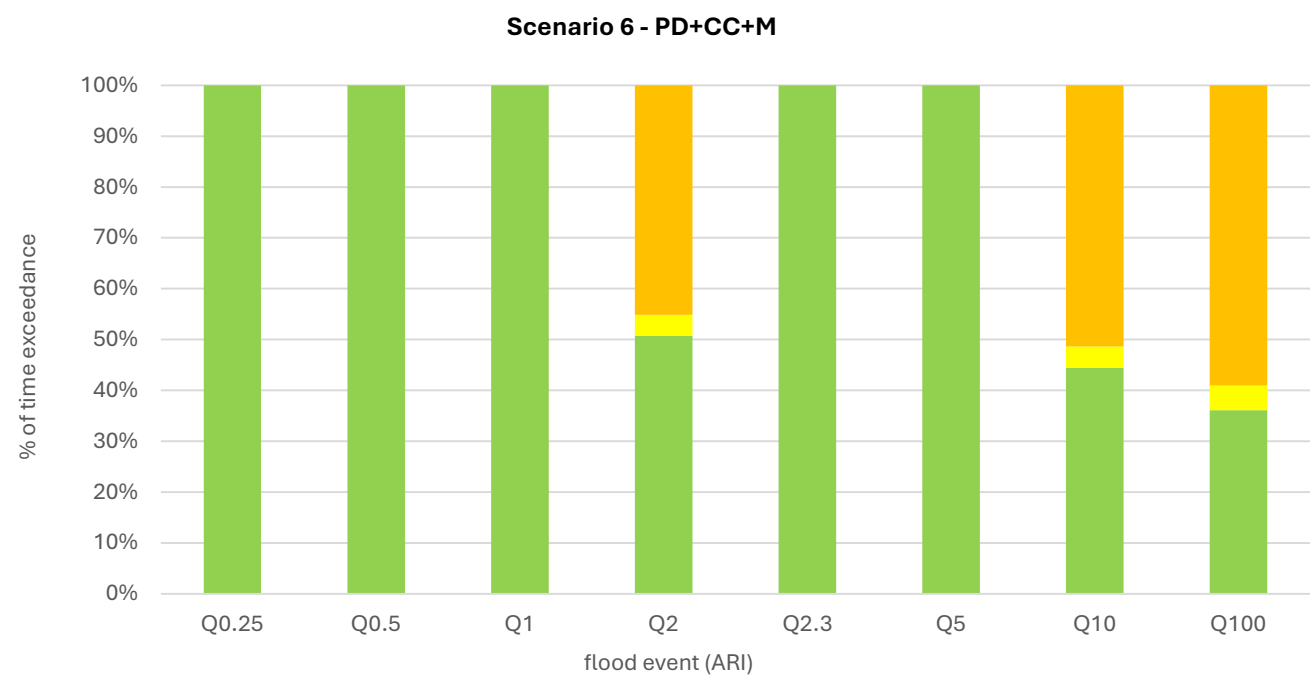
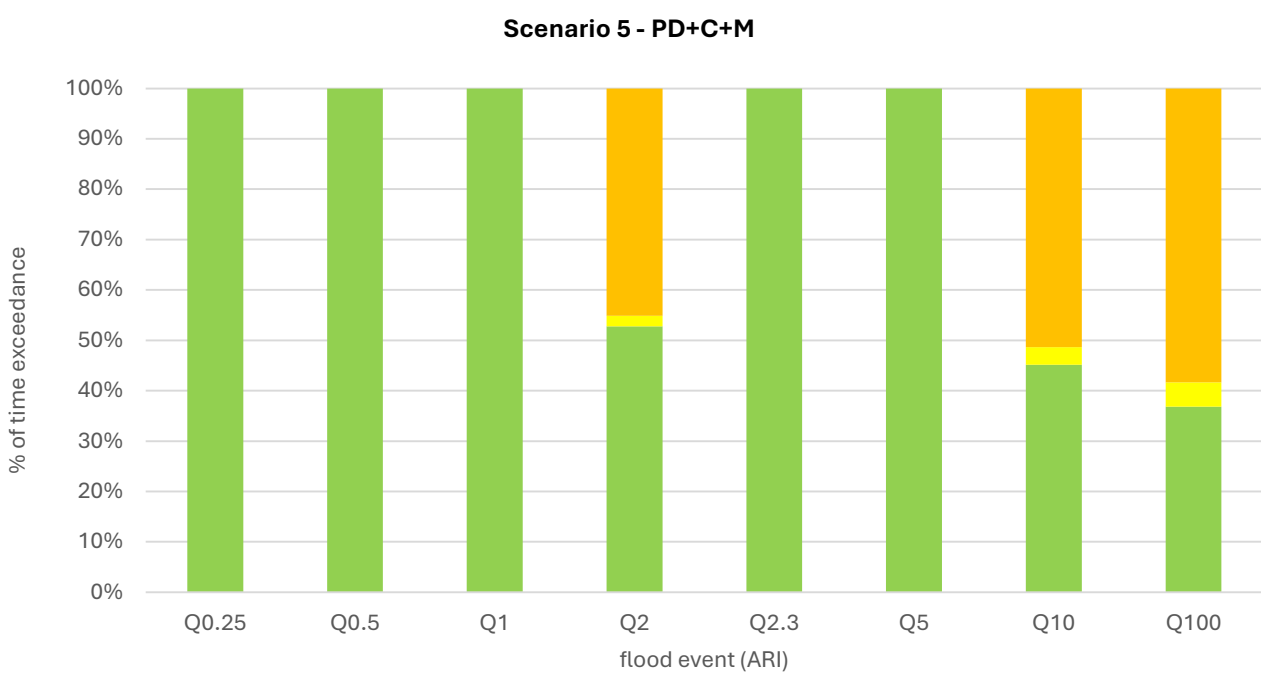
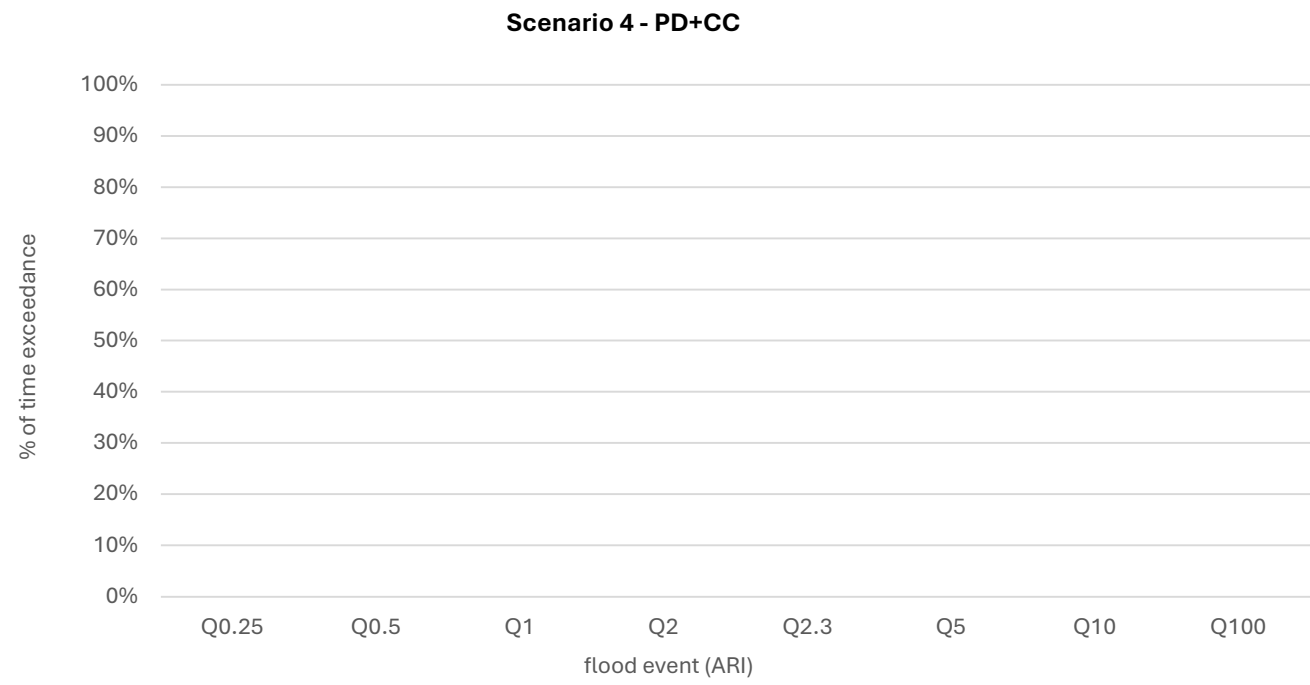
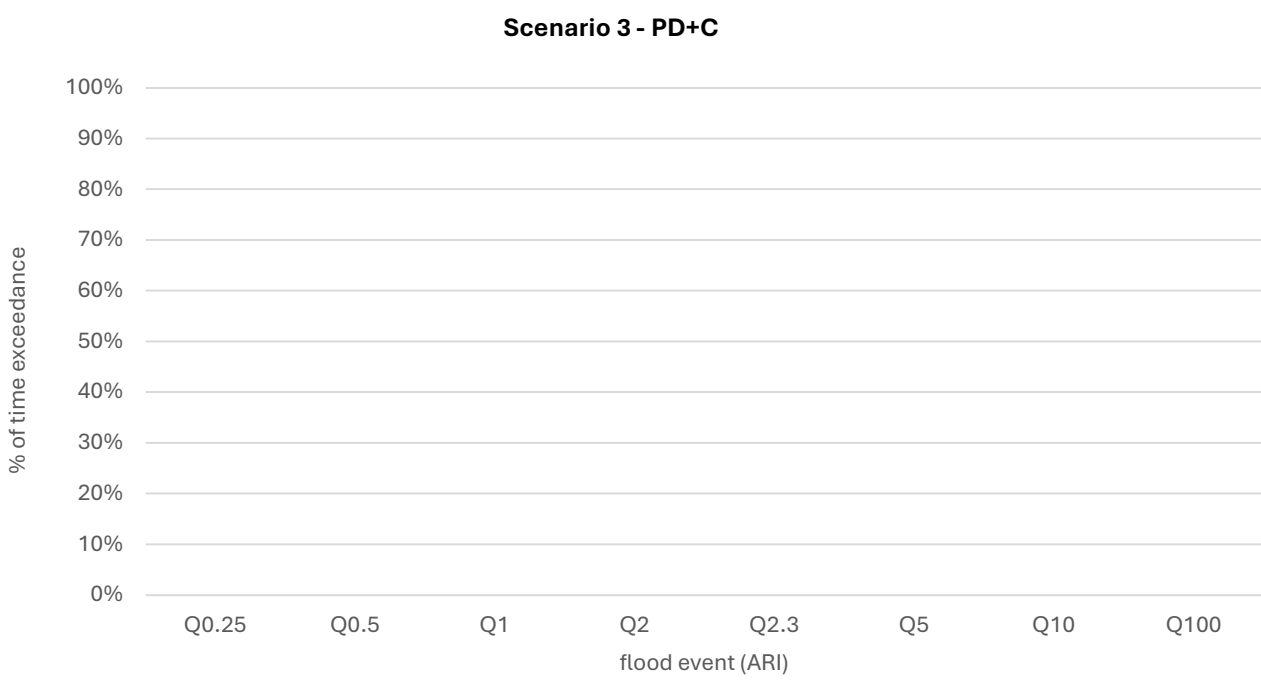
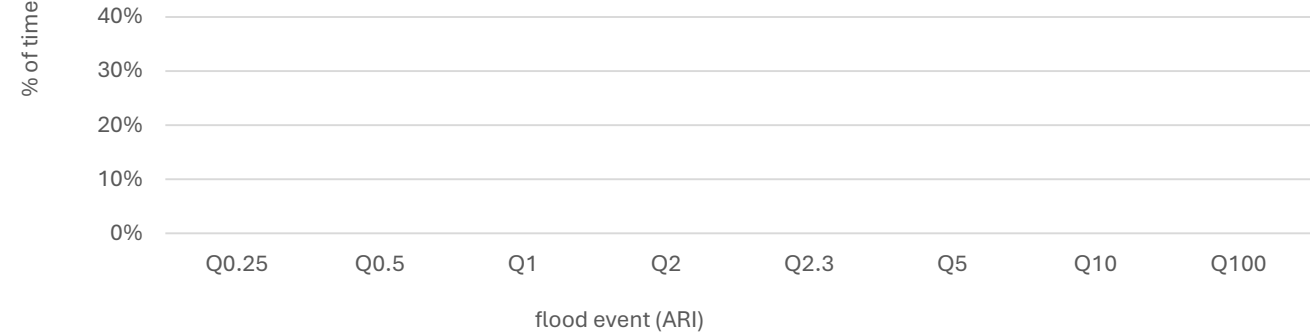
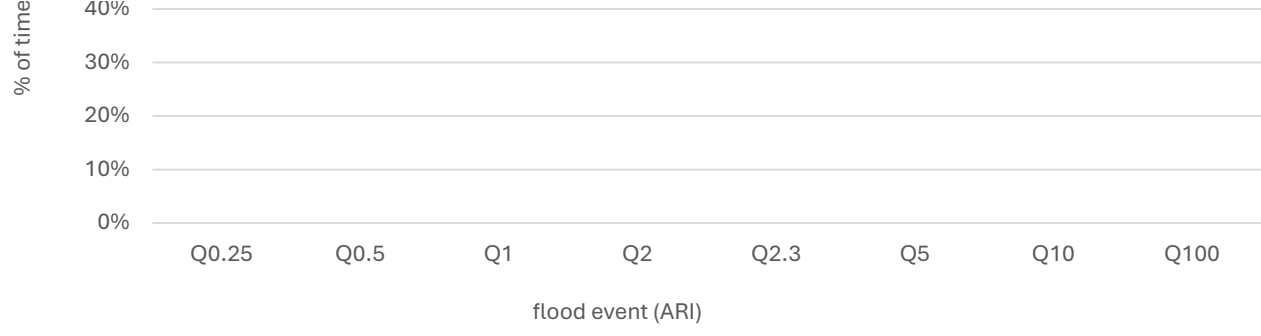
Results - 24hr Runoff Hydrographs



Results - Excess shear exceedance								
Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel. Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Existing development erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its existing development state.								
Boundary shear stress (BSS) - the force exerted on the channel by flow								
Excess shear stress (ESS) - the amount of BSS in excess of the critical shear stress threshold for initiating sediment movement								
ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Scenario 1 ED+C								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0



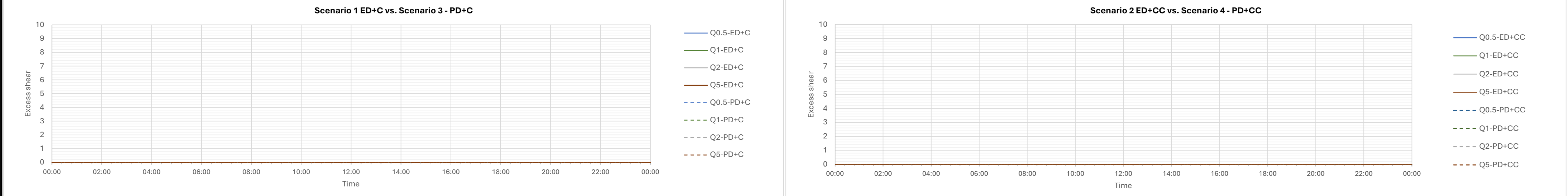
Scenario 2 ED+CC								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 3 PD+C								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 4 PD+CC								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	52.21	0.00	0.00	61.68	64.76
ESS event mean	0.00	0.00	0.00	1.58	0.00	0.00	1.87	1.96
ESS exceedance (min)								
<1 (min)	1440	1440	1440	760	1440	1440	650	530
>1 & <2 (min)	0	0	0	30	0	0	50	70
>2 & <10 (min)	0	0	0	650	0	0	740	840
>10 (min)	0	0	0	0	0	0	0	0
Scenario 6 PD+CC+M								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	53.31	0.00	0.00	62.15	65.45
ESS event mean	0.00	0.00	0.00	1.62	0.00	0.00	1.88	1.98
ESS exceedance (min)								
<1 (min)	1440	1440	1440	730	1440	1440	640	520
>1 & <2 (min)	0	0	0	60	0	0	60	70
>2 & <10 (min)	0	0	0	650	0	0	740	850
>10 (min)	0	0	0	0	0	0	0	0



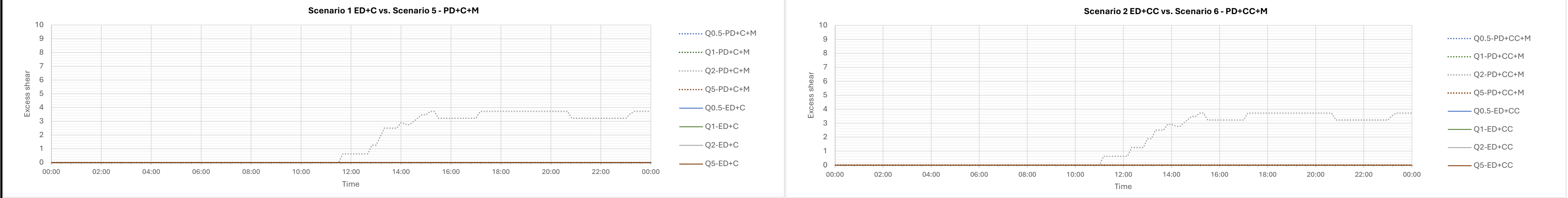
Results - Small event excess shear exceedance

These represent frequent events. Shear stress exceedances in these events indicate erosion is likely to occur often and in smaller flows.

Effect of development



Effect of post-development mitigation



Results - Excess shear comparisons

This analysis examines the percentage change in two erosion metrics between scenarios. Peak excess shear is the excess shear stress value during an event's peak flow, average excess shear takes the mean value throughout an event.

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100	Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).	Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Effect of development without climate change (Scenario 1 vs. Scenario 3)										
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	Marginal risk (<1% increase):	Marginal risk (<1% increase):
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	Moderate risk (1% - 5% increase):	Moderate risk (1% - 5% increase):
Effect of development with climate change (Scenario 2 vs. Scenario 4)										
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr	High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).	Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Effect of development without climate change with mitigation (Scenario 1 vs. Scenario 5)										
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	Marginal risk (<1% increase):	Marginal risk (<1% increase):
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	Moderate risk (1% - 5% increase):	Moderate risk (1% - 5% increase):
Effect of development with climate change with mitigation (Scenario 2 vs. Scenario 6)										
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr	High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).	Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

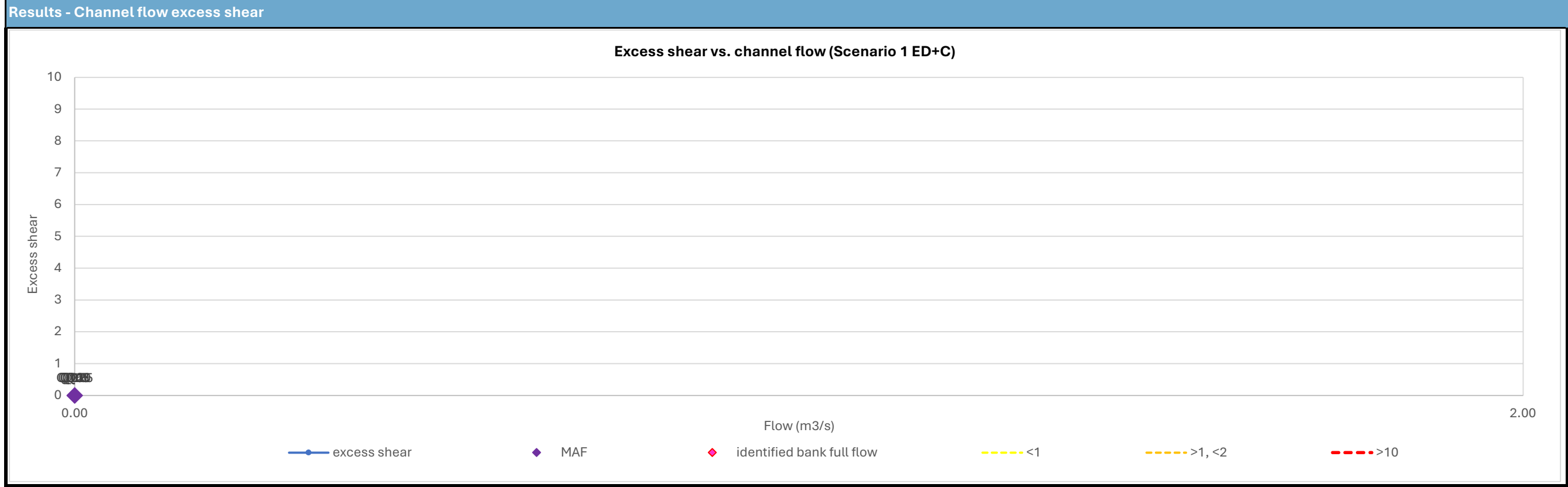
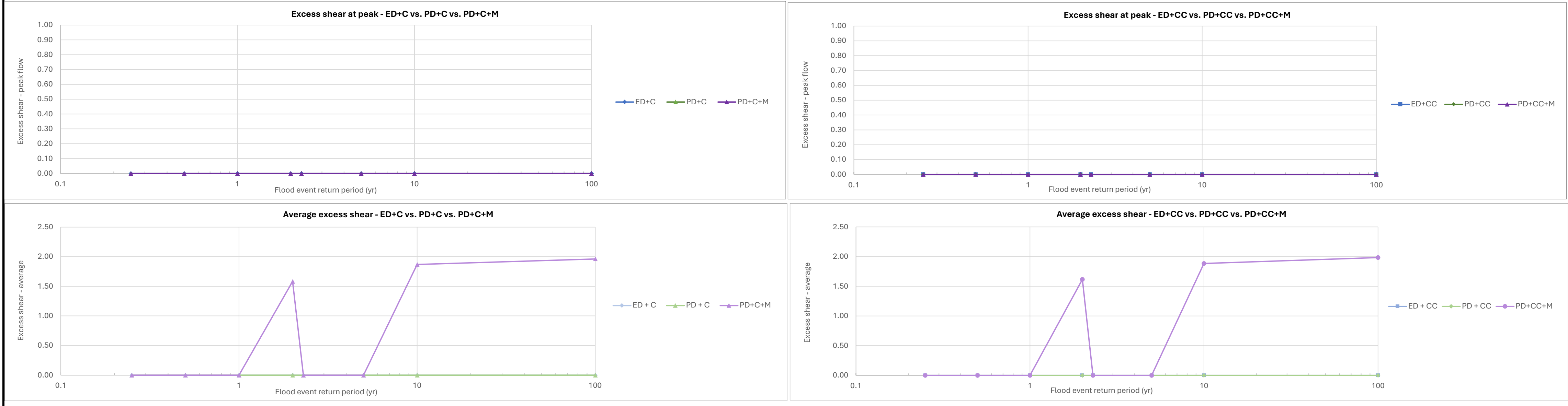
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr



Test project

Site

Site Photo

Site Map

Input summary

Catchment parameters

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	ED+C	ED+CC	PD+C	PD+CC	PD+C+M	PD+C+M
Total Area (km²)	A	0.00	0.00	0.00	0.00	0.00
Perviousness		0.0%	0.0%	0.0%	0.0%	0.0%
Pervious Area (km²)		0.00	0.00	0.00	0.00	0.00
Impervious Area (km²)		0.00	0.00	0.00	0.00	0.00
Channelisation Factor	C	0	0	0	0	0
Catchment Length (km)	L	0.00	0.00	0.00	0.00	0.00
Catchment Slope (m/m)	Sc	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00
Curve Numbers						
Soil Type	S	0	0	0	0	0
Pervious Areas	CN	0	0	0	0	0
Impervious Areas	CN	98	98	98	98	0
Weighted	CN	98.0	98.0	98.0	98.0	0
1P108						
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.0
Soil Storage (mm)	S	5	5	5	5	0
Time of Concentration (hr)	t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00
Time to Peak (hr)	t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00
P24 Rainfall Depth (mm)						
3 month ARI*		0	0	0	0	0
6 month ARI		0	0	0	0	0
1 year ARI		0	0	0	0	0
2 year ARI		0	0	0	0	0
2.3 year ARI		0	0	0	0	0
5 year ARI		0	0	0	0	0
10 year ARI		0	0	0	0	0
100 year ARI		0	0	0	0	0

Input hydrographs

Default - Q2.3

Mitigated development - Q2.3

Unmitigated development - Q10

Default - Q100

Unmitigated development - Q2.3

Default - Q10

Mitigated development - Q10

Unmitigated development - Q100

Default - Q2.3

Mitigated development - Q2.3

Unmitigated development - Q10

Default - Q100

Input channel geometry

Cross section profile

Elevation (m RL)

Chainage (m)

Catchment slope

Elevation (m RL)

Chainage (m)

Output shear stress exceedance

ARI (yr)

0.250.5122.3510100

0.250.5122.3510100

Scenario 1 ED+C

Scenario 3 PD+C

Scenario 2 ED+CC

Scenario 4 PD+CC

Scenario 5 PD+C+M

Scenario 6 PD+CC+M

BSS at peak (N/m²)

ESS at peak

ESS exceedance (min)

<1 (min)

>1 & <2 (min)

>2 & <10 (min)

>10 (min)

BSS at peak (N/m²)

ESS at peak

ESS exceedance (min)

<1 (min)

>1 & <2 (min)

>2 & <10 (min)

>10 (min)

BSS at peak (N/m²)

ESS at peak

ESS exceedance (min)

<1 (min)

>1 & <2 (min)

>2 & <10 (min)

>10 (min)

Scenario 1 ED+C vs. Scenario 3 - PD+C

Excess shear

Time

Scenario 1 ED+C vs. Scenario 5 - PD+C+M

Excess shear

Time

Threshold

Excess Shear

Indication

Green

<1.0

No erosion predicted to occur

Yellow

>1.0 <2.0

Potential for some erosion of the channel

Orange

>2.0 <10.0

Potential for channel to be mobile, (likely active erosion)

Red

>10.0

Potential rapid rates of erosion and incision of channel

Development effects summary

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

#N/A

Cross-section 1 – 3.8°C climate change

Erosion screening tool outputs

Test project

Input summary							
Catchment parameters							
		0	0	0	0	0	0
		0	0	0	0	0	0
Total Area (km²)	A	0.00	0.00	0.00	0.00		
Perviousness		0.00	0.00	0.00	0.00		
Pervious Area (km²)		0.00	0.00	0.00	0.00		
Impervious Area (km²)		0.00	0.00	0.00	0.00		
Channelisation Factor	C	0	0	0	0		
Catchment Length (km)	L	1.79	1.79	0.00	0.00		
Catchment Slope (m/m)	Sc	0.031	0.031	#DIV/0!	#DIV/0!		
Curve Numbers							
Soil Type	S	0	0	0	0		
Pervious Areas	CN	0	0	0	0		
Impervious Areas	CN	98	98	98	98		
Weighted	CN	98.0	98.0	98.0	98.0		
TP108							
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Soil Storage (mm)	S	5	5	5	5		
Time of Concentration (hr)	t _c	0.17	0.17	#DIV/0!	#DIV/0!		
Time to Peak (hr)	t _p	0.11	0.11	#DIV/0!	#DIV/0!		
P24 Rainfall Depth (mm)							
3 month ARI*		0	0	0	0	0	0
6 month ARI		0	0	0	0	0	0
1 year ARI		0	0	0	0	0	0
2 year ARI		0	0	0	0	0	0
2.3 year ARI		0	0	0	0	0	0
5 year ARI		0	0	0	0	0	0
10 year ARI		0	0	0	0	0	0
100 year ARI		0	0	0	0	0	0

* 3 month ARI estimated rainfall does not fits well in regression calculation, not recommend to use.

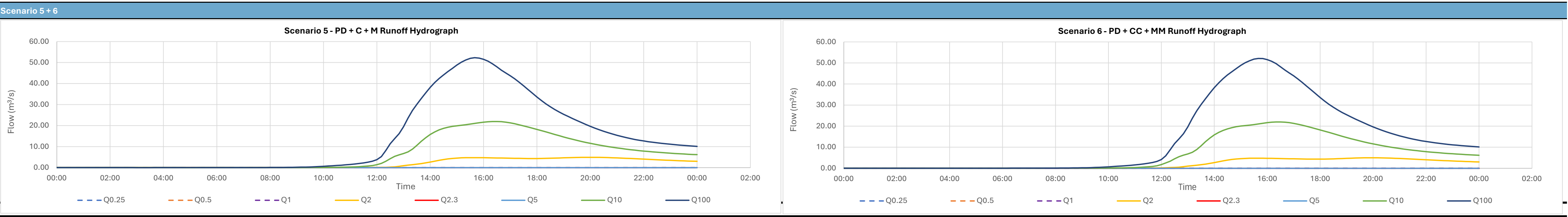
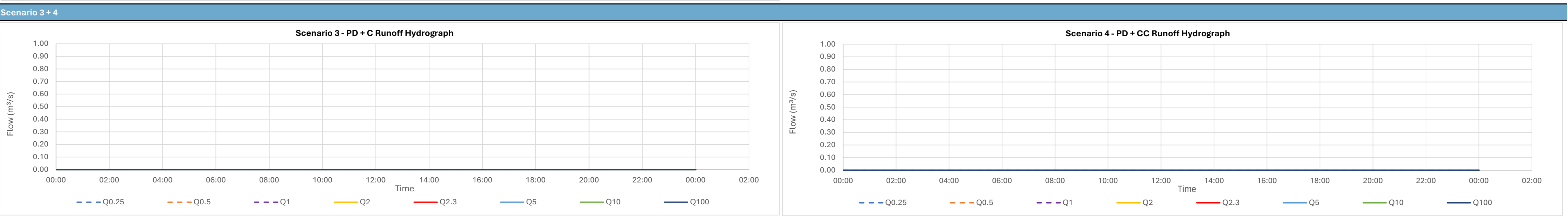
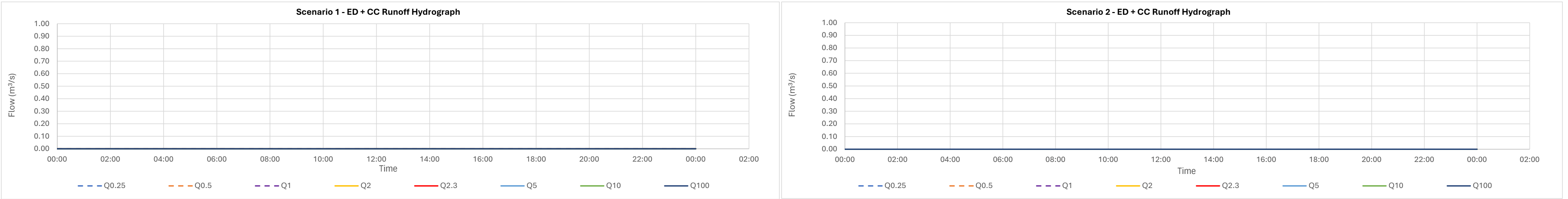
Results - TP108 Peak Flow Analysis								
ARI (yr)	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 2 ED+CC								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 3 PD+C								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 4 PD+CC								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 5 PD+C+M								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 6 PD+CC+M								
Peak flow rate, q _p (m³/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff

#N/A

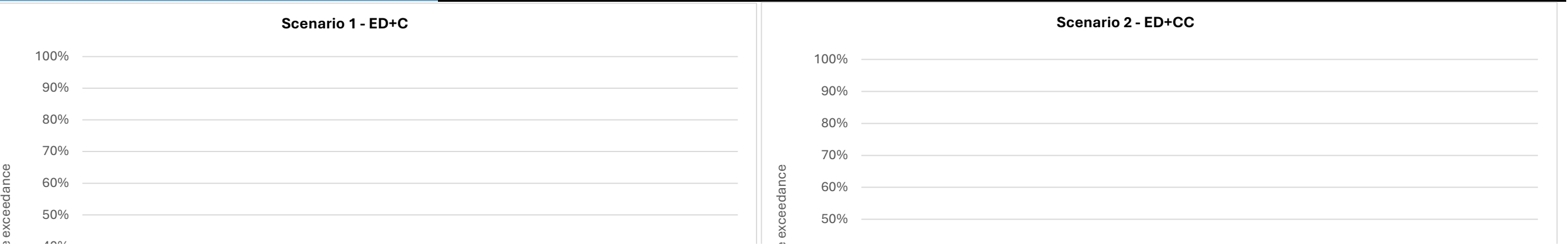
Results - Bank Full Channel Identification	
Approximate channel width (m)	11.91
Bank full water depth (m)	#N/A
Bank full flow (m³/s)	#N/A
Bank full flow excess shear	#N/A
Annual fullest flow as represented by the mean annual flood (m³/s)	0.00
Annual fullest flow as represented by the mean annual flood excess shear	0.0

Results - 24hr Runoff Hydrographs

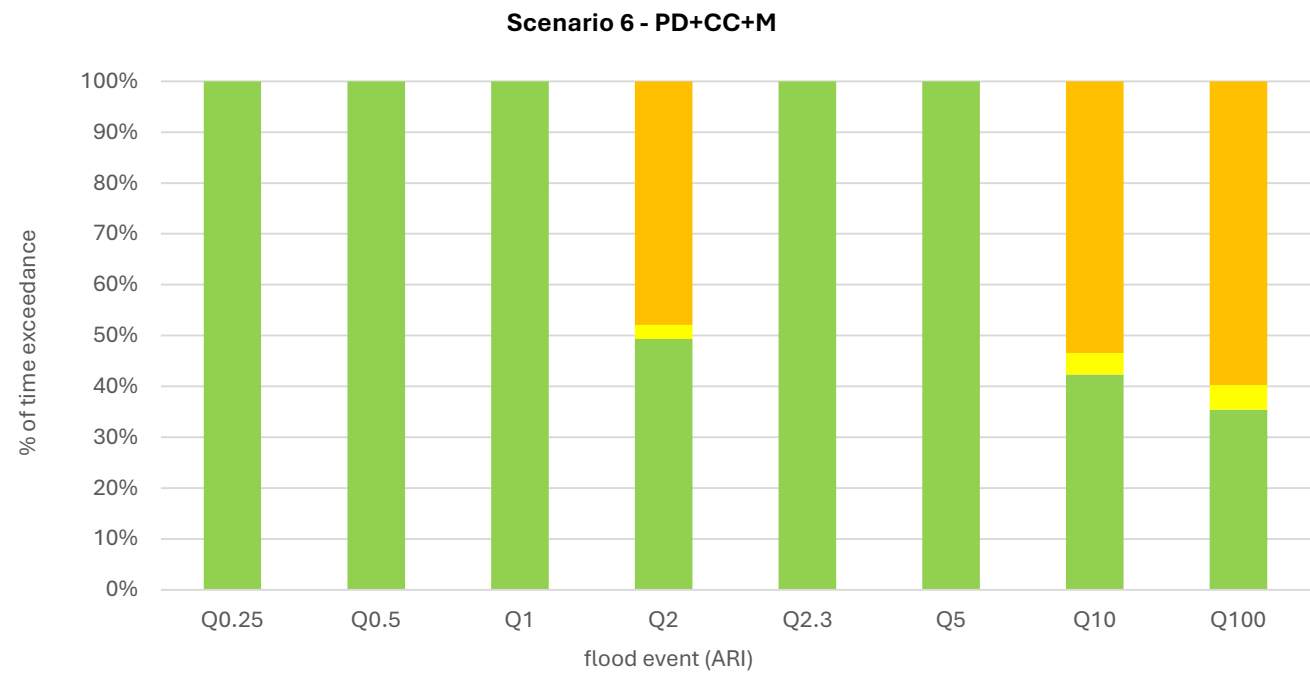
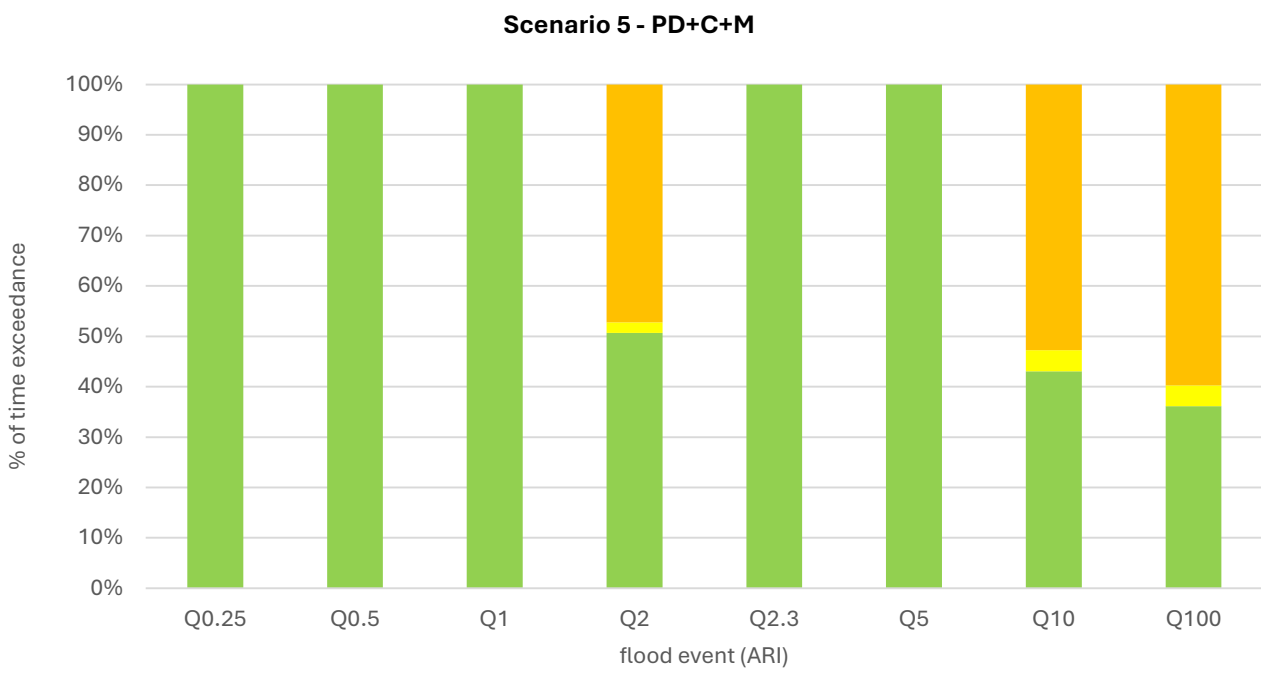
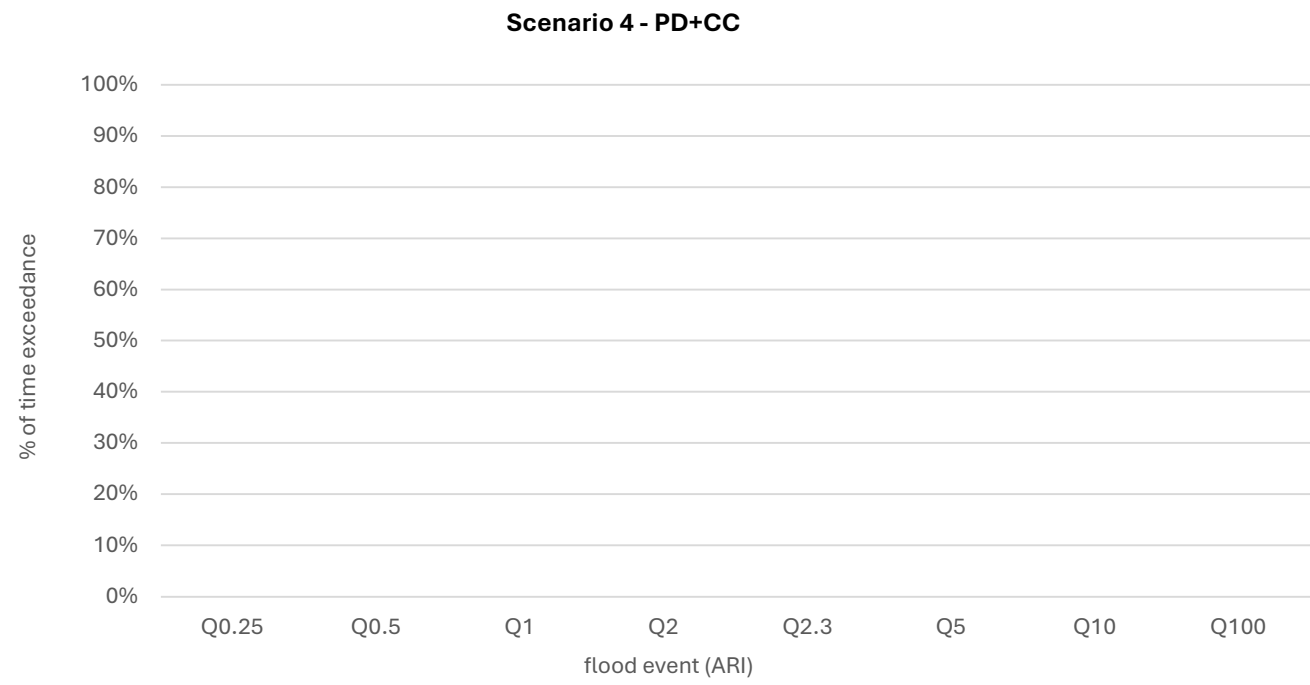
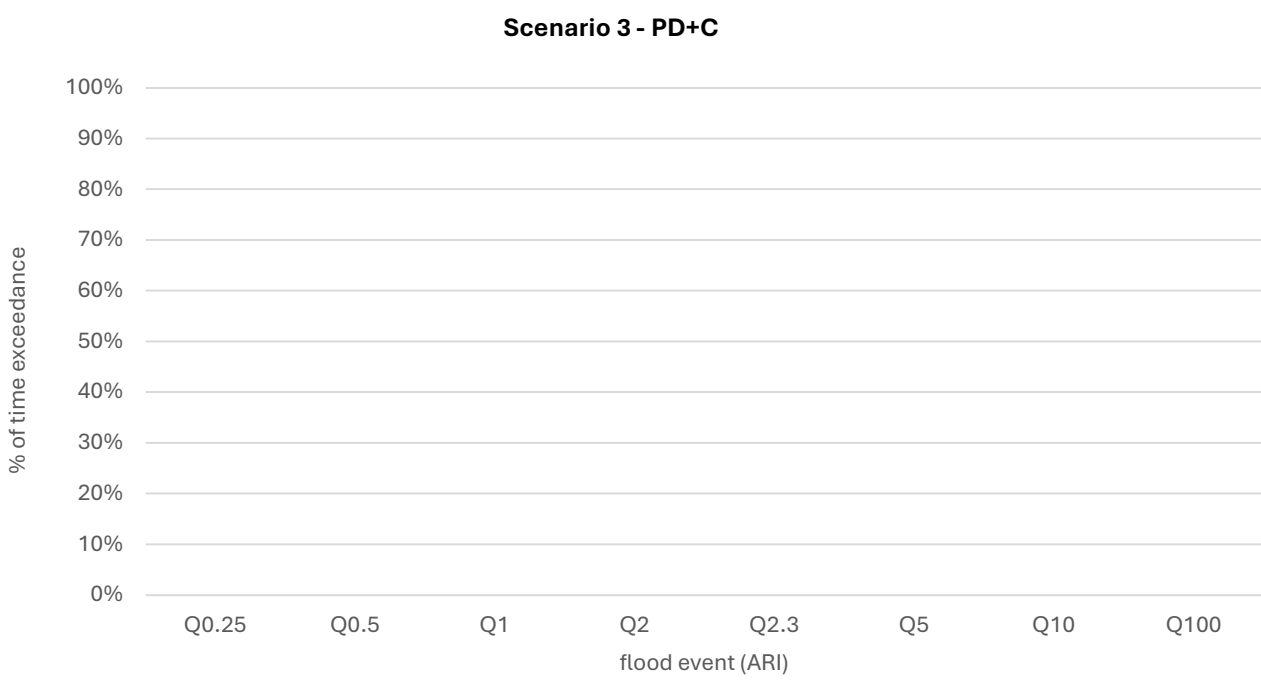
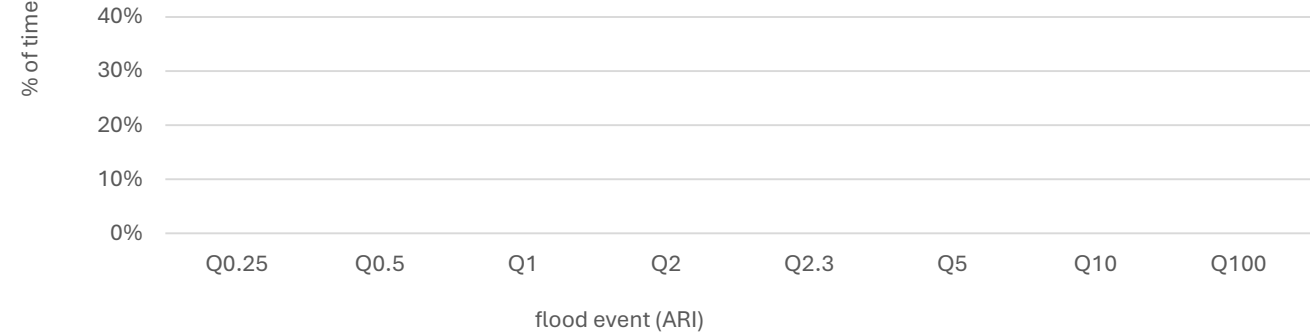
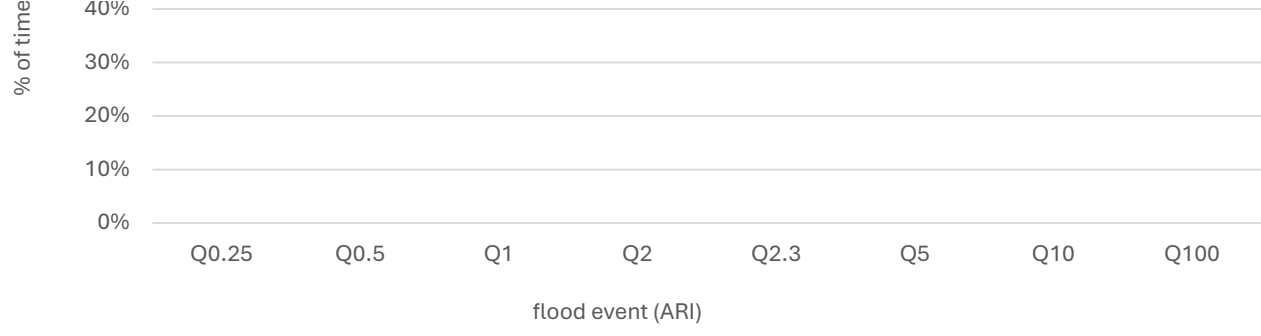
Scenario 1 + 2



Results - Excess shear exceedance								
Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel. Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Existing development erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its existing development state.								
Boundary shear stress (BSS) - the force exerted on the channel by flow								
Excess shear stress (ESS) - the amount of BSS in excess of the critical shear stress threshold for initiating sediment movement								
ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Scenario 1 ED+C								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0



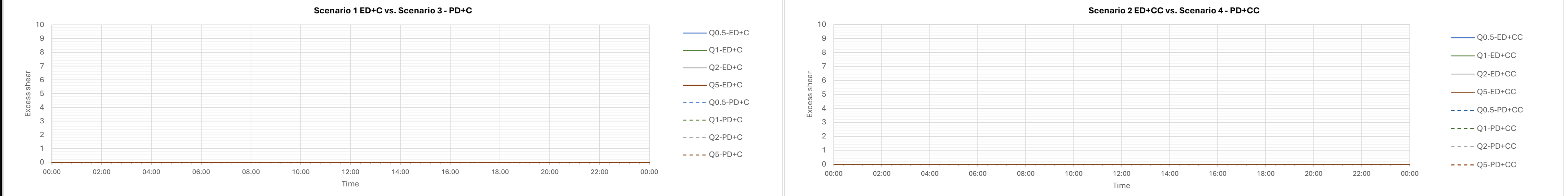
Scenario 2 ED+CC								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 3 PD+C								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 4 PD+CC								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	61.00	0.00	0.00	62.55	65.91
ESS event mean	0.00	0.00	0.00	1.85	0.00	0.00	1.90	2.00
ESS exceedance (min)								
<1 (min)	1440	1440	1440	730	1440	1440	620	520
>1 & <2 (min)	0	0	0	30	0	0	60	60
>2 & <10 (min)	0	0	0	680	0	0	760	860
>10 (min)	0	0	0	0	0	0	0	0
Scenario 6 PD+CC+M								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	62.38	0.00	0.00	63.80	66.64
ESS event mean	0.00	0.00	0.00	1.89	0.00	0.00	1.93	2.02
ESS exceedance (min)								
<1 (min)	1440	1440	1440	710	1440	1440	610	510
>1 & <2 (min)	0	0	0	40	0	0	60	70
>2 & <10 (min)	0	0	0	690	0	0	770	860
>10 (min)	0	0	0	0	0	0	0	0



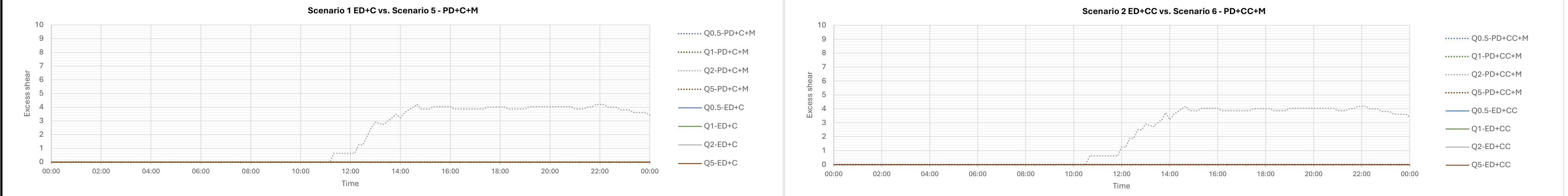
Results - Small event excess shear exceedance

These represent frequent events. Shear stress exceedances in these events indicate erosion is likely to occur often and in smaller flows.

Effect of development



Effect of post-development mitigation



Results - Excess shear comparisons

This analysis examines the percentage change in two erosion metrics between scenarios. Peak excess shear is the excess shear stress value during an event's peak flow, average excess shear takes the mean value throughout an event.

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100	Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).	Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Effect of development without climate change (Scenario 1 vs. Scenario 3)									Marginal risk (<1% increase):	Marginal risk (<1% increase):
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance		
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance		
Effect of development with climate change (Scenario 2 vs. Scenario 4)									Moderate risk (1% - 5% increase):	Moderate risk (1% - 5% increase):
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr	High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).	Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Effect of development without climate change with mitigation (Scenario 1 vs. Scenario 5)									Marginal risk (<1% increase):	Marginal risk (<1% increase):
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance		
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance		
Effect of development with climate change with mitigation (Scenario 2 vs. Scenario 6)									Moderate risk (1% - 5% increase):	Moderate risk (1% - 5% increase):
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr	High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	Without considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).	Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

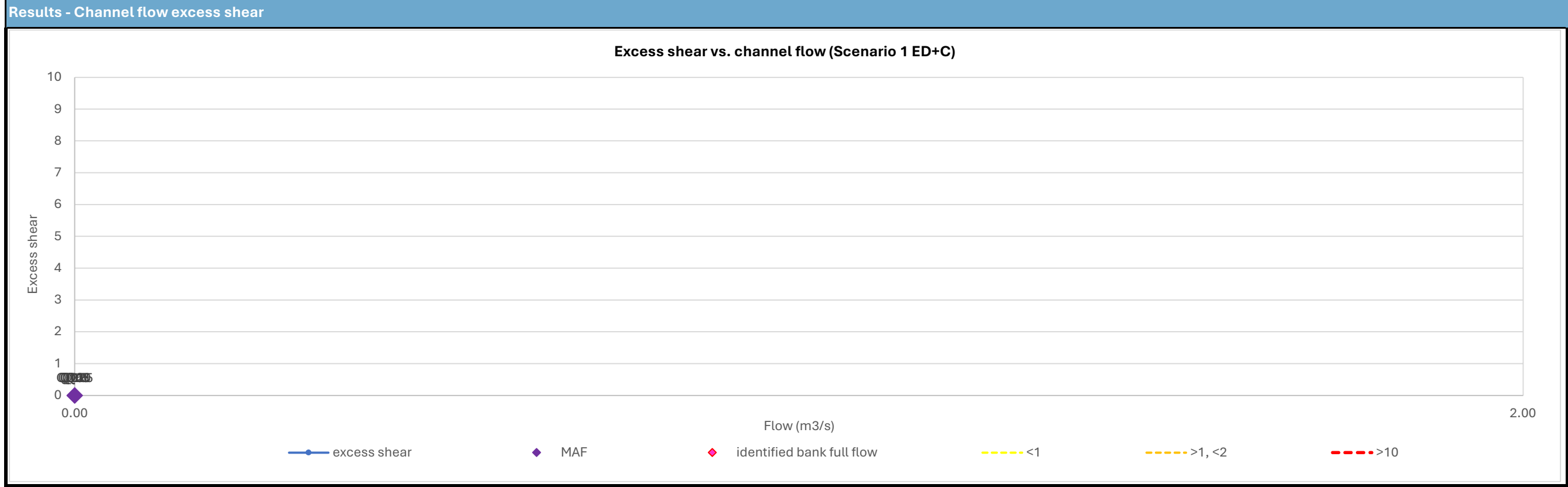
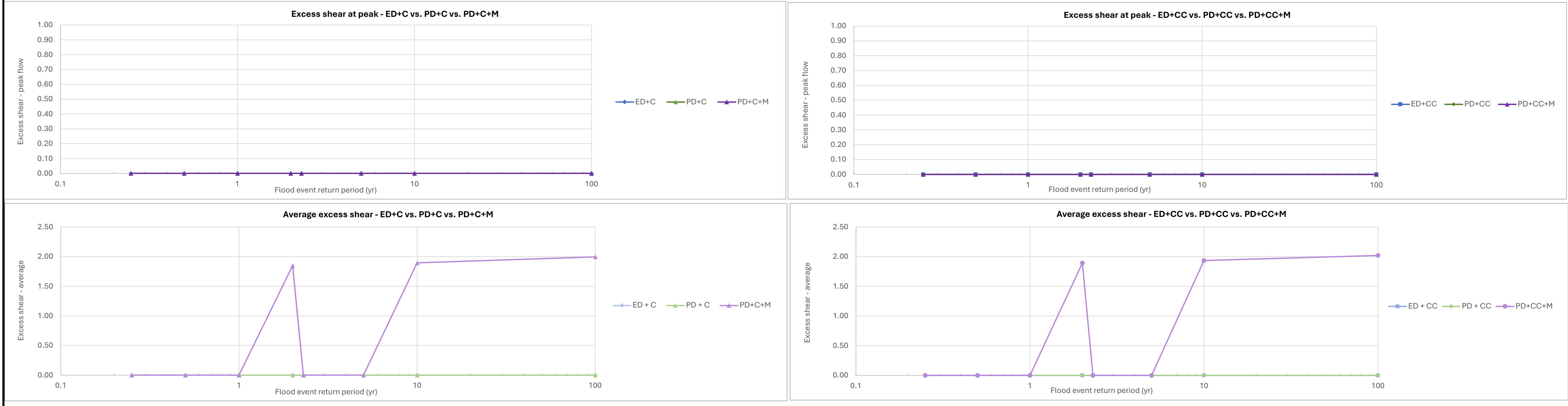
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr



Test project

Erosion Screening Tool Result Summary

Site

Erosion Screening Tool Result Summary

Site Photo

Site Map

Input channel geometry

Cross section profile

</

Cross-section 2 – No climate change

Erosion screening tool outputs

Test project

Input summary							
Catchment parameters							
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
		ED+C	ED+CC	PD+C	PD+CC	PD+C+M	PD+CC+M
Total Area (km ²)	A	0.00	0.00	0.00	0.00		
Perviousness		0.00	0.00	0.00	0.00		
Pervious Area (km ²)		0.00	0.00	0.00	0.00		
Impervious Area (km ²)		0.00	0.00	0.00	0.00		
Channelisation Factor	C	0	0	0	0		
Catchment Length (km)	L	0.00	0.00	0.00	0.00		
Catchment Slope (m/m)	Sc	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Curve Numbers							
Soil Type	S	0	0	0	0		
Pervious Areas	CN	0	0	0	0		
Impervious Areas	CN	98	98	98	98		
Weighted	CN	98.0	98.0	98.0	98.0		
TP108							
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Soil Storage (mm)	S	5	5	5	5		
Time of Concentration (hr)	t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Time to Peak (hr)	t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
P24 Rainfall Depth (mm)							
3 month ARI*		0	0	0	0	0	0
6 month ARI		0	0	0	0	0	0
1 year ARI		0	0	0	0	0	0
2 year ARI		0	0	0	0	0	0
2.3 year ARI		0	0	0	0	0	0
5 year ARI		0	0	0	0	0	0
10 year ARI		0	0	0	0	0	0
100 year ARI		0	0	0	0	0	0

* 3 month ARI estimated rainfall does not fits well in regression calculation, not recommend to use.

Results - TP108 Peak Flow Analysis								
ARI (yr)	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 2 ED+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 3 PD+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 4 PD+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 5 PD+C+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 6 PD+CC+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff

#N/A

Results - Bank Full Channel Identification	
Approximate channel width (m)	11.91
Bank full water depth (m)	#N/A
Bank full flow (m ³ /s)	#N/A
Bank full flow excess shear	#N/A
Annual fullest flow as represented by the mean annual flood (m ³ /s)	0.00
Annual fullest flow as represented by the mean annual flood excess shear	0.0

Results - 24hr Runoff Hydrographs



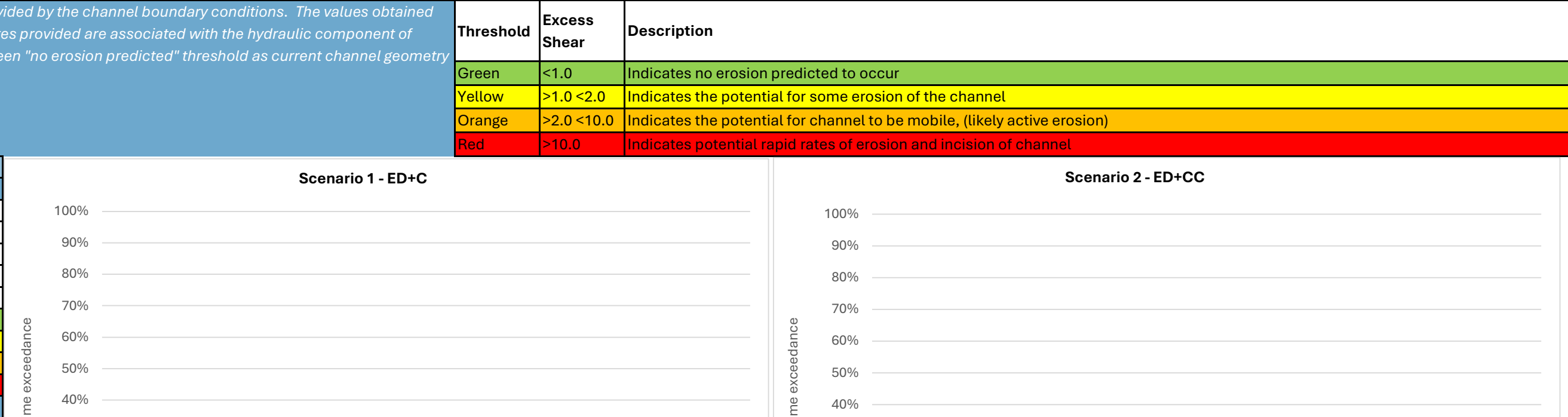
Results - Excess shear exceedance

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel. Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Existing development erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its existing development state.

Boundary shear stress (BSS) - the force exerted on the channel by flow

Excess shear stress (ESS) - the amount of BSS in excess of the critical shear stress threshold for initiating sediment movement

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Scenario 1 ED+C								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 2 ED+CC								

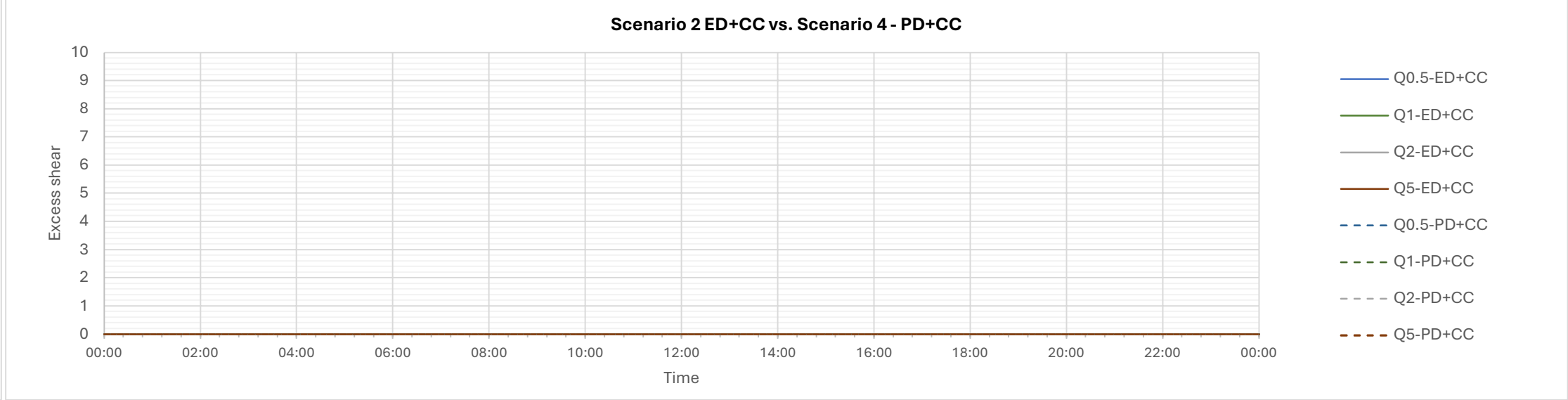
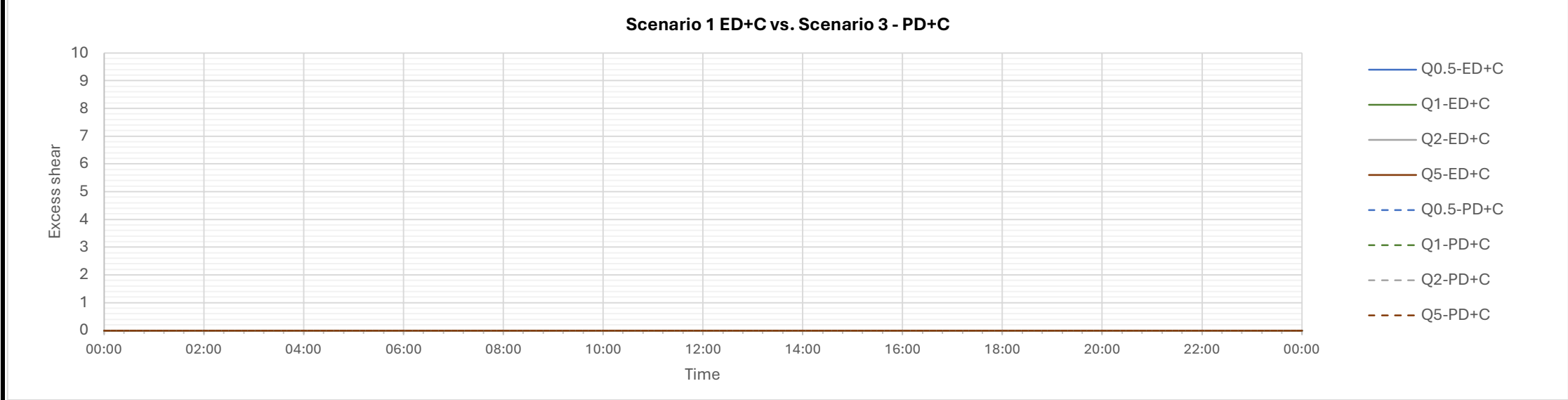


BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 3 PD+C								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 4 PD+CC								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	14.21	0.00	0.00	21.66	23.71
ESS event mean	0.00	0.00	0.00	0.43	0.00	0.00	0.66	0.72
ESS exceedance (min)								
<1 (min)	1440	1440	1440	1440	1440	1440	800	710
>1 & <2 (min)	0	0	0	0	0	0	640	730
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 6 PD+CC+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	14.53	0.00	0.00	21.95	24.02
ESS event mean	0.00	0.00	0.00	0.44	0.00	0.00	0.67	0.73
ESS exceedance (min)								
<1 (min)	1440	1440	1440	1440	1440	1440	790	720
>1 & <2 (min)	0	0	0	0	0	0	650	720
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0

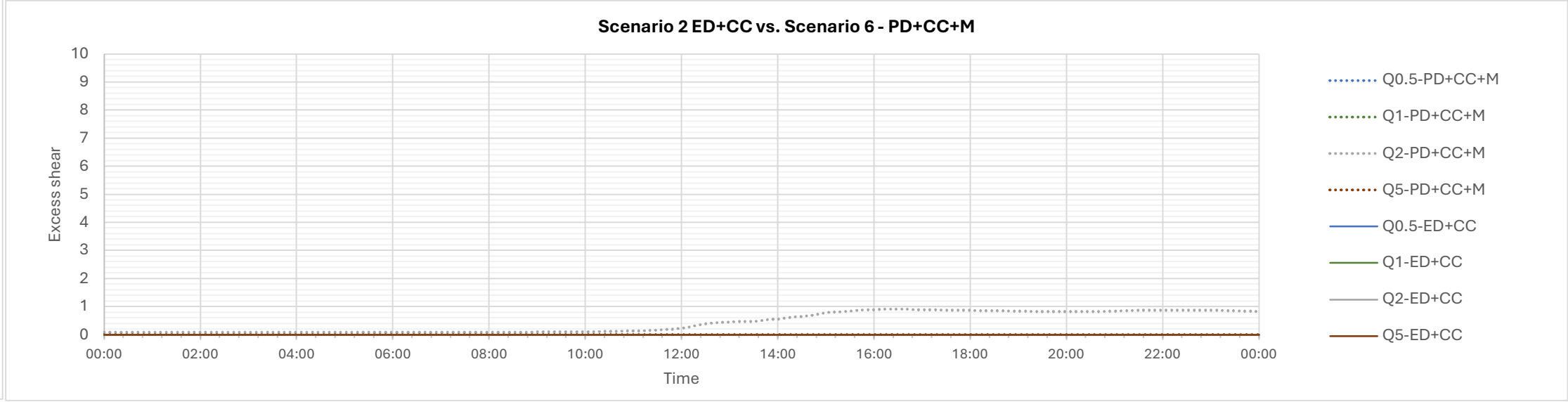
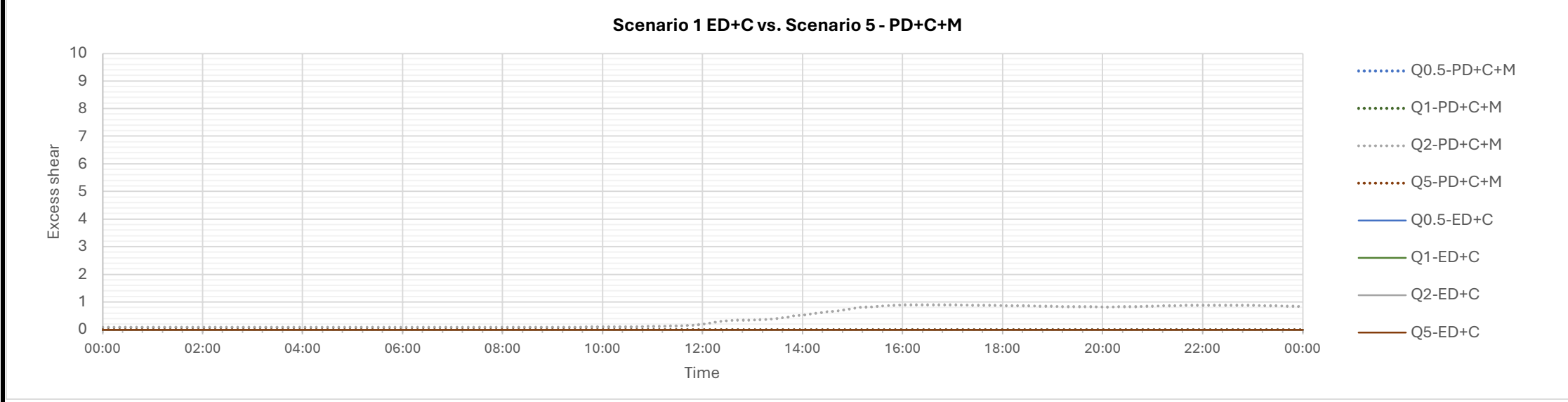
Results - Small event excess shear exceedance

These represent frequent events. Shear stress exceedances in these events indicate erosion is likely to occur often and in smaller flows.

Effect of development



Effect of post-development mitigation



Results - Excess shear comparisons

This analysis examines the percentage change in two erosion metrics between scenarios. Peak excess shear is the excess shear stress value during an event's peak flow, average excess shear takes the mean value throughout an event.

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Effect of development without climate change (Scenario 1 vs. Scenario 3)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change (Scenario 2 vs. Scenario 4)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development without climate change with mitigation (Scenario 1 vs. Scenario 5)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change with mitigation (Scenario 2 vs. Scenario 6)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

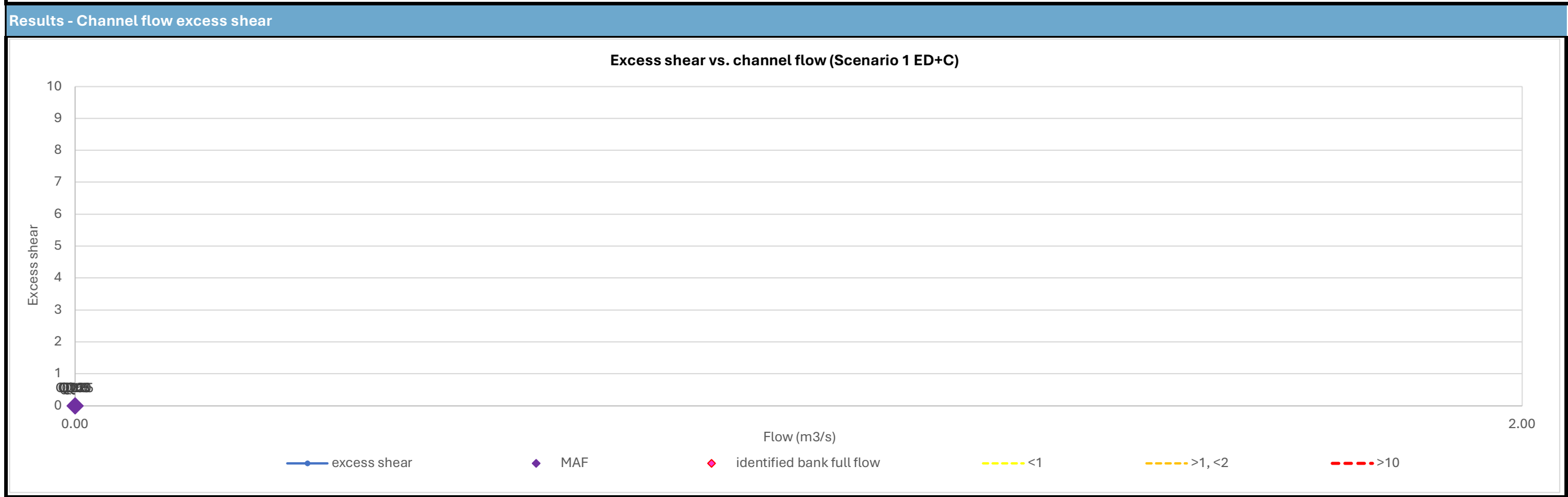
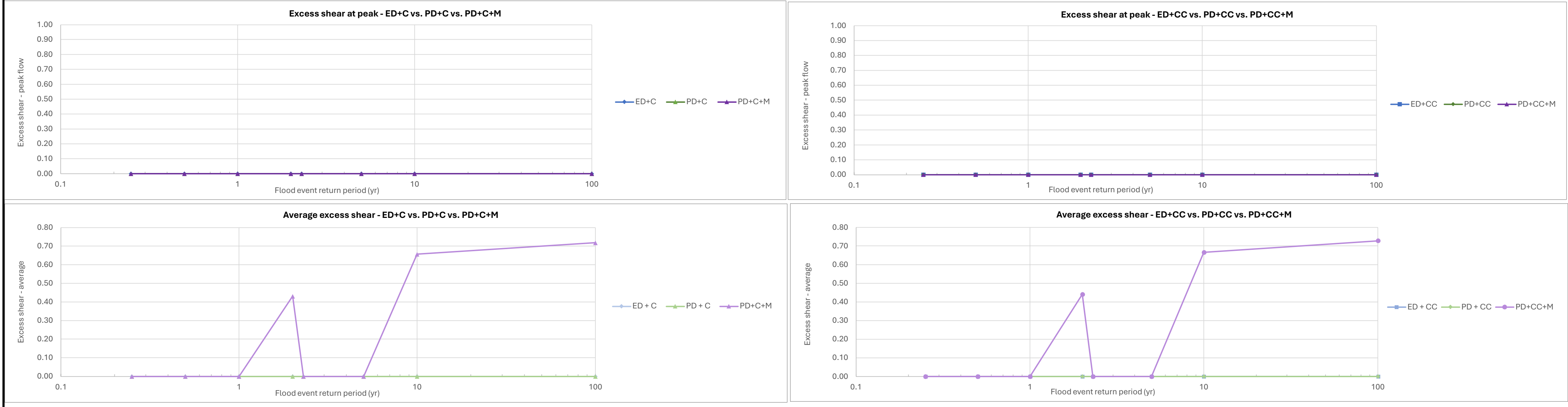
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr



[illegible]

Cross-section 2 – 3.8°C climate change

Erosion screening tool outputs

Test project

Input summary							
Catchment parameters							
		0	0	0	0	0	0
		0	0	0	0	0	0
Total Area (km ²)	A	0.00	0.00	0.00	0.00		
Perviousness		0.00	0.00	0.00	0.00		
Pervious Area (km ²)		0.00	0.00	0.00	0.00		
Impervious Area (km ²)		0.00	0.00	0.00	0.00		
Channelisation Factor	C	0	0	0	0		
Catchment Length (km)	L	0.00	0.00	0.00	0.00		
Catchment Slope (m/m)	Sc	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Curve Numbers							
Soil Type	S	0	0	0	0		
Pervious Areas	CN	0	0	0	0		
Impervious Areas	CN	98	98	98	98		
Weighted	CN	98.0	98.0	98.0	98.0		
TP108							
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Soil Storage (mm)	S	5	5	5	5		
Time of Concentration (hr)	t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Time to Peak (hr)	t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
P24 Rainfall Depth (mm)							
3 month ARI*		0	0	0	0	0	0
6 month ARI		0	0	0	0	0	0
1 year ARI		0	0	0	0	0	0
2 year ARI		0	0	0	0	0	0
2.3 year ARI		0	0	0	0	0	0
5 year ARI		0	0	0	0	0	0
10 year ARI		0	0	0	0	0	0
100 year ARI		0	0	0	0	0	0

* 3 month ARI estimated rainfall does not fits well in regression calculation, not recommend to use.

Results - TP108 Peak Flow Analysis								
ARI (yr)	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 2 ED+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 3 PD+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 4 PD+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 5 PD+C+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 6 PD+CC+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff

#N/A

Results - Bank Full Channel Identification	
Approximate channel width (m)	11.91
Bank full water depth (m)	#N/A
Bank full flow (m ³ /s)	#N/A
Bank full flow excess shear	#N/A
Annual fullest flow as represented by the mean annual flood (m ³ /s)	0.00
Annual fullest flow as represented by the mean annual flood excess shear	0.0

Results - 24hr Runoff Hydrographs



Scenario 3 + 4

Scenario 3 - PD + C Runoff Hydrograph

Scenario 4 - PD + CC Runoff Hydrograph

Scenario 5 + 6

Scenario 5 - PD + C + M Runoff Hydrograph

Scenario 6 - PD + CC + MM Runoff Hydrograph

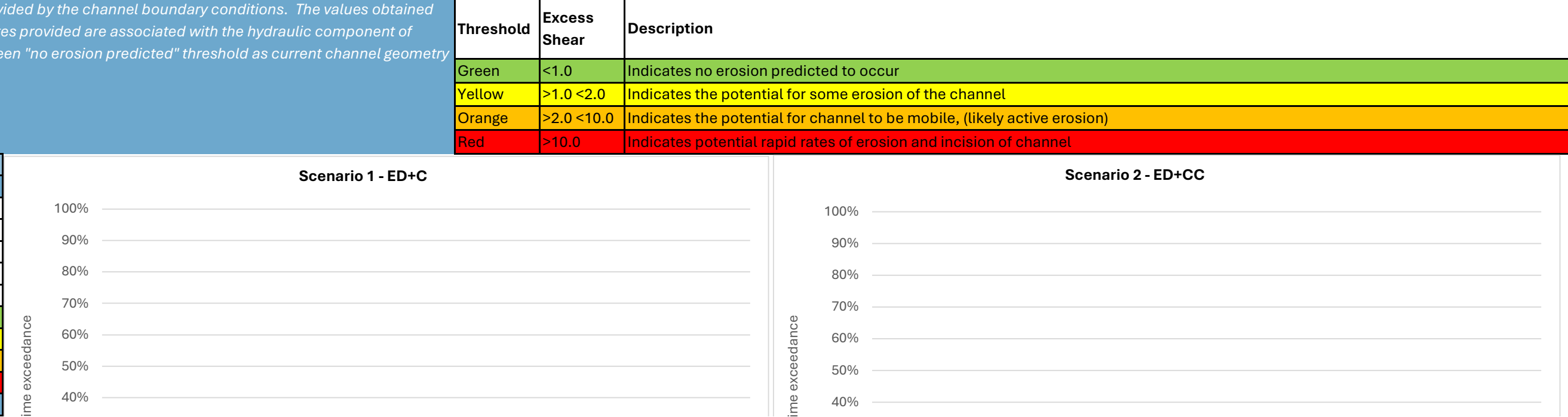
Results - Excess shear exceedance

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel. Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Existing development erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its existing development state.

Boundary shear stress (BSS) - the force exerted on the channel by flow

Excess shear stress (ESS) - the amount of BSS in excess of the critical shear stress threshold for initiating sediment movement

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Scenario 1 ED+C								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 2 ED+CC								

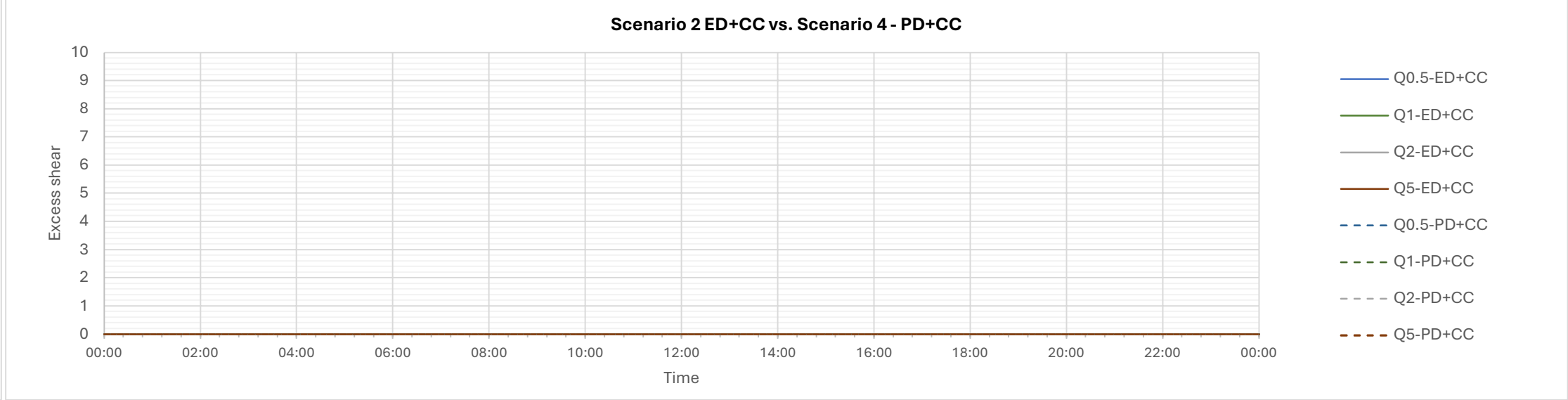
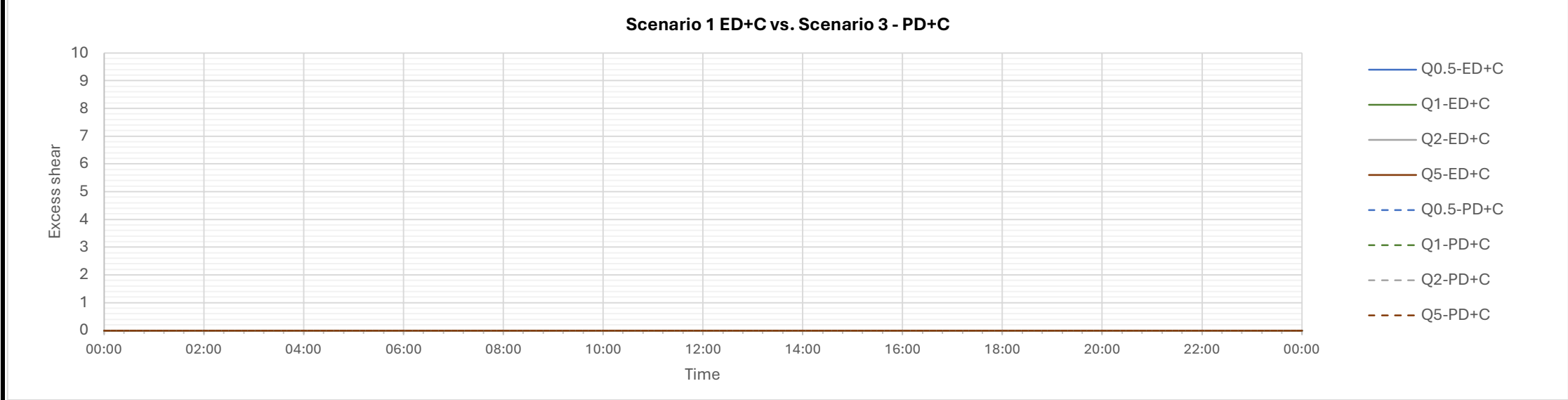


BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 3 PD+C								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 4 PD+CC								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	17.15	0.00	0.00	22.32	23.76
ESS event mean	0.00	0.00	0.00	0.52	0.00	0.00	0.68	0.72
ESS exceedance (min)								
<1 (min)	1440	1440	1440	1020	1440	1440	740	720
>1 & <2 (min)	0	0	0	420	0	0	700	720
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 6 PD+CC+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	17.41	0.00	0.00	22.57	24.06
ESS event mean	0.00	0.00	0.00	0.53	0.00	0.00	0.68	0.73
ESS exceedance (min)								
<1 (min)	1440	1440	1440	1010	1440	1440	730	720
>1 & <2 (min)	0	0	0	430	0	0	710	720
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0

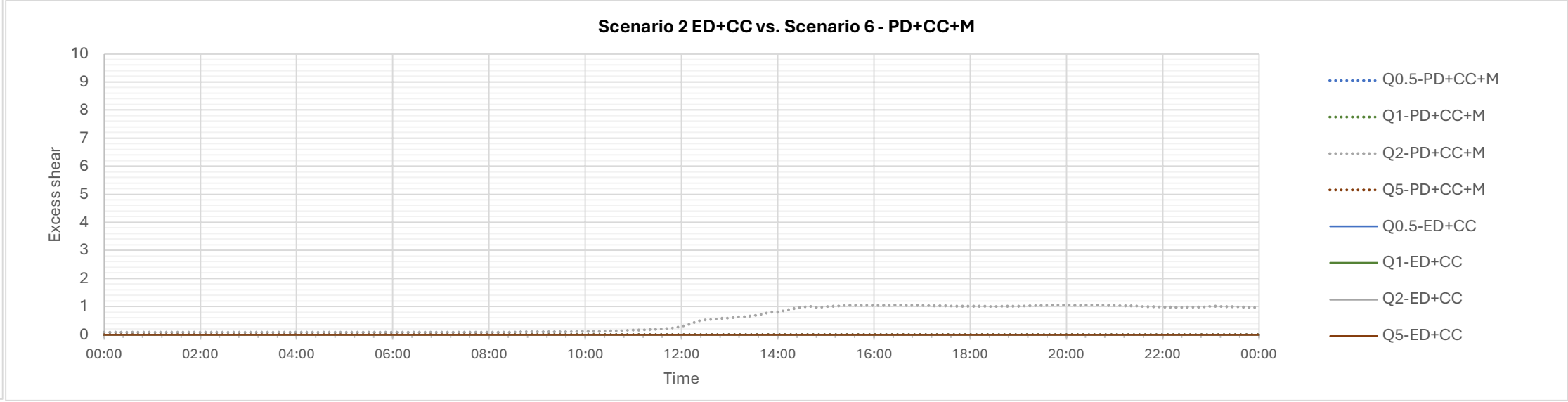
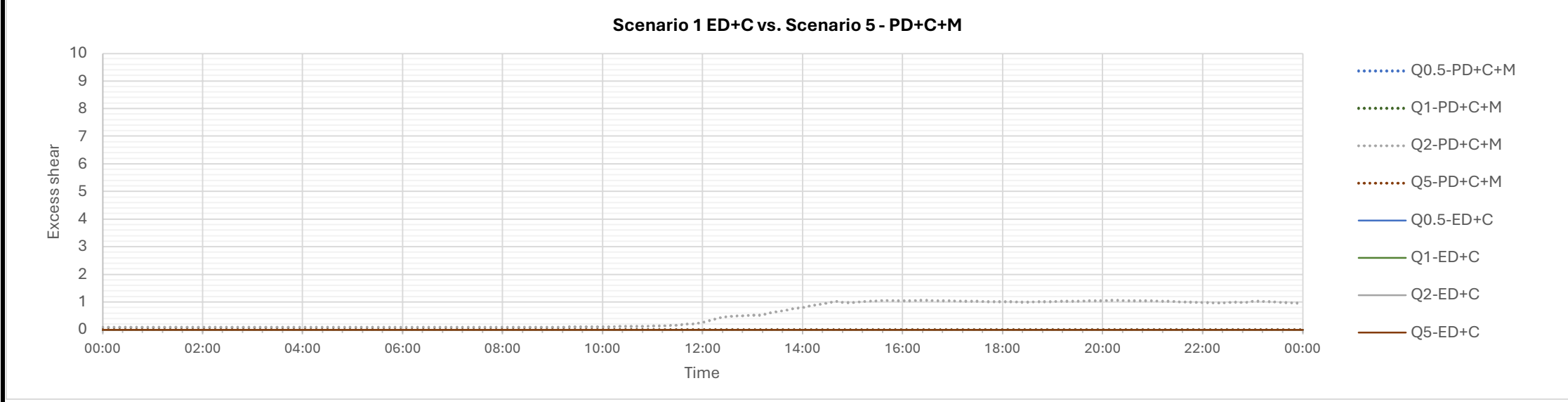
Results - Small event excess shear exceedance

These represent frequent events. Shear stress exceedances in these events indicate erosion is likely to occur often and in smaller flows.

Effect of development



Effect of post-development mitigation



Results - Excess shear comparisons

This analysis examines the percentage change in two erosion metrics between scenarios. Peak excess shear is the excess shear stress value during an event's peak flow, average excess shear takes the mean value throughout an event.

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Effect of development without climate change (Scenario 1 vs. Scenario 3)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change (Scenario 2 vs. Scenario 4)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development without climate change with mitigation (Scenario 1 vs. Scenario 5)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change with mitigation (Scenario 2 vs. Scenario 6)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

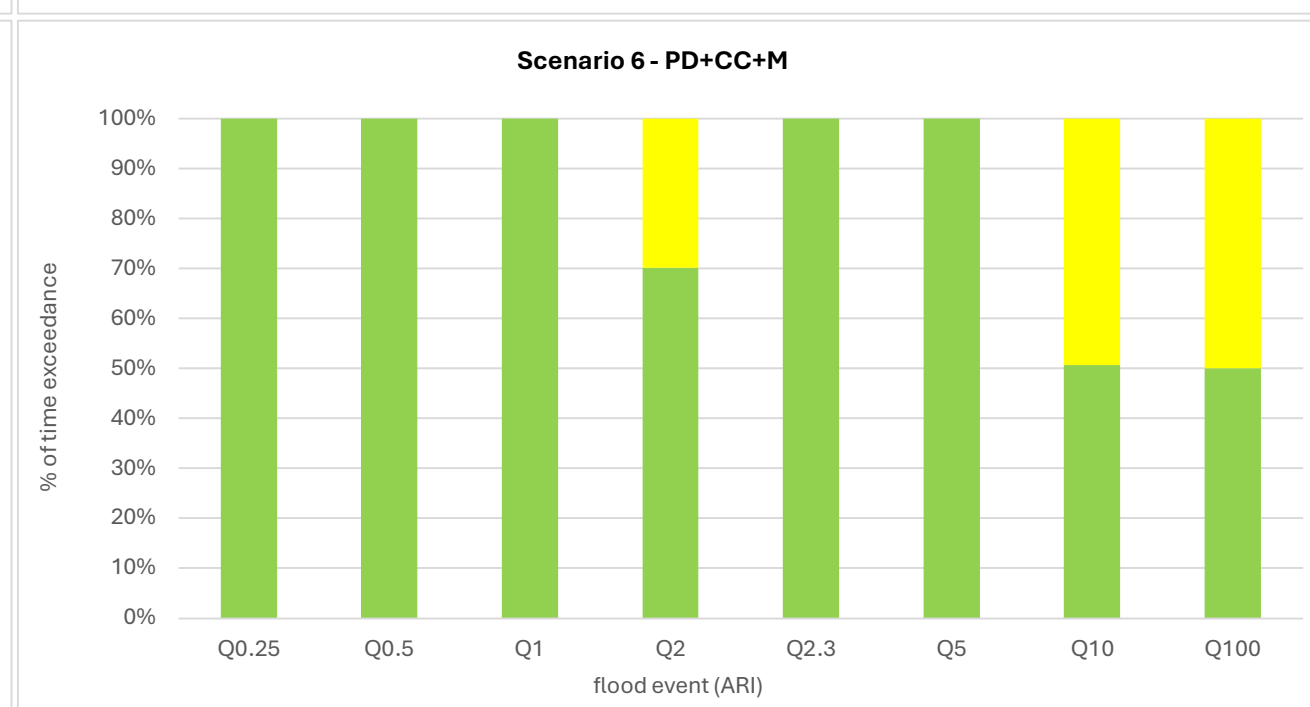
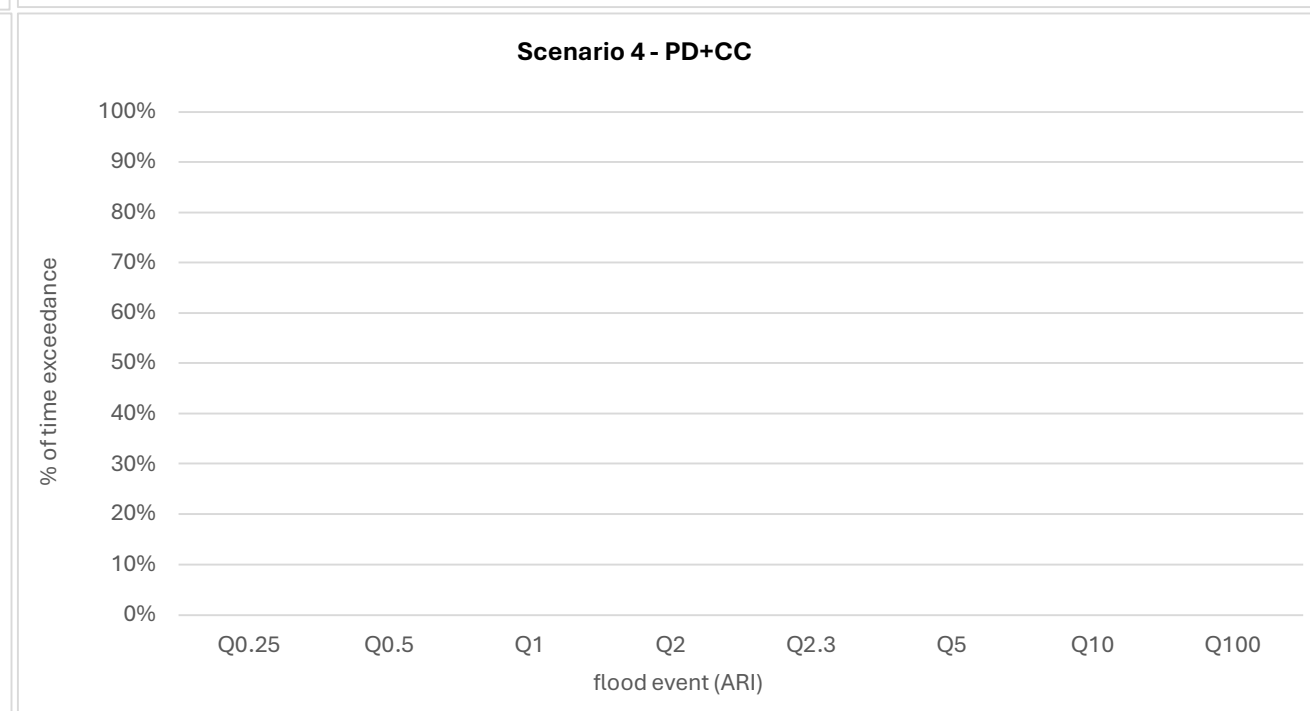
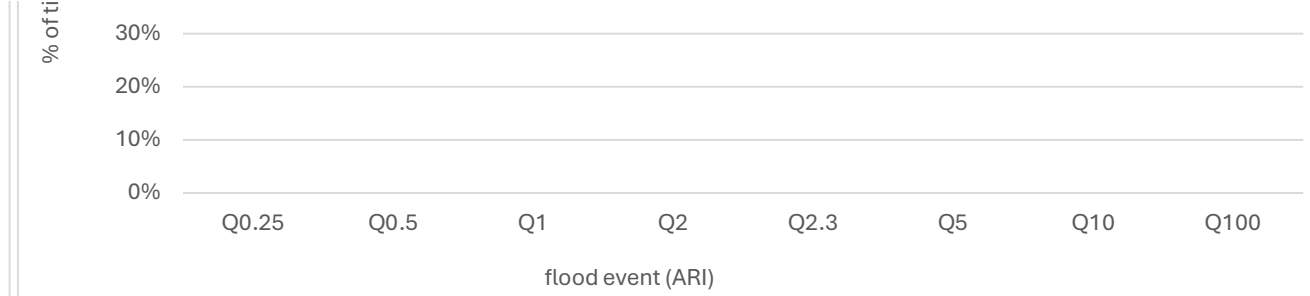
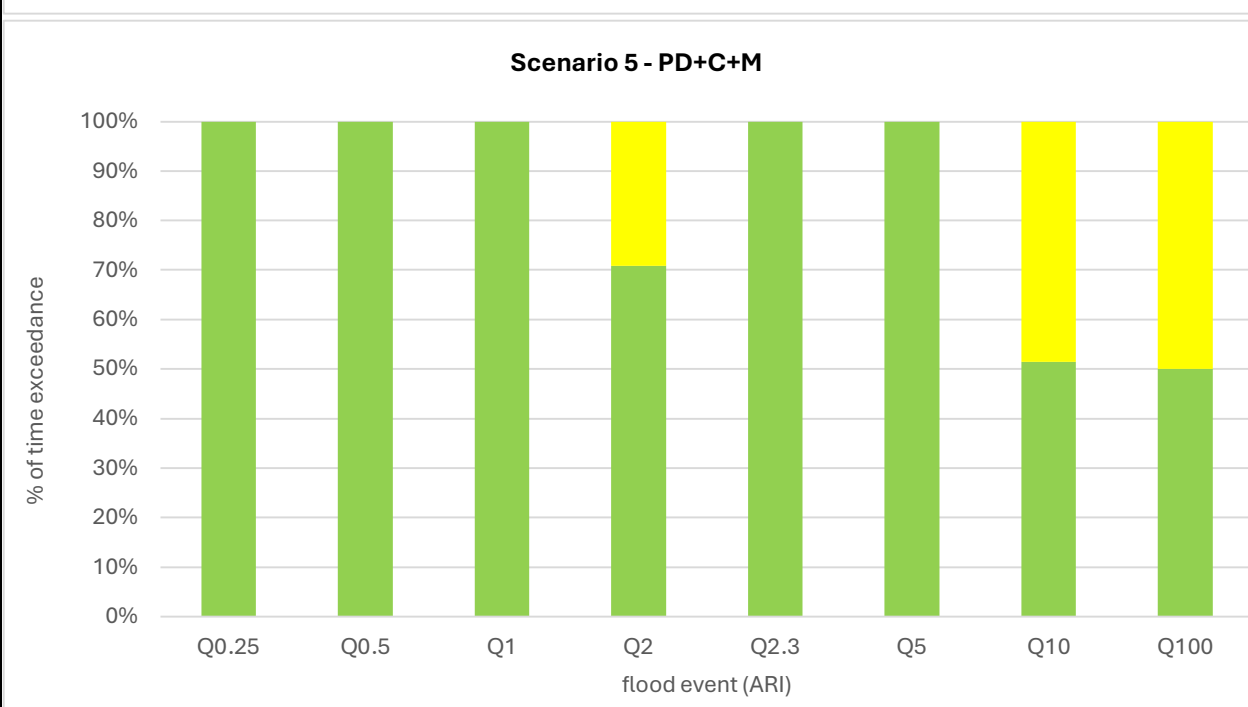
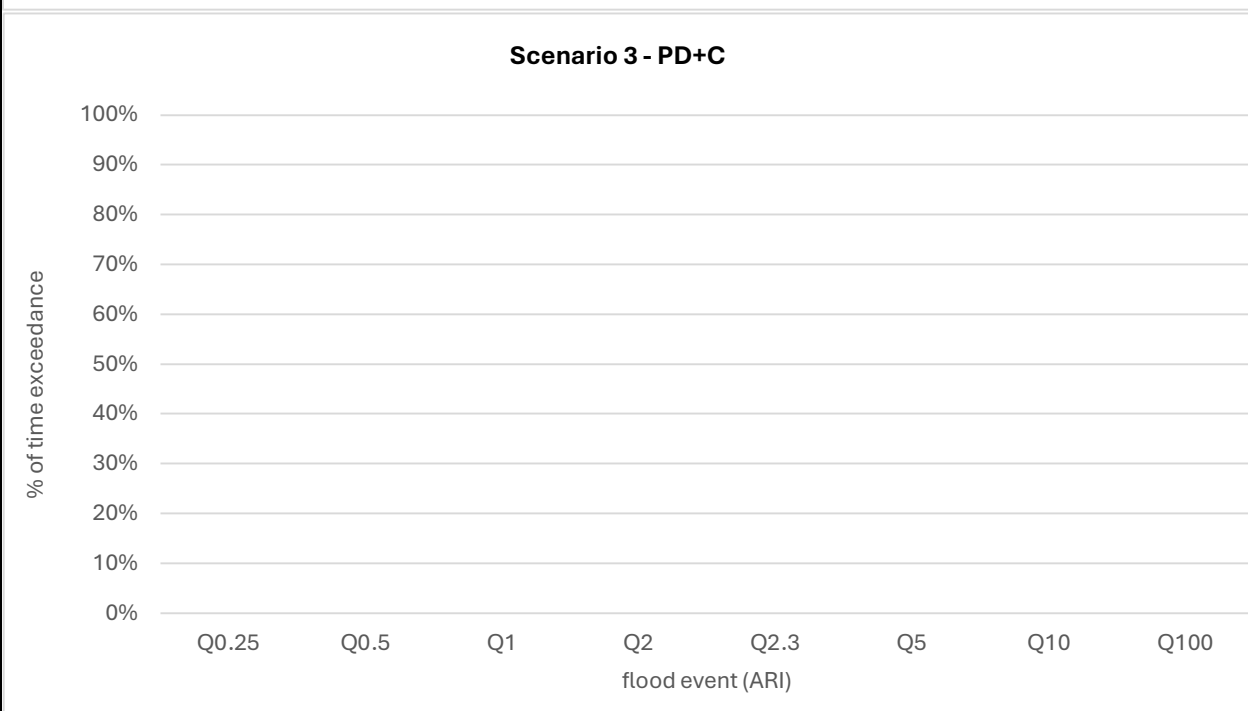
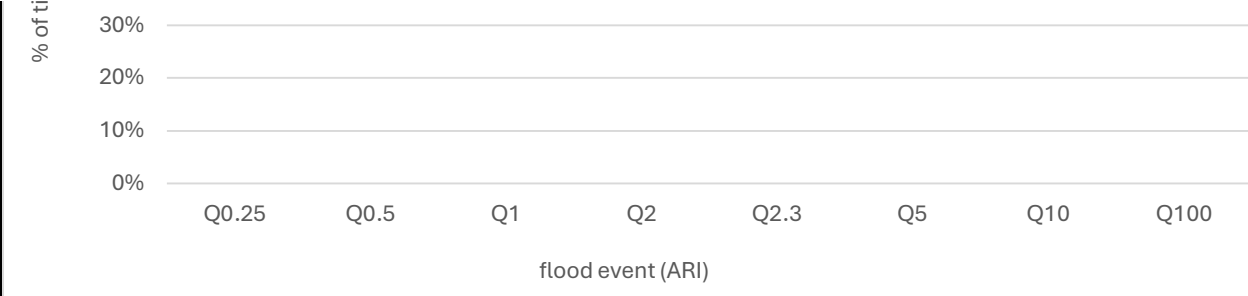
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

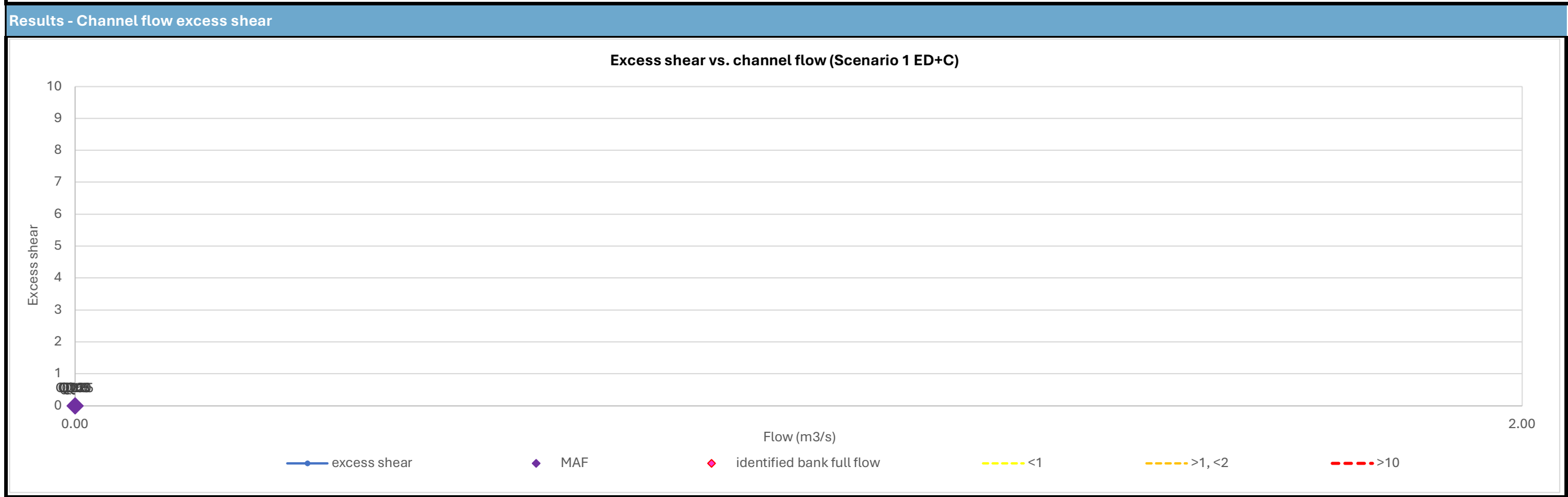
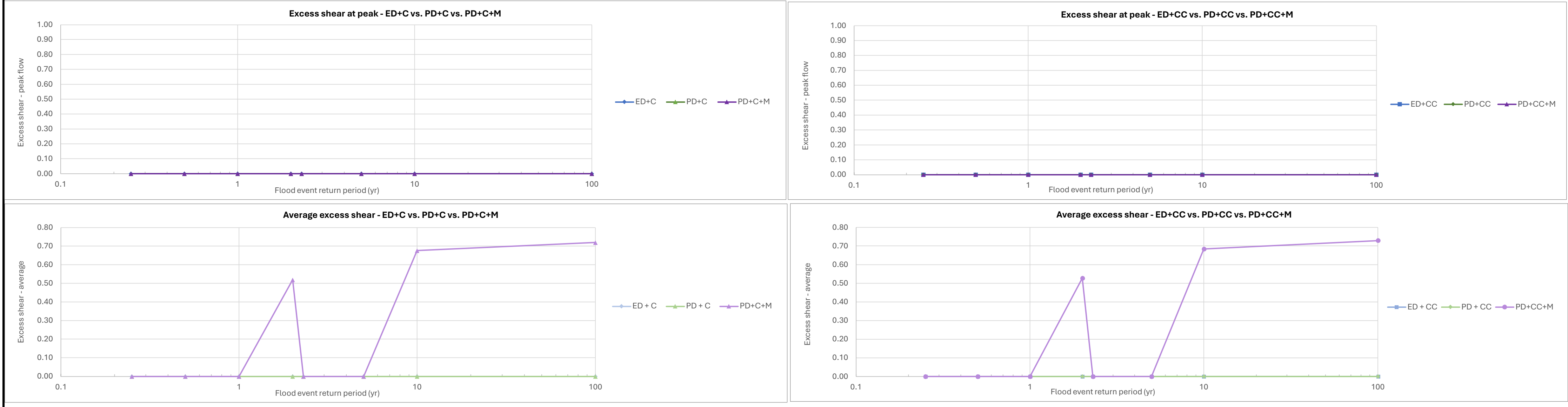
Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

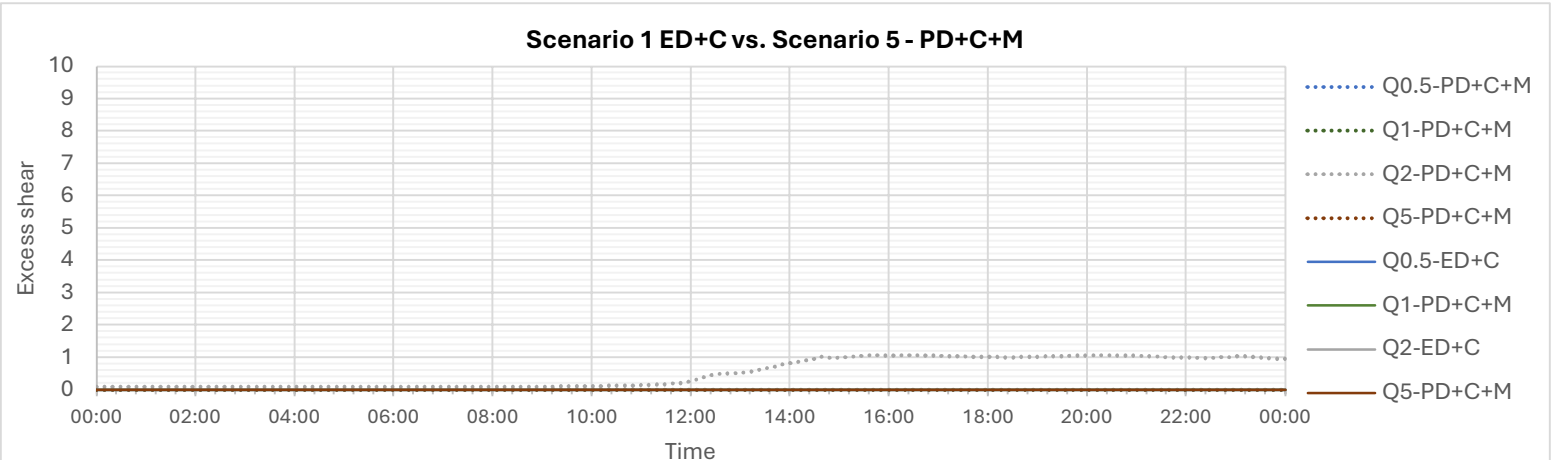
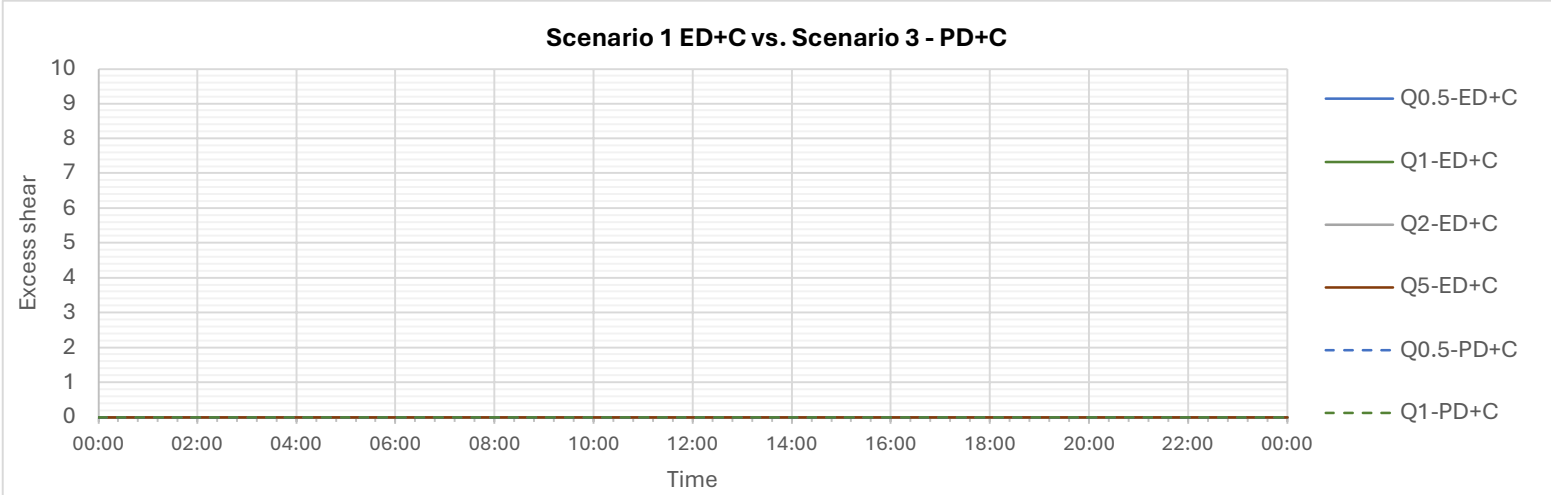
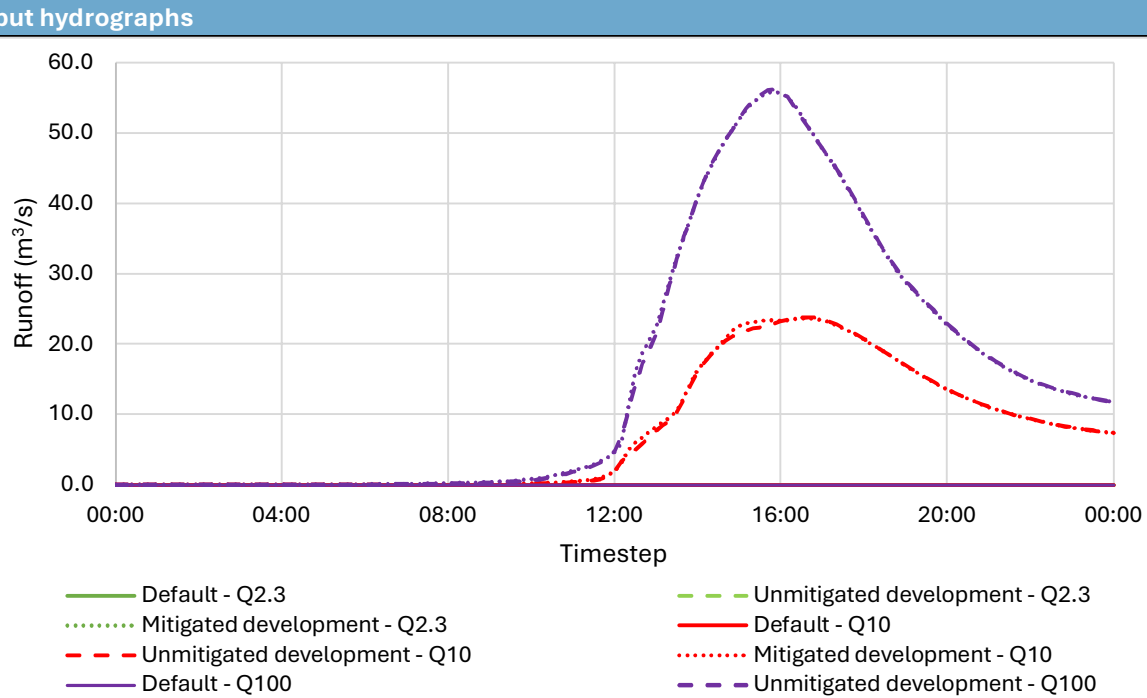
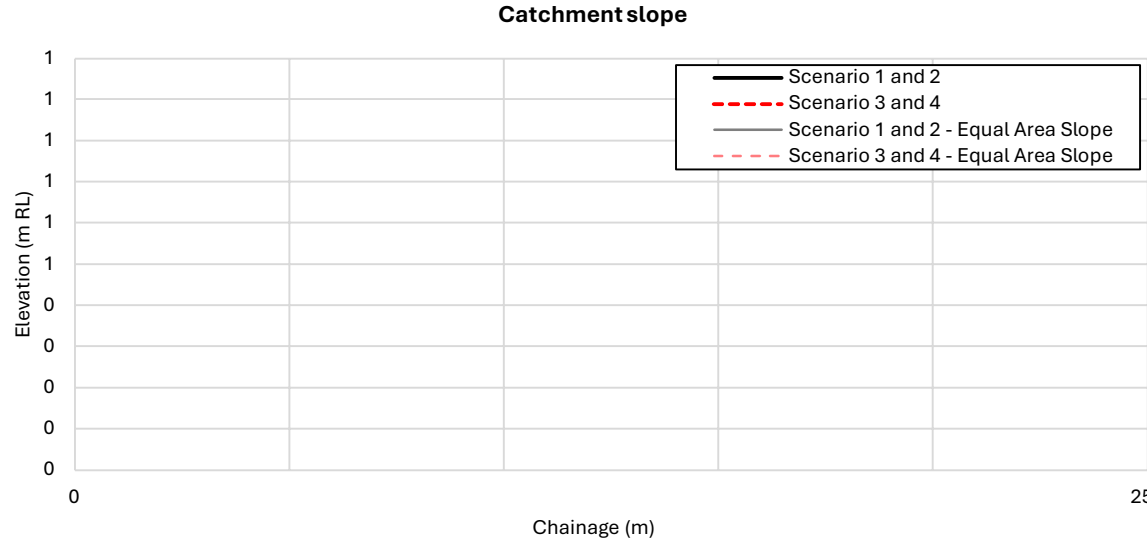


Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr



Test project		Erosion Screening Tool Result Summary										Test project		Erosion Screening Tool Result Summary																																																																																																																																																																																																																																																																																																																																																																																																																																													
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Site Photo	Site Map	Cross section profile										ARI (yr) <table><tr><th></th><th>0.25</th><th>0.5</th><th>1</th><th>2</th><th>2.3</th><th>5</th><th>10</th><th>100</th><th>0.25</th><th>0.5</th><th>1</th><th>2</th><th>2.3</th><th>5</th><th>10</th><th>100</th></tr><tr><td colspan="8">Scenario 1 ED+C</td><td colspan="8">Scenario 3 PD+C</td></tr><tr><td>BSS at peak (N/m²)</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr><tr><td>ESS at peak</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr><tr><td>ESS exceedance (min)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td><1 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<10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Scenario 5 PD+C+M								Scenario 6 PD+CC+M								BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ESS exceedance (min)																	<1 (min)	1440	1440	1440	1020	1440	1440	740	720	1440	1440	1440	1010	1440	1440	730	720	>1 & <2 (min)	0	0	0	420	0	0	700	720	0	0	0	430	0	0	710	720	>2 & <10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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Time of Concentration (hr)		t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00	0.00	0.00	0.00																																																																																																																																																																																																																																																																																																																																																																																																																																																
Time to Peak (hr)		t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00	0.00	0.00	0.00																																																																																																																																																																																																																																																																																																																																																																																																																																																
P24 Rainfall Depth (mm)																																																																																																																																																																																																																																																																																																																																																																																																																																																											
3 month ARI*			0	0	0	0	0	0	0	0	0																																																																																																																																																																																																																																																																																																																																																																																																																																																
6 month ARI			0	0	0	0	0	0	0	0	0																																																																																																																																																																																																																																																																																																																																																																																																																																																
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2.3 year ARI			0	0	0	0	0	0	0	0	0																																																																																																																																																																																																																																																																																																																																																																																																																																																
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10 year ARI			0	0	0	0	0	0	0	0	0																																																																																																																																																																																																																																																																																																																																																																																																																																																
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#N/A

Cross-section 3 – No climate change

Erosion screening tool outputs

Test project

Input summary							
Catchment parameters							
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
		ED+C	ED+CC	PD+C	PD+CC	PD+C+M	PD+CC+M
Total Area (km ²)	A	0.00	0.00	0.00	0.00		
Perviousness		0.00	0.00	0.00	0.00		
Pervious Area (km ²)		0.00	0.00	0.00	0.00		
Impervious Area (km ²)		0.00	0.00	0.00	0.00		
Channelisation Factor	C	0	0	0	0		
Catchment Length (km)	L	0.00	0.00	0.00	0.00		
Catchment Slope (m/m)	Sc	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Curve Numbers							
Soil Type	S	0	0	0	0		
Pervious Areas	CN	0	0	0	0		
Impervious Areas	CN	98	98	98	98		
Weighted	CN	98.0	98.0	98.0	98.0		
TP108							
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Soil Storage (mm)	S	5	5	5	5		
Time of Concentration (hr)	t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Time to Peak (hr)	t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
P24 Rainfall Depth (mm)							
3 month ARI*		0	0	0	0	0	0
6 month ARI		0	0	0	0	0	0
1 year ARI		0	0	0	0	0	0
2 year ARI		0	0	0	0	0	0
2.3 year ARI		0	0	0	0	0	0
5 year ARI		0	0	0	0	0	0
10 year ARI		0	0	0	0	0	0
100 year ARI		0	0	0	0	0	0

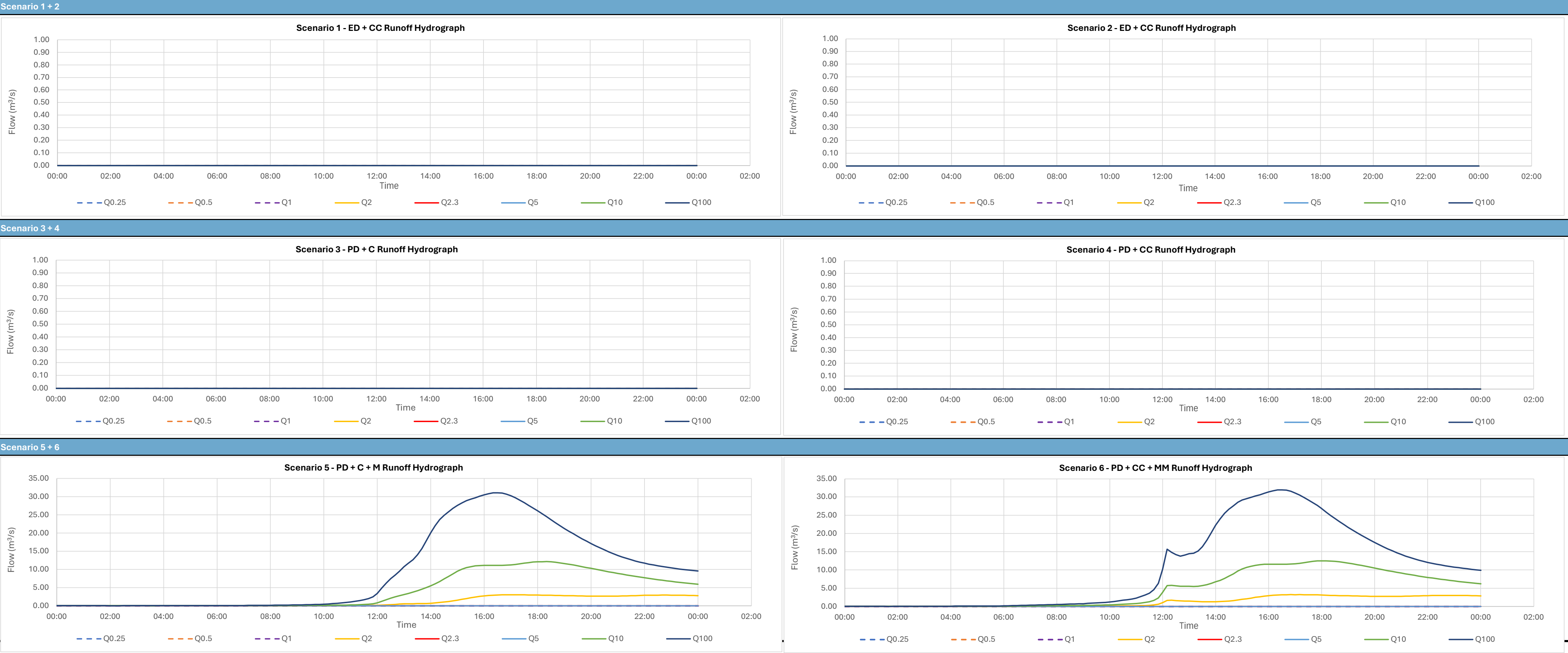
* 3 month ARI estimated rainfall does not fits well in regression calculation, not recommend to use.

Results - TP108 Peak Flow Analysis								
ARI (yr)	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 2 ED+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 3 PD+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 4 PD+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 5 PD+C+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 6 PD+CC+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff

#N/A

Results - Bank Full Channel Identification	
Approximate channel width (m)	11.91
Bank full water depth (m)	#N/A
Bank full flow (m ³ /s)	#N/A
Bank full flow excess shear	#N/A
Annual fullest flow as represented by the mean annual flood (m ³ /s)	0.00
Annual fullest flow as represented by the mean annual flood excess shear	0.0

Results - 24hr Runoff Hydrographs



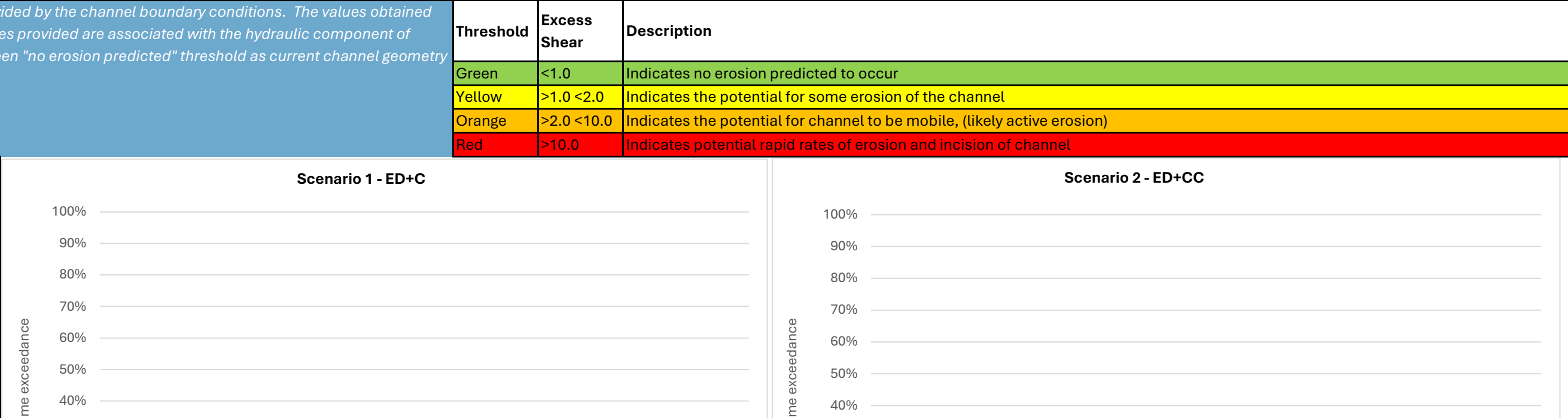
Results - Excess shear exceedance

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel. Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Existing development erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its existing development state.

Boundary shear stress (BSS) - the force exerted on the channel by flow

Excess shear stress (ESS) - the amount of BSS in excess of the critical shear stress threshold for initiating sediment movement

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Scenario 1 ED+C								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 2 ED+CC								

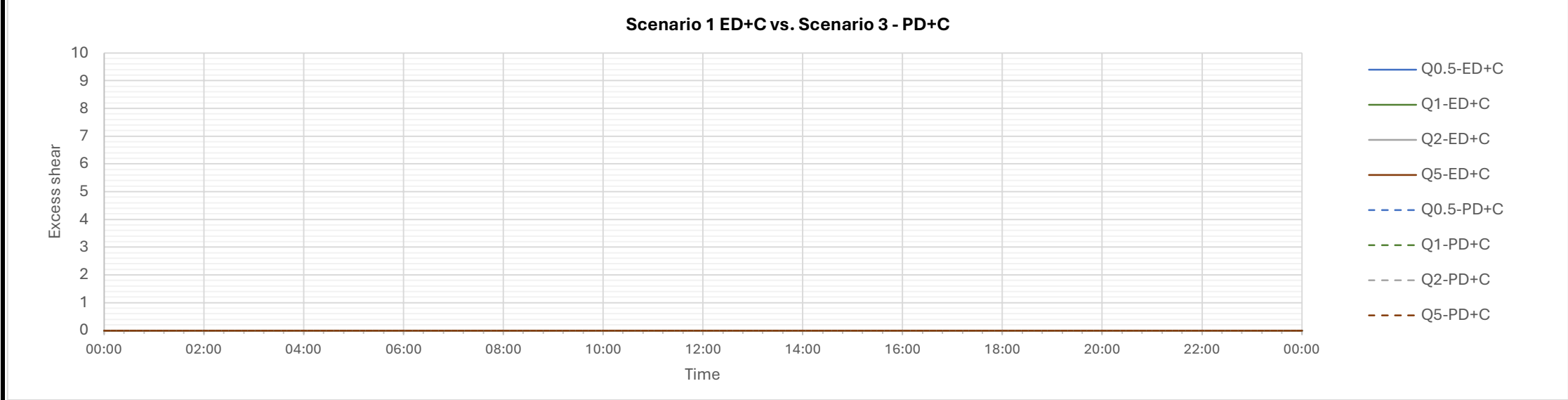


BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 3 PD+C								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 4 PD+CC								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	13.55	0.00	0.00	22.84	32.26
ESS event mean	0.00	0.00	0.00	0.41	0.00	0.00	0.69	0.98
ESS exceedance (min)								
<1 (min)	1440	1440	1440	1440	1440	1440	840	730
>1 & <2 (min)	0	0	0	0	0	0	600	470
>2 & <10 (min)	0	0	0	0	0	0	0	240
>10 (min)	0	0	0	0	0	0	0	0
Scenario 6 PD+CC+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	14.88	0.00	0.00	24.95	34.78
ESS event mean	0.00	0.00	0.00	0.45	0.00	0.00	0.76	1.05
ESS exceedance (min)								
<1 (min)	1440	1440	1440	1440	1440	1440	810	700
>1 & <2 (min)	0	0	0	0	0	0	630	470
>2 & <10 (min)	0	0	0	0	0	0	0	270
>10 (min)	0	0	0	0	0	0	0	0

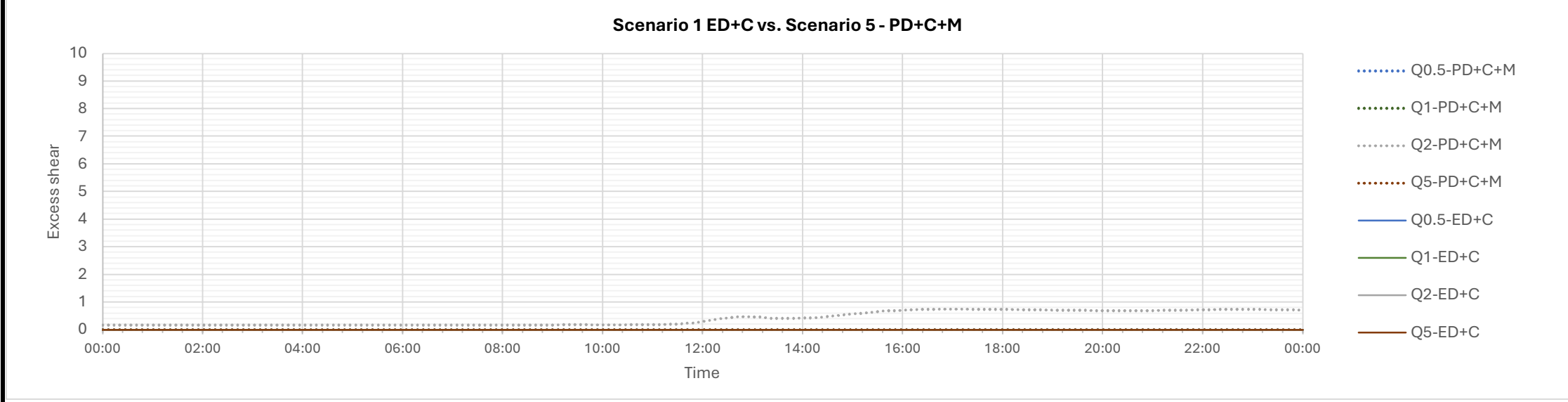
Results - Small event excess shear exceedance

These represent frequent events. Shear stress exceedances in these events indicate erosion is likely to occur often and in smaller flows.

Effect of development



Effect of post-development mitigation



Results - Excess shear comparisons

This analysis examines the percentage change in two erosion metrics between scenarios. Peak excess shear is the excess shear stress value during an event's peak flow, average excess shear takes the mean value throughout an event.

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Effect of development without climate change (Scenario 1 vs. Scenario 3)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change (Scenario 2 vs. Scenario 4)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development without climate change with mitigation (Scenario 1 vs. Scenario 5)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change with mitigation (Scenario 2 vs. Scenario 6)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

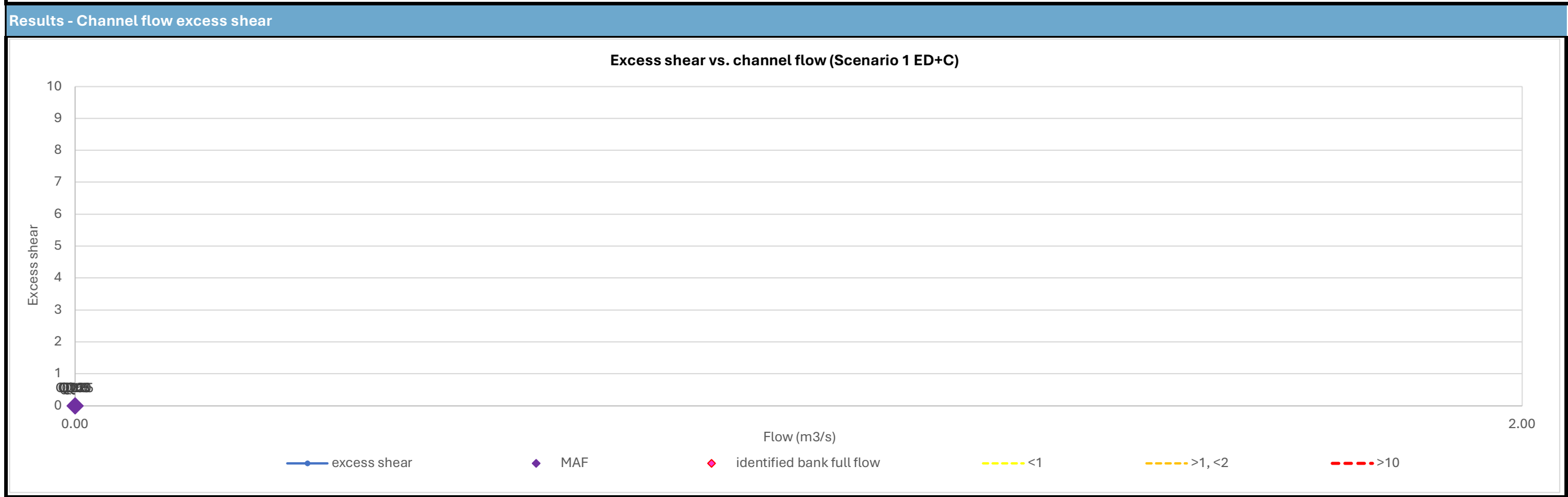
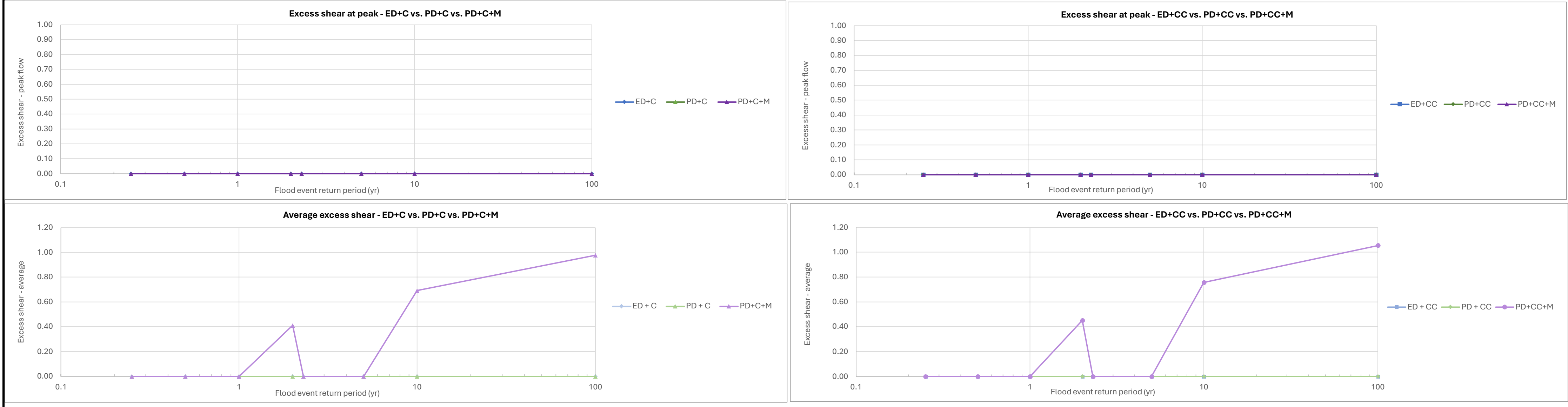
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr



Test project

Site

Site Photo

Site Map

Input summary

Catchment parameters

Total Area (km²)

Perviousness

Pervious Area (km²)

Impervious Area (km²)

Channellisation Factor

Catchment Length (km)

Catchment Slope (m/m)

Curve Numbers

Soil Type

Pervious Areas

Impervious Areas

Weighted

Scenario 1

Scenario 2

Scenario 3

Scenario 4

Scenario 5

Scenario 6

ED+C

ED+CC

PD+C

PD+CC

PD+C+M

PD+CC+M

TP108

Initial Abstraction (mm)

Soil Storage (mm)

Time of Concentration (hr)

Time to Peak (hr)

Ia

S

t_c

t_p

#DIV/0!

#DIV/0!

#DIV/0!

#DIV/0!

#DIV/0!

#DIV/0!

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

P24 Rainfall Depth (mm)

3 month ARI*

6 month ARI

1 year ARI

2 year ARI

2.3 year ARI

5 year ARI

10 year ARI

100 year ARI

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

Input channel geometry

Cross section profile

Elevation (m RL)

Chainage (m)

Catchment slope

Elevation (m RL)

Chainage (m)

Input hydrographs

Runoff (m³/s)

Timestep

Default - Q2.3

Mitigated development - Q2.3

Unmitigated development - Q10

Default - Q100

Unmitigated development - Q2.3

Default - Q10

Mitigated development - Q10

Unmitigated development - Q100

Output shear stress exceedance

ARI (yr)

0.25

0.5

1

2

2.3

5

10

100

0.25

0.5

1

2

2.3

5

10

100

Scenario 1 ED+C

Scenario 3 PD+C

Scenario 2 ED+CC

Scenario 4 PD+CC

Scenario 5 PD+C+M

Scenario 6 PD+CC+M

BSS at peak (N/m²)

ESS at peak

ESS exceedance (min)

<1 (min)

>1 & <2 (min)

>2 & <10 (min)

>10 (min)

BSS at peak (N/m²)

ESS at peak

ESS exceedance (min)

<1 (min)

>1 & <2 (min)

>2 & <10 (min)

>10 (min)

BSS at peak (N/m²)

ESS at peak

ESS exceedance (min)

<1 (min)

>1 & <2 (min)

>2 & <10 (min)

>10 (min)

Scenario 1 ED+C vs. Scenario 3 - PD+C

Scenario 1 ED+C vs. Scenario 5 - PD+C+M

Threshold

Excess Shear

Indication

Green

<1.0

No erosion predicted to occur

Yellow

>1.0 <2.0

Potential for some erosion of the channel

Orange

>2.0 <10.0

Potential for channel to be mobile, (likely active erosion)

Red

>10.0

Potential rapid rates of erosion and incision of channel

Development effects summary

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

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Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

#N/A

Cross-section 3 – 3.8°C climate change

Erosion screening tool outputs

Test project

Input summary							
Catchment parameters							
		0	0	0	0	0	0
		0	0	0	0	0	0
Total Area (km ²)	A	0.00	0.00	0.00	0.00		
Perviousness		0.00	0.00	0.00	0.00		
Pervious Area (km ²)		0.00	0.00	0.00	0.00		
Impervious Area (km ²)		0.00	0.00	0.00	0.00		
Channelisation Factor	C	0	0	0	0		
Catchment Length (km)	L	1.79	1.79	0.00	0.00		
Catchment Slope (m/m)	Sc	0.031	0.031	#DIV/0!	#DIV/0!		
Curve Numbers							
Soil Type	S	0	0	0	0		
Pervious Areas	CN	0	0	0	0		
Impervious Areas	CN	98	98	98	98		
Weighted	CN	98.0	98.0	98.0	98.0		
TP108							
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Soil Storage (mm)	S	5	5	5	5		
Time of Concentration (hr)	t _c	0.17	0.17	#DIV/0!	#DIV/0!		
Time to Peak (hr)	t _p	0.11	0.11	#DIV/0!	#DIV/0!		
P24 Rainfall Depth (mm)							
3 month ARI*		0	0	0	0	0	0
6 month ARI		0	0	0	0	0	0
1 year ARI		0	0	0	0	0	0
2 year ARI		0	0	0	0	0	0
2.3 year ARI		0	0	0	0	0	0
5 year ARI		0	0	0	0	0	0
10 year ARI		0	0	0	0	0	0
100 year ARI		0	0	0	0	0	0

* 3 month ARI estimated rainfall does not fits well in regression calculation, not recommend to use.

Results - TP108 Peak Flow Analysis								
ARI (yr)	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 2 ED+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 3 PD+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 4 PD+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 5 PD+C+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 6 PD+CC+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff

#N/A

Results - Bank Full Channel Identification	
Approximate channel width (m)	11.91
Bank full water depth (m)	#N/A
Bank full flow (m ³ /s)	#N/A
Bank full flow excess shear	#N/A
Annual fullest flow as represented by the mean annual flood (m ³ /s)	0.00
Annual fullest flow as represented by the mean annual flood excess shear	0.0

Results - 24hr Runoff Hydrographs



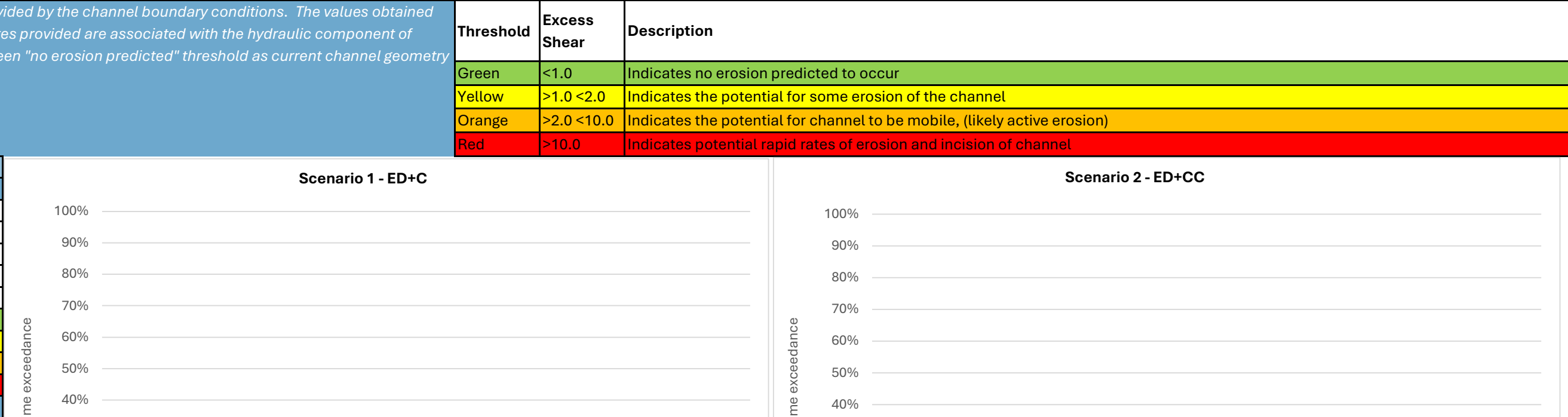
Results - Excess shear exceedance

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel. Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Existing development erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its existing development state.

Boundary shear stress (BSS) - the force exerted on the channel by flow

Excess shear stress (ESS) - the amount of BSS in excess of the critical shear stress threshold for initiating sediment movement

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Scenario 1 ED+C								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 2 ED+CC								

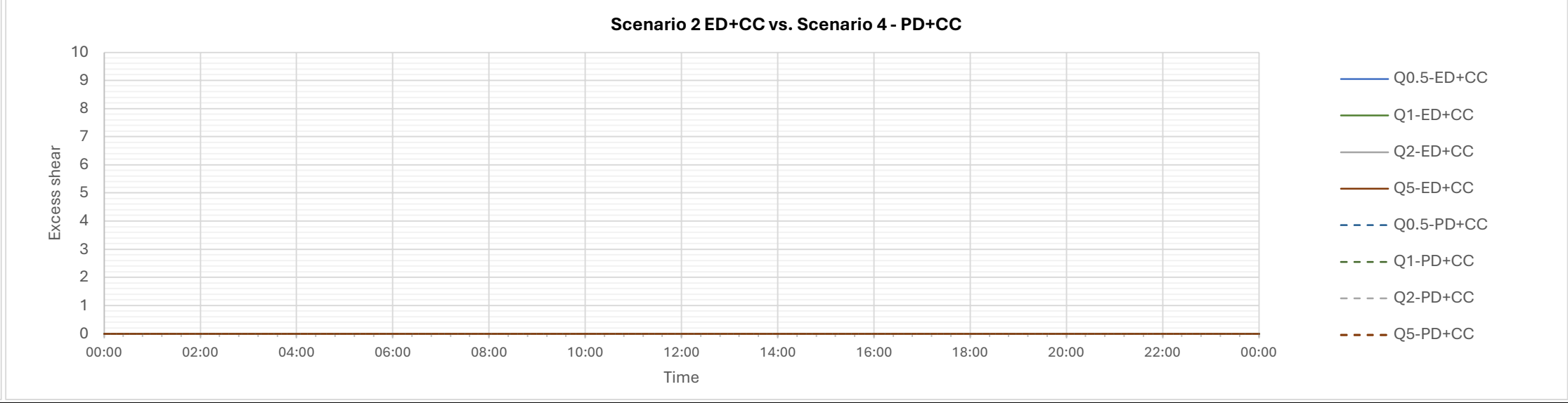
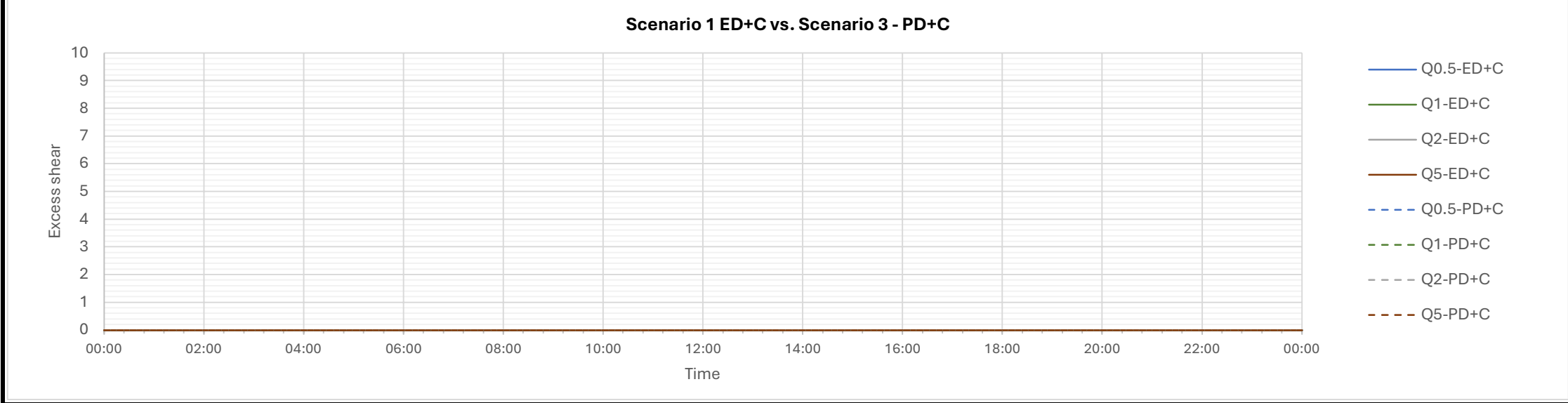


BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 3 PD+C								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 4 PD+CC								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	16.63	0.00	0.00	28.63	35.22
ESS event mean	0.00	0.00	0.00	0.50	0.00	0.00	0.87	1.07
ESS exceedance (min)								
<1 (min)	1440	1440	1440	1440	1440	1440	760	730
>1 & <2 (min)	0	0	0	0	0	0	680	300
>2 & <10 (min)	0	0	0	0	0	0	0	410
>10 (min)	0	0	0	0	0	0	0	0
Scenario 6 PD+CC+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	18.19	0.00	0.00	31.14	37.74
ESS event mean	0.00	0.00	0.00	0.55	0.00	0.00	0.94	1.14
ESS exceedance (min)								
<1 (min)	1440	1440	1440	1440	1440	1440	710	700
>1 & <2 (min)	0	0	0	0	0	0	630	270
>2 & <10 (min)	0	0	0	0	0	0	100	470
>10 (min)	0	0	0	0	0	0	0	0

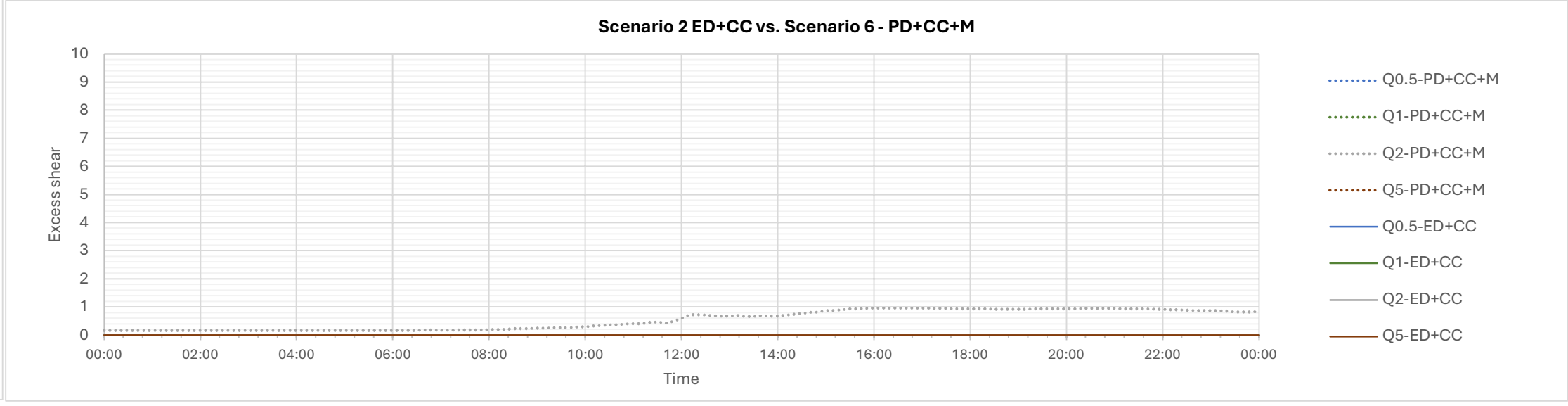
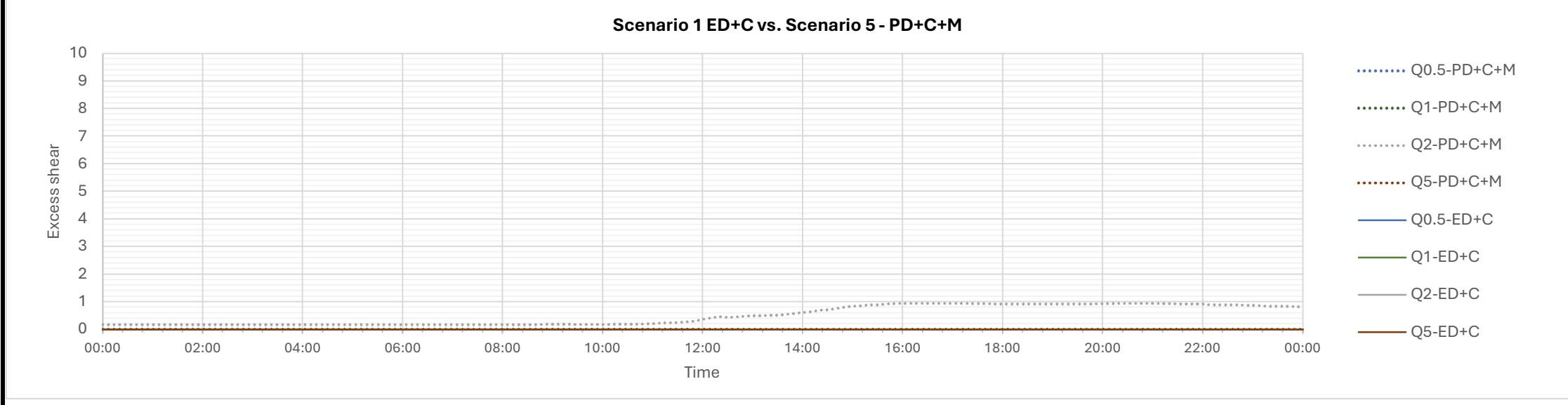
Results - Small event excess shear exceedance

These represent frequent events. Shear stress exceedances in these events indicate erosion is likely to occur often and in smaller flows.

Effect of development



Effect of post-development mitigation



Results - Excess shear comparisons

This analysis examines the percentage change in two erosion metrics between scenarios. Peak excess shear is the excess shear stress value during an event's peak flow, average excess shear takes the mean value throughout an event.

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Effect of development without climate change (Scenario 1 vs. Scenario 3)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change (Scenario 2 vs. Scenario 4)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development without climate change with mitigation (Scenario 1 vs. Scenario 5)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change with mitigation (Scenario 2 vs. Scenario 6)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

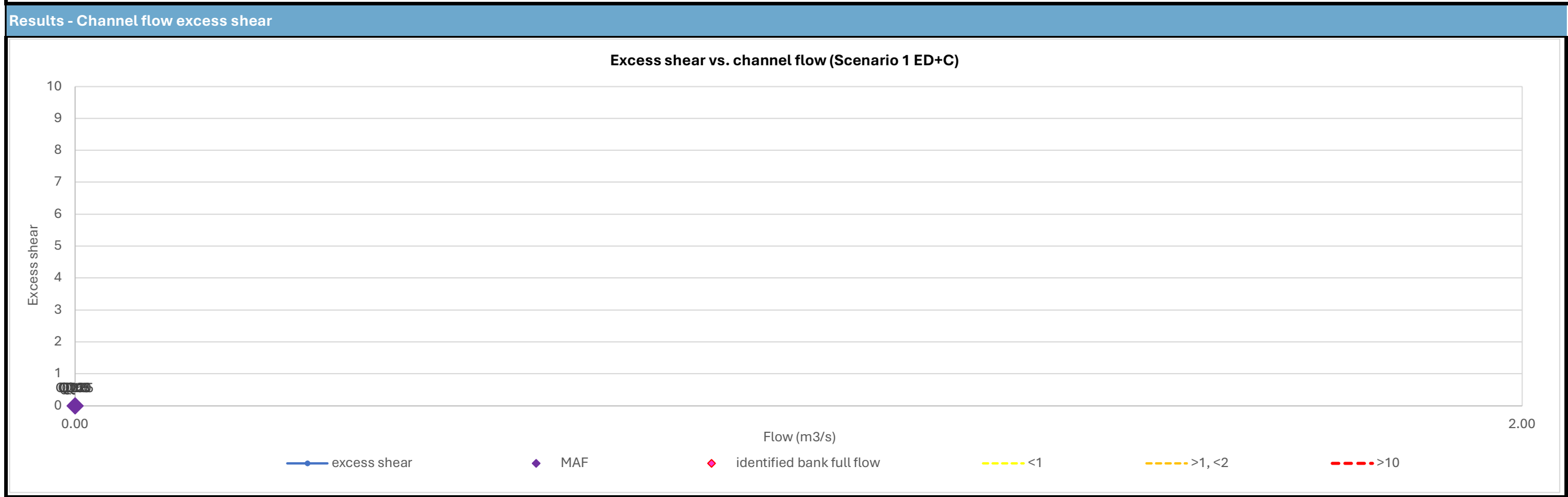
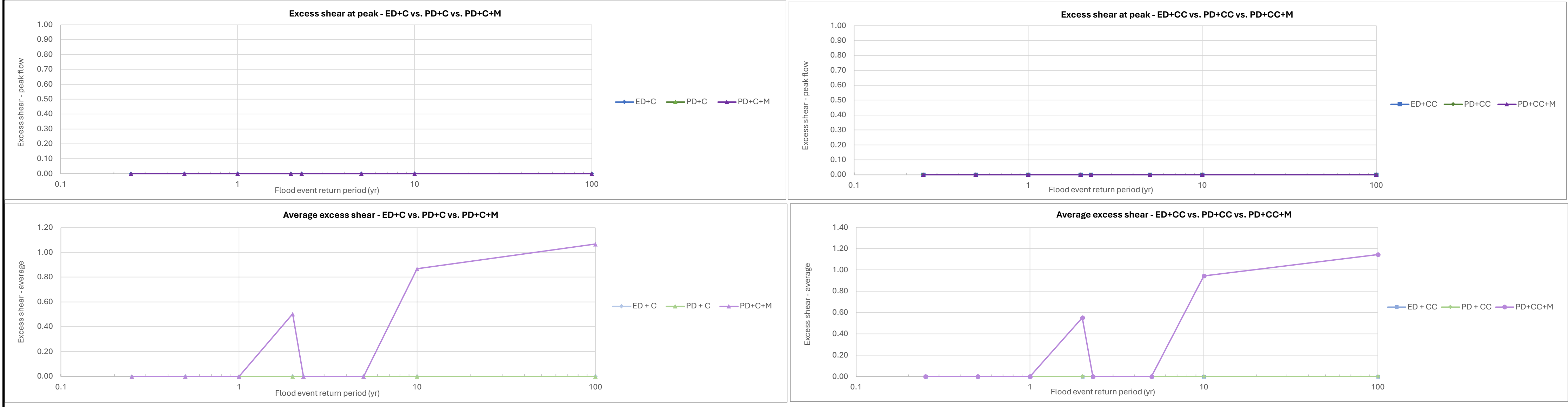
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

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High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
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Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr



Test project		Erosion Screening Tool Result Summary										Test project		Erosion Screening Tool Result Summary																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
Site		Input channel geometry										Output shear stress exceedance										Threshold	Excess Shear	Indication																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
Site Photo	Site Map	Cross section profile										ARI (yr) <table><tr><th></th><th>0.25</th><th>0.5</th><th>1</th><th>2</th><th>2.3</th><th>5</th><th>10</th><th>100</th><th>0.25</th><th>0.5</th><th>1</th><th>2</th><th>2.3</th><th>5</th><th>10</th><th>100</th></tr><tr><td colspan="17">Scenario 1 ED+C</td></tr><tr><td colspan="17">Scenario 3 PD+C</td></tr><tr><td>BSS at peak (N/m²)</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr><tr><td>ESS at peak</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr><tr><td>ESS exceedance (min)</td><td colspan="16"></td></tr><tr><td><1 (min)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>>1 & <2 (min)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>>2 & <10 (min)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>>10 (min)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td colspan="17">Scenario 2 ED+CC</td></tr><tr><td colspan="17">Scenario 4 PD+CC</td></tr><tr><td>BSS at peak (N/m²)</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr><tr><td>ESS at peak</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr><tr><td>ESS exceedance (min)</td><td colspan="16"></td></tr><tr><td><1 (min)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>>1 & <2 (min)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>>2 & <10 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(N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ESS exceedance (min)																	<1 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	>1 & <2 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	>2 & <10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Scenario 2 ED+CC																	Scenario 4 PD+CC																	BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ESS exceedance (min)																	<1 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	>1 & <2 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	>2 & <10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Scenario 5 PD+C+M																	Scenario 6 PD+CC+M																	BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ESS at 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Initial Abstraction (mm)		Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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Time of Concentration (hr)		t _c	0.17	0.17	#DIV/0!	#DIV/0!	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Time to Peak (hr)		t _p	0.11	0.11	#DIV/0!	#DIV/0!	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
P24 Rainfall Depth (mm)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
3 month ARI*			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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100 year ARI			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Input hydrographs		Runoff (m³/s) Timestep																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
Development effects summary		Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s). Marginal risk (<1% increase): Moderate risk (1% - 5% increase): High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s). Marginal risk (<1% increase): Moderate risk (1% - 5% increase): High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s). Marginal risk (<1% increase): Moderate risk (1% - 5% increase): High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s). Marginal risk (<1% increase): Moderate risk (1% - 5% increase): High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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Catchment slope

Elevation (m RL)

Chainage (m)

Scenario 1 and 2

Scenario 3 and 4

Scenario 1 and 2 - Equal Area Slope

Scenario 3 and 4 - Equal Area Slope

Cross-section 4 – No climate change

Erosion screening tool outputs

Test project

Input summary							
Catchment parameters							
		0	0	0	0	0	0
		0	0	0	0	0	0
Total Area (km ²)	A	0.00	0.00	0.00	0.00		
Perviousness		0.00	0.00	0.00	0.00		
Pervious Area (km ²)		0.00	0.00	0.00	0.00		
Impervious Area (km ²)		0.00	0.00	0.00	0.00		
Channelisation Factor	C	0	0	0	0		
Catchment Length (km)	L	0.00	0.00	0.00	0.00		
Catchment Slope (m/m)	Sc	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Curve Numbers							
Soil Type	S	0	0	0	0		
Pervious Areas	CN	0	0	0	0		
Impervious Areas	CN	98	98	98	98		
Weighted	CN	98.0	98.0	98.0	98.0		
TP108							
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Soil Storage (mm)	S	5	5	5	5		
Time of Concentration (hr)	t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Time to Peak (hr)	t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
P24 Rainfall Depth (mm)							
3 month ARI*		0	0	0	0	0	0
6 month ARI		0	0	0	0	0	0
1 year ARI		0	0	0	0	0	0
2 year ARI		0	0	0	0	0	0
2.3 year ARI		0	0	0	0	0	0
5 year ARI		0	0	0	0	0	0
10 year ARI		0	0	0	0	0	0
100 year ARI		0	0	0	0	0	0

* 3 month ARI estimated rainfall does not fits well in regression calculation, not recommend to use.

Results - TP108 Peak Flow Analysis								
ARI (yr)	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 2 ED+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 3 PD+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 4 PD+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 5 PD+C+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 6 PD+CC+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff

#N/A

Results - Bank Full Channel Identification	
Approximate channel width (m)	11.91
Bank full water depth (m)	#N/A
Bank full flow (m ³ /s)	#N/A
Bank full flow excess shear	#N/A
Annual fullest flow as represented by the mean annual flood (m ³ /s)	0.00
Annual fullest flow as represented by the mean annual flood excess shear	0.0

Results - 24hr Runoff Hydrographs



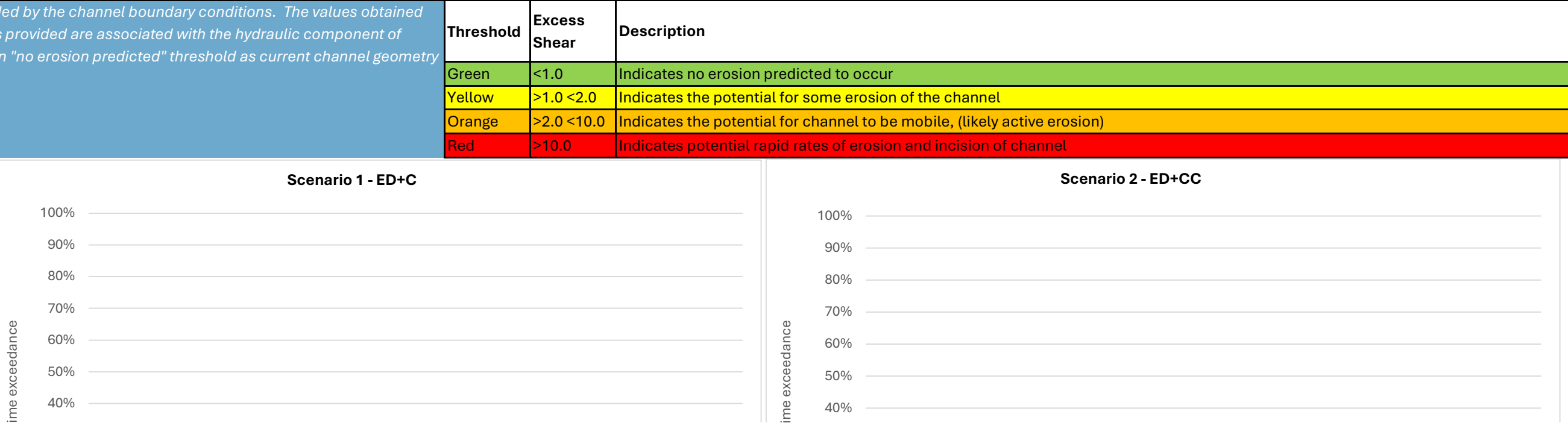
Results - Excess shear exceedance

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel. Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Existing development erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its existing development state.

Boundary shear stress (BSS) - the force exerted on the channel by flow

Excess shear stress (ESS) - the amount of BSS in excess of the critical shear stress threshold for initiating sediment movement

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Scenario 1 ED+C								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 2 ED+CC								

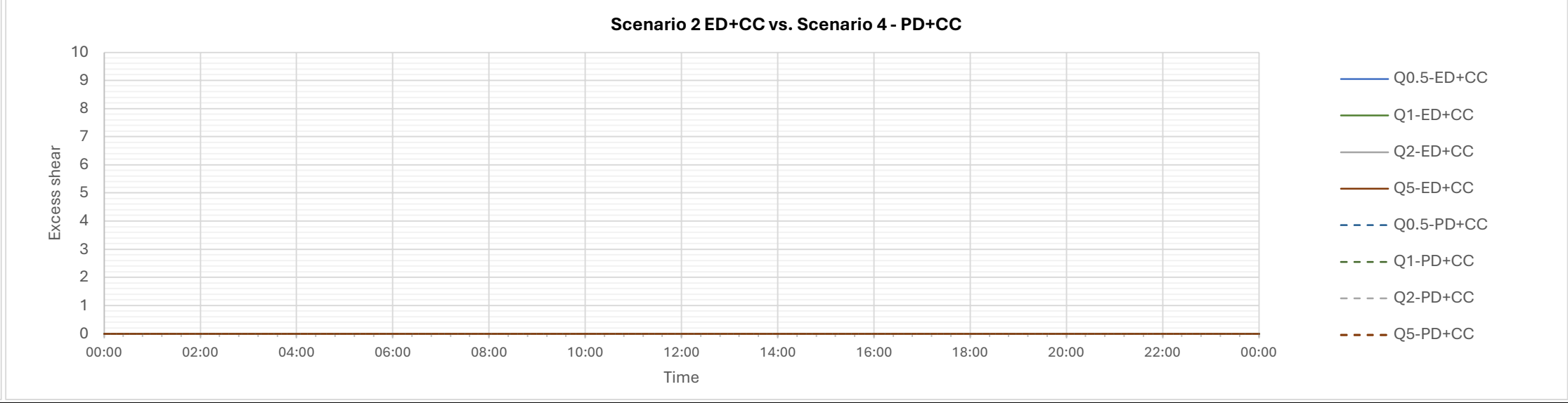
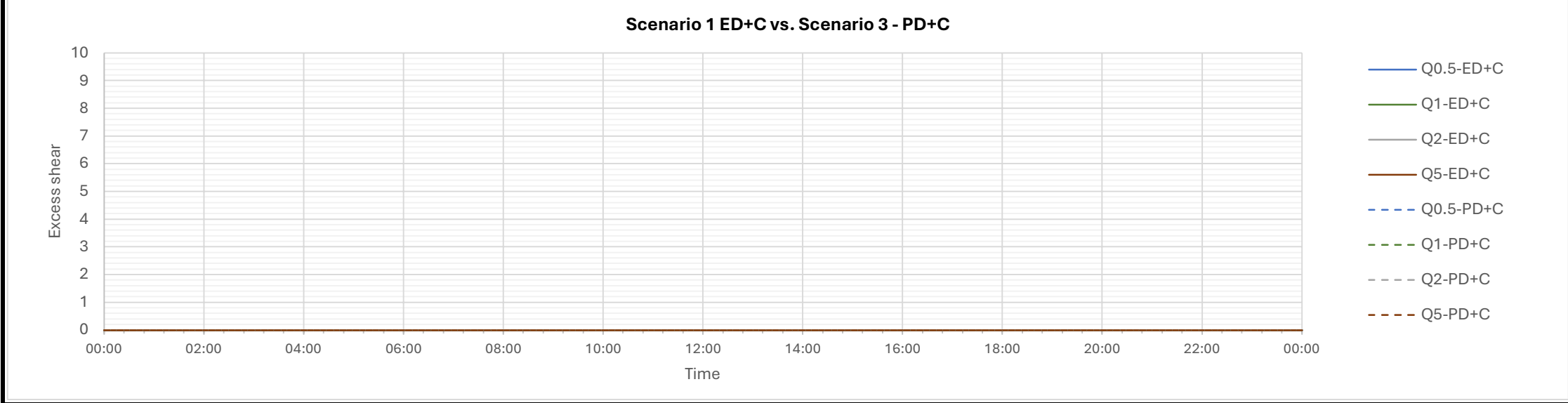


BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 3 PD+C								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 4 PD+CC								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	51.48	0.00	0.00	83.23	108.89
ESS event mean	0.00	0.00	0.00	1.56	0.00	0.00	2.52	3.30
ESS exceedance (min)								
<1 (min)	1440	1440	1440	730	1440	1440	660	530
>1 & <2 (min)	0	0	0	180	0	0	70	150
>2 & <10 (min)	0	0	0	530	0	0	710	760
>10 (min)	0	0	0	0	0	0	0	0
Scenario 6 PD+CC+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	55.92	0.00	0.00	89.92	116.54
ESS event mean	0.00	0.00	0.00	1.69	0.00	0.00	2.72	3.53
ESS exceedance (min)								
<1 (min)	1440	1440	1440	700	1440	1440	530	420
>1 & <2 (min)	0	0	0	50	0	0	170	190
>2 & <10 (min)	0	0	0	690	0	0	740	830
>10 (min)	0	0	0	0	0	0	0	0

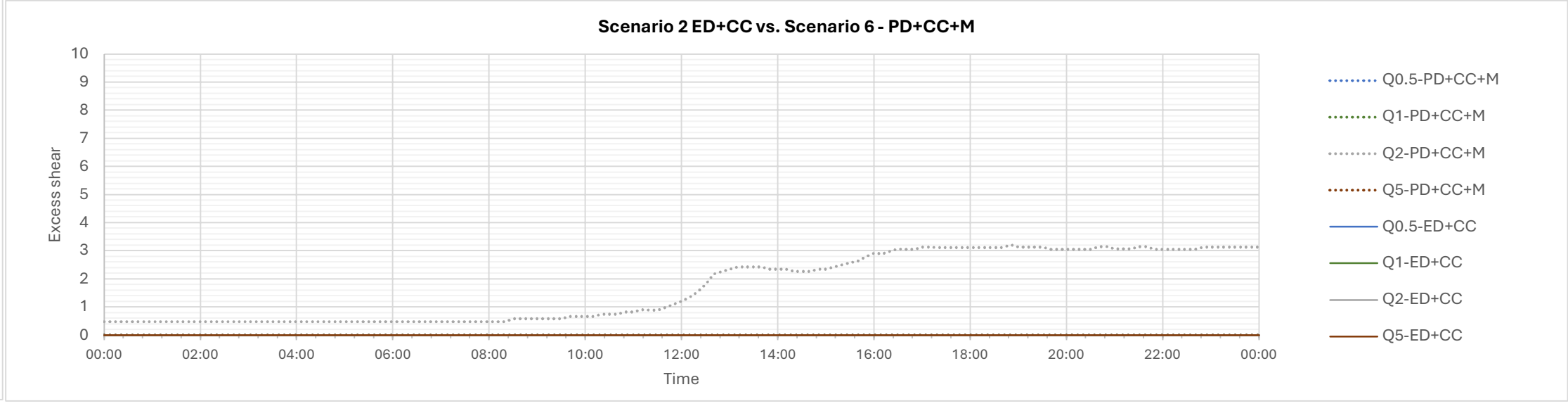
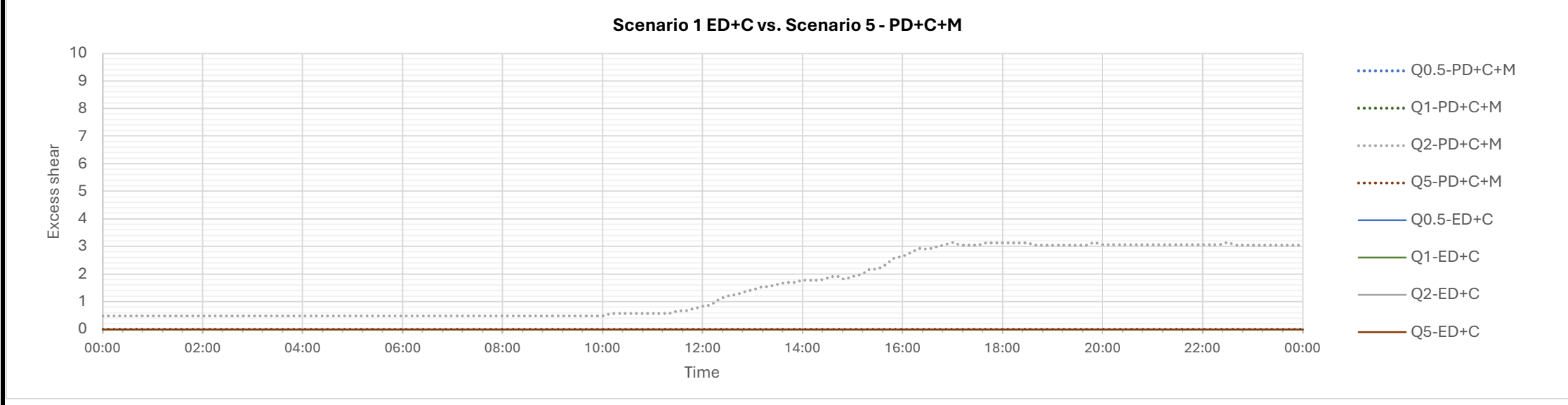
Results - Small event excess shear exceedance

These represent frequent events. Shear stress exceedances in these events indicate erosion is likely to occur often and in smaller flows.

Effect of development



Effect of post-development mitigation



Results - Excess shear comparisons

This analysis examines the percentage change in two erosion metrics between scenarios. Peak excess shear is the excess shear stress value during an event's peak flow, average excess shear takes the mean value throughout an event.

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Effect of development without climate change (Scenario 1 vs. Scenario 3)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change (Scenario 2 vs. Scenario 4)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development without climate change with mitigation (Scenario 1 vs. Scenario 5)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change with mitigation (Scenario 2 vs. Scenario 6)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

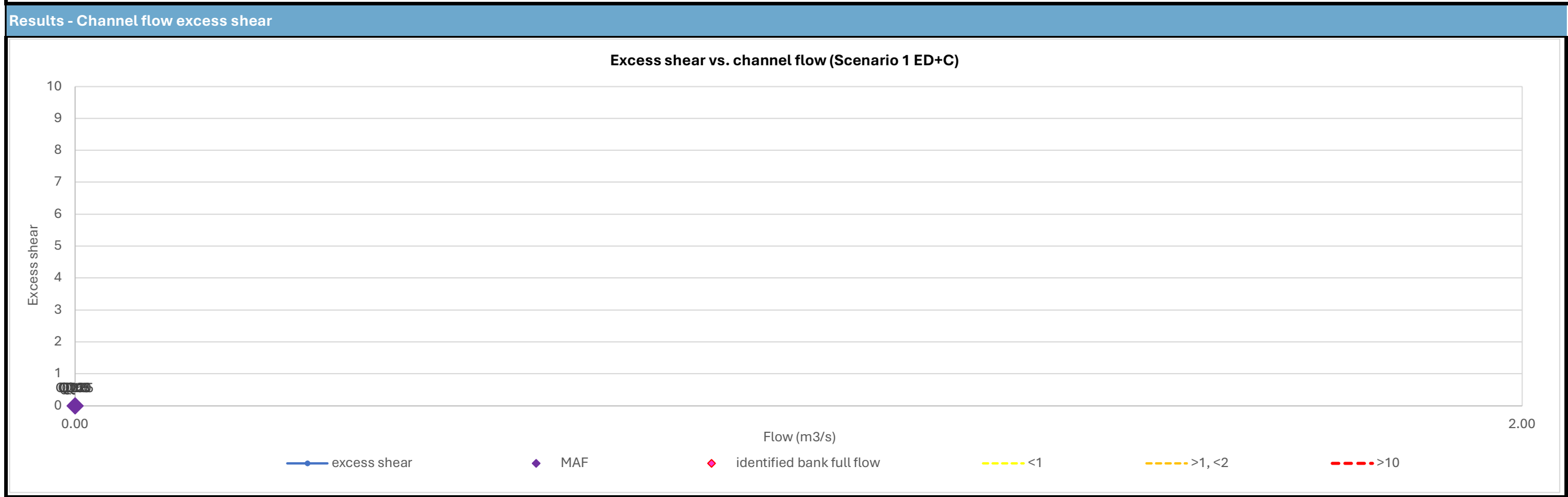
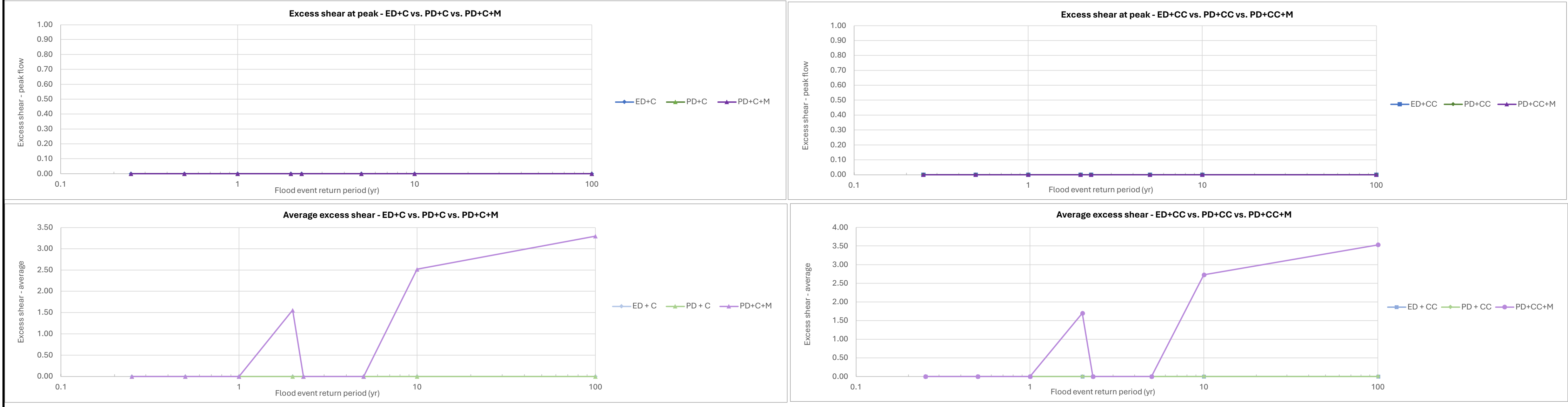
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr



Test project

Site

Site Photo

Site Map

Input summary

Catchment parameters

	0	0	0	0	0	0
	0.00	0.00	0.00	0.00	0.00	0.00
Total Area (km²)	A	0.00	0.00	0.00	0.00	0.00
Perviousness		0.0%	0.0%	0.0%	0.0%	0.0%
Pervious Area (km²)		0.00	0.00	0.00	0.00	0.00
Impervious Area (km²)		0.00	0.00	0.00	0.00	0.00
Channelisation Factor	C	0	0	0	0	0
Catchment Length (km)	L	0.0	0.00	0.00	0.00	0.00
Catchment Slope (m/n)	Sc	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00
Curve Numbers						
Soil Type	S	0	0	0	0	0
Pervious Areas	CN	0	0	0	0	0
Impervious Areas	CN	98	98	98	98	0
Weighted	CN	98.0	98.0	98.0	98.0	0
TP108						
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.0
Soil Storage (mm)	S	5	5	5	5	0
Time of Concentration (hr)	t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00
Time to Peak (hr)	t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00
P24 Rainfall Depth (mm)						
3 month ARI*		0	0	0	0	0
6 month ARI		0	0	0	0	0
1 year ARI		0	0	0	0	0
2 year ARI		0	0	0	0	0
2.3 year ARI		0	0	0	0	0
5 year ARI		0	0	0	0	0
10 year ARI		0	0	0	0	0
100 year ARI		0	0	0	0	0

Input channel geometry

Cross section profile

Catchment slope

Input hydrographs

Runoff (m³/s)

Output shear stress exceedance

ARI (yr)	0.25	0.5	1	2	2.3	5	10	100	0.25	0.5	1	2	2.3	5	10	100		
Scenario 1 ED+C									Scenario 3 PD+C									
BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
ESS exceedance (min)																		
<1 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
>1 & <2 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
>2 & <10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Scenario 2 ED+CC									Scenario 4 PD+CC									
BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
ESS exceedance (min)																		
<1 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
>1 & <2 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
>2 & <10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Scenario 5 PD+C+M									Scenario 6 PD+CC+M									
BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
ESS exceedance (min)																		
<1 (min)	1440	1440	1440	730	1440	1440	660	530	1440	1440	1440	700	1440	1440	530	420		
>1 & <2 (min)	0	0	0	180	0	0	70	150	0	0	0	50	0	0	170	190		
>2 & <10 (min)	0	0	0	530	0	0	710	760	0	0	0	690	0	0	740	830		
>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Scenario 1 ED+C vs. Scenario 3 - PD+C

Scenario 1 ED+C vs. Scenario 5 - PD+C+M

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

#N/A

Cross-section 4 – 3.8°C climate change

Erosion screening tool outputs

Test project

Input summary							
Catchment parameters							
		0	0	0	0	0	0
		0	0	0	0	0	0
Total Area (km ²)	A	0.00	0.00	0.00	0.00		
Perviousness		0.00	0.00	0.00	0.00		
Pervious Area (km ²)		0.00	0.00	0.00	0.00		
Impervious Area (km ²)		0.00	0.00	0.00	0.00		
Channelisation Factor	C	0	0	0	0		
Catchment Length (km)	L	0.00	0.00	0.00	0.00		
Catchment Slope (m/m)	Sc	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Curve Numbers							
Soil Type	S	0	0	0	0		
Pervious Areas	CN	0	0	0	0		
Impervious Areas	CN	98	98	98	98		
Weighted	CN	98.0	98.0	98.0	98.0		
TP108							
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Soil Storage (mm)	S	5	5	5	5		
Time of Concentration (hr)	t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Time to Peak (hr)	t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
P24 Rainfall Depth (mm)							
3 month ARI*		0	0	0	0	0	0
6 month ARI		0	0	0	0	0	0
1 year ARI		0	0	0	0	0	0
2 year ARI		0	0	0	0	0	0
2.3 year ARI		0	0	0	0	0	0
5 year ARI		0	0	0	0	0	0
10 year ARI		0	0	0	0	0	0
100 year ARI		0	0	0	0	0	0

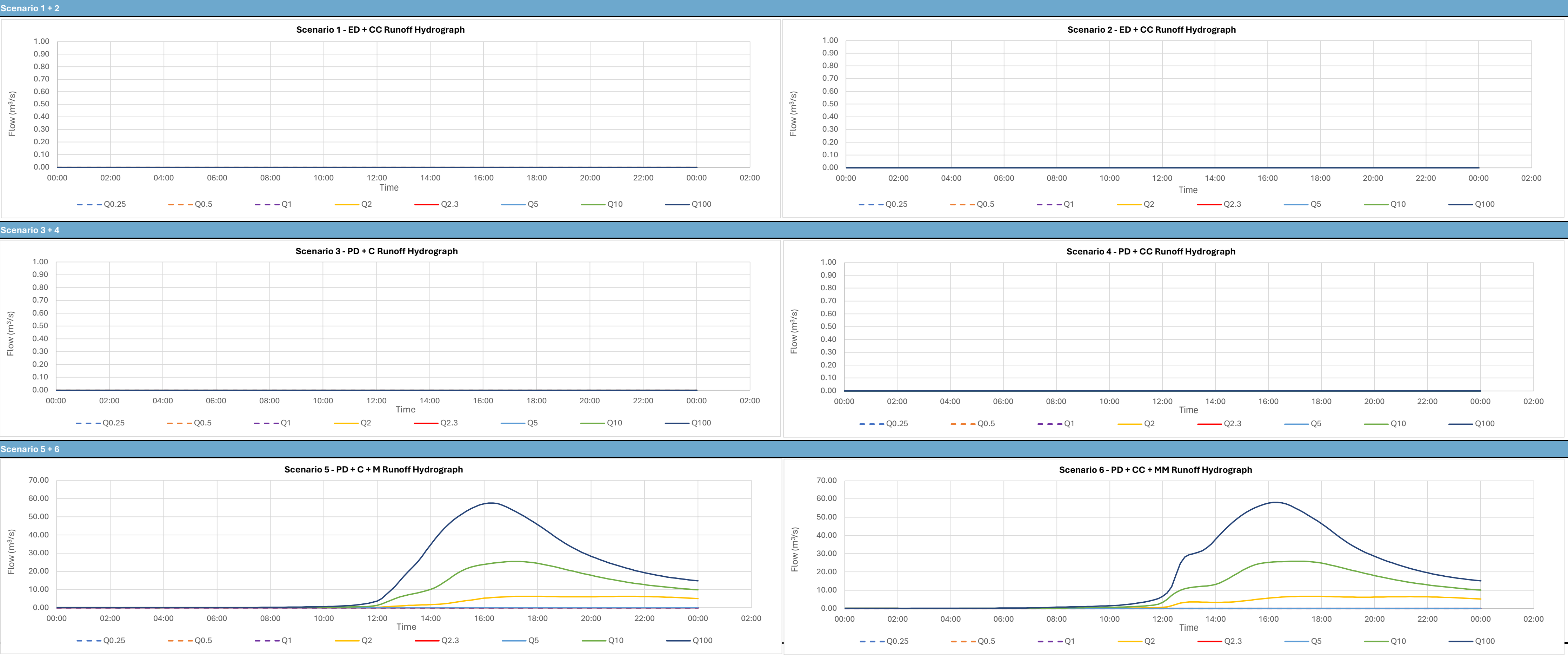
* 3 month ARI estimated rainfall does not fits well in regression calculation, not recommend to use.

Results - TP108 Peak Flow Analysis								
ARI (yr)	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 2 ED+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 3 PD+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 4 PD+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 5 PD+C+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 6 PD+CC+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff

#N/A

Results - Bank Full Channel Identification	
Approximate channel width (m)	11.91
Bank full water depth (m)	#N/A
Bank full flow (m ³ /s)	#N/A
Bank full flow excess shear	#N/A
Annual fullest flow as represented by the mean annual flood (m ³ /s)	0.00
Annual fullest flow as represented by the mean annual flood excess shear	0.0

Results - 24hr Runoff Hydrographs



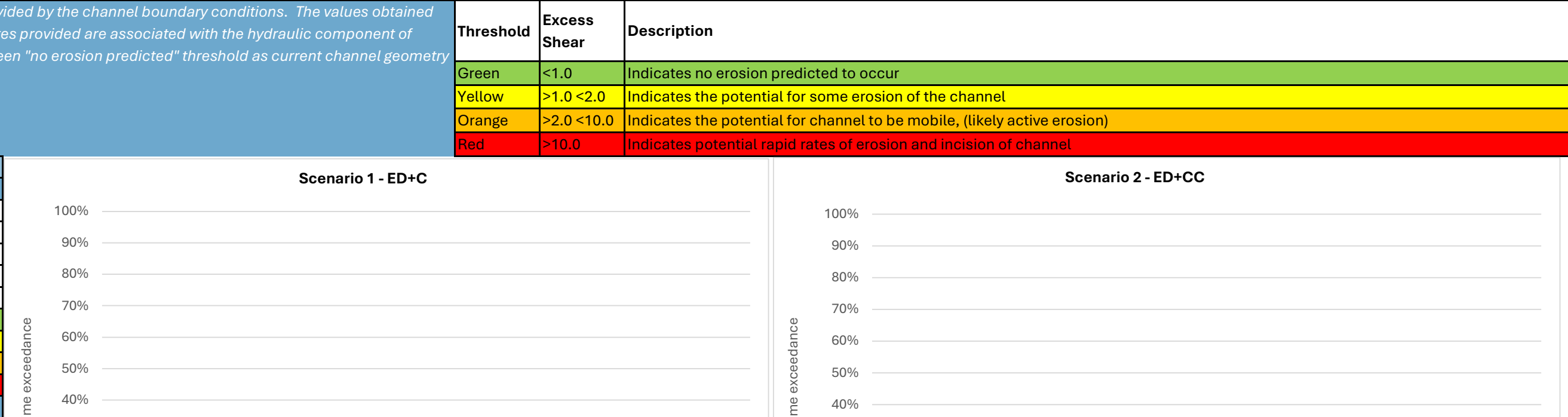
Results - Excess shear exceedance

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel. Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Existing development erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its existing development state.

Boundary shear stress (BSS) - the force exerted on the channel by flow

Excess shear stress (ESS) - the amount of BSS in excess of the critical shear stress threshold for initiating sediment movement

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Scenario 1 ED+C								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 2 ED+CC								

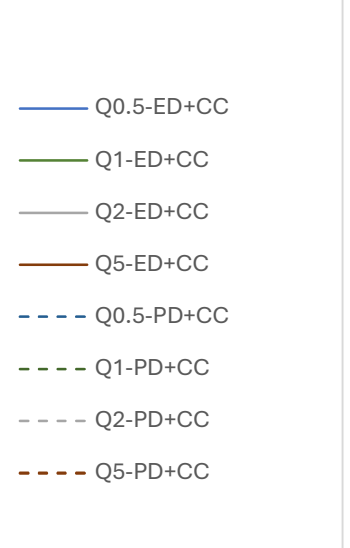
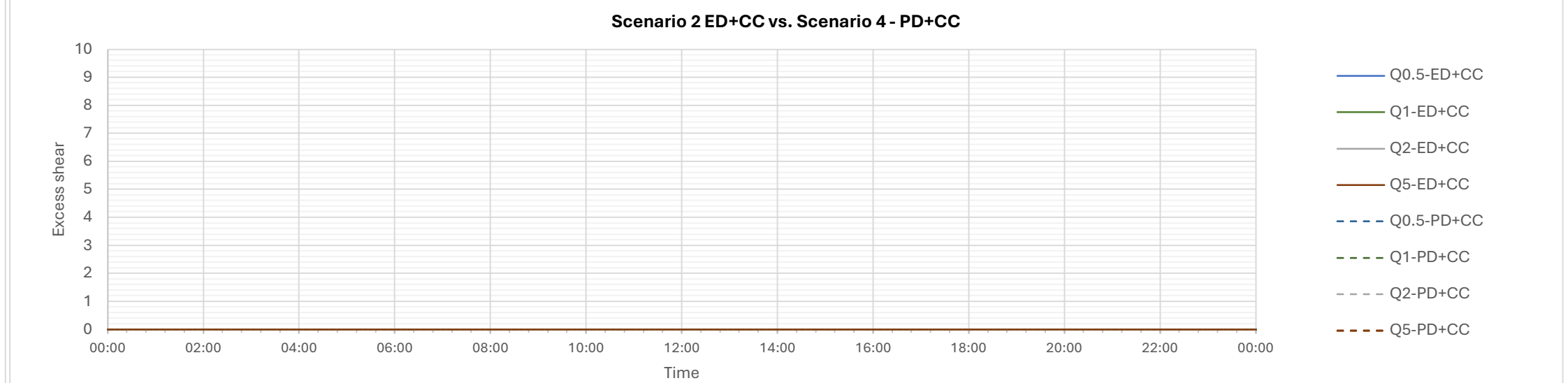
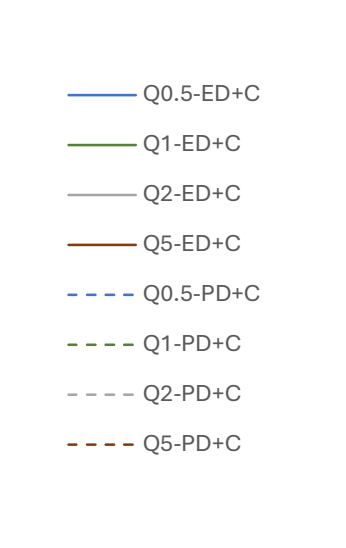
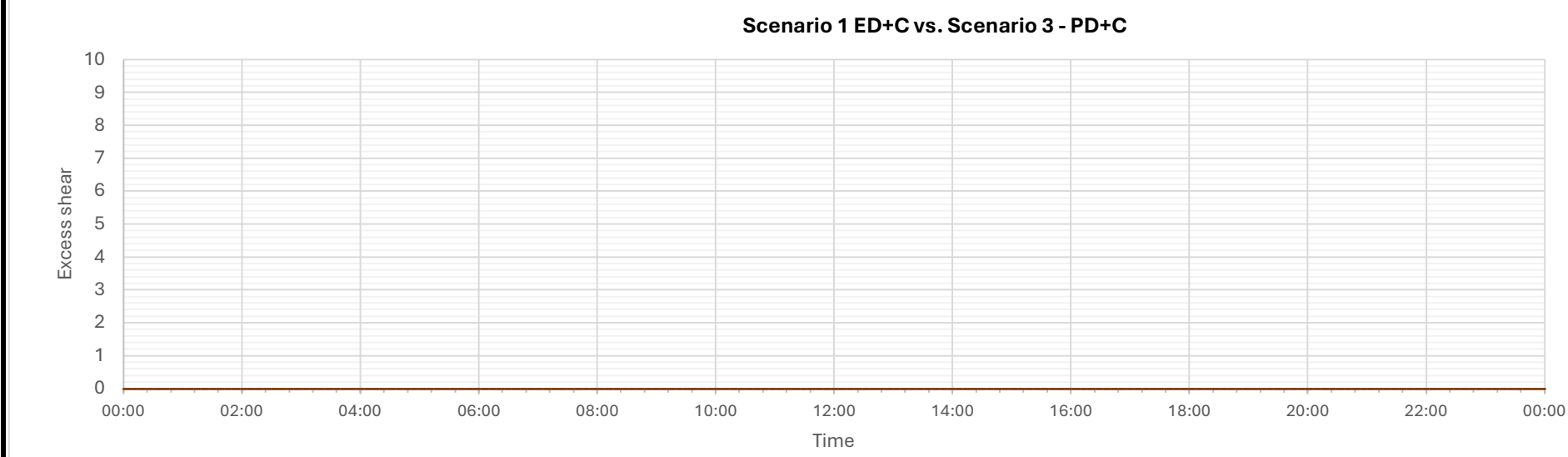


BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 3 PD+C								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 4 PD+CC								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	63.24	0.00	0.00	97.66	123.04
ESS event mean	0.00	0.00	0.00	1.92	0.00	0.00	2.96	3.73
ESS exceedance (min)								
<1 (min)	1440	1440	1440	720	1440	1440	620	510
>1 & <2 (min)	0	0	0	70	0	0	100	150
>2 & <10 (min)	0	0	0	650	0	0	720	780
>10 (min)	0	0	0	0	0	0	0	0
Scenario 6 PD+CC+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	68.85	0.00	0.00	104.52	131.14
ESS event mean	0.00	0.00	0.00	2.09	0.00	0.00	3.17	3.97
ESS exceedance (min)								
<1 (min)	1440	1440	1440	670	1440	1440	500	410
>1 & <2 (min)	0	0	0	60	0	0	170	170
>2 & <10 (min)	0	0	0	710	0	0	770	860
>10 (min)	0	0	0	0	0	0	0	0

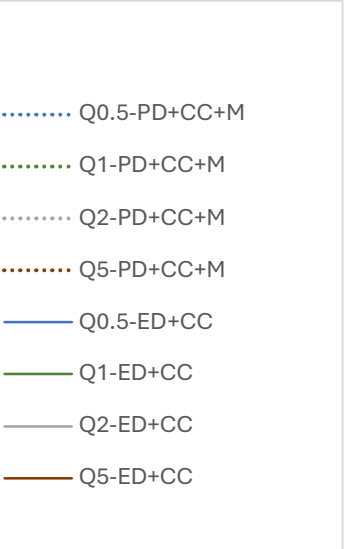
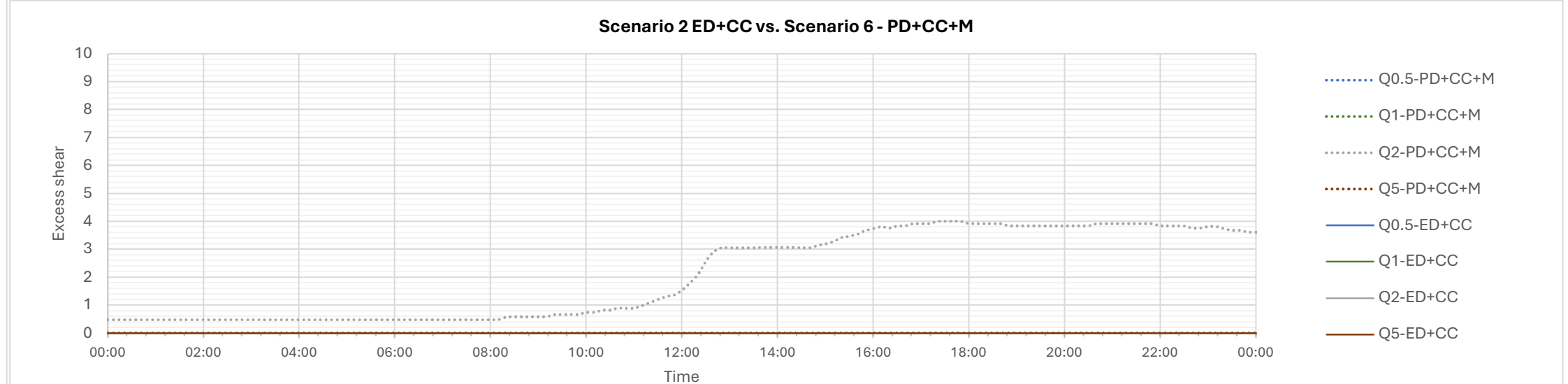
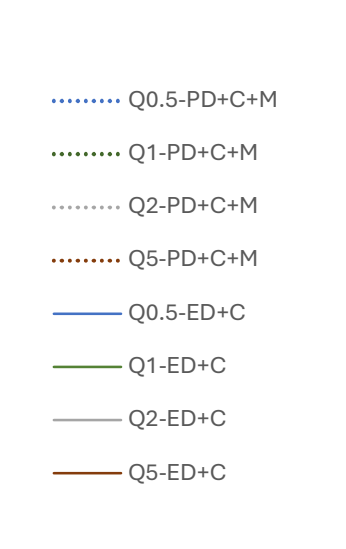
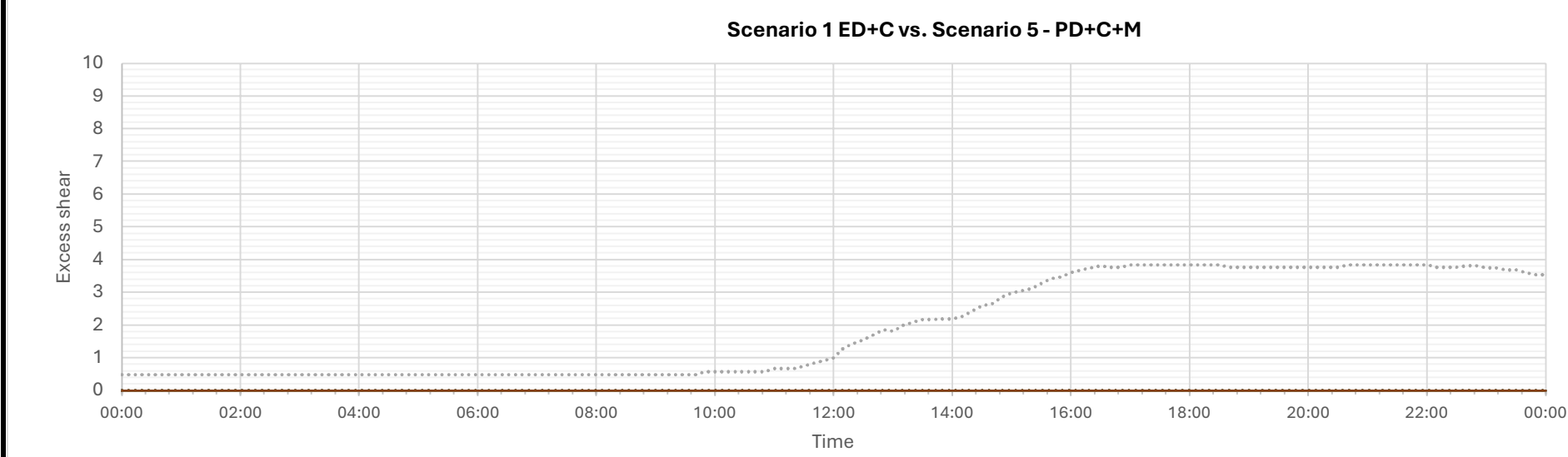
Results - Small event excess shear exceedance

These represent frequent events. Shear stress exceedances in these events indicate erosion is likely to occur often and in smaller flows.

Effect of development



Effect of post-development mitigation



Results - Excess shear comparisons

This analysis examines the percentage change in two erosion metrics between scenarios. Peak excess shear is the excess shear stress value during an event's peak flow, average excess shear takes the mean value throughout an event.

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Effect of development without climate change (Scenario 1 vs. Scenario 3)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change (Scenario 2 vs. Scenario 4)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development without climate change with mitigation (Scenario 1 vs. Scenario 5)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change with mitigation (Scenario 2 vs. Scenario 6)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

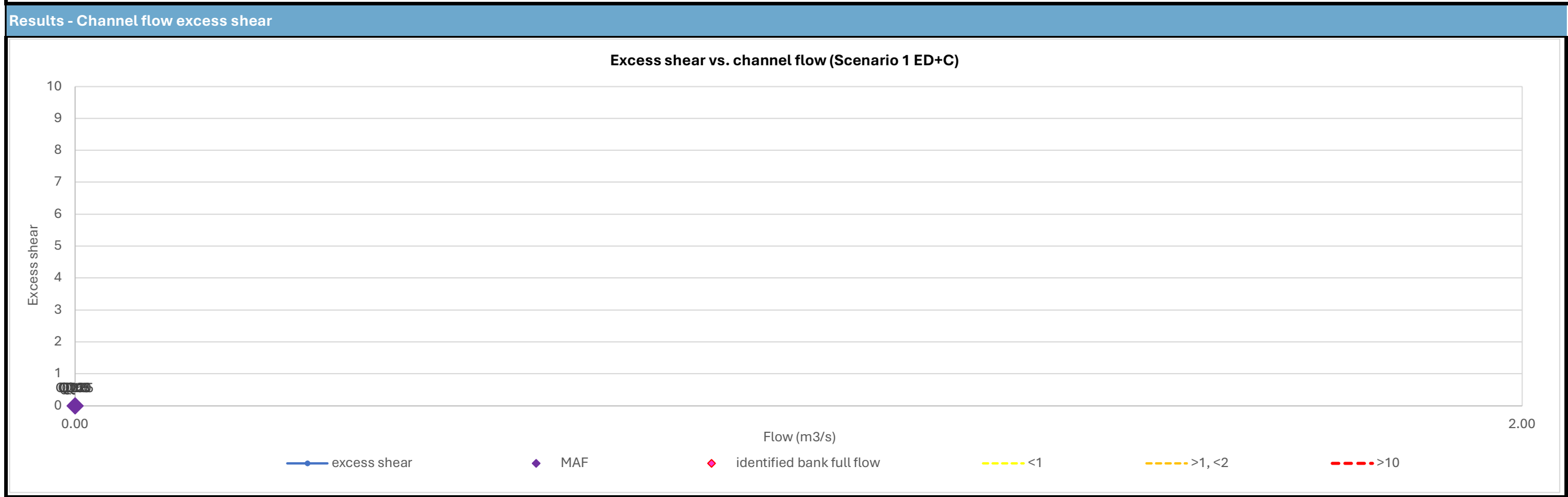
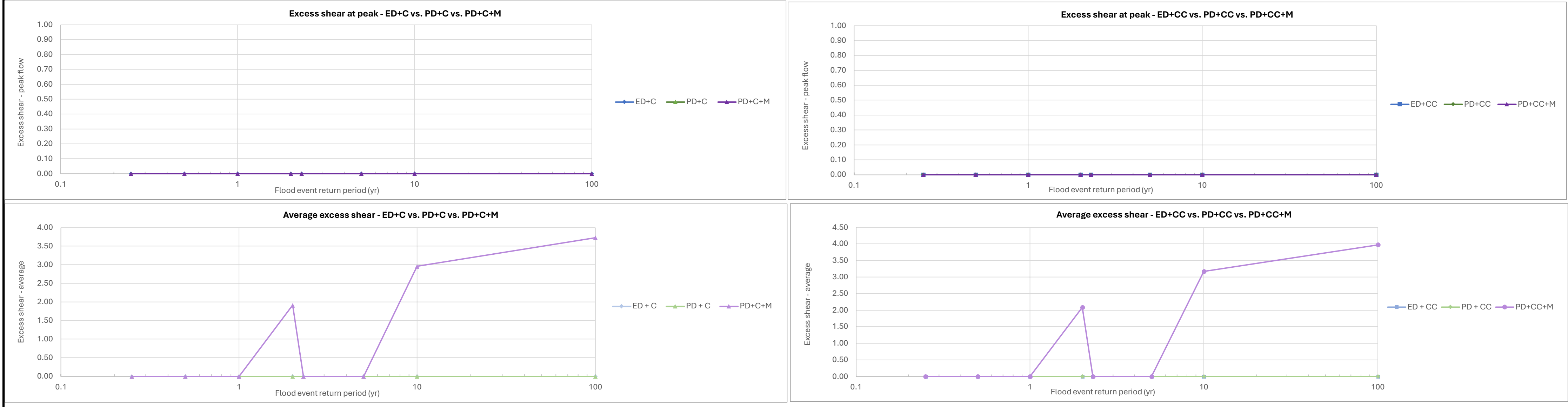
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr



test project

Site

Site Photo

Site Map

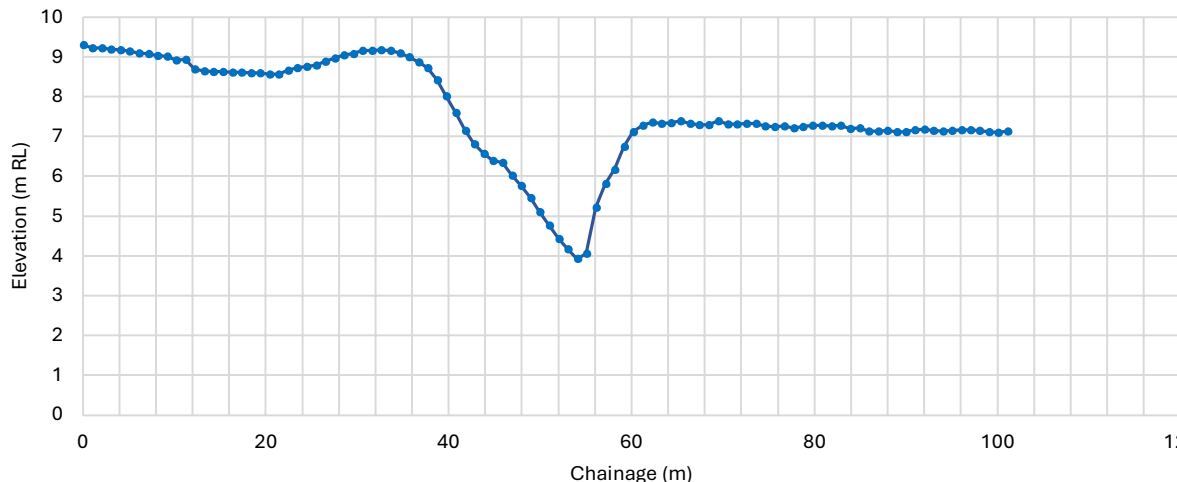
Input summary

Catchment parameters

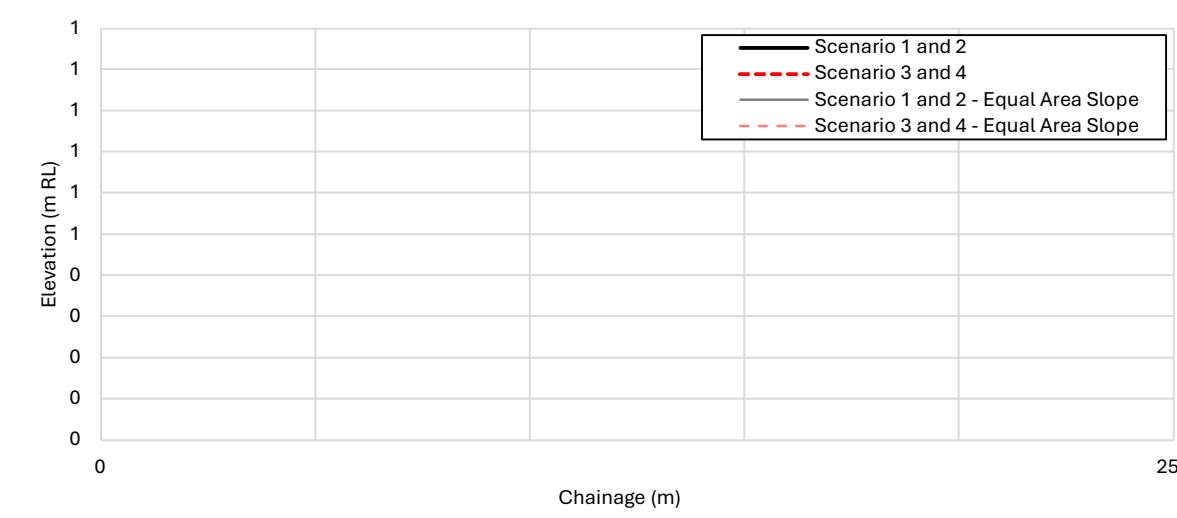
	0	0	0	0	0	0
	0.00	0.00	0.00	0.00	0.00	0
Total Area (km²)	A	0.00	0.00	0.00	0.00	0.00
Perviousness		0.0%	0.0%	0.0%	0.0%	0.0%
Pervious Area (km²)		0.00	0.00	0.00	0.00	0.00
Impervious Area (km²)		0.00	0.00	0.00	0.00	0.00
Channellisation Factor	C	0	0	0	0	0
Catchment Length (km)	L	0.00	0.00	0.00	0.00	0.00
Catchment Slope (m/m)	Sc	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00
Curve Numbers						
Soil Type	S	0	0	0	0	0
Pervious Areas	CN	0	0	0	0	0
Impervious Areas	CN	98	98	98	98	0
Weighted	CN	98.0	98.0	98.0	98.0	0
TP108						
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.0
Soil Storage (mm)	S	5	5	5	5	0
Time of Concentration (hr)	t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00
Time to Peak (hr)	t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00
P24 Rainfall Depth (mm)						
3 month ARI*		0	0	0	0	0
6 month ARI		0	0	0	0	0
1 year ARI		0	0	0	0	0
2 year ARI		0	0	0	0	0
2.3 year ARI		0	0	0	0	0
5 year ARI		0	0	0	0	0
10 year ARI		0	0	0	0	0
100 year ARI		0	0	0	0	0

Input channel geometry

Cross section profile



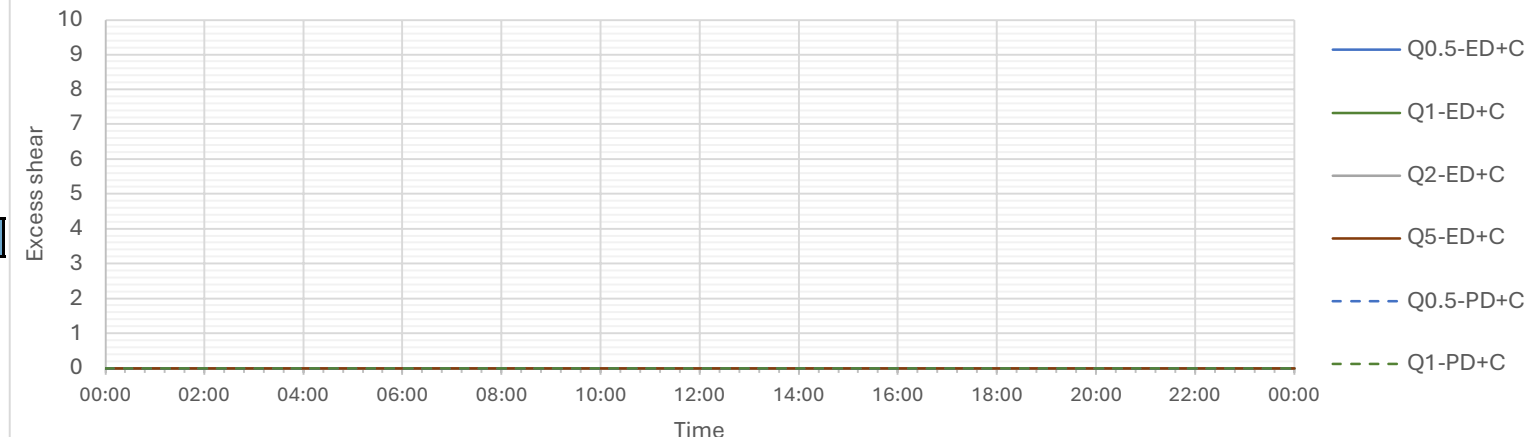
Catchment slope



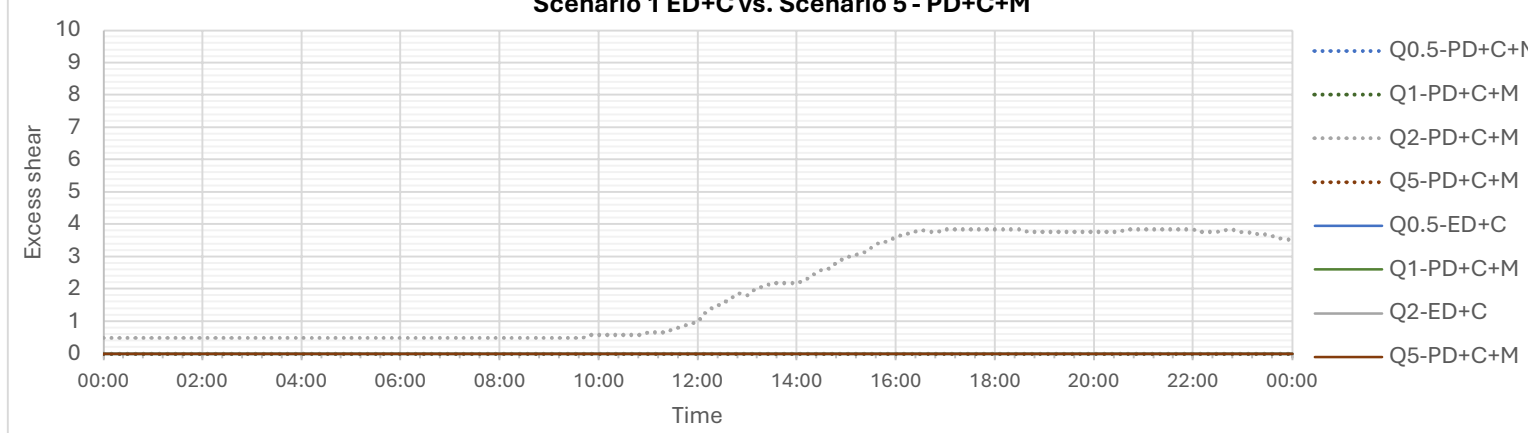
Output shear stress exceedance

ARI (yr)	0.25	0.5	1	2	2.3	5	10	100	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C									Scenario 3 PD+C							
BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS exceedance (min)																
<1 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenario 2 ED+CC									Scenario 4 PD+CC							
BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS exceedance (min)																
<1 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M									Scenario 6 PD+C+M							
BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS exceedance (min)																
<1 (min)	1440	1440	1440	720	1440	1440	620	510	1440	1440	1440	670	1440	1440	500	410
>1 & <2 (min)	0	0	0	70	0	0	100	150	0	0	0	60	0	0	170	170
>2 & <10 (min)	0	0	0	650	0	0	720	780	0	0	0	710	0	0	770	860
>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario 1 ED+C vs. Scenario 3 - PD+C



Scenario 1 ED+C vs. Scenario 5 - PD+C+M



Threshold

Excess Shear

Indication

Green

<1.0

No erosion predicted to occur

Yellow

>1.0 <2.0

Potential for some erosion of the channel

Orange

>2.0 <10.0

Potential for channel to be mobile, (likely active erosion)

Red

>10.0

Potential rapid rates of erosion and incision of channel

Development effects summary

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

#N/A

Cross-section 5 – No climate change

Erosion screening tool outputs

Test project

Input summary							
Catchment parameters							
		0	0	0	0	0	0
		0	0	0	0	0	0
Total Area (km ²)	A	0.00	0.00	0.00	0.00		
Perviousness		0.00	0.00	0.00	0.00		
Pervious Area (km ²)		0.00	0.00	0.00	0.00		
Impervious Area (km ²)		0.00	0.00	0.00	0.00		
Channelisation Factor	C	0	0	0	0		
Catchment Length (km)	L	0.00	0.00	0.00	0.00		
Catchment Slope (m/m)	Sc	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Curve Numbers							
Soil Type	S	0	0	0	0		
Pervious Areas	CN	0	0	0	0		
Impervious Areas	CN	98	98	98	98		
Weighted	CN	98.0	98.0	98.0	98.0		
TP108							
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Soil Storage (mm)	S	5	5	5	5		
Time of Concentration (hr)	t _c	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Time to Peak (hr)	t _p	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
P24 Rainfall Depth (mm)							
3 month ARI*		0	0	0	0	0	0
6 month ARI		0	0	0	0	0	0
1 year ARI		0	0	0	0	0	0
2 year ARI		0	0	0	0	0	0
2.3 year ARI		0	0	0	0	0	0
5 year ARI		0	0	0	0	0	0
10 year ARI		0	0	0	0	0	0
100 year ARI		0	0	0	0	0	0

* 3 month ARI estimated rainfall does not fits well in regression calculation, not recommend to use.

Results - TP108 Peak Flow Analysis								
ARI (yr)	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 2 ED+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 3 PD+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 4 PD+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 5 PD+C+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 6 PD+CC+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff

#N/A

Results - Bank Full Channel Identification	
Approximate channel width (m)	11.91
Bank full water depth (m)	#N/A
Bank full flow (m ³ /s)	#N/A
Bank full flow excess shear	#N/A
Annual fullest flow as represented by the mean annual flood (m ³ /s)	0.00
Annual fullest flow as represented by the mean annual flood excess shear	0.0

Results - 24hr Runoff Hydrographs



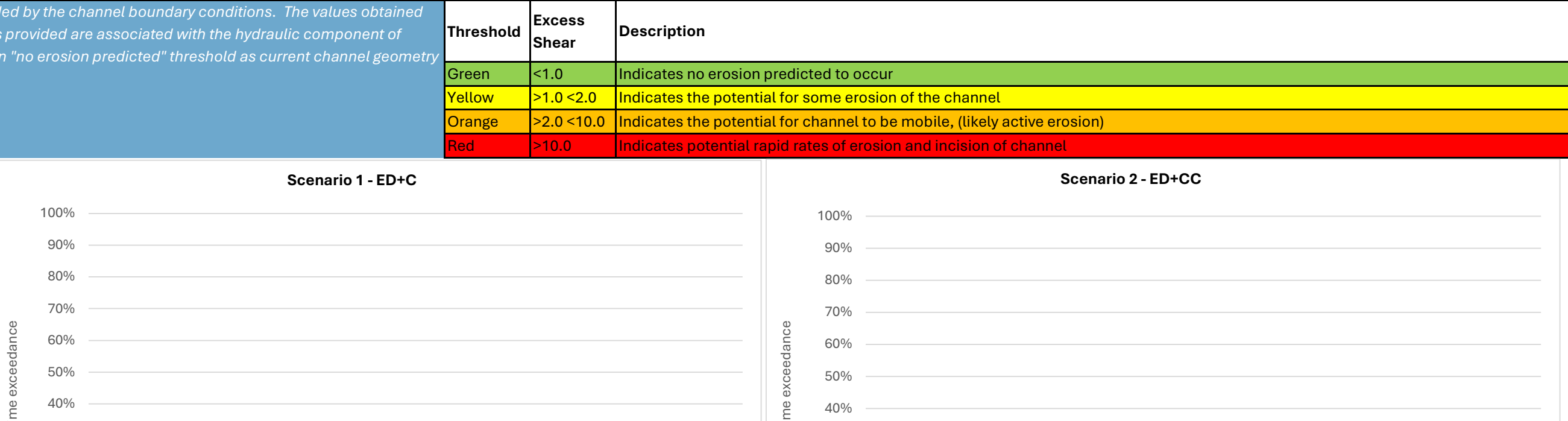
Results - Excess shear exceedance

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel. Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Existing development erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its existing development state.

Boundary shear stress (BSS) - the force exerted on the channel by flow

Excess shear stress (ESS) - the amount of BSS in excess of the critical shear stress threshold for initiating sediment movement

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Scenario 1 ED+C								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 2 ED+CC								

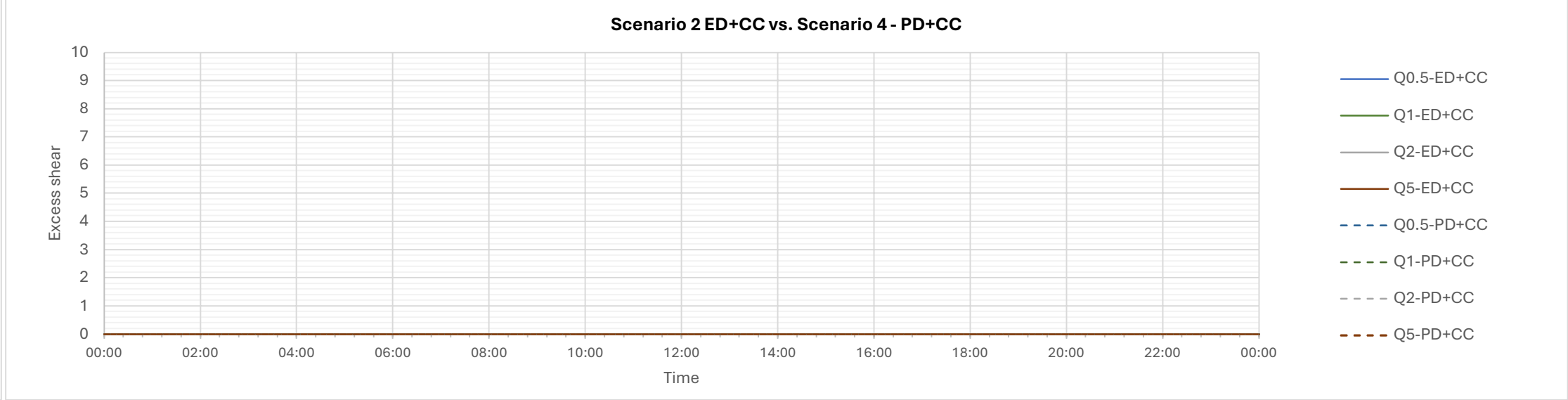
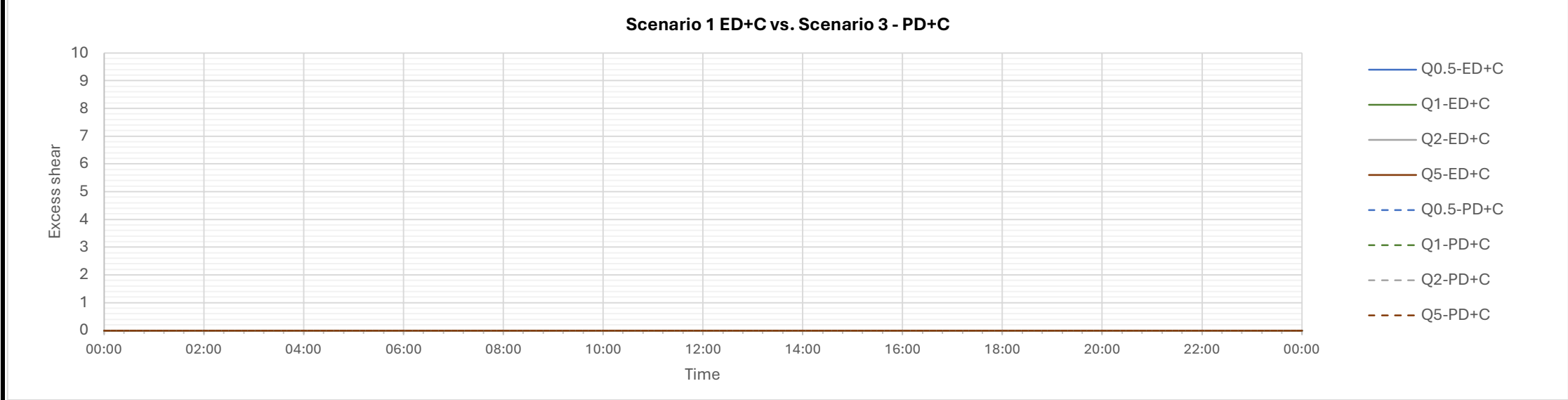


BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 3 PD+C								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 4 PD+CC								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	#N/A	0.00	0.00	#N/A	88.64
ESS event mean	0.00	0.00	0.00	#N/A	0.00	0.00	#N/A	2.69
ESS exceedance (min)								
<1 (min)	1440	1440	1440	670	1440	1440	570	430
>1 & <2 (min)	0	0	0	270	0	0	130	250
>2 & <10 (min)	0	0	0	470	0	0	730	760
>10 (min)	0	0	0	0	0	0	0	0
Scenario 6 PD+CC+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	#N/A	0.00	0.00	#N/A	91.75
ESS event mean	0.00	0.00	0.00	#N/A	0.00	0.00	#N/A	2.78
ESS exceedance (min)								
<1 (min)	1440	1440	1440	660	1440	1440	530	410
>1 & <2 (min)	0	0	0	110	0	0	170	230
>2 & <10 (min)	0	0	0	640	0	0	730	800
>10 (min)	0	0	0	0	0	0	0	0

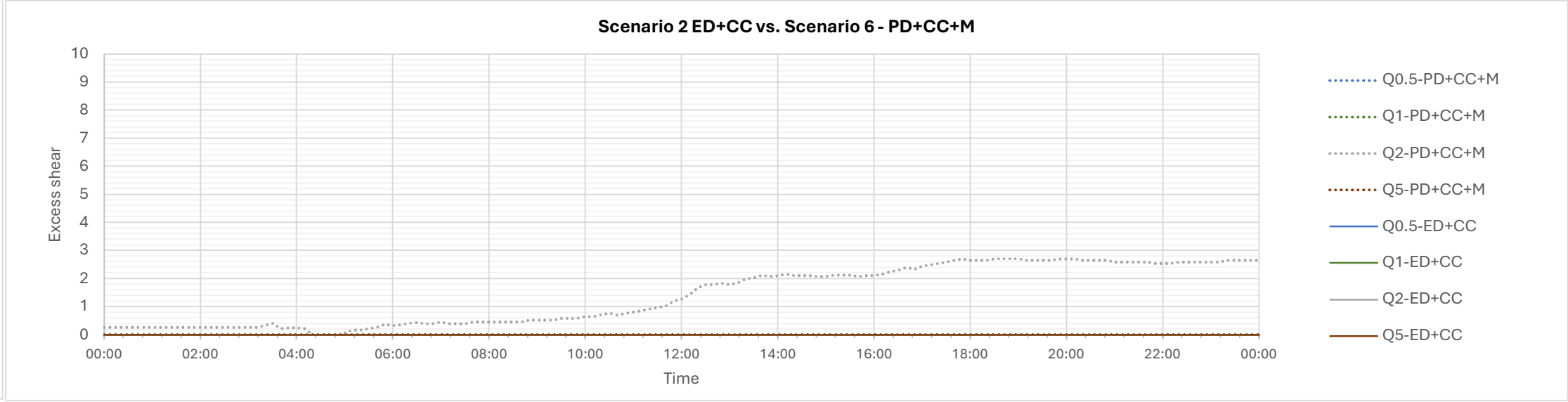
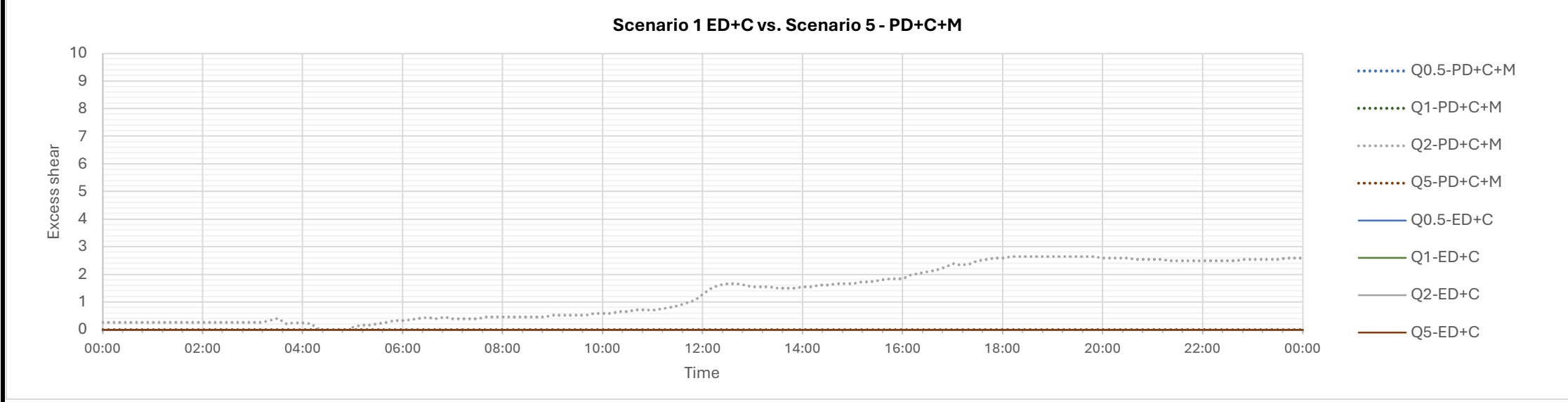
Results - Small event excess shear exceedance

These represent frequent events. Shear stress exceedances in these events indicate erosion is likely to occur often and in smaller flows.

Effect of development



Effect of post-development mitigation



Results - Excess shear comparisons

This analysis examines the percentage change in two erosion metrics between scenarios. Peak excess shear is the excess shear stress value during an event's peak flow, average excess shear takes the mean value throughout an event.

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Effect of development without climate change (Scenario 1 vs. Scenario 3)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change (Scenario 2 vs. Scenario 4)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development without climate change with mitigation (Scenario 1 vs. Scenario 5)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change with mitigation (Scenario 2 vs. Scenario 6)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

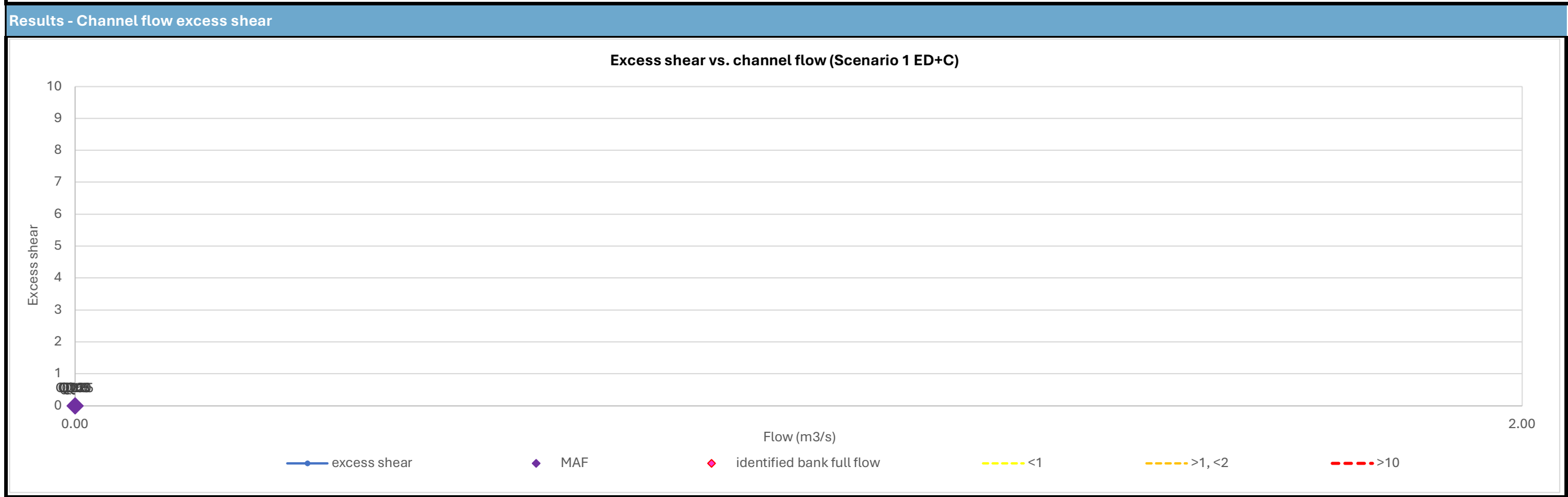
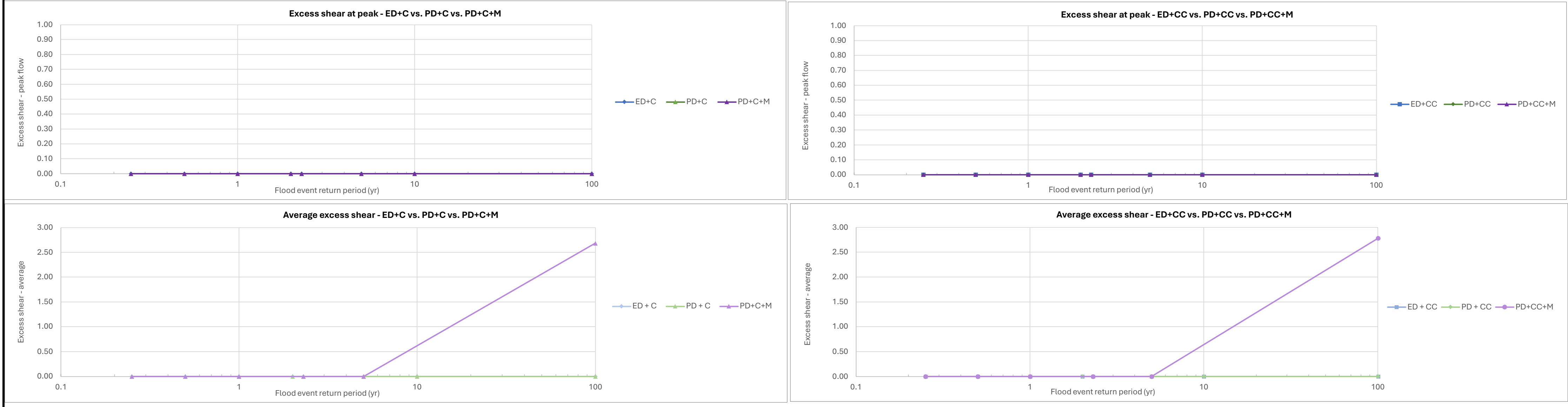
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr



[illegible]

Cross-section 5 – 3.8°C climate change

Erosion screening tool outputs

Test project

Input summary							
Catchment parameters							
		0	0	0	0	0	0
		0	0	0	0	0	0
Total Area (km ²)	A	0.00	0.00	0.00	0.00		
Perviousness		0.00	0.00	0.00	0.00		
Pervious Area (km ²)		0.00	0.00	0.00	0.00		
Impervious Area (km ²)		0.00	0.00	0.00	0.00		
Channelisation Factor	C	0	0	0	0		
Catchment Length (km)	L	1.79	1.79	0.00	0.00		
Catchment Slope (m/m)	Sc	0.031	0.031	#DIV/0!	#DIV/0!		
Curve Numbers							
Soil Type	S	0	0	0	0		
Pervious Areas	CN	0	0	0	0		
Impervious Areas	CN	98	98	98	98		
Weighted	CN	98.0	98.0	98.0	98.0		
TP108							
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
Soil Storage (mm)	S	5	5	5	5		
Time of Concentration (hr)	t _c	0.17	0.17	#DIV/0!	#DIV/0!		
Time to Peak (hr)	t _p	0.11	0.11	#DIV/0!	#DIV/0!		
P24 Rainfall Depth (mm)							
3 month ARI*		0	0	0	0	0	0
6 month ARI		0	0	0	0	0	0
1 year ARI		0	0	0	0	0	0
2 year ARI		0	0	0	0	0	0
2.3 year ARI		0	0	0	0	0	0
5 year ARI		0	0	0	0	0	0
10 year ARI		0	0	0	0	0	0
100 year ARI		0	0	0	0	0	0

* 3 month ARI estimated rainfall does not fits well in regression calculation, not recommend to use.

Results - TP108 Peak Flow Analysis								
ARI (yr)	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 2 ED+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 3 PD+C								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 4 PD+CC								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 5 PD+C+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Scenario 6 PD+CC+M								
Peak flow rate, q _p (m ³ /s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peak velocity, v _p (m/s)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Peak Froude number, Fr	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff
Runoff Volume, V ₂₄ (m ³)	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff	No runoff

#N/A

Results - Bank Full Channel Identification	
Approximate channel width (m)	11.91
Bank full water depth (m)	#N/A
Bank full flow (m ³ /s)	#N/A
Bank full flow excess shear	#N/A
Annual fullest flow as represented by the mean annual flood (m ³ /s)	0.00
Annual fullest flow as represented by the mean annual flood excess shear	0.0

Results - 24hr Runoff Hydrographs



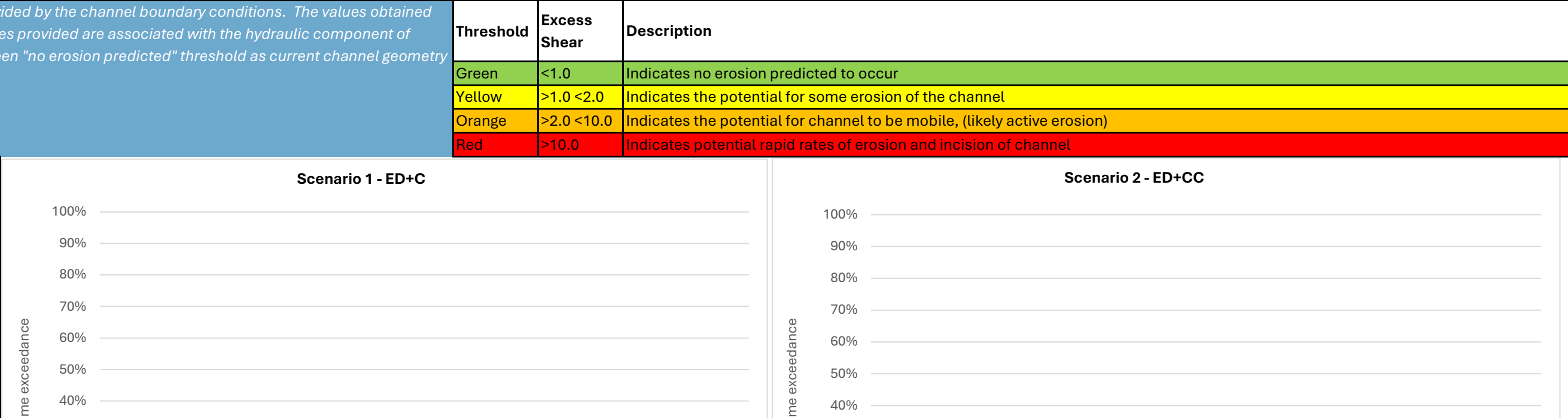
Results - Excess shear exceedance

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel. Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Existing development erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its existing development state.

Boundary shear stress (BSS) - the force exerted on the channel by flow

Excess shear stress (ESS) - the amount of BSS in excess of the critical shear stress threshold for initiating sediment movement

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Scenario 1 ED+C								
BSS at peak (N/m ²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 2 ED+CC								

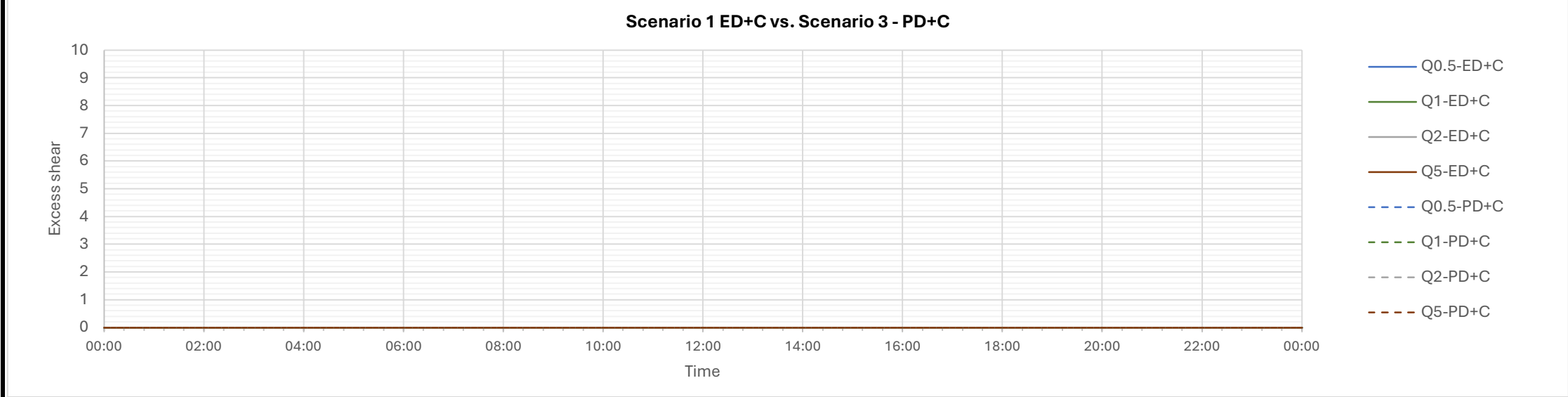


BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 3 PD+C								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 4 PD+CC								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS event mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ESS exceedance (min)								
<1 (min)	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	#N/A	0.00	0.00	#N/A	75.82
ESS event mean	0.00	0.00	0.00	#N/A	0.00	0.00	#N/A	2.30
ESS exceedance (min)								
<1 (min)	1440	1440	1440	660	1440	1440	570	450
>1 & <2 (min)	0	0	0	240	0	0	130	240
>2 & <10 (min)	0	0	0	510	0	0	730	750
>10 (min)	0	0	0	0	0	0	0	0
Scenario 6 PD+CC+M								
BSS at peak (N/m²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESS at peak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSS event mean	0.00	0.00	0.00	#N/A	0.00	0.00	#N/A	77.83
ESS event mean	0.00	0.00	0.00	#N/A	0.00	0.00	#N/A	2.36
ESS exceedance (min)								
<1 (min)	1440	1440	1440	650	1440	1440	530	430
>1 & <2 (min)	0	0	0	110	0	0	170	230
>2 & <10 (min)	0	0	0	650	0	0	730	780
>10 (min)	0	0	0	0	0	0	0	0

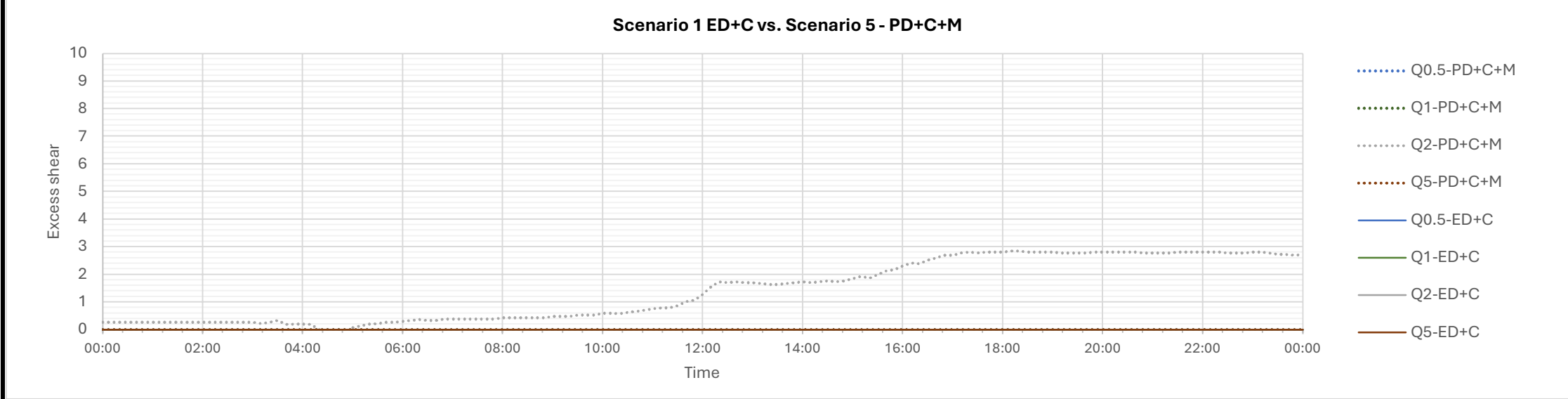
Results - Small event excess shear exceedance

These represent frequent events. Shear stress exceedances in these events indicate erosion is likely to occur often and in smaller flows.

Effect of development



Effect of post-development mitigation



Results - Excess shear comparisons

This analysis examines the percentage change in two erosion metrics between scenarios. Peak excess shear is the excess shear stress value during an event's peak flow, average excess shear takes the mean value throughout an event.

ARI (yr)	0.25	0.5	1	2	2.30	5	10	100
Effect of development without climate change (Scenario 1 vs. Scenario 3)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change (Scenario 2 vs. Scenario 4)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development without climate change with mitigation (Scenario 1 vs. Scenario 5)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Effect of development with climate change with mitigation (Scenario 2 vs. Scenario 6)								
Peak excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Average excess shear % change	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):

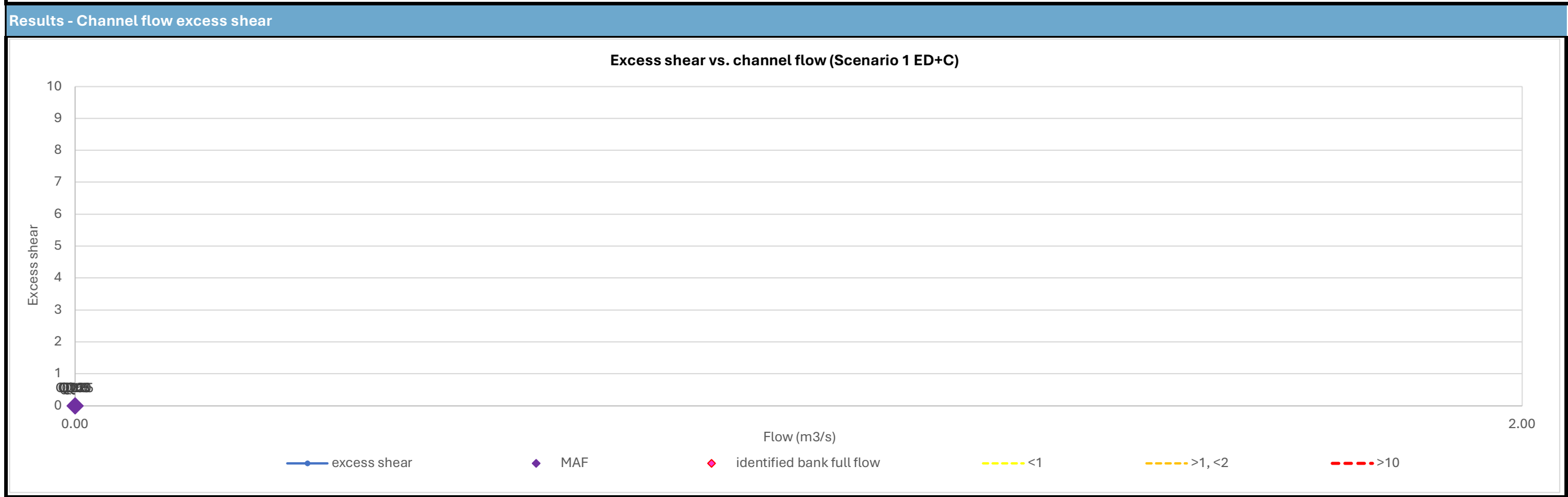
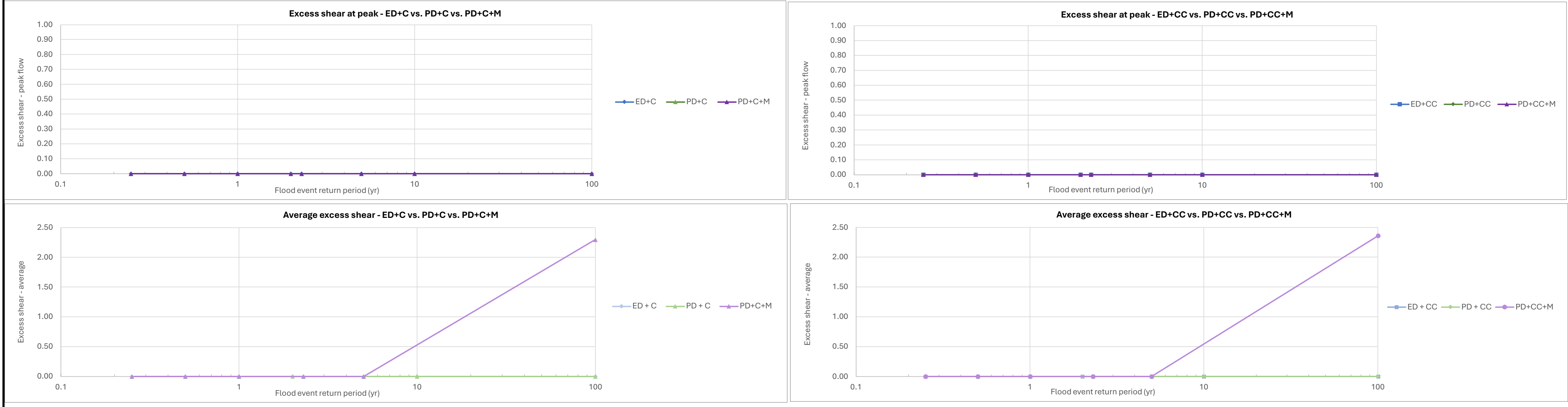
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance at peak in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr
Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).
Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr



Test project

Site

Site Photo

Site Map

Input summary

Catchment parameters

	0	0	0	0	0	0
	0.00	0.00	0.00	0.00	0	0
Total Area (km²)	A	0.00	0.00	0.00	0.00	0.00
Perviousness		0.0%	0.0%	0.0%	0.0%	0.0%
Pervious Area (km²)		0.00	0.00	0.00	0.00	0.00
Impervious Area (km²)		0.00	0.00	0.00	0.00	0.00
Channelisation Factor	C	0	0	0	0	0
Catchment Length (km)	L	1.79	1.79	0.00	0.00	0.00
Catchment Slope (m/m)	Sc	0.03	0.03	#DIV/0!	#DIV/0!	0.00
Soil Type	S	0	0	0	0	0
Pervious Areas	CN	0	0	0	0	0
Impervious Areas	CN	98	98	98	98	0
Weighted	CN	98.0	98.0	98.0	98.0	0
Initial Abstraction (mm)	Ia	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.0
Soil Storage (mm)	S	5	5	5	5	0
Time of Concentration (hr)	t _c	0.17	0.17	#DIV/0!	#DIV/0!	0.00
Time to Peak (hr)	t _p	0.11	0.11	#DIV/0!	#DIV/0!	0.00
3 month ARI*		0	0	0	0	0
6 month ARI		0	0	0	0	0
1 year ARI		0	0	0	0	0
2 year ARI		0	0	0	0	0
2.3 year ARI		0	0	0	0	0
5 year ARI		0	0	0	0	0
10 year ARI		0	0	0	0	0
100 year ARI		0	0	0	0	0

Input channel geometry

Cross section profile

Catchment slope

Input hydrographs

Scenario 1 ED+C vs. Scenario 3 - PD+C

Scenario 1 ED+C vs. Scenario 5 - PD+C+M

Output shear stress exceedance

ARI (yr)	0.25	0.5	1	2	2.3	5	10	100	0.25	0.5	1	2	2.3	5	10	100
Scenario 1 ED+C									Scenario 3 PD+C							
BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS exceedance (min)																
<1 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenario 2 ED+CC									Scenario 4 PD+CC							
BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS exceedance (min)																
<1 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1 & <2 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenario 5 PD+C+M									Scenario 6 PD+CC+M							
BSS at peak (N/m²)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS at peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESS exceedance (min)																
<1 (min)	1440	1440	1440	660	1440	1440	570	450	1440	1440	1440	650	1440	1440	590	430
>1 & <2 (min)	0	0	0	240	0	0	130	240	0	0	0	110	0	0	170	230
>2 & <10 (min)	0	0	0	510	0	0	730	750	0	0	0	650	0	0	730	780
>10 (min)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Development effects summary

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Without considering climate change, proposed development without mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

Considering climate change, proposed development with mitigation is predicted to increase the risk of shear stress exceedance on average in the 0.5yr, 1yr, 2yr, 2.3yr, 5yr, 10yr, 100yr ARI event(s).

Marginal risk (<1% increase):
Moderate risk (1% - 5% increase):
High risk (>5% increase): 0.5yr 1yr 2yr 2.3yr 5yr 10yr 100yr

#N/A

Appendix 5 – Stream erosion measures toolbox

#	Mitigation measure	Description	Why implement?	Potential advantages	Potential disadvantages
1	Esplanade reserve	Native vegetation establishment and management includes the management of both remnant vegetation and the establishment of new plant species growing on or in a site, reach or waterway	Vegetating riparian land through targeted species selection and placement can improve channel stability and reduce sediment transport	Streambank stability, improved water quality, enhanced riparian vegetation and improve terrestrial and aquatic ecosystem health	
2	Stock management	Stock management is the act of managing the access of livestock to waterways including riparian land	Stock management is implemented to retain or enhance the health of riparian vegetation and associated increased resistance against erosion forces and reduced sediment transport from the reach	Streambank stability, improved water quality, enhanced riparian vegetation and improve terrestrial and aquatic ecosystem health	Increased weed problems
3	Bank battering	Bank battering involves modification of the riverbank to a design bank angle. It can be undertaken to reduce erosion and provide conditions suitable for vegetation establishment	Bank battering is implemented to provide a relatively stable surface on which vegetation can be established. Bank battering can be used to accelerate the rate of recovery from past channel incision (where the deepening process has finished, and the dominant process is widening).	Can increase the rate of recovery and reduce the downstream impact of an incised stream system (for example through reduced erosion rates and downstream sedimentation). The approach can be applied to reduce lateral rill erosion on banks and increase the success rate for vegetation establishment.	The approach can remove bank diversity by creating a uniform surface. The approach can remove features such as vegetation providing some stability to the riverbanks and initiate erosion, which may destroy undercut banks, overhanging vegetation and other habitat features associated with steep riverbanks. Unconsolidated material on a lower bank will in most cases be removed during post-battering flow events increasing sediment loads downstream and further destabilising the bank
4	Bed load sediment retention	Management of sediment can be used for stabilising and rehabilitating incised streams through bed seeding or alternative sediment trapping	Sediment retention works can be used to capture the sediment load moving downstream. The works typically comprise structures that increase roughness, encourage deposition and reduce ongoing sediment movement. Sediment trapping structures can vary but often include logs and wire mesh or rows of piles placed perpendicular to flow.	Promotes deposition and accumulation of sediments and seeds. Incision control and sediment retention in aggrading systems.	Works can result in riverbank instabilities in the immediate vicinity of the structure through flow redirection. Timber elements may be dislodged and mobilised in flood events. Potential localised occurrence of overbank flooding may not accord with adjoining landholder's objectives.
5	Engineered log jams	Engineered log structures comprise the construction of large timber amalgams from individual pieces of timber. The purpose of the structures is to create greater hydraulic, and habitat influence than that achieved with individual pieces of timber.	Engineered log jams are implemented to provide habitat and to influence the erosion and deposition of sediment (aggradation).	Maintenance of bed diversity by causing local scour and deposition. Successful implementation can, over time, increase the channel complexity (such as meander geometry and bed diversity). Successful implementation may increase hydraulic roughness and reduce system wide stream power.	Works can result in riverbank instabilities in the immediate vicinity of structure. Timber elements may be dislodged and mobilised in flood events. Potential localised occurrence of overbank flooding may not accord with adjoining landholder's objectives.
6	Large wood installation	: Large wood installation, comprises the installation and management of single or multiple pieces of wood in the stream system to create habitat and flow diversity, reduce sediment transport (by increasing hydraulic roughness) and/or create scour holes and aid in vegetation establishment	it may be used in a reach to increase hydraulic roughness, reduce overall velocity and to encourage sedimentation/aggradation and/or instream vegetation growth within a reach.	Provision of stable instream structure in mobile bed systems. Reduced sediment transport through a reach. Aids establishment of instream vegetation.	Works can result in riverbank instabilities in the immediate vicinity of structure. Timber elements may be dislodged and mobilised in flood events. Potential localised occurrence of overbank flooding.
7	Log sills	Log sills are single or multiple pieces of large wood anchored to the channel bed and bank most commonly for the purpose of creating pool habitat, trapping sediment or as a grade control structure. Consisting of large logs usually larger than 600 mm in diameter, they are usually placed perpendicular to the flow and across the channel.	Log sills are used to create pool habitat, assist fish migration through the provision of a range of flow velocities, provide instream woody habitat and to control bed erosion by trapping and holding bedload sediment. Alternatively, it may be used in a reach as a bed grade control tool to help mitigate incision.	Provision of stable instream structure in incising bed systems. Create physical and hydraulic diversity in uniform channels.	Outflanking, erosion and sediment generation may become a problem if logs are not keyed into riverbanks correctly. Prone to undermining and outflanking without appropriate rock beaching
8	Wood revetment	Wood revetments are protective structures used to stabilise riverbanks, they are designed to maintain the bank slope or to protect it from erosion. Typically consisting of hardwood logs and driven timber piles they are founded on the bed of the stream and generally extend up the portion of the bank threatened by erosion	Wood revetment is used as a form of armouring of riverbanks against erosion. This technique is often undertaken as an alternative to hard engineering and is based on bioengineered approaches to streambank protection and in reshaped banks. Logs with rootballs attached provide a more natural approach to toe protection.	Reduces near bank velocity and shear stress (and riverbank erosion) by increasing hydraulic roughness along the lower bank. Promotes sediment depositions and provide favourable conditions for vegetation establishment.	The approach may not address the cause of erosion and as a consequence excess energy within the system may still cause erosion elsewhere. Approach is not sympathetic to the planform evolution of meandering rivers. Hence, has potential to cause planform instabilities and continuing erosion in the long term.

9	Pile fields	Pile fields, comprise several individual lines (groynes), comprising timber piles. Each timber pile is driven vertically (or near vertically) into the stream bed and / or bank. Pile fields have replaced the use of timber pile and rail structures. Pile fields and their individual groynes are permeable, allowing water to flow through the structures at a reduced velocity, resulting in deposition and accumulation of sediments. These structures are typically designed to occupy a portion of the channel width on the outside of a meander to control erosion. However, pile fields can also be designed to occupy the full channel width to collect and retain sediment across the channel.	Pile fields mitigate bank erosion by reducing near-bank flow velocity and increasing fine and coarse sediment deposition. Reduction of flow velocity within pile field promotes sediment deposition and accumulation of seeds, creating favourable conditions for riparian vegetation establishment. The establishment of vegetation along the lower bank can help provide long term stability to the bank beyond the design life of the pile fields.	Stream bank erosion control. Promotes deposition and accumulation of sediments and seeds.	Approach requires access to the riverbank and channel bed by machinery and field crews and associated instream and riverbank disturbance that will take some time to recover. Not suited to cobble bed streams where driving timber piles may not viable.
10	Rock beaching	Rock beaching involves the placement of quarried rock on riverbanks. The rock is founded on the bed of the stream and generally extends up the portion of the bank threatened by erosion. The technique provides localised protection of riverbanks and does not address system wide processes.	Rock beaching is used as a form of armouring of riverbanks against erosion. This technique is often undertaken to protect economic assets such as bridges. It is also often used in conjunction with techniques such as alignment training and rock chutes to reduce the risk of these structures failing due to bank erosion	Provides instant protection (not reliant on short term vegetation establishment). Streambank erosion control and associated reduction in sediment loads (particularly important when riparian areas are still maturing)	The approach may not address the cause of erosion and as a consequence excess energy within the system may still cause erosion elsewhere. Approach is not sympathetic to the planform evolution of meandering rivers (due to halting of meander migration at treated sites). Hence, has the potential to cause planform instabilities and continuing erosion in the long term. Potential to destroy undercut bank habitat and bank diversity.
11	Rock chutes	Rock chutes generally involve the excavation/reshaping of the bed and banks of a stream and the placement of graded (quarried) rock, often forming a small weir in the stream. Rock chutes provide a hardened, rough surface where flow energy and erosive forces can dissipate.	Rock chutes are constructed to control the gradient of channel beds. However, with careful design they can be used to address other stream management issues such as the provision of fish passage, diversion weirs, sediment stabilisation, flow control structures within constructed wetlands or the creation of riffle and pool habitat.	Reduction in incision, more stable bed substrate and banks. Provision of fish passage through existing weirs. Establishment of pool habitat and pool-riffle sequences by using multiple chutes. Gully head erosion control. Storage of eroded sediment thereby reducing sediment inputs downstream.	Successful implementation will result in reduction in downstream sediment supply, potentially starving downstream reaches. In the absence of a complementary downstream vegetation establishment program, sediment starvation can initiate incision in downstream reaches. Poorly designed and constructed structures can have an adverse impact on fish passage by creating high velocities that are impassable for some fish species or life stages.

APPENDIX F – WETLAND SIZING CALCULATIONS

APPENDIX F – WETLAND SIZING CALCULATIONS



Wetland Design Worksheet

PROJECT NUMBER: P22 - 420
ADDRESS:
BY: KD
Date: 31/05/2024

HYDROLOGY MITIGATION

	95th Pecentile	90th Percentile	
Impervious	28.52	20.71	mm
Pervious	4.12	2.19	mm
Hydrology mitigation	24.4		mm

ASSUMPTIONS (IF ANY)

	Depth (m)	H:1V (m)	Width (m)
Below PWL	0.3	10.0	3.0
	0.7	4.0	2.8
Total	1.0	5.8	
Above PWL	1.0	3.0	
Freeboard	0.5		

Width to length ratio	3
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Allowed 30% contingency for O&M track, setback, other contrainsts etc

WETLAND DESIGN PARAMETERS

Catchment ID	Area (m2)	WQV (m3)	PWV (m3)	Detention (m3)
1	53988	894	447	1054
2	28413	471	235	555
3	55101	913	456	1076
4	368181	6100	3050	7187
5	133010	2204	1102	2596
6	124382	2061	1030	2428
7	61267	1015	508	1196
8	112138	1858	929	2189
9	73227	1213	607	1429
10	28374	470	235	554
11	13536	224	112	264

Below Safety Bench		
Width (m)	Length (m)	Volume (m3)
15.6	35.6	299
11.6	23.6	134
15.6	35.6	299
45.1	124.1	3597
26.1	67.1	1054
25.1	64.1	962
16.6	38.6	351
23.6	59.6	832
18.6	44.6	468
11.6	23.6	134
8.6	14.6	53

Top of Safety Bench			
Width (m)	Length (m)	Volume (m3)	PWV (m3)
21.6	41.6	218	517
17.6	29.6	119	253
21.6	41.6	218	517
51.1	130.1	1837	5434
32.1	73.1	615	1669
31.1	70.1	568	1531
22.6	44.6	247	599
29.6	65.6	502	1335
24.6	50.6	311	779
17.6	29.6	119	253
14.6	20.6	64	117

Top of detention			
Depth (m)	Width (m)	Length (m)	Detention (m3)
1	27.6	47.6	1106
1	23.6	35.6	681
1	27.6	47.6	1106
1	57.1	136.1	7210
1	38.1	79.1	2680
1	37.1	76.1	2502
1	28.6	50.6	1228
1	35.6	71.6	2245
1	30.6	56.6	1488
1	23.6	35.6	681
1	20.6	26.6	424

Width at base (m)	Length (m)
10.0	30.0
6.0	18.0
10.0	30.0
39.5	118.5
20.5	61.5
19.5	58.5
11.0	33.0
18.0	54.0
13.0	39.0
6.0	18.0
3.0	9.0

Freeboard		
Width (m)	Length (m)	Volume (m3)
0.5	30.6	51
0.5	26.6	39
0.5	30.6	51
0.5	60.1	139
0.5	41.1	82
0.5	40.1	79
0.5	31.6	54
0.5	38.6	75
0.5	33.6	60
0.5	26.6	39
0.5	23.6	30

Contingency 30%			
Width (m)	Length (m)	area (m2)	% area
39.8	65.8	2617	0.061
34.6	50.2	1735	0.076
39.8	65.8	2617	0.059
78.1	180.8	14128	0.048
53.4	106.7	5703	0.054
52.1	102.8	5361	0.054
41.1	69.7	2862	0.058
50.2	97.0	4866	0.054
43.7	77.5	3384	0.058
34.6	50.2	1735	0.076
30.7	38.5	1181	0.109