This document is uncontrolled when printed.

FLOOD DESIGN REPORT

A2I | Albury to Illabo

Package: A2I – Culcairn Station Yard

CONTRACT NUMBER: 0052

PROJECT DOCUMENT NUMBER:

5-0052-210-IHY-G1-RP-0001

Document Control

DOCUMENT TITLE:	Flood Design Report – Culcairn Station Yard		
DOCUMENT OWNER:	Engineering Manager		
PREPARED BY:	Malinda Gunasekera	TITLE:	Engineer, Water
	Yucen Lu	TITLE:	Senior Water Resources Engineer
REVIEWED BY:	Jasmine Lee	TITLE:	Associate Water Resources Engineer
VERIFIED BY:	Eric Lam	TITLE:	Technical Director

Approved by

NAME	TITLE	SIGNATURE	DATE
Zoe Cruice	Engineering Manager		14/02/2025

Revision History

REVISION	REVISION DATE	AMENDMENT	DATE TO CLIENT
A	18/09/2024	DDR Issue for review	18/09/2024
0	14/02/2025	Issued for Use	14/02/2025

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

Specific terms and acronyms used throughout this plan and sub-plans are listed and described in Table 0-1 below.

Table 0-1: Definitions

Term	Definition
A2I	Albury to Illabo
A2P	Albury to Parkes Enhancement Project
AEP	Annual Exceedance Probability
ADC	Assumptions, Dependencies and Constraints
AHD	Australian Height Datum
ALCAM	Australian Level Crossing Assessment Model
ARF	Areal Reduction Factor
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
ARTC	Australian Railway Track Corporation
BoD	Basis of Design
BoM	Bureau of Meteorology
CIZ	Construction Impact Zone
CO	Construct Only
CRS	Coordination Reference System
CSSI	Critical State Significant Infrastructure
D&C	Design and Construct
DCN	Design Change Notice
DDR	Detailed Design Review
EMC	Electromagnetic compatibility
EDPM	Engineering, Design and Project Management
ECMP	Electromagnetic compatibility management plan
EIS	Environmental Impact Statement
FDR	Feasibility Design Review
FS	Finish-Start constraint type
FSL	Finished Surface Level
GDA	Geocentric Datum of Australia
GIR	Geotechnical Interpretative Report
HF	Human Factors
I2S	Illabo to Stockinbingal

IFC	Issued for Construction
IR	Inland Rail
ITC	Incentivised Target Cost
IV	Independent Verifier
Km	Kilometers
LPA	Licensed Project Area
LiDAR	Light Detection and Ranging
MGA	Map Grid of Australia
MIRDA	Master Inland Rail Development Agreement
NCR	Non-Conformance Report
NLPA	Non-Licensed Project Area
NtP	Notice to Proceed
PDR	Preliminary Design Review
PSR	Project Scope and Requirements
QDL	Quantitative Design Limits
RCP	Representative Concentration Pathways
RFFE	Regional Flood Frequency Analysis
REF	Review of Environmental Factors
RFI	Request for Information
S2P	Stockinbingal to Parkes
SAQP	Sampling, Analysis and Quality Plan
SDR	Systems Definition Review
SEMP	System Engineering Management Plan
TfNSW	Transport for New South Wales
TWL	Tail Water Level
UMM	Updated Mitigation Measure
V & V	Verification and Validation
WAD	Works Authorisation Deed
WAE	Work-as-Executed

1. A2P PROJECT INTRODUCTION

1.1. Albury to Parkes (A2P)

As part of the Inland Rail program of projects, the Australian Rail Track Corporation (ARTC) has appointed Martinus as the delivery contractor for the Albury to Parkes (A2P) project, which comprises the brownfield sections between Albury and Illabo (A2I) and Stockinbingal to Parkes (S2P). The greenfield portion between Illabo to Stockinbingal (I2S) is not a part of the A2P project scope.

1.2. Project Scope

The S2P section will be delivered under an REF and as such construction works associated with the two (2) Construct Only packages can commence at Contract Award. The Design and Construct for the other seven (7) projects sites will also commence at Contract Award.

The A2I section will be delivered under an EIS and requires a Notice to Proceed from ARTC before works can commence on site. Design for A2I will however commence at Contract Award. The project received State Planning approval on 8th Oct 2024, and Martinus received the Notice to Proceed from IRPL on 18 Oct 2024.

Within the A2I section there are twenty (20) locations with twenty-nine (29) Design and Construct (D&C) projects of varying degrees of design gate development:

- Murray River bridge (Structure modifications)
- Albury Station Yard (Track slews, track reconfigurations)
- Albury Station Yard Track Slews (retained 3-track alignment)
- Albury Station Yard Footbridge (footbridge replacement), both pre- and post- SDRP-response
- Riverina Highway bridge (Track lowering)
- Billy Hughes bridge (Track lowering)
- Tabletop Yard (Structure modification)
- Culcairn Station Yard (Track slews and bridge removal)
- Henty Yard (Track slews)
- Yerong Creek Yard (Track slews)
- The Rock Yard (Structure modification)
- Uranquinty Yard (Track slews)
- Pearson Street bridge (Track lowering)
- Cassidy Parade footbridge (Bridge replacement), both pre- and post- SDRP-response
- Edmondson Street Bridge (stand-alone road bridge)
- Edmondson Street Footbridge (stand-alone road bridge)
- Edmondson Street bridge and footbridge (combined Bridge replacement), post- SDRP-response
- Wagga Wagga Station Yard (Track slews)
- Wagga Wagga Footbridge (footbridge replacement), both pre- and post- SDRP-response
- Bomen Yard (Track slews)
- Harefield Yard (Track slews)
- Kemp Street Bridge (stand-alone road bridge)
- Kemp Street Footbridge (stand-along footbridge)
- Kemp Street bridge and footbridge (combined Bridge replacement)
- Junee Station Yard (Track slews and bridge removal)
- Olympic Highway Underbridge (Track reconfiguration and Structure modification)
- Junee to I2S dual track section (Track slews)
- LX605 & LX1472 Activations
- LX605 relocation and LX1472 closure, both 16m and 4m slew options

Within the S2P section, there are two (2) Construct Only projects, being:

- Daroobalgie New Loop
- Wyndham Avenue (track lowering)

and seven (7) Design and Construct (D&C) projects, being:

- Milvale Yard (Structure modification)
- Bribbaree Yard (Track slews)
- Quandialla Yard (Structure modification)
- Caragabal Yard (Track slews)
- Wirrinya Yard (Track slews)
- Lachlan River bridge (Structure modifications)
- Forbes Station (Track slews and awning modifications)

The D&C scope typically includes works associated with route clearance to accommodate the new Structure Outline D H F2 clearance envelope, necessary to accommodate the double-stacked freight container trains and this includes:

- Structure modifications
- Track reconfigurations
- Bridge replacements
- Track lowering
- Track slews and level-crossing upgrades
- Bridge removal.

1.3. Site Description

This study conducts a flood assessment for Culcairn Station Yard as shown in Figure 1-1. The background and previous studies for the site are listed below.

Figure 1-1: Site Location

1.3.1. Background

The Culcairn Station Yard design package forms part of the Albury to Illabo (A2I) Section works. The proposed track slew works on Loop Line track are located between Chainage 596+400 km to 596+865km to accommodate the proposed F2M rolling stock operations.

1.4. Objectives

This report has been prepared to support the delivery of the Culcairn Station Yard site work by providing a flood impact assessment for the Issued for Construction (IFC) stage. The flood assessment aims to estimate the flood behaviour within the study area and assess the potential flood impacts as a result of the rail design.

This report should be read in conjunction with the IFC Report– Culcairn Station Yard– (5-0052-210-PEN-G1-RP-0001.)

1.5. Scope

The scope of this study includes:

- Carrying out the flood assessment for the design in the IFC stage for the design events of 5%, 2%, 1% AEPs,1% AEP with climate change and Probable Maximum Flood (PMF).
- Checking flood assessment results against the flood impact and flood immunity criteria.
- Proposing mitigation measures (if required).

1.6. Previous Studies

1.6.1. Flood Studies

The Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013), which covers the Culcairn town catchment, indicated that the Culcairn Station Yard project site is susceptible to a combination of regional flooding from Billabong Creek and local catchment flooding in events greater in magnitude, than the 2% AEP event.

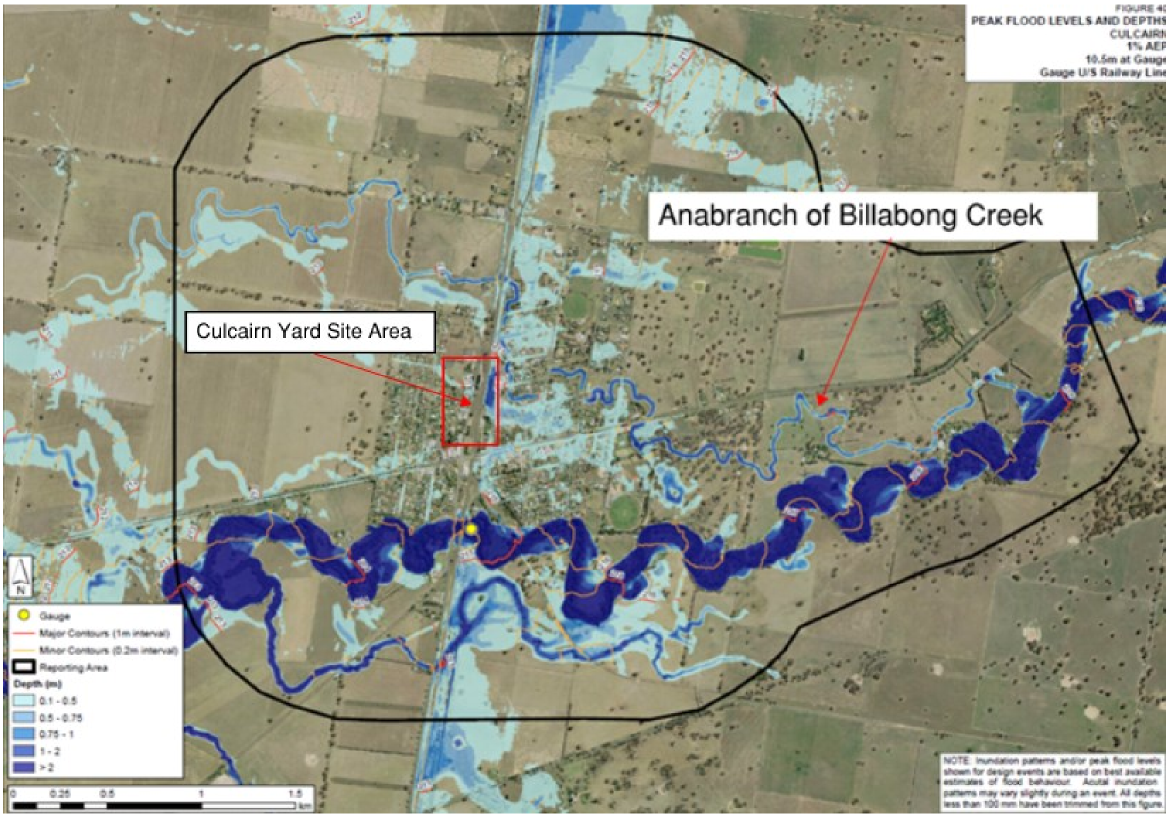


Figure 1-2: 1% AEP Flood Extent showing Billabong Creek Anabranch (Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013)

1.6.2. Reference Design

A high-level assessment using a drainage model was undertaken for the Culcairn Station Yard site during Reference Design, as outlined in the following reports:

- Reference Design Report Albury (2-0008-210-PEN-02-RP-0002.)
- A2I Technical Paper 11 (2-0008-210-EAP-00-RP-0010)

The Reference Design Report determined that the region is affected by a combination of regional and local catchment flooding. It further indicated that as the work proposed focussed on a minor track slew and no formation work, the flood impact caused by the design would be minor, and similarly, there would be negligible change to rail immunity.

1.6.3. Environmental Impact Statement

Draft Environmental Impact Statement:

- Albury to Illabo Environmental Impact Statement (EIS) Technical Paper 11 – Hydrology, flooding and water quality (July 2022) (currently under planning assessment)

The Culcairn Station Yard site was investigated as part of the draft EIS as discussed in the draft Albury to Illabo EIS Technical Paper 11 – Hydrology, flooding and water quality (July 2022). Whilst the EIS and PIR have not yet been determined, a qualitative assessment has been undertaken to assess the flood conditions of the site based on the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013). It was found that the site is affected by regional flooding in addition to local overland flows.

1.7. Purpose and Requirements

The primary purpose of this IFC flood assessment report is to describe how the design development and the associated review process will be managed.

A series of tasks and activities that the design development and design reporting process needs to address and include is described in the set of requirements within the draft Condition of Approval (CoA), PSR Annexure F, and Inland Rail's Design Management Specification.

1.8. Information Documents

The following documents have been provided 'For Information' and have been referenced/reviewed as part of the design development:

- Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013)
- Albury to Illabo (A2I) and Stockinbingal to Parkes (S2P) Projects Reference Design Report – Albury (WSP, June 2022), 2-0008-210-PEN-01-RP-0002
- Albury to Illabo draft Environmental Impact Statement (EIS) Technical Paper 11 – Hydrology, flooding and water quality (WSP, July 2022), 2-0008-210-EAP-00-RP-0010 (under assessment)

1.9. Inputs

The inputs to this flood assessment report include:

- Australian Standards and Guidelines: AS 7637 Railway Infrastructure – Hydrology and Hydraulics
- Australian Rainfall and Runoff: A Guide to Flood Estimation 2019
- Austroads Guide to Bridge Technology – Part 8: Hydraulic Design of Waterway Structures
- Inland Rail Climate Change Risk Assessment Framework

1.9.1. Input Data

Table 1-1 outlines the available information relevant to the site and used for flood modelling.

Table 1-1: Available Information

Item	Information	Type	Description / Comments
Site Specific			
1	Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013)	PDF	This report provided the following: - Information about general flood behaviour/mechanisms - Regional flows from the Billabong Creek catchment - Other information that was utilised in the DJV TUFLOW hydraulic model such as culvert invert levels/sizing, Manning's roughness values etc.

Item	Information	Type	Description / Comments
Site Specific			
2	LiDAR 2012 (The data used to create this DEM has an accuracy of 0.3m (95% Confidence Interval) vertical and 0.8m (95% Confidence Interval) horizontal)	TIF format	Downloaded from https://elevation.fsdf.org.au/ on 16/07/2024. The information is in 1m resolution in the GDA2020 projection.
3	A2P CCN EXT GDA20Z55.12da	12da	Received 23/7/24 Existing Conditions Survey in the GDA 2020 Projection from Martinus.
4	Culcairn Yard - 3d Line Strings_DDR_Default-3D.dwg	DWG	Received 29/7/24 Design top of Rail strings from DJV Rail Team
5	HDS GDA2020 240831HJ2 DRAI.12da	12da	Received 18/9/24 Survey of drainage elements outside the project boundary
6	A2P CCN EXT GDA20Z55 COMBINED_241129.12da	12da	Received 29/11/24 Survey of additional track turnout pickups

1.10. Outputs

A list of prepared flood maps with the flood maps is included in Appendix A.

1.11. Limitations and Exclusions

The following limitations and assumptions apply to the flood assessment for the IFC stage.

- The hydraulic and hydrologic model and results of the previous flood study (Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013)) are currently unavailable.
- Based on the flood maps, it is inferred that the site is subjected to regional flooding for events greater than and including the 2% AEP event as per the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013) and that incorporating the inflows from this flood study is appropriate based on a comparison of IFD rainfall data.
- In the absence of a 1% AEP + Climate Change flow from the above flood study, the flow was scaled up by a factor of 20.2% (rainfall increase factor)
- The allowable threshold for flood impacts was adopted from the Conditions of Approval (CoA)
- The details of the existing culverts used in the TUFLOW hydraulic model developed for this study were obtained from undertaken drainage survey, the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013) - where available - and where not available, these sizes and invert levels have been assumed.
- The TUFLOW Rain-on-Grid hydraulic model has not been calibrated or validated based on historical data.
- The TUFLOW Flood depths have been 'filtered' using a map cut-off depth of 0.05 m as per industry practice to eliminate immaterial sheet flow.
- An assessment of temporary works and staging has not been undertaken.
- Flood immunity is in accordance with Clause 5.4.2 and Clause 5.4.3 of Annexure B of PSR (see Table 2-1).
- Blockage assessment is carried out for the 1% AEP design scenario as per the guidance set out in ARR2019 for the culverts within the project boundary, while 20% blockage is adopted for all the other culverts, pits and pipes outside the project boundary.

2. COMPLIANCE WITH REQUIREMENTS

2.1. Project Scope and Requirements

The preliminary design has been assessed to check if it meets the Project Scope and Requirements (PSRs). This is demonstrated throughout the flood assessment with Table 2-1 below summarising the Culcairn Station Yard Site - Design Compliance with the PSRs.

Table 2-1: Flooding Criteria within PSR Annexure B Technical Requirements

Requirement	Identifier	A2P Technical Requirements Description	Compliance Evidence Reference	Comment if Non-Compliant
Project Wide	5.4.10	Without limiting the environmental management requirements in Annexure F, section 6.1.1, all D&C Works in watercourses shall comply with the NSW Department of Primary Industries Standards: Policy and Guidelines for Fish Friendly Waterway Crossings; Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings; and Policy and Guidelines for Fish Habitat Conservation and Management Update.	N/A Structure modifications do not affect any watercourses	-
Project Wide	5.4.2	Where existing flood immunity is lower than ARTC SMS minimum requirements, the functional requirements for flood immunity take precedence over the ARTC SMS.	Compliant Refer Section 6.3	-
Project Wide	5.4.3	Where existing flood immunity is higher than ARTC SMS minimum requirements, the ARTC SMS requirements for flood immunity take precedence over the functional requirements.	Compliant Refer Section 6.3	-
Project Wide	5.4.5	Bridge and culvert hydraulics shall comply with Austroads Guide to Bridge Technology Part 8: Hydraulic Design of Waterway Structures.	N/A. No bridge or culvert designs are relevant	-
A2I Technical Requirements*	IR-SR-A2I-116	The System shall comply with 0-0000-900-ESS-00-ST-0001 Inland Rail Climate Change Risk Assessment Framework.	Climate change assessment was carried out by using RCP 8.5 Year 2090, see Section 7.1 for more details.	-
A2I Technical Requirements*	IR-SR-A2I-349	The Corridor System for Enhancement Corridors shall have a flood immunity of no worse than existing.	Compliant Refer Section 6.3	-
A2I Technical Requirements*	IR-SR-A2I-350	The Corridor System, where the existing track is lowered, shall maintain the existing flood immunity.	Compliant Refer Section 6.3	-

Requirement	Identifier	A2P Technical Requirements Description	Compliance Evidence Reference	Comment if Non-Compliant
A2I Technical Requirements*	IR-SR-A2I-352	The Corridor System shall prevent damage of the formation due to ponding of water.	Compliant. No damage to the formation due to ponding of water. Existing condition is maintained. (Refer to Section 6.4)	-
A2I Technical Requirements*	IR-SR-A2I-458	The Corridor System shall prevent ponding in longitudinal open channels.	Compliant. Existing condition is maintained. (Refer to Section 6.4)	-
A2I Technical Requirements*	IR-SR-A2I-459	The Corridor System for Enhancement Corridors shall provide mitigation for flood impacts no worse than existing condition.	Compliant. No non- compliant flood impacts (Refer Section 6.4.1)	-
A2I Technical Requirements*	IR-SR-A2I-464	The Corridor System shall cause no adverse impacts either inside or outside the rail corridor when diverting water away from the track.	Compliant. No non-compliant flood impacts (Refer Section 6.4.1)	-
A2I Technical Requirements*	IR-SR-A2I-465	The Corridor System shall minimise changes to the existing or natural flow patterns.	Compliant. No non- compliant flood impacts (Refer Section 6.4.1)	-
A2I Technical Requirements*	IR-SR-A2I-541	The Structures System new underbridges shall withstand the 0.05% annual exceedance probability design flood event.	N/A. There is no new underbridge structure for this package.	-
A2I Technical Requirements*	IR-SR-A2I-735	The Third-Party System private roads shall have flood immunity no worse than existing.	Compliant. No non-compliant flood impacts (Refer Section 6.4.1)	-

2.2. Conditions of Approval - Flooding

The Conditions of Approval (CoA) have been provided under cover of IR2140-TRANSMIT-002001. The detailed design has been assessed to check if it meets the CoA and the compliance is presented in Table 2-2 below.

Table 2-2: Conditions of Approval Compliance Table

CoA #	Condition	Compliance Evidence Reference	Comment if Non-compliant
E38	All practicable measures must be implemented to ensure the design, construction and operation of the CSSI will not adversely affect flood behaviour, or adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	Compliant, see rows below.	-
E39	The CSSI must be designed with the objective to meet or improve upon the flood performance identified in the documents listed in Condition A1. Variation consistent with the requirements of this approval at the rail corridor is permitted to effect minor changes to the design with the intent of improving the flood performance of the CSSI.	Compliant Refer to Section 6.4	-
E40	Updated flood modelling of the project's detailed design must be undertaken for the full range of flood events, including blockage of culverts and flowpaths, considered in the documents listed in Condition A1. This modelling must include:	Compliant R Refer to Sections 4,6 and 7	-
E40	a) Hydrologic and hydraulic assessments consistent with Australian Rainfall and Runoff – A Guide to Flood Estimation (GeoScience Australia, 2019);	Compliant. Section 4 methodology shows that ARR2019 guidelines were used for this assessment.	-
E40	b) Use of modelling software appropriate to the relevant modelling task;	Compliant. Section 4 shows that the appropriate software (TUFLOW) was used	-
E40	c) Field survey of the existing rail formation and rail levels, should be included within the models; and	Compliant. Section 1.9.1 shows that existing field survey and rail levels were used in the models.	-
E40	d) Confirmation of predicted afflux at industrial properties adjacent to Railway Street, Wagga Wagga based on field survey.	N/A. Railway street in Wagga Wagga is not relevant to this site.	-
E40	Updated flood modelling must be made publicly available in accordance with Condition B18.	Flood design report and independent review of flood design report shall be provided to IR, through this submission, for IR to upload on the IR website, as per CoA B18 responsibility allocation.	-
E41	The Proponent's response to the requirements of Conditions E42 and E44 must be reviewed and endorsed by a suitably qualified flood consultant, who is independent of the project's design and construction and approved in accordance with Condition A16, in consultation with directly affected landowners, DCCEEW Water Group, TfNSW, DPI	Independent review of the flood modelling, model and Flood Design Report is undertaken by the Proof Engineer's specialist contractor, who satisfy and comply with the requirements of A16. Refer Appendix E	-

CoA #	Condition	Compliance Evidence Reference	Comment if Non-compliant
	Fisheries, BCS, NSW State Emergency Service (SES) and relevant Councils.	Consultation with Council will be undertaken through formal review of this Flood Design Report. Refer Appendix D	
E42	The CSSI must be designed and constructed to limit impacts on flooding characteristics in areas outside the project boundary during any flood event up to and including the 1% AEP flood event, to the following:	See E42 items below	-
E42	(a) a maximum increase in inundation time of one hour, or 10%, whichever is greater;	Compliant, Refer to Section 6.4.4	-
E42	(b) a maximum increase of 10 mm in above-floor inundation to habitable rooms where floor levels are currently exceeded;	Compliant. No flood level increase on any properties. Refer Section 6.4.1	-
E42	(c) no above-floor inundation of habitable rooms which are currently not inundated;	Compliant. No flood level increase on any properties. Refer Section 6.4.1	-
E42	(d) a maximum increase of 50 mm in inundation of land zoned as residential, industrial or commercial;	Compliant. No flood level increase in residential, industrial and commercial areas. Refer Section 6.4.1	-
E42	(e) a maximum increase of 100 mm in inundation of land zoned as environment zone or public recreation;	Compliant. No increases of more than 100mm on land zoned as environment or public recreation. Refer Section 6.4.1	-
E42	(f) a maximum increase of 200 mm in inundation of land zoned as rural or primary production, environment zone or public recreation;	Compliant. No increases of more than 200mm on land zoned as rural or primary production. Refer Section 6.4.1	-
E42	(g) no increase in the flood hazard category or risk to life; and	Compliant. No reasonable flood hazard increase or increase in Velocity x Depth to cause risk to life. Refer to Section 6.4.3 6.4.1	-
E42	(h) maximum relative increase in velocity of 10%, or to 0.5m/s, whichever is greater, unless adequate scour protection measures are implemented and/or the velocity increases do not exacerbate erosion as demonstrated through site-specific risk of scour or geomorphological assessments	Compliant. No increase in velocity of more than 0.5m/s. Refer to Section 6.4.2	-

CoA #	Condition	Compliance Evidence Reference	Comment if Non-compliant
E42	Where the requirements set out in clauses (d) to (f) inclusive cannot be met alternative flood levels or mitigation measures must be agreed to with the affected landowner.	N/A – clause (d) to (f) are compliant	-
E43	A **Flood Design Report** confirming the:		-
E43	a) final design of the CSSI meets the requirements of **Condition E42;** and	Compliant Refer to Section 6	-
E43	b) the results of consultation with the relevant council in accordance with **Condition E46**	Refer to E46	-
E43	must be submitted to and approved by the Planning Secretary prior to the commencement of permanent works that would impact on flooding.	This report will be submitted to the Planning Secretary for approval prior to the commencement of permanent works that would impact on flooding	-
E44	The **Flood Design Report** required by **Condition E43** must be approved by the Planning Secretary prior to works that may impact on flooding or the relevant council's stormwater network.	This report will be submitted to the Planning Secretary for approval prior to the commencement of permanent works that would impact on flooding	-
E45	Flood information including flood reports, models and geographic information system outputs, and work as executed information from a registered surveyor certifying finished ground levels and the dimensions and finished levels of all structures within the flood prone land, must be provided to the relevant Council, BCS and the SES in order to assist in preparing relevant documents and to reflect changes in flood behaviour as a result of the CSSI. The Council, BCS and the SES must be notified in writing that the information is available no later than one (1) month following the completion of construction. Information requested by the relevant Council, BCS or the SES must be provided no later than six (6) months following the completion of construction or within another timeframe agreed with the relevant Council, BCS or the SES.	Flood information will be provided to the relevant Council, BCS and the SES in order to assist in preparing relevant documents and to reflect changes in flood behaviour as a result of the CSSI in accordance with the requirements of CoA E45	-
E46	The design, operation and maintenance of pumping stations and storage tanks and discharges to council's stormwater network must be developed in consultation with the relevant council. The results of the consultation are to be included in the report required in **Condition E43.**	Local drainage flow regime, catchment area and imperviousness remain the same as per existing condition, there is no additional flow towards the existing Council's stormwater network. The design has not worsened the existing condition. Discharges to the council's stormwater networks have been consulted with Greater Hume Council during the briefing workshops, various stages of design submissions with the Council's comments closed out. Details are documented in 5-0052-210-PEN-J7-RP-0001.	-

2.3. Updated Mitigation Measures - Flooding

The Updated Mitigation Measures (UMM) have been provided and the detailed design has been assessed to meet the UMM and the compliance is presented in Table 2-3 below.

Table 2-3: Updated Mitigation Measures Compliance Table - Flooding

Condition	Condition or Criteria	Compliance Evidence Reference
HFWQ3	Further consultation will be undertaken with local councils and other relevant authorities to identify opportunities to coordinate the proposal with flood mitigation works committed to as part of the council's flood management plans, or other strategies.	N/A as no mitigation works are necessary.
HFWQ4	At Wagga Wagga Yard enhancement site, flood modelling would be carried out during detailed design to confirm predicted afflux at industrial properties located at Railway Street and compliance with the Quantitative Design Limits for Inland Rail. This would be informed by topographic and building floor surveys and a review of localised drainage structures (as required). Quantitative assessment of the sites of low and moderate hydraulic complexity will be carried out during detailed design, and will consider the impact of the Possible Maximum Flood event at built-up areas (where information is available) and the tenure of the upstream areas that are impacted by drainage and/or flooding. The outcomes of the assessment are to be provided to DCCEW– BCS	This report relates to Culcairn Station Yard site, and so is not relevant to Wagga Wagga Yard. Compliant. Quantitative assessment has been undertaken. Refer to Section 6
HFWQ5	At Riverina Highway bridge enhancement site, flood and drainage network modelling (including capacity and operation of the stormwater storage and pump system) will be carried out during detailed design to confirm predicted compliance with the Quantitative Design Limits (QDLs)* for Inland Rail. The modelling would be undertaken in consultation with Albury City Council.	This report relates to the Culcairn Station Yard Site and so is not relevant to the Riverina Highway track lowering site.

* QDL is superseded by CoA E42.

3. CHANGE MANAGEMENT

This section summarises the changes made to this design package due to changes in the project scope and/or evolution of the design.

3.1. Concept Design to SDR

Key design changes between the Concept Design and the SDR Design are listed in the table below.

Table 3-1: Design Differences Between Proposal and SDR

Item	Difference	Reason for Difference
N/A	N/A	Flooding Modelling assessment excluded during the SDR design stage

3.2. SDR to PDR

Key design changes between the SDR Design and the PDR Design are listed in the table below.

Table 3-2: Design Differences Between SDR and PDR

Item	Difference	Reason for Difference
N/A	N/A	Flooding Modelling assessment excluded during the PDR design stage

3.3. PDR to DDR

Key design changes between the PDR Design and the DDR Design are listed in the table below.

Table 3-3: Design Differences Between PDR and DDR

Item	Difference	Reason for Difference
1	DJV created a new TUFLOW hydraulic model, to model the area of interest	No TUFLOW hydraulic model was available for the PDR stage or earlier.

3.4. DDR to IFC

Key design changes between the DDR Design and the IFC Design are listed in the table below.

Table 3-4: Design Differences Between DDR and IFC

Item	Difference	Reason for Difference
1	Update Flood Models hydrologic methodology to reflect newly received information from the Council regarding regional flooding behaviour and recently undertaken mitigation works	Information about regional flooding behaviour and recently undertaken mitigation works which was not available at the previous design stages. This was updated to address a comment provided by the Council.
2	Update Flood Models with newly received rail survey	Rail survey was not previously available at the DDR stage or earlier
3	Update Flood Model with newly received 1m LiDAR (2015)	2015 LiDAR was not previously available at the DDR stage or earlier
4	Updating Flood Models with available drainage survey for areas outside the project boundary	Included drainage survey in Flood Models that were not included in the DDR stage or earlier

4. MODELLING METHODOLOGY

This flood assessment comprises a TUFLOW hydraulic model and a desktop analysis based on Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013).

The general flood behaviour in Culcairn is a combination of local catchment flooding and regional flooding (for the PMF event) from an anabranch of Billabong Creek. The modelling methodology involved the development of an external TUFLOW model to determine the inflow from the Billabong Creek anabranch into the internal flood model (Table 4-1) and the development of an internal TUFLOW model considering the local catchment flooding. The external flood model shown below is only for the PMF event. This flood behaviour and modelling methodology are discussed in the following sections.

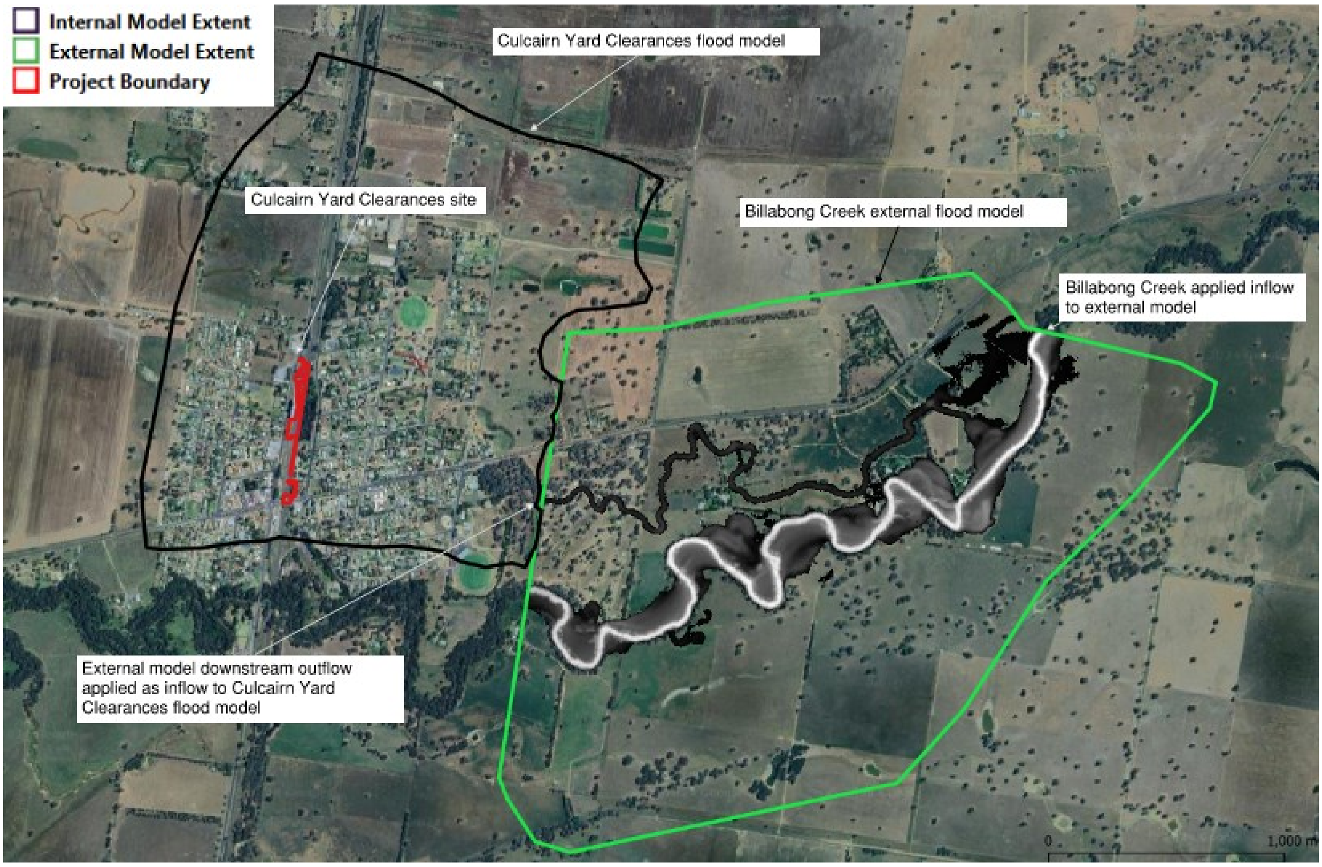


Table 4-1: TUFLOW Models Setup

4.1. Regional Flooding

The Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013) covers the Billabong Creek catchment and indicates that the Culcairn town area is susceptible to regional flooding for events greater than and including the 2% Annual Exceedance Probability (AEP) event. However, as part of the review process for the Detailed Design Review stage, information was received from the Greater Hume Shire Council which stated that due to recently undertaken mitigation works, flows from the Billabong Creek now do not enter the town in events smaller than the 1 in 500 year event (Source: External Comment Sheet - A2I | Culcairn Station Yard - Design - 2100-G1-0052-DES-001 - Greater Hume Shire Council – Comment #2) . In events greater than 1 in 500 year in this study (i.e. the PMF), flow from an anabranch of the Billabong Creek enters the Culcairn town area.

For the PMF event, an external flood model (shown in the figure above) was run using the flows extracted from the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013), which is shown in the table below. The hydrologic model used for the study used an initial loss of 10mm, a continuing loss of 1.5 mm/hr and a C routing parameter of 1.7.

Table 4-2: Billabong Creek at Olympic Highway Flow from the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013)

	5% AEP	2% AEP	1% AEP	0.5% AEP	PMF
Flow (m^3/s)	424	553	687	812	7306

As described in Section 4.3, the PMF flow was applied to the external TUFLOW model to derive the relevant inflow for the internal site flood model for the PMF event. As there was no flow in the anabranch for events smaller than the 1 in the 500 year event, no external inflow was applied for all other design events.

4.1.1. External Hydraulic Model Setup

An external TUFLOW model was developed to determine the inflow from the Billabong Creek anabranch into the internal flood model. The methodology is summarised as follows:

- Creation of a TUFLOW hydraulic model for the area of developed to determine the inflow from the Billabong Creek anabranch into the internal flood model
- The existing ground surface of the catchment used in the hydraulic model was based on the 1m resolution LiDAR data acquired from the Elevation Information System (ELVIS, https://elevation.fsdf.org.au). Feature survey data was used to represent the topography within the model area. The hydraulic model was run using a 4m cell size.
- Manning's roughness coefficients were selected based on land zoning, aerial imagery and the guidance in ARR2019 as well as the values used in Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013)
- The TUFLOW hydraulic model uses the inflow data as per Table 4-2: from Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013)
- Two types of boundary conditions were used. The first one is a flow vs time upstream inflow boundary, and the second one is a normal flow boundary condition for the downstream ends of the model.
- Flow was sampled immediately upstream of the downstream boundary of the model and this flow hydrograph was then applied as the inflow to the internal model.

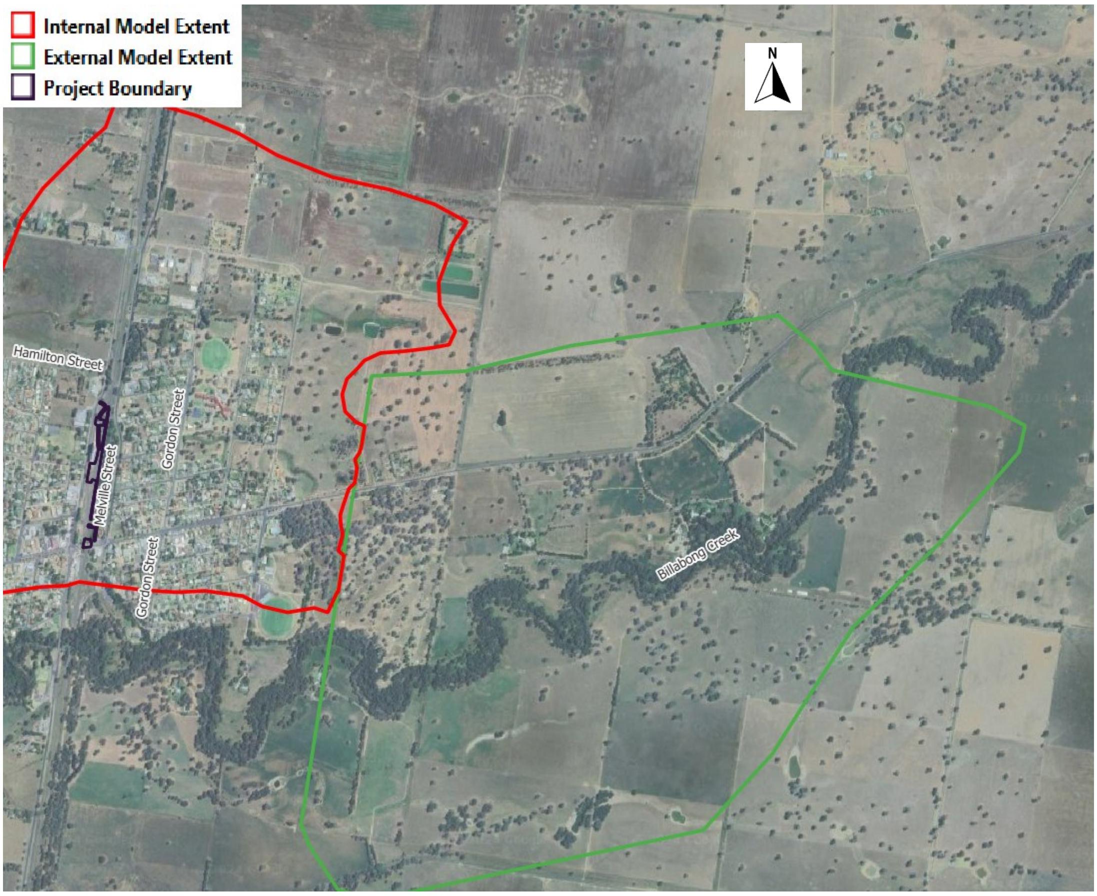


Figure 4-1: External TUFLOW Model Extent

Table 4-3:External TUFLOW Model Setup

Parameter	Comment
TUFLOW version	TUFLOW.2023-03-AE
Adopted Grid Cell Size	4m
Model Topography	Based on 1m LiDAR from ELVIS

Parameter	Comment
Inflows	Flow vs Time boundary upstream
Dams Initial Water Levels	All farm dams were assumed to be full as a conservative approach.
Drainage	No Drainage modelled
Downstream Boundary Conditions	Set as HQ (head vs flow) boundary with a slope of 0.01 based on the general slope of the area.
Manning's Roughness Values	Floodplain – 0.050 Basins/Channels/Water – 0.09 Streets/Roads – 0.020 Rail – 0.030 Medium to Dense Bush – 0.06

1.1.1.1 Drainage Network

No drainage was incorporated into the external model.

4.1.2. Design Events

The external TUFLOW hydraulic model was run for the PMF event with the provided inflows in the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013).

Table 4-4: Summary of Critical Durations for External Catchment Modelling – Culcairn Station Yard

Design Events	Critical Durations
PMF	24 hour

4.2. Local Flooding

For local catchment flooding analysis, a TUFLOW hydraulic model was developed by the DJV design team specifically for this project to assess the flooding behaviour with regard to local runoff. This was done using a TUFLOW Rainfall-on-Grid (ROG) model in which rainfall was directly applied to the model area.

4.2.1. Internal Hydraulic Model Setup

An internal TUFLOW hydraulic model was developed to assess the site for flooding. The methodology is summarised as follows:

- Creation of a new Rainfall-on-Grid TUFLOW hydraulic model for the area of interest around Culcairn Station Yard to represent the existing pre-development conditions using existing conditions survey, LiDAR and drainage information from the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013)
- The existing ground surface of the catchment used in the hydraulic model was based on the 1m resolution LiDAR data acquired from the Elevation Information System (ELVIS, https://elevation.fsdf.org.au) as well as 1m LiDAR provided by Martinus and ARTC. Feature survey data was used to represent the topography within the project site. The hydraulic model was run using a 2m cell size.
- Manning's roughness coefficients were selected based on land zoning, aerial imagery and the guidance in ARR2019 as well as the values used in Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013)
- The TUFLOW hydraulic model uses the Australian Rainfall and Runoff (ARR2019) input parameters and the Australian Bureau of Meteorology (BoM) rainfall data for the local catchment Rainfall-on-Grid model while an external inflow was applied to represent the flow from the Billabong Creek which was taken from the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013).
- Use of the Probability Neutral Burst Losses from the ARR DataHub as input to the Rainfall-on-Grid TUFLOW hydraulic model. Initial and continuing losses were considered and applied using a rainfall excess approach.
- Two types of boundary conditions were used. The first one is rainfall excess hyetographs for internal catchment inflow boundaries and the second is a normal flow boundary condition for the downstream ends of the model.
- As per ARR2019 guidelines, running of an ensemble of durations and temporal patterns to determine the critical storm durations for the site area.

- Update the existing condition TUFLOW hydraulic model to the design condition by incorporating the rail design into the existing condition hydraulic model.
- Undertaking the flood impact assessment for the 1%, 2%, 5% AEP events (Refer to Section 6.4 for details).
- Conducting a climate change risk sensitivity assessment for the 1% AEP to inform the potential impact on the railway track flood immunity.
- Conducting an assessment for the Probably Maximum Flood (PMF) event to inform the potential impact on the railway track flood immunity.
- Conducting a blockage assessment on hydraulic structures for the 1% AEP event to inform the potential impact on the railway track flood immunity
- The TUFLOW hydraulic model set-up is summarised in Table 4-5: and the model extent is shown in Figure 4-2.

Figure 4-2: Internal TUFLOW Model Extent

Table 4-5: Internal TUFLOW Model Setup

Parameter	Comment
TUFLOW version	TUFLOW.2023-03-AE
Adopted Grid Cell Size	2m
Model Topography	Based on 1m LiDAR from ELVIS. Supplemented by existing conditions survey as well as design strings for rail design

Parameter	Comment
Inflows	Rainfall on Grid is applied with a 2d_rf layer comprising the entire model extent.
Dams Initial Water Levels	All farm dams were assumed to be full as a conservative approach.
Drainage	Culverts and Pipes were modelled as 1d network elements with connections to the 2d domain via 2d_bc lines.
Downstream Boundary Conditions	Set as HQ (head vs flow) boundary with a slope of 0.01 based on the general slope of the area.
Manning's Roughness Values	Floodplain – 0.050 Basins/Channels/Water – 0.09 Streets/Roads – 0.020 Rail – 0.030 Medium to Dense Bush – 0.06

Table 1-1 presents the relevant data and inputs incorporated into the TUFLOW model, along with the dates the data was received.

4.2.2. Drainage Network

Existing condition drainage elements were used as per the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013). For the design conditions, the drainage elements are the same as there is no drainage proposed.

4.3. Hydrologic Parameters

As detailed in Section 4.2, for the internal flood model, the hydrologic modelling process was undertaken directly within the TUFLOW hydraulic model by using the Rainfall-on-Grid functionality, which applies rainfall directly to the hydraulic model. As per Table 4-6:, the rainfall losses used were as per the ARR Datahub, with a probability neutral burst loss used and a continuing loss of 1.8 mm/hr.

Using the TUFLOW hydraulic model, an ensemble of duration and temporal patterns was run for each modelled AEP event and a critical duration analysis was undertaken to determine the critical durations for the site area. These durations were then used for the flood assessment.

Table 4-6: Internal Model Hydrologic Parameters

Parameter	Value	Notes
Initial Loss (Probability Neutral Burst Loss)	Probability Neutral Burst Loss (refer Appendix B) (PMF 0mm)	ARR Data Hub
Continuing Loss	1.8 mm/hr (PMF 1mm /hr)	ARR Data Hub
Event	PMF, 1% + Climate Change, 1%, 2%, 5%	-
Duration	10min to 5760min	-
Temporal Pattern	10 Temporal Patterns for each duration (except PMF (GSDM) which uses 11 Temporal Patterns as per Jordan. Et. Al and GSAM which had 1 Temporal Pattern each)	As per ARR2019 guidelines

4.4. Hydraulic Model Update

The updates for the design conditions included the incorporation of the design rail top of the rail string, which was represented as a break line to reinforce the overtopping level of the rail. Regarding drainage, no updates were made as there is no proposed drainage.

4.5. Design Events

The TUFLOW hydraulic model was run for the 5%, 2%, and 1% AEP design events, 1% AEP + climate change and PMF. A critical duration analysis was undertaken to confirm the relevant critical duration storms in the area of interest. This involved the running of the entire ensemble of duration events and temporal patterns as per ARR2019 guidelines. These critical durations were determined by using the local catchment inflows only.

For the PMF events, GSDM events up to 180 min and GSAM for events between 180min and 360min were run for the local catchment. From this, it was determined that the critical duration for the site area was 60min GSDM. This was then run with the GSAM external inflow as per Table 4-7.

Table 4-7: Summary of Critical Durations for Local Catchment Modelling – Culcairn Station Yard

Design Events	Critical Durations	Adopted Temporal Pattern ID
5% AEP	10min/20min/540min/4320min	All 10 Temporal Patterns
2% AEP	15min/20min/540min/2160min/2880min	All 10 Temporal Patterns
1% AEP	15min/20min/360min/2880min	All 10 Temporal Patterns
1% AEP + Climate Change	15min/20min/360min/2880min	All 10 Temporal Patterns
PMF	60min (GSDM)	All 11 Temporal Patterns

4.6. Combination of External and Internal Model and Methodology Justification for PMF

As a combination of the above two models, the breakout flow from Billabong Creek from the external model (Section 4.1.1) was then applied to the local ROG model (Section 4.2.1) as an upstream inflow (Table 4-1) for the PMF event. This is formed as the final TUFLOW model to inform this flood assessment.

This method is considered as appropriate as for the PMF event, the critical duration analysis used both GSDM and GSAM storms to determine the critical duration of the local catchment (which were determined to be GSDM duration). This was then run in conjunction with the external inflow. As this flow is very large, the Main line is overtopped, and the flooding at the site is dominated by external inflow. As per the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013), GSAM was adopted the method from Guidebook of the Estimation of Probable Maximum Precipitation: Generalised Southeast Australia Method (Bureau of Meteorology, 2006).

For the PMF event, although the regional flow is dominant, GSAM remains the same for ARR1987 and 2019. Consequently, the method of applying the flow from the external model into the internal model is deemed to be suitable for this assessment.

5. MODEL COMPARISON

The results obtained by this assessment were compared to results from the Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013). The flood study set out 3 main areas of interest relevant to our site. A comparison is provided in Table 5-1 below:

Table 5-1: Comparison of Results at Areas of Interest Between Culcairn IFC TUFLOW Model Results and Flood Study Results

Area of Interest	1% AEP Flood Behaviour (Flood Study)	1% AEP Flood Behaviour (Culcairn IFC Model)
Federal, King, Munro and Balfour Street	- properties in this area have flood depths of greater than 0.5m - roads are subject to depths ranging from 0.3 to 0.5 m	- properties in this area have flood depths of greater than 0.5m (up to 1m) - roads are subject to depths up to 0.2m
Henty Street	- Henty St and its surrounds experience peak flood depths predicted to exceed 0.5 m for the 1% AEP event	- Henty St and its surrounds experience peak flood depths predicted to exceed 0.5 m for the 1% AEP event (up to 0.7m)
Melrose Street	- Most of the properties around Melrose St resulting in flood depths exceeding 0.5 m for the 1 % AEP. - Melrose St itself is subject to depths of more than 0.6 m cutting off the major evacuation route.	- Most of the properties around Melrose St resulted in flood depths exceeding 0.5 m for the 1 % AEP (up to 0.7m) - Melrose St itself is subject to depths of more than 0.5 m cutting off the major evacuation route (up to 1m)

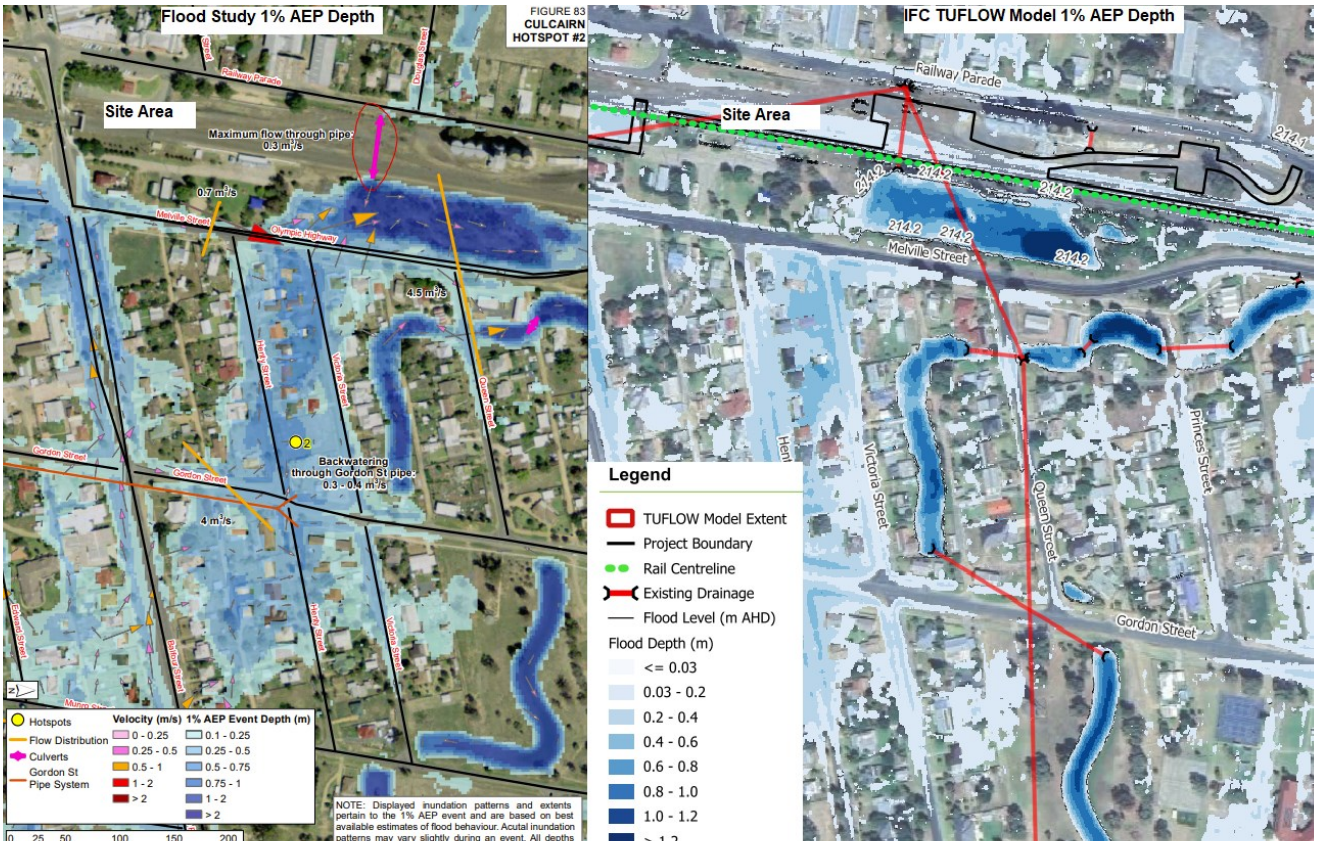


Figure 5-1: 1% AEP Flood Depth Comparison (Flood Study vs Culcairn IFC TUFLOW model)

As the above table and figure demonstrate, flood behaviour from the Culcairn IFC TUFLOW model is generally consistent with the results from the Flood Study, but generally have flood levels lower due to the lack of regional inflow for the 1% AEP event in the IFC TUFLOW model.

6. FLOOD IMPACT AND IMMUNITY ASSESSMENT

6.1. Existing Conditions

In existing conditions, the catchment area leading to the site is quite small due to the relatively elevated nature of the Culcairn Station Yard site. This results in relatively shallow flows on the site itself, up to 0.5m deep in the 1% AEP event in the channels along the western edge of the track. Immediately to the east of the site and adjacent to the rail line, is a large basin where flood depths reach up to 2m in the 1% AEP event.

Velocities are also relatively low, only being up to 0.2m/s on the site area. The Main Rail line maintains flood immunity during the 1% AEP event, while the Loop Line is overtopped.

Flood hazard is similarly very minor, being mostly category H1 with small patches of category H2 within the site area.

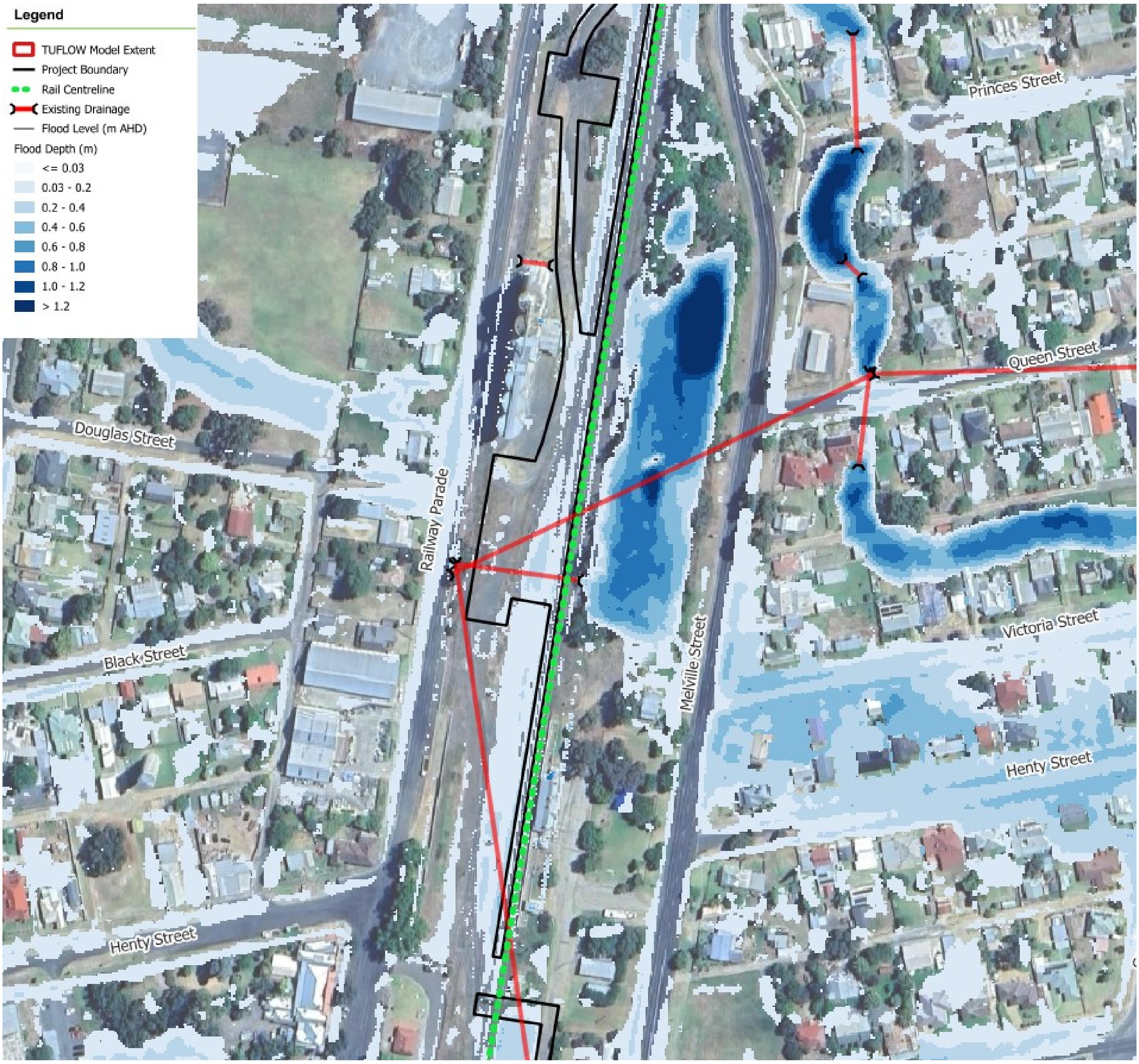


Figure 6-1: Existing Conditions Flood Extent — 1% AEP event

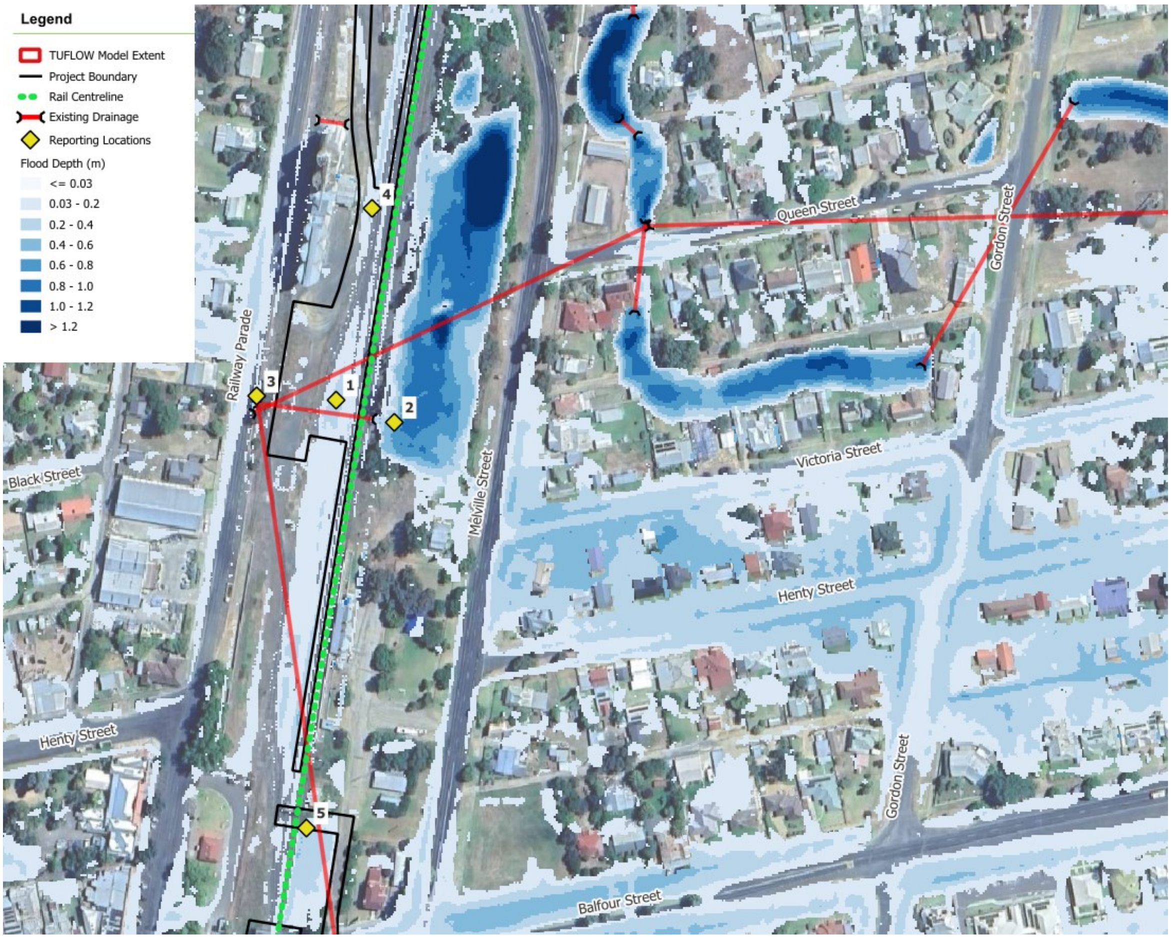


Figure 6-2: Points of Interest

Figure 6-2 shows points of interest that have been used for the flood impact assessment presented in the following sections and Table 6-1 below describes the location at each point of interest.

Table 6-1: Points of Interest

Point of Interest	Notes
1	Location within existing channel at Chainage 596+700
2	Location at the inlet of the cross culvert that takes flow underneath rail lines at Chainage 596 + 700
3	Location at the outlet of the cross culvert that takes flow underneath rail lines at Chainage 596 + 700
4	Location within existing channel at Chainage 596+600
5	Location within existing channel at Chainage 596+900

The existing condition flood behaviour is discussed in Table 6-2 to Table 6-7.

Table 6-2: Peak Flood Levels – Existing Conditions

Design Events	Flood Levels
Probable Maximum Flood (PMF)	▪ The floodwaters overtop the Main rail line and the Loop line
All other % AEP events	▪ The floodwaters do not overtop the Main rail line. ▪ The floodwaters overtop the Loop line over its formation for events greater than the 5% AEP event ▪ Refer to Table 6-3 for flood level comparison based on points of interest.

Table 6-3: Points of Interest Data – Peak Flood Levels (mAHD) – Existing Conditions

Locations	5% AEP	2% AEP	1% AEP	1% AEP + Climate Change	PMF
Point 1	215.23	215.28	215.30	215.32	216.51
Point 2	214.14	214.17	214.19	214.27	216.69
Point 3	214.19	214.22	214.23	214.25	215.82
Point 4	215.30	215.31	215.31	215.32	216.70
Point 5	215.14	215.19	215.23	215.27	216.34

Table 6-4: Peak Flood Velocity – Existing Conditions

Design Events	Flood Velocities
All % AEP events	▪ Peak velocities within the site are generally below 0.2m/s ▪ Refer to Table 6-5 for flood velocity comparison based on points of interest.

Table 6-5: Points of Interest Data – Peak Flood Velocity (m/s) – Existing Conditions

Locations	5% AEP	2% AEP	1% AEP	1% AEP + Climate Change	PMF
Point 1	0.0	0.0	0.0	0.0	1.0
Point 2	0.1	0.1	0.2	0.2	0.5
Point 3	0.4	0.4	0.4	0.6	0.8
Point 4	0.1	0.1	0.1	0.1	0.2
Point 5	0.0	0.0	0.0	0.0	1.1

The below figure shows the classification of the Hazard categories as a function of flood depth (m) and velocity (m/s).

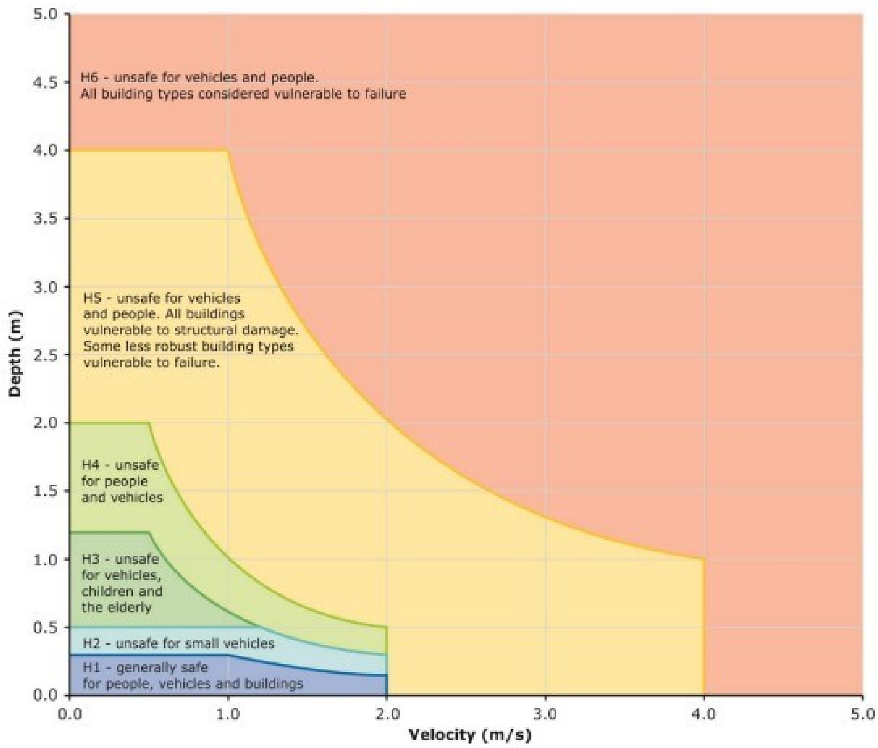


Figure 6-3: Hazard Category Classification

Table 6-6: Flood Hazard – Existing Conditions

Design Events	Flood Hazard
All %AEP events	▪ The peak hazard within the site is generally H1, other than a few areas near the culvert around Chainage 635+250m and existing channels. ▪ Refer to Table 6-7 for a comparison of flood hazard based on points of interest.

Table 6-7: Points of Interest Data – Peak Flood Hazard Category – Existing Conditions

Locations	5% AEP	2% AEP	1% AEP	1% AEP + Climate Change	PMF
Point 1	H1	H1	H1	H1	H5
Point 2	H3	H3	H3	H3	H5
Point 3	H2	H2	H2	H2	H5
Point 4	H1	H1	H1	H1	H4
Point 5	H1	H1	H1	H1	H5

6.2. Design Conditions

The Design condition hydraulic modelling incorporated the track slew of the Loop Line track.

The design conditions for flood behaviour are similar to those of the existing conditions, with minor adjustments to the Loop line causing small changes in flood behaviour around these locations.

Similar to the existing case, there are relatively shallow flows on the site itself, up to 0.5m deep in the 1% AEP event in the channels along the western edge of the track. Immediately to the east of the site and adjacent to the rail line, is a large basin where flood depths reach up to 2m in the 1% AEP event.

Velocities are also relatively low, only being up to 0.1m/s on the site area. The Main rail line maintains flood immunity during the 1% AEP event, while the Loop line is overtopped to its formation but maintains immunity to the top of the rail.

Flood hazard is similarly very minor, being mostly category H1 with small patches of category H2 within the site area during the 1% AEP event.

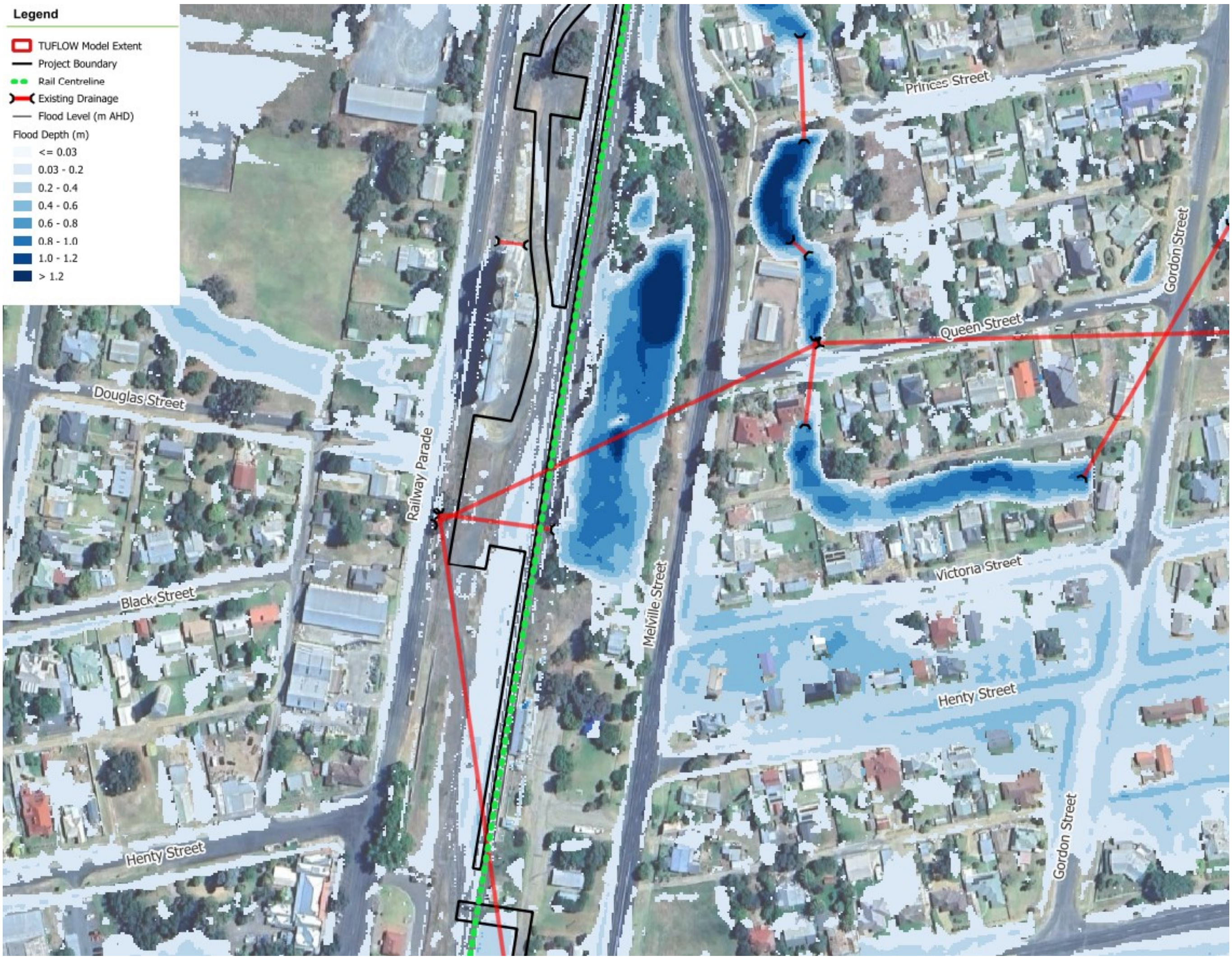


Figure 6-4: Design Conditions Flood Extent – 1% AEP Event

The design conditions for flooding behaviour are discussed below in Table 6-8.

Table 6-8: Peak Flood Levels – Design Conditions

Design Events	Flood Levels
All % AEP events	▪ The floodwaters do not overtop the Main rail line. ▪ The floodwaters overtop the Loop line over its formation for events greater than the 5% AEP event ▪ Refer to Table 6-9 for flood level comparison based on points of interest.

Table 6-9: Points of Interest Data – Peak Flood Levels (mAHD) – Design Conditions

Locations	5% AEP	2% AEP	1% AEP	1% AEP + Climate Change	PMF
Point 1	215.23	215.28	215.30	215.32	216.51
Point 2	214.14	214.17	214.19	214.27	216.69
Point 3	214.19	214.22	214.23	214.25	215.82
Point 4	215.30	215.31	215.31	215.32	216.70
Point 5	215.14	215.19	215.23	215.27	216.34

Table 6-10: Peak Flood Velocity – Design Conditions

Design Events	Flood Velocities
All % AEP events	▪ Peak velocities within the site are generally below 1m/s, other than in a few areas near the proposed design channel, Chainage 635+260m, and existing channels. ▪ Refer to Table 6-11 for velocity comparison based on points of interest.

Table 6-11: Points of Interest Data – Peak Flood Velocities (m/s) – Design Conditions

Locations	5% AEP	2% AEP	1% AEP	1% AEP + Climate Change	PMF
Point 1	0.0	0.0	0.0	0.0	1.0
Point 2	0.1	0.1	0.2	0.2	0.5
Point 3	0.4	0.4	0.4	0.6	0.8
Point 4	0.1	0.1	0.1	0.1	0.2
Point 5	0.0	0.0	0.0	0.0	1.1

Table 6-12: Flood Hazard – Design Conditions

Design Events	Flood Hazard
All %AEP events	▪ The peak hazard on the site is generally below 0.60 m^2/s ▪ Refer to Table 6-13 for velocity comparison based on points of interest.

Table 6-13: Points of Interest Data – Peak Flood Hazard Category– Design Conditions

Locations	5% AEP	2% AEP	1% AEP	1% AEP + Climate Change	PMF
Point 1	H1	H1	H1	H1	H5
Point 2	H3	H3	H3	H3	H5
Point 3	H2	H2	H2	H2	H5
Point 4	H1	H1	H1	H1	H4
Point 5	H1	H1	H1	H1	H5

6.3. Flood Immunity and Scour Protection

In terms of flood immunity, the Main line maintains immunity in all flood events other than the PMF in the existing conditions. The Loop line is overtopped in events greater than and including the 5% AEP event.

For the design conditions, the Main line also maintains immunity in all flood events other than the PMF. Similar to existing conditions, the Loop line is overtopped in events greater than and including the 5% AEP event.

Therefore, it can be seen that the immunity of the Loop line is essentially the same in the design case as it is in the existing case, although the depth of overtopping is marginally reduced due to the slightly raised track in the design case.

As per Section 6.4.2, there are no material increases in velocity that warrant a further investigation into scour protection.

6.4. Flood Impact Assessment

The flood impact assessment was conducted, and results are summarised below for events up to and including the 1% AEP event.

Due to the relatively minor nature of the changes to the track levels as a result of the design works, the flood impact of the design is also minor.

There are minor localised increases in flood levels within the rail corridor, however, these areas are within acceptable limits. Hence it is determined that it is within the limits of the Conditions of Approval (COA).

With regards to velocity increases, there are localised increases of greater than 10% as a result of the design work in the immediate vicinity of the rail lines, but the design velocities in these areas are below 0.5m/s, meaning that they are within the limits of the Conditions of Approval (COA).

With regards to hazard increase, there are no increases in Hazard as a result of the design works and, therefore, are within the limits of the Conditions of Approval (COA).

6.4.1. Changes in Peak Flood Level

The impacts presented below are due to the implementation of the design surface for the rail line.

Table 6-14: Flood Level Impact Assessment

Design Events	Changes in Peak Flood Levels (afflux)
All % AEP events	Minor localised increases are present within the rail corridor and design channels, however these are all within acceptable limits.

Table 6-15: Points of Interest Data – Changes in Flood Level (m)

Locations	5% AEP	2% AEP	1% AEP
Point 1	No Changes	No Changes	No Changes
Point 2	No Changes	No Changes	No Changes
Point 3	No Changes	No Changes	No Changes
Point 4	No Changes	No Changes	No Changes
Point 5	No Changes	No Changes	No Changes

6.4.2. Changes in Peak Flood Velocity

Table 6-16: Flood Velocity Impact Assessment

Design Events	Changes in Peak Flood Velocity
All %AEP events	There are localised increases of greater than 10% as a result of the design works in the immediate vicinity of the rail lines but the design velocities in these areas are below 0.5m/s, meaning that they are within the limits of the Conditions of Approval (COA) which state a maximum increase in velocity of 10% or 0.5m/s.

As described above, all velocity increases are within the limits of the Conditions of Approval (COA) and, therefore, compliant.

6.4.3. Changes in Peak Flood Hazard

Table 6-17: Flood Hazard Impact Assessment

Design Events	Changes in Peak Flood Hazard
All %AEP events	There are no increases in Hazard Category as a result of the design works and therefore are within the limits of the Conditions of Approval (COA).

As described above, there are no increases in Flood Hazard and therefore within the limits of the Conditions of Approval (COA) and compliant.

6.4.4. Changes in Duration of Inundation

The analysis around the change in duration of inundation was undertaken by comparing the Flow vs Time hydrographs downstream of the site and comparing them between the existing and design conditions. A location downstream of the site in a flow path that travels through a property was chosen to demonstrate there are no material changes to duration of inundation. As shown in the below figures, there is negligible change in duration of inundation between the existing and design conditions for all assessed AEP events.

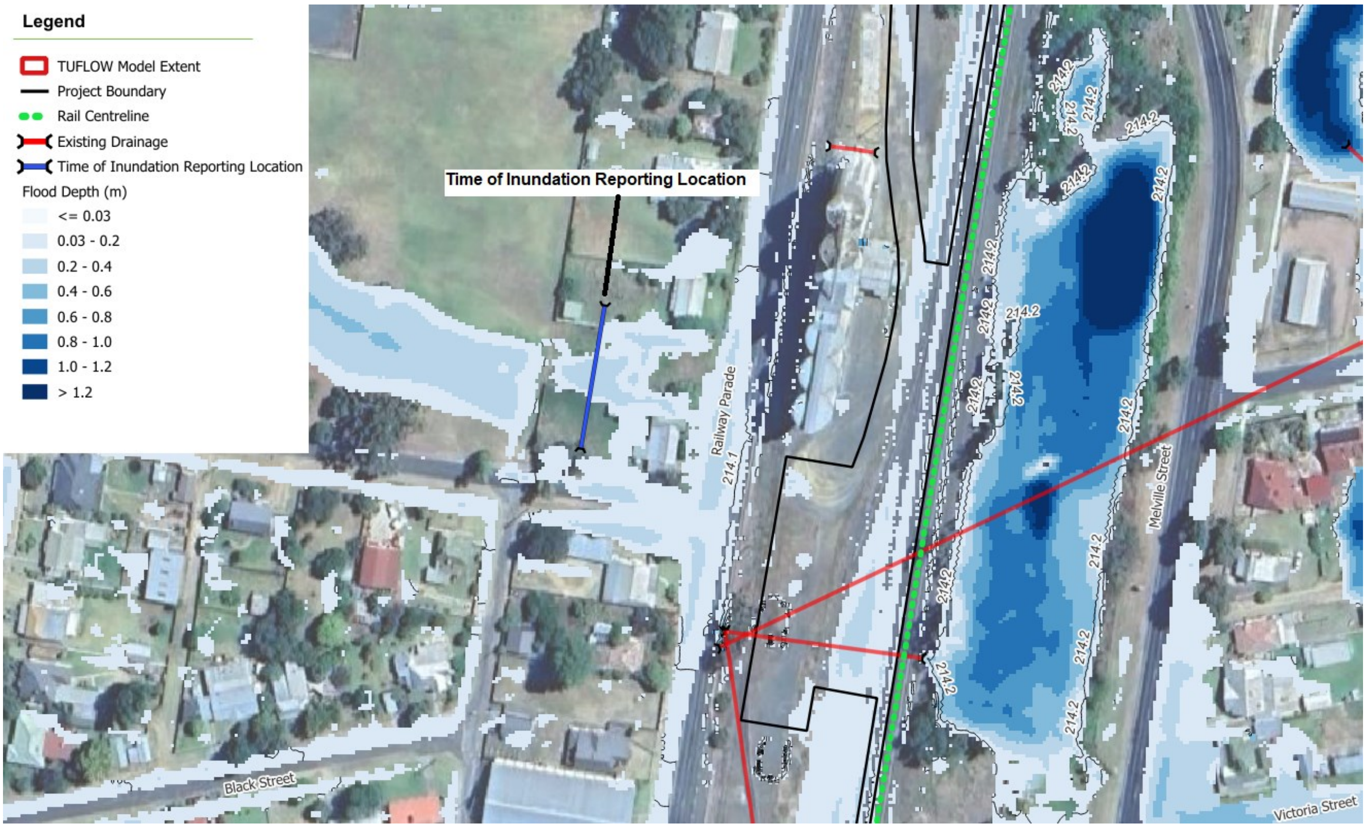


Figure 6-5: 1% AEP – Downstream Reporting Location

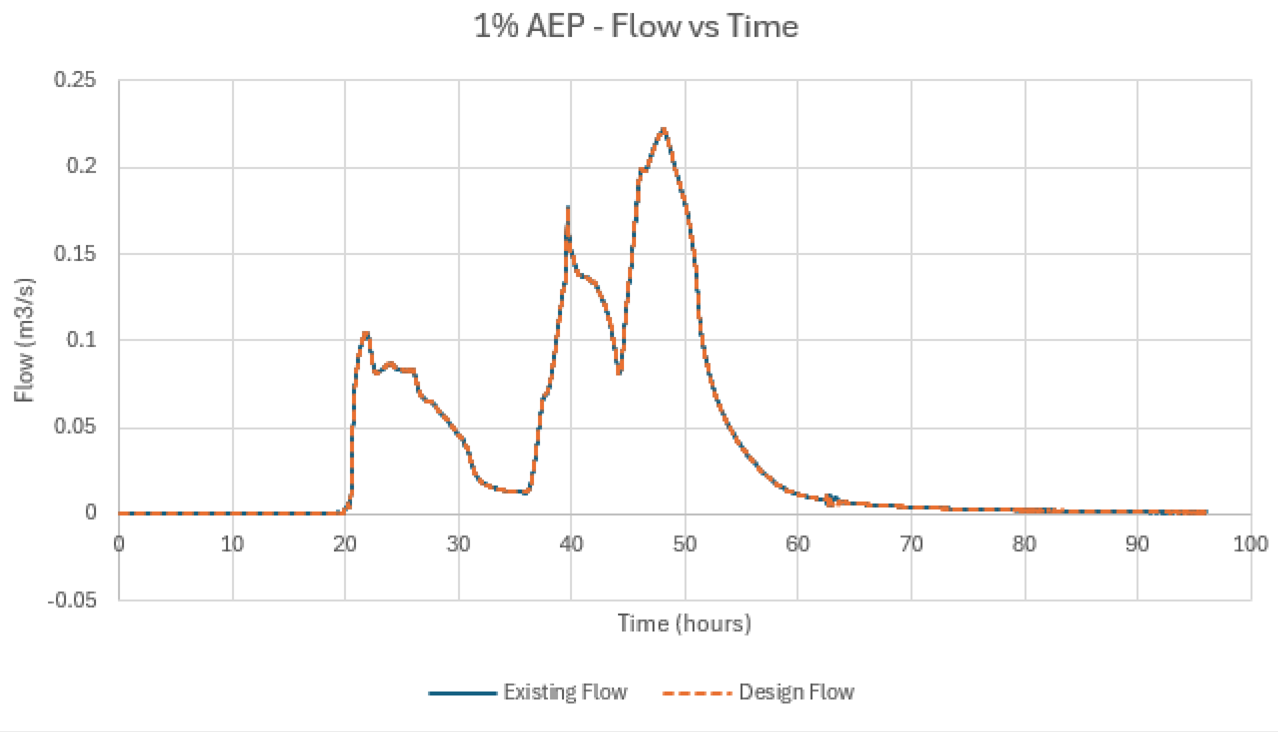


Figure 6-6: 1% AEP – Flow vs Time Downstream of the Site

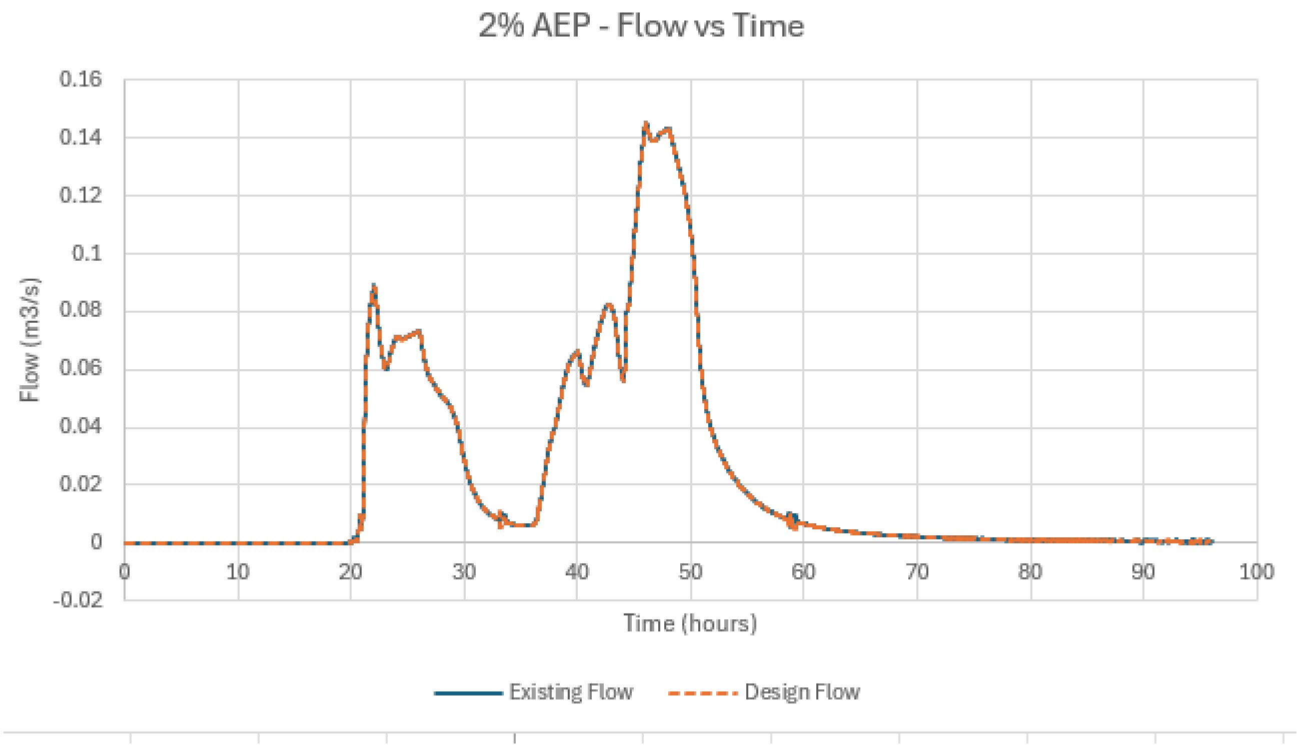


Figure 6-7: 2% AEP – Flow vs Time Downstream of the Site

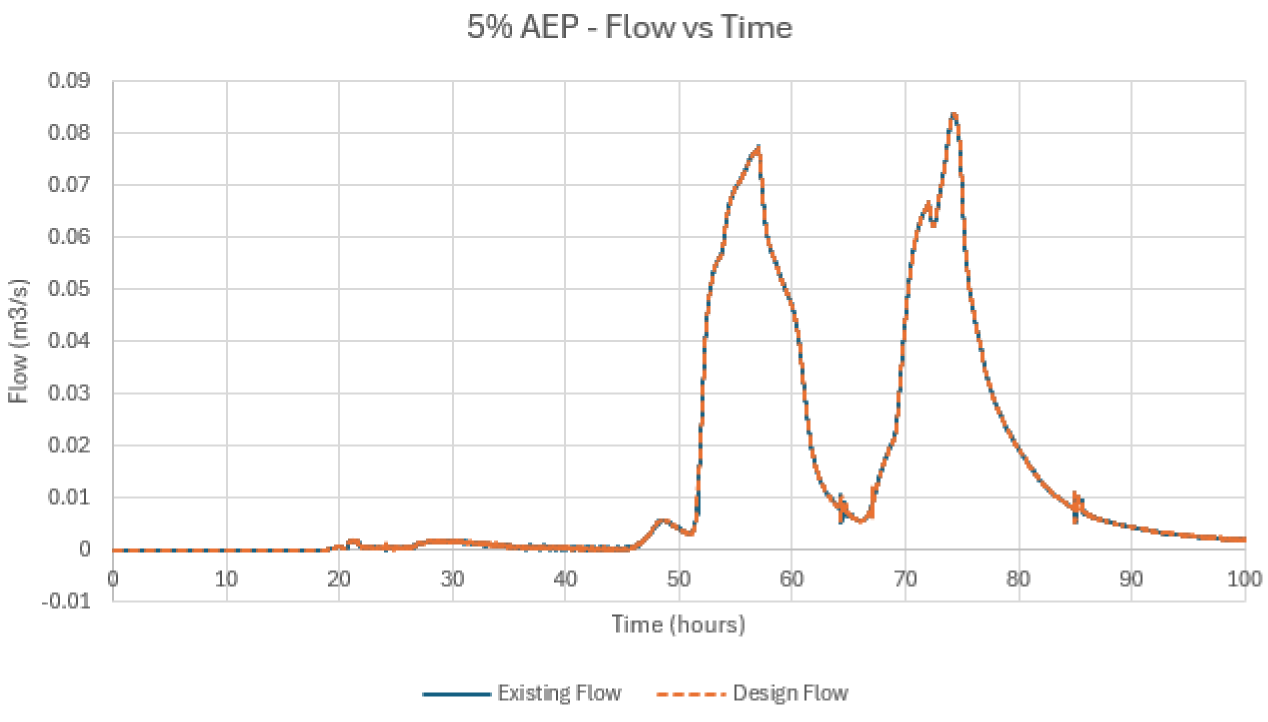


Figure 6-8: 5% AEP – Flow vs Time Downstream of the Site

7. SENSITIVITY TESTING

7.1. Climate Change Risk Assessment

There are no design criteria to assess flood impacts in a climate change scenario. Therefore, a sensitivity assessment was conducted to anticipate future climate change flood risk. As per the draft EIS report (Section 3.3.5 of Albury to Illabo Environmental Impact Statement Technical Paper 11), the Year 2090 RCP8.5 interim climate change factor sourced from the ARR Data Hub (https://data.arr-software.org/) was adopted. The use of the Year 2090 RCP8.5 interim climate change factor was associated with a 20.2% increase in rainfall.

Climate change risk assessment was carried out by running the 1% AEP with the Year 2090 RCP8.5 interim climate change factor (refer to Section 4) for details of the approach) and the results of flood depth, flood velocity and flood hazard can be found in Section 6.1 and Section 6.2. The corresponding flood maps can be found in Appendix A. The assessment is summarised as below:

- Within the study area, the Loop railway track continues to be overtopped in both the existing or design conditions in the 1% AEP event + Climate Change event. However, the depth of overtopping is slightly increased due to the increased rainfall.
- The Main line railway track still maintains its immunity to the top of the rail.

Figure 7-1: 1% AEP Climate Change – Existing Conditions Flood Depth

7.2. Blockage Assessment

A hydraulic blockage assessment was carried out for the Internal TUFLOW model as per the guidance set out in Australian Rainfall and Runoff 2019. The assessment involved assessing the site area for debris availability, mobility and transportability and this in conjunction with culvert size was used to determine the relevant blockage factors shown below. For all culverts outside the project boundary, a 20% blockage factor was applied.

Table 7-1: Culvert Blockage Percentage

Culvert	Blockage Percentage (non-PMF events)
Chainage 596 695	50%
All others	20%

Table 7-2: Culvert Blockage Parameters

Culvert	Debris Availability	Debris Mobility	Debris Transportability	AEP Adjusted Debris Potential
Chainage 596 695	High	Low	Low	Medium
All others	20%	N/A	N/A	N/A

As shown in the figures in Figure 7-2, the incorporation of blockage did not impact rail immunity as the Loop line continued to be overtopped while the Main line maintained its immunity.

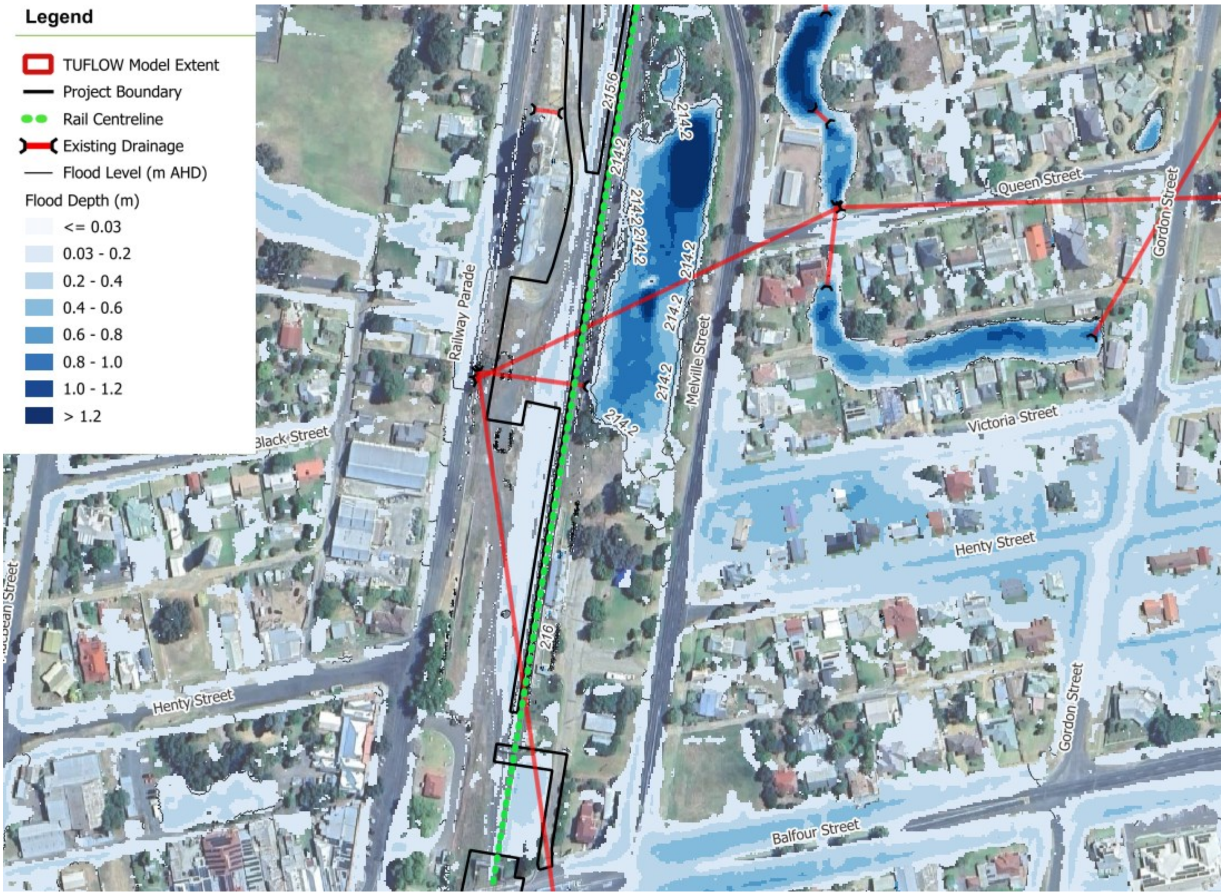


Figure 7-2: 1% AEP Blockage – Design Conditions Flood Depth

8. MITIGATION MEASURES

No mitigation measures are required as there are no non-compliances.

9. RECOMMENDATIONS AND NEXT STAGE

This is the final IFC stage of the report, and the following are finalised:

- No instances of non-compliance have been identified through the assessment.
- All comments raised by relevant parties have been resolved (refer to Appendices C, D, and E)

Consequently, there are no further recommendations.

APPENDICES

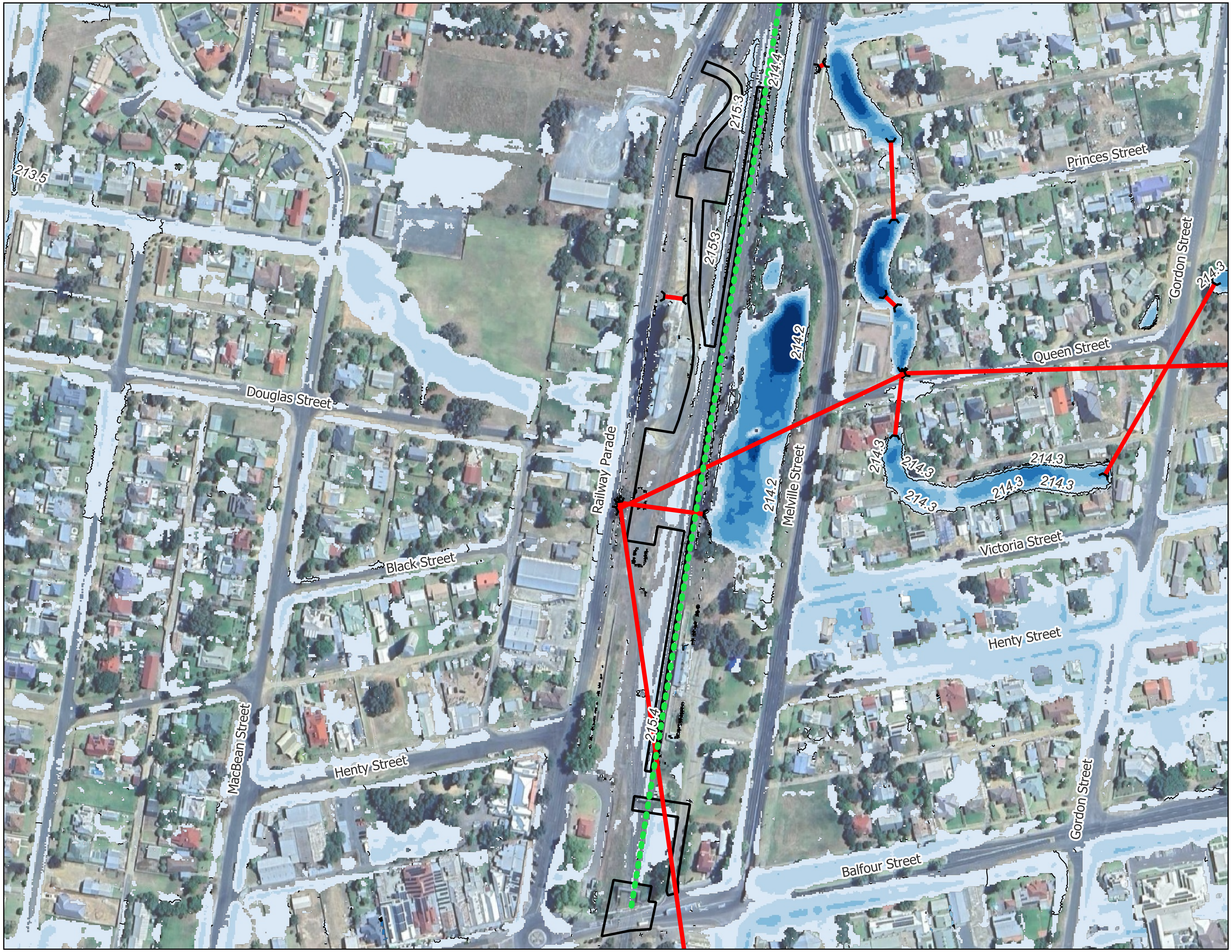
APPENDIX A - FLOOD MAPS

- A1- Existing Conditions Maps
- A2- Developed Conditions Maps
- A3- Flood Level Impact Maps
- A4- Flood Velocity Change Maps
- A5- Flood Hazard Change Maps
- A6- Blockage Assessment Maps

List of Flood Maps

Appendix A1 – Existing Conditions Maps
5% AEP Flood Depth (m) - Existing Conditions
2% AEP Flood Depth (m) - Existing Conditions
1% AEP Flood Depth (m) - Existing Conditions
1% AEP + Climate Change Flood Depth (m) - Existing Conditions
Probable Maximum Flood (PMF) Flood Depth (m) - Existing Conditions
5% AEP Velocity (m/s) - Existing Conditions
2% AEP Velocity (m/s) - Existing Conditions
1% AEP Velocity (m/s) - Existing Conditions
1% AEP + Climate Change Velocity (m/s) - Existing Conditions
Probable Maximum Flood (PMF) Velocity (m/s) - Existing Conditions
5% AEP Flood Hazard - Existing Conditions
2% AEP Flood Hazard - Existing Conditions
1% AEP Flood Hazard - Existing Conditions
1% AEP + Climate Change Flood Hazard - Existing Conditions
Probable Maximum Flood (PMF) Flood Hazard - Existing Conditions
Appendix A2 – Developed Conditions Maps
5% AEP Flood Depth (m) - Developed Conditions
2% AEP Flood Depth (m) - Developed Conditions
1% AEP Flood Depth (m) - Developed Conditions
1% AEP + Climate Change Flood Depth (m) - Developed Conditions
Probable Maximum Flood (PMF) Flood Depth (m) - Developed Conditions
5% AEP Velocity (m/s) - Developed Conditions
2% AEP Velocity (m/s) - Developed Conditions
1% AEP Velocity (m/s) - Developed Conditions
1% AEP + Climate Change Velocity (m/s) - Developed Conditions
Probable Maximum Flood (PMF) Velocity (m/s) - Developed Conditions
5% AEP Flood Hazard - Developed Conditions
2% AEP Flood Hazard - Developed Conditions
1% AEP Flood Hazard - Developed Conditions
1% AEP + Climate Change Flood Hazard - Developed Conditions

Probable Maximum Flood (PMF) Flood Hazard - Developed Conditions
Appendix A3– Flood Level Impact Maps
1% AEP - Change in Flood Level (m)
2% AEP - Change in Flood Level (m)
5% AEP - Change in Flood Level (m)
Appendix A4 – Flood Velocity Change Maps
1% AEP - Change in Flood Velocity (%)
2% AEP - Change in Flood Velocity (%)
5% AEP - Change in Flood Velocity (%)
Appendix A5 – Flood Hazard Change Maps
1% AEP - Change in Flood Hazard
2% AEP - Change in Flood Hazard
5% AEP - Change in Flood Hazard
Appendix A6 – Blockage Assessment
1% AEP + Blockage Flood Depth (m) - Design Conditions
1% AEP + Blockage Velocity (m/s) - Design Conditions
1% AEP + Blockage Flood Hazard - Design Conditions



MARTINUS

aurecon

BG&E

Legend

	TUFLOW Model Extent
	Project Boundary
	Rail Centreline
	Existing Drainage
	Flood Level (m AHD)
Flood Depth (m)	
	<= 0.03
	0.03 - 0.2
	0.2 - 0.4
	0.4 - 0.6
	0.6 - 0.8
	0.8 - 1.0
	1.0 - 1.2
	> 1.2

Notes:

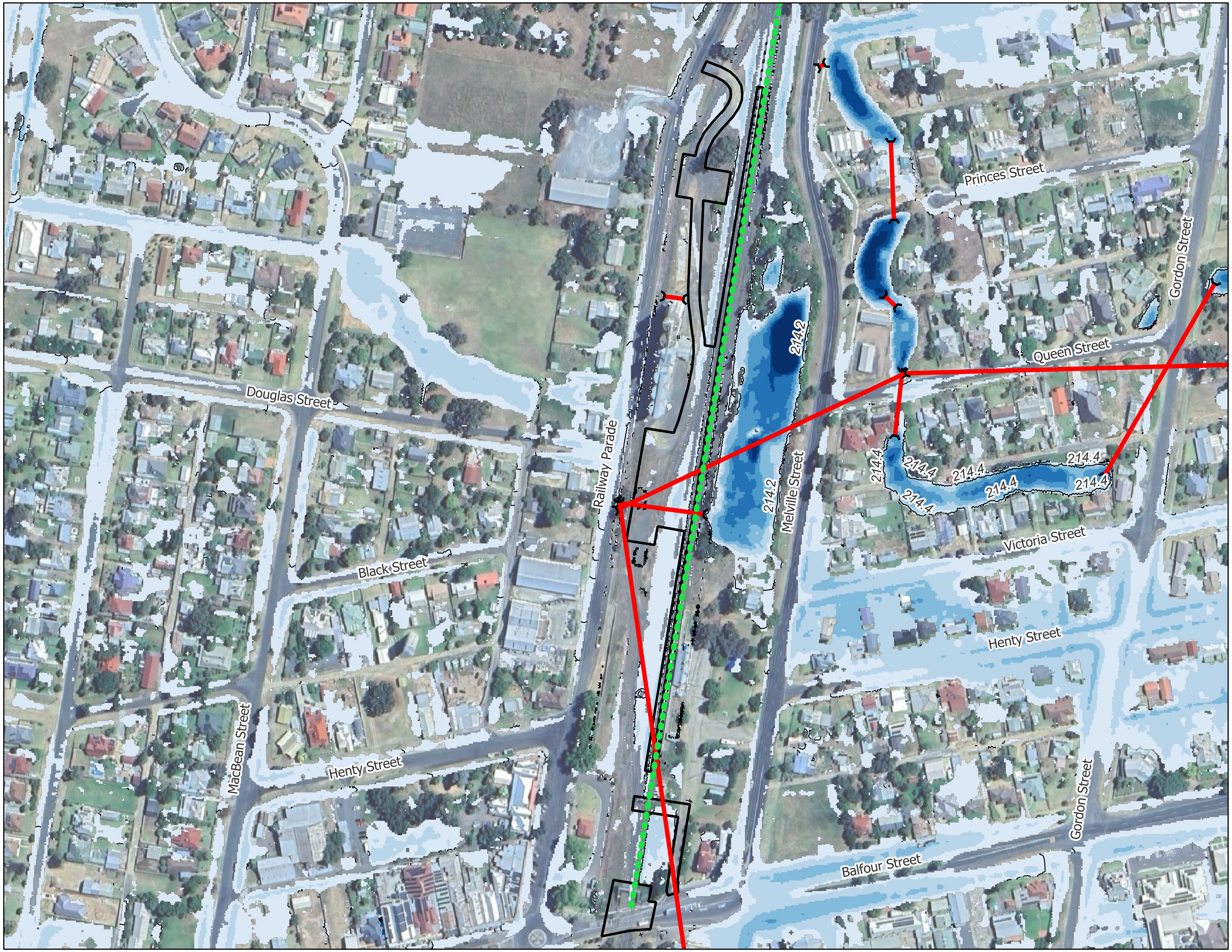
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
5% AEP Flood Depth (m) - Existing Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage
- Flood Level (m AHD)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- > 1.2

Notes:

Map by: TT

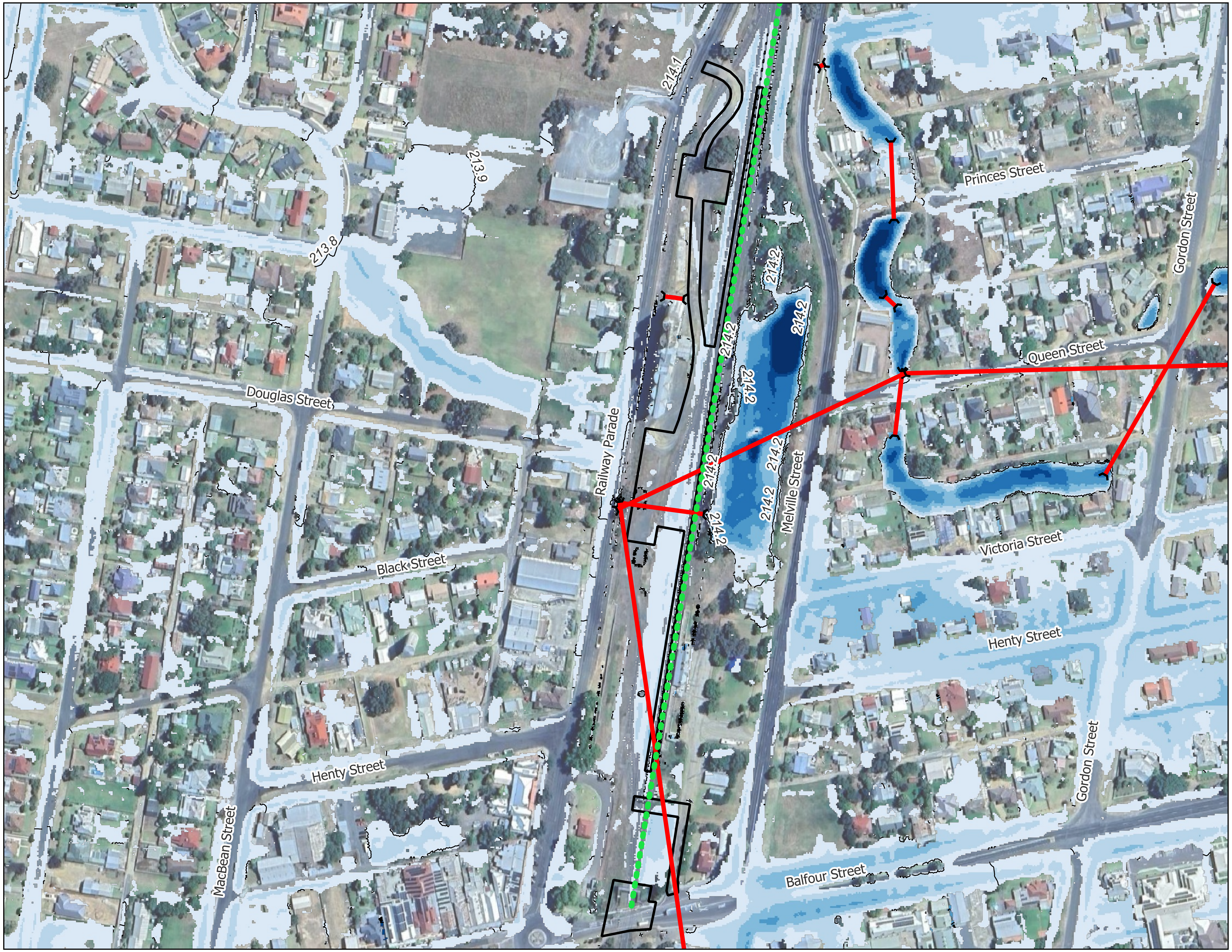
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

2% AEP Flood Depth (m) - Existing Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage
- Flood Level (m AHD)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- > 1.2

Notes:

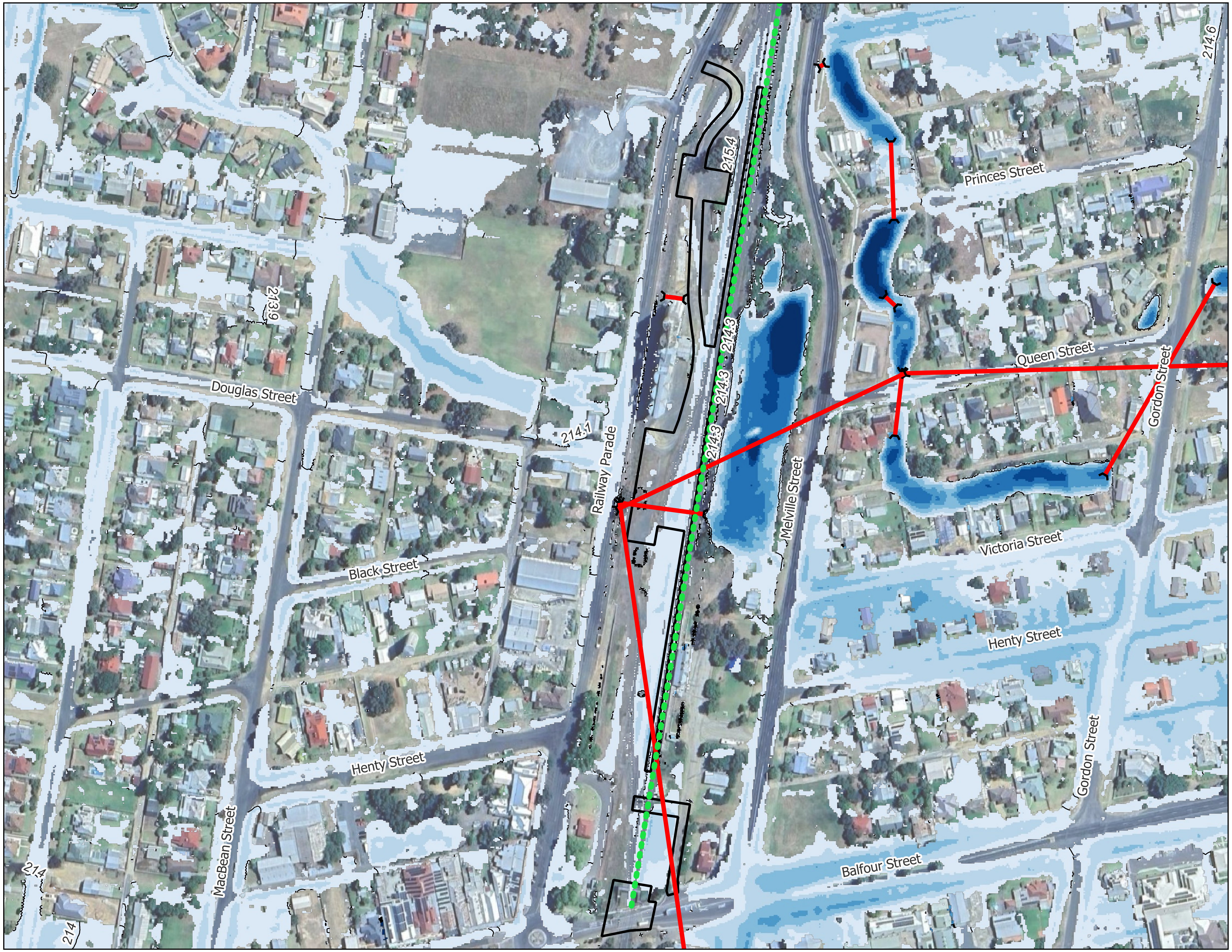
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
1% AEP Flood Depth (m) - Existing Conditions



MARTINUS

aurecon BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage
- Flood Level (m AHD)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- > 1.2

Notes:

Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

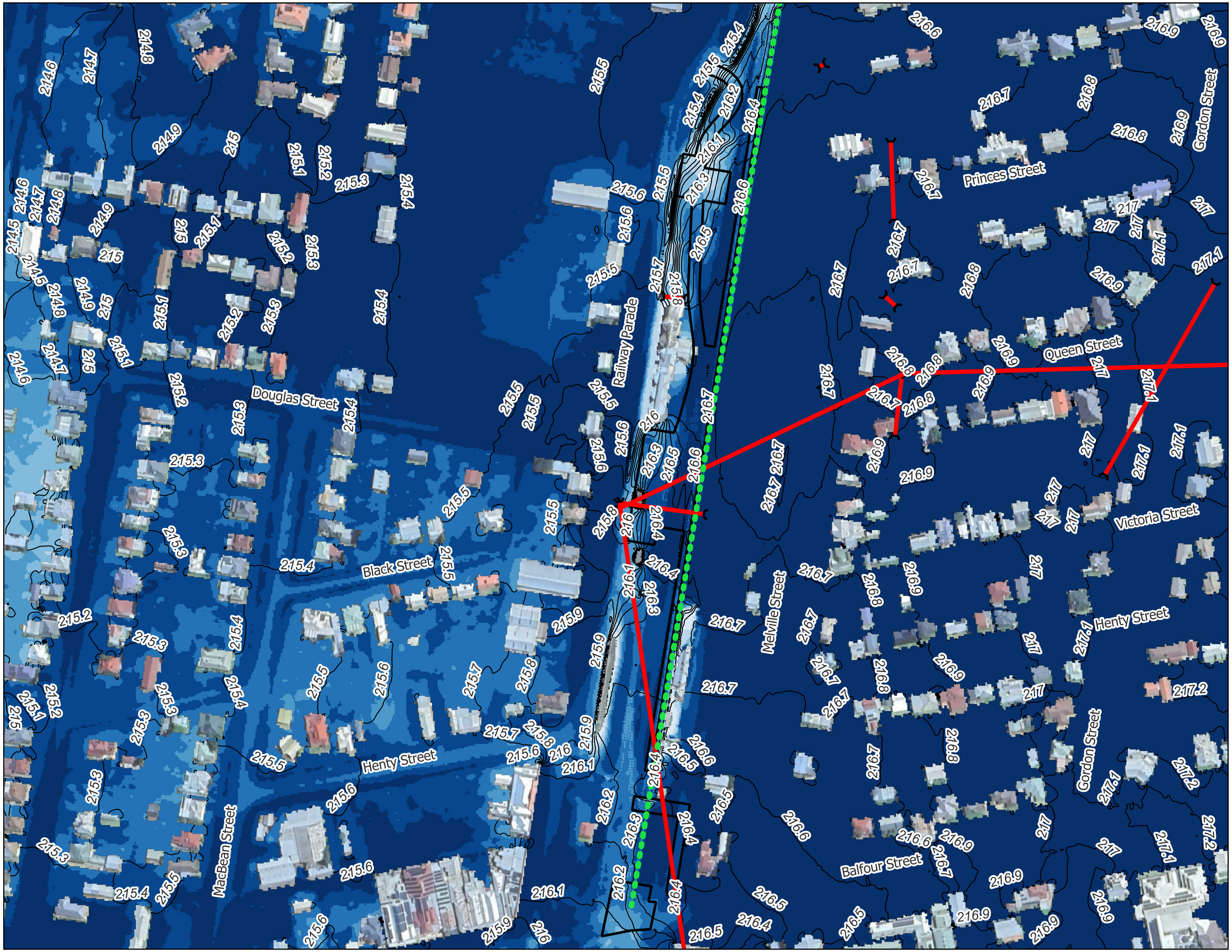
5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

1% AEP + Climate Change Flood Depth (m) - Existing Conditions

MARTINUS

aurecon BG&E



Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage
- Flood Level (m AHD)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- > 1.2

Notes:

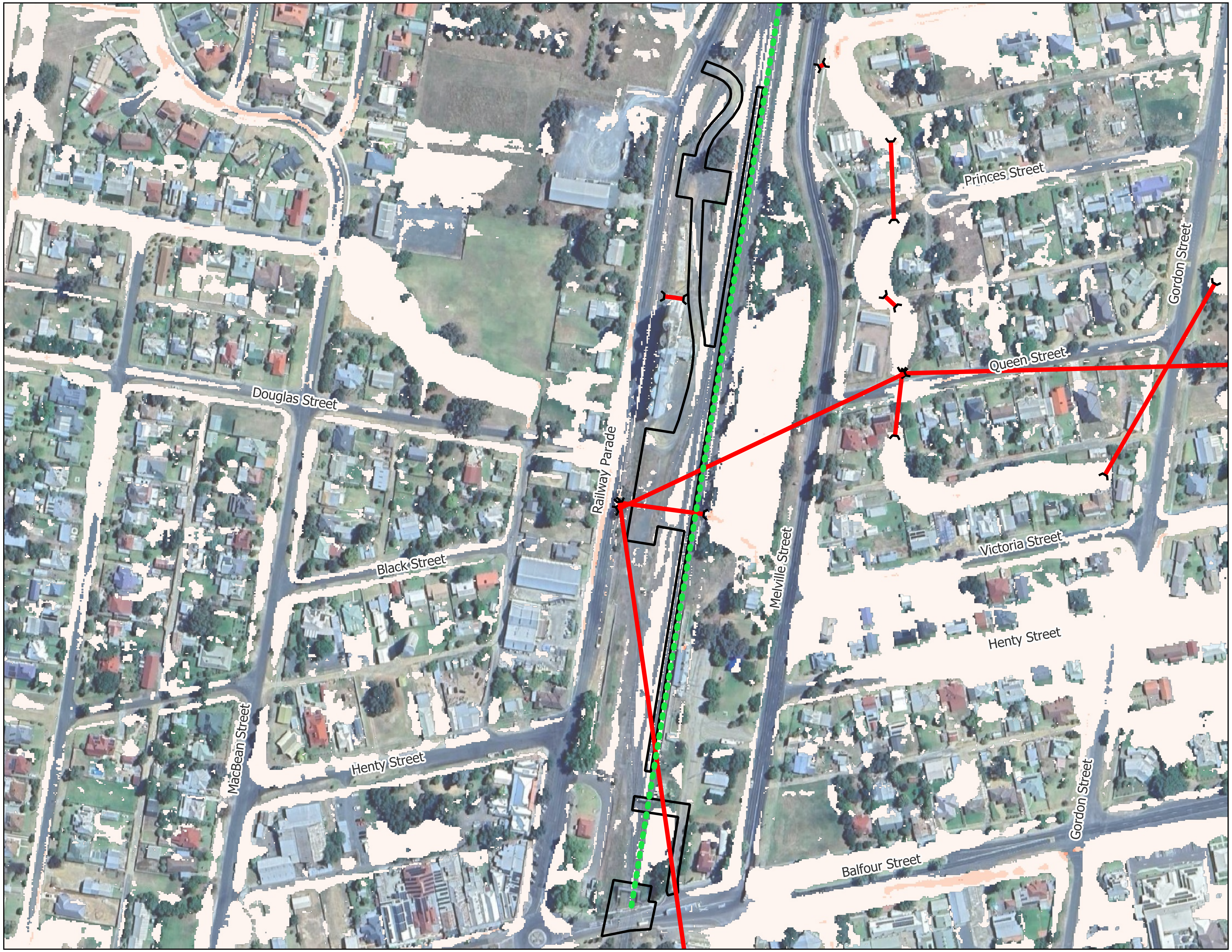
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
PMF Flood Depth (m) - Existing Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Notes:

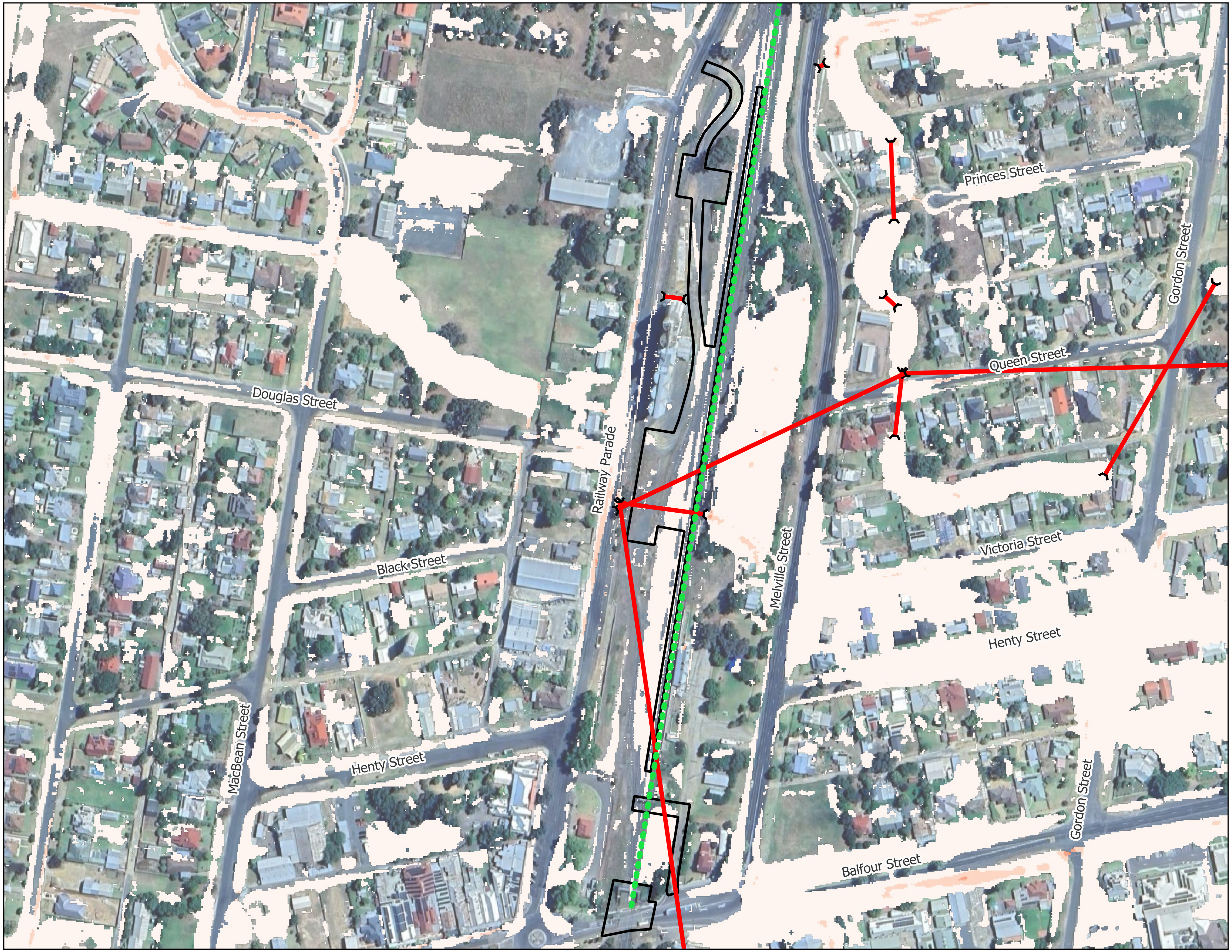
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
5% AEP Velocity (m/s) - Existing Conditions



MARTINUS
aurecon
BG&E

Legend

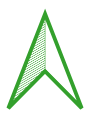
- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Notes:

Map by: TT

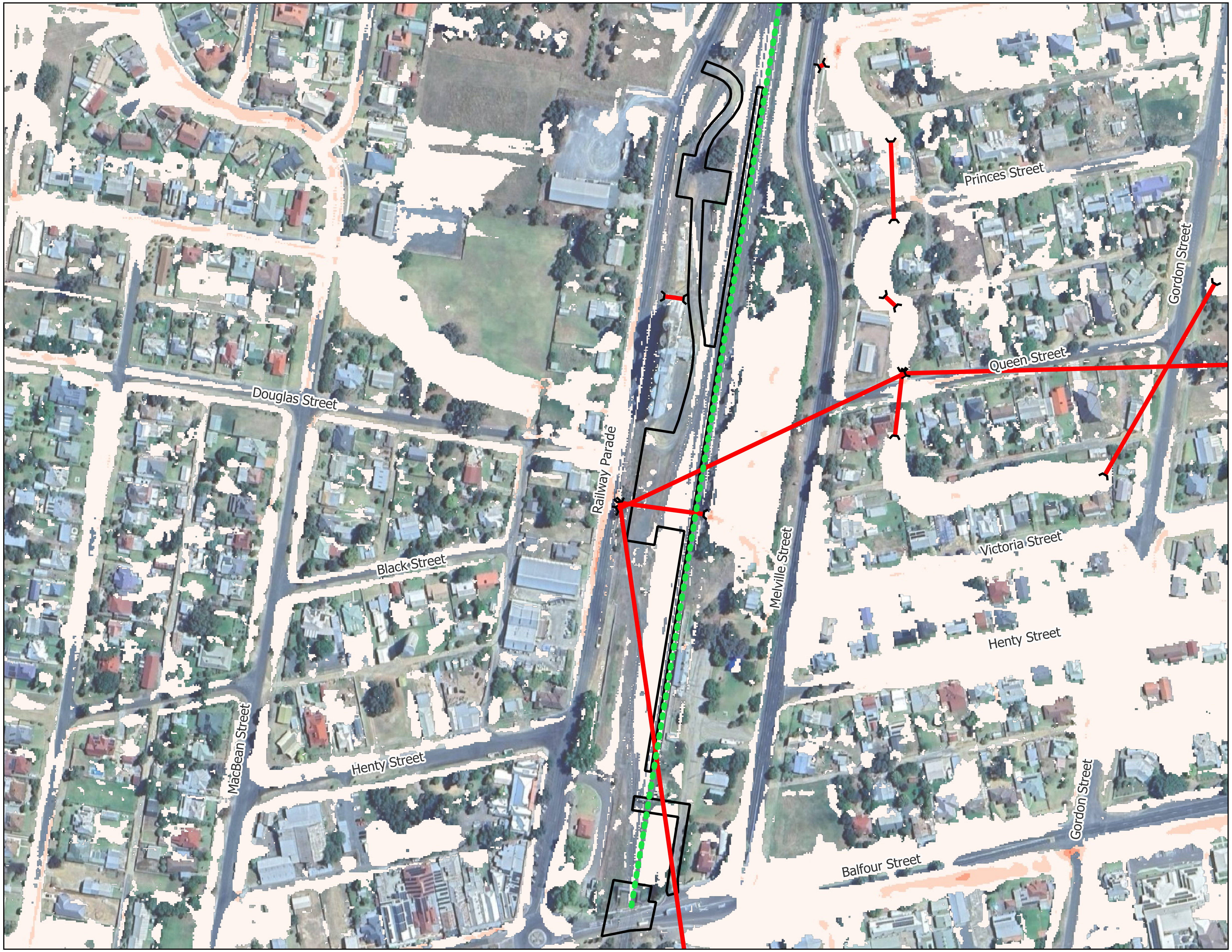


0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
2% AEP Velocity (m/s) - Existing Conditions



MARTINUS

aurecon BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

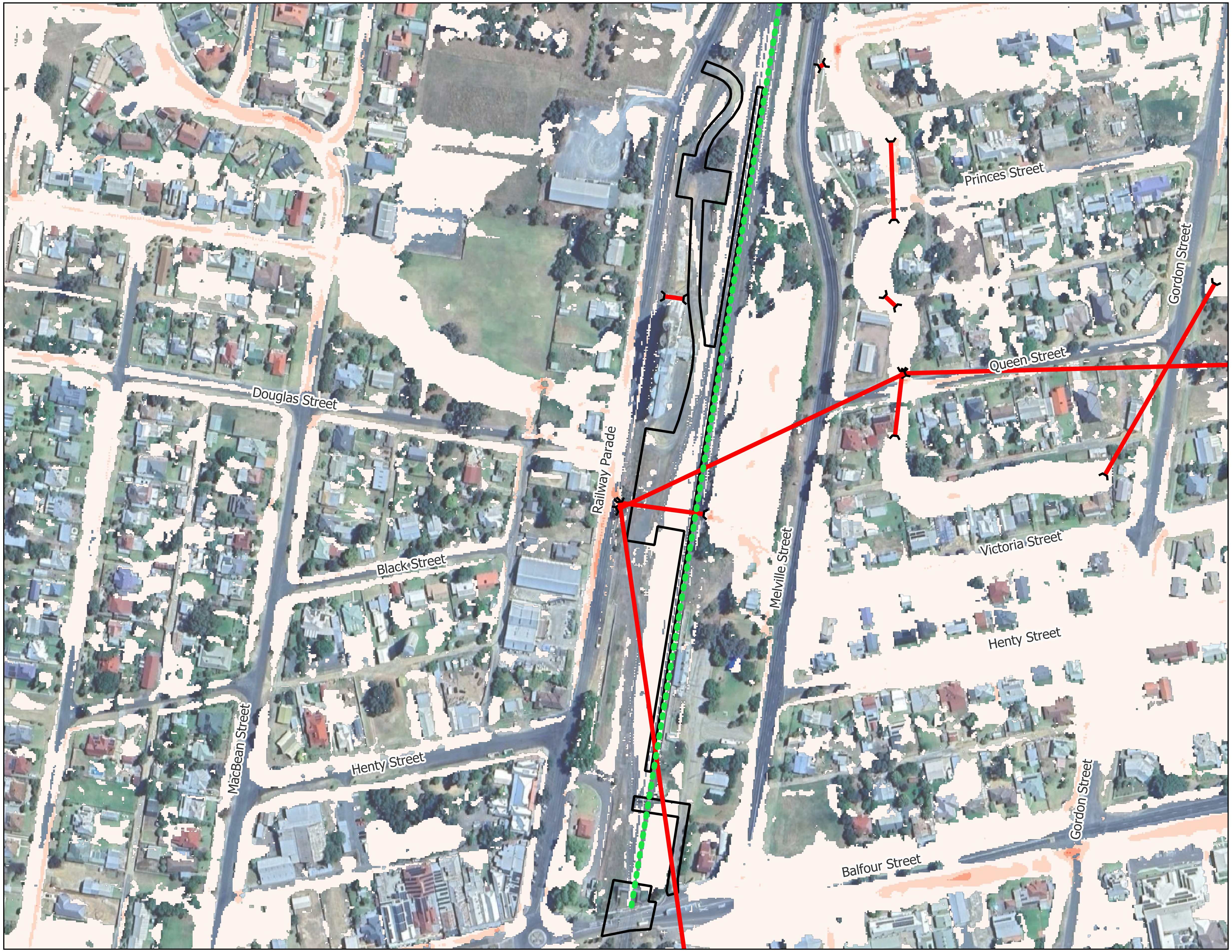
Notes:

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
1% AEP Velocity (m/s) - Existing Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Notes:

Map by: TT

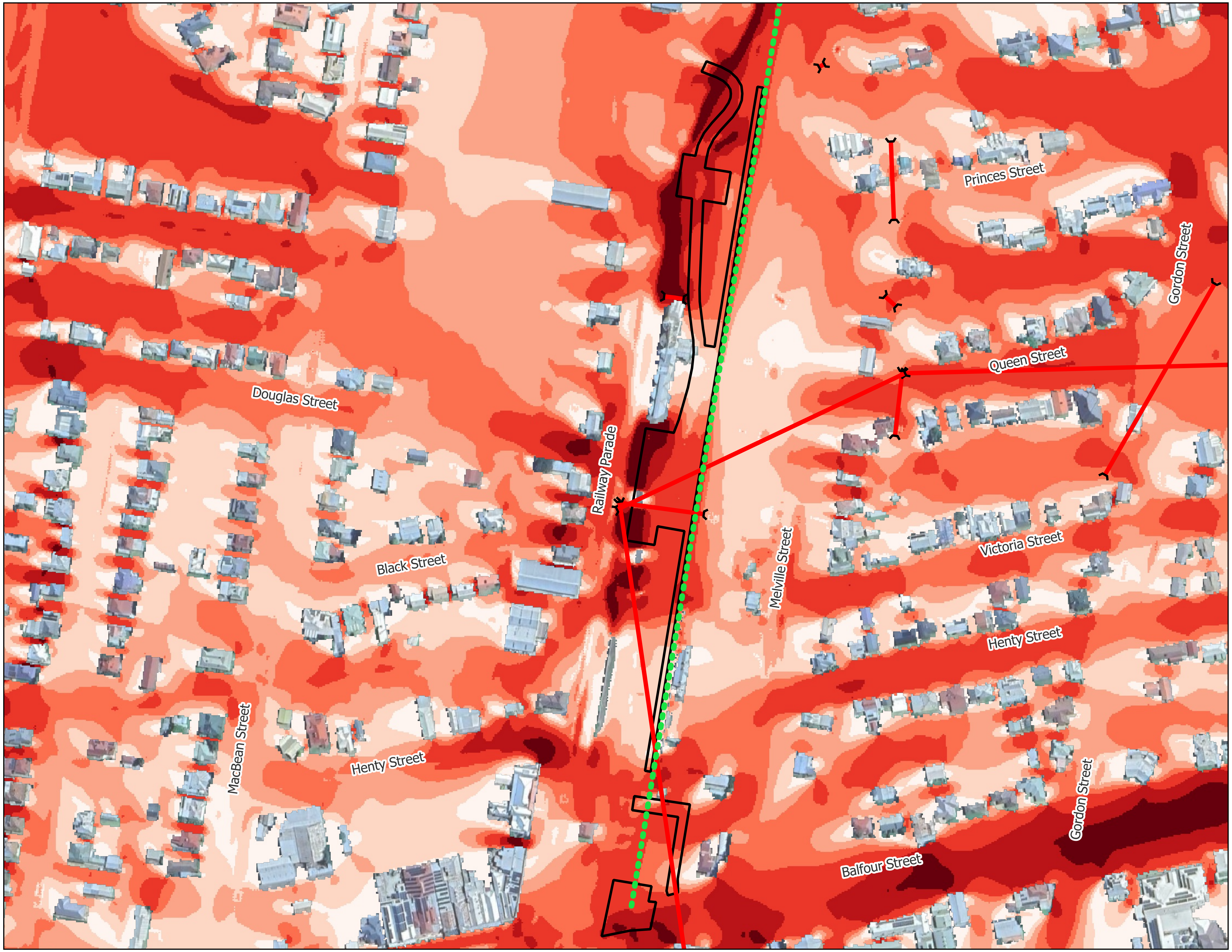
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

1% AEP + Climate Change Velocity (m/s) - Existing Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Notes:

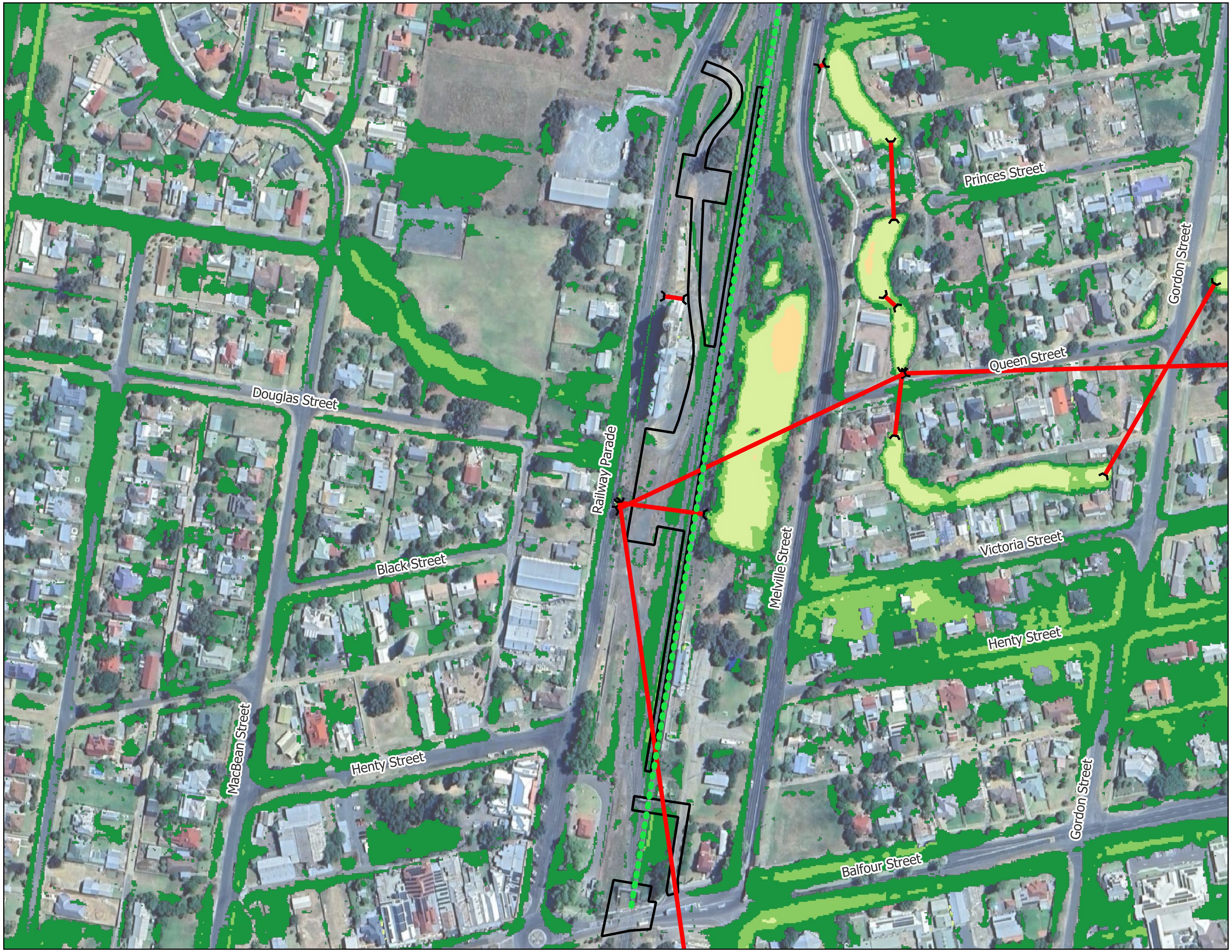
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
PMF Velocity (m/s) - Existing Conditions



MARTINUS

aurecon BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category

- H1
- H2
- H3
- H4
- H5
- H6

Notes:

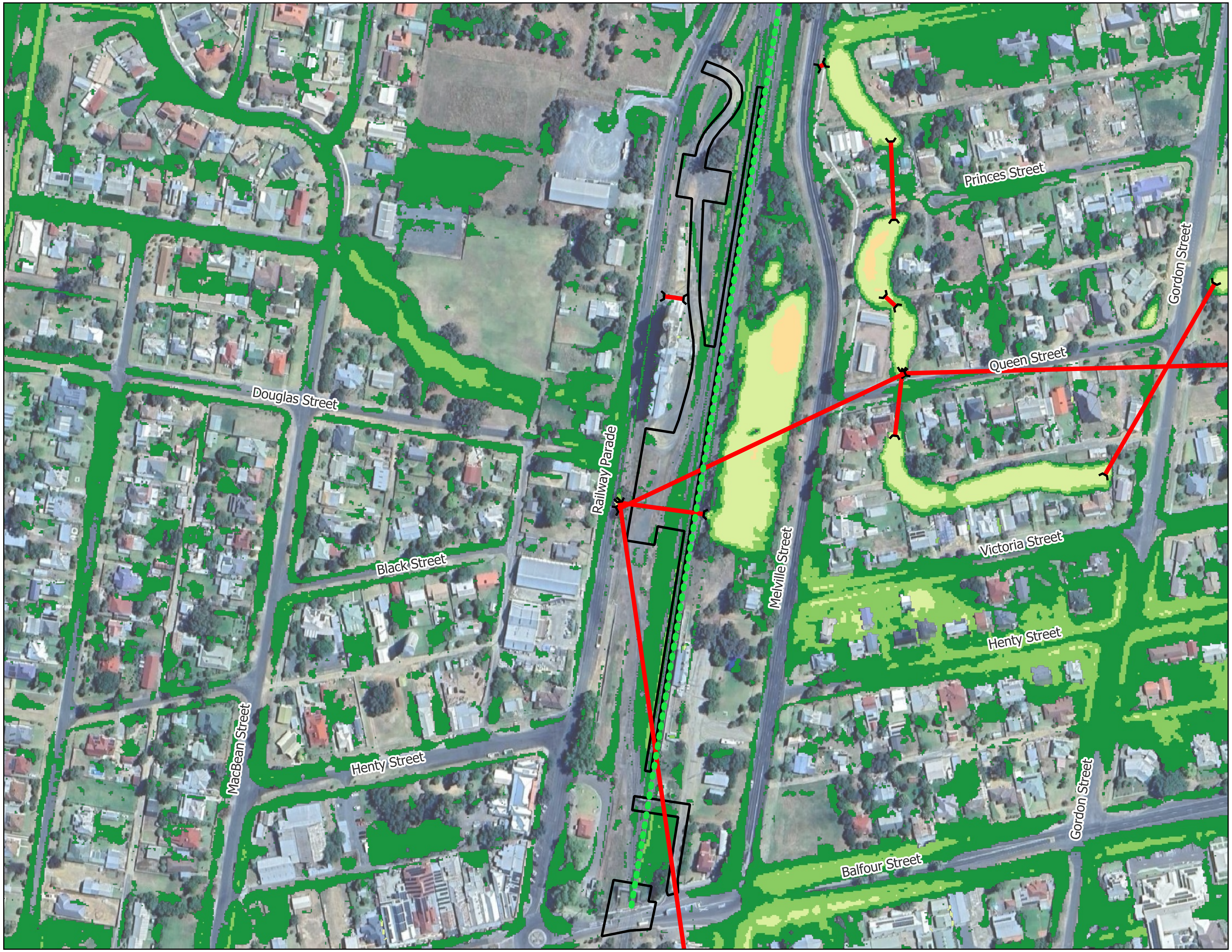
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
5% AEP Flood Hazard - Existing Conditions



MARTINUS

aurecon BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category

- H1
- H2
- H3
- H4
- H5
- H6

Notes:

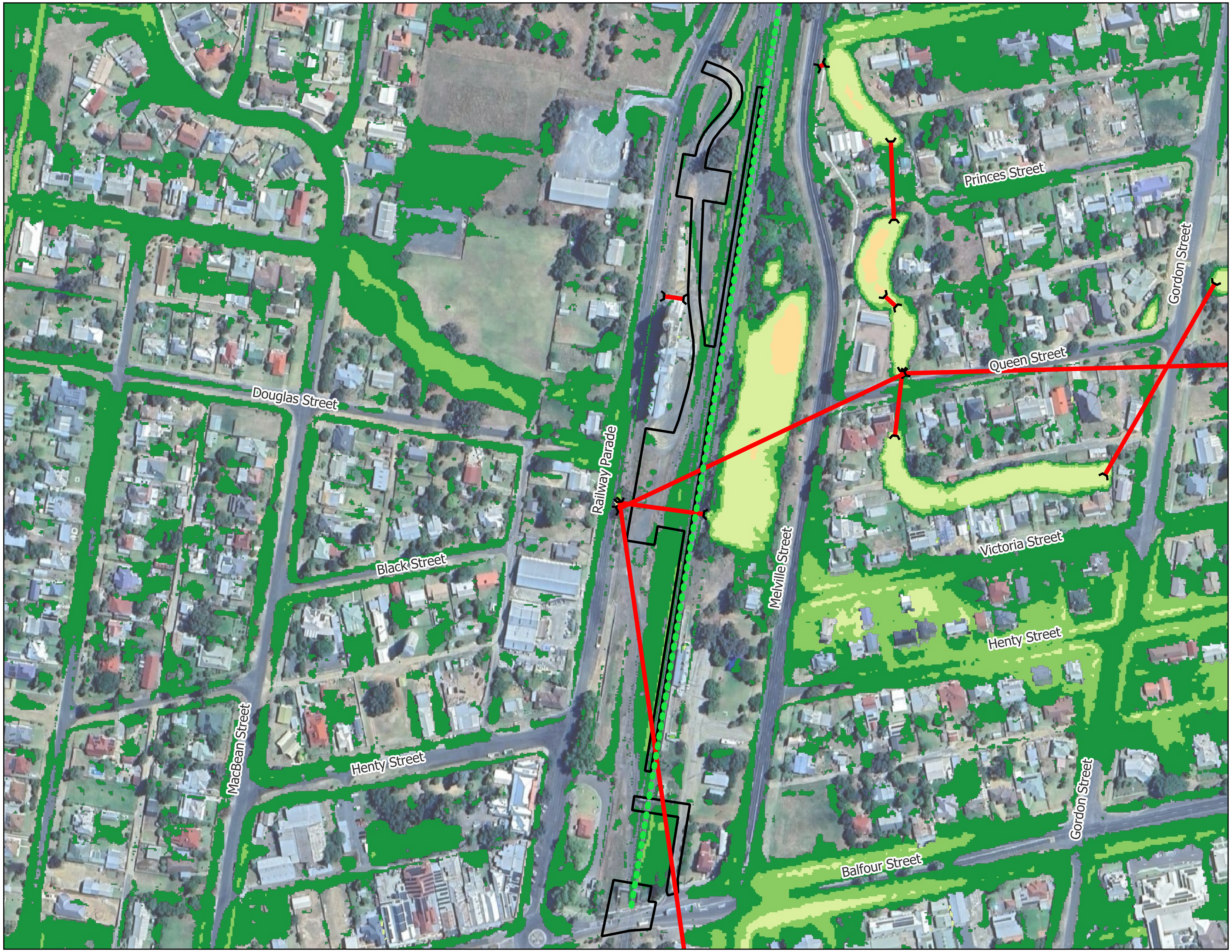
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
2% AEP Flood Hazard - Existing Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category

- H1
- H2
- H3
- H4
- H5
- H6

Notes:

Map by: TT

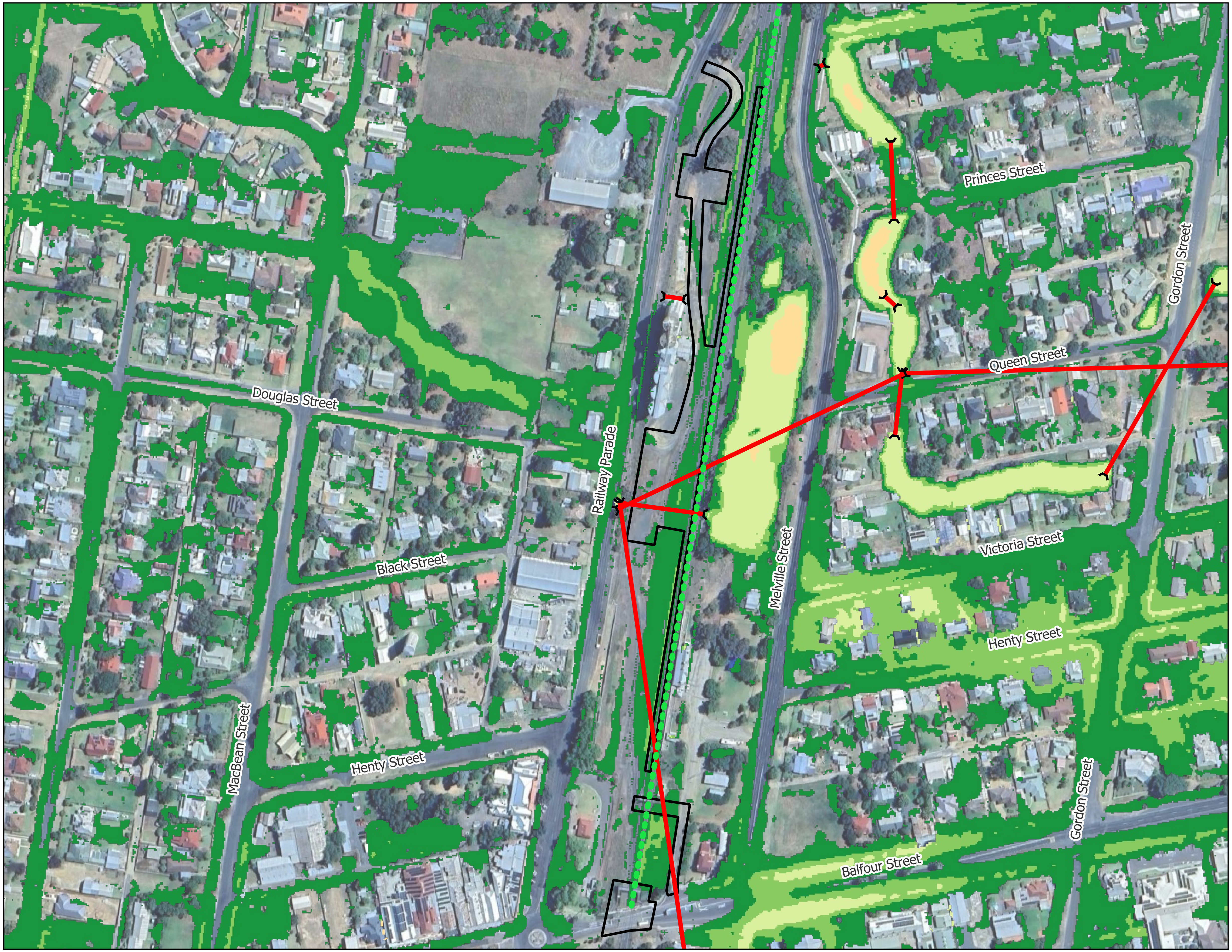
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

1% AEP Flood Hazard - Existing Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category

- H1
- H2
- H3
- H4
- H5
- H6

Notes:

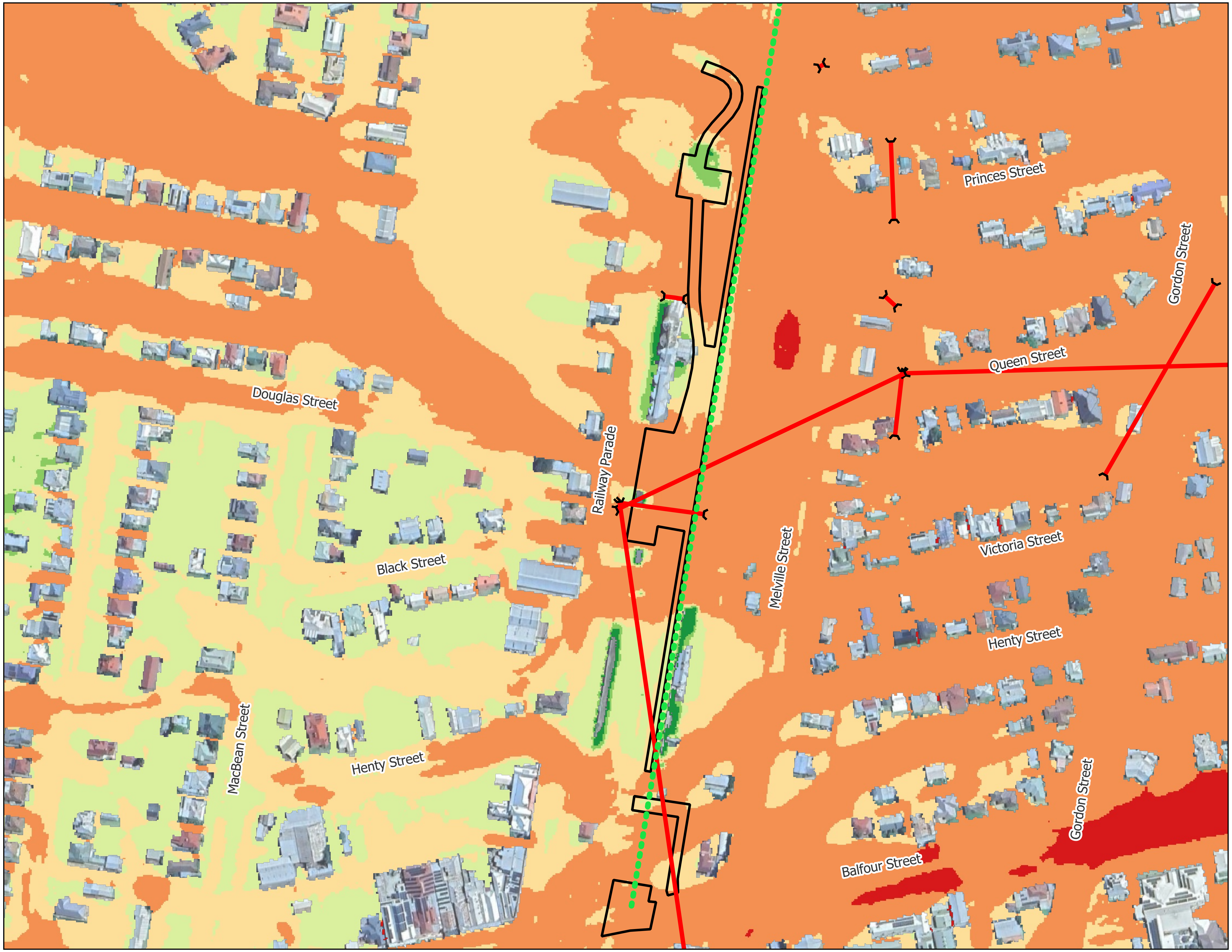
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
1% AEP + Climate Change Flood Hazard - Existing Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category

- H1
- H2
- H3
- H4
- H5
- H6

Notes:

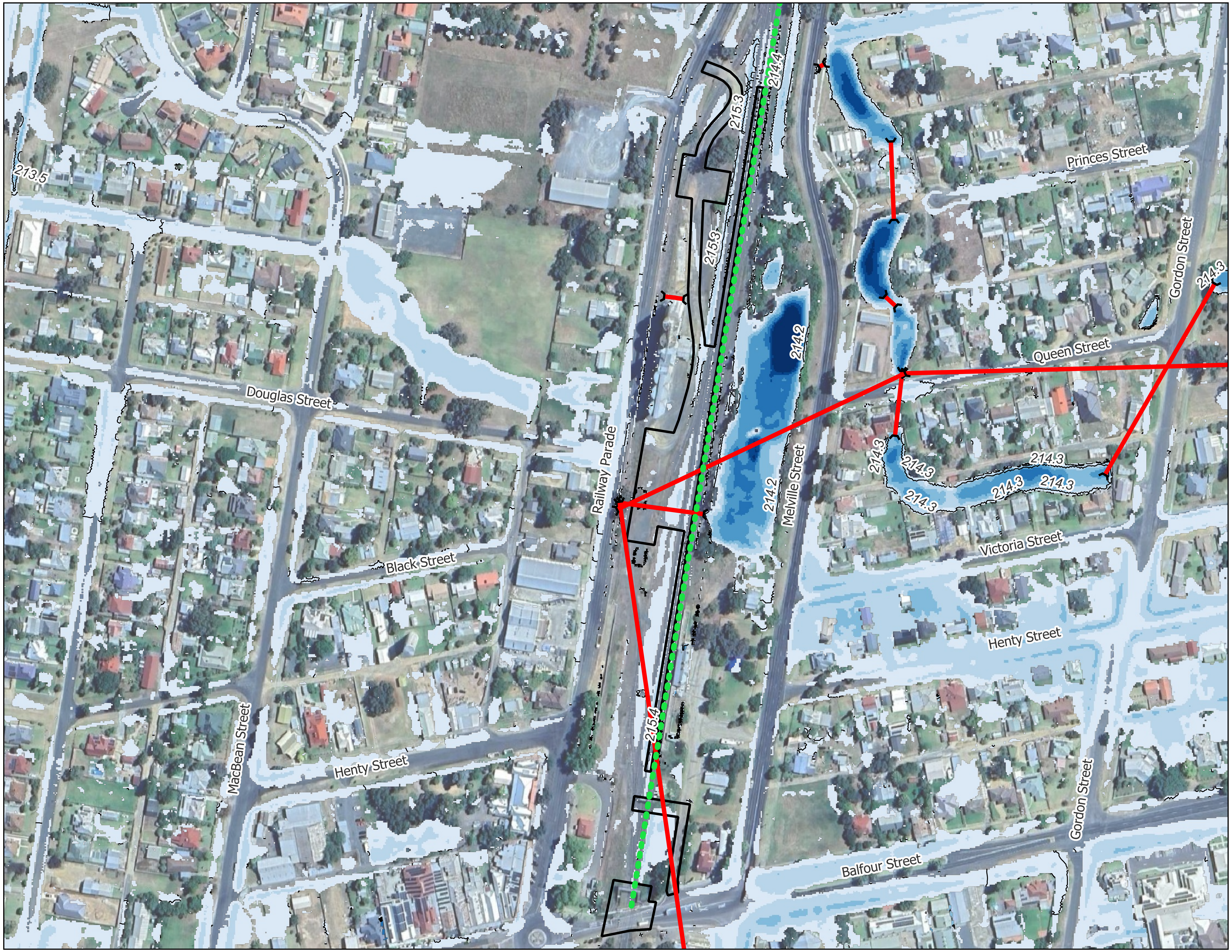
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
PMF Flood Hazard - Existing Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage
- Flood Level (m AHD)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- > 1.2

Notes:

Map by: TT

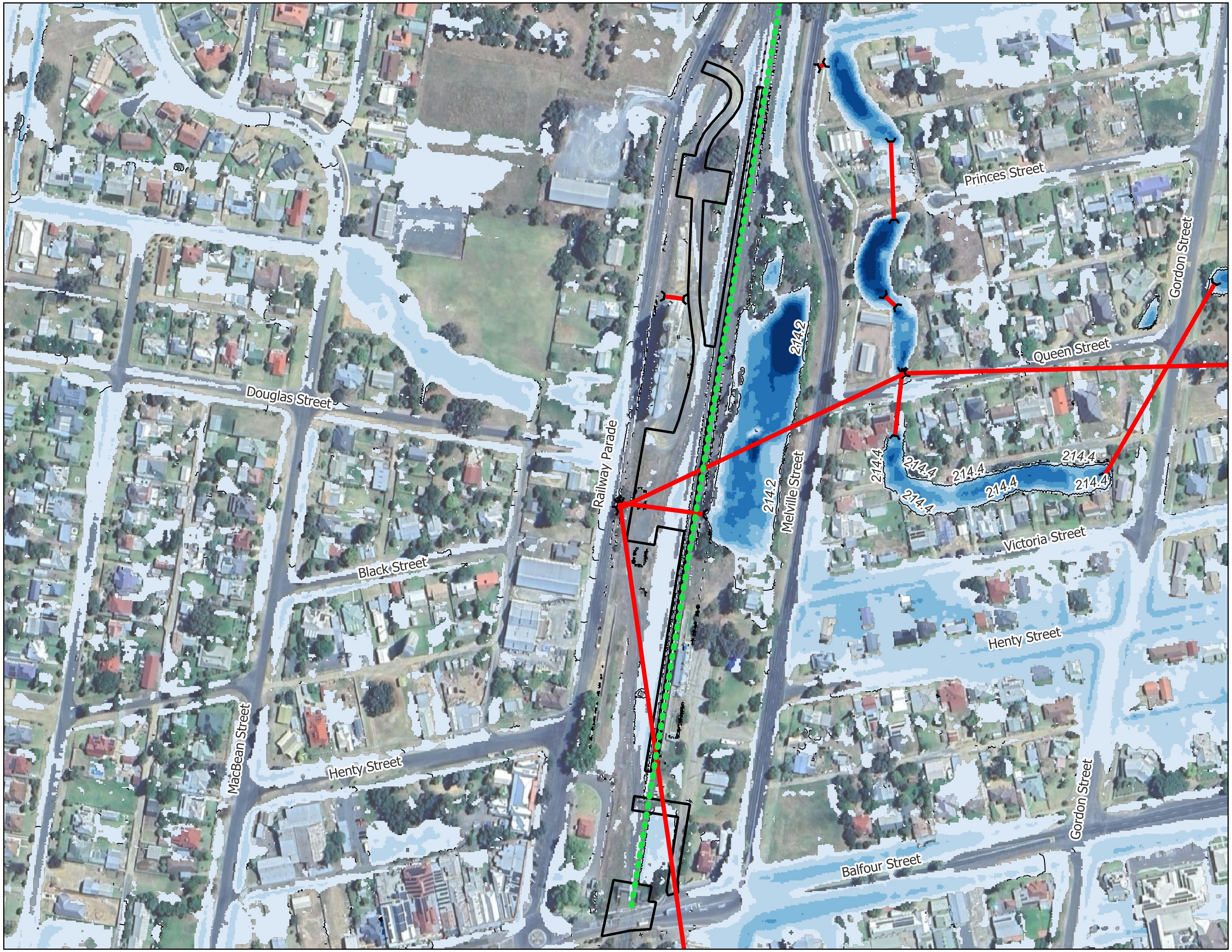
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

5% AEP Flood Depth (m) - Developed Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage
- Flood Level (m AHD)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- > 1.2

Notes:

Map by: TT

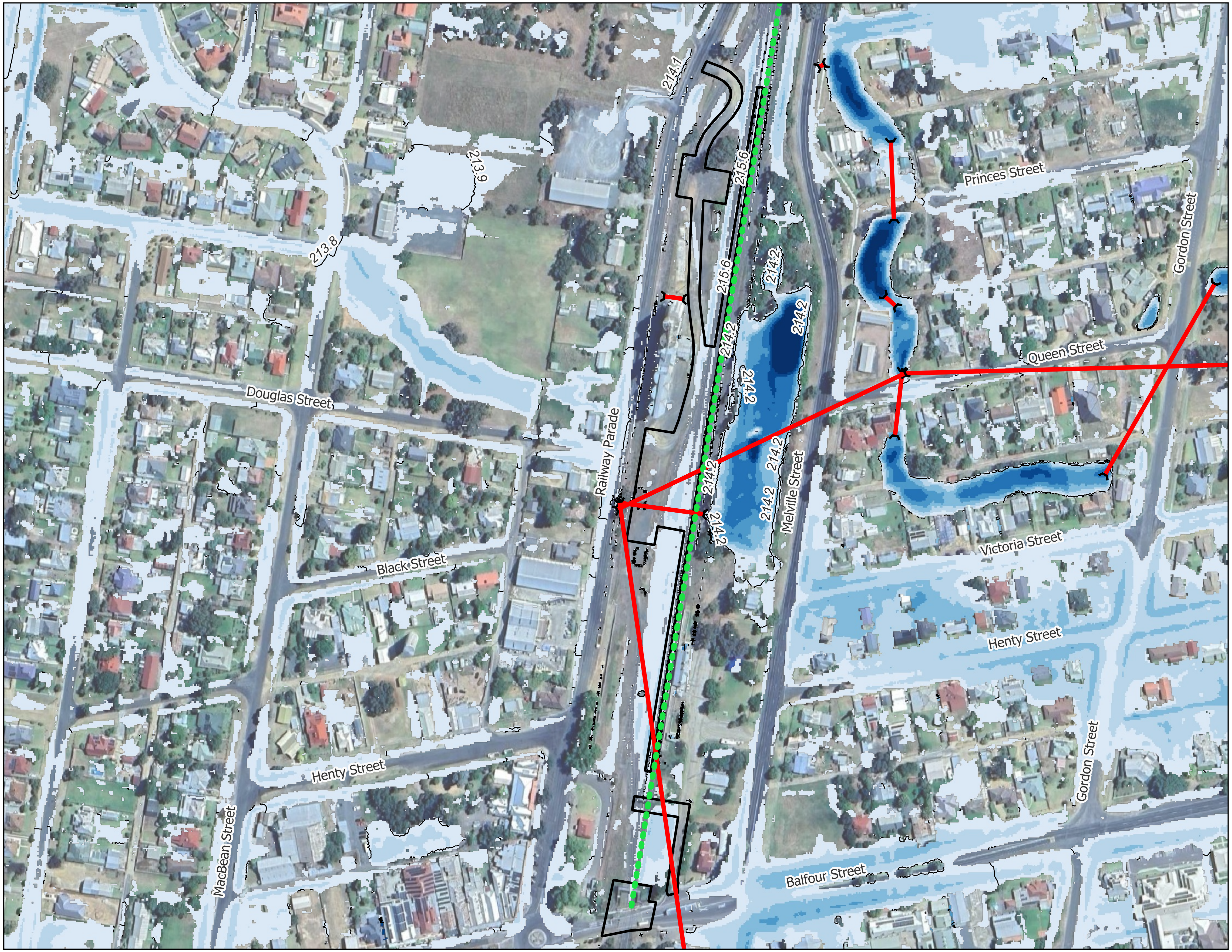
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

2% AEP Flood Depth (m) - Developed Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage
- Flood Level (m AHD)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- > 1.2

Notes:

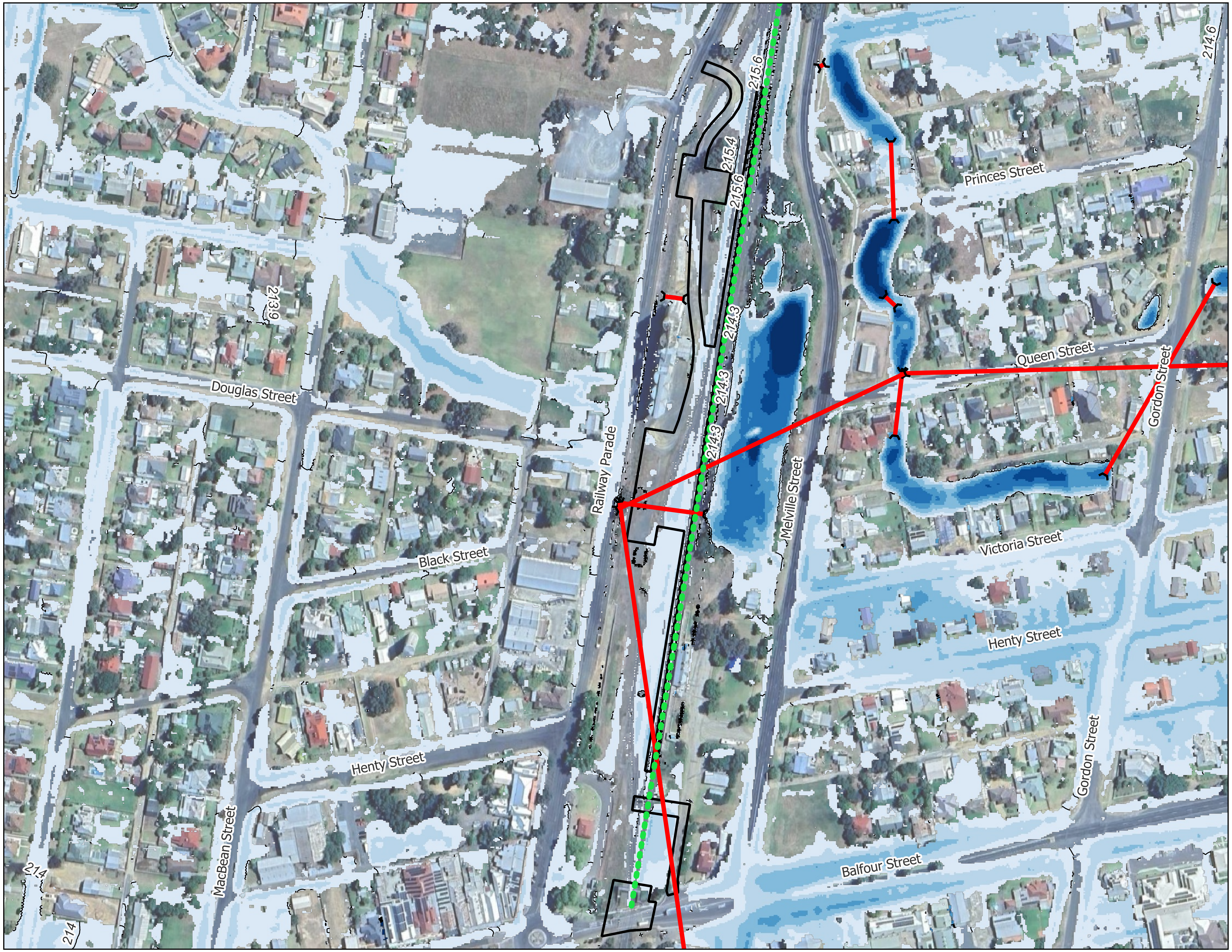
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
1% AEP Flood Depth (m) - Developed Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage
- Flood Level (m AHD)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- > 1.2

Notes:

Map by: TT

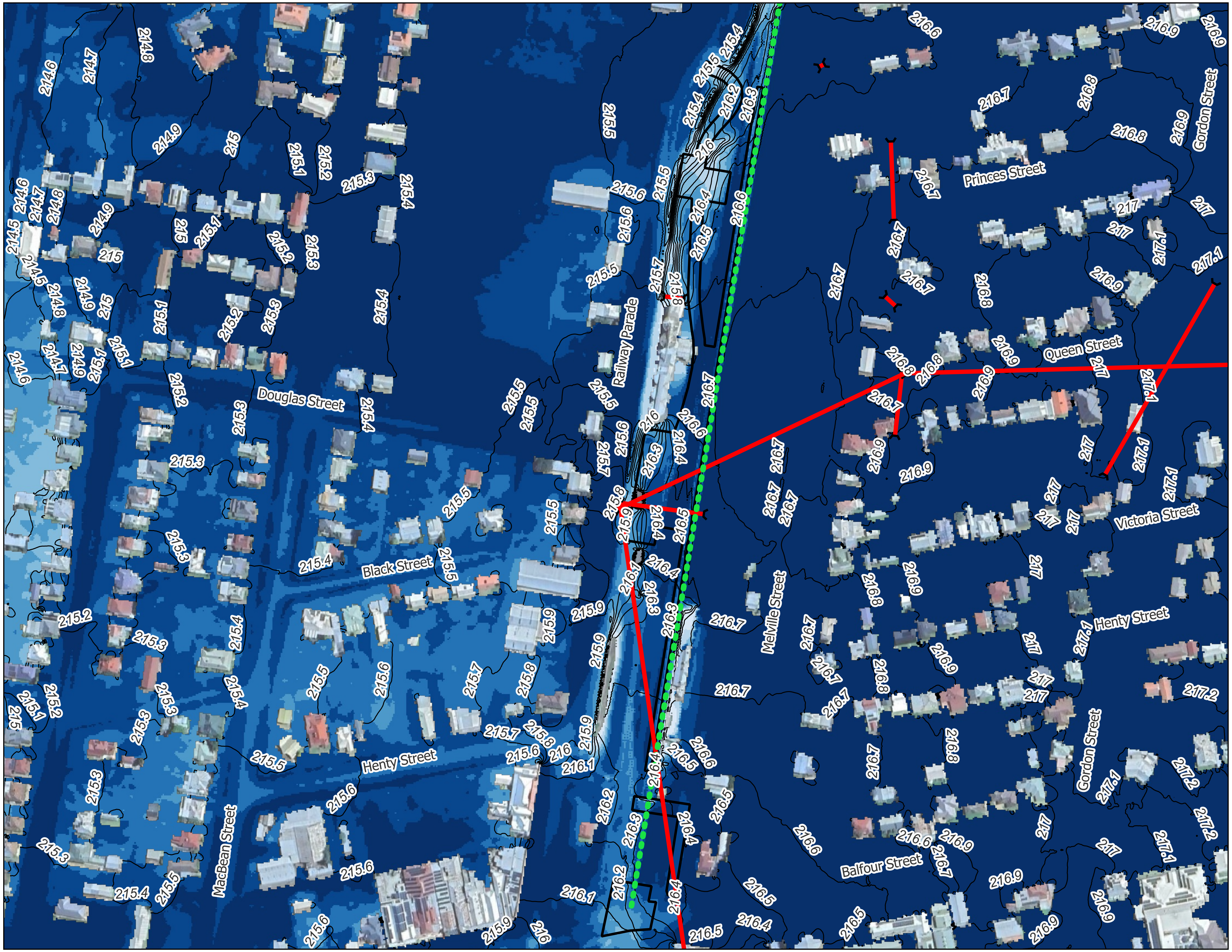
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

1% AEP + Climate Change Flood Depth (m) - Developed Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage
- Flood Level (m AHD)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- > 1.2

Notes:

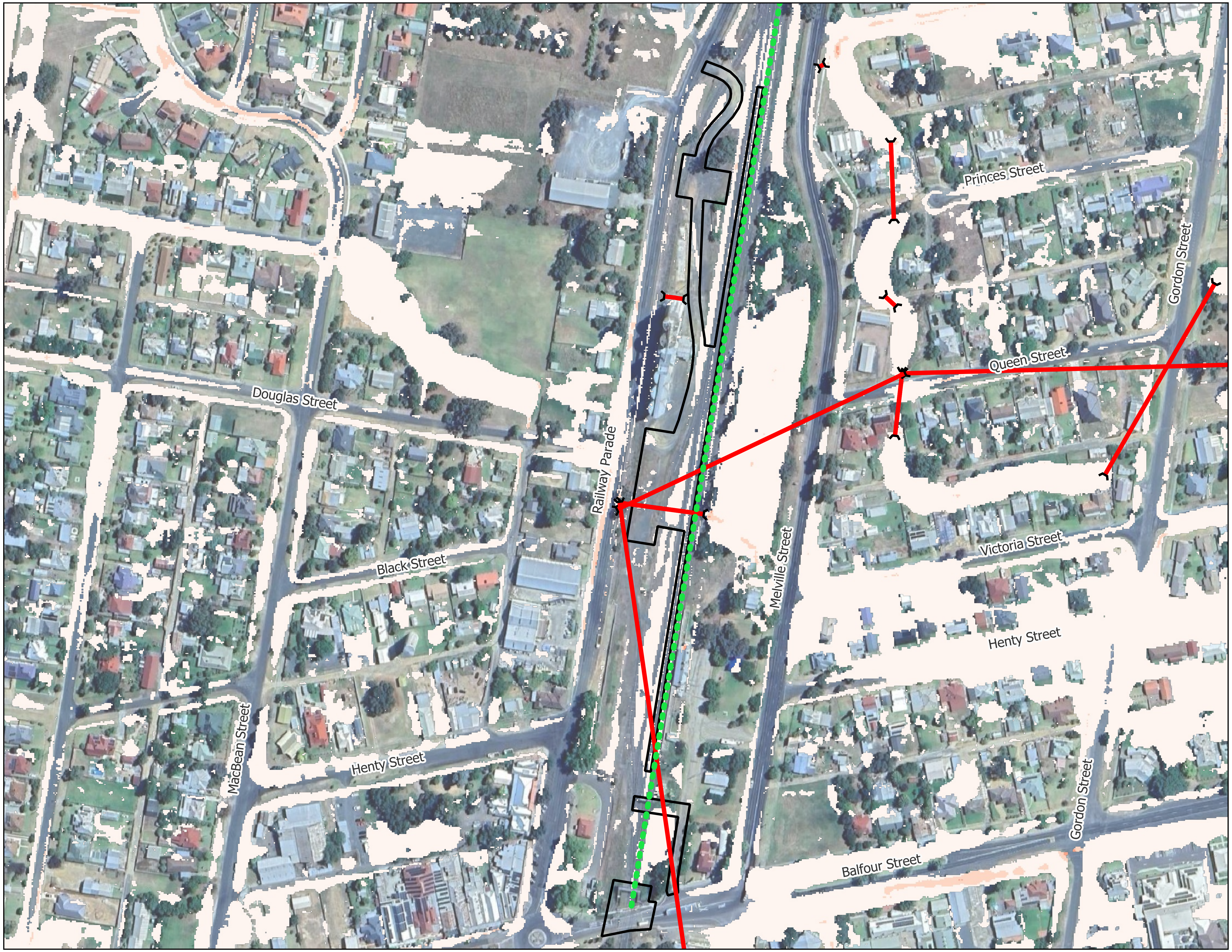
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
PMF Flood Depth (m) - Developed Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Notes:

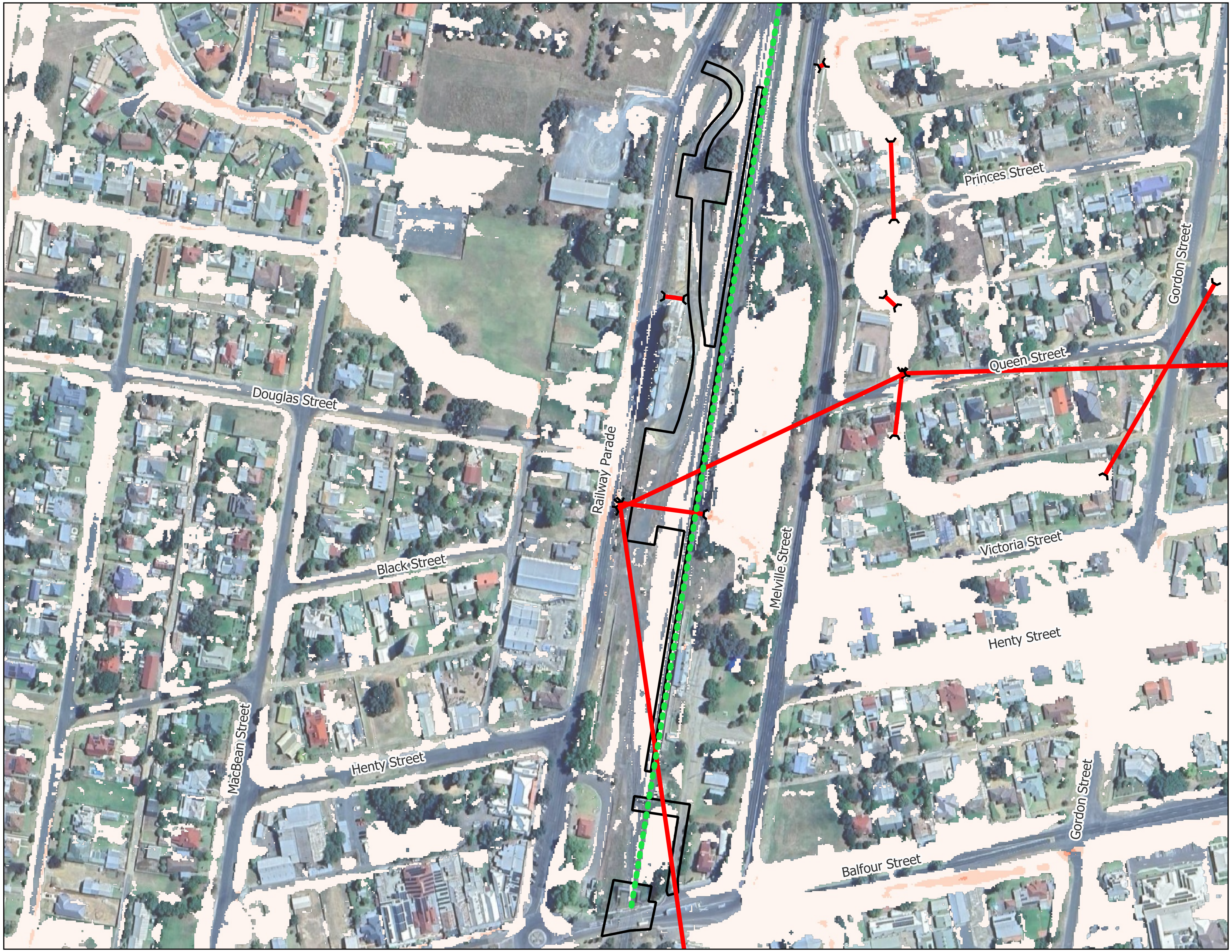
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
5% AEP Velocity (m/s) - Developed Conditions



MARTINUS

aurecon BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Notes:

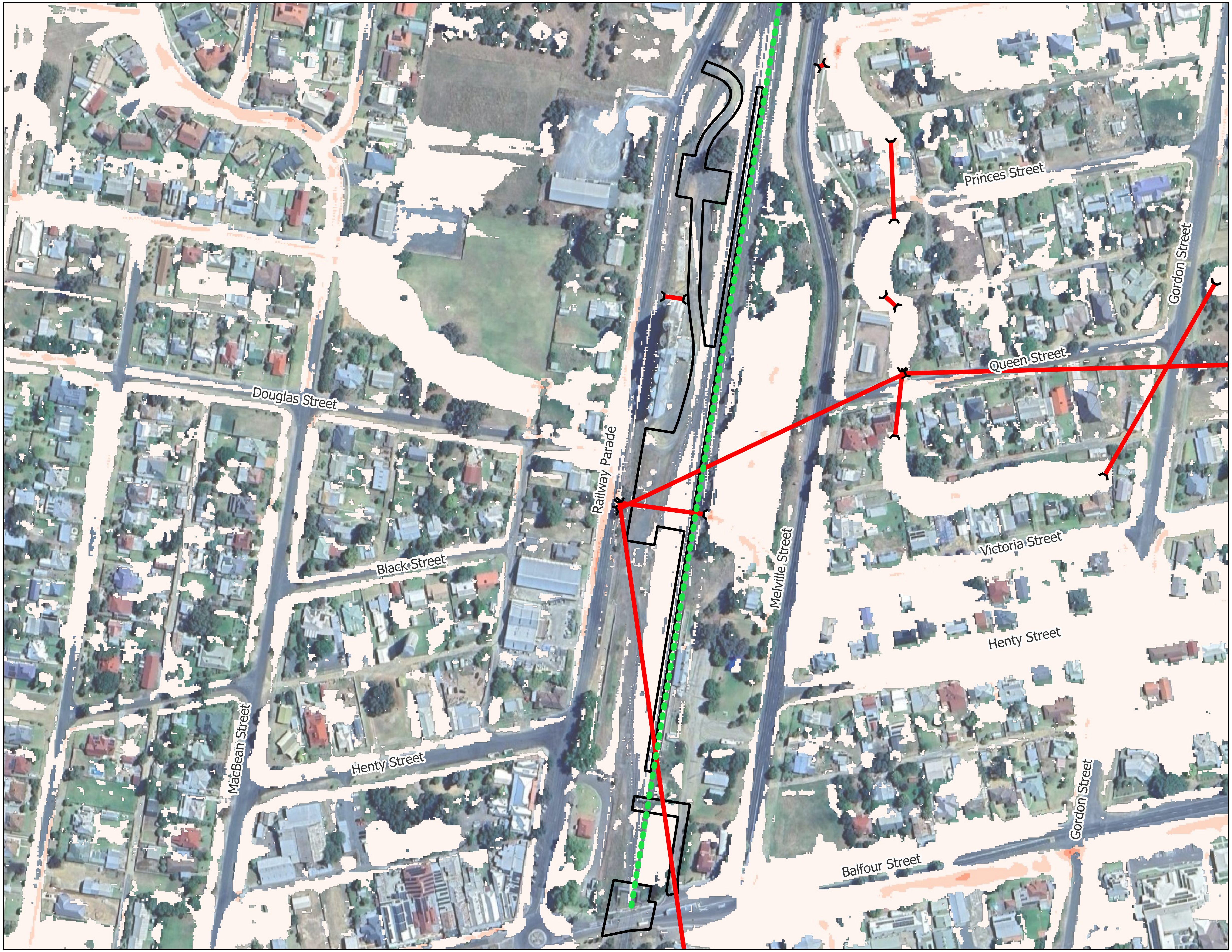
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
2% AEP Velocity (m/s) - Developed Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Notes:

Map by: TT

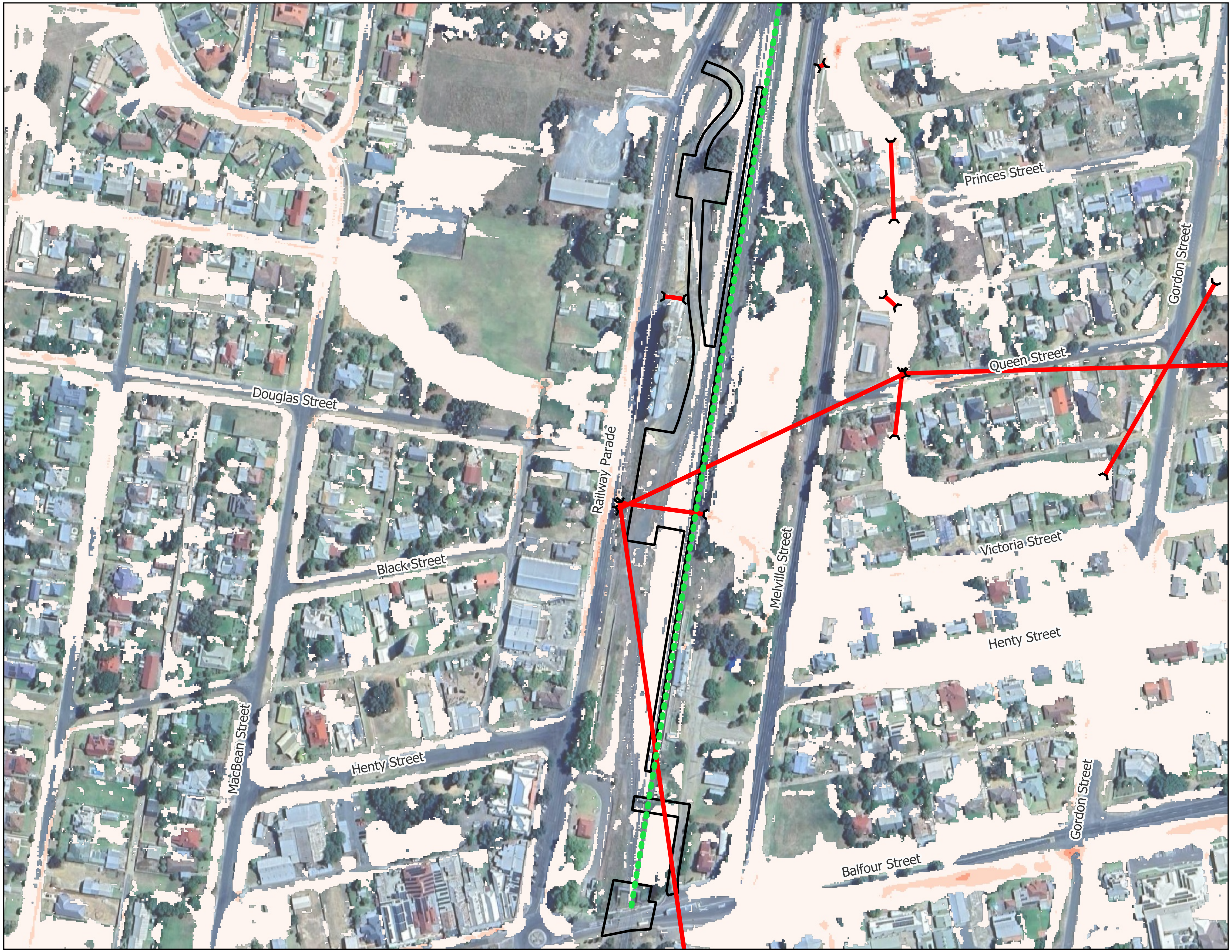
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

1% AEP Velocity (m/s) - Developed Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Notes:

Map by: TT

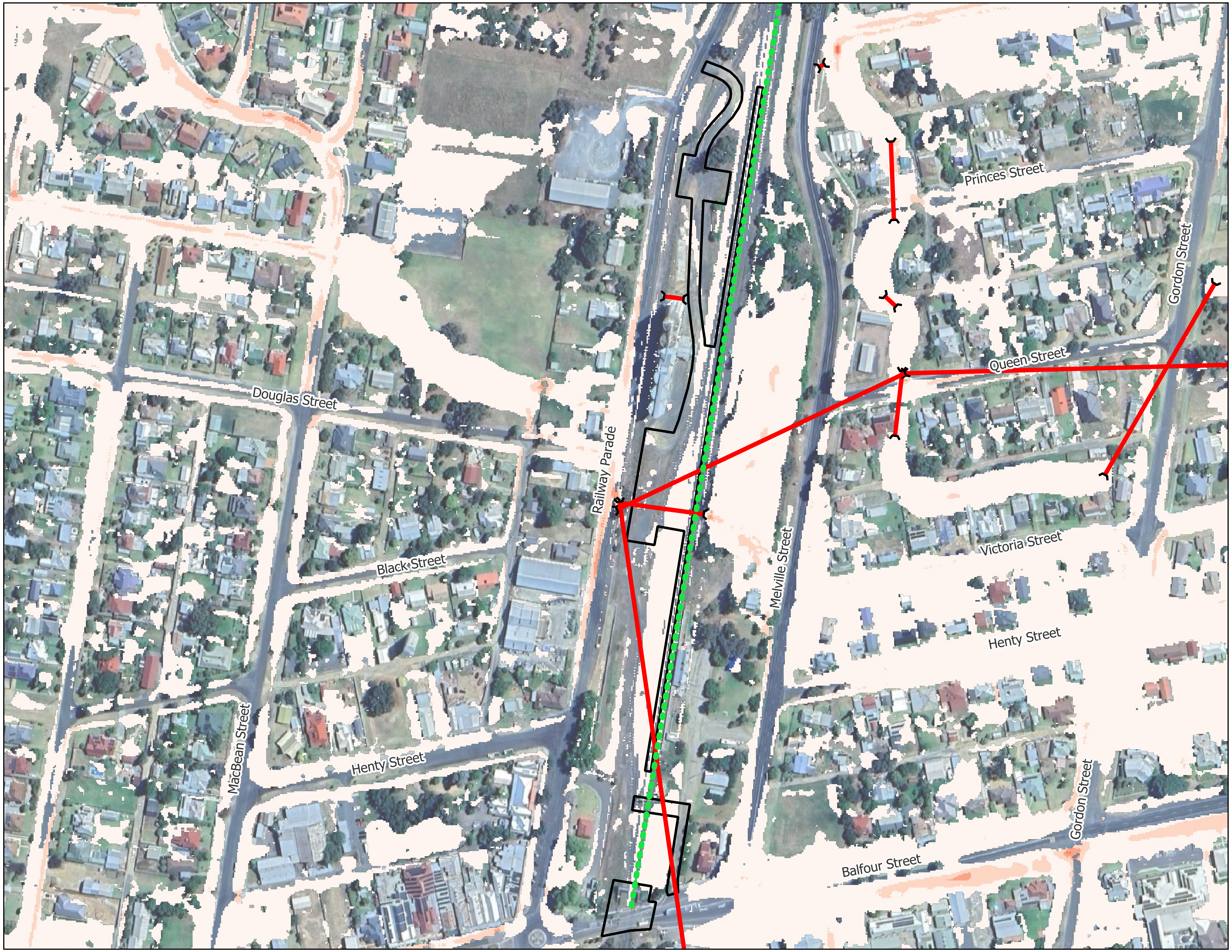
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

1% AEP+Blockage Velocity (m/s) - Developed Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Notes:

Map by: TT

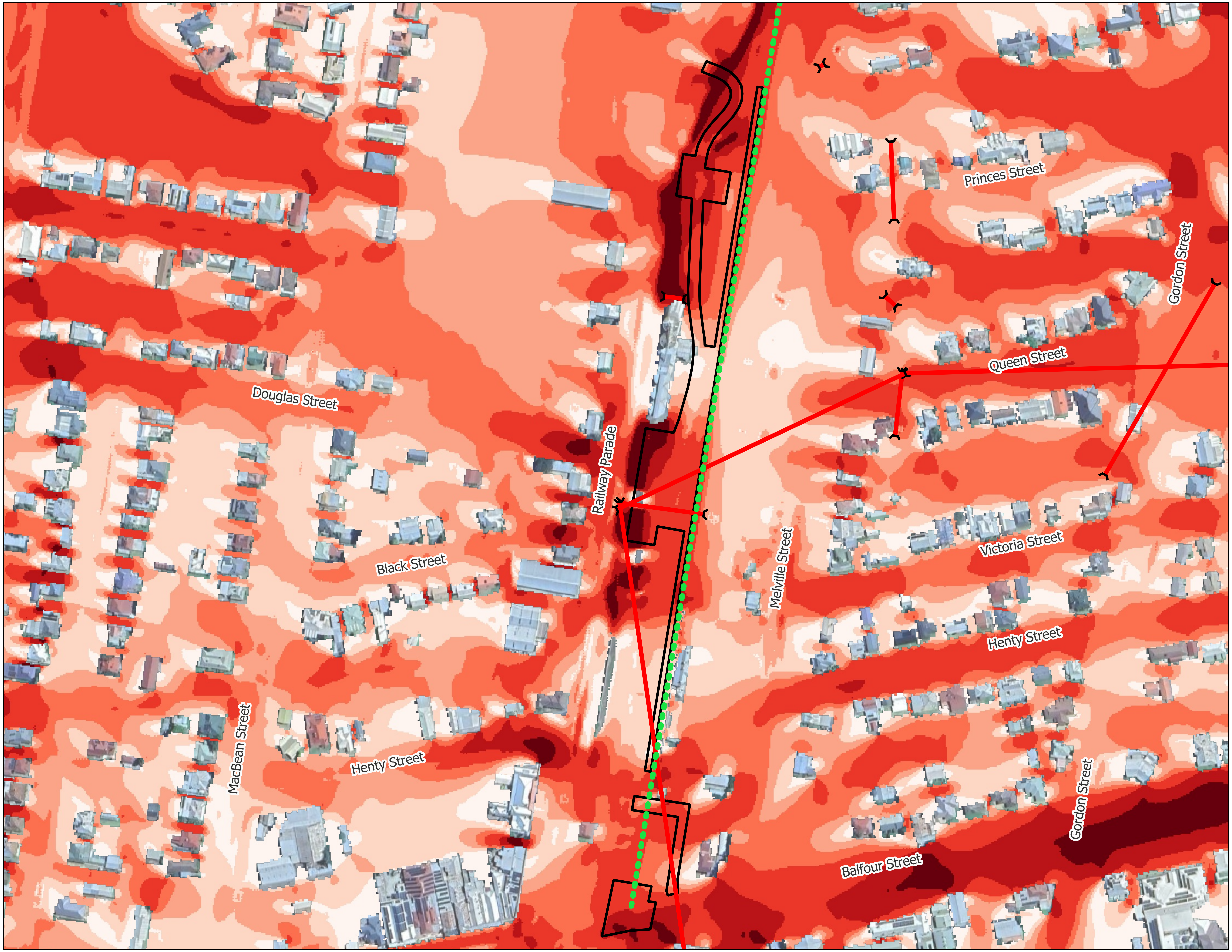
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

1% AEP + Climate Change Velocity (m/s) - Developed Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Notes:

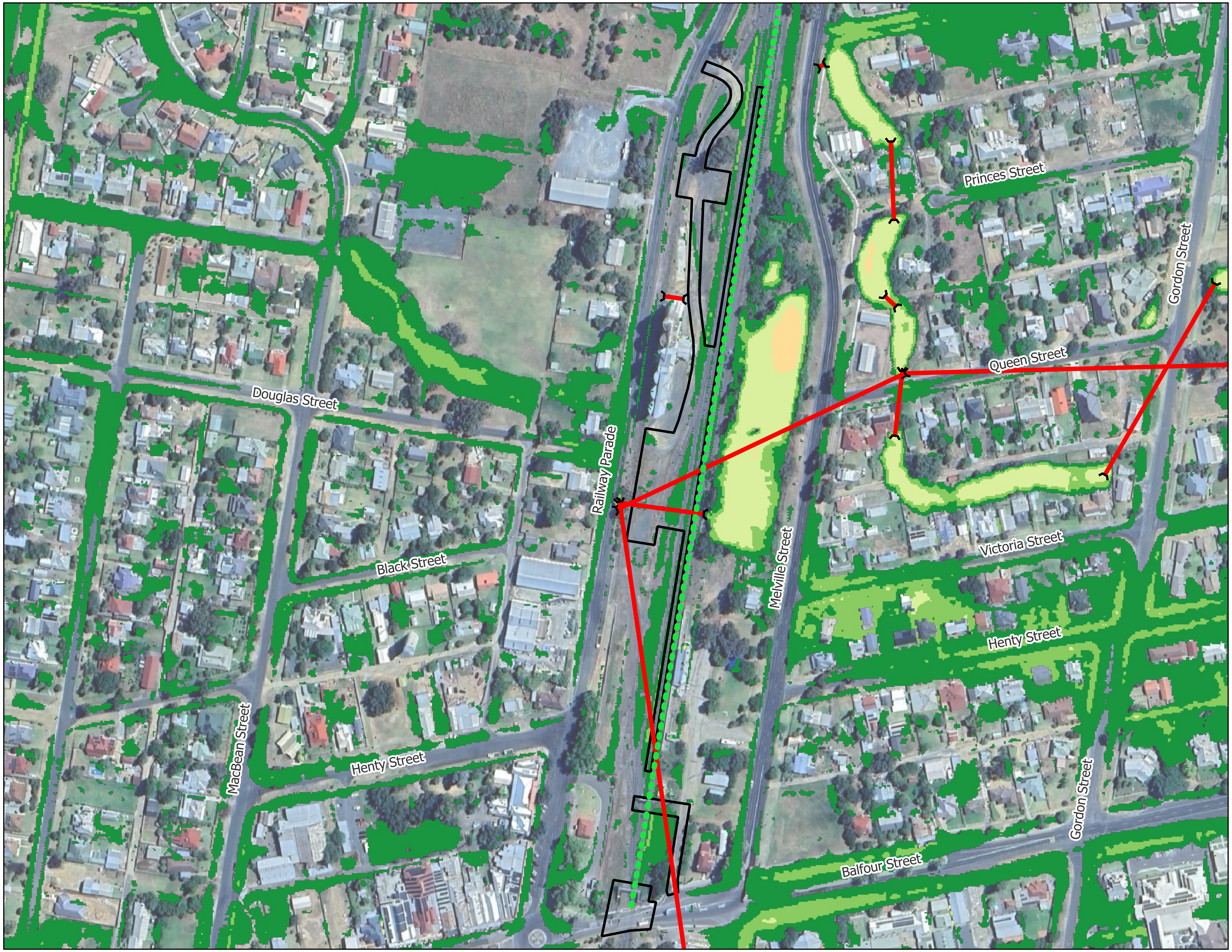
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
PMF Velocity (m/s) - Developed Conditions



MARTINUS aurecon BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category

- H1
- H2
- H3
- H4
- H5
- H6

Notes:

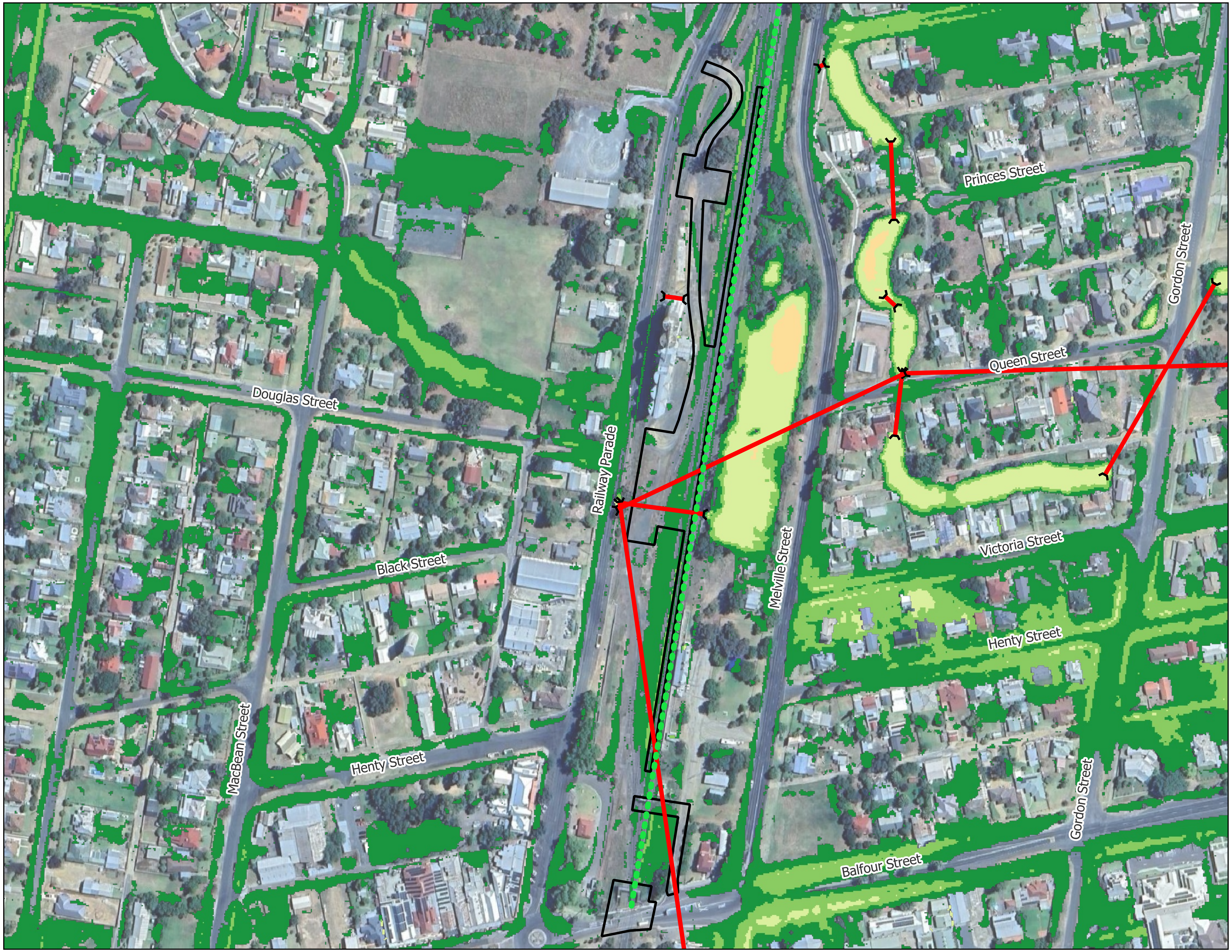
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
5% AEP Flood Hazard - Developed Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category

- H1
- H2
- H3
- H4
- H5
- H6

Notes:

Map by: TT

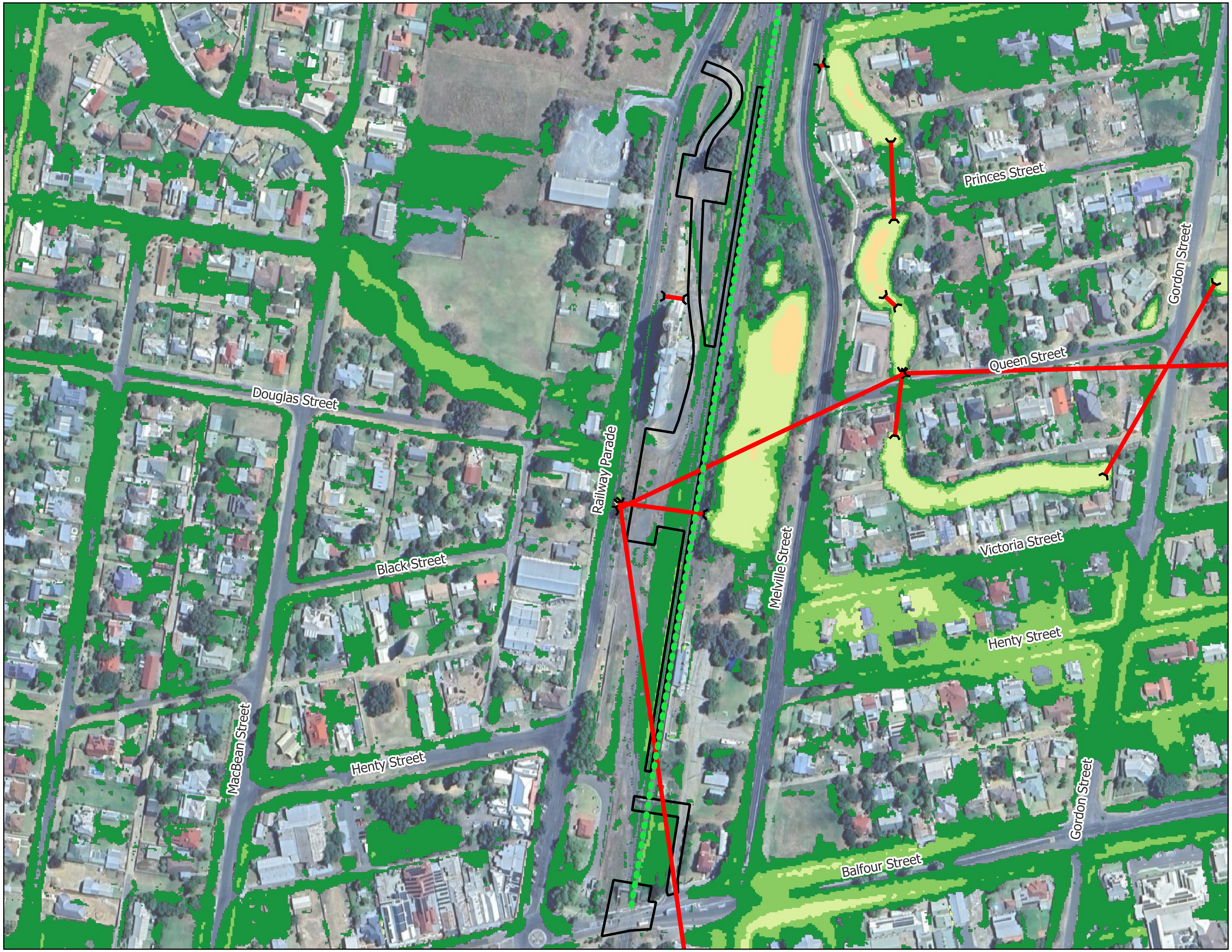
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

2% AEP Flood Hazard - Developed Conditions



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category

- H1
- H2
- H3
- H4
- H5
- H6

Notes:

Map by: TT

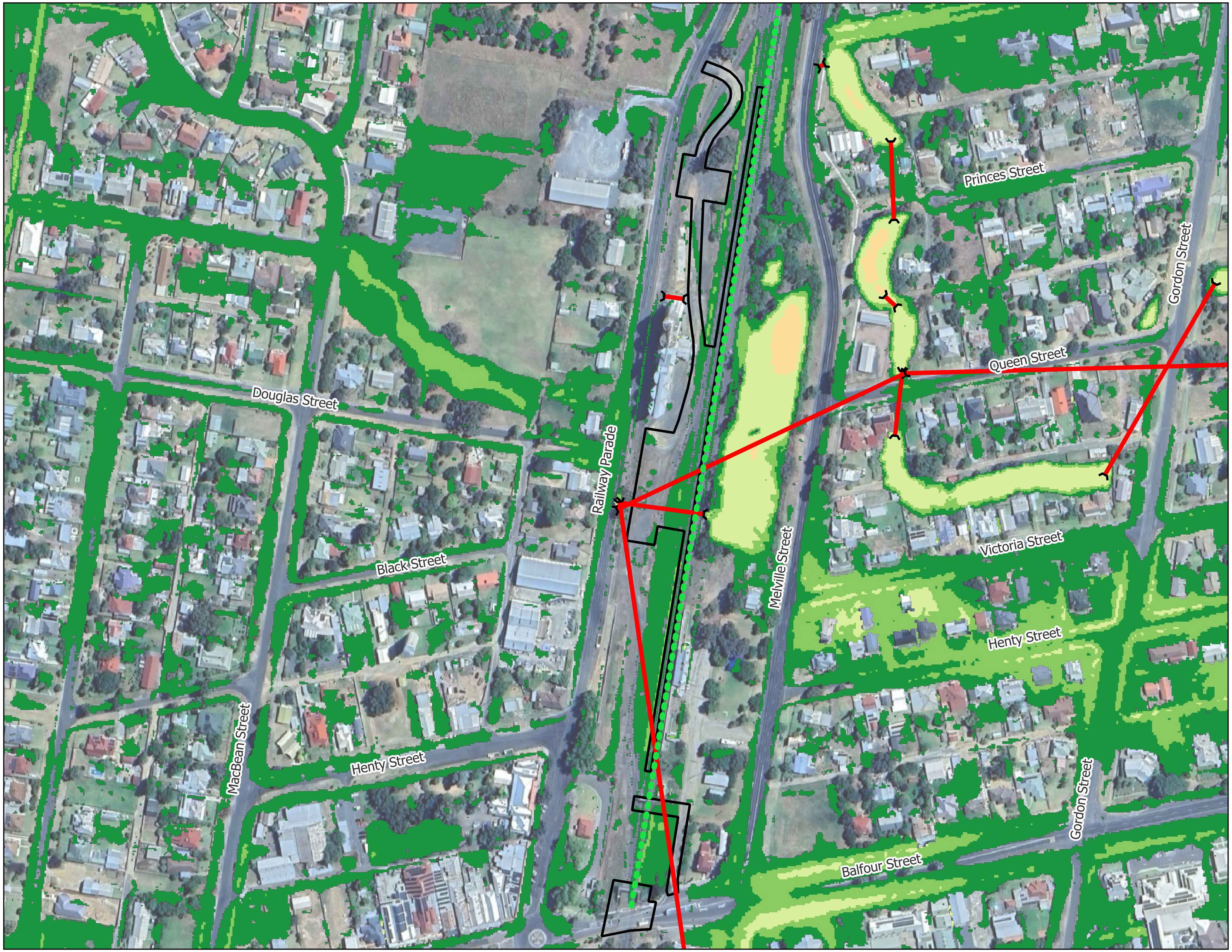
0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage

1% AEP Flood Hazard - Developed Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category

- H1
- H2
- H3
- H4
- H5
- H6

Notes:

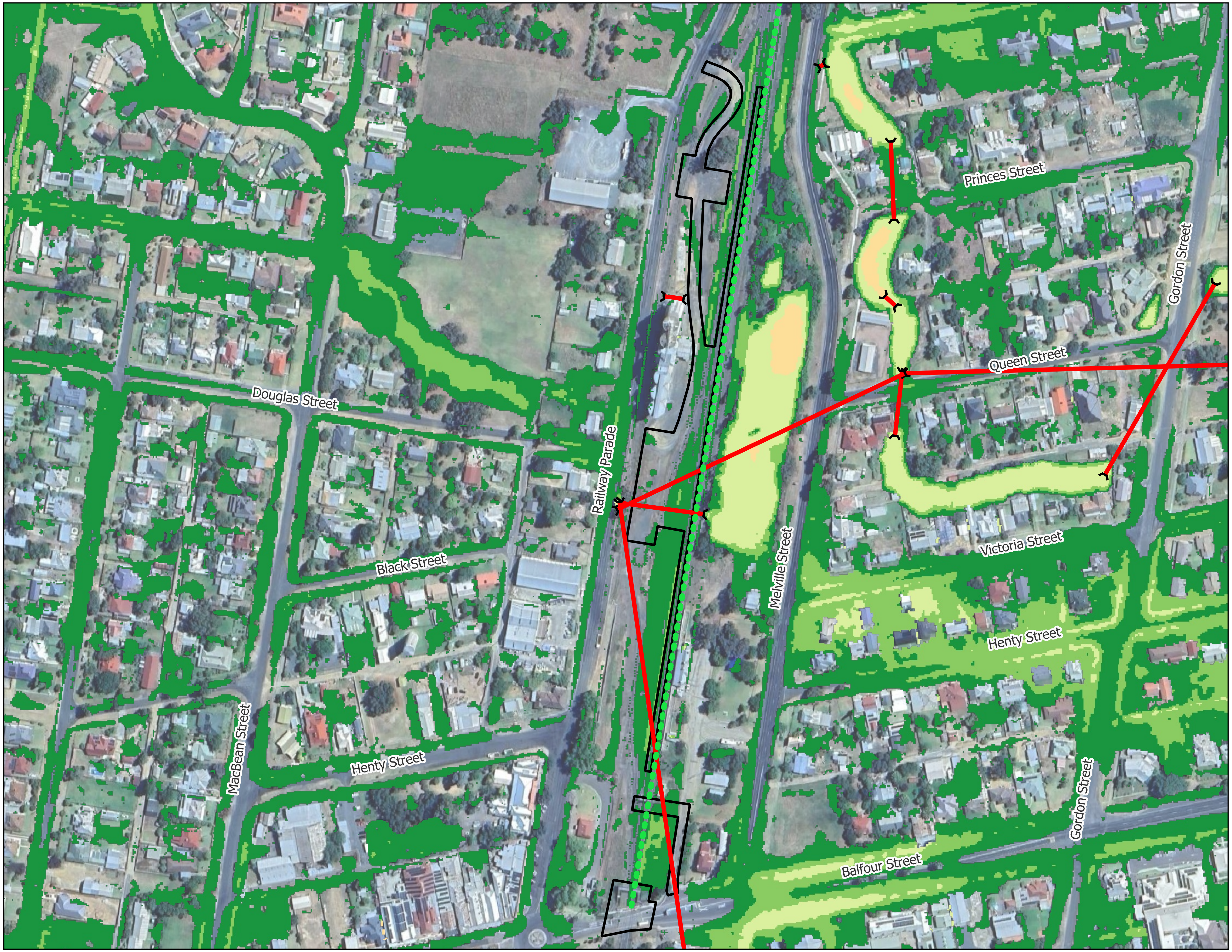
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
1% AEP + Blockage Flood Hazard - Developed Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category
- H1
- H2
- H3
- H4
- H5
- H6

Notes:

Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
1% AEP + Climate Change Flood Hazard - Developed Conditions

MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Flood Hazard Category

- H1
- H2
- H3
- H4
- H5
- H6

Notes:

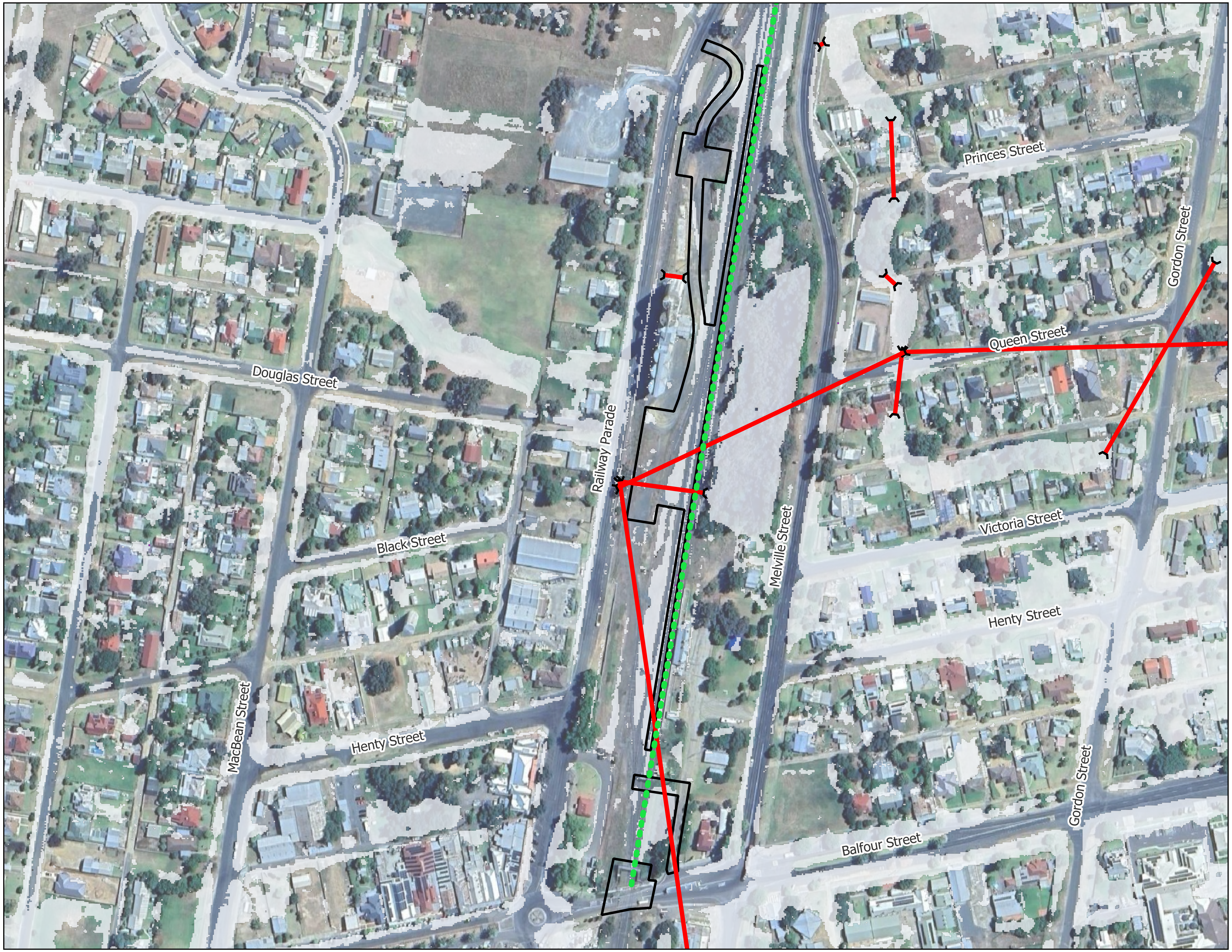
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
PMF Flood Hazard - Developed Conditions



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Change in Flood Level (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

Wet/Dry

- Was Wet - Now Dry
- Was Dry - Now Wet

Notes:

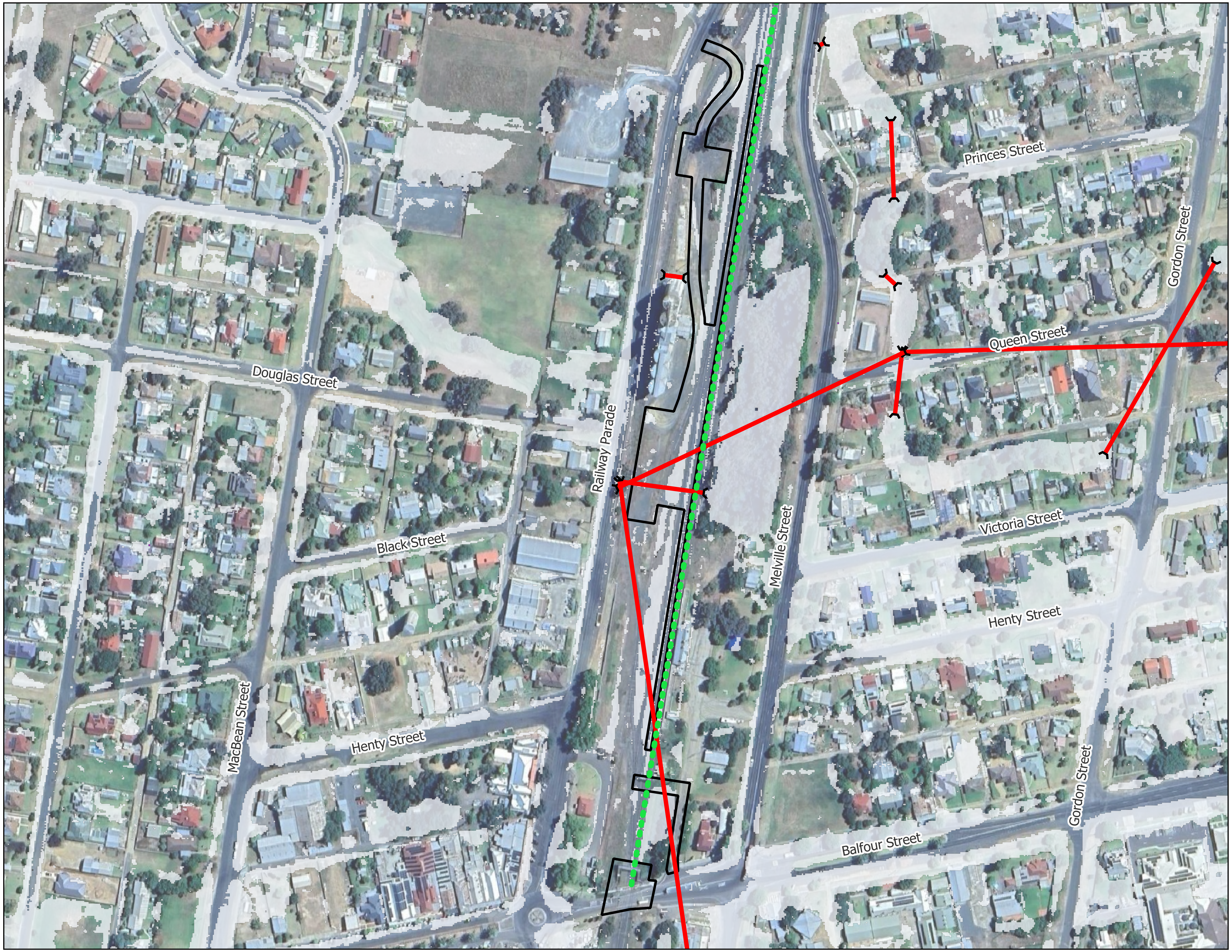
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
5% AEP - Change in Flood Level (m)



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Change in Flood Level (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

Wet/Dry

- Was Wet - Now Dry
- Was Dry - Now Wet

Notes:

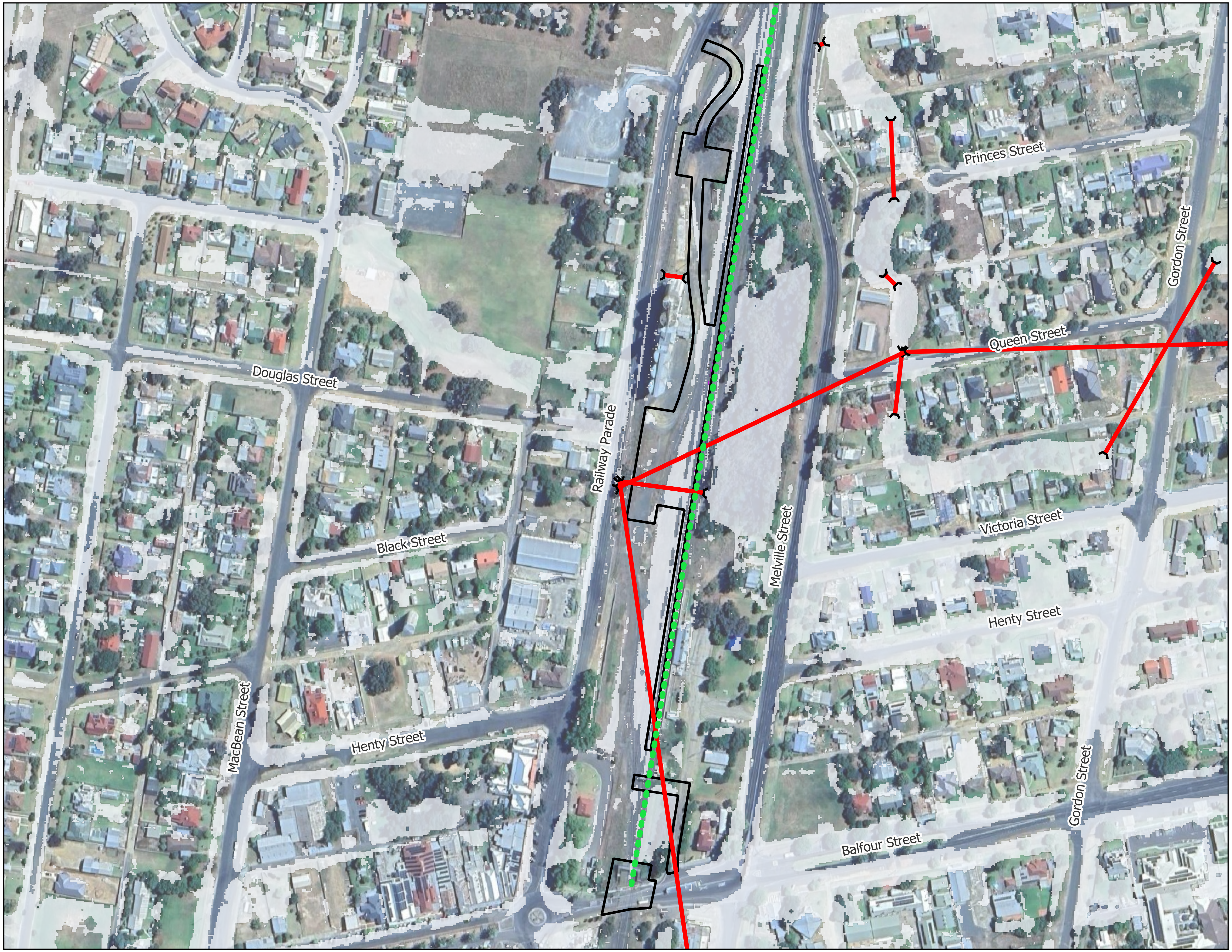
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
5% AEP - Change in Flood Level (m)



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Change in Flood Level (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

Wet/Dry

- Was Wet - Now Dry
- Was Dry - Now Wet

Notes:

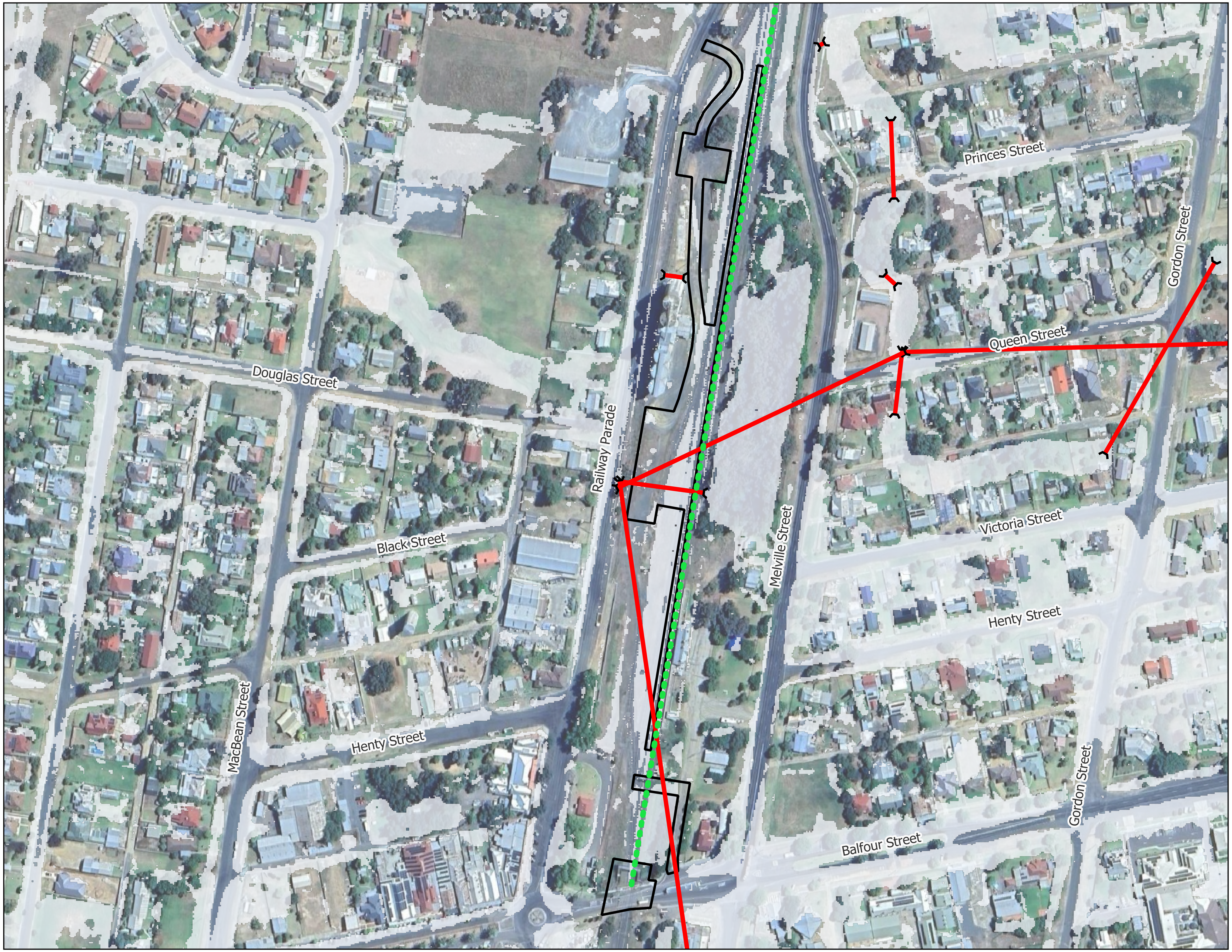
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
2% AEP - Change in Flood Level (m)



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Change in Flood Level (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

Wet/Dry

- Was Wet - Now Dry
- Was Dry - Now Wet

Notes:

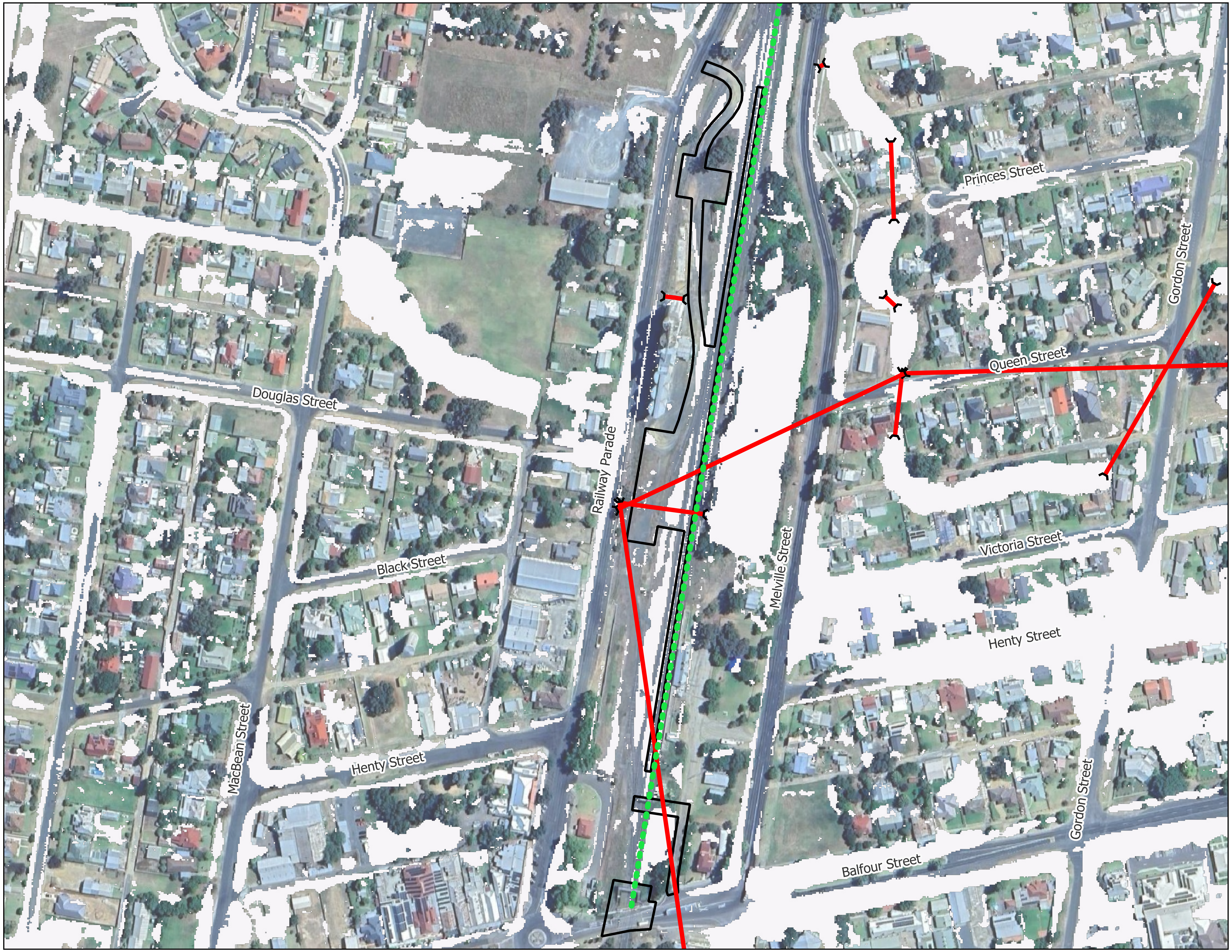
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
1% AEP - Change in Flood Level (m)



MARTINUS

aurecon BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

% Change in Velocity

- <= 10%
- > 10%

Change in Velocity (m/s)

- <= 0.5

Wet/Dry

- Was Wet - Now Dry
- Was Dry - Now Wet

Notes:

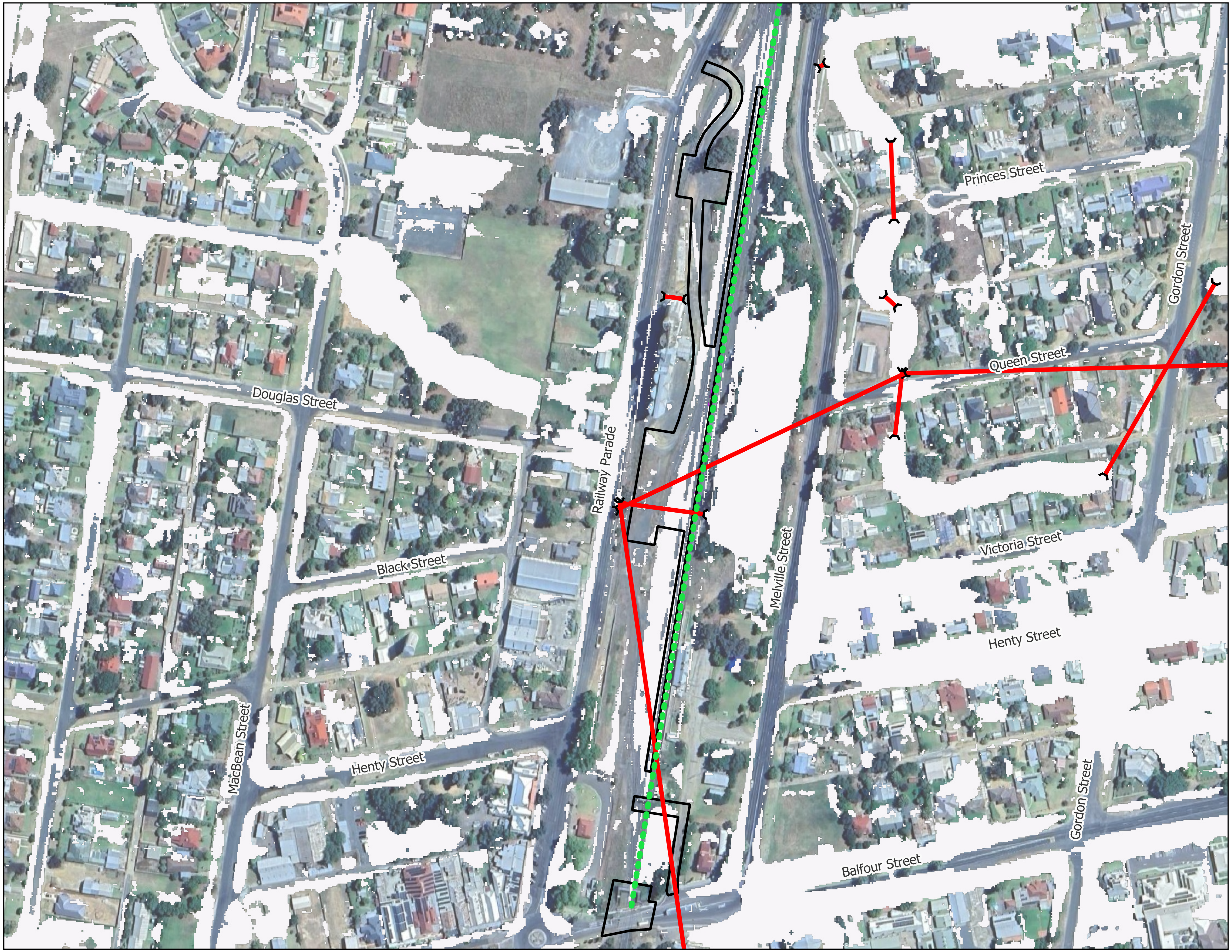
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - DDR Stage
5% AEP - Change in Velocity



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

% Change in Velocity
- <= 10%
- > 10%

Change in Velocity (m/s)
- <= 0.5

Wet/Dry
- Was Wet - Now Dry
- Was Dry - Now Wet

Notes:

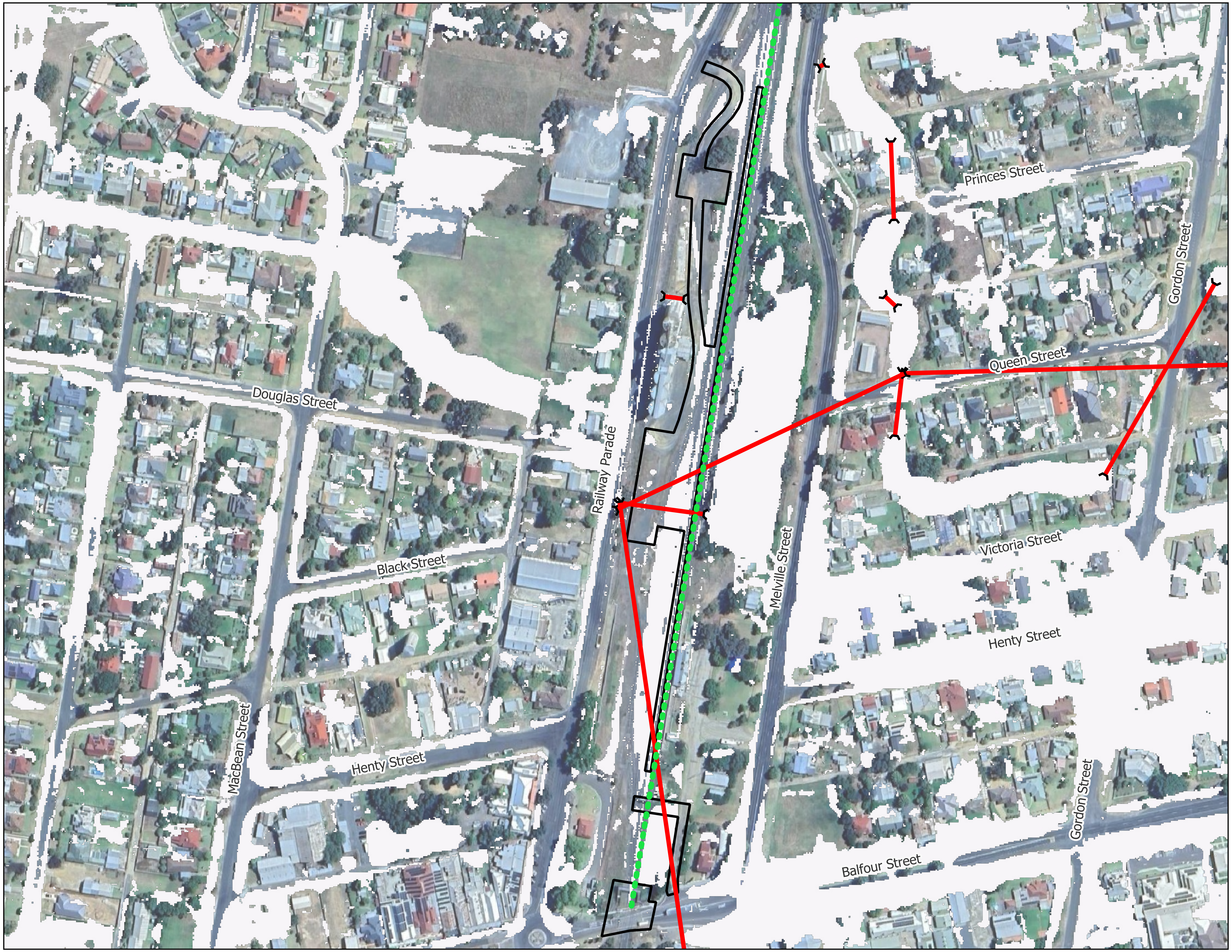
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - DDR Stage
2% AEP - Change in Velocity



Map by: TT

MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

% Change in Velocity

- <= 10%
- > 10%

Change in Velocity (m/s)

- <= 0.5

Wet/Dry

- Was Wet - Now Dry
- Was Dry - Now Wet

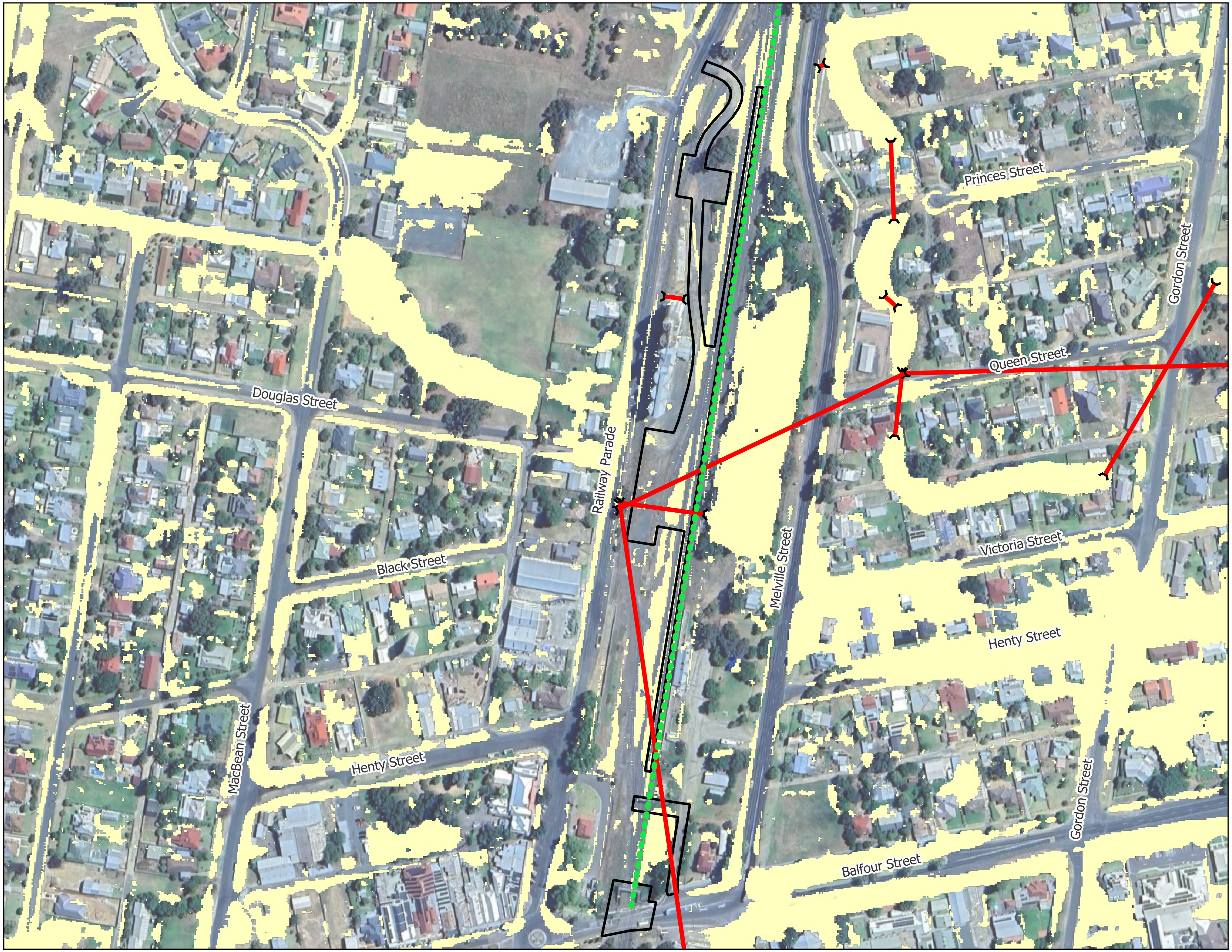
Notes:

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - DDR Stage
1% AEP - Change in Velocity



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Change in Flood Hazard Category

- Decreased 6 Classes
- Decreased 5 Classes
- Decreased 4 Classes
- Decreased 3 Classes
- Decreased 2 Classes
- Decreased 1 Class
- No Change
- Increased 1 Class
- Increased 2 Classes
- Increased 3 Classes
- Increased 4 Classes
- Increased 5 Classes
- Increased 6 Classes

Notes:

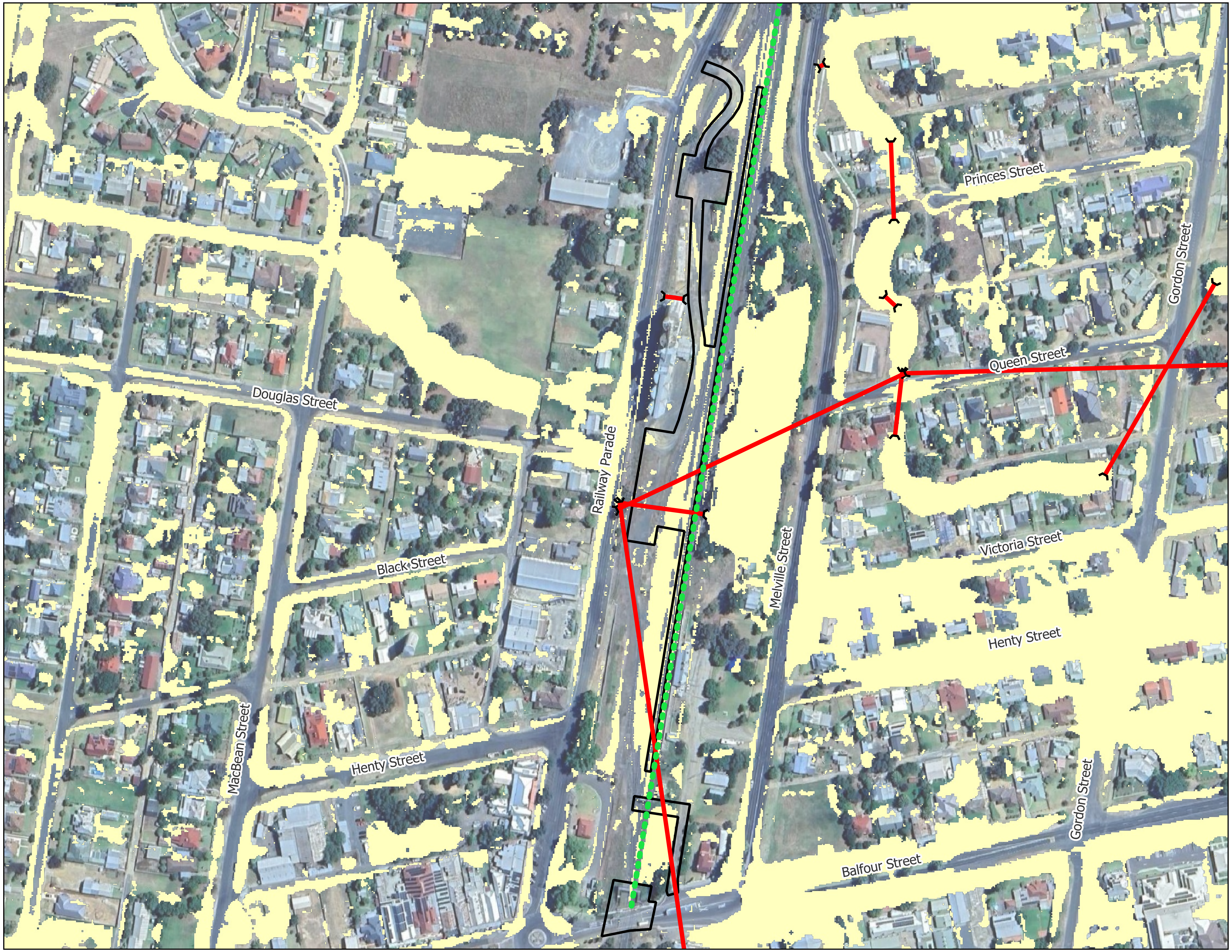
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
5% AEP - Change in Flood Hazard



MARTINUS

aurecon

BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Change in Flood Hazard Category

- Decreased 6 Classes
- Decreased 5 Classes
- Decreased 4 Classes
- Decreased 3 Classes
- Decreased 2 Classes
- Decreased 1 Class
- No Change
- Increased 1 Class
- Increased 2 Classes
- Increased 3 Classes
- Increased 4 Classes
- Increased 5 Classes
- Increased 6 Classes

Notes:

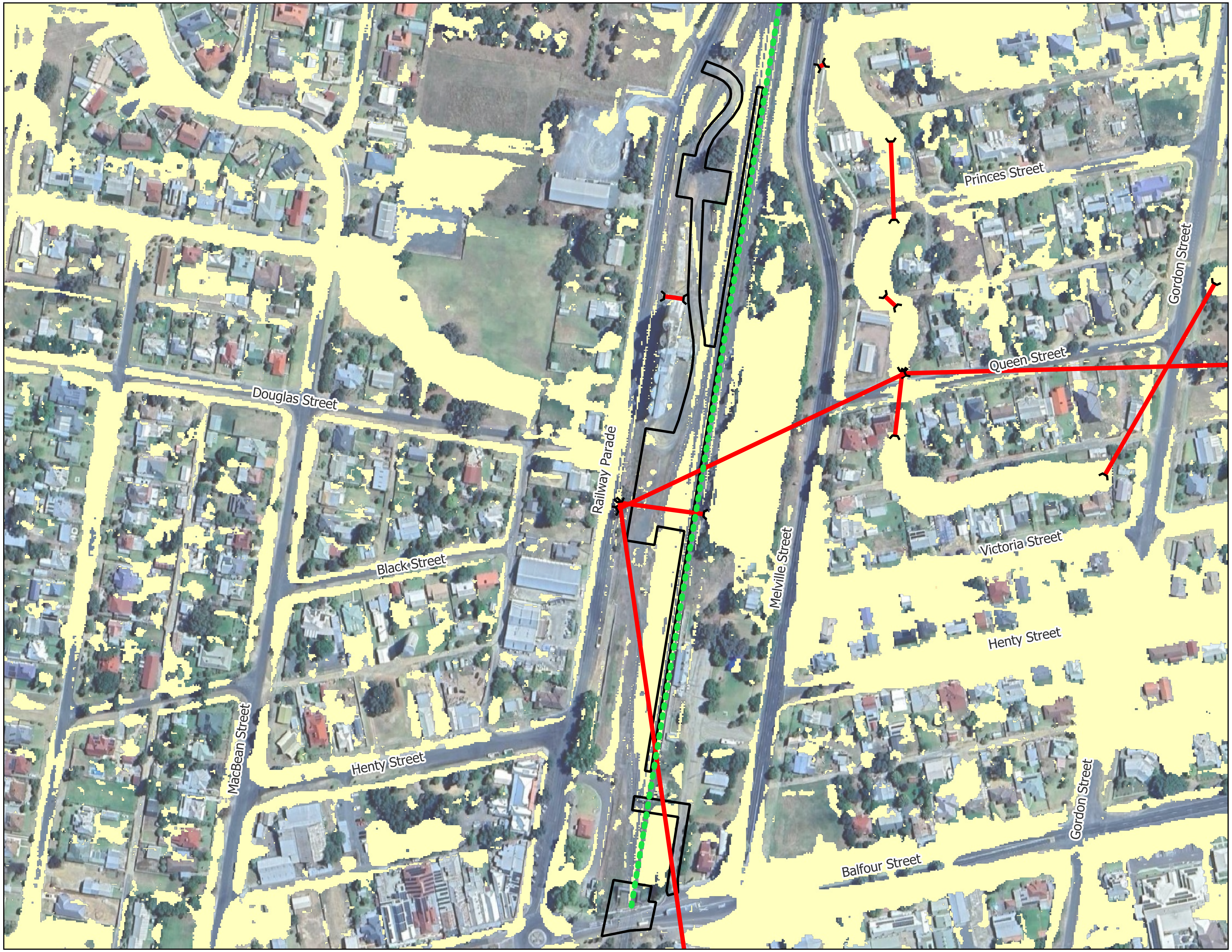
Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

Culcairn Yard - Inland Rail (A2P) - IFC Stage
2% AEP - Change in Flood Hazard



MARTINUS
aurecon
BG&E

Legend

- TUFLOW Model Extent
- Project Boundary
- Rail Centreline
- Existing Drainage

Change in Flood Hazard Category

- Decreased 6 Classes
- Decreased 5 Classes
- Decreased 4 Classes
- Decreased 3 Classes
- Decreased 2 Classes
- Decreased 1 Class
- No Change
- Increased 1 Class
- Increased 2 Classes
- Increased 3 Classes
- Increased 4 Classes
- Increased 5 Classes
- Increased 6 Classes

Notes:

Map by: TT

0 100 200 m

A3 Scale: 1:2,654.186

5/2/2025 GDA2020 MGA Zone55

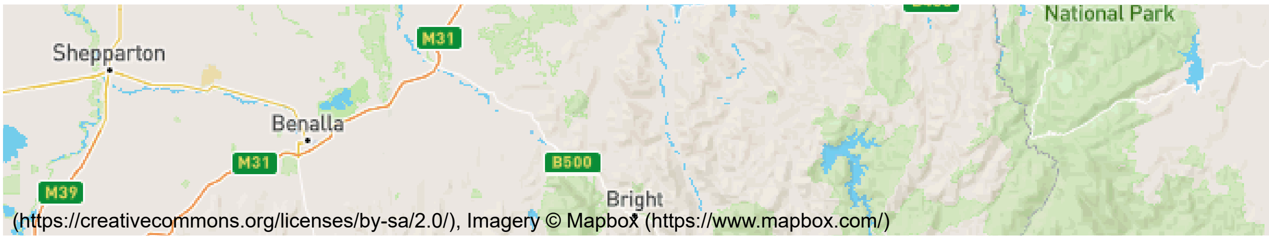
Culcairn Yard - Inland Rail (A2P) - IFC Stage
1% AEP - Change in Flood Hazard

APPENDIX B - HYDROLOGIC DATA (ARR DATA HUB)

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	147.038
Latitude	-35.666
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Probability Neutral Burst Initial Loss (./nsw_specific)	show
Baseflow Factors	show



Data

River Region

Division	Murray-Darling Basin
River Number	11
River Name	Billabong-Yanco Creeks

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^b - c\log_{10}Duration\right)Duration^{-d}\right.\right.$$
$$+ eArea^f Duration^g\left(0.3 + \log_{10}AEP\right)$$
$$\left.\left. + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
Southern Temperate	0.158	0.276	0.372	0.315	0.000141	0.41	0.15	0.01	-0.0027

Short Duration ARF

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

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

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

Note: As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. The continuing storm loss information from the ARR Datahub provided below should only be used where relevant under the loss hierarchy (level 5) and where used is to be multiplied by the factor of 0.4.

ID	2656.0
Storm Initial Losses (mm)	26.0
Storm Continuing Losses (mm/h)	4.6

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/MB.zip)

code	MB
Label	Murray Basin

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_MB.zip)

code	MB
arealabel	Murray Basin

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-35.666&longitude=147.038&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	30 August 2024 04:42PM

Median Preburst Depths and Ratios

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

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	2.1 (0.107)	1.7 (0.064)	1.5 (0.046)	1.2 (0.033)	0.9 (0.021)	0.7 (0.014)
90 (1.5)	1.8 (0.082)	1.5 (0.050)	1.3 (0.037)	1.1 (0.027)	0.7 (0.014)	0.3 (0.006)
120 (2.0)	3.6 (0.152)	2.9 (0.091)	2.5 (0.065)	2.1 (0.046)	1.0 (0.019)	0.2 (0.004)
180 (3.0)	2.2 (0.080)	2.5 (0.068)	2.7 (0.062)	2.9 (0.058)	1.4 (0.023)	0.2 (0.003)
360 (6.0)	1.7 (0.052)	1.5 (0.034)	1.3 (0.026)	1.2 (0.020)	1.9 (0.027)	2.4 (0.031)
720 (12.0)	0.1 (0.002)	0.8 (0.014)	1.2 (0.019)	1.7 (0.023)	3.0 (0.035)	4.0 (0.042)
1080 (18.0)	0.0 (0.000)	0.5 (0.008)	0.8 (0.011)	1.1 (0.013)	1.9 (0.020)	2.6 (0.024)
1440 (24.0)	0.0 (0.000)	0.2 (0.003)	0.3 (0.004)	0.4 (0.004)	1.0 (0.009)	1.4 (0.012)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

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

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

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

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

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.1 (0.004)	0.1 (0.002)	0.0 (0.001)	0.0 (0.001)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.1 (0.003)	0.0 (0.001)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

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

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	17.0 (0.871)	15.8 (0.594)	15.1 (0.477)	14.4 (0.392)	13.8 (0.320)	13.5 (0.278)
90 (1.5)	15.6 (0.711)	16.4 (0.549)	17.0 (0.478)	17.5 (0.427)	13.5 (0.280)	10.5 (0.195)
120 (2.0)	13.5 (0.567)	15.2 (0.470)	16.4 (0.427)	17.4 (0.395)	15.0 (0.289)	13.2 (0.228)
180 (3.0)	13.9 (0.517)	14.9 (0.412)	15.6 (0.366)	16.3 (0.332)	15.1 (0.262)	14.2 (0.222)
360 (6.0)	12.6 (0.383)	13.5 (0.307)	14.1 (0.273)	14.7 (0.248)	18.2 (0.262)	20.8 (0.270)
720 (12.0)	5.0 (0.123)	7.7 (0.144)	9.5 (0.152)	11.3 (0.157)	16.0 (0.190)	19.5 (0.207)
1080 (18.0)	2.8 (0.062)	5.9 (0.098)	7.9 (0.112)	9.9 (0.122)	12.3 (0.129)	14.1 (0.132)
1440 (24.0)	0.9 (0.018)	4.3 (0.065)	6.5 (0.085)	8.6 (0.098)	9.7 (0.094)	10.5 (0.090)
2160 (36.0)	0.0 (0.000)	0.8 (0.011)	1.3 (0.015)	1.8 (0.018)	3.8 (0.032)	5.2 (0.040)
2880 (48.0)	0.0 (0.000)	0.4 (0.005)	0.6 (0.007)	0.9 (0.008)	1.0 (0.008)	1.1 (0.008)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.1 (0.000)

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

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

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	36.7 (1.888)	31.7 (1.191)	28.4 (0.898)	25.2 (0.689)	26.1 (0.604)	26.8 (0.553)
90 (1.5)	26.3 (1.196)	29.9 (1.000)	32.4 (0.913)	34.7 (0.848)	29.9 (0.619)	26.2 (0.487)
120 (2.0)	32.0 (1.340)	34.9 (1.078)	36.9 (0.963)	38.8 (0.878)	41.5 (0.799)	43.6 (0.752)
180 (3.0)	25.1 (0.936)	30.3 (0.836)	33.7 (0.789)	37.0 (0.753)	33.9 (0.589)	31.7 (0.494)
360 (6.0)	25.0 (0.763)	28.0 (0.639)	30.0 (0.583)	32.0 (0.542)	39.7 (0.574)	45.5 (0.590)
720 (12.0)	14.8 (0.368)	21.2 (0.395)	25.4 (0.404)	29.5 (0.410)	32.2 (0.381)	34.3 (0.363)
1080 (18.0)	15.8 (0.350)	19.0 (0.315)	21.1 (0.298)	23.1 (0.285)	26.1 (0.274)	28.4 (0.266)
1440 (24.0)	11.2 (0.228)	16.2 (0.247)	19.4 (0.253)	22.6 (0.256)	24.1 (0.232)	25.3 (0.217)
2160 (36.0)	1.7 (0.031)	10.0 (0.137)	15.6 (0.181)	20.9 (0.211)	18.2 (0.156)	16.2 (0.124)
2880 (48.0)	0.7 (0.012)	6.0 (0.077)	9.6 (0.103)	13.0 (0.122)	16.8 (0.134)	19.8 (0.140)
4320 (72.0)	0.0 (0.001)	3.6 (0.042)	6.0 (0.059)	8.3 (0.071)	11.9 (0.087)	14.7 (0.095)

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	RCP 8.5
2030	**0.816 (4.1%)**	0.726 (3.6%)	**0.934 (4.7%)**
2040	**1.046 (5.2%)**	1.015 (5.1%)	**1.305 (6.6%)**
2050	**1.260 (6.3%)**	1.277 (6.4%)	**1.737 (8.8%)**
2060	**1.450 (7.3%)**	1.520 (7.7%)	**2.214 (11.4%)**
2070	**1.609 (8.2%)**	1.753 (8.9%)	**2.722 (14.2%)**
2080	**1.728 (8.8%)**	1.985 (10.2%)	**3.246 (17.2%)**
2090	**1.798 (9.2%)**	2.226 (11.5%)	**3.772 (20.2%)**

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	50.0	20.0	10.0	5.0	2.0	1.0
60 (1.0)	17.6	9.6	9.1	9.7	10.1	8.9
90 (1.5)	18.3	10.8	9.7	10.0	9.8	9.2
120 (2.0)	17.5	10.7	9.6	9.8	9.2	8.1
180 (3.0)	18.3	12.0	10.5	10.6	9.8	8.2
360 (6.0)	18.5	13.2	11.7	12.4	10.5	6.9
720 (12.0)	21.6	16.1	14.8	14.5	12.9	8.8
1080 (18.0)	22.0	17.0	16.3	16.6	14.8	10.1
1440 (24.0)	23.3	18.4	17.7	18.1	16.4	11.9
2160 (36.0)	25.5	20.9	20.4	20.7	19.2	14.3
2880 (48.0)	26.1	21.6	21.9	22.7	21.2	15.5
4320 (72.0)	26.5	22.2	23.5	24.0	22.3	17.6

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2018_v1
Note	As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. Probability neutral burst initial loss values for NSW are to be used in place of the standard initial loss and pre-burst as per the losses hierarchy.

Baseflow Factors

Downstream	10814
Area (km2)	4477.94911775
Catchment Number	10844
Volume Factor	0.288732
Peak Factor	0.046337

Layer Info

Time Accessed	30 August 2024 04:42PM
Version	2016_v1

Download TXT (downloads/76ebc0b2-f3aa-4691-8d54-ab58c902f9bb.txt)

Download JSON (downloads/e2aa9a96-ce7e-4cfd-b08f-6518f5f85a0d.json)

Generating PDF... (downloads/5b06ef6a-f9d9-421d-a6c8-39d98ff4d01b.pdf)

APPENDIX C - ARTC REVIEW

Document Control Information			
	Contractor DC to update for re-submission	Submitted Document No. or Transmittal No.:	Martinus-PTRAN-000864
Project:	2100 - A2I	Date Submission Received:	17/01/2025
Comment Sheet Number_Revision:	5-0052-210-IHY-G1-CS-0001_C	Comment Sheet Title:	External Comment Sheet - A2I | Flood Design Report - Culcairn Station Yard
Revision Date:	13/02/2025	Documents related in Aconex (by IR DC)	Yes

Review Comments (Reviewer)									Responses (Document Owner)					Close-Out			
#	PSR ID No. or Compliance Reference Document *(State the fully qualified reference the deliverable is non-compliant with)*	Document / drawing number - Revision Number	Section # / page #	Engineering Assurance Stage	Comment *(for example must be specific on non compliance. Reference mark-ups, if required)*	Comment Type	Full Name	Date	Full Name	Company	Date	Response *(must be specific on how the comment has been addressed. Agreed approach for re-submission)*	Documentation Section # / Figure #	Full Name	Date	Comment Status	Close-Out Comment
Example	*IR-SR-A2I-517 or 01-3500-PD-P00-DE-0008-A*	*0-0000-900-PEN-00-TE-0020_A*		*CRR*	*Is there sufficient space for a 10m maintenance vehicle to turn around at the end of the RMAR?*	*Non-Compliant*	*Joe Bloggs*	*15/02/2023*	*Fred Bloggs*	*Designer*	*15/03/2023*	*The area has been increased - now possible to turn 12.5m vehicle. The drawings are updated.*	*01-3500-PD-P00-DE-0008-A 01-3500-PD-P00-DE-0015-C*	*Jane Doe*	*27/09/2023*	CLOSED	
1	Opportunity	5-0052-210-IHY-G1-RP-0001_A.pdf	Page 10, 5-0052-210-IHY-G1-RP-0001_A, Section 1.9.1	DDR	Reference Error to be rectified	Opportunity	Ayub Ali	19/09/2024	Yucen Lu	DJV Flood modeller	8/11/2024	All reference errors will be checked and updated in the IFC design report.		Ayub Ali	20/01/2025	CLOSED	This item is closed based on the assumption that all reference errors will be checked and updated in the IFC design report.
2	Opportunity	5-0052-210-IHY-G1-RP-0001_A.pdf	Page 13, 5-0052-210-IHY-G1-RP-0001_A, Table 2-2	DDR	Reference Errors to be rectified	Opportunity	Ayub Ali	19/09/2024	Yucen Lu	DJV Flood modeller	8/11/2024	All reference errors will be checked and updated in the IFC design report.		Ayub Ali	20/01/2025	CLOSED	This item is closed based on the assumption that all reference errors will be checked and updated in the IFC design report.
3	Opportunity	5-0052-210-IHY-G1-RP-0001_A.pdf	Page 15, 5-0052-210-IHY-G1-RP-0001_A, Table 2-3	DDR	Reference Error to be rectified	Opportunity	Ayub Ali	19/09/2024	Yucen Lu	DJV Flood modeller	8/11/2024	All reference errors will be checked and updated in the IFC design report.		Ayub Ali	20/01/2025	CLOSED	This item is closed based on the assumption that all reference errors will be checked and updated in the IFC design report.
4	*PSR Annexure B: Technical Requirements (Clause 5.4.4)*	5-0052-210-IHY-G1-RP-0001_A.pdf	Page 17, 5-0052-210-IHY-G1-RP-0001_A, Section 4.1	DDR	It is understood that the IFD data extracted from ARR1987 and ARR2019 are comparable and therefore ARR1987 data have been utilised instead of ARR2019 data. We believe this approach does not comply with the IR requirements of utilising the ARR2019 guidelines and its relevant data. To my opinion ARR2019 recommended methods and data must be utilised for all drainage and flood studies of IR unless there is an obvious error in it.	Non-Compliant	Ayub Ali	19/09/2024	Yucen Lu	DJV Flood modeller	8/11/2024	As mentioned in the report, the external flows do not affect flood behaviour at the site. However, the external flow estimated under ARR1987 will not be used in the model in the next design phase. Based on comments received from Greater Hume Shire Council (Refer 5-0052-210-PEN-G1-CS-0001-GH_C - Comments #1 and #2), the mitigation measure of terminating Anabranch has been implemented so the external flow from Anabranch will not reach the township and our site in events up to and including the 1:500 year event. As such, external inflow should not be modelled and the local catchment modelling (which is already ARR2019) is sufficient to assess flood behaviour. Those changes will be updated in the IFC design stage model and report.		Ayub Ali	21/01/2025	CLOSED	This item is closed based on the assumption that the proposed changes will be included in the IFC design stage model and report.
5	*Opportunity*	5-0052-210-IHY-G1-RP-0001_A.pdf	Page 18, 5-0052-210-IHY-G1-RP-0001_A	DDR	All Reference Errors to be rectified	Opportunity	Ayub Ali	19/09/2024	Yucen Lu	DJV Flood modeller	8/11/2024	All reference errors will be checked and updated in the IFC design report.		Ayub Ali	21/01/2025	CLOSED	This item is closed based on the assumption that all reference errors will be checked and updated in the IFC design report.
6	*Opportunity*	5-0052-210-IHY-G1-RP-0001_A.pdf	Page 18, 5-0052-210-IHY-G1-RP-0001_A, Section 4.1.1	DDR	Explanation/justification needs to be incorporated here regarding creation and utilisation of an external hydraulic model for generating inflow boundary condition for the main hydraulic model. Why these two models were not be merged? How the distribution of flows between two branches were determined to be reasonable/justified?	Opportunity	Ayub Ali	19/09/2024	Yucen Lu	DJV Flood modeller	8/11/2024	Combining the models was not pursued because the resulting model would have been relatively large, leading to impractically long run times, especially since local catchment flows were modelled using a Rainfall-on-Grid approach. Additionally, only the flow from the Anabranch was considered (not the main river channel) because previous flood studies showed that the township was not affected by flooding from the main channel in events up to and including the 1% Annual Exceedance Probability (AEP). However, as mentioned previously, this external inflow is no longer relevant due to recently completed mitigation works that block flow from the Anabranch entering the township in events up to and including the 1-in-500-year event. (Refer 5-0052-210-PEN-G1-CS-0001-GH_C - Comments #1 and #2)		Ayub Ali	21/01/2025	CLOSED	This item is closed based on the assumption that the proposed changes will be included in the IFC design stage model and report.
7	Opportunity	5-0052-210-IHY-G1-RP-0001_A.pdf	Page 23, 5-0052-210-IHY-G1-RP-0001_A, Section 4.3	DDR	This section to be relocated to the modelling methodology before regional modelling (as Section 4.1).	Opportunity	Ayub Ali	19/09/2024	Yucen Lu	DJV Flood modeller	8/11/2024	In response to the Greater Hume Shire Council's comments (Refer 5-0052-210-PEN-G1-CS-0001-GH_C - Comments #1 and #2) that external flows below the Probable Maximum Flood (PMF) will not be modelled. This section will be revised to reflect the PMF only. Accordingly, the location of this section will be adjusted in the IFC design report.		Ayub Ali	21/01/2025	CLOSED	This item is closed based on the assumption that the proposed changes will be included in the IFC design stage model and report.
8	Condition of Approval E46(d)	5-0052-210-IHY-G1-RP-0001_A.pdf	Page 32, 5-0052-210-IHY-G1-RP-0001_A, Section 6.4	DDR	How 70mm increase of flood level within industrially zone land complies with Condition E46(d)? Justification is warranted.	Non-Compliant	Ayub Ali	19/09/2024	Yucen Lu	DJV Flood modeller	8/11/2024	This impact is located entirely within the project boundary and hence deemed to be compliant. The text will be updated for IFC submission to state this clearly.		Ayub Ali	21/01/2025	CLOSED	This item is closed based on the assumption that the proposed changes will be included in the IFC design report.
9	Conditions of Approval	5-0052-210-IHY-G1-RP-0001_A.pdf	Page 39, 5-0052-210-IHY-G1-RP-0001_A, Appendix A	DDR	Flood Maps are missing	Non-Compliant	Ayub Ali	19/09/2024	Yucen Lu	DJV Flood modeller	8/11/2024	The flood maps will be provided in the IFC design report.		Ayub Ali	21/01/2025	CLOSED	This item is closed based on the assumption that the proposed changes will be included in the IFC design report.

Non-Compliant:	Non-compliance which requires correction before further design development occurs.
Opportunity:	Comment which identifies an opportunity to save capex, achieve increased quality or operational outcome. Not a non-compliance.

OPEN:	Comment has not been addressed.
CLOSED:	Comment is closed. No further action.
NEXT PHASE:	Comment response has been accepted. Resulting actions have been deferred to the next Phase of the Project (for Doc Control purposes comment is considered OPEN)
TRANSFERRED:	Response is not acceptable or review has been split and the comment has been transferred to another comment sheet. (for Doc Control purposes comment is considered CLOSED)

APPENDIX D - EXTERNAL CONSULTATION REVIEW

Attachment 1: A2I Flood Design Report CONSULTATION - COMMENTS REGISTER

Stakeholder Category	Stakeholder Name	Flood Design Report name	Document reference (e.g.	Date raised	Topic that comment relates to	Comments	Full Name	Company & Role	Date	Response	Documentation Section # / Figure #
State Government Agency	TfNSW	5-0052-210-IHY-G1-RP-0001_A.1 Flood Design Report - Culcairn Yard - For Consultation 5-0052-210-IHY-G2-RP-0001_A.1 Flood Design Report - Henty Yard - For Consultation 5-0052-210-IHY-G4-RP-0001_A.1 The Rock Yard - Flood Design Report - For Consultation 5-0052-210-IHY-W1-RP-0001_A.1 Flood Design Report - Uranquinty Yard - For Consultation 5-0052-210-IHY-W9-RP-0001_A.1 Bomen Yard Flood Design Report - For Consultation	Whole document	14/11/2024	Administrative	Multiple cross-referencing links are broken in the reports. TfNSW assumes administrative errors such as these will be corrected.	Zoe Cruice	Martinus - Engineering Manager	29/11/2024	Noted. Apologies. These will be fixed to hyperlink and reference correctly.	Rev 0 Report
State Government Agency	TfNSW	5-0052-210-IHY-G1-RP-0001_A.1 Flood Design Report - Culcairn Yard - For Consultation	Whole document	14/11/2024	Environmental assessment process	The report references "draft Conditions of Approval". Please update to reflect project approval status.	Zoe Cruice	Martinus - Engineering Manager	29/11/2024	This will be updated to reflect the determined project CoA and UMM	Rev 0 Report
State Government Agency	TfNSW	5-0052-210-IHY-G1-RP-0001_A.1 Flood Design Report - Culcairn Yard - For Consultation 5-0052-210-IHY-G2-RP-0001_A.1 Flood Design Report - Henty Yard - For Consultation 5-0052-210-IHY-G4-RP-0001_A.1 The Rock Yard - Flood Design Report - For Consultation 5-0052-210-IHY-W1-RP-0001_A.1 Flood Design Report - Uranquinty Yard - For Consultation 5-0052-210-IHY-W9-RP-0001_A.1 Bomen Yard Flood Design Report - For Consultation	Blockage Assessment section of each report	14/11/2024	Blockage assumptions	All assessments adopted a site-specific blockage, but a consistent 20% blockage for all culverts outside of the project area. What informed this assumption? If the purpose was to assess ARR2019 blockage guidelines, TfNSW suggests that the blockage rates for all culverts should be informed by this guidance as even off-site culverts have the potential to influence flows within the sites.	Yucen Lu	DJV Flood Modeller	3/12/2024	A technical memo has been provided to provide explanation and justification of the proposed approach. Please review this memo (5-0052-210-IHY-99-ME-0001) and advise if the blockage assessment and assumptions are acceptable.	Technical Memo
State Government Agency	TfNSW	5-0052-210-IHY-G1-RP-0001_A.1 Flood Design Report - Culcairn Yard - For Consultation 5-0052-210-IHY-G2-RP-0001_A.1 Flood Design Report - Henty Yard - For Consultation 5-0052-210-IHY-G4-RP-0001_A.1 The Rock Yard - Flood Design Report - For Consultation 5-0052-210-IHY-W1-RP-0001_A.1 Flood Design Report - Uranquinty Yard - For Consultation 5-0052-210-IHY-W9-RP-0001_A.1 Bomen Yard Flood Design Report - For Consultation	Blockage Assessment section of each report	14/11/2024	Blockage assumptions	Why was the ARR2019 blockage guidance not included in the design runs? One of the compliance requirements is that all modelling be undertaken in line with this guidance. The design runs have not been undertaken with this blockage guidance incorporated. A typical blockage sensitivity test would have been to include the ARR2019 blockage guidance in the design runs, and then to assess higher and/or lower rates of blockage as necessary.	Yucen Lu	DJV Flood Modeller	3/12/2024	A technical memo has been provided to provide explanation and justification of the proposed approach. Please review this memo (5-0052-210-IHY-99-ME-0001) and advise if the blockage assessment and assumptions are acceptable.	Technical Memo
State Government Agency	TfNSW	5-0052-210-IHY-G1-RP-0001_A.1 Flood Design Report - Culcairn Yard - For Consultation	Section 1.4	14/11/2024	Detailed Design Report	The report states that it should be read in conjuction with the Detailed Design Report – Culcairn Station Yard (5-0052-210-PEN-G1-RP-0001). The Detailed Design Report has not been provided to TfNSW.	Zoe Cruice	Martinus - Engineering Manager	29/11/2024	The track and civil detailed design reports can be provided. These detailed design reports provide an overview, and discipline specific description of the scope of works and impacts.	
State Government Agency	TfNSW	5-0052-210-IHY-G1-RP-0001_A.1 Flood Design Report - Culcairn Yard - For Consultation	Section 1.11	14/11/2024	Climate change assumptions	The report states that flow was scaled to represent climate change impacts. Should this be that rainfall intensity was scaled? If the statement is correct, given hydrological modelling was undertaken, why was the rainfall intensity not scaled instead, as per ARR2019 guidance?	Malinda Gunasekera/ Yucen Lu	DJV Flood Modeller	3/12/2024	Regarding the regional flows, the flows themselves were scaled rather than the rainfall intensity. This approach was necessary because the Hydrologic WBNM model from the original flood study was unavailable, and the DJV did not develop an independent hydrological model. As detailed in Section 4 of the methodology, the resultant WBNM flows from the flood study/report were used directly as inputs to the TUFLOW models. However, it should be noted that a comment was received from Greater Hume Shire Council (Ref: 5-0052-210-PEN-G1-CS-0001-GH_C , Comment 2 and Comment 1) which stated "The major Anabranch as shown on Figure 1-2 has been terminated with no flood flows to reach the township up to >1:500 Event" as a result of "implemented Flood Mitigation Works as determined through Council FRMSP". This information was not available at the time the DDR Flood Design Report was being prepared. Therefore, the modelling methodology will be changed in the next design phase by only considering local catchment flooding for all events other than the PMF. In addition, 1 in 500 Event is larger than the 1% AEP with climate change, so no flood flows from Anabranch to the township for 1% with climate change. As such, this comment will not be relevant.	Rev 0 Report
State Government Agency	TfNSW	5-0052-210-IHY-G1-RP-0001_A.1 Flood Design Report - Culcairn Yard - For Consultation	Section 1.6.3	14/11/2024	Environmental assessment process	The report states that the EIS and PIR have not yet been determined. Please update to reflect project approval status.	Zoe Cruice	Martinus - Engineering Manager	29/11/2024	This will be updated to reflect the determined project CoA and UMM	Rev 0 Report
State Government Agency	TfNSW	5-0052-210-IHY-G1-RP-0001_A.1 Flood Design Report - Culcairn Yard - For Consultation	Section 4.1	14/11/2024	Routing parameter	The report states that a WBNM 'C' routing parameter of 1.7 was used. WBNM guidance is to use 1.6 unless a change is supported by calibration. The report states no calibration was undertaken, therefore TfNSW queries why the routing parameter was adjusted?	Malinda Gunasekera/ Yucen Lu	DJV Flood Modeller	3/12/2024	The WBNM 'C' value of 1.7 was from Culcairn, Henty, Holbrook Flood Studies (WMA Water, 2013), which was calibrated. DJV cited the value in the Flood Design Report and did not run or change the WBNM model as the model is not available. The above information will be included in the next design report.	Rev 0 Report

APPENDIX E - INDEPENDENT FLOOD CONSULTANT REVIEW

Project: 2100 **Deliverable:** Culcairn Station Yard

Comment Sheet Reference: 5-0052-210-IHY-G1-CS-0001-PE_C

Review Comments (Reviewer)											Responses (Document Owner)					Close-Out				
#	Document number / drawing number - Revision Number	Section # / page #	Company	Full Name	Functional Area	Date	Design Gate	Comment (for example must be specific on non compliance. Reference mark-ups, if required)	Compliance Reference Document (State the fully	Comment Type	Full Name	Role	Date	Response (must be specific on how the comment has been addressed)	Where addressed (Section # / Figure #)	Full Name	Company	Date	Comment Outcome	Close-Out Comment
1	5-0052-210-IHY-G1-RP-0001_A	TUFLOW files	Hatch	Sam Drysdale	Flood Assessment	11/12/2024	DDR	No comments		Minor	Zoe Cruice	Engineering Manager	21/12/2024	Noted.		Darren Lyons	Hatch	20/01/2025	CLOSED	None

OFFICIAL

MARTINUS

Head Office | 1/23-27 Waratah Street | KIRRAWEE NSW 2232