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Flood Impact and Risk Assessment

For

Development Application

For

Huntlee Stage 2 Urban Release Area

for Huntlee Pty Ltd

Report Document Control

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Contents

Acronyms

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AR&R 2019	Australian Rainfall and Runoff 2019
BoM	Bureau of Meteorology
CCC	Cessnock City Council
DCP	Development Control Plan
DTM	Digital Terrain Model
EIS	Environmental Impact Statement
ELVIS	Elevation and Depth Data Source (Provided by Aus Government and Partners)
EY	Exceedances per Year (measure of the likelihood of a flood event)
FIRA	Flood Impact and Risk Assessment
FPA	Flood Planning Area (Area below the Flood Planning Level)
FPL	Flood Planning Level
FRMS&P	Flood Risk Management Study and Plan
GPU	Graphics Processing Unit
GSDM	Generalised Short Duration Method (PMP Calculation)
Ha	Hectares – Measure of Area
HPC	Heavily Parallelised Compute
Hr	Measure of Time (Hour)
IFD	Intensity-Frequency-Duration Rainfall
LEP	Local Environmental Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging Terrain Data
mm	Measure of Length / height / distance (millimetres)
m	Measure of length / height / distance (metres)
m AHD	Meters above Australian High Datum

m/s	Measure of velocity (metres per second)
m^3/s	Measure of flow rate (cubic metres per second)
mins	Measure of Time (minutes)
NSW DPE	New South Wales Office Department of Planning and Environment
NSW OEH	New South Wales Office of Environment and Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
QUDM	Queensland Urban Drainage Manual (4^{th} Edition)
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
RoG	Rainfall on Grid
SCC	Singleton City Council
SEARS	Secretary's Environmental Assessment Requirements
SES	State Emergency Service
SSD	State Significant Development
SSDA	State Significant Development Application
TUFLOW	A 1D and 2D hydraulic modelling software
WCD	Wine Country Drive
XP-RAFTS	1D hydrologic modelling software

1. Introduction

This Flood Risk and Impact Assessment supports an Environmental Impact Statement and State Significant Development Application (SSDA) that seeks consent for the Huntlee New Town Stage 2 development, comprising the concept development for the Stage 2 sites including Villages 2 and 3, land off Old North Road and the Town Centre North area, and the detailed development for the central and southern areas of Village 2. The proposal represents the next phase of an extensive planning, assessment and consultation process completed to date for the development of the Huntlee New Town site.

Specifically, this SSDA proposes the following works for the Huntlee New Town:

- A Concept Master plan for the Stage 2 site, comprising:
  - Overall Stage 2 development footprint, including:
    - The remaining Town Centre North area,
    - Villages 2 and 3, and
    - A large lot residential area located to the south of the site on Old North Road;
  - Proposed land use and development yield, including the provision for residential subdivision of approximately 5,000 lots;
  - Associated new road network and required upgrades to existing network;
  - Site-wide open space and riparian areas;
- Detailed development of Village 2 Central and South and Eastern connection to the Town Centre, comprising:
  - Demolition and clearing of existing built form structures;
  - Clearing of existing vegetation within proposed development footprints;
  - Open space, recreation, community and riparian areas;
  - Construction of road and access infrastructure;
  - Bulk earthworks;
  - Stormwater and drainage works;
  - Utilities and services, including
    - Sewer and potable water reticulation;
    - Electricity and communications infrastructure;
  - Subdivision to facilitate approximately 1,750 lots across the Village 2 Central and South areas and Town Centre development lots, comprising approximately 1,730 residential lots, eight (8) medium density super lots, two (2) commercial/mixed use lots and open space areas; and
  - Select clearing and grading to establish temporary Asset Protection Zones where development interfaces with the Concept Master plan area.

Figure 1, presented overleaf, demonstrates the location of the Stage 2 Concept and Detailed areas, in the context of the surrounding development.

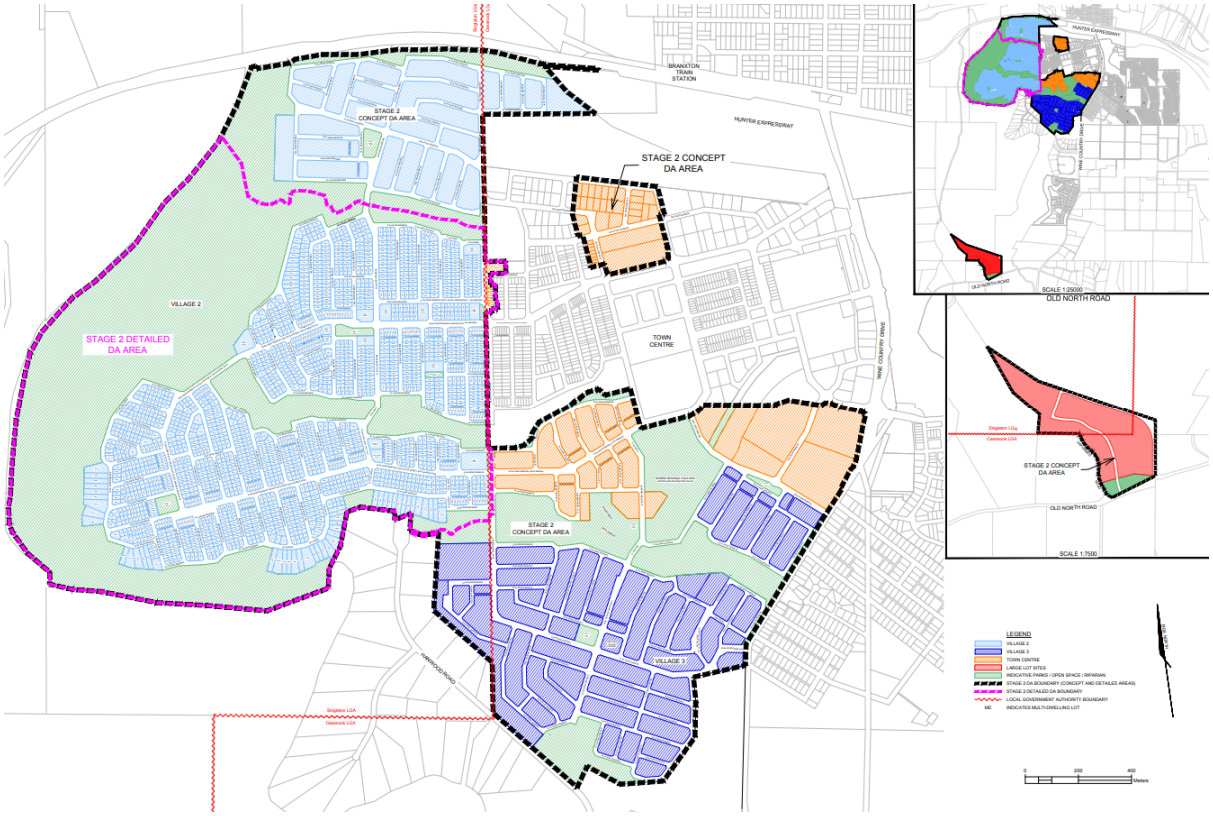

Figure 1 - Proposed Concept and Detailed Area Layout (Daly Smith) (Refer to Subdivision Plans for higher resolution plans)

1.1 The Site

The subject site forms a large component of the 1,622 hectare Huntlee New Town, situated to the south of Branxton in the Hunter Valley. It is located approximately 20km north of Cessnock, 23km south-east of Singleton, and 55km north-west of Newcastle.

The subject Site comprises a number of allotments located in both Cessnock and Singleton Local Government Areas (LGAs). It has a combined area of approximately 541.71ha, is irregular in shape and is generally extended to the west and south of the approved Huntlee Town Centre. The site is bound to the west by the Black Creek and floodplain. An aerial photo of the site is provided in Figure 2.

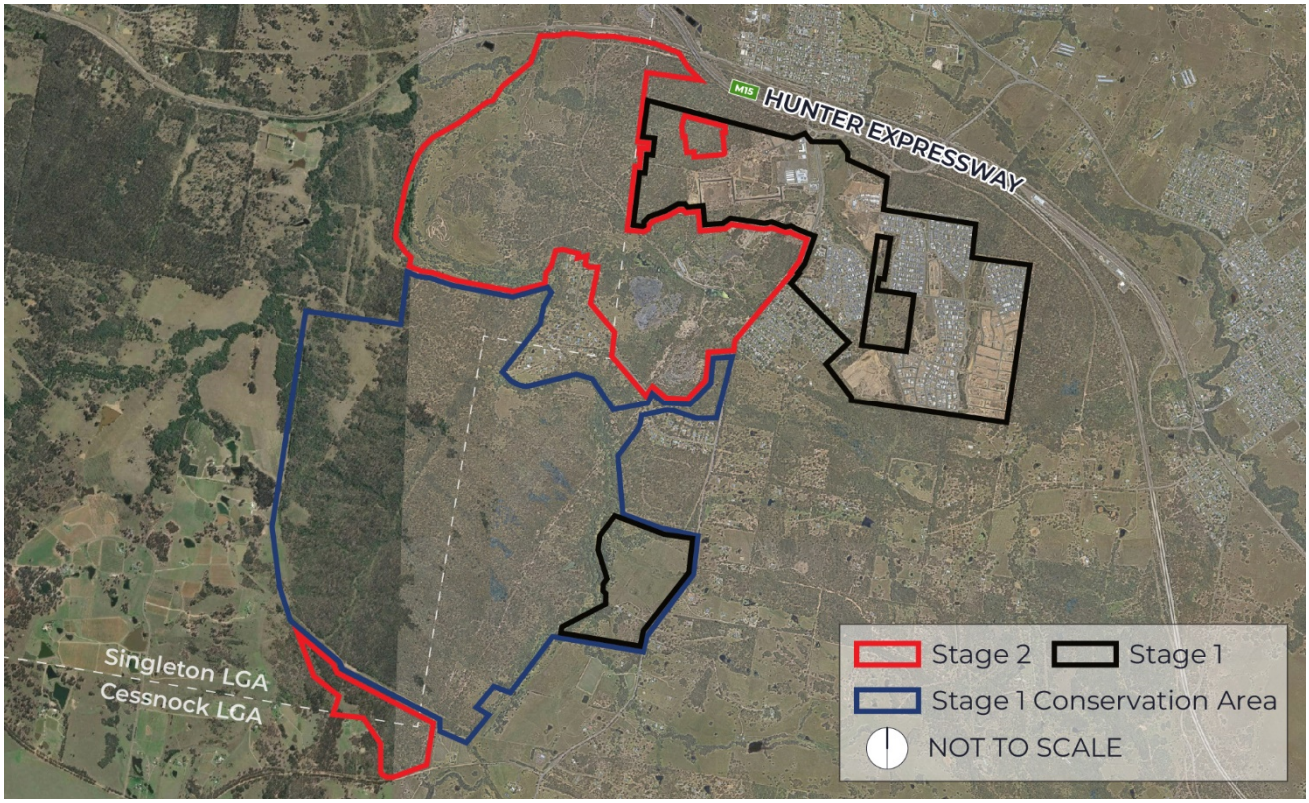

Figure 2 - Site Aerial (Nearmap/Ethos Urban)

1.1 Planning Secretary's Environmental Assessment Requirements

This report aims to respond to the flood related assessment requirements set out in the Planning Secretary's Environmental Assessment Requirements (SEARS) for the proposed development (SSD-70748466).

Flood related SEARS assessment requirements are reproduced in Table 1 below. A response to where the requirement has been addressed within this Flood Risk and Impact Assessment (FIRA) is also presented in the following Table 1.

Table 1 - Flood related SEARS Requirements (SSD - 70748466)

Reference	Requirement	FIRA Reference
SEARS Item 12	Identify and describe any on-site flood impacts and risks associated with the proposed development, having regard to the relevant provisions of the NSW Floodplain Development Manual and other local or State studies and guidance.	This study has been prepared with consideration to the NSW Floodplain Development Manual (2005), Council's Local Environmental Plan, Development Control Plan and the Draft Singleton Flood Risk Management Study and Plan (BMT, 2022).
	Describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood, or an equivalent extreme event.	Refer to the results section of this report. Events ranging from the 0.5EY (Exceedances per Year) to the PMF (Probable Maximum Flood) have been considered herein.
	Assess the impacts of the development, including any changes to flood risk both on-site or off-site, and identify any mitigation and management measures to minimise the impacts of flooding on the proposed development.	Refer to the Detention Performance and Flood Impacts Sections of this report. The findings of this report demonstrate the proposed development is not expected to create a significant adverse impact in adjacent properties.
	Address matters raised by Biodiversity Conservation Division at Appendix B	Refer to below responses to the Department of Planning and Environment (Biodiversity Conservation Division) – Flooding and Coastal Erosion requirements.

Reference	Requirement	FIRA Reference
Singleton Council (referral) – Flood Planning	The site includes flood prone land within the Black Creek floodplain. The EIS should not only take into consideration and address the current flood controls, but consideration should also be given to the Draft Singleton Floodplain Risk Management Study and Plan currently on exhibition.	The Draft Singleton Flood Risk Management Study and Plan (BMT, 2022) has been used in the preparation of this FIRA.
Department of Planning and Environment (Biodiversity Conservation Division) – Flooding and Coastal Erosion	The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including: a. Flood prone land. b. Flood planning area, the area below the flood planning level. c. Hydraulic categorisation (floodways and flood storage areas).	a. Please refer to Figure B10 for the extent of flood prone land (PMF extents) b. Please refer to Figure D3 for the extent of the Flood Planning Area. c. Please refer to Figures B5, B8, B11, B15, B18, and B21 for hydraulic categorisation for major and extreme events.
	The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year (10% AEP), 1 in 100 year (1% AEP) flood levels and the Probable Maximum Flood, or an equivalent extreme event.	The FIRA modelling methodology and model parameters are described in the respective sections of this report. Events ranging from the 0.5EY to the PMF have been considered herein.
	The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: Current flood behaviour for a range of design events as identified in 11 above. This includes the 1 in 200 (0.5% AEP) and 1 in 500 year (0.2% AEP) flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Events ranging from the 0.5EY to the PMF have been considered herein. Flood impacts during events ranging from the 1% AEP to the PMF are presented in Figures C1-C3. A sensitivity test with respect to climate change is presented in Figure D1. The results suggest the proposed development is not expected to create significant adverse impacts off-site.

Reference	Requirement	FIRA Reference
	Modelling in the EIS must consider and document: a. The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood. b. Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories. c. Relevant provisions of the NSW Floodplain Development Manual 2005.	a. Flood impacts during events ranging from the 1% AEP to the PMF are presented in Figures C1-C3. b. Flood impacts during events ranging from the 1% AEP to the PMF are presented in Figures C1-C3. c. This FIRA has been prepared with consideration to the NSW Floodplain Development Manual 2005.
Department of Planning and Environment (Biodiversity Conservation Division) – Flooding and Coastal Erosion	The EIS must assess the impacts on the proposed development on flood behaviour, including: **a.** Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure. **b.** Consistency with Council floodplain risk management plans. **c.** Compatibility with the flood hazard of the land. **d.** Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land. **e.** Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site. **f.** Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses. **g.** Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council. **h.** Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council.	a. Flood impacts during events ranging from the 1% AEP to the PMF are presented in Figures C1-C3 (Refer to Section 5.3.4). Stormwater detention is proposed to mitigate increases in peak flows during local catchment events (refer to Section 5.1.1). The results suggest the proposed development is not expected to create significant adverse impacts off-site. b. This FIRA has been prepared with consideration to the Draft Singleton Flood Risk Management Study and Plan (BMT, 2022). c. Development has been sited to be located outside the extent of the Flood Planning Area and outside the Floodway categorisation. d. Development has been sited to be located outside the extent of the Flood Planning Area and outside the Floodway categorisation. e. Flood impacts during events ranging from the 1% AEP to the PMF are presented in Figures C1-C3. Stormwater detention is proposed to mitigate increases in peak flows during local

Reference	Requirement	FIRA Reference
	i. Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES. **j.** Any impacts the development may have on the social and economic costs to the community as consequence of flooding	catchment events. The results suggest the proposed development is not expected to create significant adverse impacts off-site. f. Flood impacts during events ranging from the 1% AEP to the PMF are presented in Figures C1-C3 (Refer to Section 5.3.4). Stormwater detention is proposed to mitigate increases in peak flows during local catchment events (refer to Section 5.1.1). The results suggest the proposed development is not expected to create significant adverse impacts off-site. g. Evacuation, Warning time and Emergency Management is discussed in Section 6.4. h. Evacuation, Warning time and Emergency Management is discussed in Section 6.4. i. Evacuation, Warning time and Emergency Management is discussed in Section 6.4. j. The proposed development has been sited in above the Flood Planning Area. There are potential social and economic costs to the community during events in excess of the standard 1% AEP + 500mm however, these are not considered inconsistent with industry practice.
Department of Planning and Environment (Biodiversity Conservation Division) – Flooding and Coastal Erosion		

2 Site Characteristics

2.1 Existing Site Description

The Site is located approximately 1.6km North-West of the existing North Rothbury township. Covering an area of approximately 532 hectares, the Site is bordered to the east by WCD, west and south by Black Creek and north by Main Northern Railway and Hunter Expressway. An aerial depiction of the site in its existing state is provided below in Figure 3**.**

The Site is predominately cleared grazing land and bushland. The average surface slopes across the proposed subdivision are approximately in a range of 1% to 8%. The site falls in different directions including south, south-west, west and north-west towards Black Creek and towards the Main Northern Railway and Hunter Expressway towards norths. Black Creek is a significant feature of the Singleton Shire Council LGA and Cessnock Council LGA. with a large proportion of the Cessnock Council LGA population living within its catchment.

Figure 3 - Existing Site (Source: Nearmap)

2.2 Catchments and Flooding Mechanisms

There are two dominant flooding mechanisms at the subject site. These are recognised as the broader Black Creek and Hunter River regions and the Local Onsite Watercourses. These are discussed further below.

2.2.1 Regional Black Creek and Hunter River

The Regional Black Creek and Hunter River flood mechanism has been reviewed by the Draft Singleton Floodplain Risk Management Study and Plan prepared by BMT and dated December 2022, herein referred to as the Singleton FRMS&P (BMT, 2022).

The site lies in the vicinity of the confluence of Black Creek and the Hunter River. The modelling prepared for the purposes of the Singleton FRMS&P (BMT, 2022) suggests flooding at the subject site, during major and extreme events, is largely dominated by the Hunter River. During the peak of the Hunter River event, flows in the Hunter River travel back up Black Creek and eventually drain out as flood water in the Hunter River recedes.

2.2.2 Local Onsite Watercourses

Natural drainage within the upper reaches of Stage 2 is characterised by a number of unnamed ephemeral tributaries which drain in a westerly direction towards Black Creek. These tributaries convey runoff from upstream rural/urban catchments which have been depicted below in Figure 4**.**

The Local Catchment watercourses are unnamed and thus for the purposes of this report have been referred to as Tributaries 3, 4, 5 and 6. Note that Tributaries 1 and 2 are located within the Stage 1 project area, please refer to the Stage 1 Project Area for the details of these tributaries.

Each of the existing watercourses entering site have been classified in accordance with the Strahler method. The classifications have been summarised in Table 2.

Table 2 - Entering Watercourse Classification

Water Course	Catchment Area (Hectares)	Strahler Order (Through Subject Site)
Tributary 3	130.8	1st to 2nd
Tributary 4	115.7	1st
Tributary 5	136.0	1st to 2nd
Tributary 6	193.4	2nd

A small portion of the Stage 2 project boundary drains towards Tributary 2 as shown in the following Figure 4. This catchment has been assessed as part of a separate approval / design for Stage 1. Please refer to the Stage 1 Project Area Approval for details.

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
ANVIL CREEK
SWEETWATER CREEK
BLACK CREEK
BRANXTON
GRETA
WINE COUNTRY DRIVE
BLACK CREEK
Dillans Scrub

Catchment drains to Stage 1 Boundary. Refer to Stage 1 Project Area Approval for details

Legend

- Stage2 Boundary
- Watercourses

Catchments

- Tributary 3
- Tributary 4
- Tributary 5
- Offline Basin 1
- Offline Basin 2
- Offline Basin 3
- Offline Basin 4

0 200 400 Metres

1:14,000

Figure 4 [B]

Site Watercourses and Catchments

Huntlee Stage 2 (NL220566)

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3 Methodology

Singleton Council have provided a copy of the Draft Singleton Floodplain Risk Management Study and Plan (FRMS&P) (BMT, 2022) for specific use on this project. The Draft Singleton Floodplain Risk Management Study and Plan was prepared by BMT and is dated November 2022.

Using the Draft Singleton FRMS&P (BMT, 2022), the following approach has been adopted in preparation of this Flood Impact and Risk Assessment:

3.1.1 Local Catchment (Site Tributaries):

- Review of available information including previous studies, the proposed development layout, LiDAR elevation data, Aerial Imagery and Cadastre.
- Site visit to review site constraints, measure accessible stormwater infrastructure and ground truth modelling assumptions.
- Construction of a one-dimensional XP-RAFTS model to estimate the existing peak flows derived by the local waterways through the subject site.
- Modification of the one-dimensional XP-RAFTS model to include the proposed development and design of local catchment stormwater detention basins.
- Comparison of the XP-RAFTS peak flow derived by the pre and post developed catchments for each tributary during the 0.5EY, 20%, 10%, 5%, 2% and 1% AEP.
- Construction of a two-dimensional TUFLOW model using information presented in the Draft Singleton FRMS&P (BMT, 2022) TUFLOW model to review the flood extents through the local tributaries across the subject site the 0.5EY, 20%, 10%, 5%, 2%, 1%, 1 in 500 AEP and PMF design storm events for both the existing and developed case scenarios.

3.1.2 Regional Catchment (Black Creek and Hunter River)

- Setup a detailed site specific and truncated version of the regional Draft Singleton FRMS&P (BMT, 2022) TUFLOW flood model.
- Amend site specific regional catchment TUFLOW model to include existing case and Developed case lumped XP-RAFTS local catchment flows derived by the Local Catchment XP-RAFTS modelling discussed above.
- Update truncated regional catchment TUFLOW model to include available detailed survey and developed case terrain.
- Update truncated regional catchment TUFLOW model to include updated existing and developed case Manning's surface roughness.
- Run truncated regional catchment TUFLOW model for the 1%, 1 in 200 AEP, 1 in 500 AEP and PMF design storm events.
- Comparison of the existing and developed case results to review the impact the proposed development has on the existing flood behaviour on-site and in adjacent properties.

3.1.3 Reference Documents

This study has been prepared with consideration to the following plans and reports:

- Masterplan Layout prepared by Daly Smith and dated 22nd of October 2023.
- Physical Infrastructure Report prepared by Northrop Consulting Engineers and dated November 2023.

This assessment has been prepared with the consideration of the following guidelines and documents:

- NSW Department of Planning and Environment (DPE) - Secretary's Environmental Assessment Requirements (SEARS).
- Cessnock Council Local Environmental Plan 2011.
- Cessnock Council Development Control Plan 2010.
- Singleton Council Local Environmental Plan 2013.
- Singleton Council Development Control Plan 2014.
- Australian Rainfall and Runoff 2019 Guidelines (AR&R 2019).
- Australian Rainfall and Runoff Project 15: Two-Dimensional Modelling in Urban and Rural Floodplains (2012).
- NSW Floodplain Development Manual (NSW Government 2005).
- NSW Flood Risk Management Manual (DPE 2023).
- The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method" (BoM, 2003).

4 Model Parameters

4.1 Local Catchment Modelling

4.1.1 Hydrological Model Parameters

The hydrological model used for the local catchment modelling was developed in XP-RAFTS using Laurenson Hydrology. As per the latest Australian Rainfall and Runoff Guidelines (ARR 2019); initial loss, continuing loss and pre-burst rainfall portions of the design storm events have been considered as part of this study as shown in the below Figure 5.

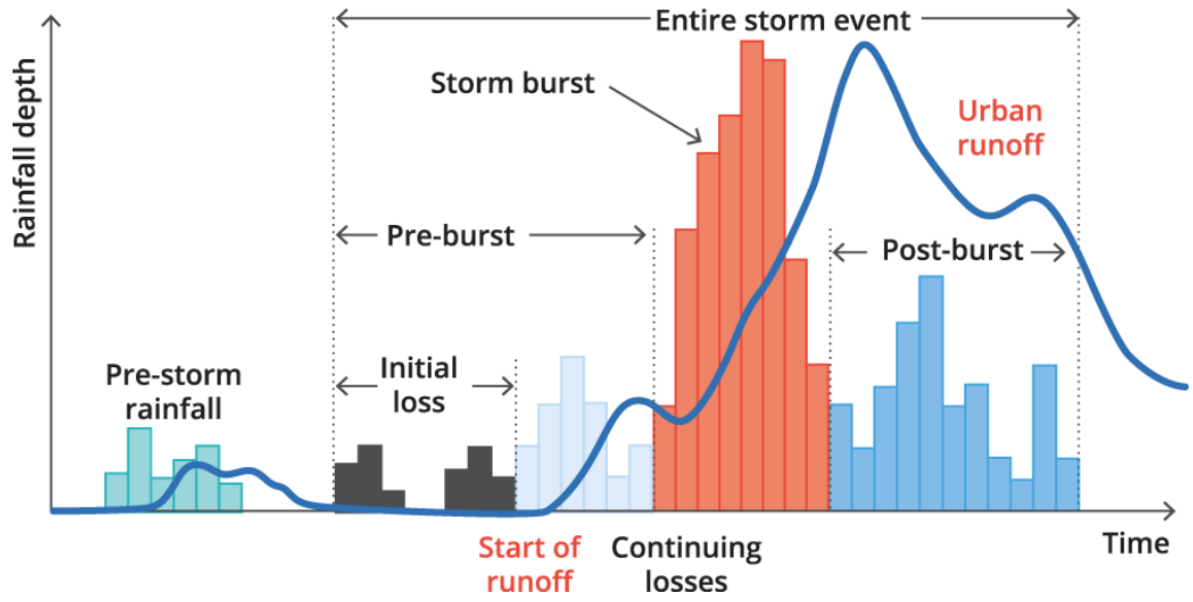


Figure 5 - Conceptual Design Storm Pattern (ARR 2019 Figure 9.6.4)

It is noted that the Singleton FRMS&P (BMT, 2022) used Rainfall on Grid (RoG) hydrology for the Local Catchment Modelling as presented in Annex B of the Study (BMT, 2022). XP-RAFTS hydrology has been used herein as an alternative as it provides a more efficient iterative modelling methodology, particularly when designing stormwater detention. This methodology is consistent with modelling prepared for Stage 1 of the Huntlee Urban Release Area and is noted as an acceptable methodology in the latest Australian Rainfall and Runoff Guidelines (ARR 2019).

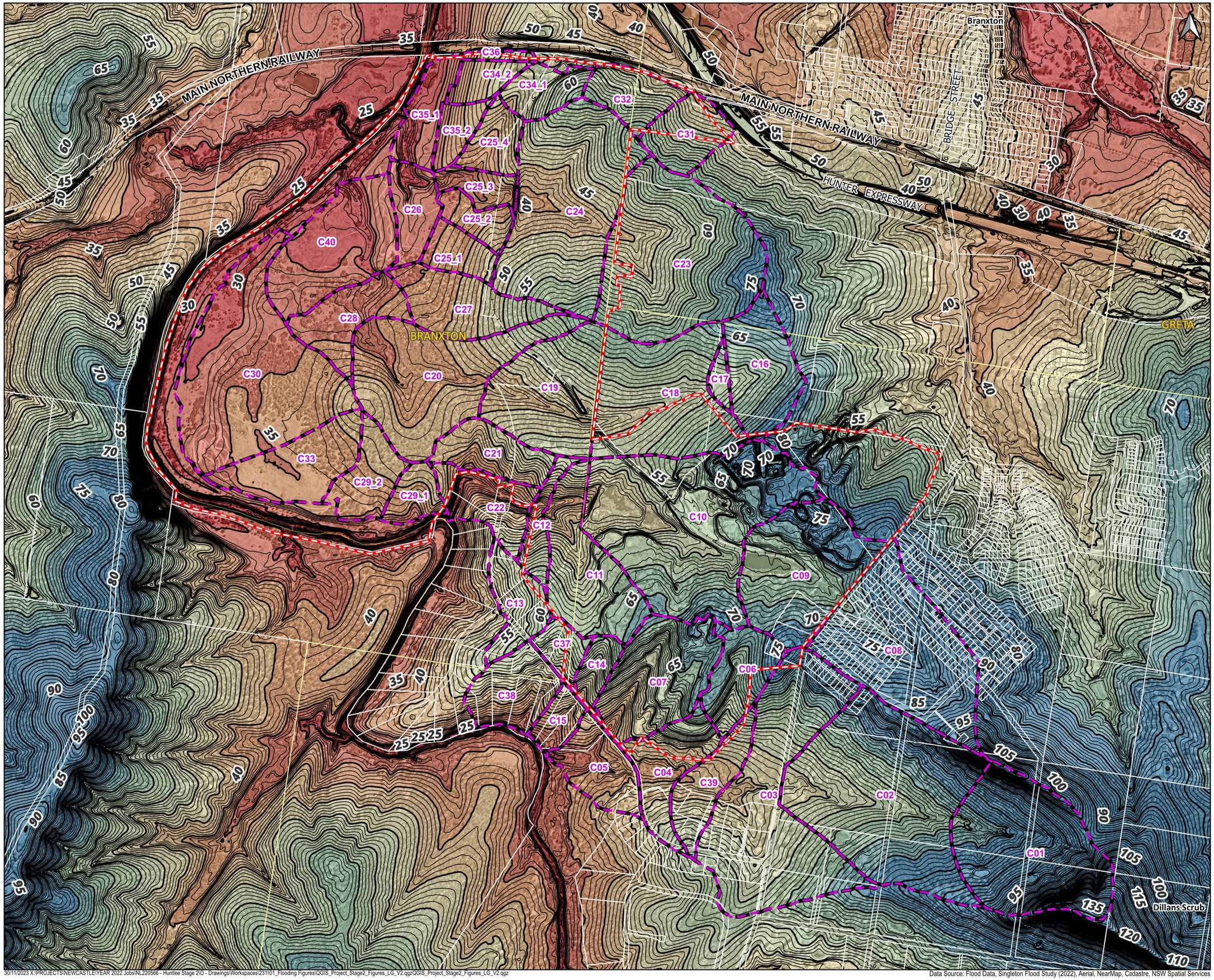
The input data for the Laurenson Hydrological model includes sub-catchment data, design rainfall, temporal patterns, pre-burst rainfall and the initial and continuing losses, each of which have been summarised in the report sections below.

4.1.1.1 Sub-Catchment Properties

The local catchment tributaries were split into sub-catchments which were digitised using a combination of detailed survey, LiDAR, aerial imagery and cadastral data. Existing case and Developed case sub-catchment extents are presented in the following Figure 6 and Figure 7 respectively. Similarly, sub-catchment properties for both the existing and developed case scenarios are summarised in Table 20 and Table 21 of Appendix B respectively.

Catchment slope has been determined individually for each sub-catchment, while impervious percentages for rural areas have been estimated from review of aerial imagery.

Hydrological roughness was based on a review of aerial imagery and an average surface roughness over the full extent of each sub-catchment. This included a review of creeks, pasture grass and bushland within the extent of each sub catchment.



Legend

- Stage2 Boundary
- Sub-Catchments
- Terrain Contours (5m)
- Terrain Contours (1m)

Terrain (mAHD)

- <= 30.0
- 30.0 - 35.0
- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 55.0
- 55.0 - 60.0
- 60.0 - 65.0
- 65.0 - 70.0
- > 70.0

0 200 400 Metres

1:14,000

Figure 6 [B]

Existing Case
Local Catchments

Huntlee Stage 2
(NL220566)

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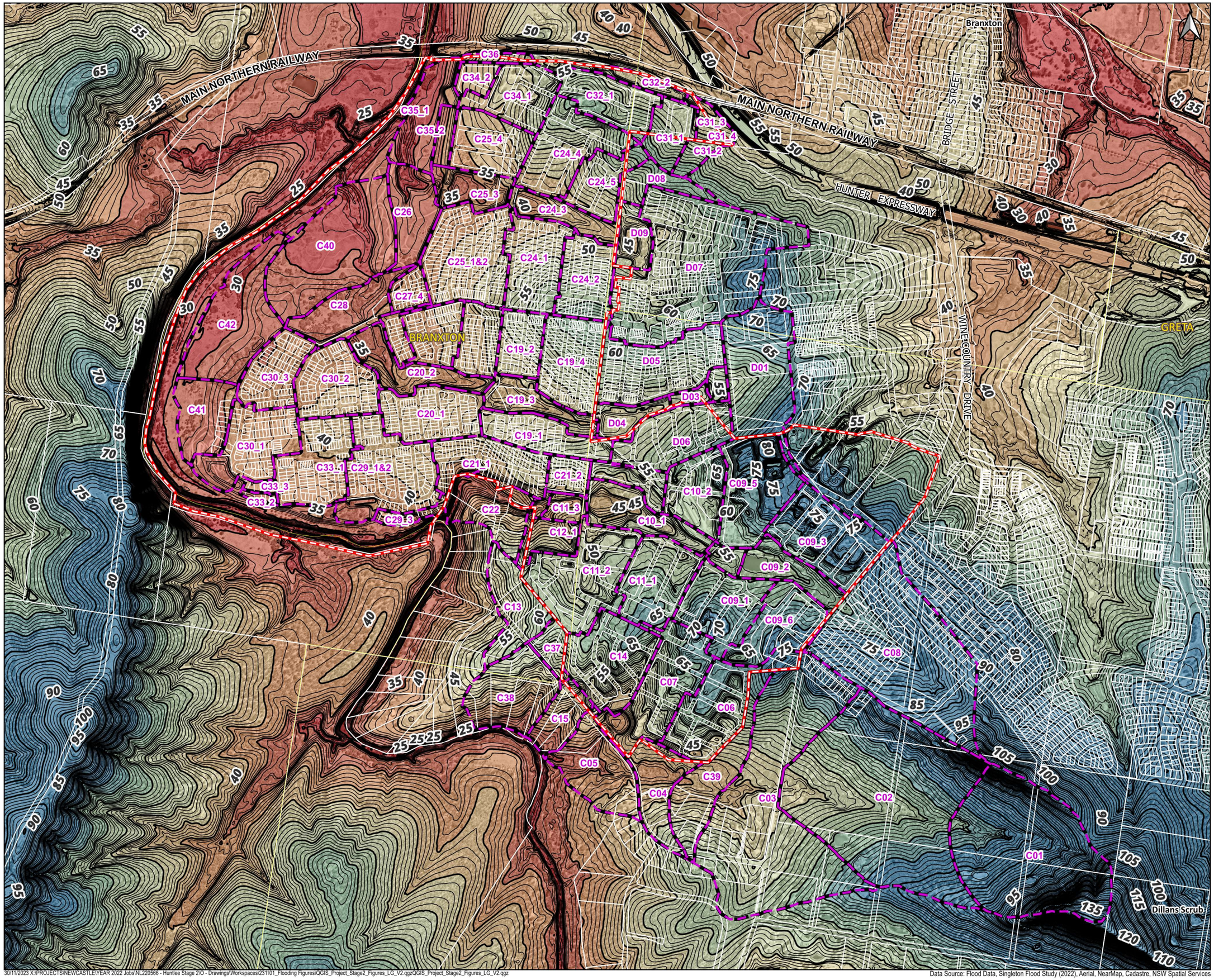
Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Sub-Catchments
- Terrain Contours (5m)
- Terrain Contours (1m)

Terrain (mAHD)

- <= 30.0
- 30.0 - 35.0
- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 55.0
- 55.0 - 60.0
- 60.0 - 65.0
- 65.0 - 70.0
- > 70.0

0 200 400 Metres

1:14,000

Figure 7 [B]

Developed Case Local Catchments

Huntlee Stage 2 (NL220566)

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Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

During the existing case, hydrological roughness was based on an average of 0.020 for water bodies, 0.025 for road reserves and bare soil, 0.045 for pasture grass and 0.090 for bushland for each sub catchment. For developed case conditions, a typical 0.035 was used for pervious roughness while 0.015 was used for impervious surfaces.

Being an urban residential land use, a typical 85% impervious fraction has been adopted over the developed areas of the catchment. This is expected to be a worst-case impervious percentage and is considered conservative. This assumption is expected to be fine-tuned at future development phases and the layout is updated.

4.1.1.2 Catchment Lag

Lag times between sub-catchments was estimated based on the guidance presented in QUDM 4th Edition, in particular Table 4.6.6. Average flow path grades and distance was determined using a combination of LiDAR elevation data and detailed survey.

Adopted catchment link lag times for the existing case and developed case scenarios are summarised in Table 22 and Table 23 of Appendix B, respectively.

4.1.1.3 Burst Rainfall

The latest AR&R 2019 Intensity-Frequency-Duration (IFD) rainfall depths have been obtained from the Bureau of Meteorology (BoM) for a location over the local catchment study area. For the local catchment analysis, storm durations ranging from the 10-minute to 24-hour were considered to determine the critical storm duration.

The latest AR&R 2019 temporal patterns for the "East-Coast South" region were applied to the 0.5 EY, 20%, 10%, 5%, 2%, 1% AEP design storm depths. To remain conservative, Areal Reduction Factors have not been considered for the local catchment. Catchments upstream of the proposed development have a catchment area of less than 1km^2 and therefore areal reduction Areal Reduction Factors have the potential to underestimate flows.

The Generalised Short Duration Method (GSDM) and procedures outlined in the Publication *"The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method"* (BOM, 2003) were used to develop design storm depths and patterns for the Probable Maximum Flood (PMF). Storm durations ranging from 15 minutes to 3 hours were modelled for the local catchment to determine the critical event for the Probable Maximum Flood (PMF).

A summary of the rainfall depths used for this assessment are provided in the following Table 3.

Table 3 - Rainfall Intensity-Frequency-Duration (BoM, 2020)

Duration (mins)	0.5 EY (mm)	20% AEP (mm)	10% AEP (mm)	5% AEP (mm)	1% AEP (mm)	1 in 500 AEP (mm)	PMF (mm)
10	12.7	15.9	19.3	22.7	31.9	41.8	-
15	15.9	19.9	24.1	28.5	40.1	52.5	180
20	18.2	22.9	27.7	32.7	45.8	60.2	-
25	20.1	25.2	30.5	35.9	50.2	66	-
30	21.7	27.1	32.7	38.6	53.7	70.7	260
45	25.2	31.4	37.7	44.4	61.2	80.8	330
60	27.7	34.5	41.4	48.5	66.6	87.8	410

Duration (mins)	0.5 EY (mm)	20% AEP (mm)	10% AEP (mm)	5% AEP (mm)	1% AEP (mm)	1 in 500 AEP (mm)	PMF (mm)
90 (1.5hr)	31.5	39.1	46.8	54.7	74.6	98.2	500
120 (2hr)	34.5	42.6	51.0	59.6	81.0	107	580
150 (2.5hr)	-	-	-	-	-	-	650
180 (3hr)	39.2	48.4	57.8	67.6	91.9	120	700
270 (4.5hr)	44.8	55.4	66.2	77.4	106	138	-
360 (6hr)	49.4	61.3	73.4	85.9	118	154	-
540 (9hr)	57.1	71.2	85.7	101	140	182	-
720 (12hr)	63.4	79.7	96.2	113	158	206	-
1080 (18hr)	73.8	93.5	114	134	190	248	-
1440 (24hr)	82.0	105	128	152	215	282	940

4.1.1.4 Storm Losses

The methodology adopted by this investigation for storm losses and pre-burst rainfall is consistent with the local catchment modelling presented in Annex B of the Draft Singleton FRMSP&P (BMT, 2022). Australian Rainfall and Runoff (2019) storm losses have been used in combination with the NSW Specific Transformational pre-burst rainfall depths.

A multiplication factor of 0.4 has been applied to the ARR continuing loss, as recommended by the Review of ARR Design Inputs for NSW' (OEH, 2019) and also performed by the Draft Singleton FRMSP&P (BMT, 2022). The following Table 7 presents rainfall losses used in this study which are based on the recommended values in Singleton Floodplain Risk Management Study and Plan (2022).

With the intended land-use for the proposed developed to be urban land use, developed pervious initial losses were reduced by a factor of 0.7 as recommended by ARR (2019).

Table 4 - Modelled Hydrologic Losses and Roughness Parameters

Land-use	Initial Loss (mm)	Continuing Loss (mm/hr)
Rural Pervious (ARR Data Hub)	25.0	2.1
Rural Pervious	25.0	0.84
Impervious (Singleton Flood Study (2022))	2.0	0.0
Modelled Pervious (Existing Areas)	25.0	0.84
Modelled Pervious (Developed Areas)	17.5	0.84
Modelled Impervious	2.0	0.0

4.1.1.5 Pre-Burst Rainfall

As mentioned above, the NSW Specific Transformational pre-burst depths have been used for this study. Use of the NSW Specific Transformational pre-burst depths is consistent with the methodology adopted by the Draft Singleton FRMS&P (BMT, 2022).

Pre-burst rainfall was added to the design rainfall events and distributed evenly over four timesteps prior to the burst of the design storm events. The resultant burst rainfall loss for each event was then determined by the difference between the NSW-Specific Transformational pre-burst rainfall and the Storm Losses presented in Table 4 above.

A summary of the pre-burst depths is presented in Table 5.

Table 5 - NSW-Specific Transformational Pre-Burst Rainfall (AR&R Data Hub)

Duration (mins)	0.5 EY (mm)	20% AEP (mm)	10% AEP (mm)	5% AEP (mm)	2% AEP (mm)	1% AEP (mm)
60 (1hr)	8.8	13.4	13.7	12.8	14.1	17.6
90 (1.5hr)	12.9	14.9	14.7	12.9	13.5	15.6
120 (2hr)	7.0	12.3	13.8	14.0	15.0	18.2
180 (3hr)	9.3	13.3	14.5	14.9	15.1	19.5
360 (6hr)	10.9	14.0	14.2	15.6	16.0	20.3
720 (12hr)	10.4	13.5	13.9	14.9	14.2	20.3
1080 (18hr)	8.2	12.3	12.9	15.0	12.9	21.3
1440 (24hr)	5.7	10.2	11.1	12.6	12.4	19.8

4.1.2 TUFLOW Hydraulic Model Parameters

The hydraulic model for this study was developed using the TUFLOW two-dimensional hydrodynamic modelling software using the HPC GPU solver. The existing and developed case TUFLOW model setup is presented in Figure 8 to Figure 9.

4.1.2.1 Terrain Data

The terrain data used for the two-dimensional model is based on the terrain used in the Singleton FRMS&P (BMT, 2022). Additional LiDAR elevation data was obtained from the ELVIS – Elevation and Depth – Foundation Spatial Data website over areas that were not covered by the Singleton FRMS&P (BMT, 2022).

Detailed survey obtained over the subject site was then overlayed the available LiDAR data to create the existing case terrain. Similarly, developed case terrain prepared using 12d design software was overlayed the existing case terrain to produce the developed case terrain.

Some additional regrading has also been entered into the model manually where limited information of stormwater infrastructure was available (such as at the decommissioned rail corridor).

Further to the above, some minor terrain fixes were also entered into the existing and developed case models based on observations made during a site investigation and from a review of aerial imagery.

As mentioned above, it is anticipated additional detailed survey will be obtained over the subject site during future design phases. In addition, future road and stormwater design will occur at detailed design stage.

Existing and developed case terrain is presented in Figure 8 and Figure 9 respectively.

4.1.2.2 Grid Extent, Size and Timestep

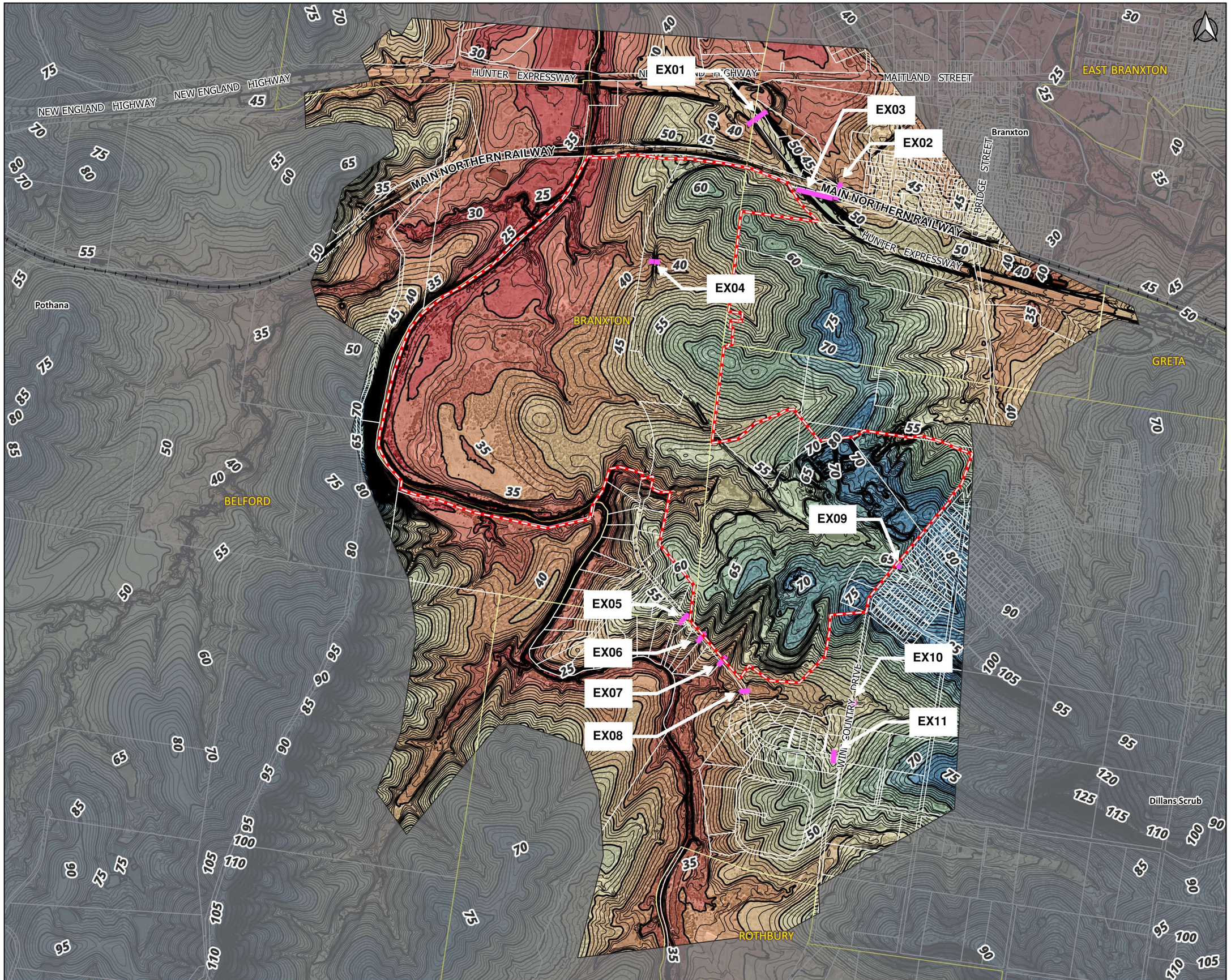
The latest HPC GPU TUFLOW solver, in particular version 2020-10-AC has been used for the purposes of the analysis.

Figure 8 and Figure 9 present the local catchment two-dimensional model extent with the grid extending east of Wine Country Drive, west of Black Creek and approximately 250m north and 1000m south of the subject site.

A four-metre cell size has been used over the local catchment which was considered a suitable size for the purposes of this study. An adaptive timestep has been used which enables more efficient model run times while, still maintaining a high degree of accuracy.

4.1.2.3 Catchment Roughness

Catchment roughness was based on the Singleton FRMS&P (BMT, 2022), a review of hydraulic literature, aerial imagery and relevant developed case inputs including the site layout and landscape plans. Figure 10 and Figure 11 present the extent of the existing and developed case land use while, the below **Table 5** presents the adopted hydraulic roughness for each.



Legend

- Stage2 Boundary
- Model Extent
- Stormwater Network
- Terrain Contours (5m)
- Terrain Contours (1m)

Terrain (mAHD)

- <= 30.0
- 30.0 - 35.0
- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 55.0
- 55.0 - 60.0
- 60.0 - 65.0
- 65.0 - 70.0
- > 70.0

0 300 600 Metres

1:18,999.999981

Figure 8 [B]

Existing Case Terrain and Stormwater Network

Huntlee Stage 2
(NL220566)

NORTHROP

30/11/2023 X:\PROJECTS\NEWCASTLE\YEAR 2022 Jobs\NL220566 - Huntlee Stage 2\O - Drawings\Workspaces\231101_Flooding Figures\QGIS_Project_Stage2_Figures_LG_V2.qgzQGIS_Project_Stage2_Figures_LG_V2.qgz

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

DEV01
Offline Basin 3 (OB3).
Tributary 3 Basin 3 (T3 B3)
DEV02
Tributary 3 Basin 2 (T3 B2)
DEV03
DEV04
Tributary 3 Basin 1 (T3 B1). (Separate Approval)
DEV05
Tributary 4 Basin 4 (T4 B4)
DEV06
Tributary 4 Basin 3 (T4 B3)
DEV07
DEV08
Tributary 4 Basin 1 (T4 B1). (Separate Approval)
Offline Basin 2 (OB2).
DEV09
Tributary 4 Basin 2 (T4 B2). (Separate Approval)
DEV10
DEV11
DEV12
Tributary 5 Basin 1 (T5 B1).
Offline Basin 1 (OB1).
Offline Basin 4 (OB4).
DEV13
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
BRIDGE STREET
WINE COUNTRY DRIVE
BRANXTON
NORTH ROTHBURY

Legend

- Stage2 Boundary
- Model Extent
- Stormwater Network
- Terrain Contours (5m)
- Terrain Contours (1m)

Terrain (mAHD)

- <= 30.0
- 30.0 - 35.0
- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 55.0
- 55.0 - 60.0
- 60.0 - 65.0
- 65.0 - 70.0
- > 70.0

0 200 400 Metres
1:12,000

Figure 9 [B]

Developed Case Terrain and Stormwater Network

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

Legend

- Stage2 Boundary
- Model Extent

Existing Land Use

- Pasture Grass
- Roads
- Buildings
- Black Creek-Mid Reach
- Black Creek-Upstream
- Railway
- Low Density Urban
- Medium Density Urban
- Dense Vegetation
- Soil
- Water Bodies
- Commercial/Industrial

0 300 600 Metres

1:19,000

Figure 10 [B]

Existing Case Surface Roughness

Huntlee Stage 2
(NL220566)

NORTHROP

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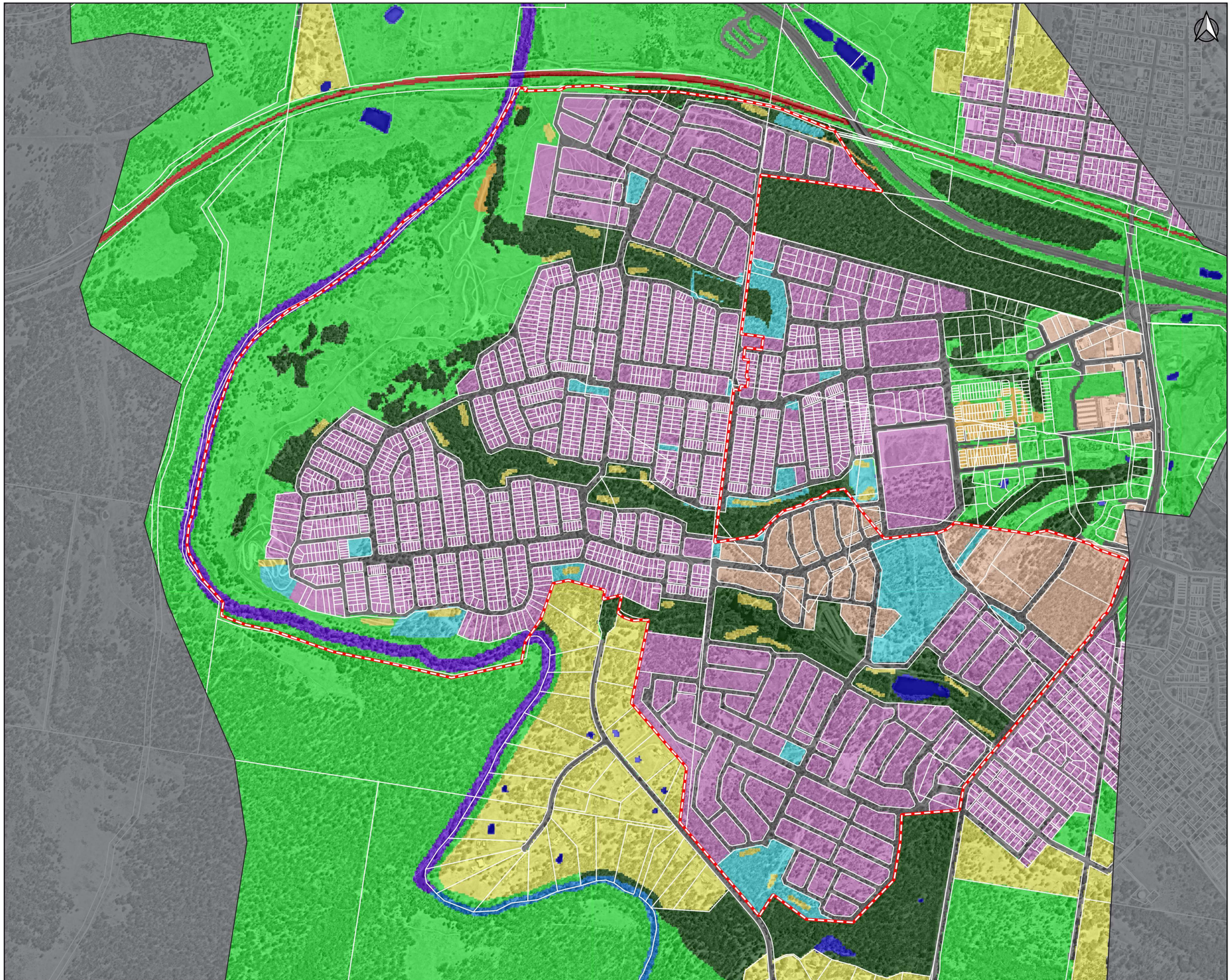
Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent

Developed Case Land Use

- Pasture Grass
- Roads
- Black Creek-Mid Reach
- Black Creek-Upstream
- Railway
- Low Density Urban
- Medium Density Urban
- Dense Vegetation
- Bio Basins
- Maintained Grass
- Soil
- Water Bodies
- Commercial/Industrial

0 200 400 Metres

1:12,000

Figure 11 [B]

Developed Case Surface Roughness

Huntlee Stage 2
(NL220566)

NORTHROP

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Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

Table 5 - Modelled Hydraulic Roughness Parameters

Land use Type	Roughness (Manning's)
Pasture Grass	0.040
Roads	0.030
Buildings	1.000
Hunter River Wide	0.020
Hunter River Narrow	0.045
BC Mid Reach	0.060
BC Upstream	0.080
Railway	0.050
Medium Density Urban	0.250
Dense Vegetation	0.100
Soil	0.025
Water Bodies	0.020
Maintained Grass	0.035
Commercial / Industrial	0.300

4.1.2.4 Boundary Conditions

Inflow hydrographs produced by the XP-RAFTS model were applied directly to the two-dimensional grid via a series of inflow boundaries for each sub-catchment.

A 5% AEP tailwater condition has been assumed in Black Creek for the local catchment events up to and including the 1% AEP while, a 1% AEP tailwater condition in Black Creek has been assumed for the 1 in 500 AEP and PMF design storm events.

An outlet head boundary is located in Black Creek, downstream of the New England Highway. Tailwater levels at the model outlet have been based on the results presented in the Draft Singleton FRMS&P (2022) for the respective 5% and 1% AEP events.

4.1.2.5 Hydraulic Structures

Figure 8 and Figure 9 presents the existing and developed case stormwater infrastructure across the subject site. The modelled stormwater network was based on observations made during a site investigation, aerial imagery and LiDAR elevation data. The following Table 6 provides a summary of the modelled existing case infrastructure.

Table 6 - Existing Case Infrastructure (Estimated and Assumed – Not Survey)

Reference (Refer to Figure 8)	Number of	Size and Type
EX01	1	1350mm RCP
EX02	1	1050mm RCP
EX03	1	1200mm RCP
EX04	2	2.4w x 1.2h RCBC
EX05	1	450mm RCP
EX06	1	750mm RCP
EX07	1	2100mm RCP
EX08	3	1200mm RCP
EX09	3	600mm RCP
EX10	3	1200mm RCP
EX11	2	600mm RCP

A 0% blockage factor has been applied to existing culverts across to limit the potential for artificial detention behind culvert crossings. In addition, major hydraulic structures (such as bridges) across the Main Northern Railway, The Hunter Expressway and New England Highway remain largely unchanged when compared to the Singleton FRMS&P (BMT, 2022).

Developed case hydraulic structures are based on XP-RAFTS stormwater detention modelling. A summary of the developed case infrastructure is presented in the following Table 7. It is noted that the proposed stormwater infrastructure presented in Table 7 above is considered concept level only. Further analysis is expected at detailed design stage.

Table 7 - Developed Case Infrastructure

Reference (Refer to Figure 9)	Purpose	Number of	Size and Type
DEV01	OB3 Low Flows	1	450x375mm RCP
	OB3 High Flows	1	Weir at 1.87m Depth 3.3m wide
DEV02	T3 B3 Low Flows	1	750mm RCP
	T3 B3 High Flows	1	Weir at 3.4m Depth 23m wide
DEV03	T3 B2 High Flows	2	900x750mm RCBC
DEV04	T3 B1 Low Flows	2	375mm RCP
	T3 B1 High Flows	2	600mm RCP
DEV05	T4 B4 Low Flows	1	675mm RCP
	T4 B4 High Flows	5	600mm RCP

Reference (Refer to Figure 9)	Purpose	Number of	Size and Type
DEV06	T4 B3 Low Flows	1	600x450mm RCBC
	T4 B3 High Flows	4	600mm RCP
DEV07	T4 B2 Low Flows	1	525mm RCP
	T4 B2 High Flows	1	Weir at 3.08m Depth 25m wide
DEV08	T4 B1 Low Flows	1	600mm RCP with Grate
DEV09	OB2 Low Flows	1	450x300mm RCBC
	OB2 High Flows	1	Weir at Depth 0.75m 8m wide
DEV10	OB1 Low Flows	1	450mm SQ RCBC
	OB1 High Flows	1	Weir at 1.2m Depth 3.3m Width
DEV11	T5 B1 Low Flows	1	900x750mm RCBC
	T5 B1 High Flows	6	900mm RCP
DEV12	Culvert Crossing	3	2.1m RCP
DEV13	OB4 Low Flows	1	600mm RCP
	OB4 High Flows	1	Weir at Depth 4.84m 4m Width

The latest AR&R 2019 blockage guidelines have been used to determine likely blockage factors at each developed case structure. The following design blockage factors have been applied to the proposed outlet for each detention basin. Thes conditions are generally consistent with other blockage assumptions used for detention basins elsewhere throughout the Huntlee Subdivision.

- Low Flow Pipes – 50% Blockage; and
- High Flow Pipes – 15% Blockage.

An unblocked scenario has been considered when reviewing the pre-to-post peak flow for each basin. The above blockage has been considered as a sensitivity test for both the XP-RAFTS and TUFLOW modelling.

4.2 Regional Catchment Modelling

4.2.1 Hydrological Model Parameters

Hydrology used in the regional catchment modelling is based on the Singleton FRMS&P (BMT, 2022). The original Singleton FRMS&P (BMT, 2022) inflows in the vicinity of the site have been amended to include the lumped local catchments prepared for the purposes of the Local Catchment modelling.

Where overlapping catchment inflows were observed, in particular Catchments BC_014 and BC_018 from the Singleton FRMS&P (BMT, 2022), flows were scaled down using a ratio of the overlapping

areas. This resulted in a reduction of 19.7% and 13.3% for catchments BC_014 and BC_018 respectively.

4.2.2 Hydraulic Model Parameters

4.2.2.1 Terrain

Terrain for the regional catchment modelling is based on the Singleton FRMS&P (BMT, 2022). Additional terrain modifications imported into the local catchment model were also introduced into the regional catchment model. Refer to the above Local Catchment terrain section for further details.

4.2.2.2 Grid Extent, Size and Timestep

The Singleton FRMS&P (BMT, 2022) model extent was trimmed to reduce model run time for the purposes of this investigation. The Singleton FRMS&P (BMT, 2022) model was trimmed at the Confluence of Black Creek and the Hunter River, approximately 7.5km north of the subject site.

The updated regional catchment TUFLOW model extent is defined by the upstream extents of Black Creek, and continues downstream to the confluence of Black Creek and the Hunter River. The original TUFLOW extent was then maintained downstream of the confluence.

The truncated model extent is presented in Figure 12 and Figure 13 overleaf.

4.2.2.3 Catchment Roughness

Roughness values adopted in the truncated regional flood model are presented in Figure 12 and Figure 13. Catchment roughness used in the truncated regional flood model was based on those used by the original Singleton FRMS&P (BMT, 2022).

Additional site-specific amendments to the surface roughness were included in the truncated regional TUFLOW model. The updated were consistent with those discussed in the Local Catchment model parameters section above.

4.2.2.4 Boundary Conditions

Local lumped catchment inflows for both the existing and developed case scenarios were applied directly to Black Creek at the outlet of each tributary. As mentioned above, where overlapping catchment inflows were observed, inflows from the Singleton FRMS&P (BMT, 2022) model were scaled down using a ratio of the overlapping areas. These were scaled back using the boundary condition database.

In addition to the updated local catchment inflows, an inflow boundary was created at the upstream end of the Hunter River (in the North-western corner of the TUFLOW model extent). Flows generated by the upstream Hunter River catchment were applied at this location and were extracted from the results presented in the Singleton FRMS&P (BMT, 2022).

All other inflow boundaries remained unchanged when compared to the original Singleton FRMS&P (BMT, 2022).

Similarly, the original Singleton FRMS&P (BMT, 2022) outlet boundary condition near Gosforth was used in by the site-specific truncated model.

4.2.2.5 Hydraulic Structures

Hydraulic structures outside the extent of the subject site remain largely unchanged when compared to the original Singleton FRMS&P (BMT, 2022).

Updated hydraulic structures at the subject site were included in the truncated model. These are presented and discussed in the local catchment model parameters section above.

Roughit
Glendon
GLENDON
ELDERSLIE
Elderslie
STANHOPE
Stanhope
LAMBS VALLEY
Corinda
Lower Belford
Kirkton
LOWER BELFORD
Stamford
DALWOOD
LAMBS VALLEY
BRANXTON
Hillsborough
Dalwood
Belford
LECONFIELD
Leconfield
GOSFORTH
Gosforth
East Branxton
Branxton
BRANXTON
MAIN NORTHERN RAILWAY
LUSKINTYRE
BELFORD
Pothana
Luskintyre
WINDERMERE
Windermere
Anambah
ANAMBAH
North Rothbury
Greta
GRETA
NORTH ROTHBURY
Dillans Scrub
Illalong
Windella
OSWALD
Oswald
Lochinvar
Harpers Hill
POKOLBIN
LOCHINVAR
Rothbury
Allandale
MAIN NORTHERN RAILWAY
FARLEY
LOVEDALE
POKOLBIN
BISHOPS BRIDGE
Bishops Bridge
KEINBAH
BISHOPS BRIDGE
Keinbah

Legend

- Stage2 Boundary
- Model Extent
- Stormwater Network
- 2D Inflows
- 2D Inflows
- Downstream Outlet

Regional Model Land Use

- Hunter River-Wide
- Hunter River Narrow
- Pasture Grass
- Roads
- Black Creek-Downstream
- Black Creek-Mid Reach
- Black Creek-Upstream
- Railway
- Low Density Urban
- Medium Density Urban
- Dense Vegetation
- Soil
- Water Bodies
- Commercial/Industrial

0 1,000 2,000 Metres

1:70,000

Figure 12 [B]

Regional Model
Developed Case Model
Setup

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

Roughit
Glendon
GLENDON
ELDERSLIE
Elderslie
STANHOPE
Stanhope
LAMBS VALLEY
Corinda
Lower Belford
Kirkton
LOWER BELFORD
Stamford
DALWOOD
LAMBS VALLEY
BRANXTON
Hillsborough
Dalwood
LECONFIELD
Leconfield
GOSFORTH
Gosforth
Belford
East Branxton
Branxton
BRANXTON
MAIN NORTHERN RAILWAY
LUSKINTYRE
Luskintyre
BELFORD
Pothana
WINDERMERE
Windermere
Anambah
ANAMBAH
North Rothbury
Greta
GRETA
NORTH ROTHBURY
Dillans Scrub
Illalong
OSWALD
Oswald
Lochinvar
Windella
Harpers Hill
POKOLBIN
LOCHINVAR
Rothbury
Allandale
MAIN NORTHERN RAILWAY
FARLEY
LOVEDALE
POKOLBIN
BISHOPS BRIDGE
Bishops Bridge
KEINBAH
Keinbah
BISHOPS BRIDGE

Legend

- Stage2 Boundary
- Model Extent
- Stormwater Network
- 2D Inflows
- 2D Inflows
- Downstream Outlet

Regional Model Land Use

- Hunter River-Wide
- Hunter River Narrow
- Pasture Grass
- Roads
- Black Creek-Downstream
- Black Creek-Mid Reach
- Black Creek-Upstream
- Railway
- Low Density Urban
- Medium Density Urban
- Dense Vegetation
- Bio Basins
- Maintained Grass
- Soil
- Water Bodies
- Commercial/Industrial

0 1,000 2,000 Metres
1:70,000

Figure 13 [B]

Regional Model
Developed Case Model
Setup

Huntlee Stage 2
(NL220566)

NORTHROP

29/11/2023 X:\PROJECTS\NEWCASTLE\YEAR 2022 Jobs\NL220566 - Huntlee Stage 2\O - Drawings\Workspaces\231101_Flooding Figures\QGIS_Project_Stage2_Figures_LG_V2.qgzQGIS_Project_Stage2_Figures_LG_V2.qgz

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

5 Results

5.1 Stormwater Detention

The XP-RAFTS model has been used to review the pre-developed and post-developed peak flow rates for the proposed development. Generally, the confluence point for each of the local catchment tributaries with Black Creek have been used for the purposes of the comparison.

As a result, the following seven comparison points have been used for the purposes of the investigation (refer to Figure 4 for locations):

- **Discharge Point 1:** Offline Basin 3.
- **Discharge Point 2:** Tributary 3.
- **Discharge Point 3:** Tributary 4.
- **Discharge Point 4:** Offline Basin 2.
- **Discharge Point 5:** Offline Basin 1
- **Discharge Point 6:** Tributary 5.
- **Discharge Point 7:** Offline Basin 4

It is anticipated that the detention basins will continue to be updated during future project phases. The results presented below demonstrates that from a concept level analysis, stormwater detention is expected to be feasible for the proposed development.

5.1.1 Detention Performance

A summary of the pre-developed and post developed peak flow results at each discharge point is presented in the below Tables 6-12.

Table 8 - Pre to Post Comparison Discharge Point 1 (Offline Basin 3)

Storm Event	Pre-Developed Flow (m^3/s)	Post-Developed Flow (m^3/s)	Difference (m^3/s)
0.5EY	0.63	0.61	-0.02
20% AEP	0.96	0.77	-0.19
10% AEP	1.21	0.92	-0.29
5% AEP	1.51	1.06	-0.45
2% AEP	2.03	1.39	-0.64
1% AEP	2.61	2.48	-0.13

Table 9 - Pre to Post Comparison Discharge Point 2 (Tributary 3)

Storm Event	Pre-Developed Flow (m^3/s)	Post-Developed Flow (m^3/s)	Difference (m^3/s)
0.5EY	3.34	2.96	-0.38
20% AEP	5.25	4.70	-0.55
10% AEP	6.92	6.91	-0.01
5% AEP	8.39	8.37	-0.02
2% AEP	11.07	10.77	-0.30
1% AEP	13.83	13.26	-0.57

Table 10 - Pre to Post Comparison Discharge Point 3 (Tributary 4)

Storm Event	Pre-Developed Flow (m^3/s)	Post-Developed Flow (m^3/s)	Difference (m^3/s)
0.5EY	2.38	2.33	-0.05
20% AEP	3.44	3.20	-0.24
10% AEP	4.73	4.32	-0.41
5% AEP	5.89	5.36	-0.53
2% AEP	6.98	6.83	-0.15
1% AEP	8.58	8.33	-0.25

Table 11 - Pre to Post Comparison Discharge Point 4 (Offline Basin 2)

Storm Event	Pre-Developed Flow (m^3/s)	Post-Developed Flow (m^3/s)	Difference (m^3/s)
0.5EY	0.74	0.73	-0.01
20% AEP	1.08	1.02	-0.06
10% AEP	1.40	1.36	-0.04
5% AEP	1.81	1.63	-0.18
2% AEP	2.32	1.98	-0.34
1% AEP	2.88	2.69	-0.19

Table 12 - Pre to Post Comparison Discharge Point 5 (Offline Basin 1)

Storm Event	Pre-Developed Flow (m^3/s)	Post-Developed Flow (m^3/s)	Difference (m^3/s)
0.5EY	0.66	0.65	-0.01
20% AEP	1.03	0.78	-0.25
10% AEP	1.38	0.89	-0.49
5% AEP	1.69	1.03	-0.66
2% AEP	2.20	1.73	-0.47
1% AEP	2.67	2.42	-0.25

Table 13 - Pre to Post Comparison Discharge Point 6 (Tributary 5)

Storm Event	Pre-Developed Flow (m^3/s)	Post-Developed Flow (m^3/s)	Difference (m^3/s)
0.5EY	3.75	3.74	-0.01
20% AEP	5.83	4.83	-1.00
10% AEP	7.55	6.71	-0.84
5% AEP	9.19	9.05	-0.14
2% AEP	12.10	11.88	-0.22
1% AEP	14.90	13.93	-0.97

Table 14 - Pre to Post Comparison Discharge Point 7

Storm Event	Pre-Developed Flow (m^3/s)	Post-Developed Flow (m^3/s)	Difference (m^3/s)
0.5EY	4.96	4.95	-0.01
20% AEP	7.56	7.24	-0.32
10% AEP	9.87	9.36	-0.51
5% AEP	12.31	11.33	-0.98
2% AEP	15.71	14.44	-1.27
1% AEP	17.69	17.66	-0.03

5.1.2 Detention Volume

A total of nine detention basins have been proposed throughout the site in order to mitigate post development increases in stormwater runoff. The preliminary size of each basin is presented in Table 15 below. Both the blocked and unblocked volumes are presented in Table 15.

The basin sensitivity to blockage is also presented in Table 15. Blockage for this test included a 50% and 15% for low and high flow hydraulic controls respectively. The values presented in Table 15 presents the difference between the blocked and unblocked scenarios. The results presented in Table 15 highlight that basins with pipes / culverts as high flow outlet controls have the greatest sensitivity to blockage.

As previously discussed, it is expected the basins and outlet controls will be further analysed during future project phases.

Table 15 - Detention Basin Volumes (1% AEP Volume)

Detention Basin	Unblocked Volume (ML)	Blocked Volume (ML)	Sensitivity to Blockage (ML)
Offline Basin 3	7.0	7.2	+0.2
Tributary 3 Basin 2	11.3	22.0	+10.7
Tributary 3 Basin 3	22.5	23.2	+0.7
Tributary 4 Basin 3	23.7	35.0	+11.3
Tributary 4 Basin 4	27.8	45.7	+17.9
Offline Basin 2	7.1	7.2	+0.1
Offline Basin 1	14.6	15.4	+0.8
Tributary 5 Basin 1	47.0	63.0	+16.0
Offline Basin 4	17.9	19.9	+2.0

A blockage sensitivity test has also been performed as part of the TUFLOW modelling. Additional information is presented in the Discussion Section of this report.

5.2 Local Catchment Flooding

5.2.1 Critical Duration

The critical duration was determined in XP-RAFTS with storm durations ranging from 10-minutes to the 24-hours considered for the 0.5EY, 20%, 10%, 5% and 1% AEP and 1 in 500AEP design storm events. For events more frequent than the PMF, the duration that produced the highest median peak flow through each tributary was considered the critical duration.

For the two-dimensional model, up to four critical durations observed in XP-RAFTS across the subject site (for both existing and developed case models) were passed into the two-dimensional model. All ten temporal patterns for each duration were passed to the two-dimensional TUFLOW model. The median pattern for each storm duration was calculated with the duration producing the highest median value classified as the critical event as recommended in the latest ARR 2019 guidelines.

The below Table 16 presents the critical duration ensembles passed into the two-dimensional TUFLOW model for each return interval for both the existing and developed case models.

Table 16 - Two-dimensional model duration ensembles (Existing and Developed)

Design Storm Event	Duration One	Duration Two	Duration Three	Duration Four
0.5 EY	30min	90min	360min	-
20% AEP	30min	90min	360min	-
10% AEP	30min	90min	360min	-
5% AEP	30min	90min	180min	-
1% AEP	10min	30min	60min	120min
1 in 500 AEP	10min	30min	60min	

During PMF, all durations ranging from the 15-minute to the three-hour design storm duration were passed to the two-dimensional model. The duration that produced the maximum flood level for the PMF was considered the critical event. Review of the PMF results suggests the critical duration for the local catchment PMF event ranges from the 15-minute to the 60-minute durations.

5.2.2 Existing Case Results

Figures A1 to A5 of Appendix A presents the Local Catchment existing case flood depth and elevation through the subject site for the 0.5EY, 20%, 10%, 1% AEP and PMF design storm events.

Across the subject site, flows from each overland flow path are observed running in a westerly direction before terminating at their confluence with Black Creek along the western boundary of the subject site.

In the upper reaches of the catchment, flood depths range from up to approximately 300mm during the 0.5 EY to in the order of 0.5-1.0m during the 1% AEP. Figure A5 of Appendix A shows flood depths during the PMF exceed 2 meters through the upper reaches of the catchment.

5.2.3 Developed Case Results

Figures B1-B4, B7 and B10 of Appendix A presents the developed case local catchment flood depth, elevation contours through the subject site during the 0.5 EY, 20%, 10%, 1% AEP, 1 in 500 AEP and PMF design storm events respectively.

Similar flood depths are observed during the developed case when compared to the existing case scenario with the exception of the increased depths around the proposed detention basins, which is expected.

In addition, Figure B4 of Appendix A shows all proposed lots are located outside the extent of the Local Catchment 1% AEP design storm event. Similarly, all proposed road crossings are shown to be flood free during the 1% AEP design storm event.

Figures B5, B8 and B11 of Appendix A present the local catchment Hydraulic Categories during the 1% AEP, 1 in 500 AEP and PMF design storm events. Local catchment Hydraulic Categories are based on the Local Catchment calculations presented in the Singleton FRMS&P (BMT, 2022), reproduced in Table 17 below.

Table 17 - Local Catchment Hydraulic Categories

Classification	Criteria	Description
Floodway	Velocity * Depth ≥ 1.0 m^2/s AND Velocity ≥ 0.1 m/s OR Velocity > 0.8 m/s	Areas and flow paths where significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections)
Flood Storage	Depth ≥ 1.5 m	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks
Flood Fringe	Remaining Flood Extent Depth < 1.5 m	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour

Figures B6, B9 and B12 of Appendix A present the flood hazard conditions through the creek during the 1%, 1 in 500 AEP and PMF design storm events. Flood hazard conditions have been based on the latest AR&R hazard categories summarised in Figure 14 overleaf.

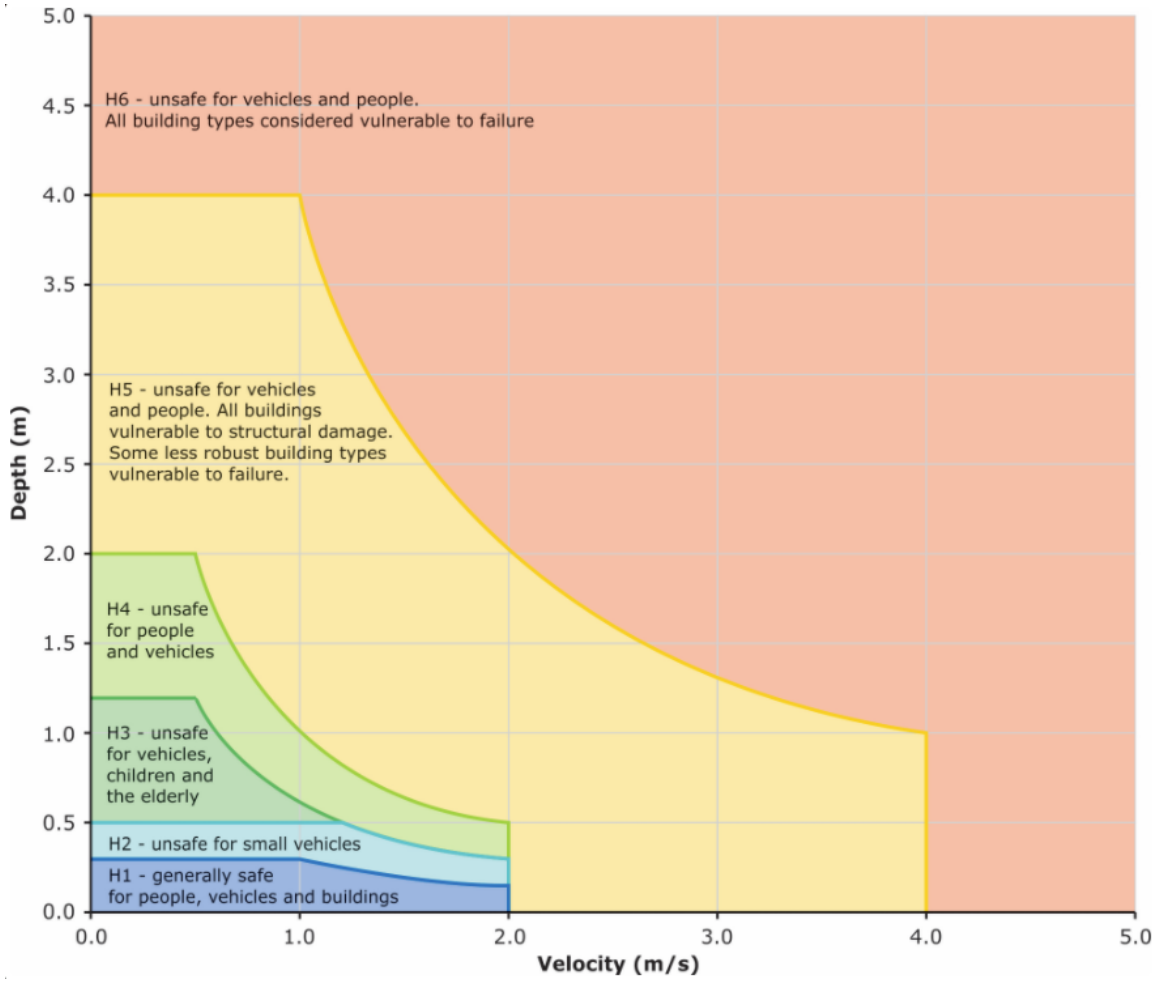


Figure 14 - Flood Hazard Categories (AR&R 2019)

5.3 Regional Catchment Flooding

5.3.1 Critical Duration

The critical duration modelled for the regional catchment flood event is based on the findings of the Draft Singleton FRMS&P (BMT, 2022). The Draft Singleton FRMS&P (BMT, 2022) suggests the 24-hour duration was modelled at Black Creek while a representative Flood Frequency Analysis hydrograph was entered for the broader Hunter River catchment. These critical events remain unchanged herein.

For local catchment runoff, the 24-hour critical duration was run in the XP-RAFTS model. The most common temporal pattern that produced the median result at each tributary outlet was then passed into the regional catchment TUFLOW model. A review of the temporal patterns discharging from these catchments suggested that the 24-hour, Temporal Pattern 3 was the most common median temporal pattern and was therefore passed into the TUFLOW model.

5.3.2 Existing Case Results

Figures A6 to A9 of Appendix A presents the Regional Catchment existing case flood depth and elevation points adjacent to the subject site for the 1%, 1 in 200 AEP, 1 in 500 AEP and PMF design storm events.

Flood depths in Black Creek are in the order of 11m during the 1% AEP and increase to approximately 18m during the PMF. Flood Elevations in Black Creek in the vicinity of the site during

the 1% AEP, 1 in 200 AEP, 1 in 500 AEP and PMF design storm events are summarised in the following Table 18.

Table 18 - Black Creek Flood Levels

Design Storm Event	Flood Elevation (m AHD)
1% AEP	33.17
1 in 200 AEP	35.07
1 in 500 AEP	36.98
PMF	39.91

5.3.3 Developed Case Results

Figures B13, B14, B17 and B20 of Appendix A presents the Regional Catchment developed case flood depth and elevation points during the 1%, 1 in 200 AEP, 1 in 500 AEP and PMF design storm events.

Figure B13 shows that generally all lots and the development are located outside the extent of the Regional Catchment 1% AEP design storm event. During the 1 in 200 AEP, Figure B14 shows low lying lots and perimeter roads start to become vulnerable to flooding with the above Table 18 suggests an increase in flood depth in the order of 1.9m is expected when compared to the 1% AEP. Flooding during the 1 in 200 AEP results in up to approximately 500mm across the western perimeter roads in two locations. These locations are presented in Figure 15 and discussed further in the Climate Change Sensitivity Test section below.

During the 1 in 500 AEP, the above Table 18 suggests flood levels increase by up to approximately 3.8m when compared to the 1% AEP. As a result, Figure B17 shows flood levels continue into the development with maximum depths in the order 2.5m expected across the western perimeter roads. In the north-western portion of the site, lots and the perimeter roads generally remain above the flood levels.

During the PMF, Table 18 shows flood levels in Black Creek increase by up to 6.7m when compared to the 1% AEP design storm event. Figure B17 shows maximum flood depths across the perimeter roads are expected to be in the order of 5.5m during the PMF.

Figures B15, B18 and B21 of Appendix A presents the Regional Catchment developed case Hydraulic Categories during the 1 in 200 AEP, 1 in 500 AEP and PMF design storm events. The Hydraulic Categories for the Regional Catchment have been based on the Hunter River Floodplain Flood Function Criteria calculations presented in the Singleton FRMS&P (BMT, 2022), reproduced in Table 20 overleaf.

The results presented in Figure B15 suggests the proposed perimeter roads remain outside the extent of Flood Storage during the 1 in 200 AEP design storm event. During the 1 in 500 AEP, Figure B18 shows flood storage is observed in the lower reaches of the western perimeter roads and lots while, Figure B21 shows a maximum of flood storage flow behaviour is expected across the proposed development during the PMF. It is noted that the proposed development is shown to be located outside the extent of floodway for all return intervals considered.

Table 19 - Regional Catchment Hydraulic Categories (>1% AEP)

Classification	Criteria	Description
Floodway	Velocity * Depth ≥ 1.5 m^2/s AND Velocity ≥ 0.6 m/s Plus 1% AEP Floodway	Areas and flow paths where significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections)
Flood Storage	Depth ≥ 1.5 m	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks
Flood Fringe	Remaining Flood Extent Depth < 1.5 m	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour

Flood hazard conditions have been assessed using the latest Australian Rainfall and Runoff Guidelines (2019) presented in Figure 14 above. Figures B16, B19 and B22 of Appendix A present the developed case flood hazard conditions during the 1 in 200 AEP, 1 in 500 AEP and PMF design storm events.

Figure B16 of Appendix A suggests flood hazard conditions across the site remain relatively low with generally a maximum of H2 observed in proposed lots during the 1 in 200 AEP. Up to H3 hazard conditions are observed in the perimeter roads during this event.

During the 1 in 500 AEP, Figure B19 of Appendix A suggests hazard conditions in the lots and perimeter roads increase to a maximum of H5 while up to H6 is observed during the PMF as shown in Figure B22.

It is important to recognise the magnitude and likelihood of these events. As outlined in the Draft FRMS&P (BMT, 2022), the regional PMF design storm event has a nominal Annual Exceedance Probability of 0.0016% (or 1 in 62,500 year ARI). The approaching catchments (i.e. Hunter River and Black Creek) are very large and it is anticipated given the magnitude of the event, enough warning time will be available for future residents to evacuate prior to the peak of the event. Multiple flood gauges are located upstream of the site including at Singleton.

5.3.4 Flood Impacts

Figures C1, C2 and C3 of Appendix A presents the flood impacts during a Regional Catchment 1% AEP, 1 in 200 AEP and PMF design storm events.

The results presented in Figures C1 to C3 suggest the changes in flood depth are only expected around the proposed development and does not continue into adjacent public or private property. As such, the proposed development is not expected to create a significant adverse flood impact.

The negligible change in flood levels external to the site is expected to be due to the vast quantity of available flood storage within the broader regional Black Creek and Hunter River catchments and the negligible relative loss of flood storage created by the proposed development.

It is noted that stormwater detention is expected to mitigate increased flows created during a Local Catchment flood event. Pre to post peak flow rates and detention performance is presented in Section 5.1 above.

6 Discussion

6.1 Climate Change Sensitivity Test

A sensitivity test has been performed using the regional catchment results to review the potential impact of Climate Change on the proposed development. For the purposes of the investigation, the 1 in 200 AEP has been used as a proxy for climate change. Use of the 1 in 200 AEP is consistent with the assessment performed by the Draft Singleton FRMS&P (BMT, 2022).

The results of the sensitivity test are presented in Figure D1 of Appendix A. The results suggest an increase in the order of 1.9m is expected within Black Creek due to climate change. Review of Figure B14 of Appendix A suggests only a small number of lots are expected to become prone to flooding under a potential future climate. These areas are highlighted in the below Figure 15.

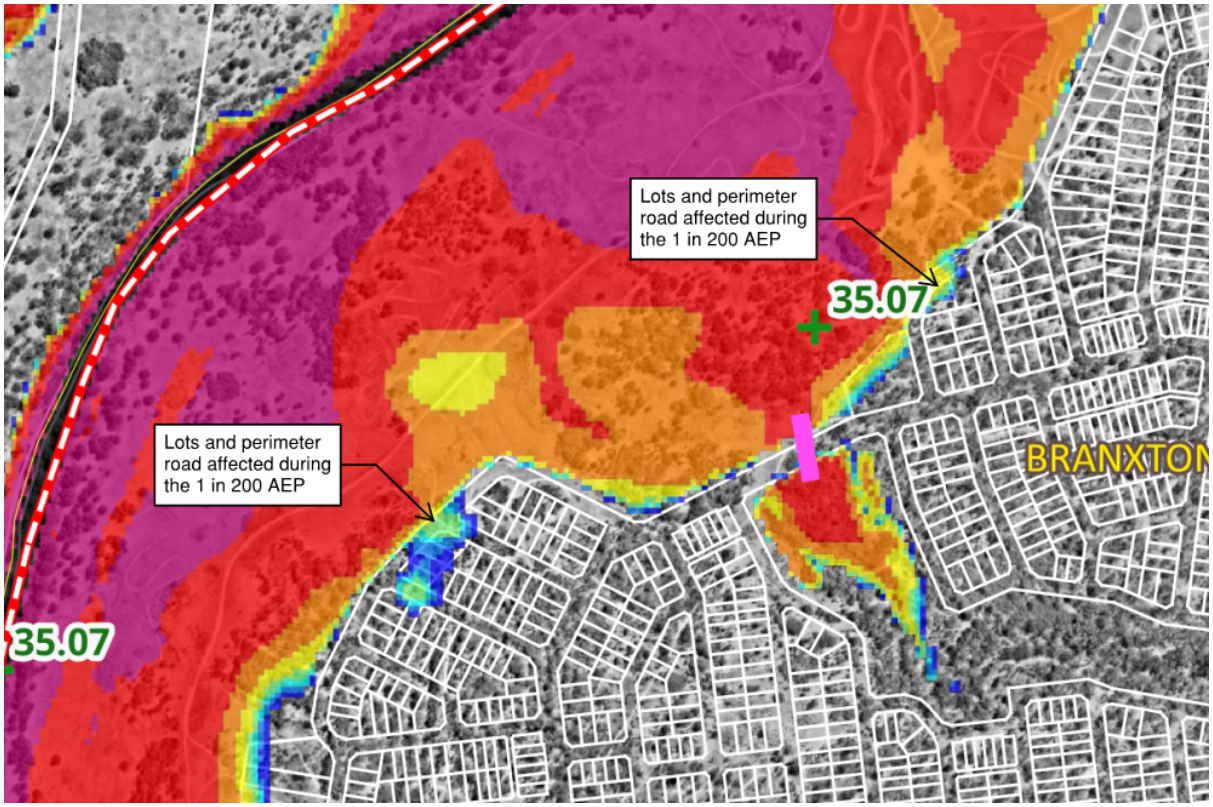


Figure 15 - Lots affected by flooding under potential future climate conditions.

Figures B15 and B16 of Appendix A suggests these lots are expected to be exposed to Flood Fringe and low hazard flood conditions during a 1 in 200 AEP. Similarly, rising road evacuation is expected to be available from these lots during future climate conditions. As such, the increased risk to life and property in these areas is expected to remain low, during the future climate scenario.

It is important to note that the perimeter roads have already been raised well above the required Flood Planning Level presented by the Draft Singleton FRMS&P (BMT, 2022) (i.e. the 1% AEP + 500mm). Minimum levels around the perimeter roads adjacent to Black Creek are in the order of 34.2m AHD. This is approximately 1m above the adjacent 1% AEP flood levels in Black Creek.

Similar to the above, a review of Figure B7 of Appendix A suggests that all lots remain outside the extent of flooding during the local catchment 1 in 500 AEP design storm event. This suggests the road and lot design is not sensitive to potential future climate conditions.

6.2 Blockage Sensitivity Test

Noting an unblocked scenario has been used for the purposes of detention design, a sensitivity test has been performed to review the impact increased blockage may have at each detention basin during the 1% AEP design storm event. The blockage factors presented below have been applied at each of the proposed detention basins:

- Low Flow Pipes – 50% Blockage; and
- High Flow Pipes – 15% Blockage.

As mentioned above, these blockage factors are based on the latest ARR 2019 guidelines and are generally consistent with previous blockage assumptions used throughout the remainder of Huntlee Stage 1.

The blocked results compared to the unblocked scenario to review the potential impact blockage may have at each basin. Figure D2 of Appendix A shows Tributary 3, Basin 2 is expected to have the greatest sensitivity to blockage with increases up to 1-2 meters observed. Similarly, increases of up to approximately 500mm are expected in Tributary 5, Basin 1 while up to 250mm is expected in the proposed basins in Tributary 4. All offline detention basins are expected to have less than 100mm increase in water levels due to blockage. This is expected to be due to the high flow weirs rather than culverts / pipes.

It is anticipated that a debris screen (or approved equivalent) will be introduced at basin outlets to limit the potential for debris blockage.

As discussed previously, it is anticipated the design of each detention basin will be reviewed in greater detail during future phases of the development are rolled out.

6.3 Flood Planning Area

The Flood Planning Area for the subject site is presented in Figure D3 of Appendix A. The Flood Planning Area has been based on the definition presented in the Draft Singleton FRMS&P (BMT, 2022) namely, the 1% AEP + 500mm freeboard.

The extent presented in Figure D3 of Appendix A has been prepared using the maximum 1% AEP levels for both the Regional and Local catchment events presented herein.

The results presented in Figure D3 show the majority of lots are located outside the extent of the Flood Planning Area with the exception of the proposed lots that back onto Black Creek along the western side of the site. These lots are still expected to have sufficient developable space to accommodate a building footprint outside the extent of the Flood Planning Area. This remains true during future climate conditions with Figure D1 showing land outside the extent of the 1 in 500 AEP for each of these lots.

6.4 Evacuation and Warning Time

It is noted that all proposed lots have been sited with a developable area above the 1% AEP design storm event as shown in Figures B4 and B13 of Appendix A. As such, evacuation during the peak of the 1% AEP should not be required (during both local and regional flooding mechanisms). Similarly, the proposed roads and trafficable culvert crossings are sited above the 1% AEP, enabling residents to move around the site as required during both a major regional and local flood event.

During the worst case regional PMF event, the lowest reaches of the developable portions of the subject site are expected to be affected by up to approximately 5.5 meters of flood water. The Draft

Singleton FRMS&P suggests there is a relatively slow rate of rise within the Hunter River floodplain with a warning time in the order of 27 hours expected prior to the peak of a 1% AEP and following activation of an SES “Minor Flood Event” at Singleton.

During the PMF regional event all lots are expected to have a rising road evacuation path that continues towards Wine Country Drive. This is highlighted by Figure D4 of Appendix A which presents recommended evacuation paths from the lower lying areas to Wine Country Drive. With the availability of rising road evacuation, the site Flood Emergency Response Classification is expected to be defined as an Area with Rising Road Access in accordance with the latest advice presented in the Flood Risk Management Manual (DPE, 2023). A schematic representation of this classification is presented in the below Figure 16.

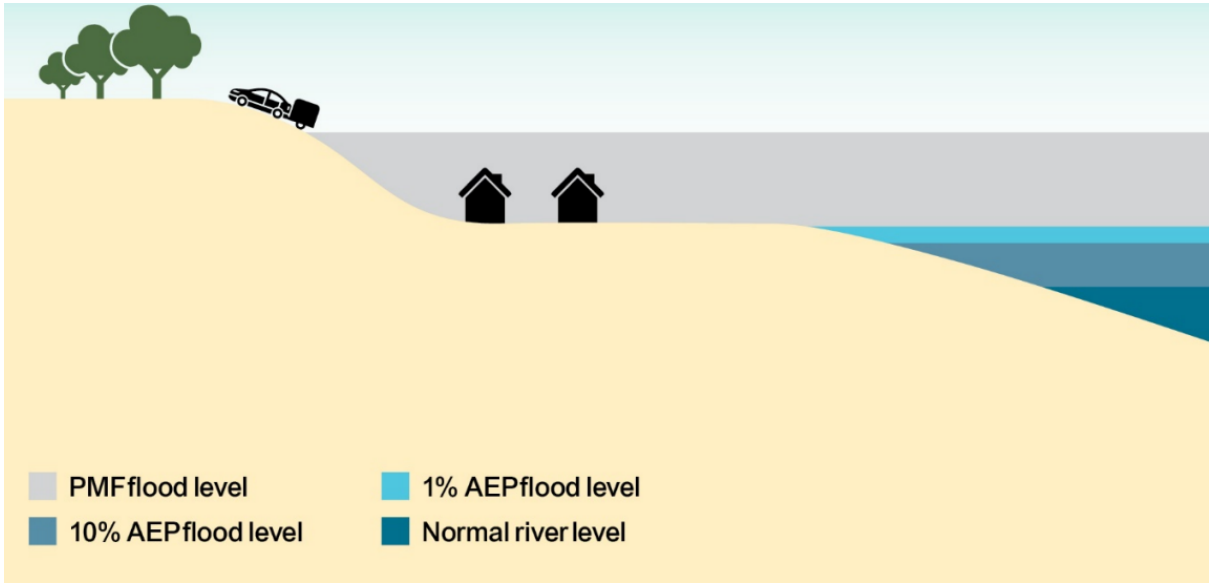


Figure 16 - Areas with Rising Road Access (FRMM EM01; DPE, 2023: Figure 13)

With approximately 27 hours’ notice expected prior to the peak of a flood event, it is anticipated enough time will be available for future residents to evacuate prior to the peak of the event. Self-motivated evaluation is also expected to be possible if residents ignore SES warnings. This is due to the relatively slow rate of rise expected at the subject site and the availability for rising road access.

7 Conclusion

A Flood Impact and Risk Assessment has been prepared for the Huntlee New Town Stage 2 development. This report has been prepared to support the Environmental Impact Statement and State Significant Development Application (SSDA) submission for the proposed development.

Presented herein is the existing and proposed flood behaviour for a range of flood events including both the regional and local flooding mechanisms. The results presented herein demonstrate the proposed development is located above the necessary Flood Planning Levels (i.e. the 1% AEP + 500mm) and proposed perimeter roads and lots are generally located outside the extent of the Flood Planning Area.

An assessment of the pre to post development peak flow regimes has been undertaken including the design of a number of detention basins throughout the development. Similarly, pre to post flood impacts during the regional catchment flood event have been analysed. The results suggest the proposed development is not expected to create a significant adverse impact in adjacent properties.

An assessment on evacuation paths has been performed which demonstrates a rising road evacuation path is expected to be available for lots prone to flooding during rare and extreme flood events. Access to Wine Country Drive is expected to be available for these lots with ample warning time prior to the peak of the event expected to be available.

We commend our findings to the Department for their review.

Appendix A – Flood Figures

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
WINE COUNTRY DRIVE
BRANXTON
NORTH ROTHBURY

Legend

- Stage2 Boundary
- Model Extent
- Stormwater Network
- Flood Contours(1m)

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

Figure A1 [B]

Existing Case Local Model 0.5 EY Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
WINE COUNTRY DRIVE
BRANXTON
NORTH ROTHBURY

Legend

- Stage2 Boundary
- Model Extent
- Stormwater Network
- Flood Contours(1m)

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

Figure A2 [B]

Existing Case Local Model 20% AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

Legend

- Stage2 Boundary
- Model Extent
- Stormwater Network
- Flood Contours(1m)

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

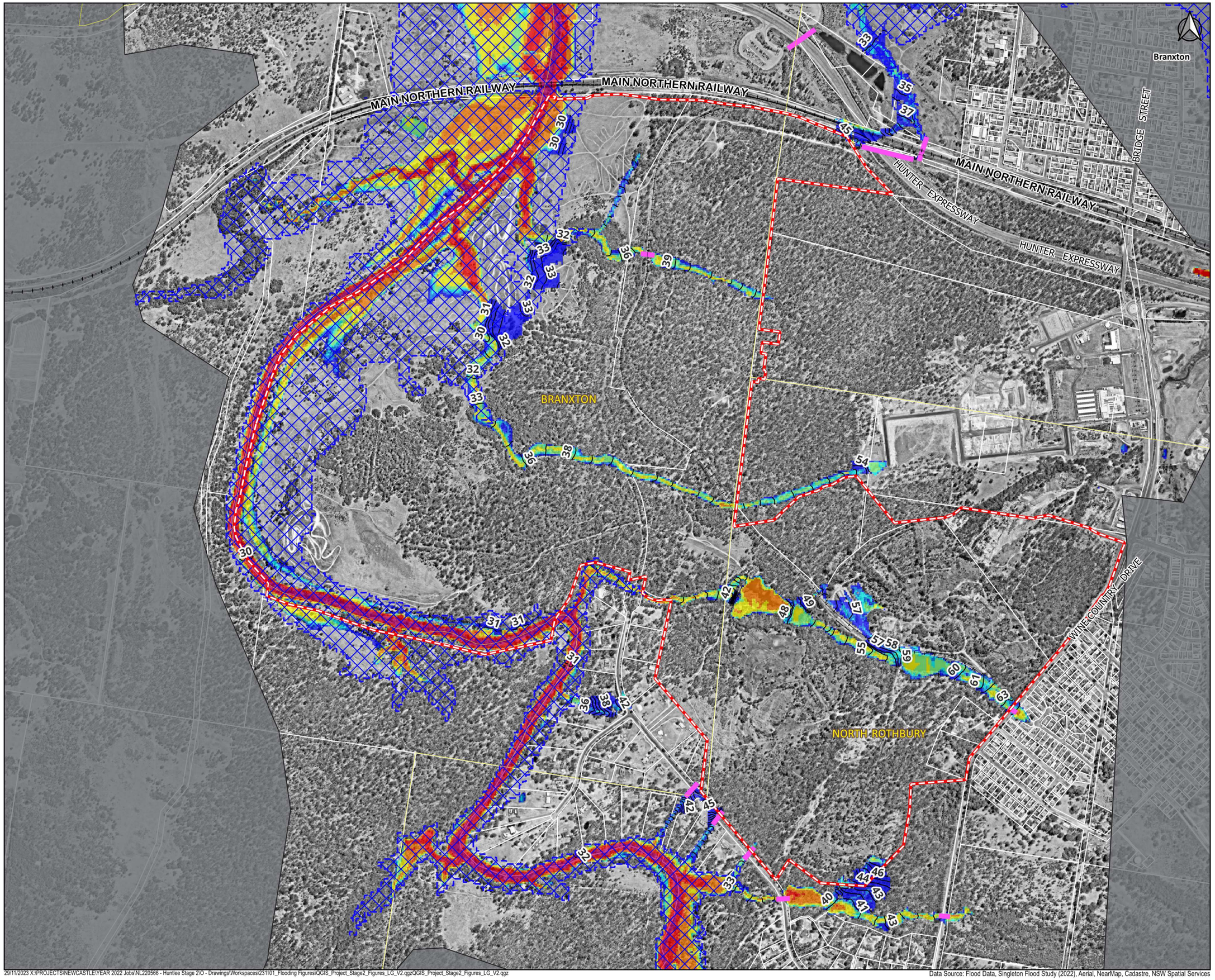
Figure A3 [B]

Existing Case Local Model 10% AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- 1% AEP Regional Flood Extent
- Stormwater Network
- Flood Contours(1m)

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

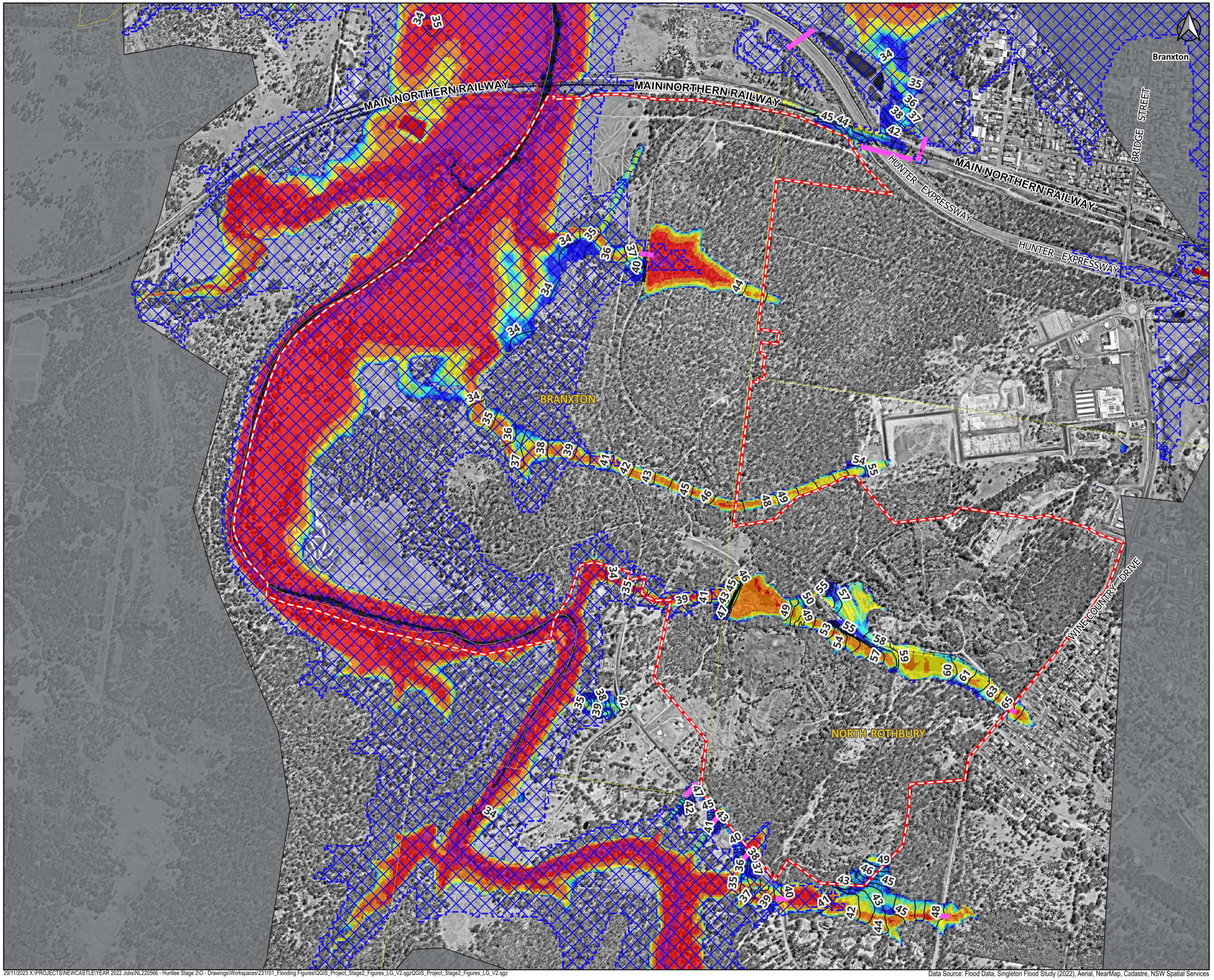
Figure A4 [B]

Existing Case Local Model 1% AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- PMF Regional Flood Extent
- Stormwater Network
- Flood Contours(1m)

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

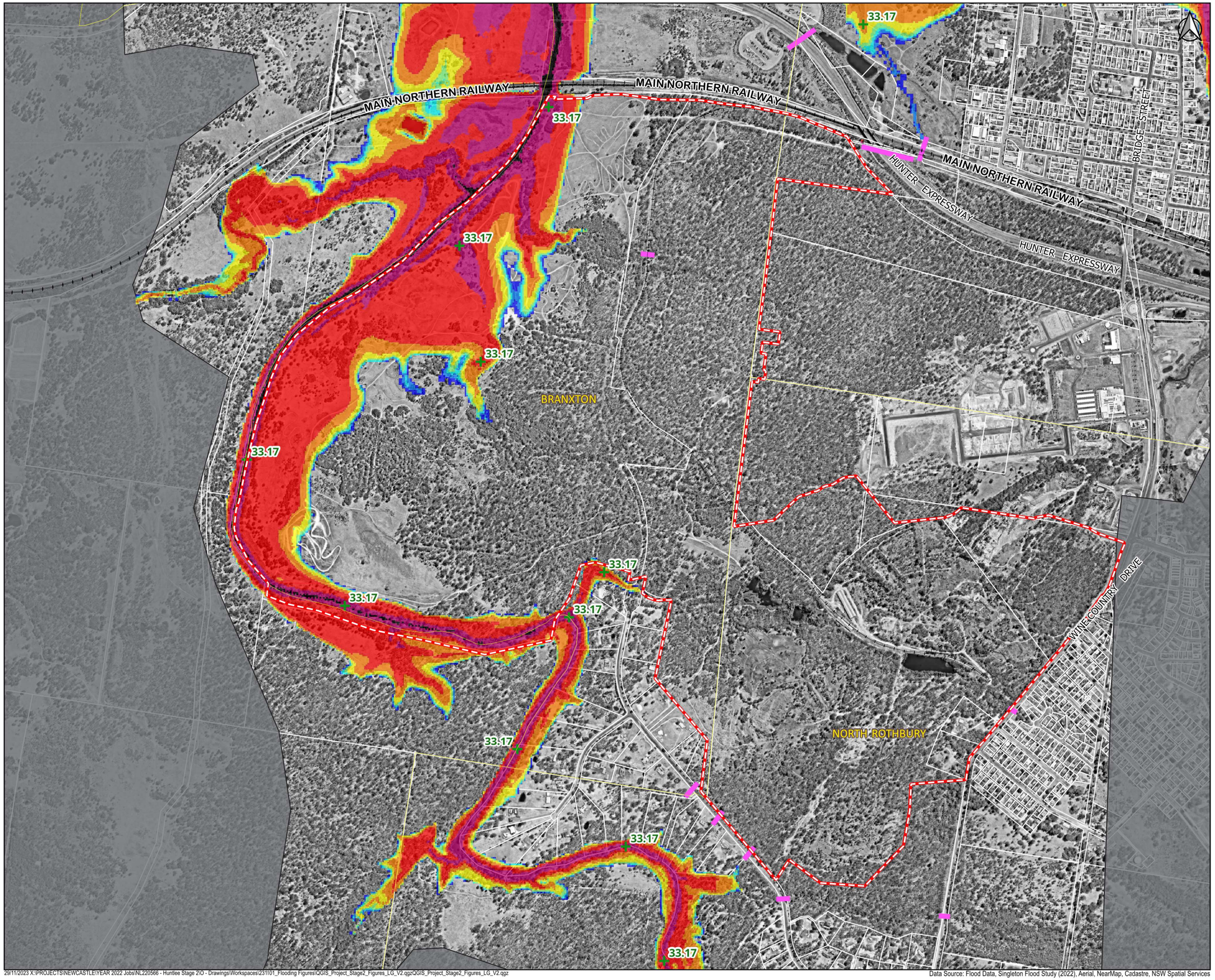
Figure A5 [B]

Existing Case Local Model PMF Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Flood Elevation

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

Figure A6 [B]

Existing Case Regional Model
1% AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
WINE COUNTRY DRIVE
BRANXTON
NORTH ROTHBURY
35.07
35.07
35.07
35.07
35.07
35.07
35.07
35.07
35.07

Legend

- Stage2 Boundary
- Model Extent
- Flood Elevation

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

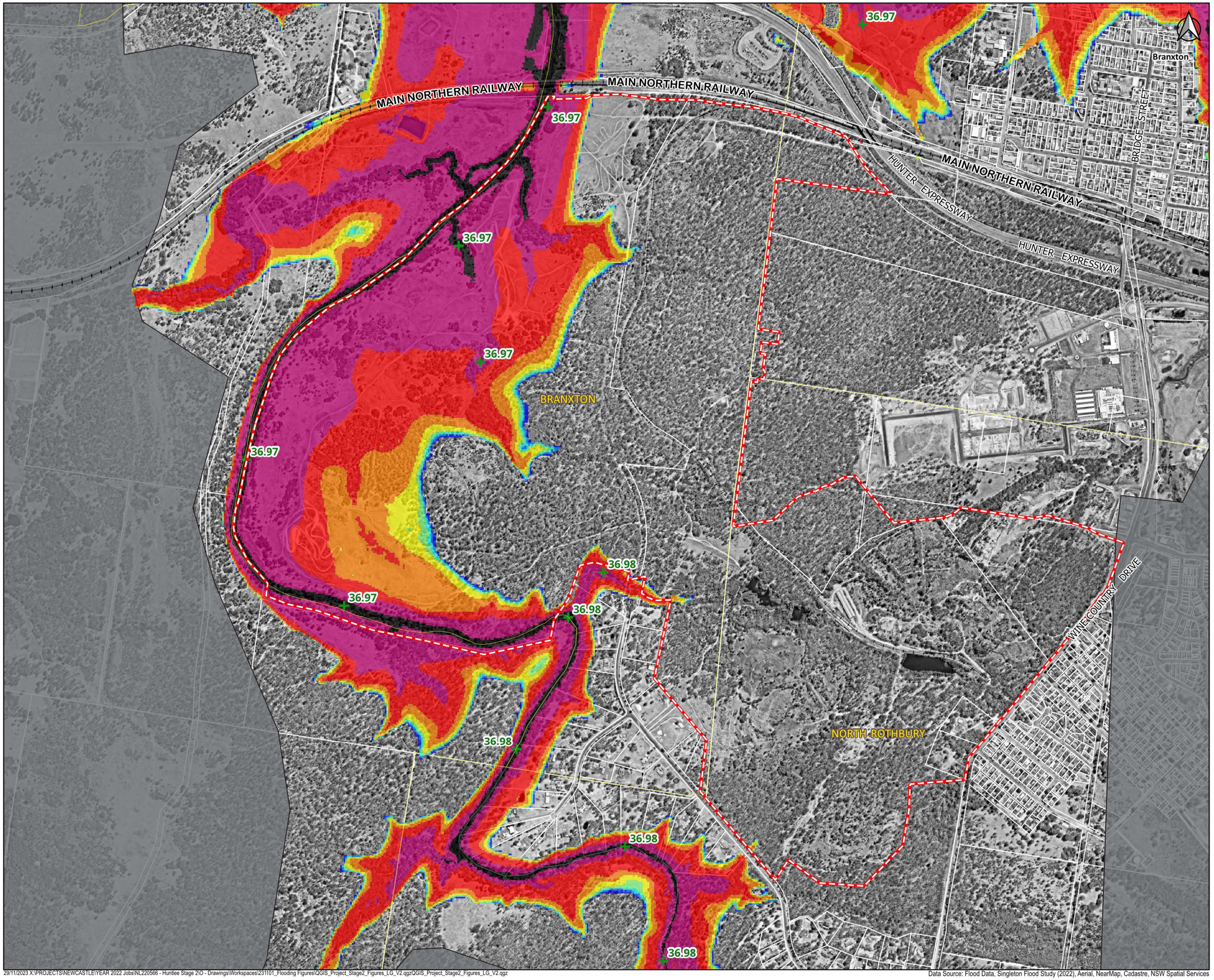
Figure A7 [B]

Existing Case Regional Model
1in200 AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Flood Elevation

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

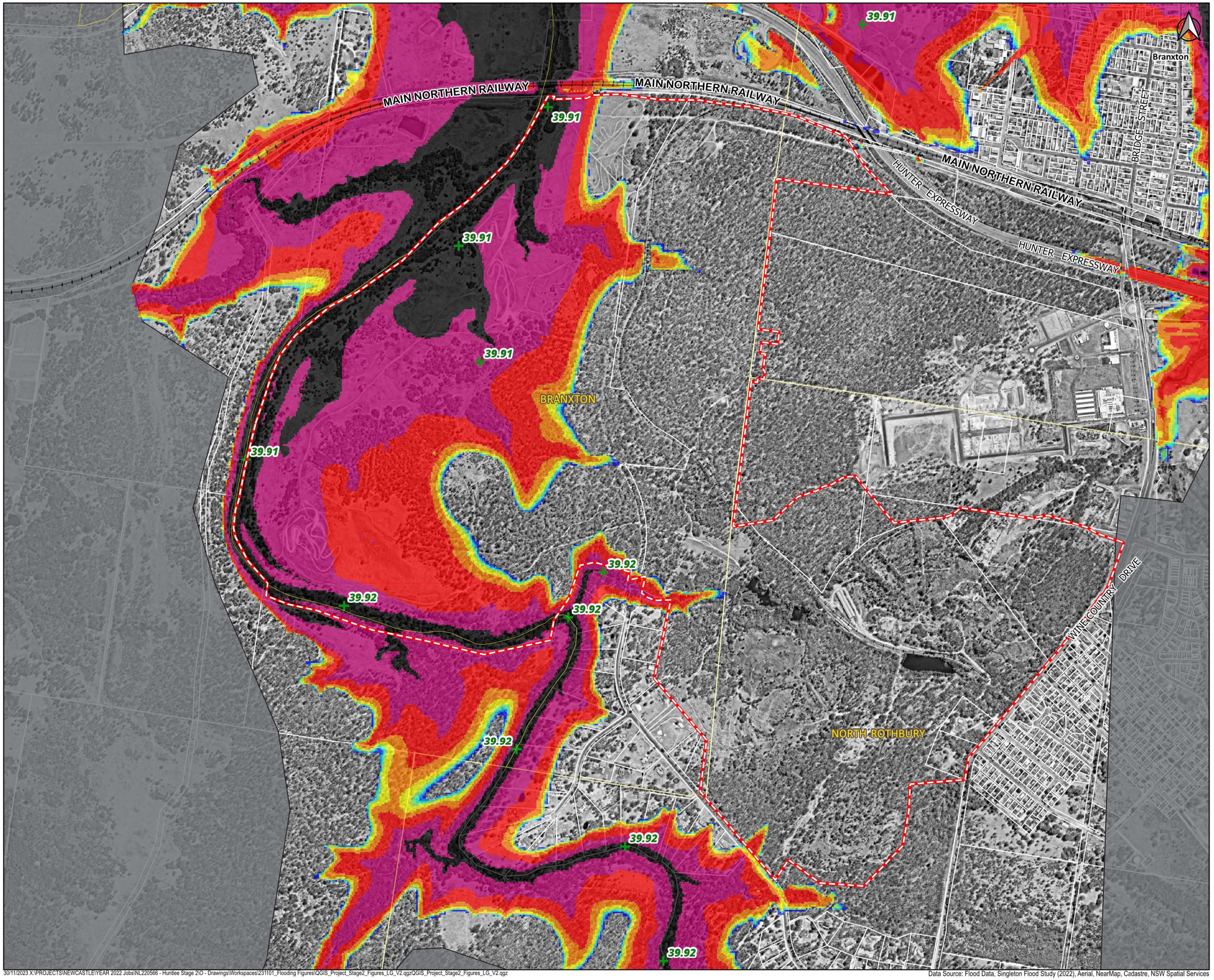
Figure A8 [B]

Existing Case Regional Model
1in500 AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Flood Elevation

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

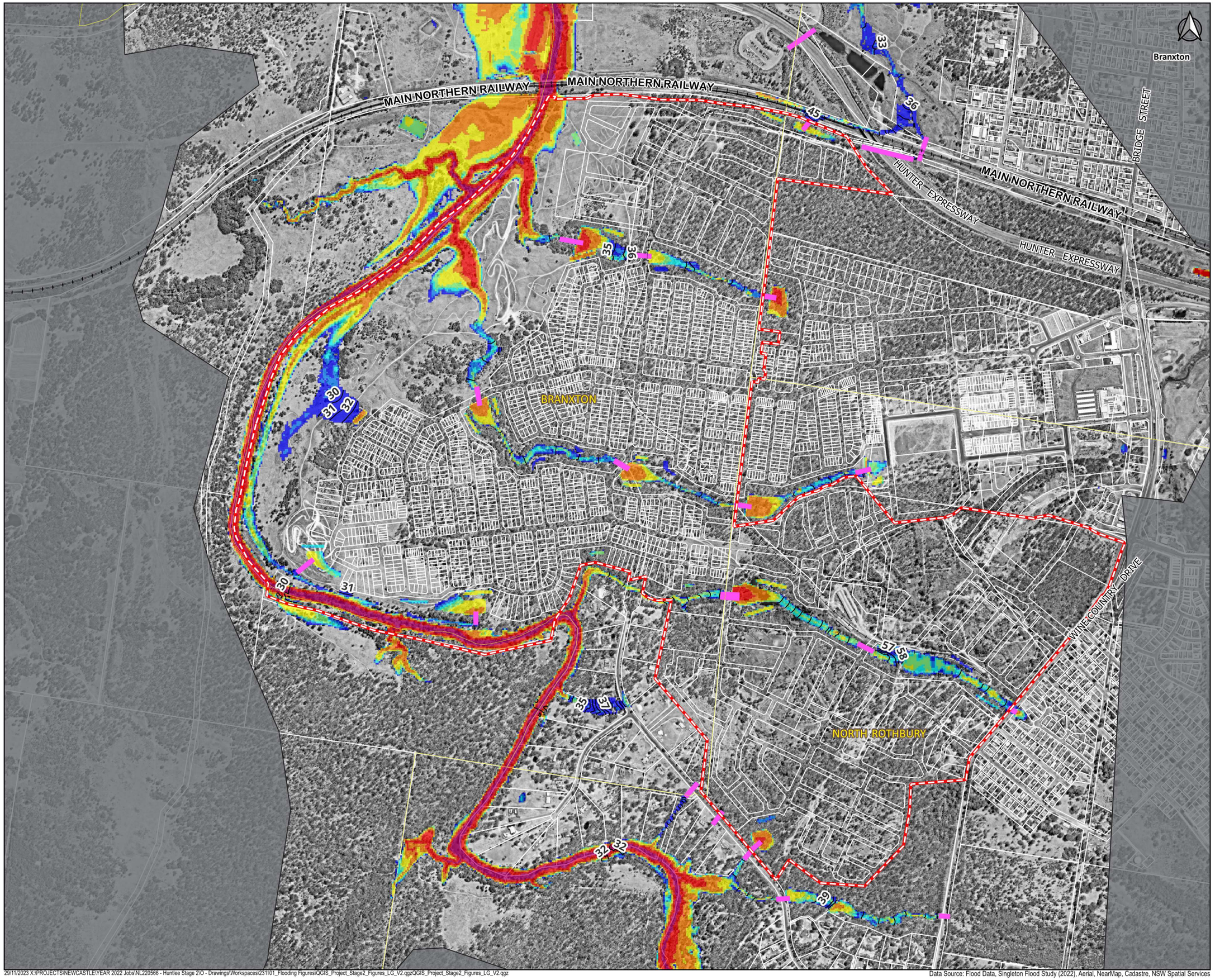
Figure A9 [B]

Existing Case Regional Model
PMF Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout
- Stormwater Network
- Flood Contours(1m)

Depth(m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

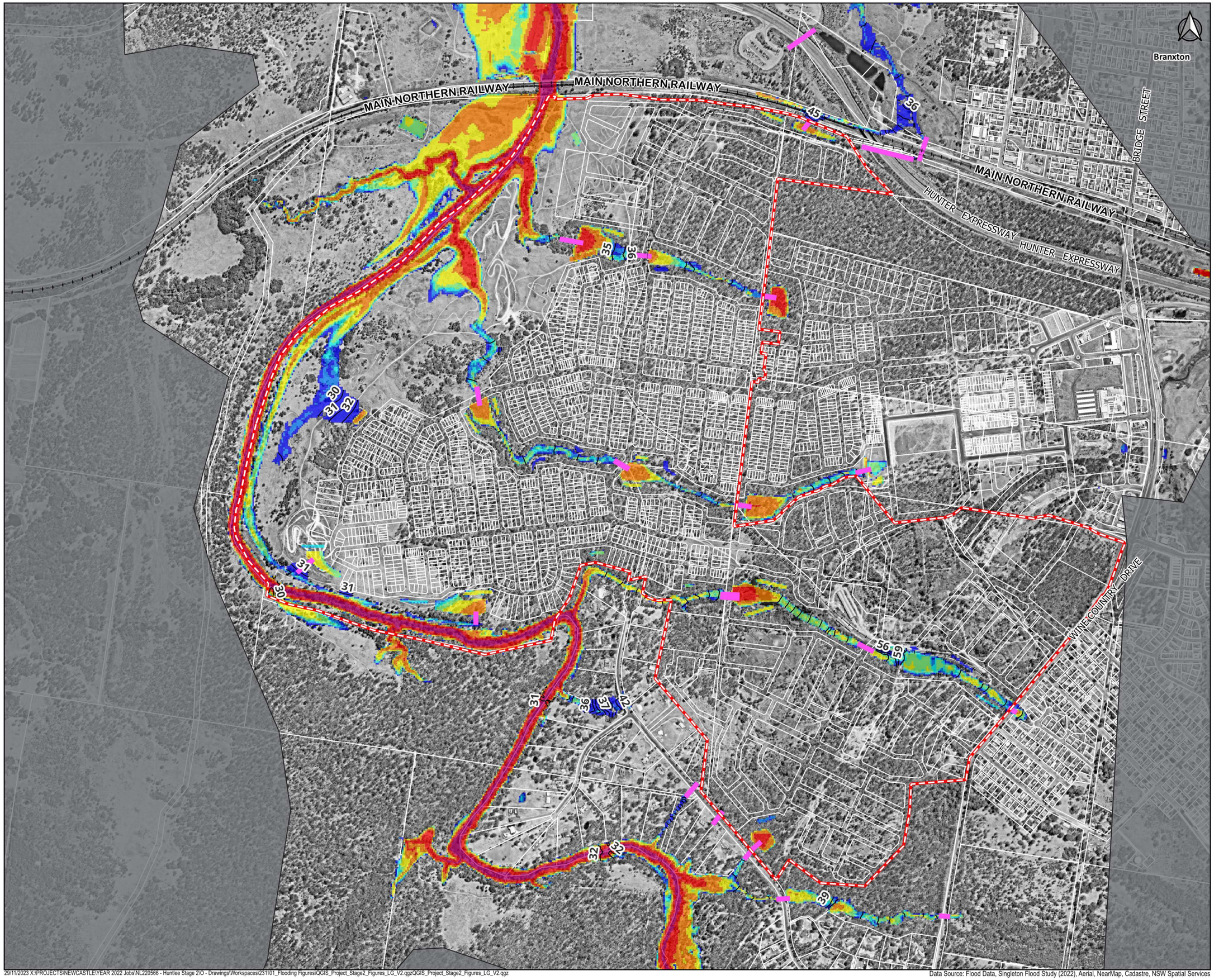
Figure B1 [B]

Developed Case Local Model
0.5 EY Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout
- Stormwater Network
- Flood Contours(1m)

Depth(m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

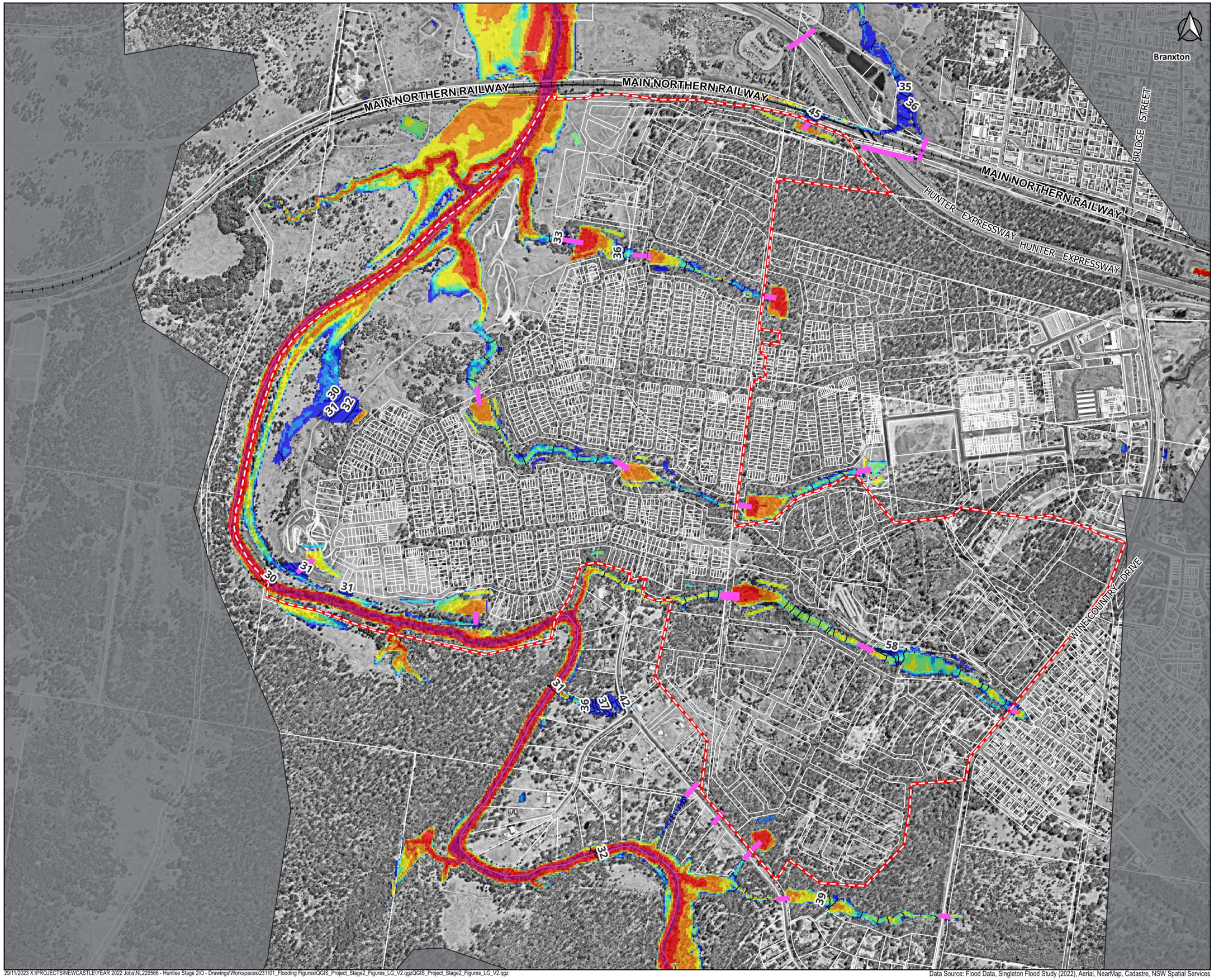
Figure B2 [B]

Developed Case Local Model
20% AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout
- Stormwater Network
- Flood Contours(1m)

Depth(m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

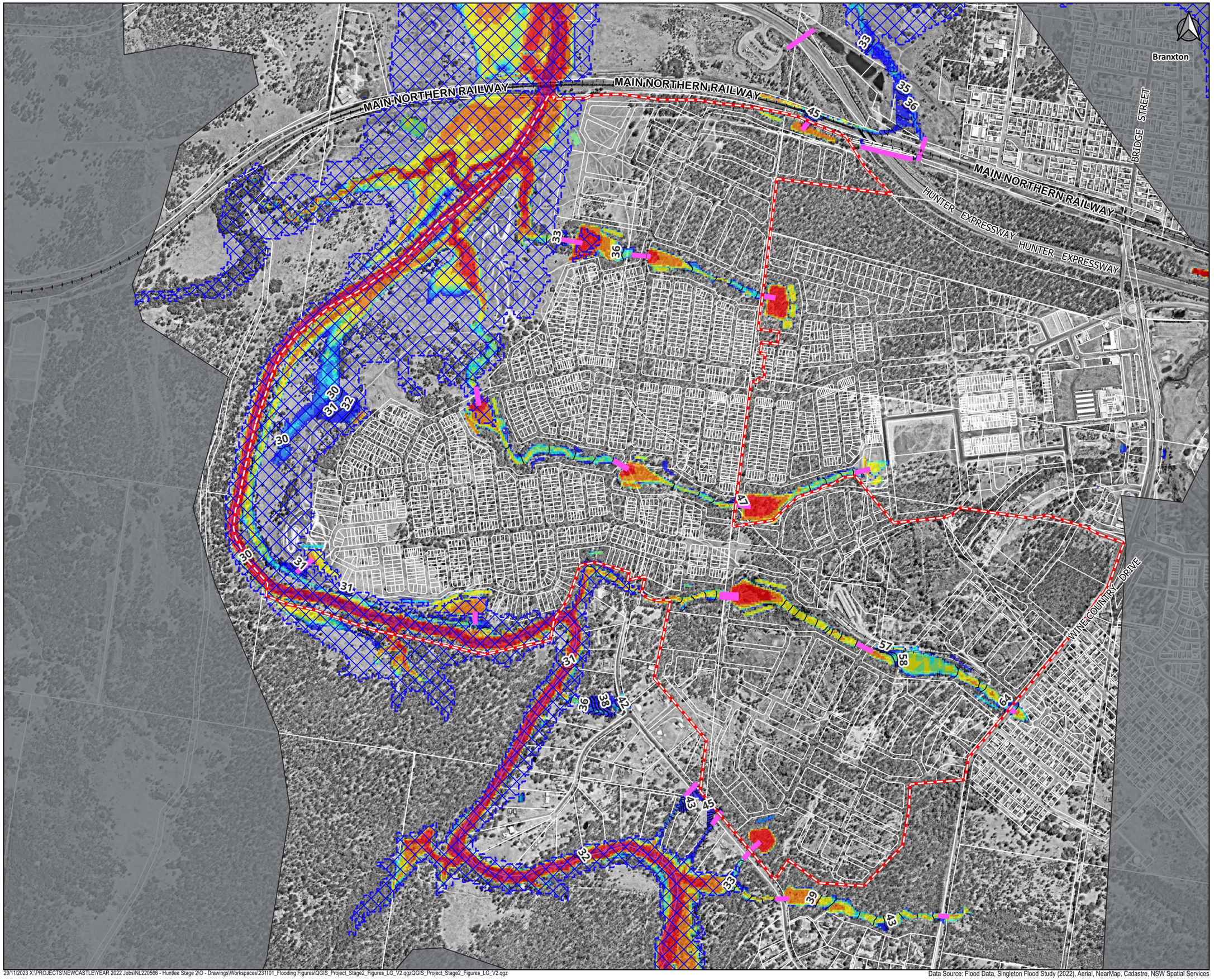
Figure B3 [B]

Developed Case Local Model
10% AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- 1% AEP Regional Flood Extent
- Development Layout
- Stormwater Network
- Flood Contours(1m)

Depth(m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

Figure B4 [B]

Developed Case Local Model
1% AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Model Extent
- 1% AEP Regional Flood Extent
- Development Layout

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 200 400 Metres
1:12,500

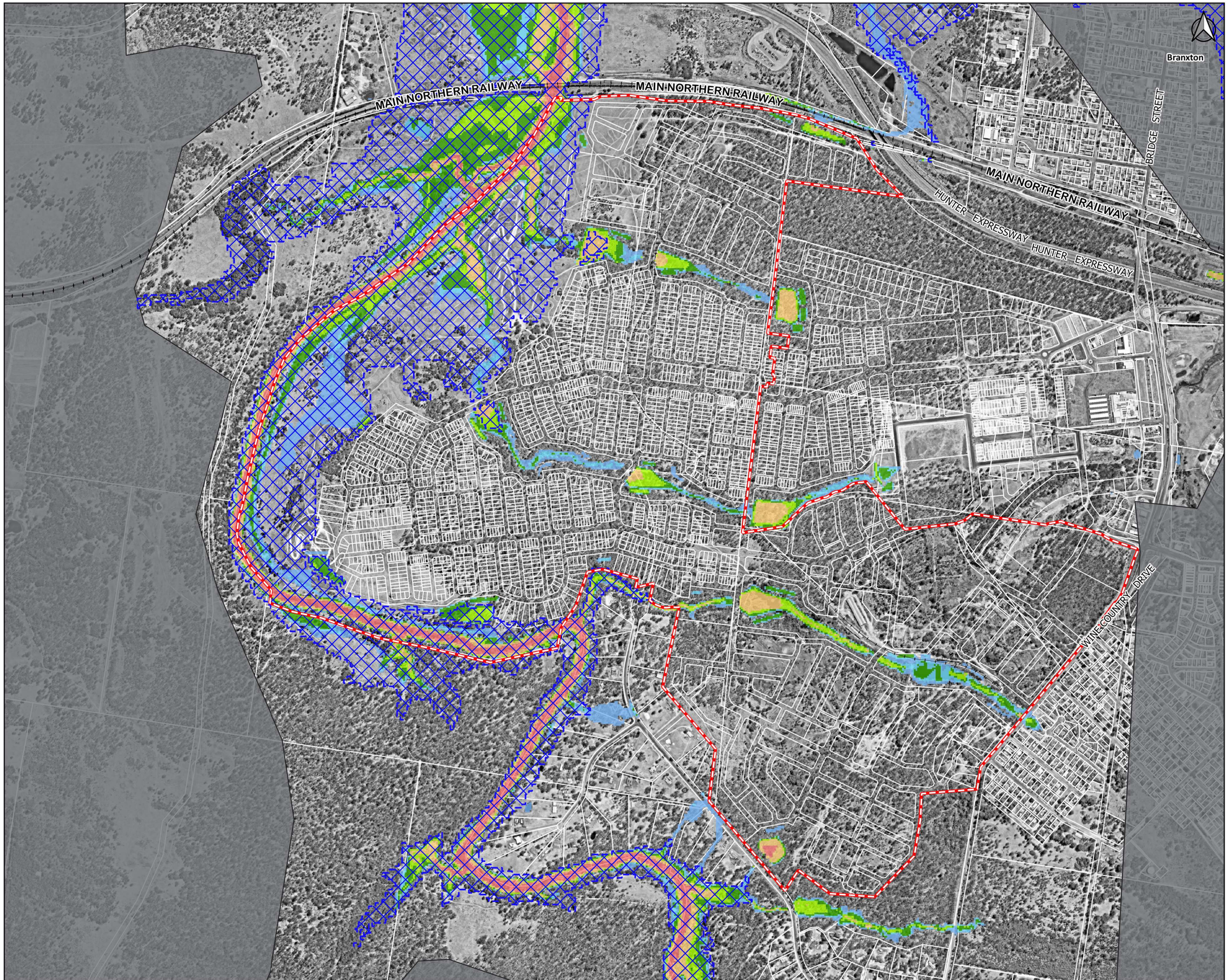
Figure B5 [B]

Developed Case Local Model 1% AEP Hydraulic Categories

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- 1% AEP Regional Flood Extent
- Development Layout

Hazard(ARR2019)

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

0 200 400 Metres

1:12,500

Figure B6 [B]

Developed Case Local Model
1% AEP Flood Hazard

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
BRANXTON
NORTH ROTHBURY
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Model Extent
- 1in500 AEP Regional Flood Extent
- Development Layout
- Stormwater Network
- Flood Contours(1m)

Depth(m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

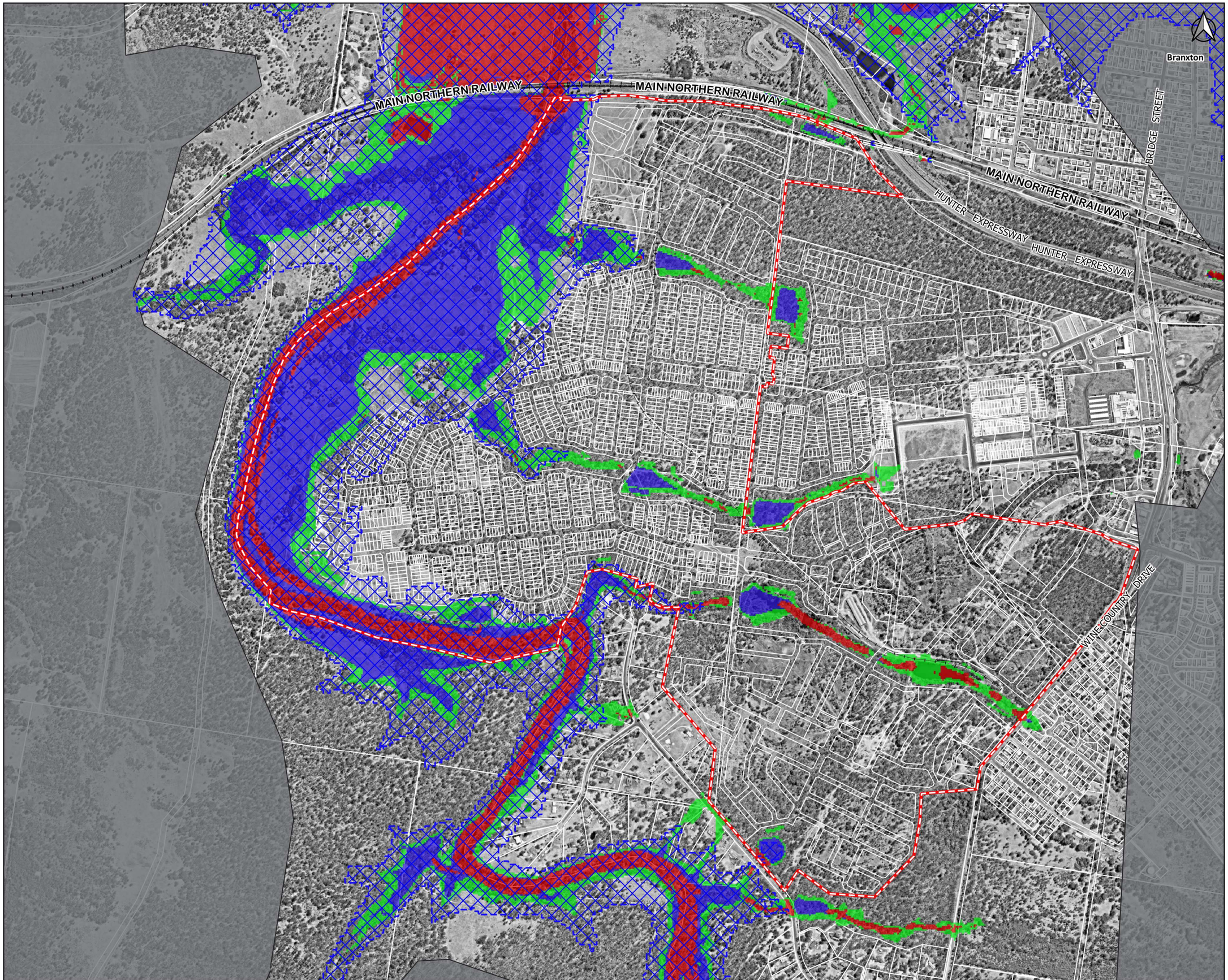
Figure B7 [B]

Developed Case Local Model 1in500 AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- 1in500 AEP Regional Flood Extent
- Development Layout

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 200 400 Metres

1:12,500

Figure B8 [B]

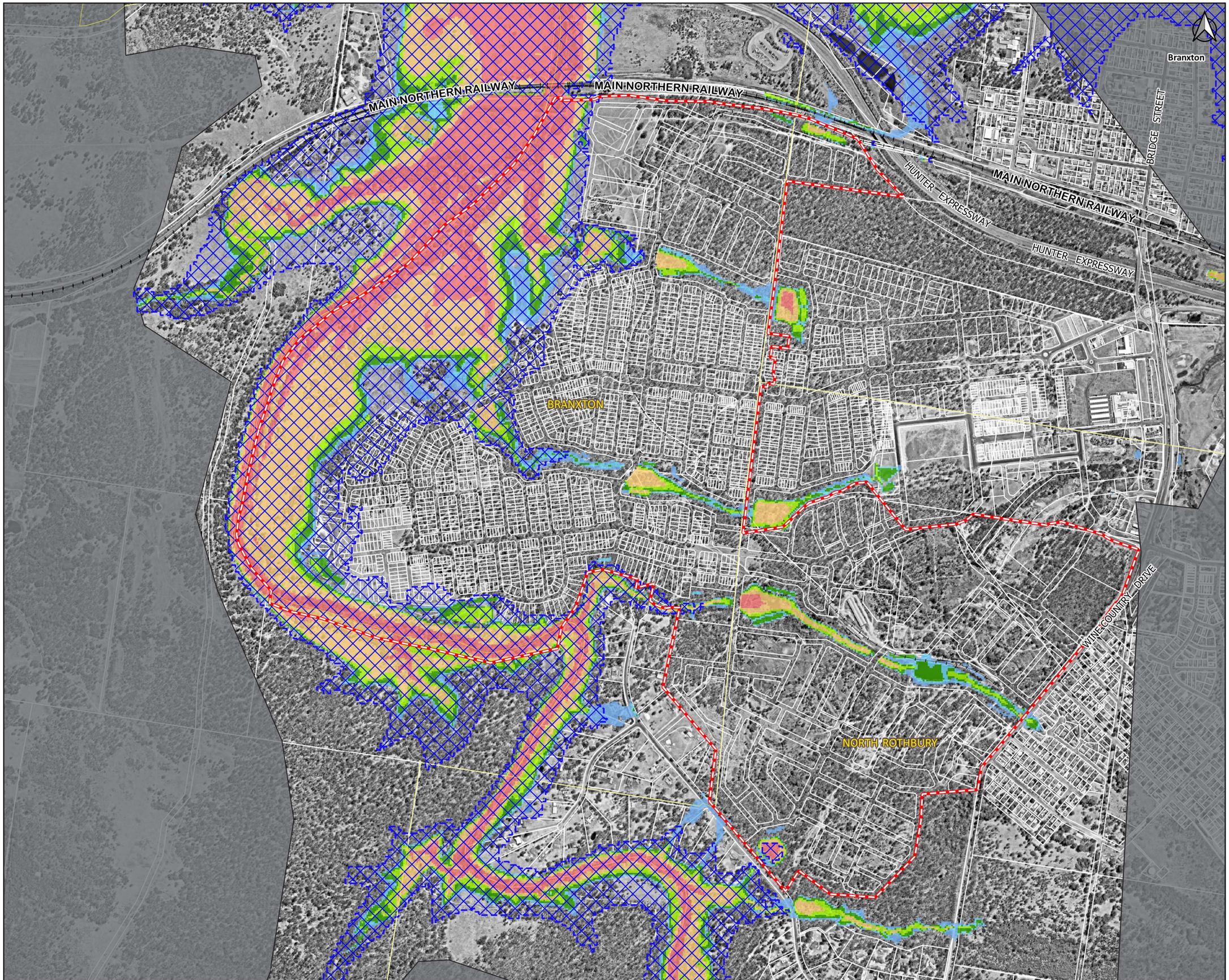
Developed Case Local Model 1in500 AEP Hydraulic Categories

Huntlee Stage 2
(NL220566)

NORTHROP

29/11/2023 X:\PROJECTS\NEWCASTLE\YEAR 2022 Jobs\NL220566 - Huntlee Stage 2\O - Drawings\Workspaces\231101_Flooding Figures\QGIS_Project_Stage2_Figures_LG_V2.qgzQGIS_Project_Stage2_Figures_LG_V2.qgz

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- 1in500 AEP Regional Flood Extent
- Development Layout

Hazard(ARR2019)

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

0 200 400 Metres

1:12,500

Figure B9 [B]

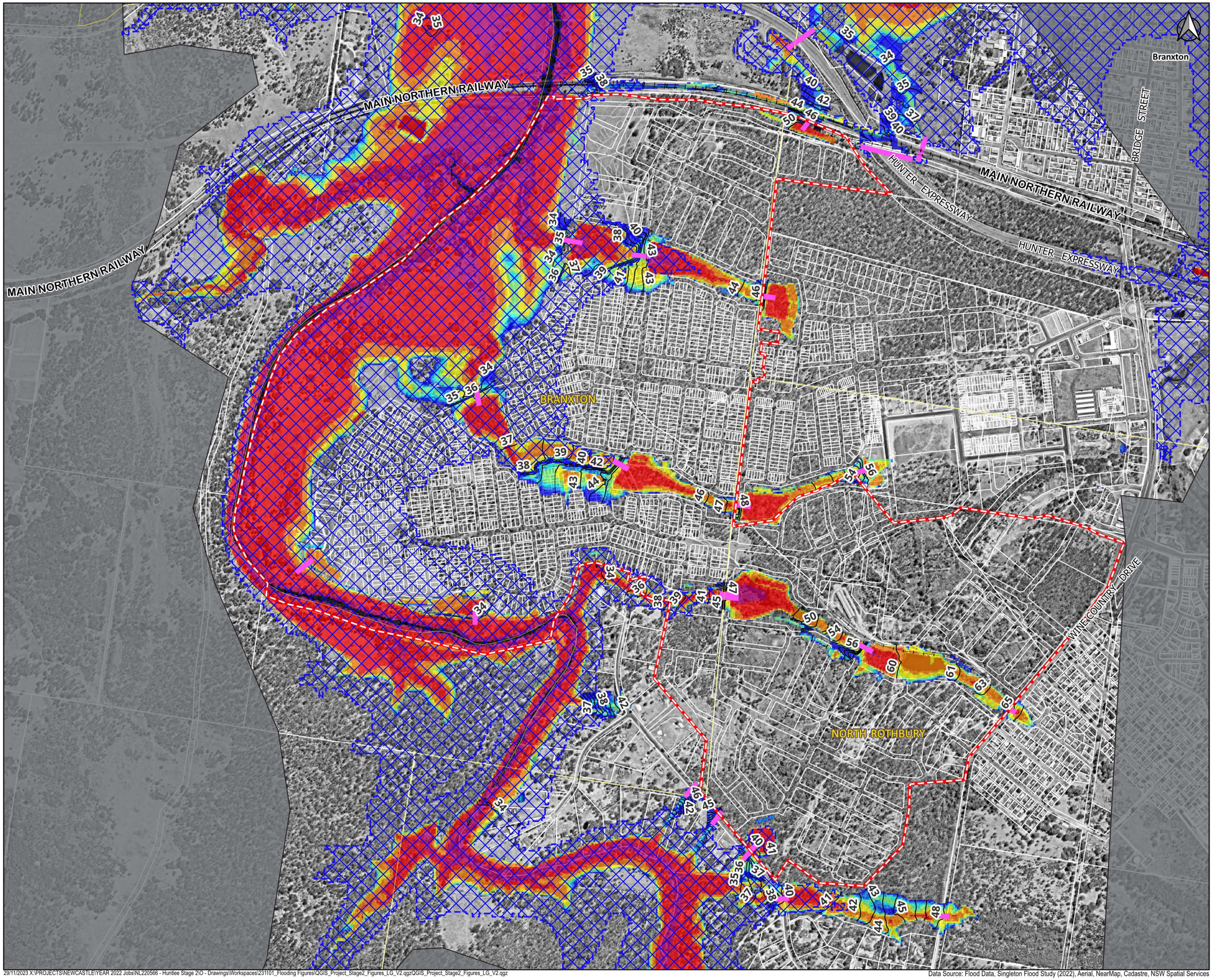
Developed Case Local Model 1in500 AEP Flood Hazard

Huntlee Stage 2
(NL220566)

NORTHROP

29/11/2023 X:\PROJECTS\NEWCASTLE\YEAR 2022 Jobs\NL220566 - Huntlee Stage 2\O - Drawings\Workspaces\231101_Flooding Figures\QGIS_Project_Stage2_Figures_LG_V2.qgzQGIS_Project_Stage2_Figures_LG_V2.qgz

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- PMF Regional Flood Extent
- Development Layout
- Stormwater Network
- Flood Contours(1m)

Depth(m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

Figure B10 [B]

Developed Case Local Model PMF Flood Elevation and Depth

Huntlee Stage 2 (NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
BRANXTON
NORTH ROTHBURY
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Model Extent
- PMF Regional Flood Extent
- Development Layout

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 200 400 Metres

1:12,500

Figure B11 [B]

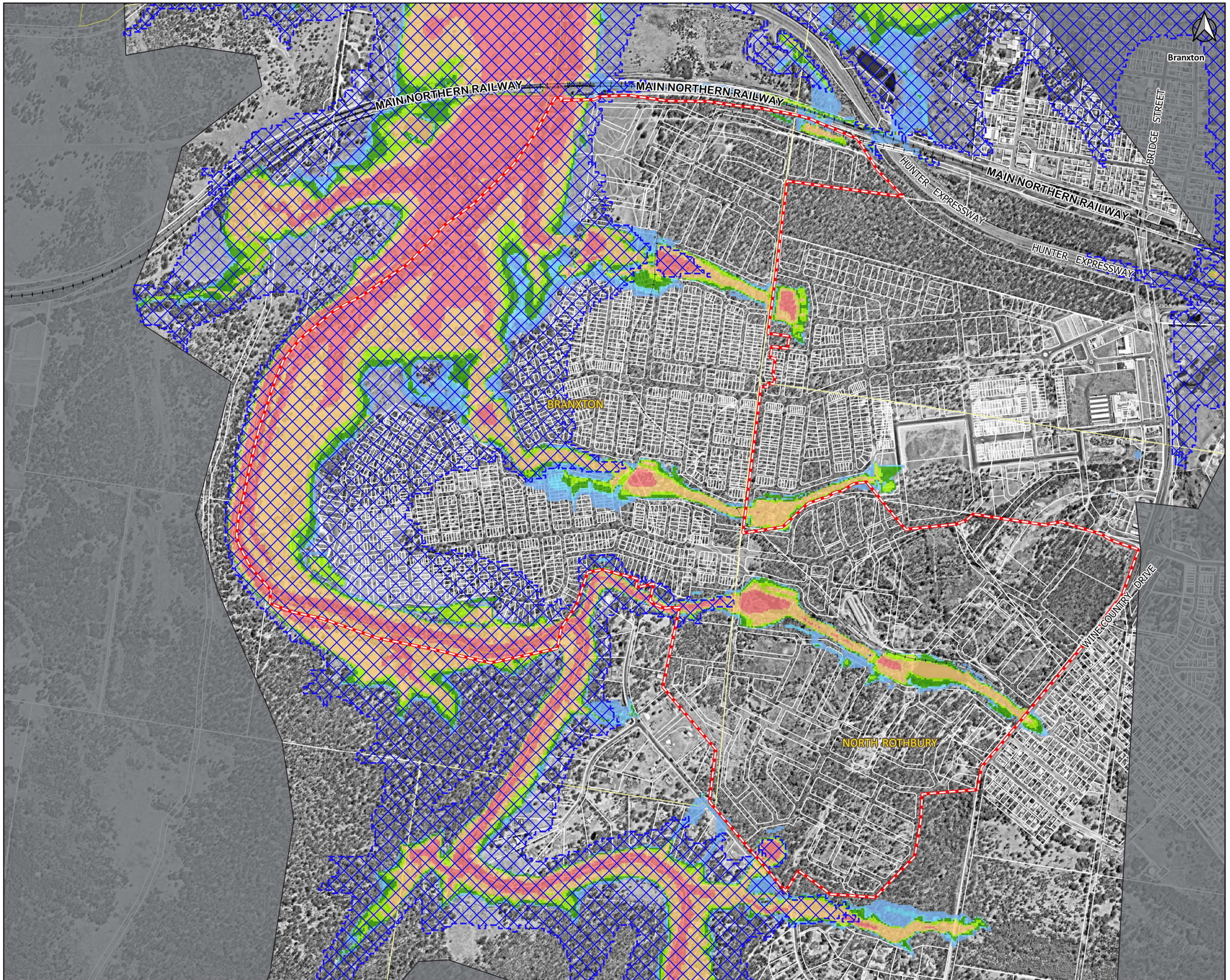
Developed Case Local Model
PMF Hydraulic Categories

Huntlee Stage 2
(NL220566)

NORTHROP

29/11/2023 X:\PROJECTS\NEWCASTLE\YEAR 2022 Jobs\NL220566 - Huntlee Stage 2\O - Drawings\Workspaces\231101_Flooding Figures\QGIS_Project_Stage2_Figures_LG_V2.qgzQGIS_Project_Stage2_Figures_LG_V2.qgz

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- PMF Regional Flood Extent
- Development Layout

Hazard(ARR2019)

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

0 200 400 Metres

1:12,500

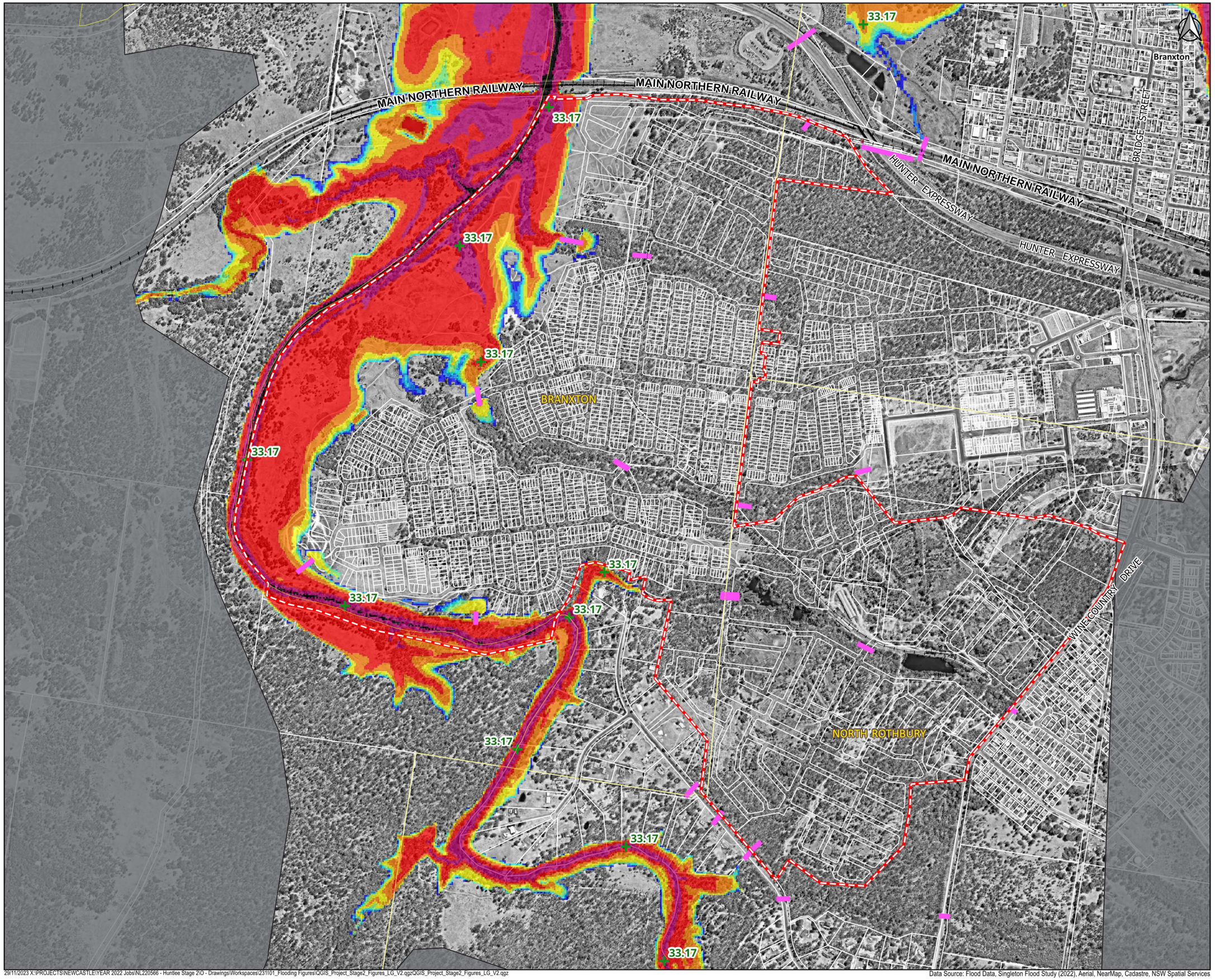
Figure B12 [B]

Developed Case Local Model
PMF Flood Hazard

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout
- Stormwater Network
- Flood Elevation

Depth(m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

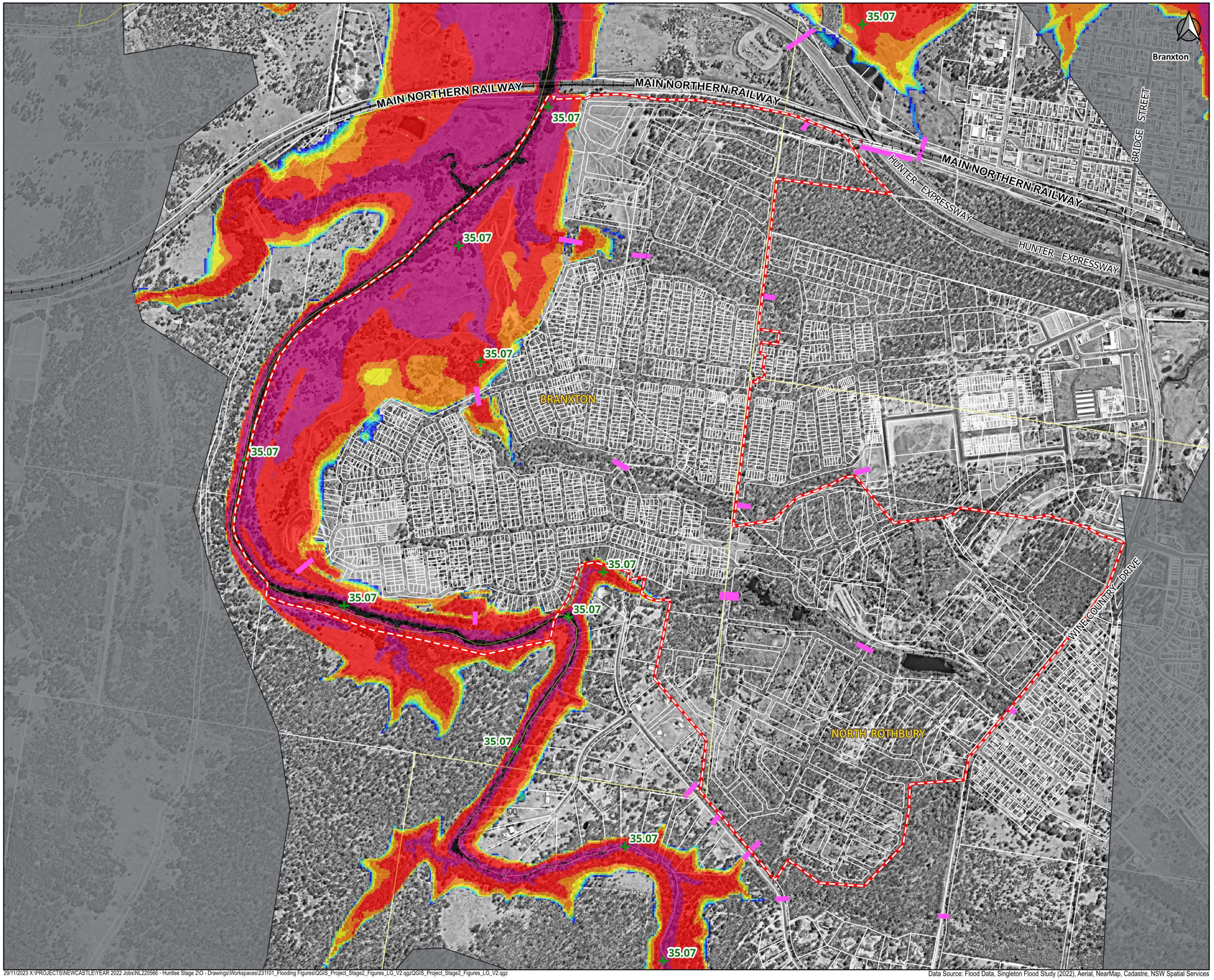
Figure B13 [B]

Developed Case Regional Model
1% AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout
- Stormwater Network
- Flood Elevation

Depth(m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

Figure B14 [B]

Developed Case Regional Model
1in200 AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

29/11/2023 X:\PROJECTS\NEWCASTLE\YEAR 2022 Jobs\NL220566 - Huntlee Stage 2\O - Drawings\Workspaces\231101_Flooding Figures\QGIS_Project_Stage2_Figures_LG_V2.qgzQGIS_Project_Stage2_Figures_LG_V2.qgz

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
BRANXTON
NORTH ROTHBURY
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Model Extent
- Development Layout

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 200 400 Metres

1:12,500

Figure B15 [B]

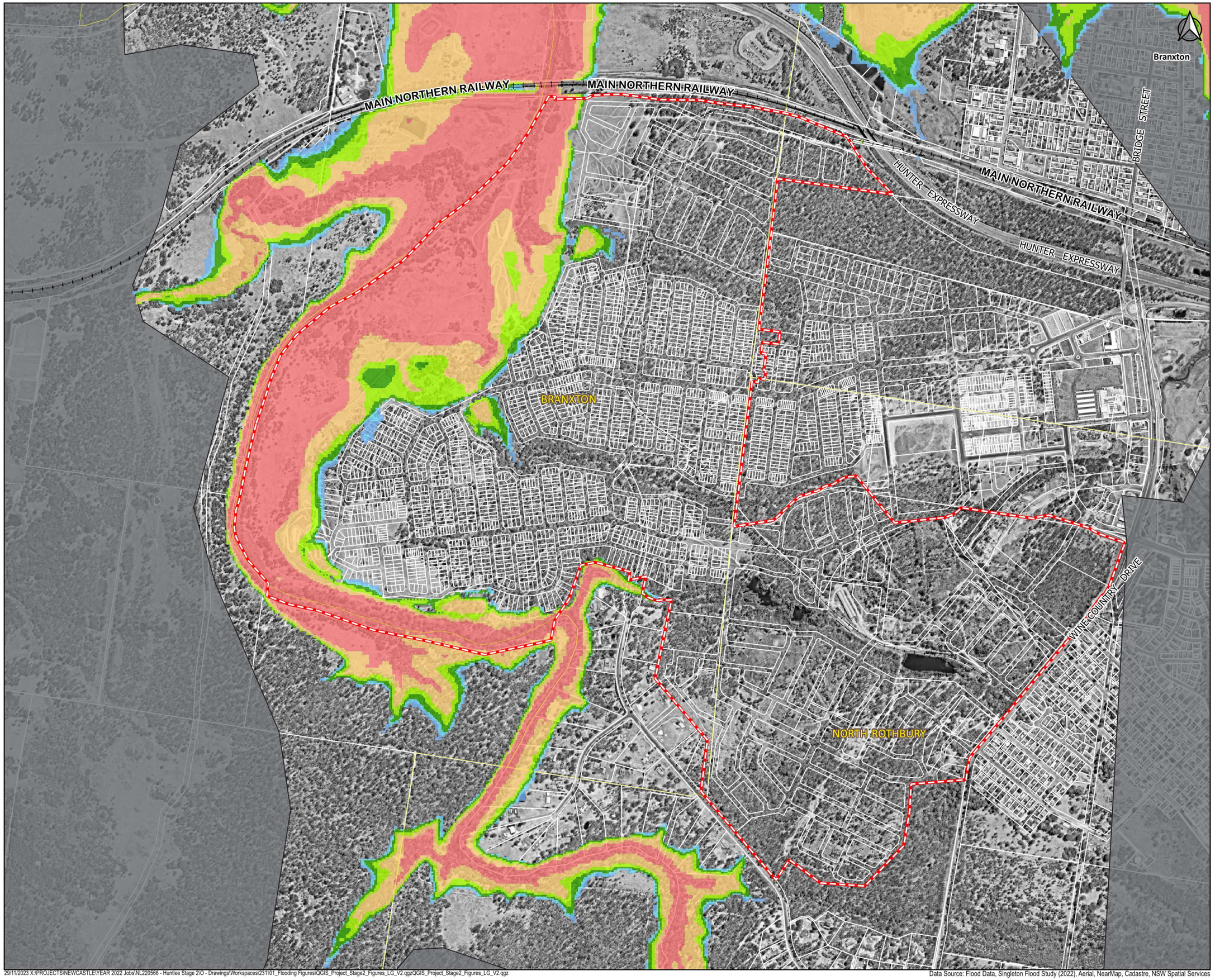
Developed Case Regional Model
1in200 AEP Hydraulic Categories

Huntlee Stage 2
(NL220566)

NORTHROP

29/11/2023 X:\PROJECTS\NEWCASTLE\YEAR 2022 Jobs\NL220566 - Huntlee Stage 2\O - Drawings\Workspaces\231101_Flooding Figures\QGIS_Project_Stage2_Figures_LG_V2.qgzQGIS_Project_Stage2_Figures_LG_V2.qgz

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout

Hazard(ARR2019)

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

0 200 400 Metres

1:12,500

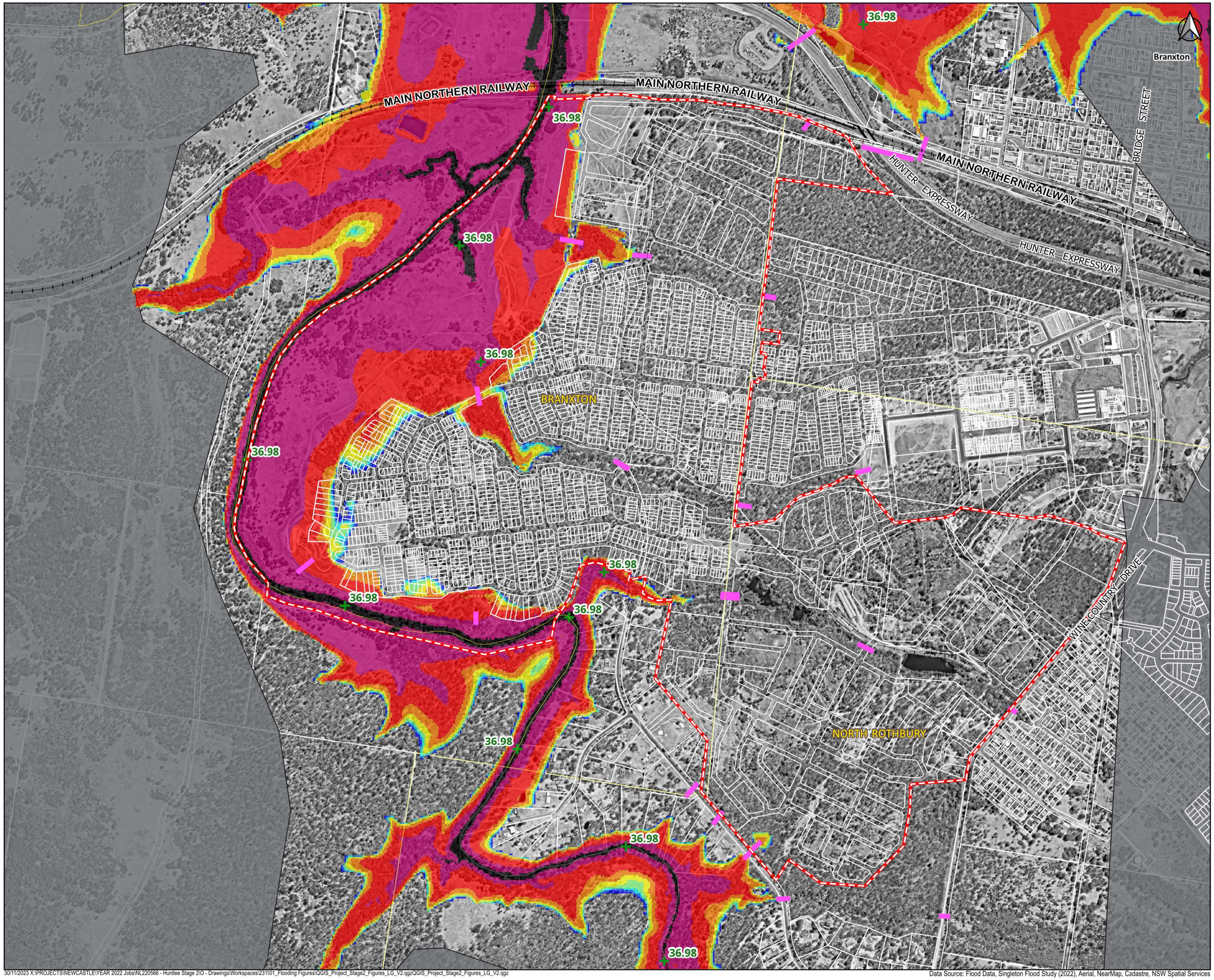
Figure B16 [B]

Developed Case Regional Model
1in200 AEP Flood Hazard

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout
- Flood Elevation

Depth(m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

Figure B17 [B]

Developed Case Regional Model
1in500 AEP Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

30/11/2023 X:\PROJECTS\NEWCASTLE\YEAR 2022 Jobs\NL220566 - Huntlee Stage 2\O - Drawings\Workspaces\231101_Flooding Figures\QGIS_Project_Stage2_Figures_LG_V2.qgzQGIS_Project_Stage2_Figures_LG_V2.qgz

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
BRANXTON
NORTH ROTHBURY
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Model Extent
- Development Layout

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 200 400 Metres

1:12,500

Figure B18 [B]

Developed Case Regional Model
1in500 AEP Hydraulic Categories

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
BRANXTON
NORTH ROTHBURY
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Model Extent
- Development Layout

Hazard(ARR2019)

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

0 200 400 Metres

1:12,500

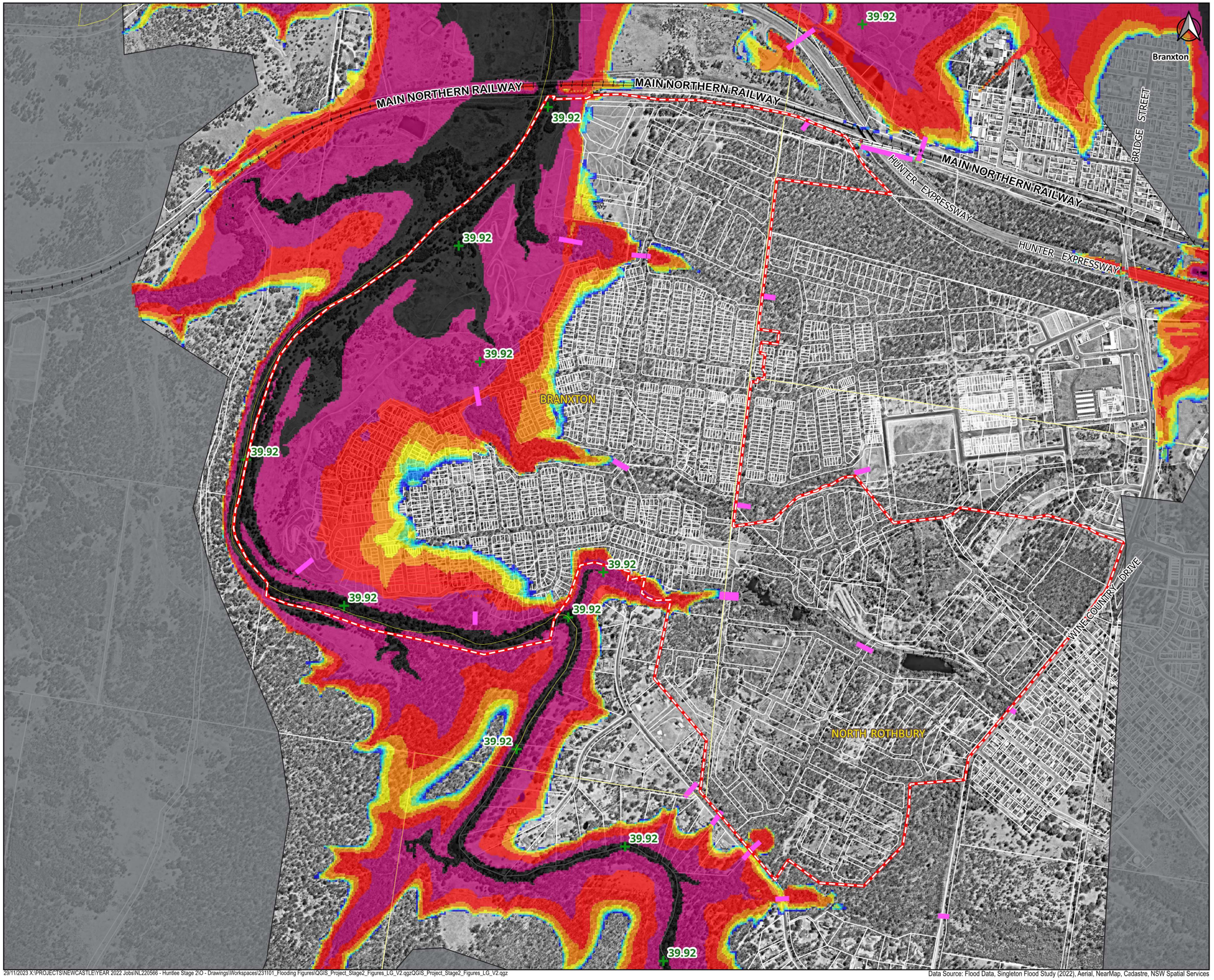
Figure B19 [B]

Developed Case Regional Model
1in500 AEP Flood Hazard

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout
- Stormwater Network
- Flood Elevation

Depth(m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- Greater than 10.0

0 200 400 Metres

1:12,500

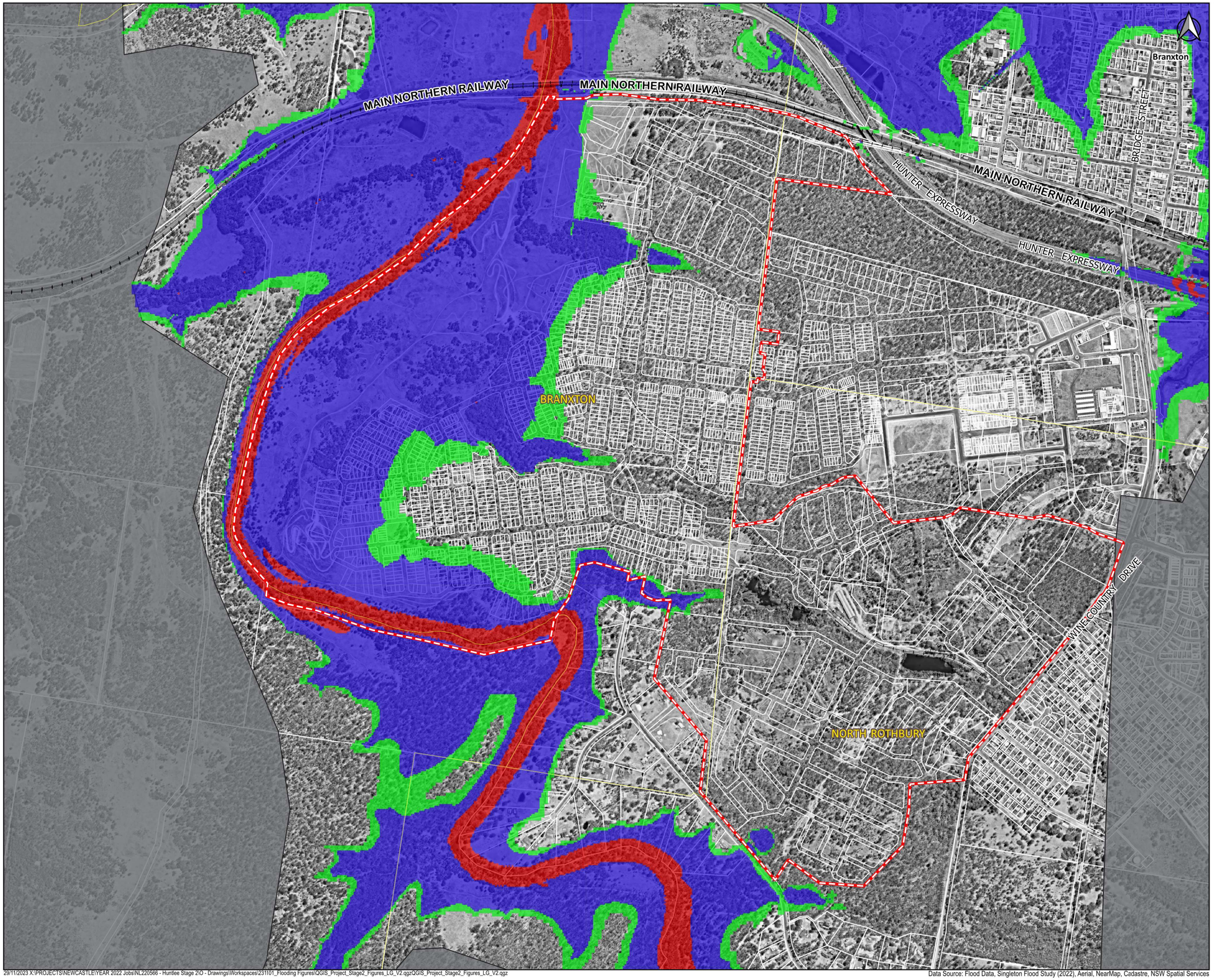
Figure B20 [B]

Developed Case Regional Model
PMF Flood Elevation and Depth

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 200 400 Metres

1:12,500

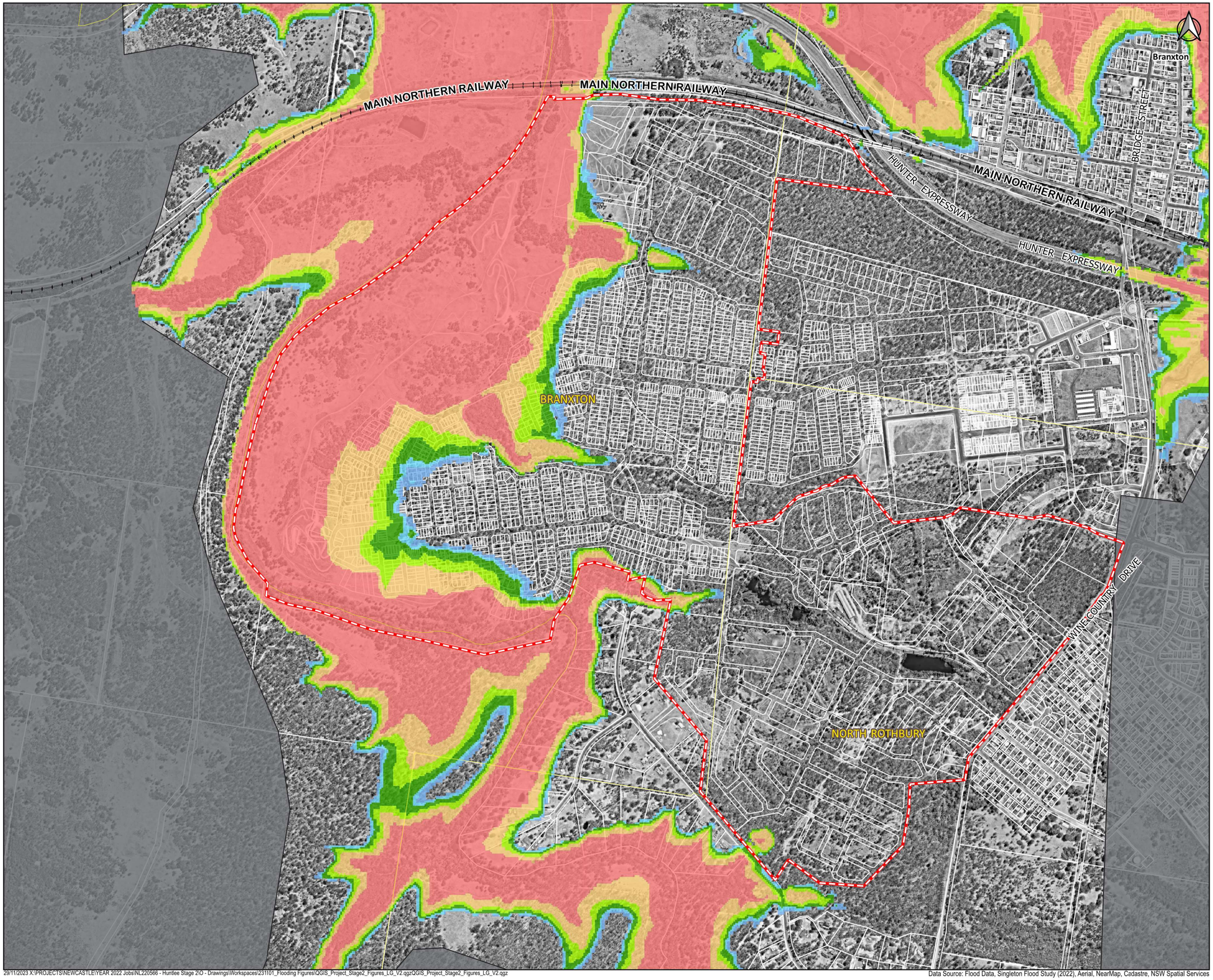
Figure B21 [B]

Developed Case Regional Model
PMF Hydraulic Categories

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout

Hazard(ARR2019)

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

0 200 400 Metres

1:12,500

Figure B22 [B]

Developed Case Regional Model
PMF Flood Hazard

Huntlee Stage 2
(NL220566)

NORTHROP

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Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
BRANXTON
NORTH ROTHBURY
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Development Layout

Depth Difference(m)

- Less than -0.50
- -0.50 - -0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.01
- -0.01 - 0.01
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- Greater than 0.50

0 200 400 Metres

1:12,500

Figure C1 [B]

Regional Model
1% AEP Flood Depth Difference

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
BRANXTON
NORTH ROTHBURY
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Development Layout

Depth Difference(m)

- Less than -0.50
- -0.50 - -0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.01
- -0.01 - 0.01
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- Greater than 0.50

0 200 400 Metres

1:12,500

Figure C2 [B]

Regional Model
1in500 AEP Flood Depth Difference

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
BRANXTON
NORTH ROTHBURY
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Development Layout

Depth Difference(m)

- Less than -0.50
- -0.50 - -0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.01
- -0.01 - 0.01
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- Greater than 0.50

0 200 400 Metres

1:12,500

Figure C3 [B]

Regional Model
PMF Flood Depth Difference

Huntlee Stage 2
(NL220566)

NORTHROP

29/11/2023 X:\PROJECTS\NEWCASTLE\YEAR 2022 Jobs\NL220566 - Huntlee Stage 2\O - Drawings\Workspaces\231101_Flooding Figures\QGIS_Project_Stage2_Figures_LG_V2.qgzQGIS_Project_Stage2_Figures_LG_V2.qgz

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY

MAIN NORTHERN RAILWAY

MAIN NORTHERN RAILWAY

HUNTER EXPRESSWAY

HUNTER EXPRESSWAY

BRIDGE STREET

Branxton

BRANXTON

NORTH ROTHBURY

WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Model Extent
- Development Layout

Depth Difference(m)

- <= 0.01
- 0.01 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- > 3.00

0 200 400 Metres

1:12,500

Figure D1 [B]

Developed Case Regional Model

1in200 AEP - 1% AEP

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
BRANXTON
NORTH ROTHBURY
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Model Extent
- Development Layout
- Stormwater Network

Depth Difference(m)

- Less than -0.50
- -0.50 - -0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.01
- -0.01 - 0.01
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- Greater than 0.50

0 200 400 Metres

1:12,500

Figure D2 [B]

Developed Case Local Model
1% AEP Blockage - 1% AEP Unblocked

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
MAIN NORTHERN RAILWAY
HUNTER EXPRESSWAY
HUNTER EXPRESSWAY
BRIDGE STREET
Branxton
BRANXTON
NORTH ROTHBURY
WINE COUNTRY DRIVE

Legend

- Stage2 Boundary
- Model Extent
- Flood Planning Area
- Development Layout

0 200 400 Metres

1:12,500

Figure D3 [B]

Flood Planning Area

Huntlee Stage 2
(NL220566)

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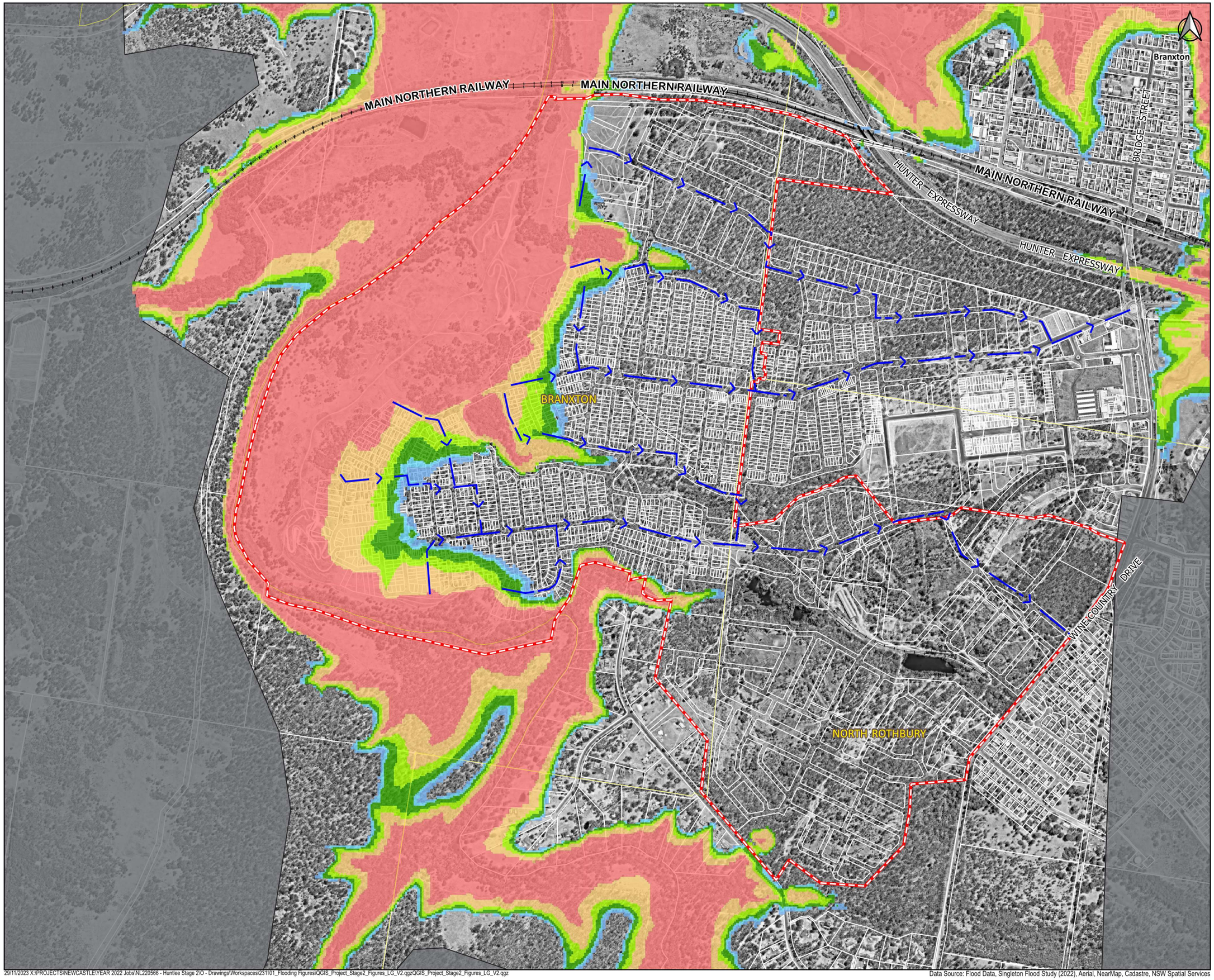
Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services



Legend

- Stage2 Boundary
- Model Extent
- Development Layout

Hazard(ARR2019)

- H1
- H2
- H3
- H4
- H5
- H6
- Evacuation Routes

0 200 400 Metres

1:12,500

Figure D4 [B]

Developed Case Regional Model
PMF Flood Hazard
Evacuation Routes

Huntlee Stage 2
(NL220566)

NORTHROP

Data Source: Flood Data, Singleton Flood Study (2022), Aerial, NearMap, Cadastre, NSW Spatial Services

Appendix B – Sub Catchment Properties

Table 20 - Existing Case Catchment Properties

Catchment Reference	Area (ha)	Impervious (%)	Slope (%)	Roughness* (Manning's)
C01	29.20	0.0	8.3	Pervious = 0.090
C02	44.47	1.6	3.8	Pervious = 0.067
C03	37.64	10.5	3.4	Pervious = 0.065
C04	10.49	8.2	4.1	Pervious = 0.075
C05	8.78	8.4	3.7	Pervious = 0.078
C06	9.05	0.0	4.4	Pervious = 0.077
C07	17.86	0.0	6.6	Pervious = 0.075
C08	29.87	54.7	4.7	Pervious = 0.045
C09	23.15	1.5	3.8	Pervious = 0.063
C10	44.79	1.3	3.8	Pervious = 0.062
C11	16.95	0.0	4.4	Pervious = 0.058
C12	4.24	0.0	6.8	Pervious = 0.077
C13	7.29	10.6	4.4	Pervious = 0.053
C14	3.64	4.4	7.2	Pervious = 0.077 Impervious = 0.025
C15	3.64	8.2	5.9	Pervious = 0.073
C16	13.02	0.0	4.9	Pervious = 0.090
C17	1.66	0.0	1.0	Pervious = 0.090
C18	25.76	0.0	3.1	Pervious = 0.090
C19	19.29	0.0	3.8	Pervious = 0.087
C20	27.41	0.0	2.8	Pervious = 0.085
C21	8.21	0.0	7.1	Pervious = 0.088
C22	8.80	3.6	4.4	Pervious = 0.080
C23	36.66	0.0	3.9	Pervious = 0.090
C24	35.37	0.0	3.9	Pervious = 0.090
C25_1	4.89	0.0	4.1	Pervious = 0.059
C25_2	4.34	0.0	3.3	Pervious = 0.059
C25_3	4.06	0.0	3.0	Pervious = 0.090
C25_4	5.47	0.0	3.5	Pervious = 0.065
C26	6.55	0.0	1.7	Pervious = 0.052

Catchment Reference	Area (ha)	Impervious (%)	Slope (%)	Roughness* (Manning's)
C27	12.26	0.0	3.8	Pervious = 0.090
C28	9.52	0.0	2.3	Pervious = 0.062
C29_1	4.31	0.0	4.6	Pervious = 0.085
C29_2	7.57	0.0	2.1	Pervious = 0.083
C30	38.82	0.0	1.0	Pervious = 0.065
C31	7.77	0.0	6.7	Pervious = 0.088
C32	6.96	0.0	5.1	Pervious = 0.085
C33	12.75	0.0	1.9	Pervious = 0.064
C34_1	5.73	0.0	4.6	Pervious = 0.069
C34_2	3.91	0.0	5.1	Pervious = 0.050
C35_1	6.61	0.0	3.1	Pervious = 0.052
C35_2	3.88	0.0	5.2	Pervious = 0.045
C36	1.1	0.0	5.6	Pervious = 0.052
C37	3.81	8.9	4.6	Pervious = 0.059
C38	9.41	5.3	7.3	Pervious = 0.068
C39	8.18	4.9	4.9	Pervious = 0.090
C40	19.07	0.0	1.4	Pervious = 0.050

* Where impervious roughness not shown, typical 0.015 has been used.

Table 21 - Developed Case Catchments Properties

Catchment Reference	Area (ha)	Impervious (%)	Slope (%)	Roughness (Manning's)*
C03	37.06	10.4	3.4	Pervious = 0.065
C04	6.59	9.8	3.9	Pervious = 0.080
C05	8.95	8.8	3.7	Pervious = 0.078
C06	10.59	85.0	3.4	Pervious = 0.035
C07	11.71	85.0	6.6	Pervious = 0.035
C09_1	8.98	85.0	3.3	Pervious = 0.035
C09_2	5.25	2.7	2.7	Pervious = 0.066
C09_3	11.53	85.0	4.7	Pervious = 0.035
C09_4	1.40	13.5	3.8	Pervious = 0.085
C09_5	11.05	15.0	4.8	Pervious = 0.035
C09_6	7.98	85.0	3.9	Pervious = 0.035

Catchment Reference	Area (ha)	Impervious (%)	Slope (%)	Roughness (Manning's)*
C10_1	6.88	3.6	3.6	Pervious = 0.074
C10_2	6.84	58.0	4.4	Pervious = 0.035
C10_3	3.08	85.0	4.7	Pervious = 0.035
C11_1	8.88	85.0	3.7	Pervious = 0.035
C11_2	12.92	85.0	2.1	Pervious = 0.035
C11_3	1.76	0.0	3.9	Pervious = 0.090
C12_1	2.87	85.0	3.8	Pervious = 0.035
C12_2	0.61	0.0	7.8	Pervious = 0.070
C12_3	0.63	0.0	8.3	Pervious = 0.090
C13	6.89	10.5	4.4	Pervious = 0.053
C14	10.63	85.0	4.9	Pervious = 0.035
C15	4.28	11.7	6.8	Pervious = 0.075
C16 (D01 MOD21)	14.56	74.6	6.9	Pervious = 0.035
C17 (D02 MOD21)	1.08	0	1	Pervious = 0.060
C18_1 (D03 MOD21)	1.02	0	3.5	Pervious = 0.060
C18_2 (D04 MOD21)	3.13	0.0	3.0	Pervious = 0.060
C18_3 (D05 MOD21)	11.86	85.0	2.7	Pervious = 0.035
C18_4 (D06 MOD21)	13.42	85.0	5.7	Pervious = 0.035
C19_1	6.52	85.0	1.9	Pervious = 0.035
C19_2	4.67	85.0	3.6	Pervious = 0.035
C19_3	5.06	0.0	5.8	Pervious = 0.082
C19_4	9.02	85.0	3.3	Pervious = 0.035
C20_1	8.17	85.0	2.1	Pervious = 0.035
C20_2	6.48	0.0	1.9	Pervious = 0.088
C21_1	8.18	85.0	4.5	Pervious = 0.035
C21_2	2.57	85.0	4.1	Pervious = 0.035
C22	**7.17**	**4.4**	**4.4**	**Pervious = 0.085 Impervious = 0.018**

Catchment Reference	Area (ha)	Impervious (%)	Slope (%)	Roughness (Manning's)*
C23_1 (D07 MOD21)	32.23	85.0	5.2	Pervious = 0.035
C23_2 (D08 MOD21)	4.79	29.1	4.5	Pervious = 0.090
C23_3 (D09 MOD21)	3.81	0.0	5.1	Pervious = 0.060
C24_1	8.70	85.0	3.2	Pervious = 0.035
C24_2	7.07	85.0	4.2	Pervious = 0.035
C24_3	4.46	0.0	5.4	Pervious = 0.085
C24_4	10.03	85.0	3.8	Pervious = 0.035
C24_5	5.54	73.5	4.1	Pervious = 0.035
C25_1&2	12.65	85.0	2.1	Pervious = 0.035
C25_3	4.61	0.0	3.0	Pervious = 0.088
C25_4	7.16	79.7	3.9	Pervious = 0.035
C27_1	1.85	85.0	1.9	Pervious = 0.035
C27_2	5.20	85.0	0.9	Pervious = 0.035
C27_3	4.76	85.0	2.2	Pervious = 0.035
C27_4	2.22	85.0	0.9	Pervious = 0.035
C28	7.02	0.0	1.8	Pervious = 0.062
C29_1&2	12.61	85.0	1.1	Pervious = 0.035
C29_3	1.39	85.0	2.6	Pervious = 0.035 Impervious = 0.015
C30_1	10.16	85.0	3.2	Pervious = 0.035
C30_2	8.61	85.0	2.7	Pervious = 0.035
C30_3	6.49	85.0	1.8	Pervious = 0.035
C31_1	4.48	47.4	3.0	Pervious = 0.081
C31_2	1.63	0.0	6.8	Pervious = 0.090
C31_3	1.12	0.0	3.2	Pervious = 0.070
C31_4	1.02	0.0	5.9	Pervious = 0.090
C32_1	6.88	85.0	2.5	Pervious = 0.035
C32_2	1.82	0.0	3.3	Pervious = 0.085
C33_1	9.25	85.0	1.7	Pervious = 0.035
C33_2	0.54	85.0	4.8	Pervious = 0.035
C34_1	6.93	85.0	2.4	Pervious = 0.035

Catchment Reference	Area (ha)	Impervious (%)	Slope (%)	Roughness (Manning's)*
C34_2	1.99	85.0	2.9	Pervious = 0.035
C35_1	6.95	0.0	3.1	Pervious = 0.052
C35_2	1.73	85.0	8.3	Pervious = 0.035
C37	2.29	14.5	5.0	Pervious = 0.061
C39	8.68	5.0	5.0	Pervious = 0.087
C41	6.51	0.0	1.3	Pervious = 0.052
C42	13.69	0.0	1.1	Pervious = 0.056

* Where impervious roughness not shown, typical 0.015 has been used.

Table 22 - Existing Case Lag Time

Link	Lag Time (mins)	Link	Lag Time (mins)
C01 - C02	14.6	J01 - C22	4.9
C02 - C03	6.0	C16 - C17	0.5
C03 - C39	2.8	C17 - C18	6.5
C39 - C04	0.9	C18 - C19	26.5
C06 - C04	10.1	C19 - C20	40.2
C04 - C05	9.3	C20 - C28	13.9
C07 - C05	6.8	C28 - C40	10.4
C05 - C15	0.3	C23 - C24	5.1
C14 - C15	2.7	C24 - C25_3	10.3
C37 - C38	2.8	C25_2 - C25_3	1.1
C08 - C09	6.0	C25_4 - C25_3	5.2
C09 - Wetland 2	7.3	C34_1 - C25_4	6.7
Wetland 2 - Wetland 1	0.6	C25_3 - C26	4.1
Wetland 1 - C10	1.1	C25_1 - C26	7.4
C10 - C11	3.9	C27 - C26	10.6
C11 - C12	2.0	C34_2 - C35_1	3.8
C12 - J01	15.7	C35_2 - C35_1	3.5
C21 - J01	0.1	C36 - C35_1	3.0

Table 23 - Developed Case Lag Time

Link	Lag Time (mins)	Link	Lag Time (mins)
C01 - C02	14.6	C19_1 - C19_3	0.0

Link	Lag Time (mins)
C02 - C03	6.0
C03 - C39	2.8
C39 - C04	0.9
C04 - C05	9.3
C06 - C07	7.0
C14 - C07	0.0
C07 - C05	7.3
C05 - C15	0.3
C37 - C38	2.8
C08 - C09_2	6.0
C09_3 - C09_2	0.9
C09_6 - C09_2	0.8
C09_2 - C09_4	3.9
C09_1 - C09_4	0.4
C09_5 - C09_4	0.5
C09_4 - C10_1	5.2
C10_2 - C10_1	0.4
C10_3 - C10_1	0.0
C11_1 - C10_1	0.7
C11_2 - C10_1	1.1
C10_1 - C11_3	4.1
C12_1 - C11_3	1.0
C21_2 - C11_3	1.8
C11_3 - C12_3	2.0
C12_2 - C12_3	0.0
C12_3 - J01	15.7
C21_1 - J01	0.1
J01 - C22	4.9
C16(D01) - C17(D02)	0.5
C17(D02) - C18_1(D03)	3.0

Link	Lag Time (mins)
C19_2 - C19_3	0.0
C19_4 - C19_3	2.0
C19_3 - C20_2	22.4
C20_1 - C20_2	0.4
C27_1 - C20_2	0.8
C27_2 - C20_2	3.3
C27_3 - C20_2	5.9
C30_2 - C20_2	0.0
C20_2 - C28	13.9
C28 - C40	10.4
C30_3 - C40	39.2
C23_1(D07) - C23_3(D09)	0.5
C23_2(D08) - C23_3(D09)	4.5
C23_3(D09) - C24_3	3.9
C24_1 - C24_3	0.3
C24_2 - C24_3	4.5
C24_4 - C24_3	0.3
C24_5 - C24_3	2.3
C24_3 - C25_3	1.9
C25_1&2 - C25_3	0.0
C25_4 - C25_3	0.0
C34_1 - C25_4	5.4
C25_3 - C26	4.1
C34_2 - C35_1	3.8
C35_2 - C35_1	3.5
C36 - C35_1	3.0
C31_1 - C32_2	0.2
C32_1 - C32_2	0.1
C31_2 - C31_4	2.4
C31_4 - C31_3	0.6

Link	Lag Time (mins)
C18_1 (D03) - C18_2(D04)	3.5
C18_3 (D05) - C18_2(D04)	0.5
C18_4 (D06) - C18_2(D04)	0.5
C18_2(D04) - C19_3	8.9

Link	Lag Time (mins)
C33 - C29_1&2	0.0
C29_3 - C29_1&2	0.0
C30_1 - C41	17.6
C41 - C42	36.9