NORTHROP

Flood Impact Assessment

for

Civitas – Stage 3 Development

for **Damasa Pty Ltd**

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Prepared by	DN	18/10/2024
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Abbreviations

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff 2019
BoM	Bureau of Meteorology
DCP	Development Control Plan
FFL	Finished Floor Level
FPL	Flood Planning Level
LGA	Local Government Area
LEP	Local Environmental Plan
LiDAR	Light Detection and Ranging (also see ALS)
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)
PMF	Probable Maximum Flood

Introduction

Northrop Consulting Engineers have undertaken a flood investigation on behalf of Damasa Pty Ltd to determine the flood impact of the proposed development of Stage 3 of the Civitas development, located along Morgan Street, Wagga Wagga.

The purpose of this correspondence is to accompany a development application submission to Council. Included herein is the following.

- A description of the existing site and proposed development.
- Previous flood investigations related to the subject site.
- The methodology adopted for this assessment.
- A summary of the TUFLOW model parameters.
- Flood results for the existing and developed case, and flood impacts.
- A discussion of compliance with Council's LEP and DCP.

Background Information and Model Development Chronology

Civitas Masterplan

The proposed development, Stage 3, is part of the greater overall layout for the Civitas Masterplan. Stages 1 and 2 have previously been submitted and approved by Council, with construction of Stage 1 completed and Stage 2 under construction. Both stages have included the establishment of commercial office buildings, and associated carparking and street embellishments fronting Morgan Street

Stage 3 Submission Overview

The Stage 3 development has undergone various stages to achieve the outcome put forward for this Development Application. The following provides a summary of the actions undertaken:

- Receipt of the Lyall and Associates model '589dm001 - 190-205 Morgan Street, Wagga Wagga' in September 2023. This model was used as the basis for the site-specific flood study.
- The provided model was updated to include details specific to the subject site, amended to include Stages 1 and 2, and run to reflect both the current existing and proposed Stage 3 developed case scenarios.
- A memorandum summarising the Civitas Stage 3 Flood Model Overview was submitted in December 2023. This outlined a comparative assessment of the model provided by Lyall and Associates (as provided by Council), against the site-specific flood model modified by Northrop. This report was provided to commence the process towards the confirmation of a 'Base Case' model which satisfied Council and their consultant. This document can be provided if requested.
- The previous version of this Flood Impact Assessment was prepared in January 2024. The model adopted the approach and parameters outlined in the model review submitted to Lyall and Associates.
- In June 2024, a meeting with Lyall and Associates was organised to discuss the changes Northrop made to the modelling received from Council in September 2023, and as presented in the memorandum dated December 2023.
- Following the meeting of June 2024 and subsequent correspondence with Lyall and Associates, a revised 'Base Case' model was prepared and provided for review in July 2024.
- Following review and further discussion, it was agreed with Lyall and Associates this model was suitable to be adopted as the 'Base Case' model in August 2024.
- This 'Base Case' model was adopted as the 'Existing Case' scenario in this version of the Flood Impact Assessment.
- The revised developed case results from the updated flood model have also been collated and presented as part of this version of the Flood Impact Assessment.

Site Description

Existing Site

The subject site covers an area of approximately 1.3ha and is bordered by Murray Street to the east, Morgan Street to the South, and commercial properties surrounding the remaining borders of the site. The commercial properties to the west and north of the Stage 3 development may be developed in the future as part of the overall Masterplan for Civitas, with an existing private property located along the eastern boundary of the site, at 74 Murray Street, to remain.

The subject site is currently developed with residential properties along the eastern boundary, and three separate buildings for commercial operations located along Morgan Street.

The subject site is generally flat, with a slight north-westerly fall, as shown in Figure A1 of Attachment 1. During rainfall events, this encourages flows towards Wollundry Lagoon located approximately 150m north of the subject site, which ultimately flows into the Murrumbidgee River. During major flood events, flows exceed the capacity of the underground network and stormwater channels, and flood waters enter the site.

The site location is shown below in Figure 1, with the yellow border indicating the extent of the Civitas Masterplan, and the red indicating the Stage 3 boundary.

Figure 1 – Subject Site

Proposed Development

The proposed development consists of three structures, replacing the existing buildings that are located within the site. The existing buildings located from 66-72 and 80 Murray Street will be demolished, in addition to the buildings within 185 Morgan Street.

The three stages of the proposed development include:

- Stage 3A and 3B – Ground floor FFLs of buildings are to be raised up to approximately 179.61m AHD. This is above the 1% AEP plus 300mm freeboard requirement.
- Stage 3C – Construction of townhouses, with the floor levels set at 179.61m AHD for all areas excluding the garages, which are set at 179.0m AHD to provide additional flood storage.

The proposed design has considered the existing flood conditions, allowing the flow paths between the Stage 3A/B boundary and the existing building to the north and along the driveway and landscaped area between the Stage 3B and 3C buildings.

An overview of the proposed development is shown below in Figure 2.

Figure 2 – Proposed Stage 3 Development

Previous Studies

Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan (2011)

The purpose of the Wagga Wagga Major Overland Flow Flood Study (MOFFS) was to assess the flooding mechanism caused from intense rainfall over the contributing catchment, as opposed to riverine flooding. Overland flow throughout the Wagga Wagga LGA was determined and used to develop solutions for properties at risk in these rainfall events. The assessment included a hydrological model (Watershed Bounded Network Model) and hydraulic model (TUFLOW).

The following table outlines the results from this study, focusing on two locations. One located upstream of the subject site, whilst the other is immediately downstream of the site. Figure 3 presents the locations which these values were extracted from (Figure 32 of the MOFFS Report).

Table 1 - City Model Results *(Extracted from Wagga Wagga Major Overland Flow Flood Study, 2011)*

Location	10% AEP	5% AEP	1% AEP	0.5% AEP	PMF
4	179.1	179.2	179.3	179.3	180.1
5	177.9	178.1	178.5	178.6	180.0

Figure 3 – Point Locations (Figure 32 from 2011 MOFFS Report)

Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan (2021)

A revised Wagga Wagga Overland Flow FRMS&P was undertaken by WMAwater, on behalf of Wagga Wagga Council, in 2021 to assess the impact of overland flow flooding. The previous flood study, completed in 2011 by WMAwater, forms the basis of the study. The main objective of this study was to develop flood risk mitigation strategies that address existing, future and continuing flood problems due to local catchment flooding in Wagga Wagga.

The results from the updated study are shown in Figure 4 to Figure 7. Figure 4 and Figure 5 present the flood depth in the 1% AEP and PMF, respectively, and indicate the subject site is inundated in both events with depths up to 0.5m and 1.0m.

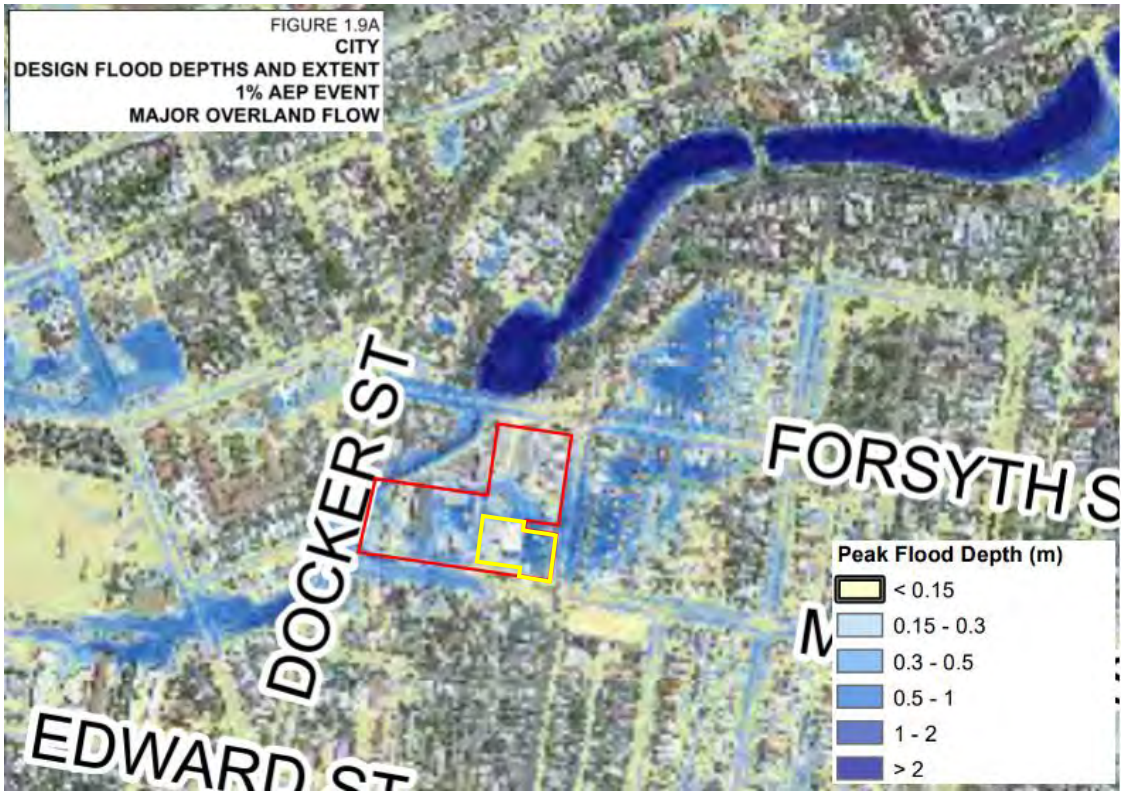

Figure 4 – 1% AEP Flood Depth (wmawater,2021) [Stage 3 development shown in Yellow]

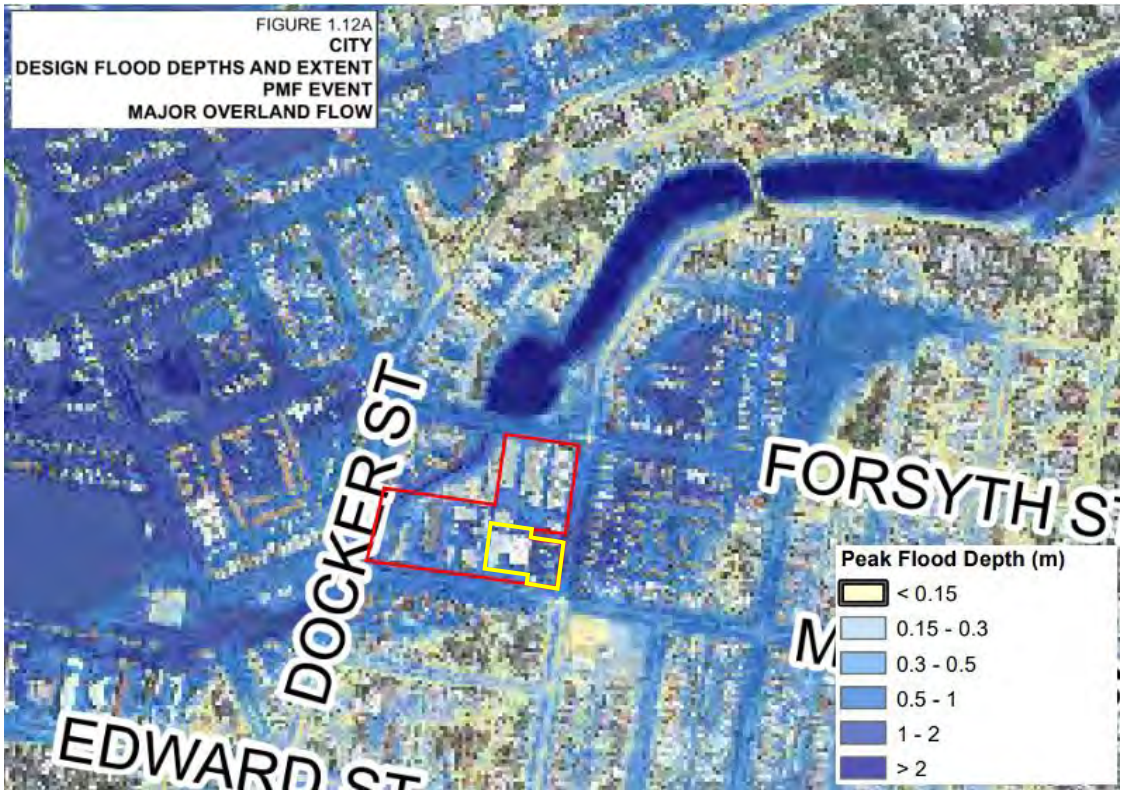

Figure 5 – PMF Flood Depth (wmawater,2021) [Stage 3 development shown in Yellow]

The hydraulic categorisation for the 1% AEP event is shown in Figure 6 and indicates the subject site acts as flood storage within the 1% AEP flood event.

The flood storage is defined as the following:

- Parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
- If the capacity of a flood storage area is substantially reduced, for example by the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased.
- Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.

Given the nature of the development and the Council DCP requirements, the categorisation of the subject site as flood storage resulted in a significant focus on developing a layout that maintains the existing storage within the site, to minimise offsetting flows to surrounding properties.

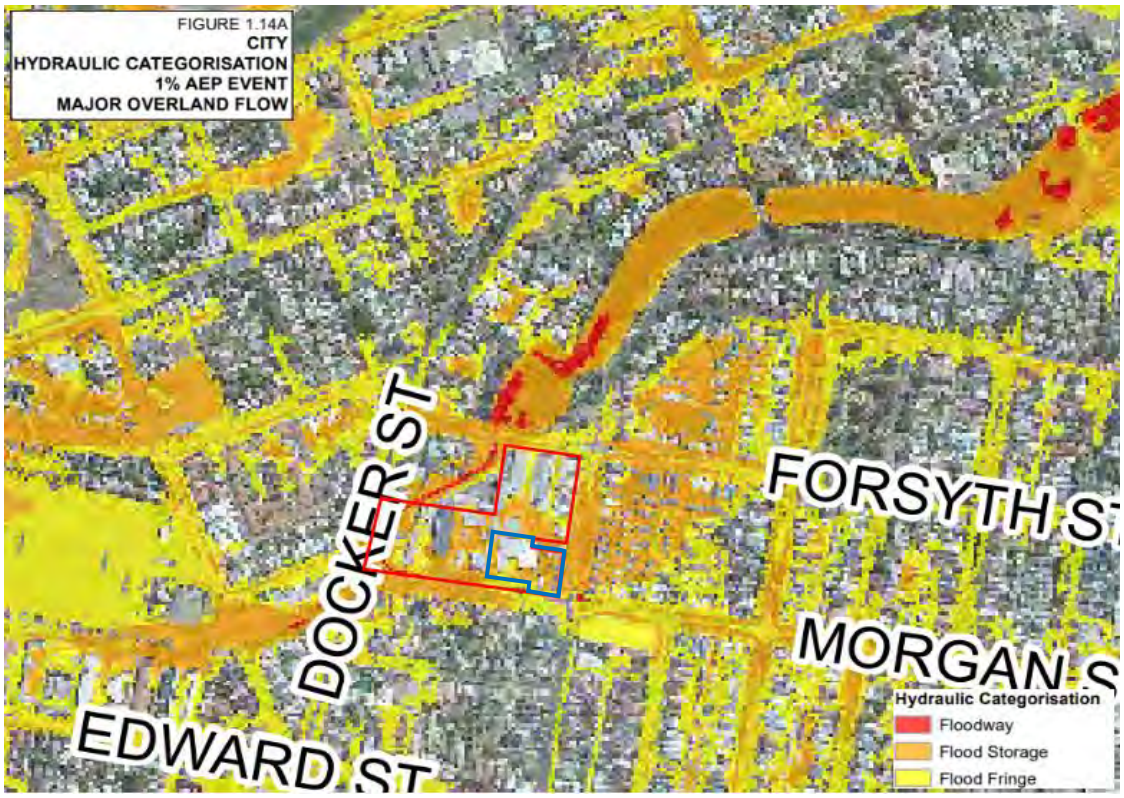

Figure 6 – 1% AEP Flood Categorisation (wmawater, 2021) [Stage 3 development shown in Yellow]

Figure 7 presents the 1% AEP flood hazard, in accordance with the AR&R 2019 Flood Hazard Curves. The existing subject site is classified as a combination of H1 to H3. Access via Morgan Street into the subject site contains no constraints, whilst entering from Murray Street is unavailable due to the specified hazard.

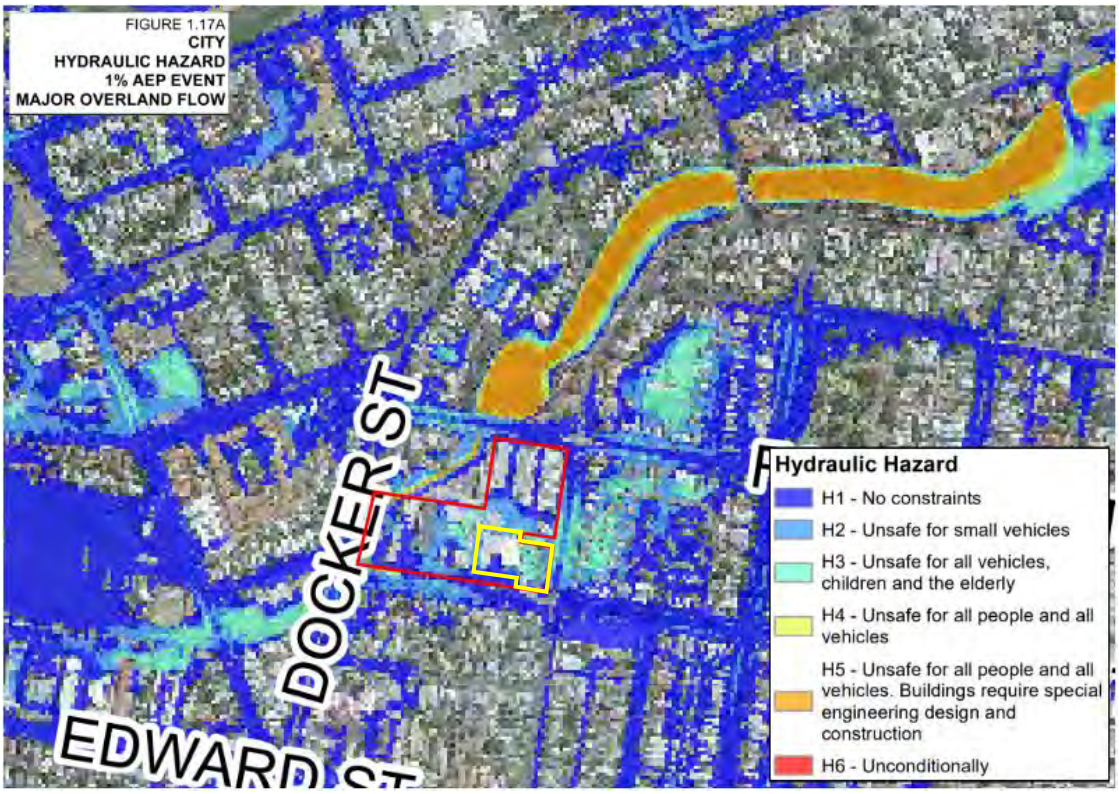

Figure 7 – 1% AEP Hydraulic Hazard AR&R 2019 (wmawater, 2021)

Revision of Wagga Wagga MOFFS (2023)

A revised TUFLOW model was developed by Lyall and Associates in 2023, to provide an updated overland flow flood study for the Wagga Wagga city catchment. The revised model includes the following:

- An extended stormwater network, consisting of pit and pipes throughout the model extent, in addition to revised sizing of the pipes already contained in the previous studies. Using the updated stormwater network, additional flows are captured and conveyed through the 1D network.
- Inclusion of a Quadtree mesh. This reduces the grid cell sizes within the model over the extent specified, providing a better representation of the surface levels and the dispersion of flows. In the quadtree domain, the cells were reduced from 5.0m to 2.5m.
- Updated terrain modifications to reflect the 2D surface, specifically in areas where the grid cell size was reduced as part of the quadtree domain.
- Updated the scenarios incorporating the floodgate for the Murrumbidgee River and pump within the Wollundry lagoon.

Through the inclusion of these updates, the model developed by Lyall and Associates provided a more accurate representation of the Wagga Wagga City flood behaviours and therefore, formed the basis of the Stage 3 development model.

Methodology

This assessment has been undertaken through the following methodology:

- Desktop review of previous investigations including the Major Overland Flow FPMS&P (WMAwater, 2021), LiDAR elevation data, aerial photography and the revised TUFLOW model data provided by Council.
- Site visit to review the existing topography, nearby stormwater infrastructure, landuse, and surface roughness.
- Receipt of the updated Lyall and Associates TUFLOW model from Council. An analysis of the Council results was undertaken to assess the flows expected through and around the subject site.
- Modifications to the Council model to include site-specific details. This included using detailed survey for the subject site, additional flow constrictions for fences and retaining walls, modified terrain roughness and the modelling approach for newly constructed buildings within the site extent.
- Liaison with Lyall and Associates to agree on the modifications made to the supplied model to form the Existing Case Model.
- Run the modified Existing Case Model for the 10% AEP, 5% AEP, and 1% AEP design storm events.
- Modification of the TUFLOW model to include the proposed layout for the development, in addition to the deconstruction of existing buildings.
- Run the Developed Case Model for the 10% AEP, 5% AEP and 1% AEP design storm events.
- Comparison of the two-dimensional flood elevations to review the effects of the proposed development on the flood behaviour within the subject site and in adjacent properties.

A description of the model assumptions and parameters, along with the presentation of the results and discussion with respect to compliance with Council's Planning Requirements are presented herein.

TUFLOW Model

TUFLOW Model Events

As part of the model received by Council, multiple recurrence intervals for the flood events were included. These were assumed as the critical temporal patterns for the study area, and included the 30-minute, 2-hour, 6-hour and 9-hour for the 10% and 5% AEP, whilst the 1% AEP includes the 30-minute, 1-hour, 1.5-hour, 2-hour, 6-hour and 12-hour flood events.

For each of the event durations, two scenarios in accordance with Lyall and Associates model were executed. These include:

- Flood gates open
- Flood gates closed due to elevated tailwater levels in Murrumbidgee River and stormwater evacuation pumps operating to capacity.

Each of these events were enveloped in the results files, to determine the critical duration and scenario for the subject site, in the existing and developed model.

Existing Case Scenario

This study was undertaken using the revised Council TUFLOW model, which was provided by Lyall and Associates in September 2023. The TUFLOW model uses version 2020-10-AF with HPC GPU solver for the assessment.

Northrop made various changes when assessing the flood conditions for the subject site. These included the following:

- The inclusion of detailed survey for the subject site, received in February 2023. The use of detailed survey is preferable over LiDAR for the site-specific study.
- The inclusion of the existing retaining wall which runs along the northern boundary of Stage 1, in addition to brick walls around the residential buildings adjacent the subject site boundary.
- Inclusion of the design surface for Stage 2, within the Masterplan extent.
- Modified representation of the buildings within the Masterplan extent, that have been completed/are to be completed prior to the construction of Stage 3.
- The inclusion of the two channel crossings which are part of the Stage 2 works within the Masterplan extent, as documented within the separation application.

Within the Lyall and Associates model, buildings have been represented using an increased roughness coefficient, which reduces the flow conveyance whist providing flood storage within buildings. This approach was modified within the Civitas Masterplan extent, as the floor levels of newly constructed buildings have been set in accordance with Council's DCP requirements. As such, these are represented using a block-out which modifies the cells contained to be inactive, allowing no passage of flows.

Aside from the changes listed above, the TUFLOW model inputs are consistent with those provided in the Lyall and Associates model. These changes made were not expected to significantly change the results of the model, however, would provide a better representation of the flooding conditions at the subject site. An overview of the existing case model setup and roughness is presented in Figure A2 of Attachment 1.

Developed Case Scenario

Each of the buildings within Stage 3 have been represented in the model using block-outs as adopted for the Stage 1 and 2 buildings in the Masterplan extent. The floor level between 3A and 3B will be constructed at 179.61m AHD to provide flood immunity in the 1% AEP flood event and the landscaped area behind the townhouses will be lowered to increase the conveyance through the site and limit the impacts of the development on the existing property located at 74 Murray Street. These surface levels were represented as block z-shapes within the model.

Similarly, the proposed Stage 3A driveway into the basement carparks has been modelled to provide immunity in the events modelled. The proposed driveway ramps up to an elevation of 179.615m AHD, limiting the ability of floodwaters to enter the carpark, before ramping down into the basement.

The Stage 3 developed case model also incorporates the temporary carpark within 187 Morgan Street, and the removal of the existing building at 80 Murray Street. The extent of this building is shown in Figure 2. Whilst these are independent of the proposed Stage 3 development, these are important in the mitigation of flooding.

No additional stormwater infrastructure has been included as part of this stage, with the flood impacts mitigated through the proposed ground levels. Additional storage through the balance of the Masterplan extent is available within the proposed carpark to the west of Stage 3A.

An overview of the model setup and roughness is presented in Figure A3 of Attachment 1.

Results

The TUFLOW model has been executed for the 10%, 5% and 1% AEP flood events, for the existing and developed case models. These have been used to assess the impact of the proposed development on the surrounding properties.

Critical Durations in the vicinity of the Subject Site

The study received from Council provided multiple recurrence intervals for the flood events, which were assumed as the critical temporal patterns for the study area. From these events, the critical duration for the Stage 3 development area was determined and is summarised in Table 2 below. Figure A4 to A6 present the critical event in the vicinity of the subject site.

It is noted for the existing case, developed case, and flood impacts, an envelope of all supplied events has been used.

Table 2 – Critical Duration within TUFLOW Model

Flood Event	Existing Case	Developed Case
10% AEP	Flood Gates Open w/ Pump 2-hour duration	Flood Gates Open w/ Pump 2-hour duration
5% AEP	Flood Gates Open w/ Pump 2-hour duration	Flood Gates Open w/ Pump 2-hour duration
1% AEP	Flood Gates Open w/ Pump 2-hour duration	Flood Gates Open w/ Pump 1.5 & 2-hour duration

It is noted that the models executed are based on recurrence intervals provided by Council, and as such, no events exceeding the 1% AEP have been modelled.

Existing Case Results

The results presented are an envelope of each of the critical durations surrounding the subject site, as provided by Lyall and Associates. The results for each of the existing case flood events modelled are presented in Figures B1 to B6. Figure B1, B3 and B5 include the flood depth and elevation, whilst Figures B2, B4 and B6 indicate the flood hazard.

Figures B1 and B3 show depths up to approximately 440mm and 560mm in the 10% and 5% AEP flood events, with the peak flood level across the Stage 3 area at approximately 178.98m AHD and 179.08m AHD, respectively.

Figure B5 presents the existing case flood depth and elevation across the site in the 1% AEP. The flood elevation across the site reaches approximately 179.20m AHD, resulting in depths up to 740mm within the proposed development location. This elevation was used to determine the finished floor level within the proposed development.

Flood hazard is based on the latest Australian Rainfall and Runoff Guidelines with the hydraulic behaviour and pedestrian, vehicle and building thresholds summarised for each category overleaf in Figure 8.

During the 10% and 5% AEP flood events, the site is generally hazard H1, with shallow, slow-moving flows throughout the Stage 3 development area. Isolated areas of H2 are shown along the eastern boundary of the buildings located at 187 Morgan Street. This is also visible in the flow across the site which runs between the Post Office and 187 Morgan Street. This is presented in Figures B2 and B4.

Similarly, the flood hazard across the subject site in the 1% AEP flood event ranges from H1 to H3 and is presented in Figure B6.

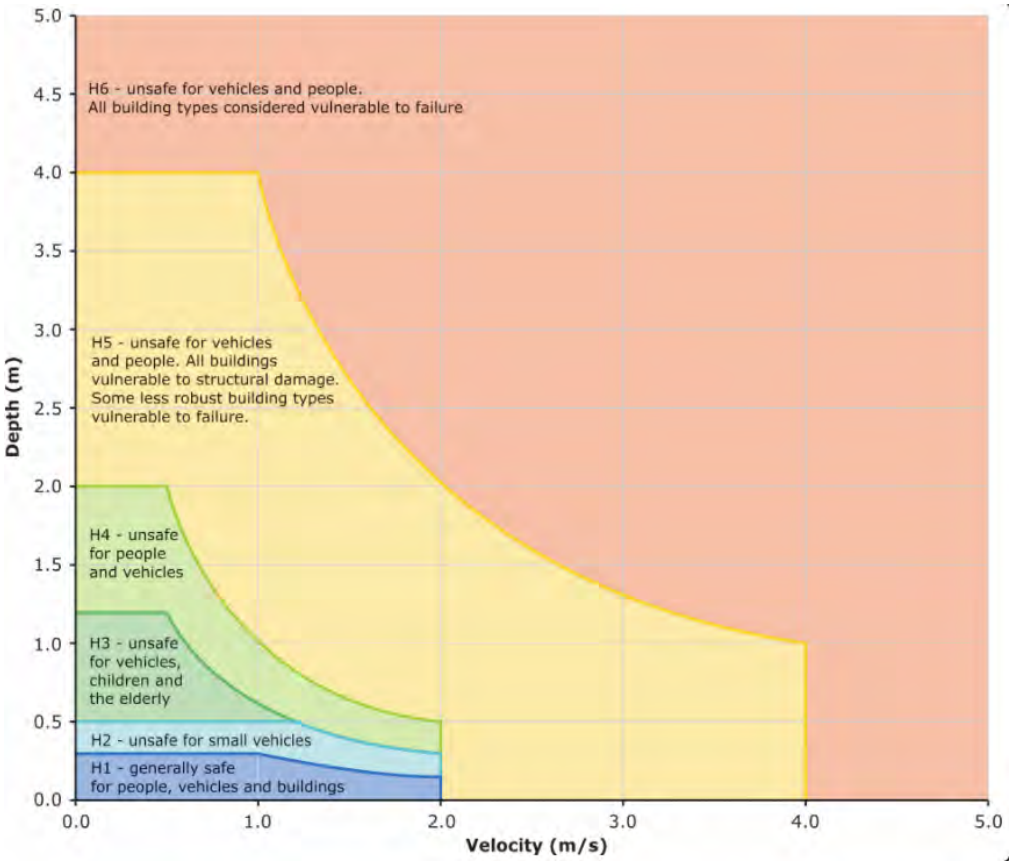

Figure 8 – Australian Rainfall and Runoff (2019) Hazard Categories

Developed Case Results and Finished Floor Levels

With the proposed Stage 3 development set at 179.61m AHD and the removal of the two existing buildings on the site, the developed case model was executed for the 10%, 5% and 1% AEP flood events, and the results are presented in Figures C1 to C6.

Similar to the existing case model, the flood depths reach up to approximately 440mm and 545mm in the 10% and 5% AEP flood events. Based on these depths, the elevation across the site is relatively unchanged, with the 5% AEP remaining around 179.09m AHD whilst the 10% AEP flood elevation was increased by 20mm from 178.98m AHD to 179.00m AHD within the subject site.

Figure C5 shows the 1% AEP flood depth and elevation for the developed case model. From this, it is evident that the flow paths through the site are maintained with flows running between the existing post office and the proposed Stage 3 development, in addition to the flow path along the back of the townhouses. Although inundation is shown within the garage space for each of the townhouses, 400mm of freeboard is maintained for the finished floor level, with the flood level through these areas sitting at approximately 179.20m AHD

The 1% AEP developed case flood behaviour reflects similar flood conditions as the existing case model, with the exception of the additional flow through the eastern boundary, due to the removal of the existing building at 80 Murray Street. Through removing this building and increasing the conveyance capacity along the eastern boundary, the flood depths in the developed case scenario are similar. The flood elevation reaches a maximum of 179.2m AHD through the Stage 3 development, with flood depths up to 670mm adjacent to the raised pad.

Figures C2, C4 and C6 present the developed case flood hazard. Figure C2 and C4 show a reduced area of hazard H3, with the majority of the Stage 3 development extent represented as H1. The remaining hazard remains consistent with that shown in the existing case model. Within Figure C6 the flood hazard is relatively unchanged from the existing case results, aside from an increased extent of H2 through the Stage 3 development. This is due to greater flows traversing the site.

The private property located within the eastern boundary of the development at 74 Murray Street shows a small increase in the extent of H3, from 235m^2 to 260m^2 within the backyard area. However, given this area is already impacted by H3 flows, this is not expected to have significant adverse effects, with residents expected to avoid this area in major rainfall events.

Flood Impacts

Figure D1 presents the pre-to-post comparison of the 10% AEP flood elevation across the site and surrounding area. This shows a 17mm increase in flood level to the east of the site. Similarly, the 5% AEP flood elevation is presented in Figure D2 and shows an increase of up to 13mm in the properties east of Murray Street. We do not believe this increase is significant in the minor flood events, as these properties are likely affected already by floodwater in these events, by depths of up to 500mm.

Figure D3 presents the pre-to-post comparison of the 1% AEP flood elevation across the site and surrounding area. This indicates the proposed development has minimal impacts on the surrounding properties with a maximum increase of approximately 4mm within Murray Street. An isolated increase up to 12mm is shown adjacent to Morundah Street. This increase is likely due to an additional wet cell in this location and does not reflect an increased risk. As the impact from the proposed development is generally within 10mm, the site is not considered to have created a significant adverse impact on the surrounding area.

Compliance with Planning Controls

This section discusses the planning controls that apply to the proposed development and how these have been considered in the proposed Stage 3 Development.

Local Environment Plan

Council LEP requirements relating to flooding are presented below in Table 3.

Table 3 – Wagga Wagga Local Environmental Plan 2010

Council Requirement	Response
5.21 Flood planning	
(1) The objectives of this clause are as follow	
(a) to minimise the flood risk to life and property associated with the use of land,	The habitable floor level adopted within the proposed development has been set in accordance with the Wagga Wagga Overland Flow FRMS&P Freeboard Assessment. As such, the finished floor level is set, at a minimum, the 1% AEP flood level plus 300mm freeboard, limiting the risk and potential for floodwaters to inundate the proposed development. Risk to life mitigation measures are further discussed in Items 2(c) and 2(d) below.
(b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,	Consideration has been given to the flood function of the subject site based on the existing flood conditions as presented in Council's studies and the site-specific overland flow study. The proposed Stage 3 development has been designed to maintain the existing flow paths through the site, and acts as flood storage within the 1% AEP flood event. On this basis, the proposed Stage 3 does not change the existing flood behaviour and is therefore, considered compatible with the flood function.
(c) to avoid adverse or cumulative impacts on flood behaviour and the environment,	As illustrated within the model, the proposed development is not expected to significantly impact other properties within the surrounding environment. A cumulative impact assessment has not been undertaken as other similar development would need to undertake the same impact assessment and be similarly sympathetic to the existing flood behaviour.
(d) to enable the safe occupation and efficient evacuation of people in the event of a flood.	The proposed development is subject to overland flow flooding, and therefore short flood durations. We believe shelter in place is appropriate for this flooding mechanism whilst the flood passes.

Council Requirement	Response
(2) Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development –	
(a) is compatible with the flood function and behaviour on the land, and	The subject site is classified as flood storage, as presented in the Wagga Wagga MOFFS. Through maintaining the existing flow path along the north of the proposed Stage 3A and 3B development and proving storage and conveyance through the driveway of Stage 3C, the flood behaviour of the proposed development is largely unchanged. This is also aided by the removal of buildings within the Masterplan extent, and subject to separate approval.
(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and	As presented in the result section of the report, the proposed developed is not expected to adversely affect adjacent properties during any of the design storm events modelled.
(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and	The proposed development is subject to flash flooding from overland flow, from the upstream catchment, with short flood durations. We believe shelter in place is appropriate for this flooding mechanism whilst the flood passes. Therefore, the proposed development is not expected to affect the existing evacuation routes for the surrounding area. Should emergency services be required, a flood hazard of H1 is shown in both the existing and developed case 1% AEP flood event, through the centre of the road in Forsyth Street or via Morgan Street. This allows accessible passage for evacuation, if required in this event.
(d) incorporates appropriate measures to manage risk to life in the event of a flood, and	The upper floors of the proposed development provide refuge in the event of a PMF to manage the risk to life.
(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses.	The proposed development is located outside the extents of the Wollundry Lagoon and is already developed across its plan area. We believe incorporation of standard civil engineering and stormwater design will assist in preventing erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses during construction, and in the operational phase.
(3) In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters –	
(a) the impact of the development on projected changes to flood behaviour as a result of climate change,	Based on the information presented in the Wagga Wagga MOFFS report, an allowance of 0.1m has been included within the floor level of the proposed development, to account for Climate Change.

Council Requirement	Response
(b) the intended design and scale of buildings resulting from the development,	The proposed development maintains a similar footprint and purpose to the existing subject site.
(c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,	We believe on-site flood refuge is an appropriate measure to manage the risk to life within the proposed development. Within the event of local overland flow flooding, vertical evacuation can be sought within the proposed development, under the direction of the building managers or emergency services.
(d) the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.	Given the location of the site it is unlikely to be significantly impacted by coastal erosion.
5.22 Special flood considerations	
Development consent must not be granted to development on land to which this clause applies unless the consent authority has considered whether the development –	
(a) will affect the safe occupation and efficient evacuation of people in the event of a flood, and	The FFL has been set in accordance with the DCP and the freeboard assessment conducted in the MOFFS. As such, safe occupation in the event of local flooding can be sought on the site. Due to the typology of the development refuge is expected to be available on-site above the PMF, limiting the requirement for evacuation to be performed, unless instructed by the building managers or emergency services. Should emergency services be required, or evacuation instructed, a flood hazard of H1 is shown through the centre of the road in Forsyth Street or via Morgan Street. This allows accessible passage for evacuation, if required, for events up to the 1% AEP. Occupants, however, should remain within the Stage 3 development unless instructed elsewise.
(b) incorporates appropriate measures to manage risk to life in the event of a flood, and	This has been discussed in 2(d)
(c) will adversely affect the environment in the event of a flood.	The proposed development is located outside the extents of the Wollundry Lagoon, and ultimately the Murrumbidgee River, and therefore is not affecting the existing conditions within or around the watercourse. The proposed development maintains a similar footprint and function to the existing buildings, and therefore is not expected to result in adverse effects.

Development Control Plan

Section 4.2 of the Wagga Wagga Development Control Plan 2010 outlines the flooding requirements, for developments subjected to environmental hazards. This is summarised below in **Table *4***. As specified in the Flood Risk Management Study, the proposed development is located in a Low Flood Risk area, and therefore, the precinct specific controls and conditions have been included also in **Table *4***.

Table 4 – Wagga Wagga Development Control Plan 2010

Council Requirement	Response
Minimise the public and private costs of flood damage.	The proposed development is not expected to result in significant adverse impacts to surrounding properties and subsequent impact on flood damage.
Minimise the risk of life during floods by encouraging construction and development that is "flood proofed" and compatible with the flood risk of the area.	The proposed development has been cited in accordance with Council's requirements noting a minimum of 300mm freeboard has been applied to habitable floors. This is in accordance with the Freeboard Assessment undertaken as part of the MOFFS. Similarly, the proposed driveway ramp into the basement carpark has been designed at 179.615m AHD, to provide flood immunity in the 1% AEP, with a minimum allowance of 300mm freeboard.
Ensure that development and construction are compatible with the flood hazard.	The development has been placed at, or above, the necessary Flood Planning Levels. As noted above, the driveway into the basement carpark has been designed to limit the extent of flooding. This raises the development above the flood hazard in the 1% AEP event and we believe this is compatible with the end use.
Require compatibility with the Floodplain Development Manual 2005 as relevant.	The proposed development has been designed in accordance with Council's LEP and DCP requirements. As such, the proposed development is considered to be consistent with the NSW Flood Risk Management Manual 2023 (superseding the NSW Floodplain Development Manual 2005).
Development in the Central Wagga precinct (being the area protected by levees) is to comply with the provisions as follows:	
Floor levels • Minimum floor height 225mm above ground level within the building footprint • Consider local drainage and ponding of stormwater within the levee	• Finished Floor Levels have been set at 179.61m AHD in accordance with MOFFS, as stated above. This allows a minimum of 300mm above ground level. • This has been addressed as part of this Flood Impact Assessment.

Conclusion

Northrop Consulting Engineers have been engaged by Damasa Pty Ltd to prepare a flood impact assessment for the proposed Stage 3 development located along Morgan Street, Wagga Wagga. This has been undertaken using the regional flood model, constructed by Lyall and Associates as the base model, with site-specific details and assumptions added to the model.

- We believe the model amendments are an appropriate representation of the existing and proposed Stage 3 developed conditions.
- From the results presented, it is likely the proposed development will have negligible impacts on the flood behaviour for surrounding properties.
- The proposed development provides onsite refuge for short-duration flood events, which we believe will result in minimal impacts on the emergency evacuation procedures should this be required during major flood events.
- We believe the proposed development generally complies with Council's requirements from a floodplain management perspective.

We commend our assumptions and results to Council for assessment. Should you have any queries, please feel free to contact the undersigned on (02) 4943 1777.

Prepared by

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Attachment 1 – Flood Figures

Figure A1 – Existing Terrain

Figure A2 – Existing Case Model Setup and Roughness

Figure A3 – Developed Case Model Setup and Roughness

Figure A4 – 10% AEP Critical Duration

Figure A5 – 5% AEP Critical Duration

Figure A6 – 1% AEP Critical Duration

Figure B1 – Existing Case 10% AEP Flood Depth & Elevation

Figure B2 – Existing Case 10% AEP Flood Hazard

Figure B3 – Existing Case 5% AEP Flood Depth & Elevation

Figure B4 – Existing Case 5% AEP Flood Hazard

Figure B5 – Existing Case 1% AEP Flood Depth & Elevation

Figure B6 – Existing Case 1% AEP Flood Hazard

Figure C1 – Developed Case 10% AEP Flood Depth & Elevation

Figure C2 – Developed Case 10% AEP Flood Hazard

Figure C3 – Developed Case 5% AEP Flood Depth & Elevation

Figure C4 – Developed Case 5% AEP Flood Hazard

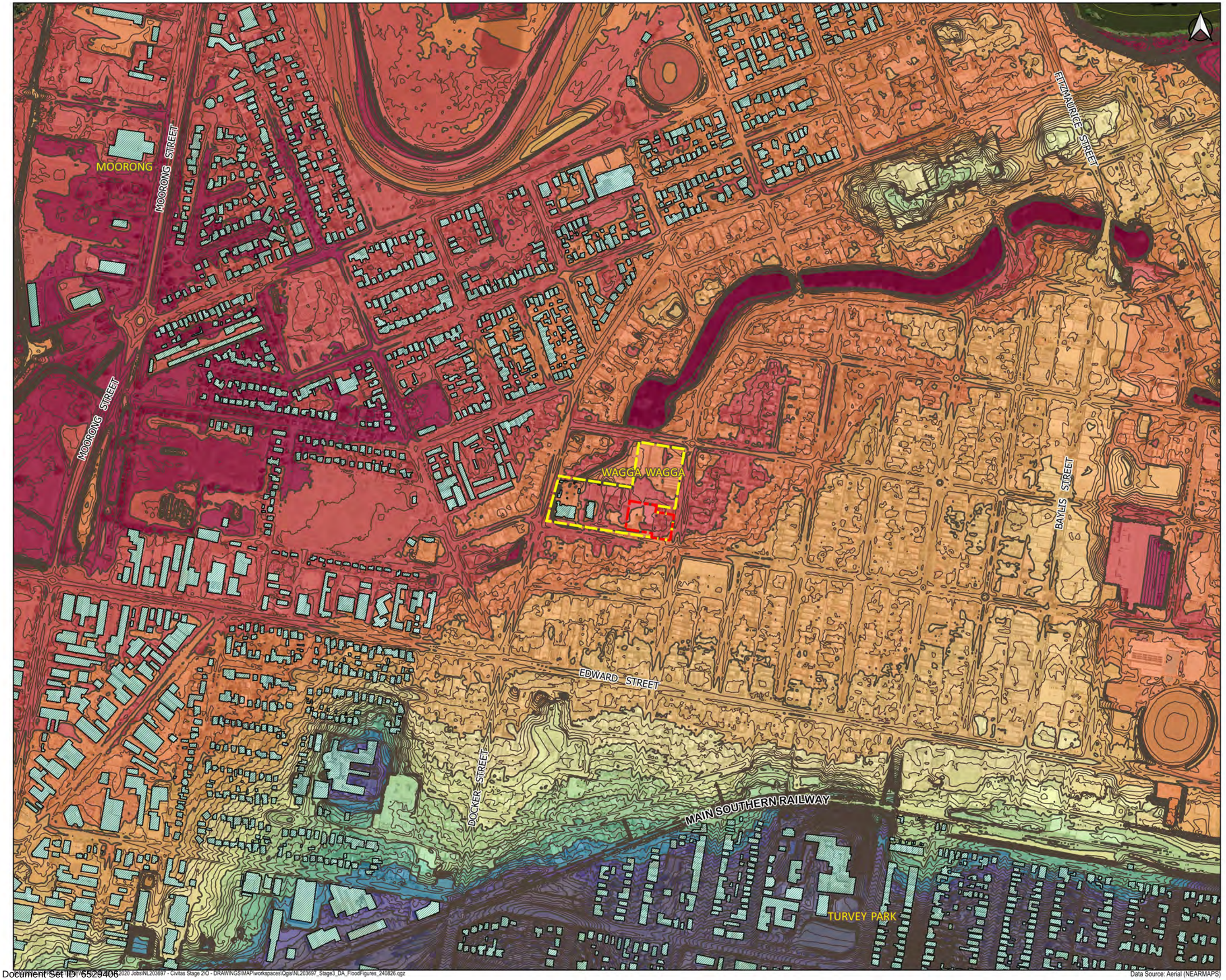
Figure C5 – Developed Case 1% AEP Flood Depth & Elevation

Figure C6 – Developed Case 1% AEP Flood Hazard

Figure D1 – Pre to Post Comparison - 10% AEP Flood Elevation

Figure D2 – Pre to Post Comparison - 5% AEP Flood Elevation

Figure D3 – Pre to Post Comparison - 1% AEP Flood Elevation



Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent
- Major Contours (1.0m)
- Minor Contours (0.25m)

Topography (mAHD)

- <= 176.0
- 176.0 - 177.0
- 177.0 - 178.0
- 178.0 - 179.0
- 179.0 - 180.0
- 180.0 - 181.0
- 181.0 - 182.0
- 182.0 - 183.0
- 183.0 - 184.0
- 184.0 - 185.0
- 185.0 - 186.0
- 186.0 - 187.0
- 187.0 - 188.0
- 188.0 - 189.0
- > 189.0

0 100 200 300 m

1:7,500

Figure A1
Existing Terrain

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)

Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent

Surface Roughness

- Pasture | DEFAULT (0.045)
- Residential Lots (0.060)
- Industrial Lots (0.070)
- Roads | Hardstand (0.020)
- Vegetation (0.100)
- Roads (0.020)
- Building Extents (10.0)

0 100 200 300 m

1:7,500

Figure A2
Existing Case
Model Setup and Roughness

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

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Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent

Surface Roughness

- Pasture | DEFAULT (0.045)
- Residential Lots (0.060)
- Industrial Lots (0.070)
- Roads | Hardstand (0.020)
- Vegetation (0.100)
- Roads (0.020)
- Building Extents (10.0)

0 20 40 60 80 m

1:2,000

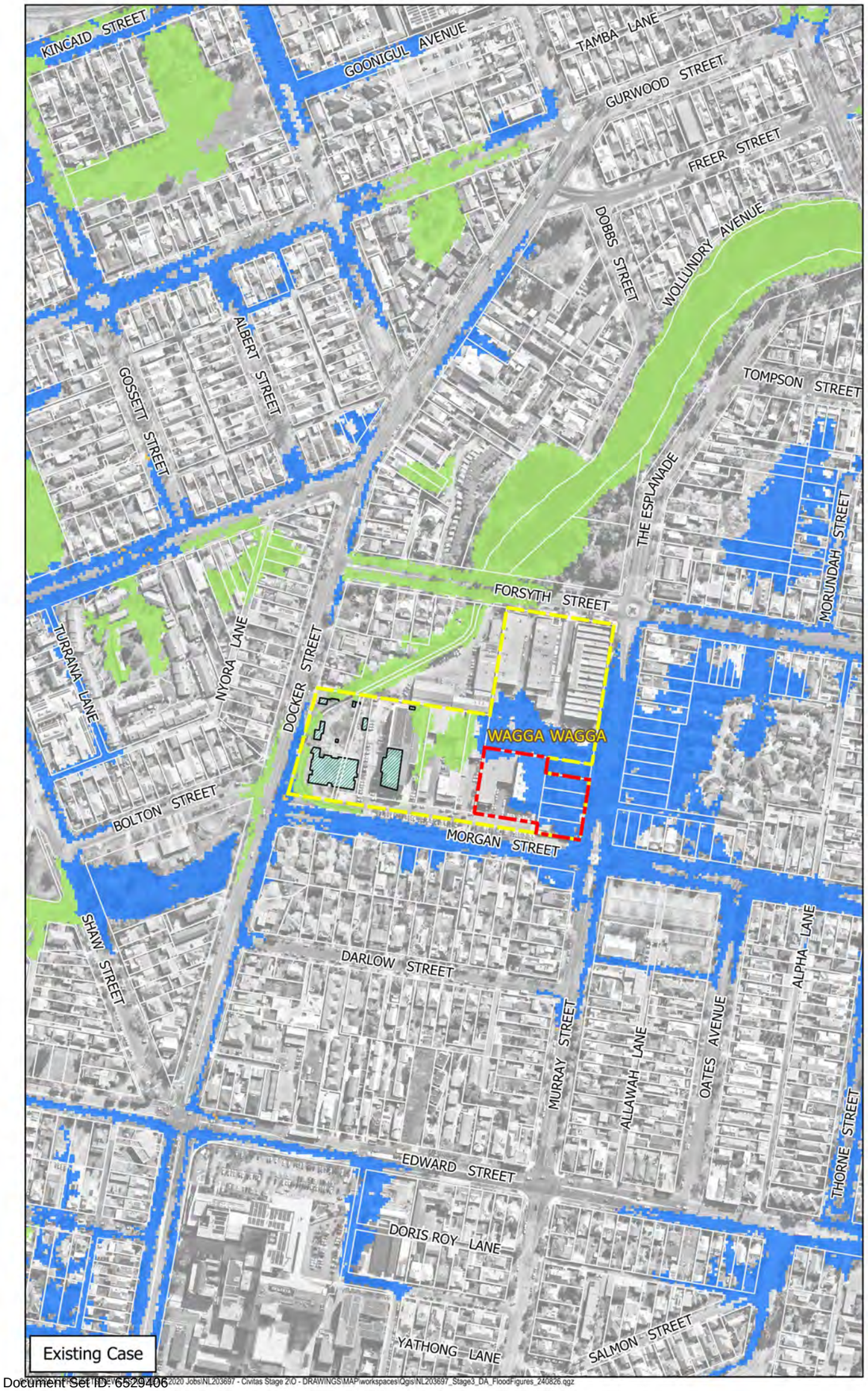
Figure A3

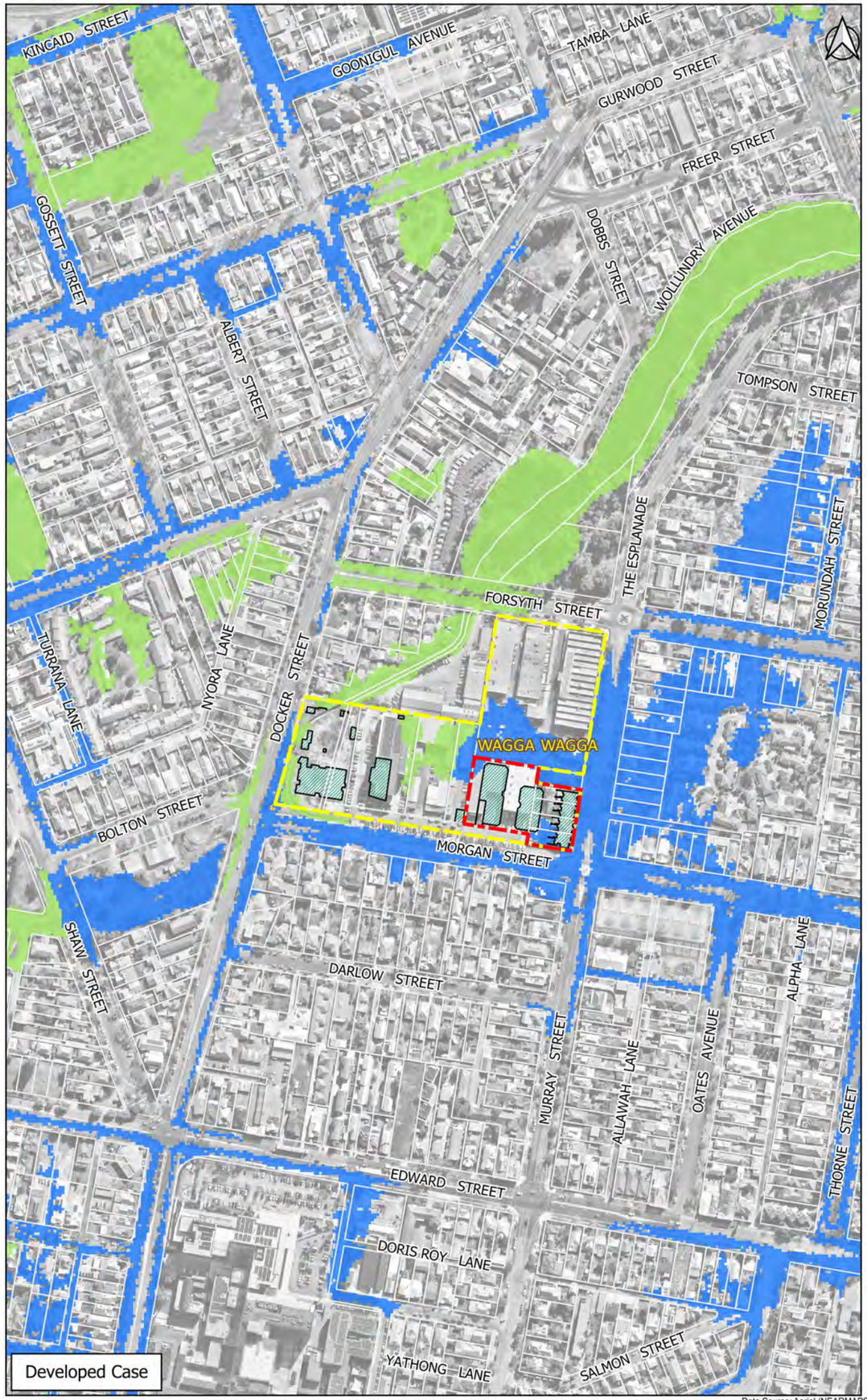
Developed Case
Model Setup and Roughness

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)





Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent

Critical Duration

- GC & P - 2 hour
- GC & P - 9 hour
- GO - 2 hour
- GO - 9 hour

0 50 100 150 m

1:4,500

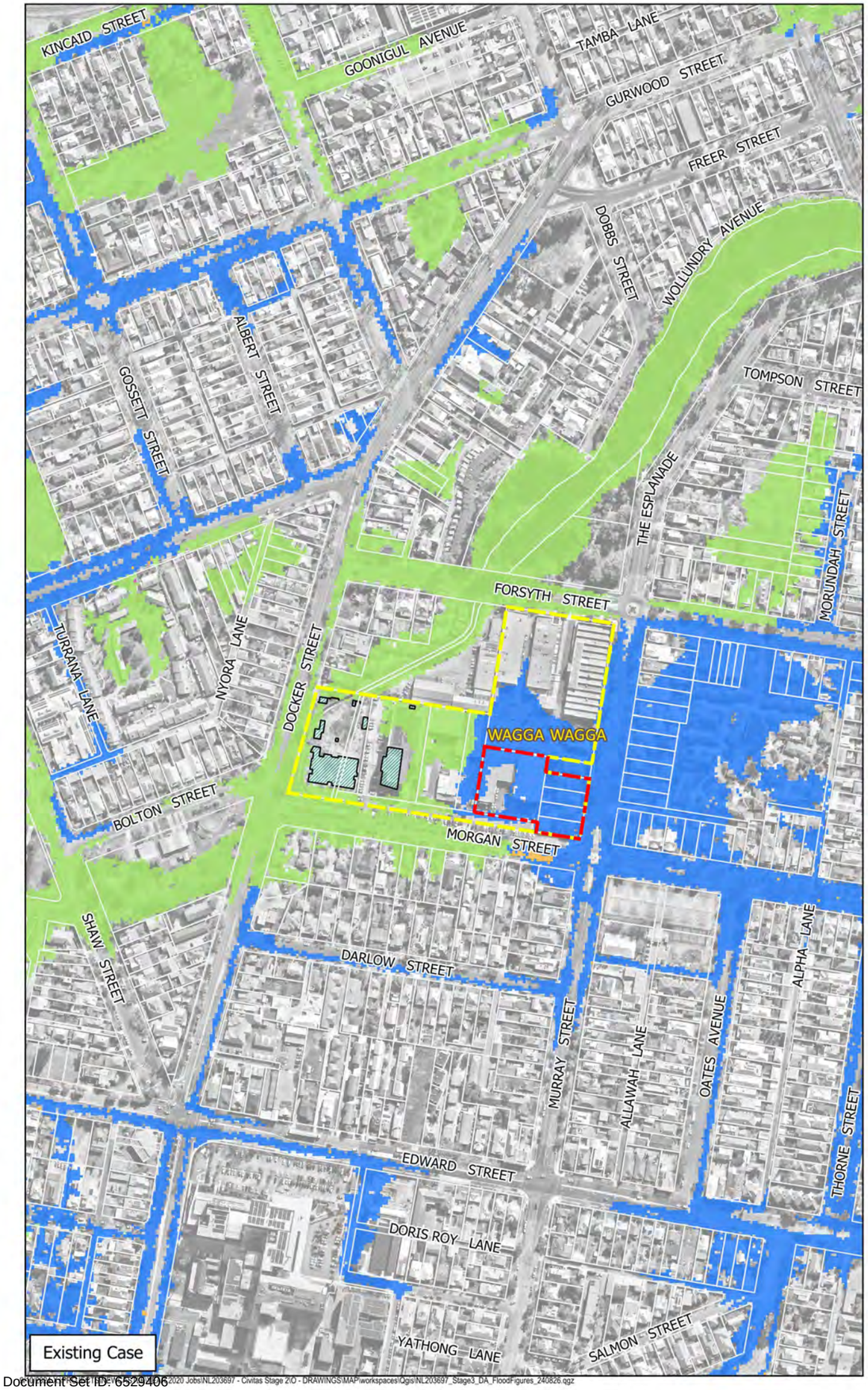
Figure A4

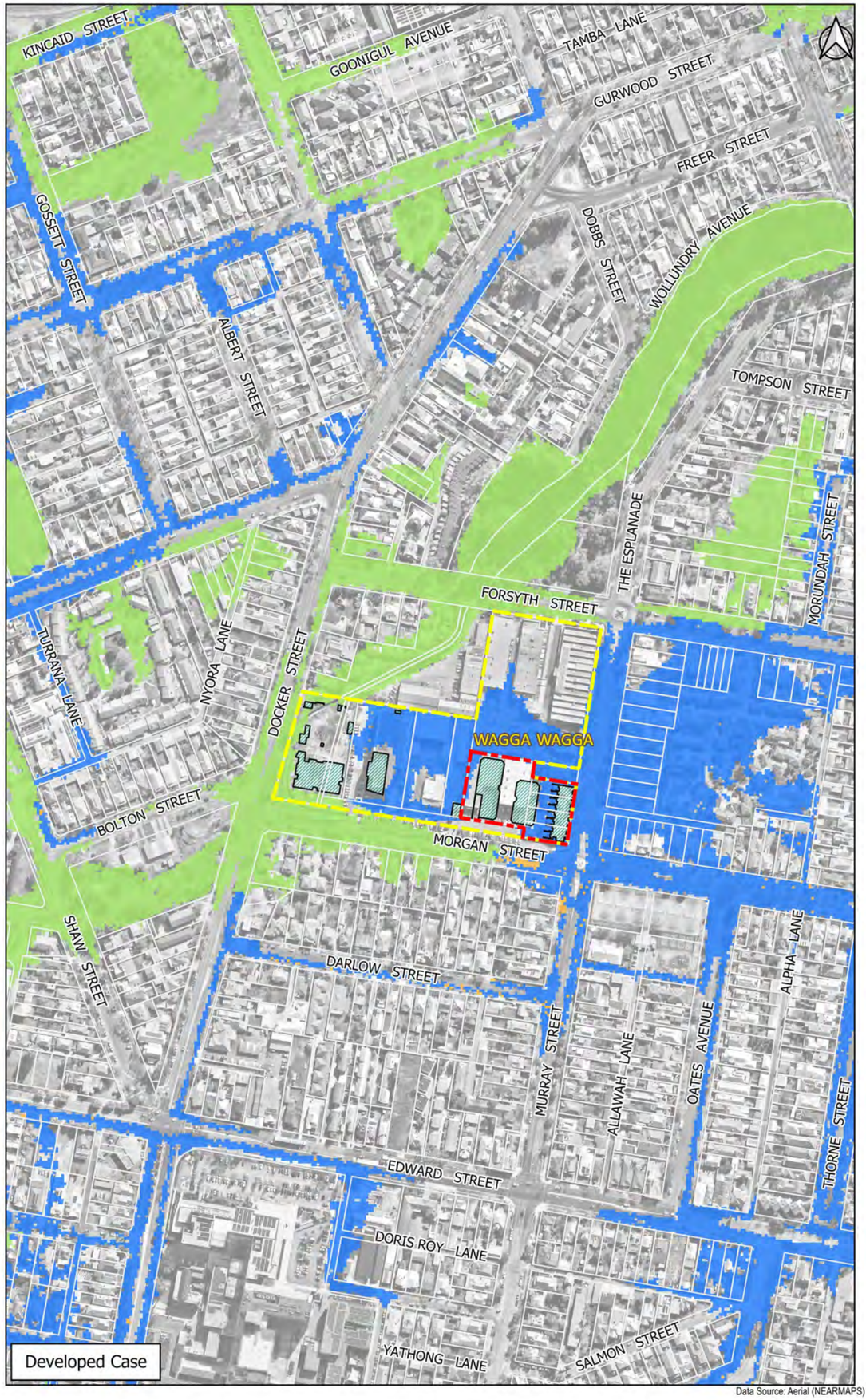
10% AEP Flood Event Critical Duration (Inclusive of Scenarios: Gates Open and Closed)

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)





Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent

Critical Duration

- GC & P - 2 hour
- GC & P - 9 hour
- GO - 2 hour
- GO - 9 hour

0 50 100 150 m

1:4,500

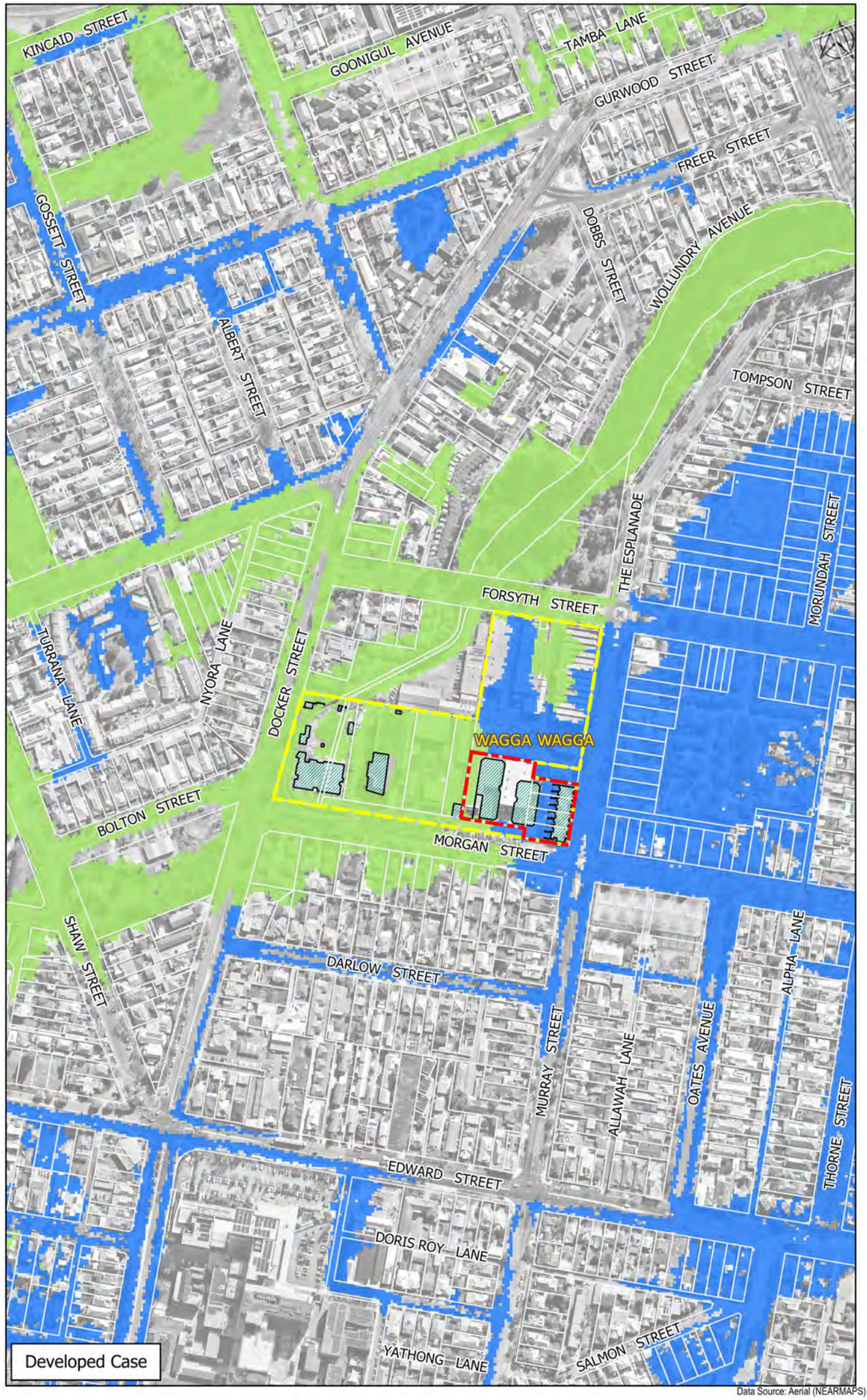
Figure A5

5% AEP Flood Event
Critical Duration
(Inclusive of Scenarios: Gates Open and Closed)

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)



Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent

Critical Durations

- GC & P - 2 hour
- GC & P - 12 hour
- GO - 2 hour
- GO - 12 hour

0 50 100 150 m

1:4,500

Figure A6

1% AEP Flood Event
Critical Duration
(Inclusive of Scenarios: Gates Open and Closed)

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)

Legend
Masterplan Extent
Stage 3 Boundary
Building Extent
500mm Flood Contours
100mm Flood Contours

Flood Depth (m)

- <= 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 5.00

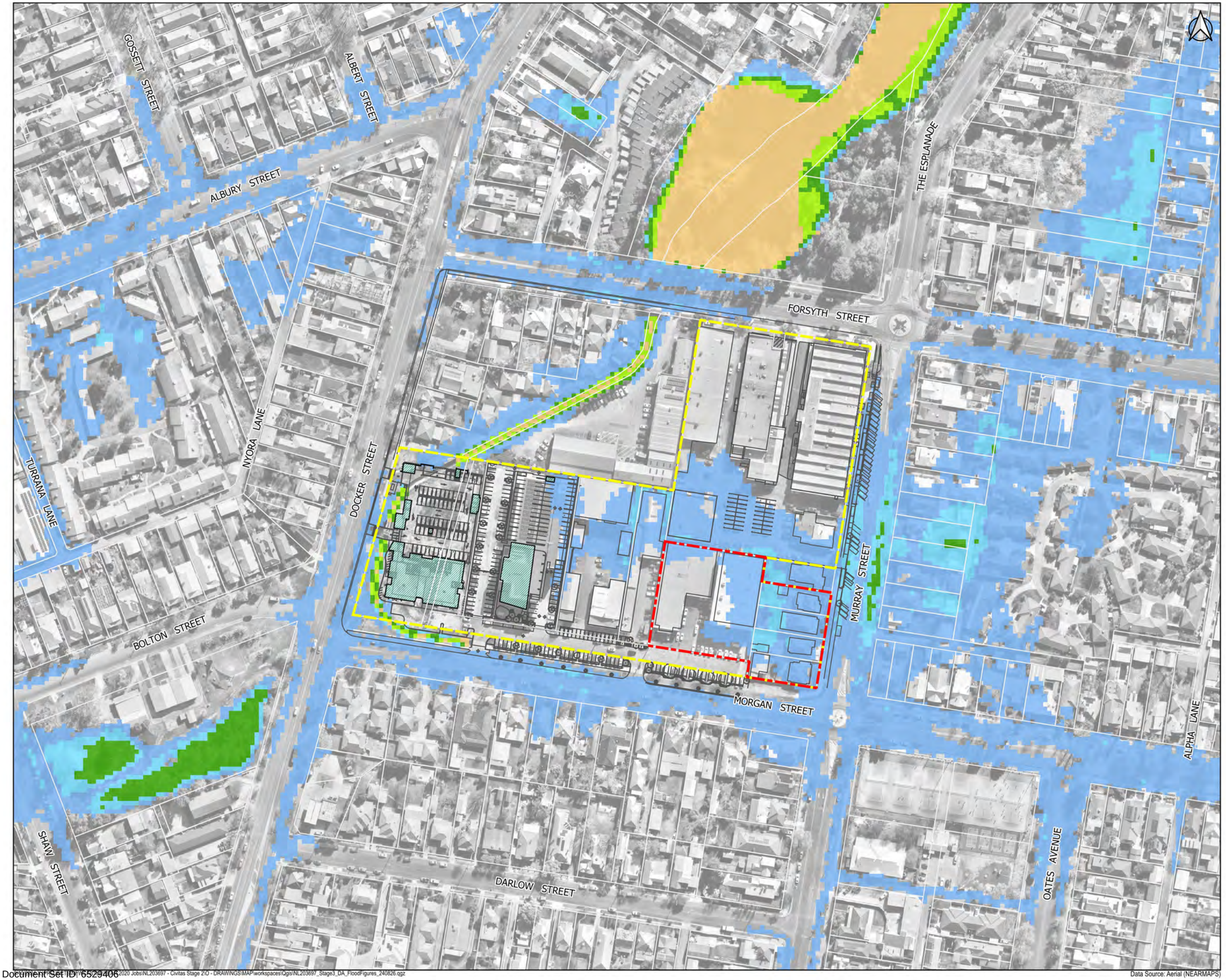
0 20 40 60 80 m
1:2,000

Figure B1
Existing Case 10% AEP Flood Depth & Elevation

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)



Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent

Flood Hazard (AR&R 2019)

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

0 20 40 60 80 m

1:2,000

Figure B2

Existing Case
10% AEP Flood Hydraulic Hazard

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)

Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent
- 500mm Flood Contours
- 100mm Flood Contours

Flood Depth (m)

- <= 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 5.00

0 20 40 60 80 m

1:2,000

Figure B3

Existing Case
5% AEP Flood Depth & Elevation

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

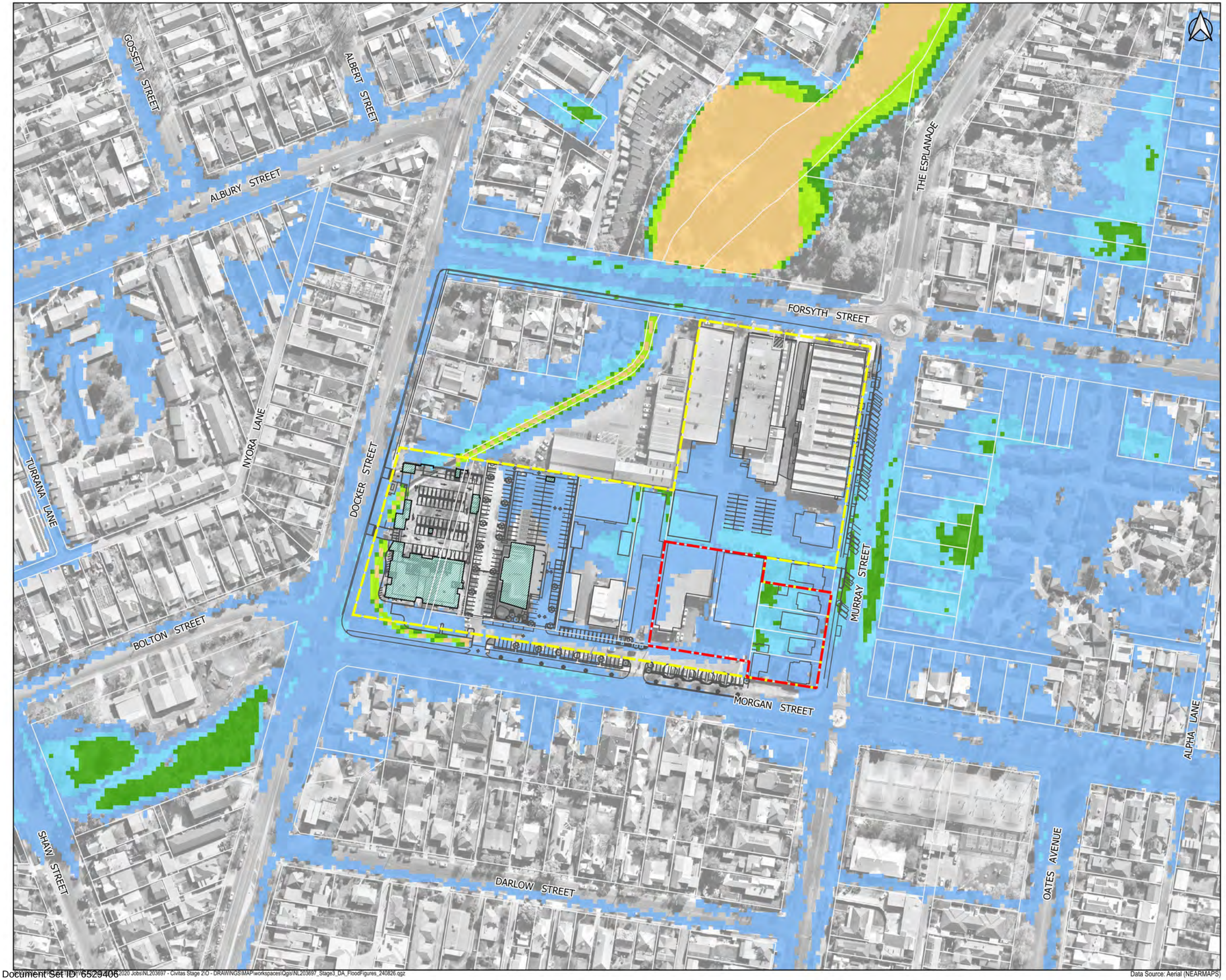


Figure B4
Existing Case
5% AEP Flood Hydraulic Hazard

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)

Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent
- 500mm Flood Contours
- 100mm Flood Contours

Flood Depth (m)

- <= 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 5.00

0 20 40 60 80 m

1:2,000

Figure B5

Existing Case
1% AEP Flood Depth & Elevation

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)

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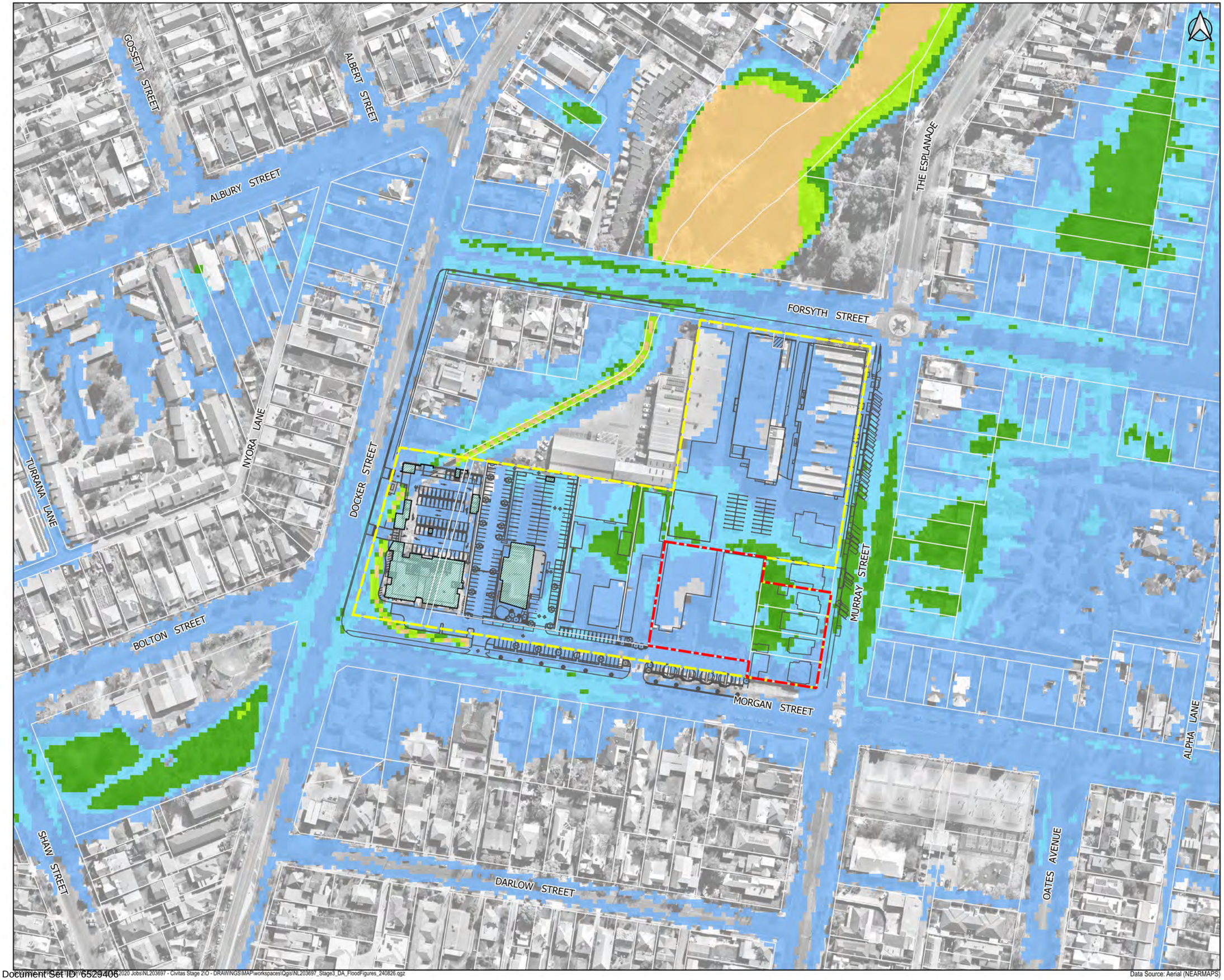


Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent

Flood Hazard (AR&R 2019)

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

0 20 40 60 80 m

1:2,000

Figure B6

Existing Case
1% AEP Flood Hydraulic Hazard

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)

Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent
- 500mm Flood Contours
- 100mm Flood Contours

Flood Depth (m)

- <= 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 5.00

0 20 40 60 80 m

1:2,000

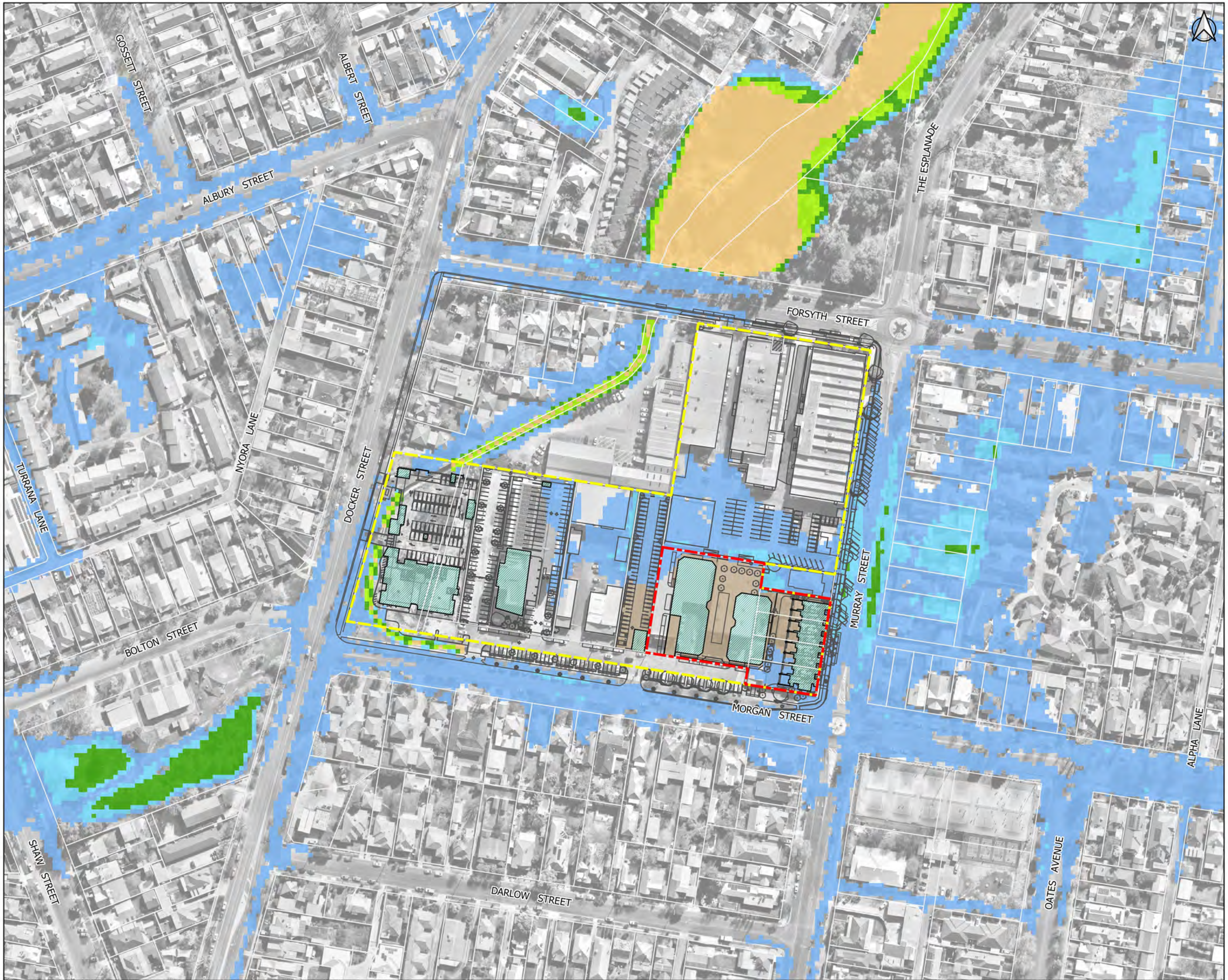
Figure C1

Developed Case
Stage 3 Development
10% AEP Flood Depth & Elevation

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)



Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent

Flood Hazard (AR&R 2019)

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

0 20 40 60 80 m

1:2,000

Figure C2

Developed Case
Stage 3 Development
10% AEP Flood Hydraulic Hazard

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Legend
- Masterplan Extent
- Stage 3 Boundary
- Building Extent
- 500mm Flood Contours
- 100mm Flood Contours

Flood Depth (m)
- <= 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 5.00

0 20 40 60 80 m

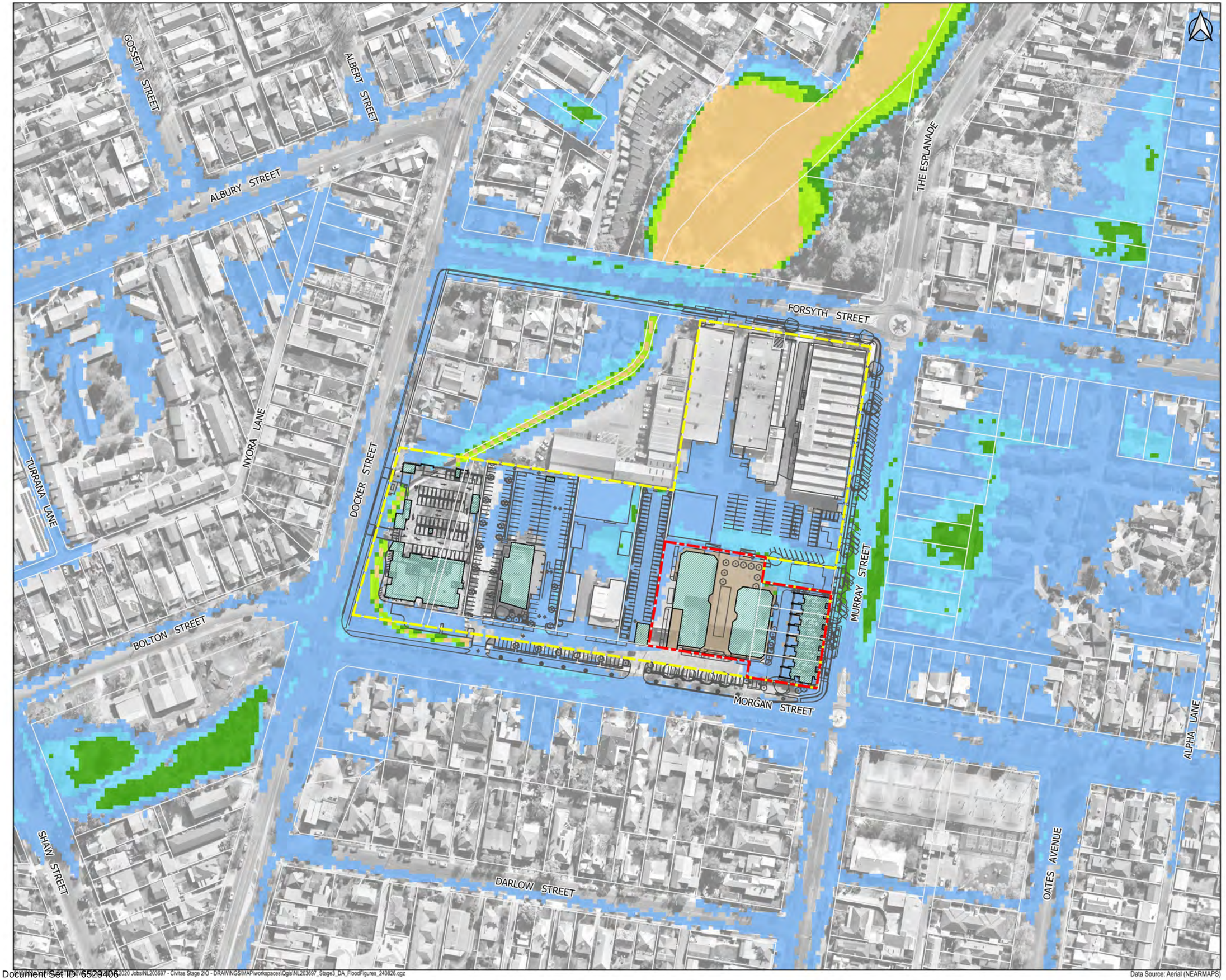
1:2,000

Figure C3
Developed Case
Stage 3 Development
5% AEP Flood Depth & Elevation

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)



Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent

Flood Hazard (AR&R 2019)

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

0 20 40 60 80 m

1:2,000

Figure C4

Developed Case
Stage 3 Development
5% AEP Flood Hydraulic Hazard

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)

Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent
- 500mm Flood Contours
- 100mm Flood Contours

Flood Depth (m)

- <= 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 5.00

0 20 40 60 80 m

1:2,000

Figure C5

Developed Case
Stage 3 Development
1% AEP Flood Depth & Elevation

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)

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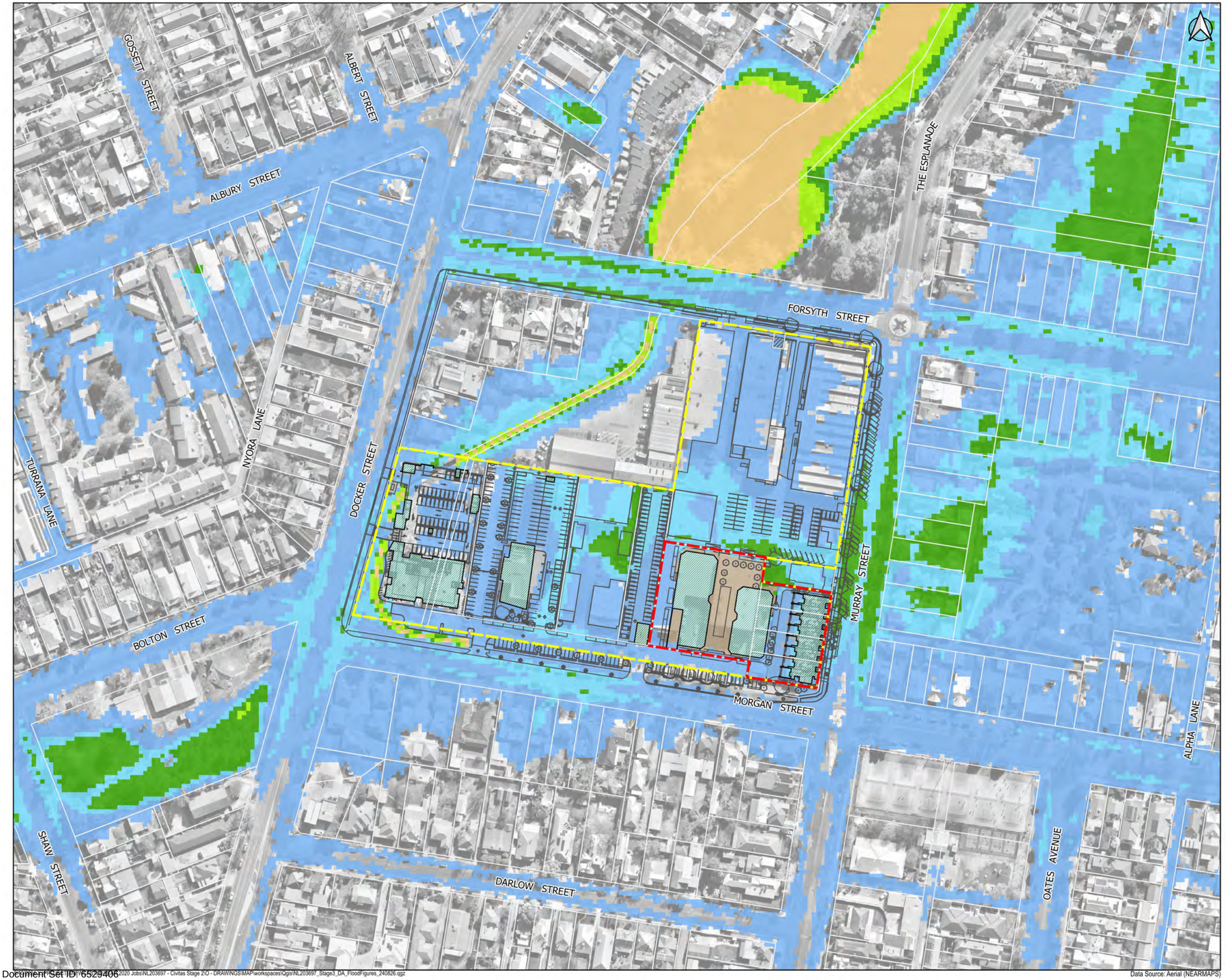


Legend

- Masterplan Extent
- Stage 3 Boundary
- Building Extent

Flood Hazard (AR&R 2019)

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

0 20 40 60 80 m

1:2,000

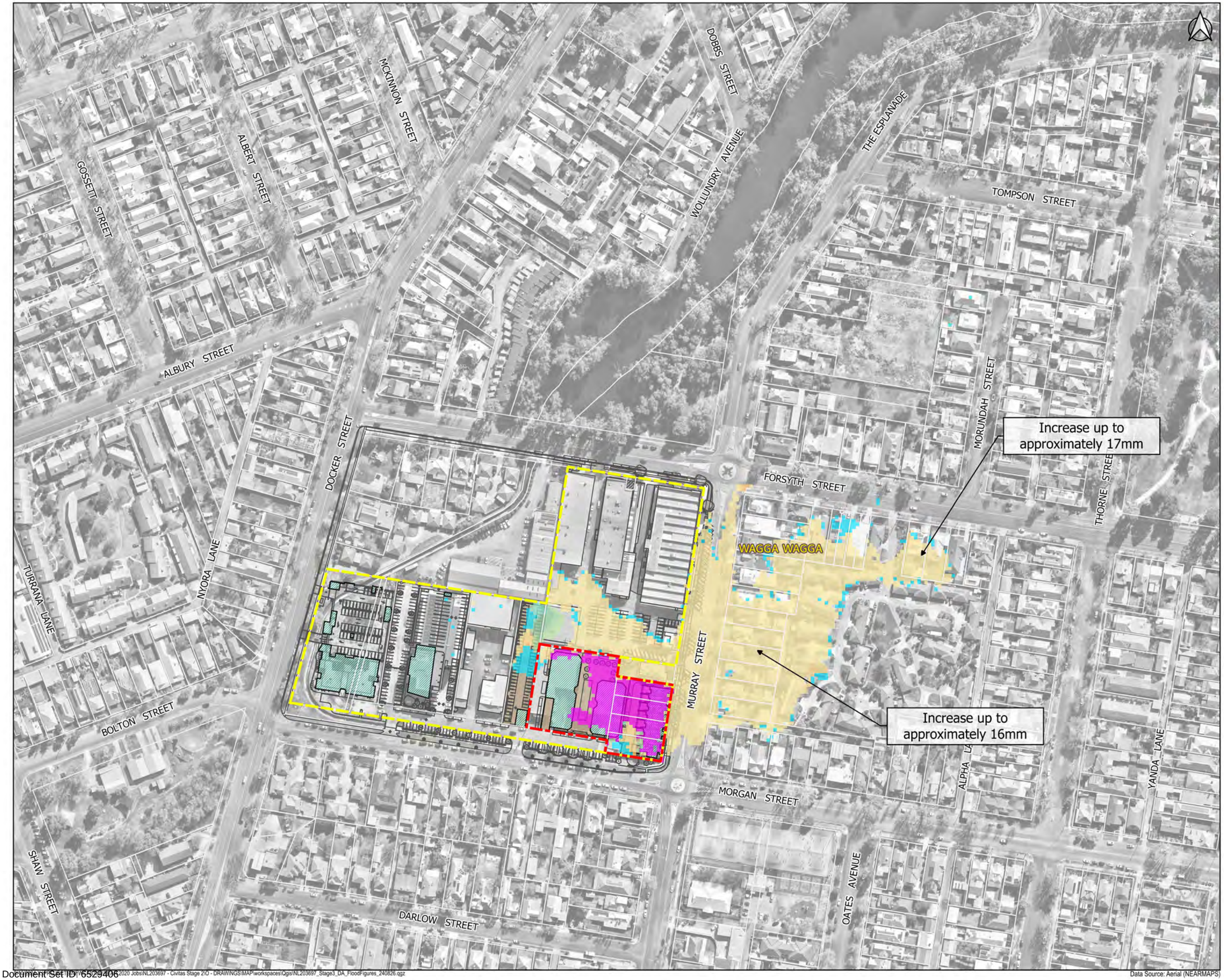
Figure C6

Developed Case
Stage 3 Development
1% AEP Flood Hydraulic Hazard

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)



Legend

- Masterplan Extent
- Stage 3 Boundary
- Developed Layout

Wet/Dry

- Was Wet Now Dry
- Was Dry Now Wet

Elevation Difference (m)

- <= -0.300
- -0.300 - -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- 0.200 - 0.300
- > 0.300

0 20 40 60 80 m

1:2,500

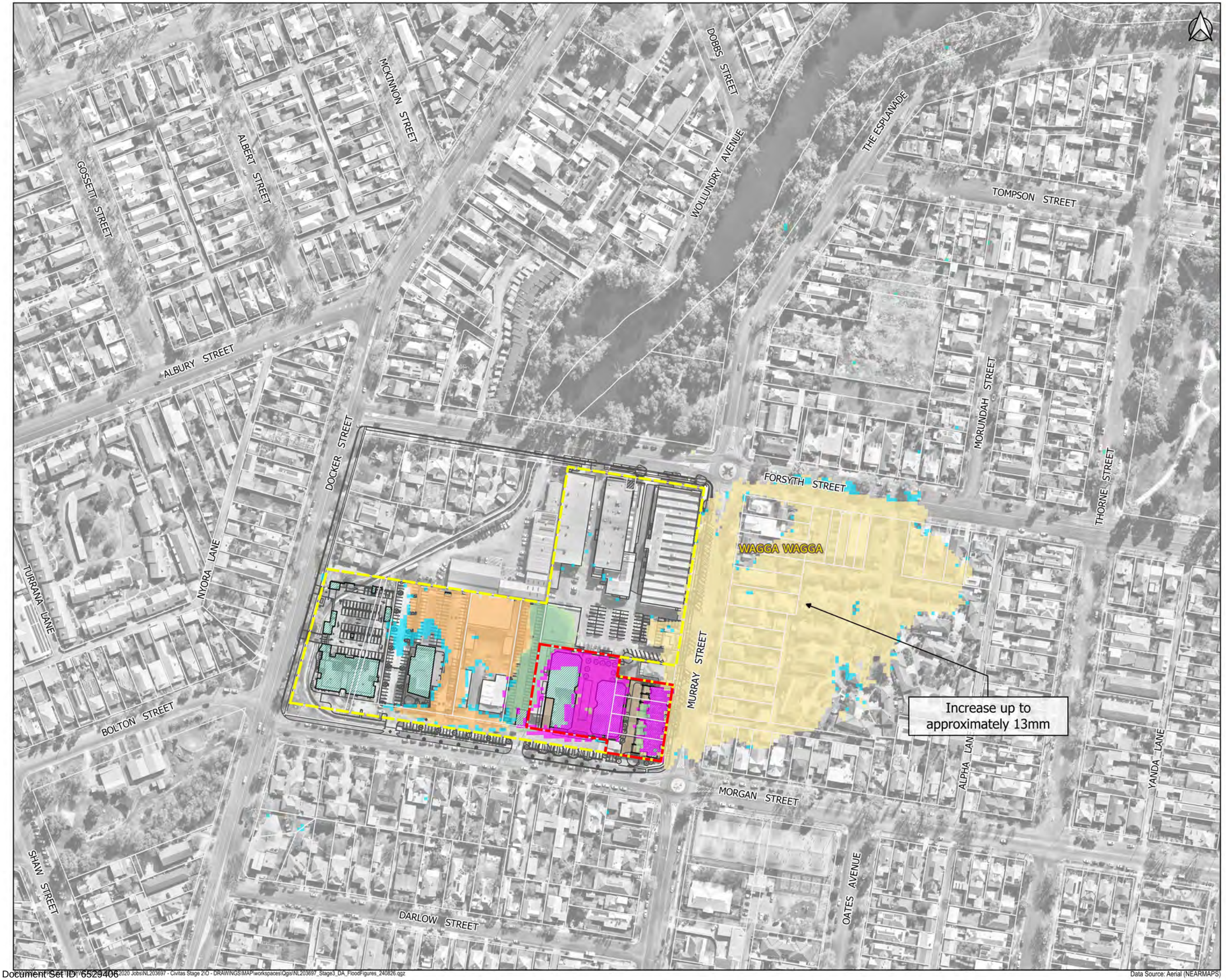
Figure D1

Pre-to-Post Comparison
10% AEP Flood Elevation

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP

Data Source: Aerial (NEARMAPS)



Legend

- Masterplan Extent
- Stage 3 Boundary
- Developed Layout

Wet/Dry

- Was Wet Now Dry
- Was Dry Now Wet

Elevation Difference (m)

- <= -0.300
- -0.300 - -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- 0.200 - 0.300
- > 0.300

0 20 40 60 80 m

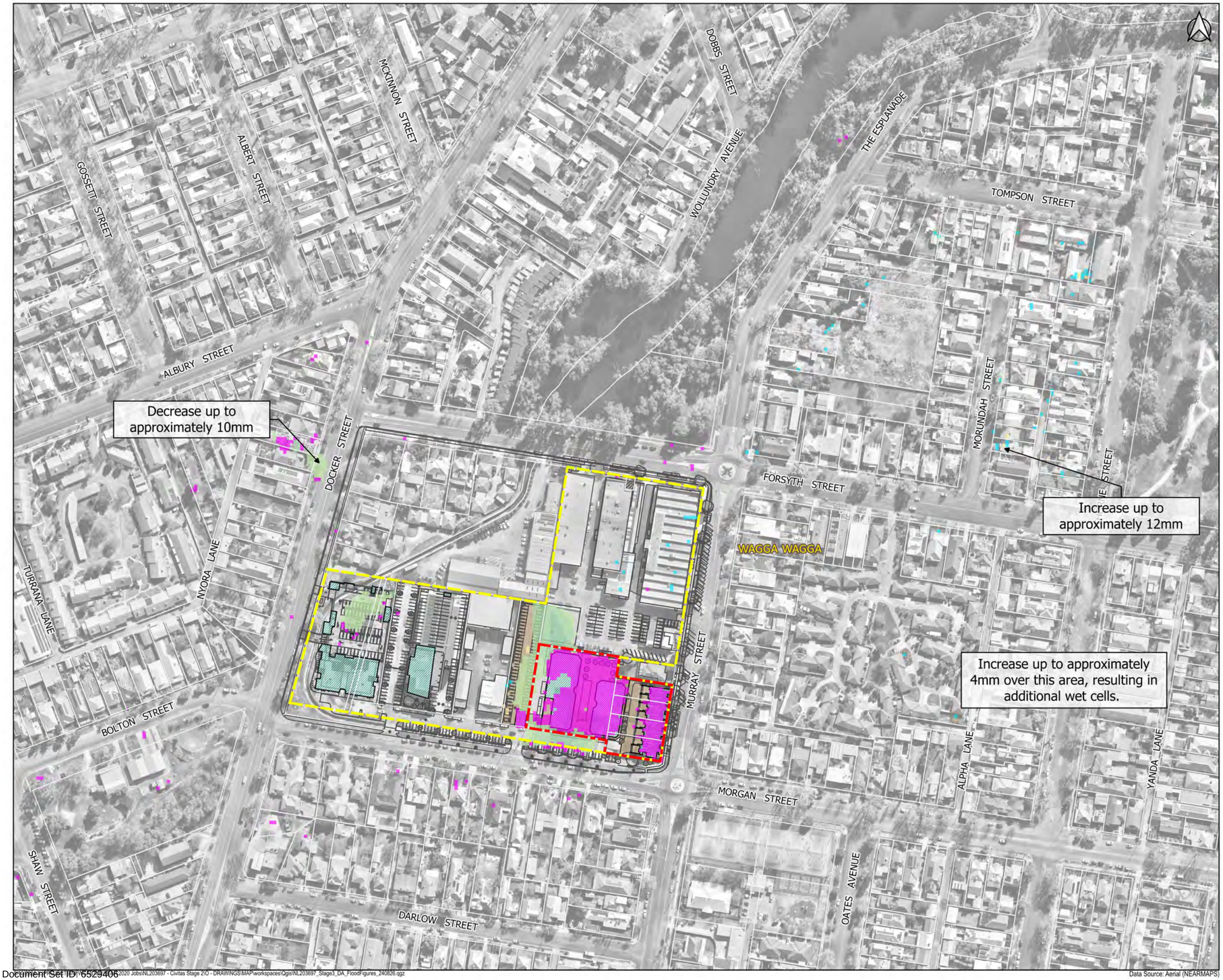
1:2,500

Figure D2

Pre-to-Post Comparison
5% AEP Flood Elevation

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP



Legend

- Masterplan Extent
- Stage 3 Boundary
- Developed Layout

Wet/Dry

- Was Wet Now Dry
- Was Dry Now Wet

Elevation Difference (m)

- <= -0.300
- -0.300 - -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- 0.200 - 0.300
- > 0.300

0 20 40 60 80 m

1:2,500

Figure D3

Pre-to-Post Comparison
1% AEP Flood Elevation

Civitas Stage 3
Morgan Street, Wagga Wagga
NL203697

NORTHROP