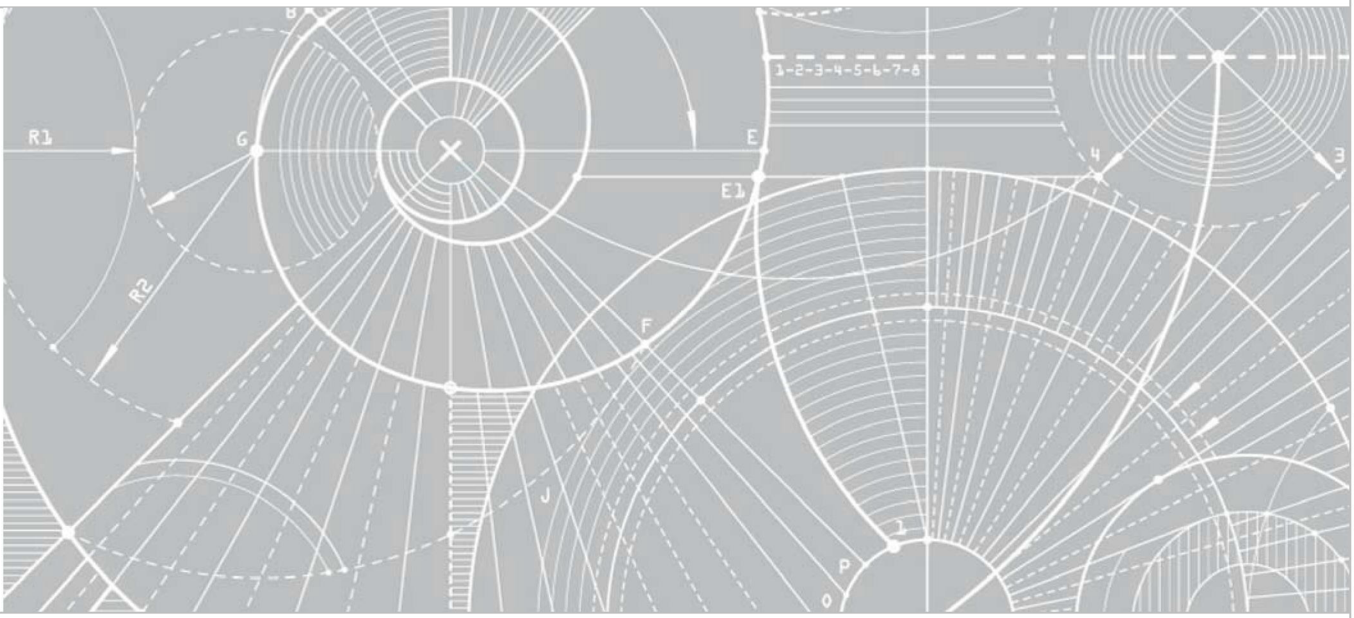
Central Precinct of St Mary's Project Development

EAST WEST CONNECTOR FLOOD ASSESSMENT REPORT

Final Report

February 2018



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Central Precinct of St Mary's Project Development: East West Connector

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Document history and status

Revision	Date	Description	By	Review	Approved
0	29/1/2018	Draft for Lend Lease review	Alana Scott	Samantha Watt	John Constandopoulos
1	16/2/2018	Draft updated based on Lend Lease comments	Alana Scott	Samantha Watt	John Constandopoulos
2	21/2/2018	Final report	Alana Scott	Samantha Watt	John Constandopoulos

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

Executive Summary

Lendlease is developing a series of villages as part of their St Mary's Project, including the Dunheved and Central Precincts in the Penrith City Council and Blacktown City Council area. These two development areas are located adjacent to South Creek and Ropes Creek, near the confluence of the two creeks.

In 2015, a fill plan and associated impacts on flood levels was prepared in support of the Bulk Earthworks Development Application (DA) process (DA14/1228), which gained Council approval on 20 August 2015. The Bulk Earthworks DA recommended a series of flood mitigation measures as part of the delivery of the East West Connector road, and recommended the future assessment of flood impacts during the preparation of the East West Connector road design, to confirm that upstream and downstream impacts remain consistent with those approved within the Bulk Earthworks DA. Subsequent to this assessment, the design of the East West Connector road has been further progressed. As such, Lendlease is submitting a Development Application which seeks approval to construct the East West Connector road and other associated infrastructure according to the refined design.

Previously, potential flooding impacts in South Creek and its tributaries due to the proposed development were assessed by Jacobs using the 1D/2D hydraulic modelling program MIKEFLOOD. This report and associated work builds on the 2015 assessment, and identifies the impacts of the refined design.

The MIKEFLOOD model developed as part of the 2015 assessment has been revised to provide a more detailed assessment of the refined East West Connector Road design and capture the additional detail which has become available during the design evolution process. The updated model has been developed with consistent assumptions and verified to produce results consistent with PCC's South Creek Flood model, developed in RMA-2 by Worley Parsons.

The refined developed scenario consists of the approved fill layouts for both the Dunheved and Central Precinct areas, filling of Regional Open Space areas, upgrades to the East West Connector road and the associated South Creek and Ropes Creek bridges, inclusion of additional high flow culverts to the west of South Creek and inclusion of a bank of pipes under the proposed Links Connector Road. A small berm has been included at the southern end of the Dunheved fill platform, as well as a backwater prevention device on the culvert in the Dunheved riparian corridor, to prevent flow into the industrial area on Links Road.

Consistent with what was approved as part of the bulk earthworks DA, a number of hydraulic improvements to the floodway are proposed as part of the planned development to maintain flood conveyance through this reach. Some refinement of these has been incorporated as part of the evolution of the design. The following list includes all elements included within the current design:

- Removal of Old Munitions Road embankment;
- Removal of stockpiles on the western floodplain;
- Increased waterway area through the South Creek bridge;
- Increased waterway area through the Ropes Creek bridge; and
- Additional culverts under the western section of the East West Connector.

The channel conveyance within South Creek is essentially unchanged upstream and downstream of the site boundary. Additionally, there is no change in the timing of flows arriving at locations downstream of the site.

The development scenario produces 34 mm impact at the upstream site boundary and 7 mm at the downstream site boundary during a 1% AEP regional tailwater event. This represents a minor decrease (from 38 mm) in the predicted impacts compared to those approved as part of the Bulk Earthworks DA.

Upstream impacts affect a total of four (4) lots - the Sydney Water Recycled Water Scheme site, Dunheved Golf Course and Links Road. This is less than the total of five (5) lots reported as impacted in the 2015 body of work. No buildings are impacted on these lots inundated within the developed scenario. There is no increase in the duration of flooding expected within the Golf Course under developed conditions.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

Impacts at the downstream boundary are 7 mm and 11 mm in the regional and local tailwater scenarios. The characteristics of the floodplain result in relatively little attenuation, meaning these small impacts propagate for a significant distance downstream in the local tailwater event. However, these impacts do not cause a significant increase in flood extent, or result in inundation of additional properties.

No additional properties will be affected by the Flood Planning Area in the developed scenario. Four (4) upstream industrial properties on Links Road will potentially be affected by an increase in the Flood Planning Area. This is consistent with the previous Bulk Earthworks DA reporting, which indicated 4 lots would be impacted by an increase in FPA area, and one impacted by a decrease.

Velocity changes in the 1% AEP event at the downstream boundary of the site represent less than a 1% increase. At the upstream site boundary, there is a minor change to the velocity profile due to the increased conveyance along the western bank of South Creek, as well as an increase within South Creek itself.

It is important to consider the potential for cumulative filling within the floodplain as part of a merit-based assessment. The Lendlease site encompasses the width of the South Creek floodplain through this reach. The Central Precinct and Dunheved fill areas form part of a larger regional plan which includes handover of the residual floodplain areas to the NSW Government to manage as Regional Park. Therefore, future filling and further encroachment within this section of South Creek is highly unlikely. Hence, the assessment for the proposed developed scenario can be considered to be a cumulative assessment of the total fill possible in this reach of the floodplain.

The developed scenario presented here provides an appropriate balance of flood immunity, upstream and downstream flood impacts, constructability and environmental impact that is achievable and consistent with the Bulk Earthworks DA approval.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

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Contents

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

1. Introduction

1.1 Background

Lendlease is developing a series of villages as part of their St Mary's Project including the Dunheved and Central Precincts in the Penrith City Council (PCC) area. These two development areas are located adjacent to the South Creek and Ropes Creek floodplains, near the confluence of the two creeks. In 2015, a fill plan and associated impacts on flood levels was presented to Council as part of the Bulk Earthworks Development Application (DA) process (DA14/1228), which gained Council approval on 20 August 2015.

The Bulk Earthworks approval included allowance for upgrade to the East West Connector Road based on a concept design to raise the road and offset upstream flood impacts through increased conveyance through the South Creek structures. Subsequent to this assessment, the design of the East West Connector road has been further progressed. As such, Lendlease is submitting a Development Application which seeks approval to construct the East West Connector road and other associated infrastructure according to a refined design.

Since the Bulk Earthworks approval, consultation between PCC and Lendlease has identified a need to raise parts of the Regional Open Space (ROS) areas to be located between the Central Precinct fill area and South Creek to provide a level of flood immunity to the planned facilities. This Development Application also seeks approval for the filling of these areas to provide the target flood immunity identified by PCC.

Lendlease commissioned Jacobs to provide an updated flood assessment for the revised development. This assessment builds on the work done in 2015 for the Bulk Earthworks DA, detailed in the *Central Precinct of St Mary's Project Development: Flood Assessment Report, Final (REVL)*, 20 July 2015 (Jacobs, 2015). The MIKEFLOOD hydrodynamic model used for the Bulk Earthworks assessment has been further refined for the purposes of this more detailed assessment of the East West Connector road design. The refined model has been developed with consistent assumptions and aims to produce consistent results with both the previous model and PCC's RMA-2 model.

1.2 Purpose of the report

The purpose of this report is to detail the flood assessment of the proposed modified East West Connector road and associated works to demonstrate consistency with the approved outcomes of the Bulk Earthworks DA approval.

The report details the refinement and application of the MIKEFLOOD hydraulic model built for the Bulk Earthworks flood assessment to assess the impacts of the proposed East West Connector road development and associated works, consistent with PCC's requirements.

1.3 Report outline

This report details the hydraulic modelling and assessment of potential flood impacts, under the following headings:

- Section 2 - Review of available information
- Section 3 - Hydraulic model development
- Section 4 – Existing flood behaviour
- Section 5 - Flood assessment for development scenario
- Section 6 - Conclusions and recommendations

1.4 Reliance Statement

The sole purpose of this report and the associated services performed by Jacobs is to provide a model consistent with Penrith City Council's model to assess potential impacts of the Central Precinct development area in accordance with the scope of services set out in the contract between Jacobs and the Lendlease.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

In preparing this report, Jacobs has relied upon, and presumed accurate, certain information (or absence thereof) provided by Lendlease, PCC, Worley Parsons and other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from a variety of sources. The sources are identified at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose of the project and by reference to applicable standards, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of Lendlease, and is subject to, and issued in connection with, the provisions of the agreement between Jacobs and Lendlease. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

2. Review of available information

2.1 Previous investigations

2.1.1 SKM MIKE11 model

In 2007, SKM developed a MIKE11 hydrodynamic model incorporating lateral linking (quasi two-dimensional) to assess the potential flooding impacts in South Creek and its tributaries to the proposed development, on the Dunheved and Central Precincts of the St Marys Project. Reporting on this assessment can be found in, the *Dunheved Precinct Development Application* (SKM, March 2007) and *Addendum* (SKM, December 2007).

2.1.2 Worley Parsons RMA-2 model

In 2013, Worley Parsons was commissioned by PCC to undertake the *South Creek Flood Study*. As part of this study, Worley Parsons developed an RMA-2 hydrodynamic model.

While the RMA-2 model has not been made available, selected model outputs were provided to Jacobs for the purpose of model verification in the vicinity of the Dunheved and Central Precinct sites (the Project site). This information was provided in a memo dated 5 July 2013 and entitled *South Creek Flood Study: Provision of DRAFT Results at ADI Site, St Marys* (Worley Parsons, 2013). Information provided within this memo included:

- inflow hydrographs for 5%, 1% and PMF flood events;
- tailwater conditions for these events for both regional and local flood events;
- resulting flood surface profiles for these events with both regional and local tailwater conditions;
- resulting flood extents for these six events; and
- classification of flood characteristics in the flood corridor.

The hydrographs provided were exported from the RMA-2 for both Ropes Creek and South Creek. The locations of the hydrograph exports were directly upstream of the Project site. Three hydrographs were provided at each location for the 5% AEP, 1% AEP and PMF events.

A downstream tailwater level was provided for each event based on two tailwater scenarios, representing a local flood event and a local event coincident with a regional flood event in the Hawkesbury River. The tailwater for each flood scenario was reported at a location in South Creek 2.6 km downstream of Richmond Road.

Water surface level profiles were provided along both South and Ropes Creeks. The South Creek profile extended from Dunheved Road to Eighth Avenue while the flood profile in Ropes Creek extending from Ropes Crossing Boulevard to the confluence with South Creek.

Maps of flood inundation extents were provided for the 5% AEP, 1% AEP and PMF events with local tailwater conditions. Hydraulic category mapping was provided based on the 1% AEP flood under local tailwater conditions.

2.1.3 Jacobs MIKEFLOOD model

In 2015, potential flooding impacts in South Creek and its tributaries due to the proposed development on the Dunheved and Central Precincts of the St Marys Project were assessed by Jacobs using the 1D/2D hydraulic modelling program MIKEFLOOD. The assessment was developed with consistent assumptions to produce results consistent with PCC's RMA-2 model. The MIKEFLOOD model was also developed to be consistent with the MIKE11 model (SKM 2007). Worley Parsons undertook an independent peer review of REVKA of this Flood Assessment Report in July 2015 and found the approach and model "*to be a suitable tool for the assessment of flood behaviour and flood impacts for the Lendlease site*".

Full details of the model development and flood assessment can be found in the report, *Central Precinct of St Mary's Project Development: Flood Assessment Report, Final (REVL)*, 20 July 2015 (Jacobs, 2015).

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

2.2 Additional data collected for this study

2.2.1 Data on waterway crossings

Hydraulic structures within the model area were characterised using detailed ground survey and additional survey sourced during the 2015 work. However, detailed survey was not available at the time for several smaller existing drainage structures.

Additional survey was gained on the following structures following completion of the 2015 assessment (see Figure 2-1):

- Culverts under the East West Connector to the east and west of Ropes Creek Bridge
- Culvert along the East West Connector, in-between the South Creek Bridge and Ropes Creek overflow culverts (north-east of South Creek Bridge)
- Culverts under Link road, adjacent to the Dunheved Precinct
- Culvert within formed channel within Dunheved Precinct
- Culvert within formed channel adjacent to Dunheved Precinct on the eastern side, downstream of the St Marys WWTP site.

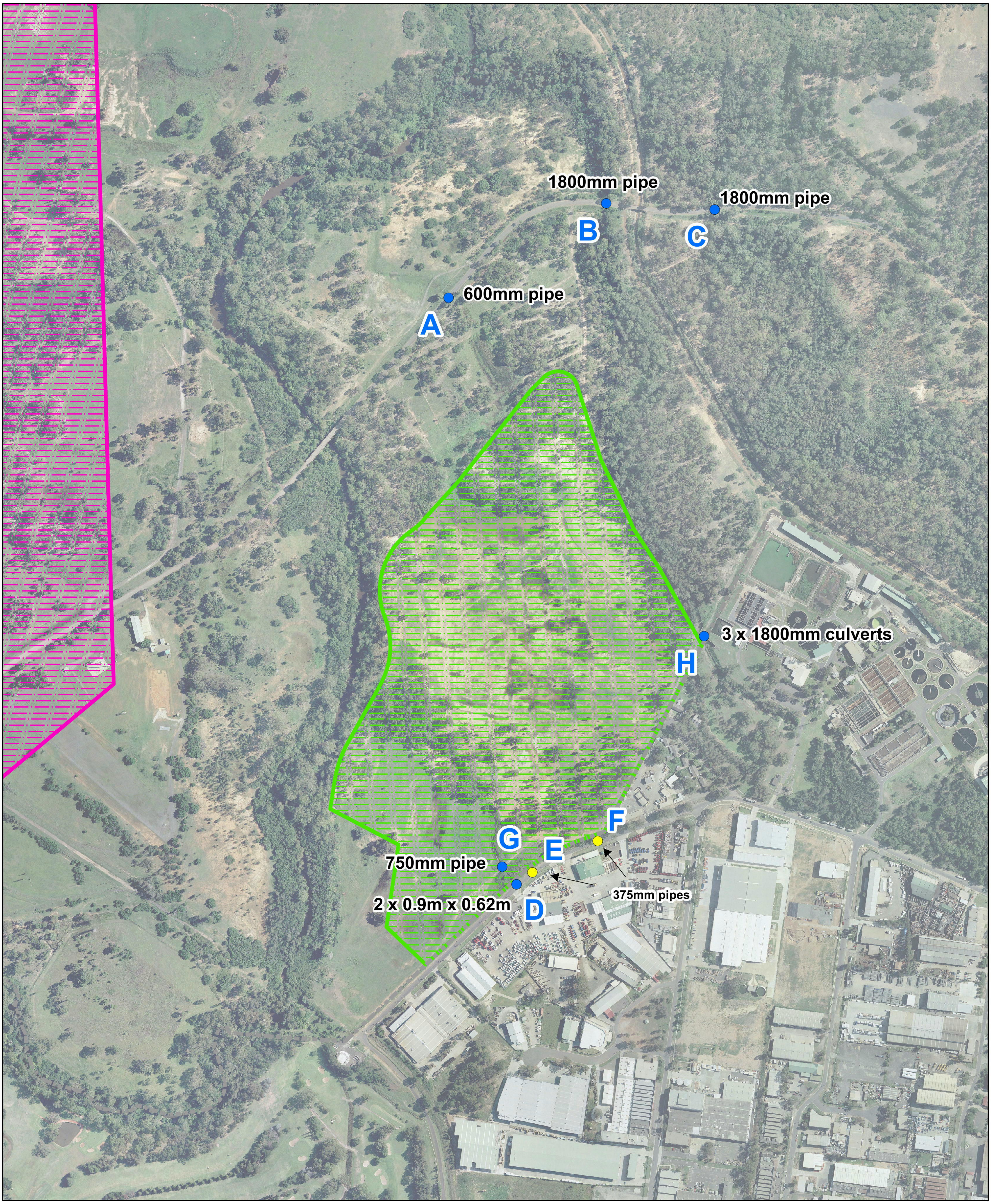
2.3 Proposed Design

The following updated design elements were provided by Lendlease:

- The fill layout for the proposed East West Connector road
- The fill layout for the Link Connector road (previously described within the bulk earthworks DA as Dunheved Link road).
- The fill layout and culvert configuration for the structure under the Link Connector road.
- Updated bridge design for the South Creek and Ropes Creek bridges
- Culvert configuration at South Creek Overflow
- Approved fill layout for the Dunheved precinct site
- Fill layout for the Regional Open Space areas

The Central Precinct fill remained as per previous modelling in 2015. The layout is discussed in more detail in Section 5.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

Structures

Not Modelled

Modelled

Site Boundary

Dunheved Precinct

Central Precinct

ABC Structures Reference Name

0 55 110 220 330 440 550 Meters

Scale in A4

Figure 2-1
Location of surveyed transverse drainage structures

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3. Hydraulic model development

3.1 Adopted hydraulic modelling approach

The previous MIKEFLOOD model from the 2015 investigation was adopted and adapted for this work. MIKEFLOOD links the two-dimensional (2D) hydraulic modelling package MIKE21 to the one dimensional (1D) hydraulic modelling package MIKE11. This allows for detailed 1D modelling of specific hydraulic structures inside a 2D flood model.

The MIKE21 model represents the investigation area topography as a terrain grid, with the following parameters input to the model to define flow behaviour:

- Downstream boundary conditions;
- Terrain roughness (entered as Manning's roughness); and
- Eddy viscosity;
- Design or historical inflow time series.

The hydraulic model area did not change from the 2015 work; it starts approximately 500 m downstream of Christie St and extends just past the Richmond Road Bridge over South Creek. The model extent extends significantly upstream and downstream of the Project site for use of the modelling results to assess flood impacts through the Project site, as well as upstream and downstream of the site. The adopted hydraulic model extent is shown in Figure 3-1.

The downstream boundary conditions did not change from the 2015 work, where downstream boundary conditions were adopted to replicate those nominated by Worley Parsons (2013). In the 2015 body of work, the sensitivity of the model to the adopted downstream boundary conditions was tested in the MIKEFLOOD model and was found to have little impact on the model results upstream on Richmond Road. This is due to the action of the Richmond Road Bridge as a hydraulic control.

Hydraulic roughness values (Manning's M) were used to describe the different surfaces in the hydraulic model. Chosen roughness values have not changed since the 2015 work.

As per the 2015 work, a uniform eddy viscosity of 0.5 was applied across the full model area, consistent with the 10 m resolution grid adopted, as recommended by the model developers.

3.2 Model refinements

To facilitate the more detailed design of the proposed structures under the East West Connector, the following refinements to the existing case model used for the 2015 investigation were undertaken:

- Update to 2016 version of MIKEFLOOD
- Updated existing structure information based on updated survey data
- Updated modelling approach for existing culverts to the east and west of Ropes Creek Bridge, based on updated survey data
- Included modelling of culverts not previously represented, according to updated survey data
- Updated representation of existing Ropes Creek bridge
- Updated structure loss values, based on detailed review of head loss against first principles estimates.

Additionally, new hydrologic inputs were created in order to model more frequent flood event required for assessment of the target ROS area flood immunity. Details on the refined aspects of the model are presented in the following sections.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

3.2.1 Terrain updates

The terrain used in the hydraulic modelling was as per the 2015 work, with small terrain modifications near structures with improved representation in the model.

3.2.2 Boundary conditions

No hydrologic modelling was undertaken for this assessment. As per the 2015 work, model inflows for the 5%, 1% and PMF flood events were as provided by Worley Parsons (Worley Parsons, 2013). It was assumed that the provided hydrographs were representative of flows for the critical duration storm at the Project site. No verification of the appropriateness of the adopted flows was undertaken.

To assess the flood immunity for the ROS areas, inflow hydrographs and downstream tail water conditions for the 20% AEP flood event were required although not provided by Worley Parsons.

A flood frequency analysis (FFA) was completed for the South Creek @ G.W.H" (212048) gauge, located approximately 2.5 km upstream of the model inflow boundary. A Log Pearson 3 (LP3) distribution fitted by LH Moments was found to reasonably match the historic dataset, as well as the Worley Parsons 5% AEP peak flow. Based on this, a peak inflow of 275 m^3/s was adopted for the South Creek 20% AEP. The Ropes Creek and South Creek 5% AEP inflow hydrographs were scaled based on the ratio of South Creek peaks to produce 20% AEP inflow hydrographs.

A downstream tail water condition of 11.0 mAHD was adopted for the 20% AEP regional flood event, based on linear extrapolation of the Worley Parsons boundary conditions. For the 20% AEP local flood event, a tail water level of 5 mAHD was assumed. This was determined as a level at which flows within South Creek and Ropes Creek will not be backwater influenced by downstream tailwater levels.

It is noted that there is some uncertainty in the inflow and tail water conditions adopted for the 20% AEP event, particularly by the adoption of the South Creek inflow ratio to generate the Ropes Creek inflow. However, these estimates provide an indication of flooding in the 20% AEP event suitable for planning purposes.

3.2.3 Hydraulic structure updates

Subsequent to the 2015 work, site survey was undertaken to collect information on eight existing structures within the model area. Information on the structure type, location, size and invert levels was collected (see Table 3.1). These details were used to build structure code in MIKE11, which was linked to the MIKE21 model though MIKEFLOOD coupling software. Where required, the 10 m model terrain was adjusted to match the invert levels of the detailed structure survey and ensure smooth connection between the 2D and 1D models.

Table 3.1 : Structure Survey

Structure name	Structure type	Size	Upstream Invert Level	Downstream invert Level	Length
A	Circular Culvert	0.6m	16.6058	16.3368	15.0686
B	Circular Culvert	1.8m	13.455	12.988	22.7962
C	Circular Culvert	1.8m	15.1498	14.935	Not surveyed- assumed 15m
D	Box culvert	2 x 0.9m x 0.62m	18.719	18.593	13.258
E	Circular culvert	0.375m	Not surveyed- structure not modelled		
F	Circular culvert	0.375m	Not surveyed- structure not modelled		
G	Circular culvert	0.75m	18.33	18.2	11.153
H	Circular culvert	3 x 1.8m	15.56	15.46	19.5

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

A first principles review of the hydraulic performance of the culverts traversing the East West connector indicated that structure losses were under-represented in the 1% AEP event. As such, the inflow and outflow head loss factor was changed in MIKE11 for key structures through the EWC (see Table 3.2, Table 3.3). The resulting head drop as identified in the model results were compared to a hand-calculation, which supported the final values chosen. This process was repeated for the other modelled flood events.

Table 3.2 : Existing Conditions EWC structure flow regime

Flood Event		South Creek Bridge	B Culvert	Ropes Creek Bridge	C Culvert
5% AEP	Local TW	Above Soffit	Above Bridge Deck	Above Bridge Deck	Above Soffit
	Regional TW	Above Soffit	Above Bridge Deck	Above Bridge Deck	Above Soffit
1% AEP	Local TW	Above Soffit	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck
	Regional TW	Above Soffit	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck
PMF	Local TW	Above Soffit	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck
	Regional TW	Above Soffit	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck

Table 3.3 : Existing Conditions models "Inflow, Outflow" losses in MIKE 11

Flood Event		South Creek Bridge	B Culvert	Ropes Creek Bridge	C Culvert
5% AEP	Local TW	1 , 2	1 , 2	1.5 , 3	1.5 , 3
	Regional TW	1 , 2	1 , 2	1.5 , 3	1.5 , 3
1% AEP	Local TW	1 , 2	1 , 2	1.5 , 3	1.5 , 3
	Regional TW	1 , 2	1 , 2	1.5 , 3	1.5 , 3
PMF	Local TW	1 , 2	1 , 2	1.5 , 3	1.5 , 3
	Regional TW	1 , 2	1 , 2	1.5 , 3	1.5 , 3

3.3 Model verification results

The results of the refined existing case model (E078) based on the model updates described in Section 3.2 were compared to the 2015 existing case results (E061) and the Worley Parsons (2013) results.

A comparison with the 2015 existing case (E061) peak flood depth for the 1% AEP Regional Tailwater event is shown in Figure 3-1. The updated (E078) model shows higher water levels than previously identified upstream of Ropes Creek Bridge. This is primarily owing to the updated representation of the culverts either side of Ropes Creek Bridge based on newly available survey. Previously, these were modelled as 'gaps' in the terrain, which is modelled as a 10m grid. The reduction of flow area from the 10 m grid gap down to the 1.8 m RCP culvert causes localised increased peak flood levels.

In the Bulk Earthworks Development Application, the model was required by PCC to provide good agreement with the RMA-2 model results produced by Worley Parsons in 2013. As such, in the 2015 body of work, the parameters within the Jacobs MIKEFLOOD hydraulic model were adjusted to create a model that had similar hydraulic behaviours to the RMA-2 model. This process was undertaken with a focus on the 1% AEP event with local tailwater conditions, which was provided by Worley Parsons. Peak water surface level long sections were extracted from the Jacobs model for the 1% AEP local tailwater event and compared to the Worley Parsons RMA-2 model results for the same event.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

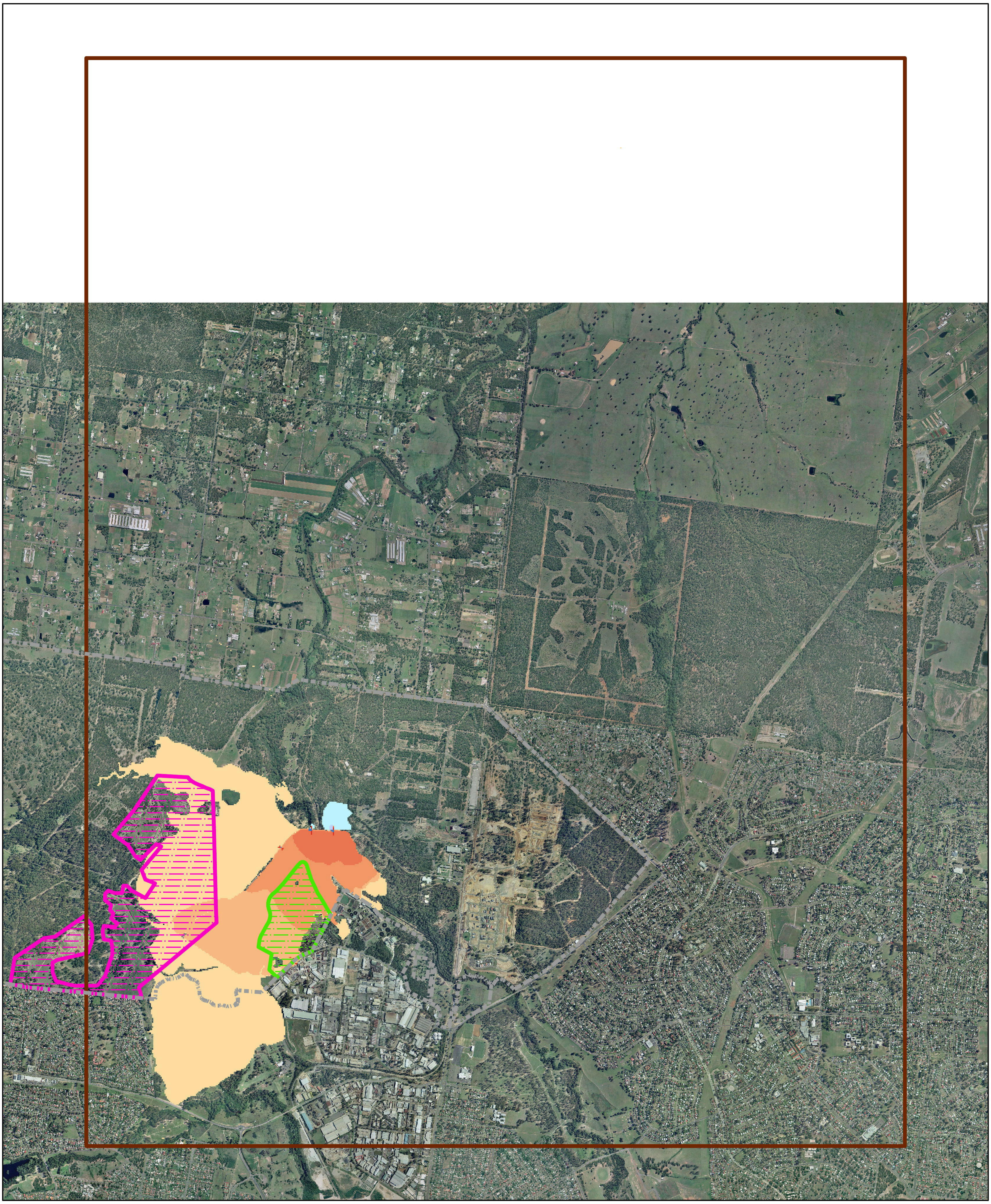

Figure 3-1: Peak Flood Inundation
1% AEP Regional Tailwater
Jacobs Model E078 less E061

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Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

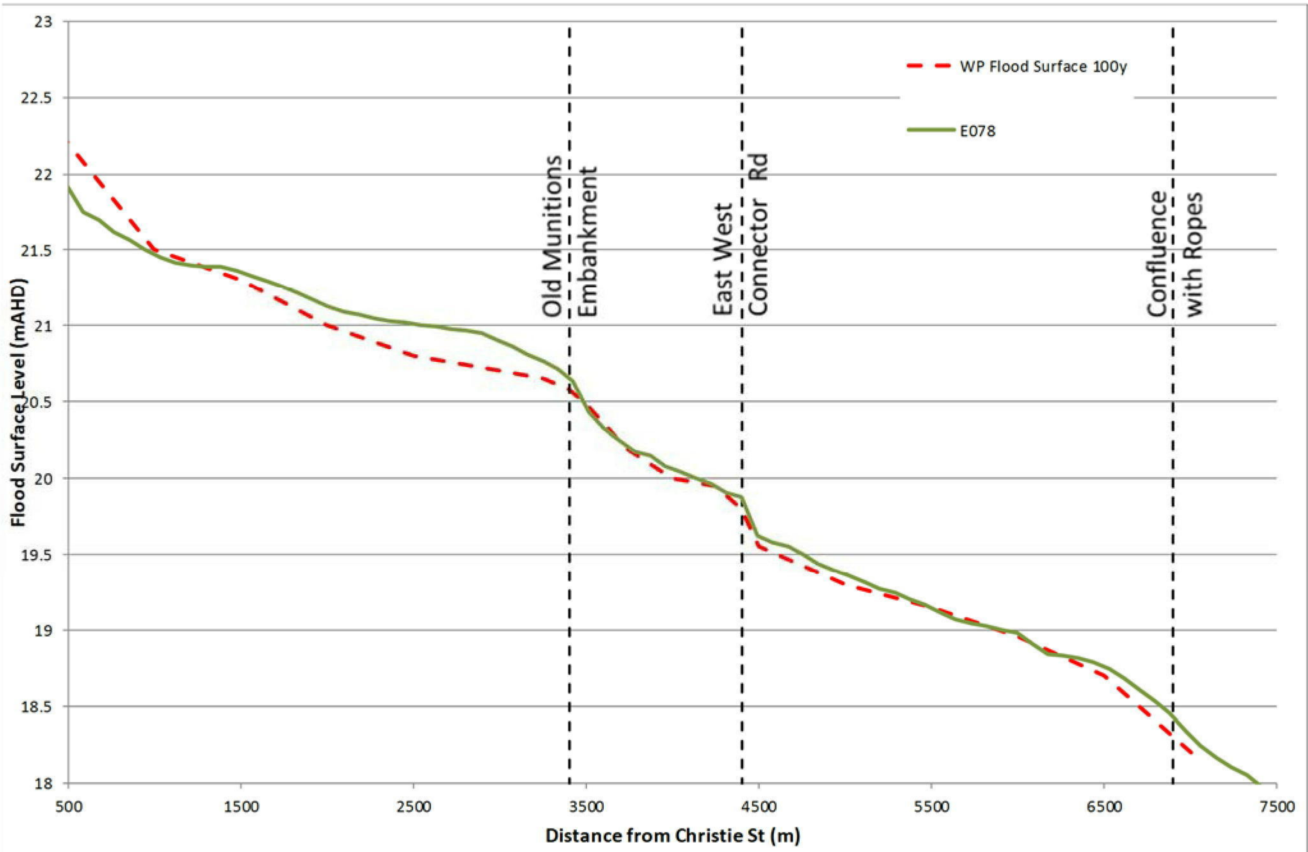
Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

The comparison of Jacobs' long sections against the long sections provided by Worley Parsons has been undertaken for the updated existing model (E078) and shows a consistent level of agreement with that presented in the Bulk Earthworks DA. The comparison for South Creek is as shown in Figure 3-2. This shows a maximum difference in flood surface level of approximately 300 mm, with the majority of the profile being in close agreement. Figure 3-3 shows the comparison for Ropes Creek in the 1% AEP local tailwater event, with a difference of less than 400 mm in the upstream extent of Ropes Creek.

Similar long section comparisons were undertaken for the 5% AEP and PMF events, with the Jacobs levels generally within +/- 400 mm of the Worley Parsons levels. Differences between the two models are likely to be due to differences in the representation of hydraulic structures and other landform features within the model area.

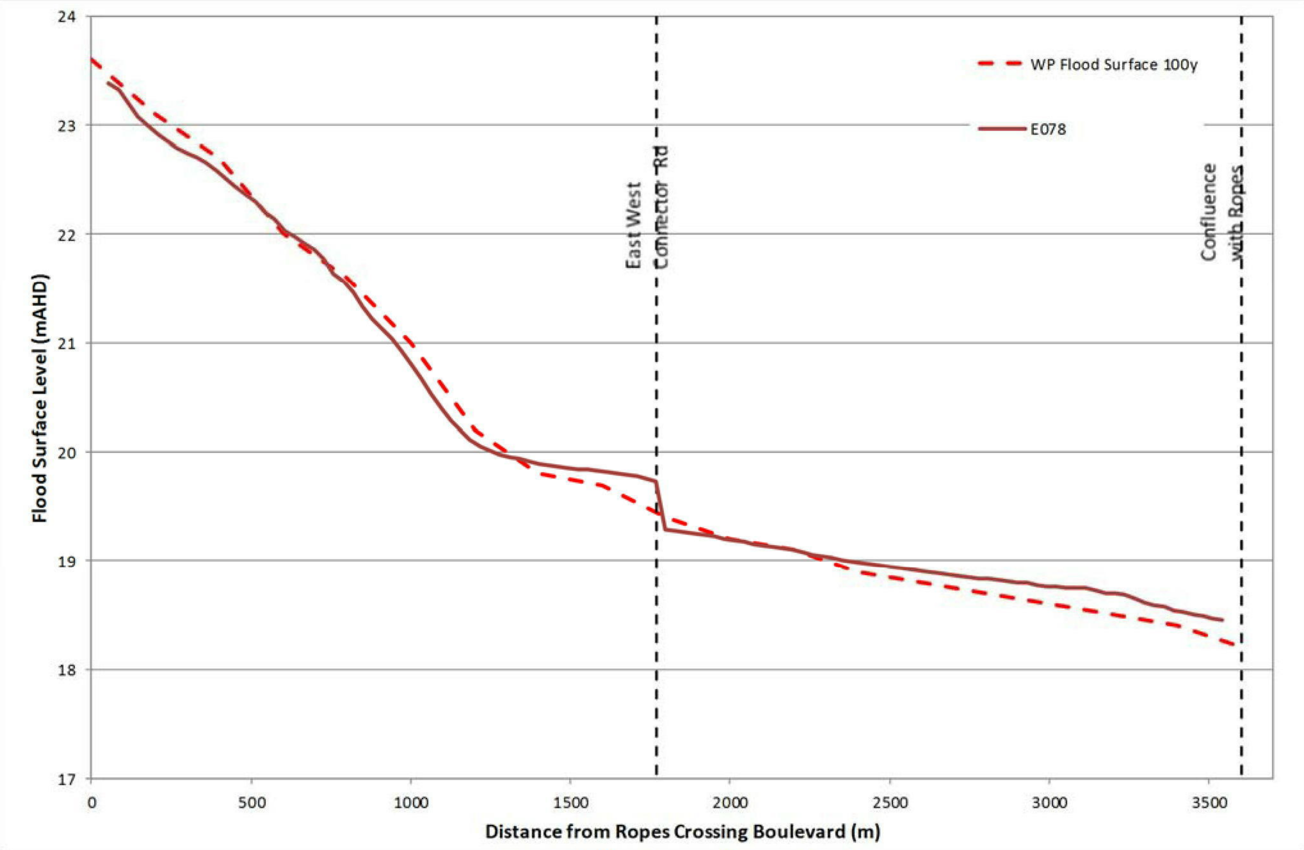
Figure 3-4 shows a comparison of the peak water surface level contours between the two models for the 1% AEP local tailwater event. This plot shows good agreement between the two models with a similar pattern of flooding.

A check was undertaken where the Bulk Earthworks developed case was simulated in the updated model and compared to the updated existing case. The calculated development impacts were broadly consistent with previous reporting in the bulk earthworks DA.



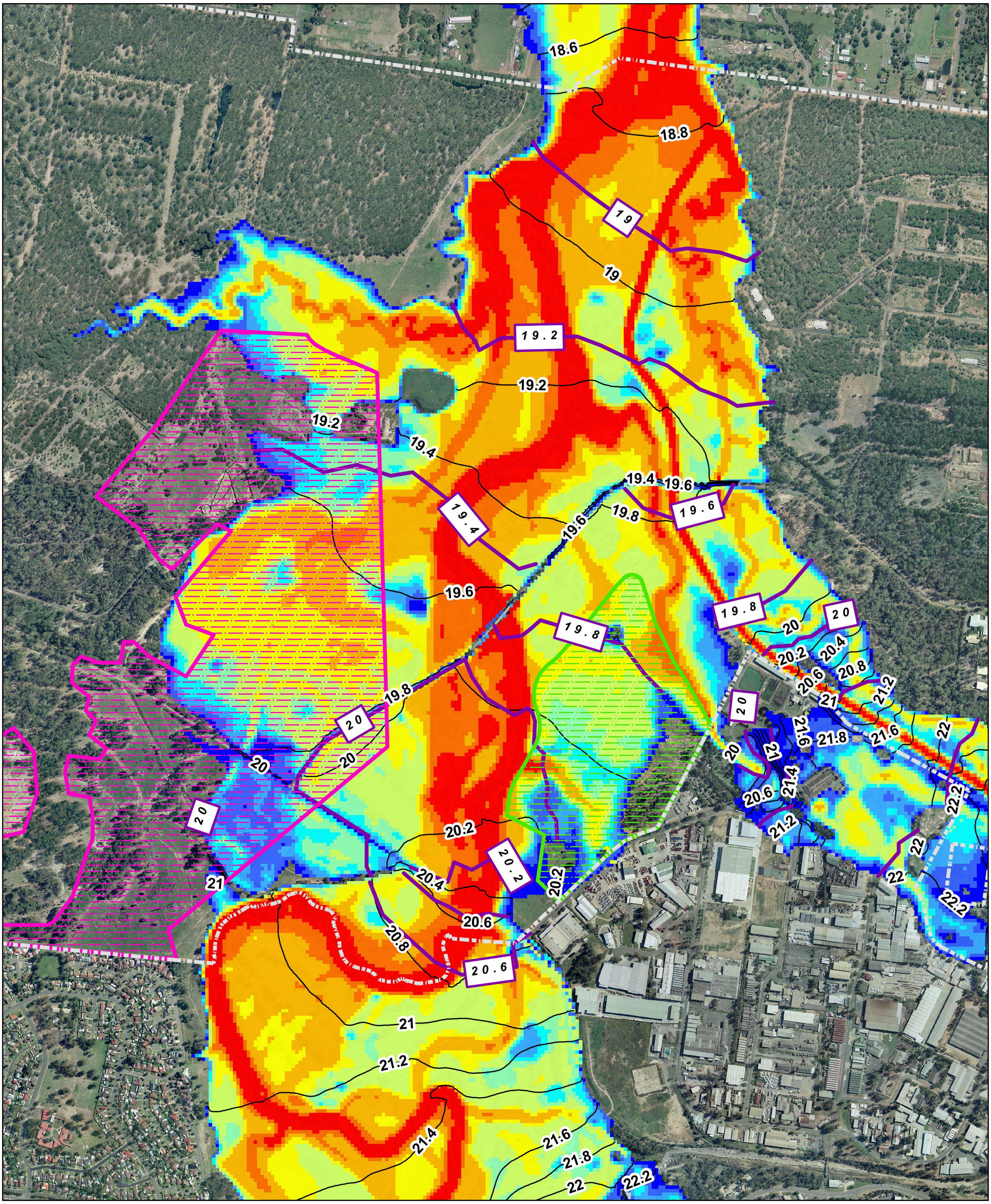
■ **Figure 3-2 South Creek Long Section Comparison for 1% AEP Local Tailwater Event**

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



- **Figure 3-3 Ropes Creek Long Section Comparison for 1% AEP Local Tailwater Event**

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary

Dunheved Precinct

Central Precinct

WP 2013 Flood Contour (mAHD)

Jacobs Flood Contour (mAHD)

Peak Flood Depth (m)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- > 4.0

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure 3-4: Peak Flood Inundation Comparison of Jacobs and WP Models 100 year ARI Local Tailwater Existing Conditions - E078

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3.4 Conclusions on model verification

The refined model adopted by Jacobs for the purpose of this study was found to have reasonable agreement with both the flood model developed for the Bulk Earthworks DA and the flood model produced by Worley Parsons. It was considered a consistent tool for the assessment of the potential flood impacts of the Dunheved and Central Precincts, as required by PCC.

The independent peer review of the original model by Worley Parsons concluded that "*the MIKEFLOOD model predicts peak 100 year ARI flood levels that are generally in good agreement with the RMA-2 modelling results that were generated for the South Creek Flood Study (2015), particularly within the subject site*". The refined model results indicate that this conclusion should also be applicable to the refined model.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

4. Existing flood behaviour

The refined existing flood model predicts peak flood levels that are relatively consistent with those presented in the Bulk Earthworks flood assessment, with the exception of the area immediately upstream of the East West Connector bridge over Ropes Creek. For completeness, the characterisation of the existing flood conditions has been reproduced here with mapping updated to the refined existing case (E078).

4.1 General

The project sites spans an area of floodplain across South Creek and Ropes Creek in St Mary's, west of Sydney.

Current land use at the project site is currently a mixture of open space and remnant vegetation. The areas upstream of the project site are made up of open space, residential and commercial areas. The area downstream of the project site consists of less densely populated rural residential area.

The existing flooding conditions have been characterised for the following six events:

- 5% AEP with local tailwater
- 5% AEP with regional tailwater
- 1% AEP with local tailwater
- 1% AEP with regional tailwater
- PMF with local tailwater
- PMF with regional tailwater

4.2 Long section profiles

Long section profiles of both South and Ropes Creek were created for the six existing case flood events. The long section distance reflects the flow path length at the invert of the channel.

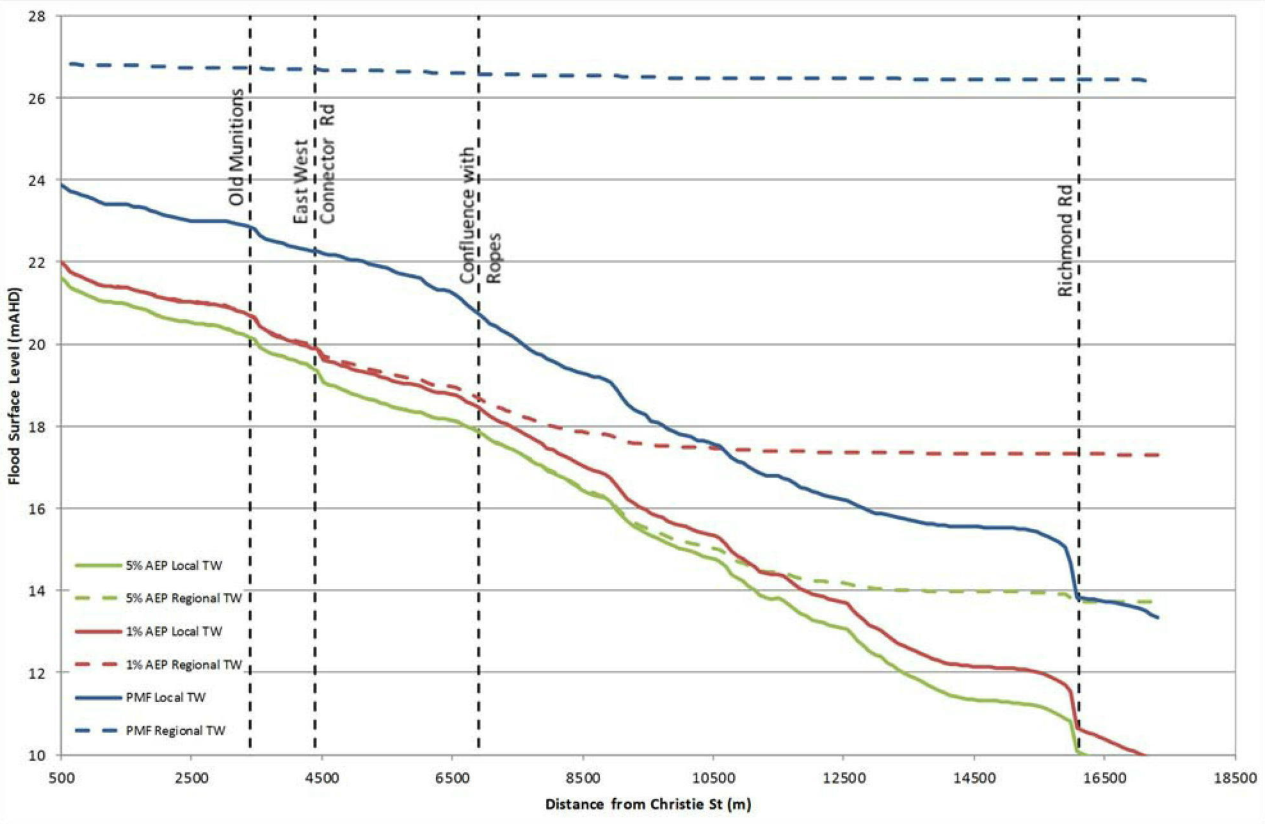
4.2.1 South creek

Within South Creek, the long section profile was taken along the centre line of the creek from Christie Street to just downstream of Richmond Road. The long section profiles for the six events are shown in Figure 4-1.

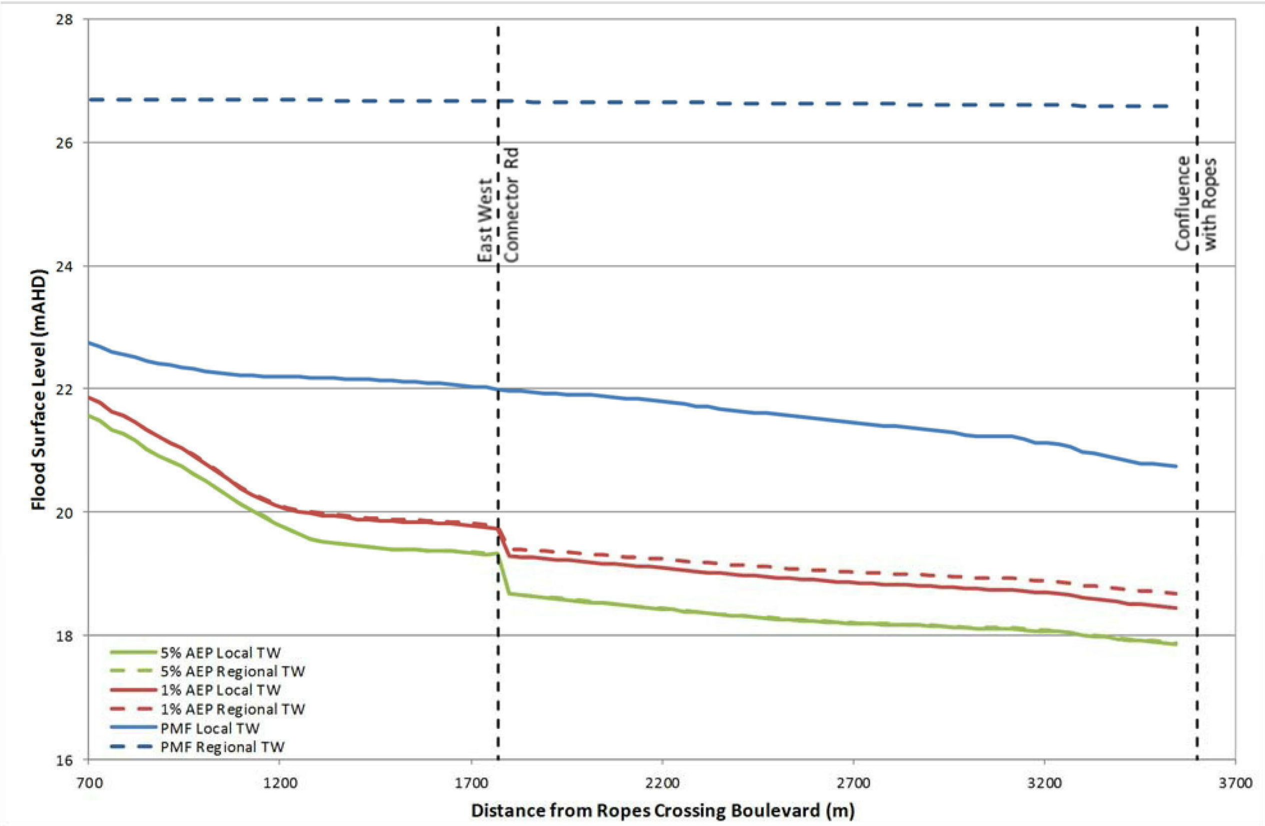
4.2.2 Ropes Creek

Within Ropes Creek, the long section profile was taken along the centre line of the creek from Ropes Crossing Boulevard to the confluence with South Creek. The Long section profiles for the six events are shown in Figure 4-2.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



- **Figure 4-1 Long section profile in South Creek for existing flooding conditions (E078)**



- **Figure 4-2 Long section profile in Ropes Creek for existing flooding conditions (E078)**

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

4.3 Flood extents and flood level contours

Peak flood inundation depth and water surface level contours were produced for the six existing case flood events. Maps displaying these inundation extent results are presented in Appendix A of this report.

4.4 Velocity

Peak velocities were extracted from the MIKEFLOOD results for the six flood events discussed above. Maps displaying the peak velocities for the six events are presented in Appendix B of this report.

4.5 Flow intensity (Velocity Depth Product)

The NSW Government's Floodplain Development Manual (2005) (the Manual) identifies three hydraulic categories within the floodplain:

- Floodways, defined as "areas conveying a significant proportion of the flood flow … where partial blocking will adversely affect flood behaviour to a significant and unacceptable extent."
- Flood storage areas, defined as "areas outside floodways which, if completely filled with solid material, would cause peak flood levels to increase anywhere by more than 0.1m and/or would cause the peak discharge anywhere downstream to increase by more than 10%."
- Flood fringe areas, defined as "the remaining area affected by flooding".

The South Creek Flood Study (Worley Parsons, 2015) included hydraulic category mapping for the South Creek floodplain through an iterative process based on Velocity X Depth product mapping and encroachment analysis.

It was not possible to reproduce this iterative process as part of this Flood Impact Assessment. However, an assessment of the peak velocity-depth product was used as a proxy to further verify the flooding behaviour found in the Jacobs model against the flood behaviour in the RMA-2 model. Mapping of the velocity-depth product for the Existing (E078) and Developed (D301) scenarios is shown in Appendix C for the 1% AEP regional tailwater event.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

5. Flood assessment for development scenario

5.1 Proposed Development

Lendlease proposes to develop the Dunheved and Central Precinct areas of the St Mary's Project. The proposed development including filling within the floodplain, modifications to road embankments and hydraulic structures and some channel works within South Creek were approved as part of the Bulk Earthworks DA (August 2015).

Parts of the proposed development have been refined since this approval based on further stages of design. The proposed modifications include refinement of the design of the East West Connector and Link Connector roads and hydraulic structures, inclusion of filling of the Regional Open Space areas, revision of the levee adjacent to the Dunheved Precinct and inclusion of backwater prevention on a hydraulic structure within the Dunheved Precinct.

5.2 Developed case modelling

The current proposed development has been modelled in the MIKEFLOOD model to assess potential flooding impacts. The model bathymetry and representation of specific hydraulic structures has been modified to represent the proposed developed conditions.

As for the existing case model, the inflow and outflow losses for key East West Connector structures were modified in order to adequately represent head loss (see Table 5.1,

Table 5.2). The modelled head loss across each structure was expressed as a multiplier of the velocity head through the structure and found to be within reasonable bounds. It can therefore be concluded that the 1D-2D linkages are appropriately representing flow through the structures in the developed case model.

Table 5.1 : Developed Conditions EWC structure flow regime

Flood Event		South Creek Overflow Culverts	South Creek Bridge	Link Connector Culverts	B Culvert	Ropes Creek Bridge	C Culvert
20% AEP	Regional TW	Below Bridge Soffit	Below Bridge Soffit	Below Bridge Soffit	Above Bridge Soffit	Below Bridge Soffit	Above Bridge Soffit
5% AEP	Local TW	Below Bridge Soffit	Below Bridge Soffit	Below Bridge Soffit	Above Bridge Soffit	Below Bridge Soffit	Above Bridge Soffit
	Regional TW	Below Bridge Soffit	Below Bridge Soffit	Below Bridge Soffit	Above Bridge Soffit	Below Bridge Soffit	Above Bridge Soffit
1% AEP	Local TW	Above Bridge Soffit	Below Bridge Soffit	Below Bridge Soffit	Above Bridge Soffit	Partial	Above Bridge Soffit
	Regional TW	Above Bridge Soffit	Below Bridge Soffit	Below Bridge Soffit	Above Bridge Soffit	Partial	Above Bridge Soffit
PMF	Local TW	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck
	Regional TW	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck	Above Bridge Deck

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

Table 5.2 : Developed Conditions models "Inflow, Outflow" losses in MIKE 11

Flood Event		South Creek Overflow Culverts	South Creek Bridge	Link Connector Culverts	B Culvert	Ropes Creek Bridge	C Culvert
20% AEP	Regional TW	0.5 , 1	0.4 , 0.4	0.5 , 1	1 , 2	0.3 , 0.3	1.5 , 3
5% AEP	Local TW	0.5 , 1	0.4 , 0.4	0.5 , 1	1 , 2	0.3 , 0.3	1.5 , 3
	Regional TW	0.5 , 1	0.4 , 0.4	0.5 , 1	1 , 2	0.3 , 0.3	1.5 , 3
1% AEP	Local TW	1 , 2	0.4 , 0.4	0.5 , 1	1 , 2	0.3 , 0.3	1.5 , 3
	Regional TW	1 , 2	0.4 , 0.4	0.5 , 1	1 , 2	0.3 , 0.3	1.5 , 3
PMF	Local TW	1 , 2	0.5 , 1	0.5 , 1	1 , 2	0.5 , 1	1.5 , 3
	Regional TW	1 , 2	0.5 , 1	0.5 , 1	1 , 2	0.5 , 1	1.5 , 3

5.2.1 Proposed Design

The refined proposed design (D301) has been represented in the model. The representation of the following design elements remain unchanged from the representation in the approved Bulk Earthworks DA model (D209):

- inclusion of the proposed bulk earthworks DEM for Central Precinct into the model;
- removal of the abutment and embankments of Old Munitions Rd; and
- removal of the stockpiles on the north-western South Creek floodplain.

The modified design elements within the refined design (D301) are listed in Table 5.3. The layout of the proposed fill and the location of these modifications are shown in Figure 5-1.

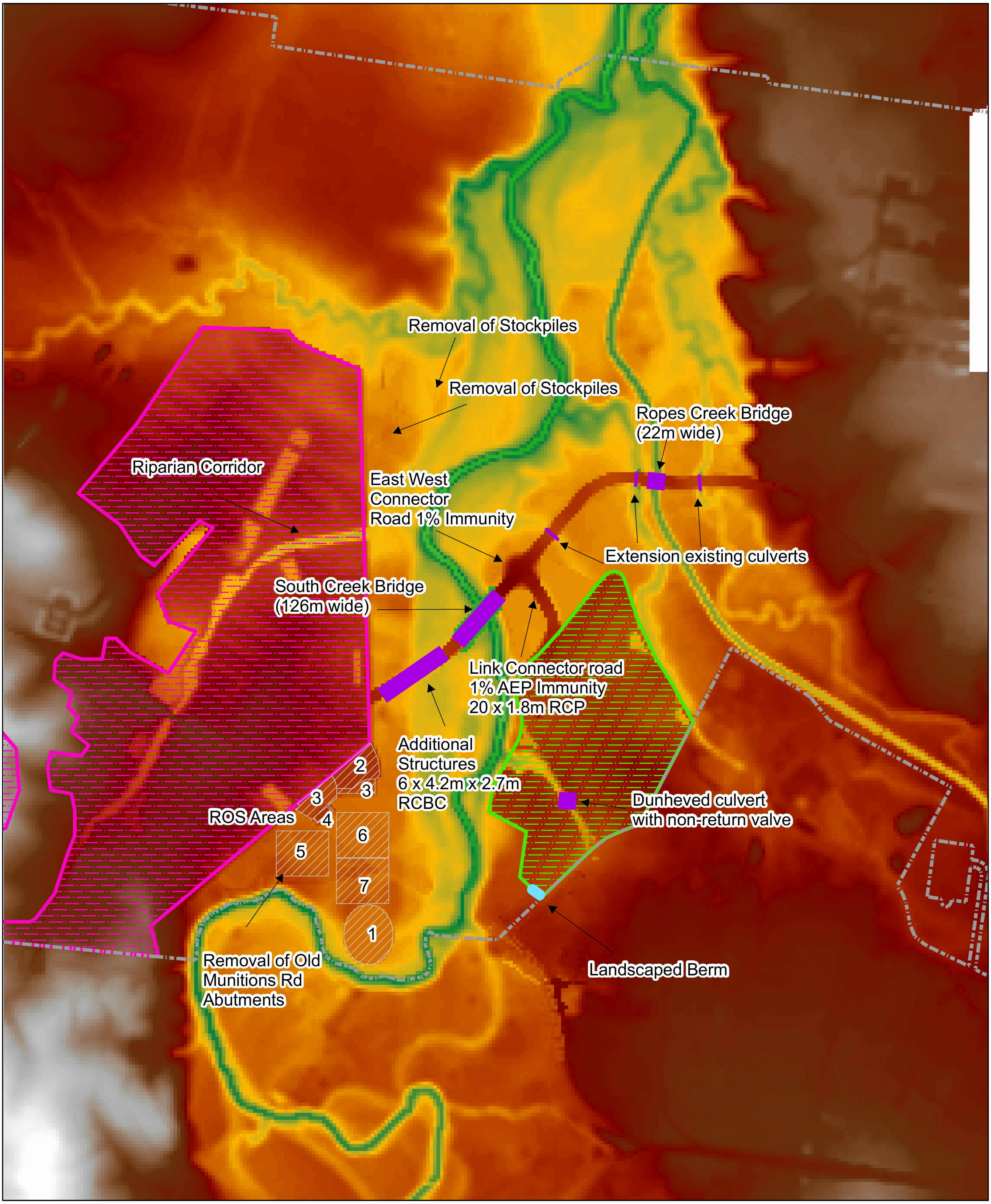
Table 5.3 : Refined Design Elements

Design Element	Design Reference
Inclusion of the Dunheved fill into the model (consistent with the approved fill levels in place of a flat fill platform);	Parsons Brinckerhoff "Dunheved Development Filling and Works" D-F000-DAC001
Inclusion of fill for four Regional Open Space areas into the model;	Cardno drawing CV-Cardno-EWC2-1311-1312
Raising the crest level of the East West Connector Road above the 1% AEP and incorporate of revised batters according to the refined design (Cardno, received 1/12/2017) (crest levels vary from ~21.3 – 22.6 mAHD);	Refer Cardno drawings CV-Cardno-EWC1 -1301-1305 and CV-Cardno-EWC2-1301-1302
Inclusion of a bank of 6/ 4200 X 2700 mm RCBC under the East West Connector to the west of the South Creek Bridge with an upstream invert of 16.8 mAHD;	Cardno drawing CV-Cardno-EWC-1301
Inclusion of a refined South Creek bridge design (Waeger, received 15/11/17), including raised bridge deck (soffit above 1% AEP water level), increased bridge width, and increased waterway opening under the East West Connector (approximately 126 m deck length);	NL172056_SOUTH CREEK GENERAL ARRANGEMENT_171115.dwg
Inclusion of new Ropes Creek bridge design (Waeger, received 15/11/17), including raised bridge deck (soffit partially above 1% AEP water level), increased bridge width, and slightly increased waterway opening under the East West Connector (22.4 m overall deck length);	NL172056_ROPES CREEK GENERAL ARRANGEMENT_171115.dwg

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

Design Element	Design Reference
Lengthening of three existing culverts under the East West Connector due to widening of the road;	Cardno drawing CV-Cardno-EWC1 -1301-1305
Inclusion of the Link Connector road with a crest level to provide 1% AEP immunity with freeboard, according to the refined design (Cardno, received 1/12/2017);	Refer Cardno drawings CV-Cardno-EWC2 -1303-1305 and CV-Cardno-EWC3-1301
Inclusion of 20 / 1800 mm RCP under the Link Connector road with an upstream invert of ~18 mAHD;	Refer Cardno drawings CV-Cardno-EWC2 -1302
Landscaping either side of Link Connector road to provide a structure invert at ~18 mAHD;	Refer Cardno drawings CV-Cardno-EWC2 -1302
Inclusion of a landscaped berm at the southern end of the Dunheved fill area; and	Refer Cardno drawings CV-Cardno-EWC2 -1305
Inclusion of a non-return valve on the proposed culvert within the Dunheved riparian corridor.	Refer Cardno drawings CV-Cardno-EWC2 -1305

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Area of bathymetry change
- Site Boundary
- ROS Fill Areas
- Dunheved Precinct
- Central Precinct

Model Bathymetry (mAHD)

High : 40

Low : 0

0 125 250 500 750 1,000 1,250 Meters

Scale in A4

Figure 5-1: Model Bathymetry Developed Conditions - D301

Job No: EN04189
Last Modified: 15/02/2018
By: S.Watt

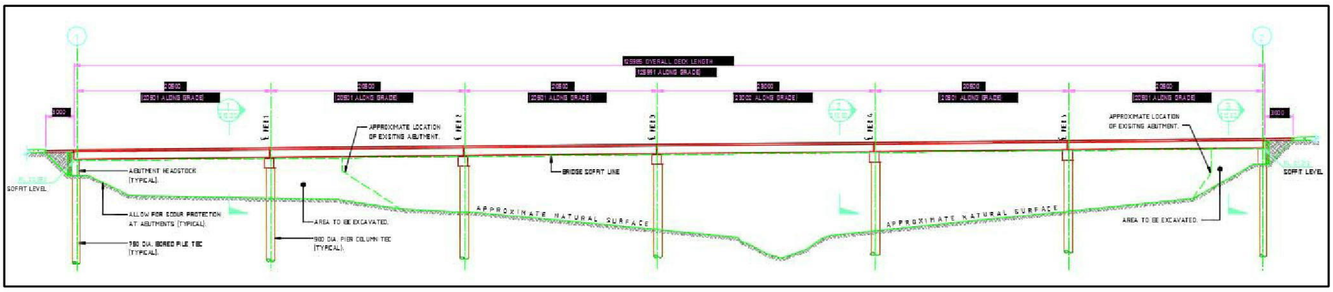
Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

It is noted that final batter slopes for the East West Connector road may be steepened in the final, marginally decreasing the amount of fill on the floodplain. This would be expected to have a negligible impact on the reported flood impacts of the design and the conclusions of this report.

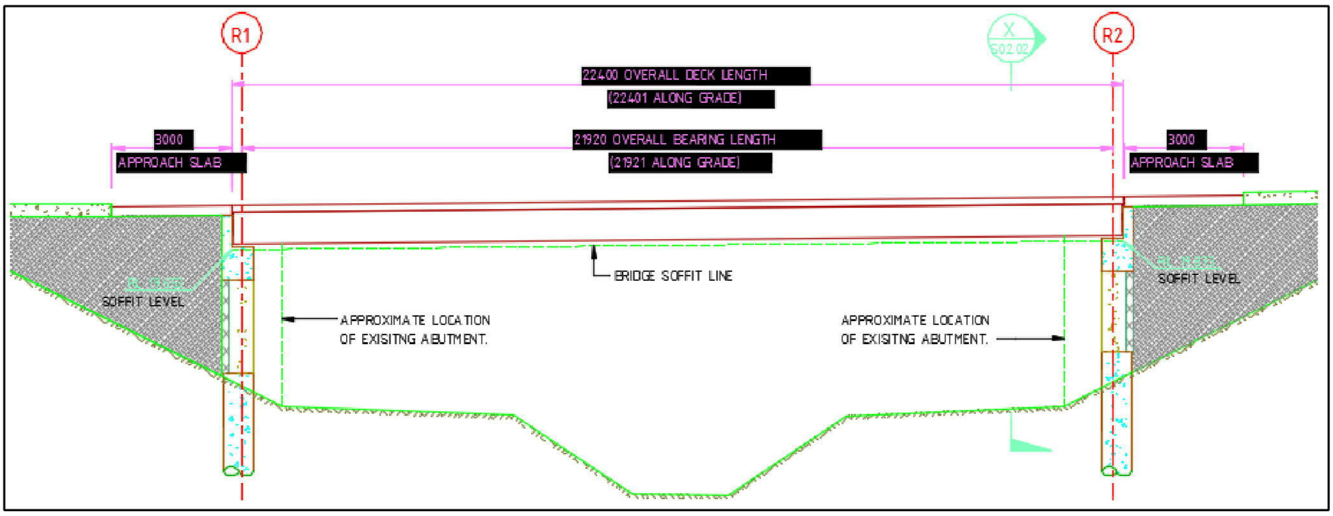
Figure 5-2 and Figure 5-3 present the refined designs for South Creek and Ropes Creek bridges under the East West Connector, respectively. Table 5-4 presents the resultant change in the waterway area for South Creek.

Table 5-4 Proposed changes to the South Creek bridge waterway opening under the East West Connector Road

Model Definition	South Creek
Original waterway opening (m^2)	490
Approximate developed case waterway opening (m^2)	745
Developed waterway – maximum top width (m)	126m



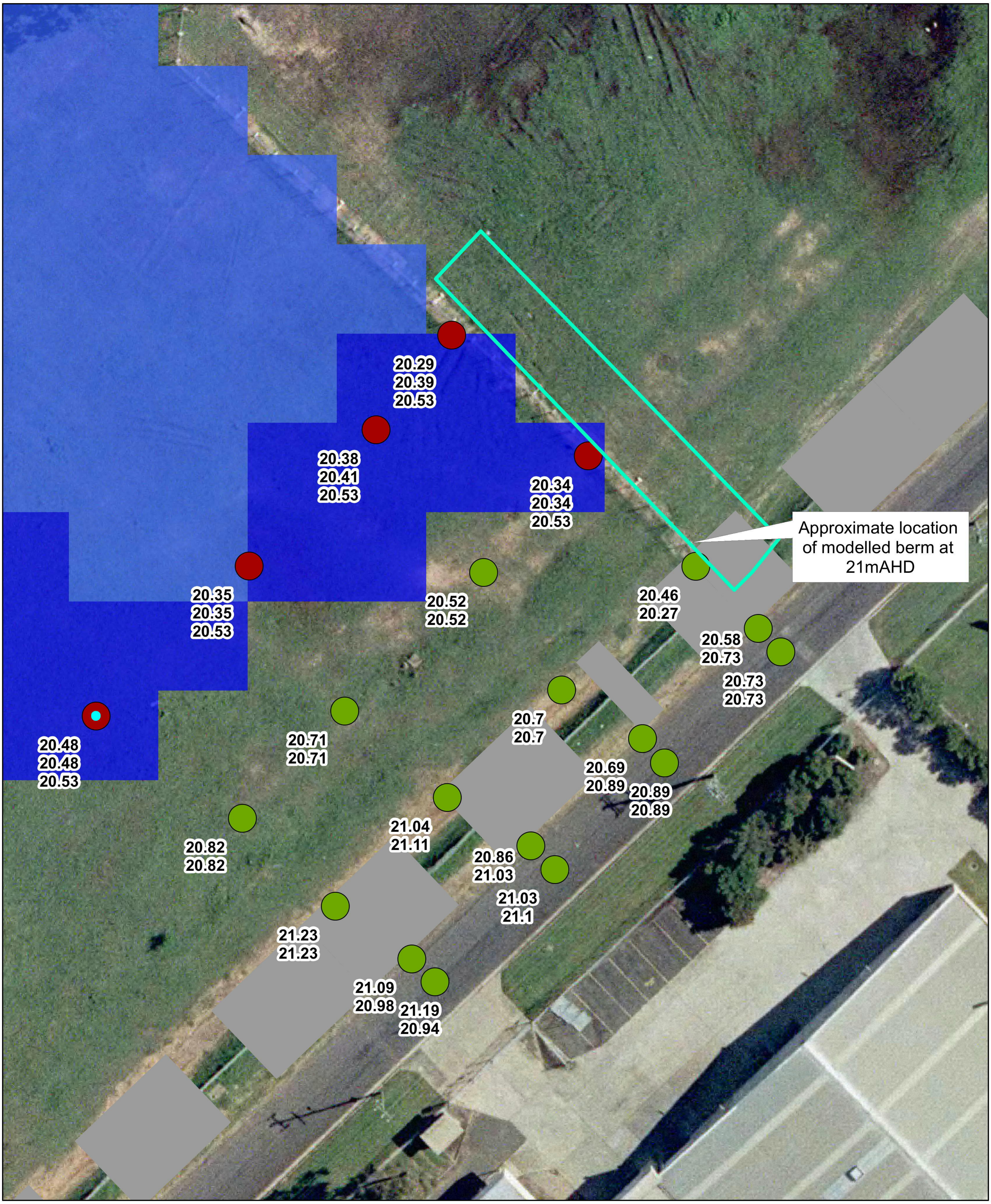
- **Figure 5-2 East West Connector Road crossing of South Creek, dashed green line indicating approximate location of existing abutment**



- **Figure 5-3 East West Connector Road crossing of Ropes Creek, dashed green line indicating approximate location of existing abutment**

A small landscaped berm has been included in the model to stop floodwaters backing up into the southern end of the Dunheved Precinct. The modelled berm is approximately 40 m long, 10 m wide and 300-800 mm high, with a modelled crest level of 21 mAHD. The modelled berm location, local survey and flood levels are presented on Figure 5-4.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary

Peak Flood Depth (m)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- > 4.0

Survey Level Model Terrain — Survey Points

Survey Level Model Terrain 1% WSL D301 — Inundated Survey Points

0 5 10 20 30 40 50 Meters

Scale in A3

Figure 5-4: Berm Analysis 1% AEP Regional Tailwater Developed Conditions - D301

Job No: EN04189
Last Modified: 29/01/2018
By: S.Watt

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

The lower south-west corner of the Dunheved fill platform is lower than the 1% AEP Regional Tailwater flood peak water surface level, meaning the bund is required to prevent inundation of the Dunheved precinct. Without the bund, as the detailed survey around the proposed berm area shows, a localised low spot exists in Links Road and the footpaths on either side. Flood water may flow through the end of the Dunheved fill area and onto Links Road and nearby industrial properties. No local cross-drainage structures under Links Road were identified in the survey that would allow flow to enter these properties if a berm was in place.
The exact configuration of the berm can be determined during detailed design.

The developed flooding conditions for the preferred option (D301) have been modelled for the 5% and 1% AEP and the PMF with local and regional tail water conditions.

5.2.2 Alternative options considered

The proposed refined design (D301) has been determined via assessment of a series of design iterations to produce an optimal design solution to meet a wide-range of criteria including:

- PCC requirements;
- maintenance of connectivity between the Central Precinct and Dunheved areas;
- availability of alternative evacuation routes from both Central Precinct and Dunheved areas;
- minimisation of upstream and downstream flood impacts consistent with the Bulk Earthworks DA approval;
- compliance with appropriate design standards; and
- constructability and maintenance considerations.

Alternatives considered:

- alternative bridge configurations including alternative deck/soffit levels;
- additional structures under the East West Connector Road to the west of the bridge over South Creek; and
- additional structures under the Link Connector Road.

5.3 Developed conditions flood behaviour

Mapping of peak flood depths and velocities under developed conditions can be found in Appendix D and Appendix E respectively.

Flood behaviour is modified in the refined developed case (D301) consistent with the modification seen in the approved developed case (D209). The following provides a summary of these changes.

The placement of the fill areas has resulted in a constriction in the waterway width, particularly in the area around the East West Connector Road. However, this constriction is partially offset by a number of hydraulic improvements within the floodplain including:

- Removal of Old Munitions Road embankment;
- Removal of stockpiles on the western floodplain;
- Increased waterway area through the South Creek bridge;
- Increased waterway area through the Ropes Creek bridge; and
- Additional culverts under the western section of the East West Connector.

It should be noted that while the developed scenario for Central Precinct causes constriction of flows through the site, it does not change the distribution of flows, as the floodplain flows as one through this section of the creek.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

The East West Connector Road continues to act as a hydraulic control within the South Creek and Ropes Creek floodplains. Under existing conditions, flow is constricted through the existing bridges and culverts under the road, sections of the road are overtopped in a 5% AEP event, and it acts as a large weir in larger events. Under developed conditions, the proposed raising of the road increases the immunity of the road and decreases the weir flow over the road. This is offset by the proposed increase in waterway area through South Creek and Ropes Creek Bridge, and additional culverts under the western section of the road.

A localised increase in velocity is observed near the additional structures under the East West Connector, as well as upstream/downstream of the Ropes Creek and South Creek bridges. Appropriate scour protection will be included as necessary.

During flood events, flow breaks out of South Creek, flowing east along the upstream toe of the East West Connector Road to join Ropes Creek. Under proposed developed conditions, the Link Connector Road (which will connect the Dunheved Precinct with the East West Connector) crosses this overflow path. A large bank of culverts has been proposed along this link to allow flow through this overflow path.

The target design immunity has been achieved for each of the design elements as per Table 5.6.

Table 5.5 : Immunity of design

Design Element	Achieved Immunity
East West Connector Road	1% AEP
Link Connector Road	1% AEP
ROS area 1	20% AEP
ROS area 2	1% AEP
ROS area 3	5% AEP
ROS area 4	1% AEP
ROS areas 5,6,7	20% AEP (no fill)

5.4 Potential flood impacts

The potential flood impacts of the refined developed scenario (D301) have been assessed and found to be consistent with the impacts reported for the approved developed scenario (D209). In general, the impacts of the refined developed scenario are reduced compared to those previously reported and approved.

Section 5.4.1presents the detailed analysis of impacts for the refined developed scenario while Section 5.4.2 presents a comparison between the impacts of the refined developed scenario with the impacts of the approved developed scenario.

The potential flood impacts of the development have been assessed through production of afflux mapping and velocity mapping. As previously reported, the regional tailwater condition produces critical flood levels throughout the model area. The 1% AEP event with regional tailwater conditions has been used for all detailed analyses of flood impact.

For properties where potential impacts in excess of 20 mm have been identified, more detailed survey has been obtained, and the potential impacts on over-floor flooding have been assessed.

The existing and developed Flood Planning Area (FPA) have been mapped and a comparison undertaken to identify any properties that may be impacted by additional planning constraints under the developed scenario. The FPA is an area that would be inundated in a flood event with a peak level 500 mm higher than the 1% AEP event.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

5.4.1 Impacts for developed scenario (D301)

Impact mapping of the six modelled flood events has been provided for the refined developed case (D301), with mapping of impacts on flood depths in Appendix F and mapping of velocity impact maps in Appendix G of this report.

These afflux maps show the changes to the flow patterns due to the filling and constriction of the flood plain, and changed configuration of the East West Connector Road. The impacts of the proposed filling on flood levels in the 1% AEP flood event are generally limited to within the Central Precinct boundaries (i.e. within the land area owned by Lendlease).

There are no newly flooded properties in the developed case for the 1% AEP Regional Tailwater flood event. That is, the flood impacts do not inundate any properties that are not affected by flooding under existing conditions.

Figure 5.5 presents the potential upstream impacts for the preferred option, identifying the maximum afflux at the upstream site boundary for the 1% AEP regional tailwater conditions as 34 mm.

Increased flooding greater than 20mm upstream of the Lendlease site is limited to 3 lots and the Links Rd road reserve, detailed in Table 5.6 and Figure 5.5. For these properties, more detailed survey was obtained, and it was determined that no buildings on these properties will be flooded above surveyed floor levels. A reduction of flood levels is also experienced on several lots upstream of the Lendlease site.

Table 5.6 Summary of impacted lots upstream

Lot	Plan	Description	Impact on Lot (mm)*
1	DP234336	Dunheved Golf Course	33
20	DP773781	Dunheved Golf Course	31
1	DP600517	Sydney Water Recycled Water Scheme	28
-	-	Links Road	20

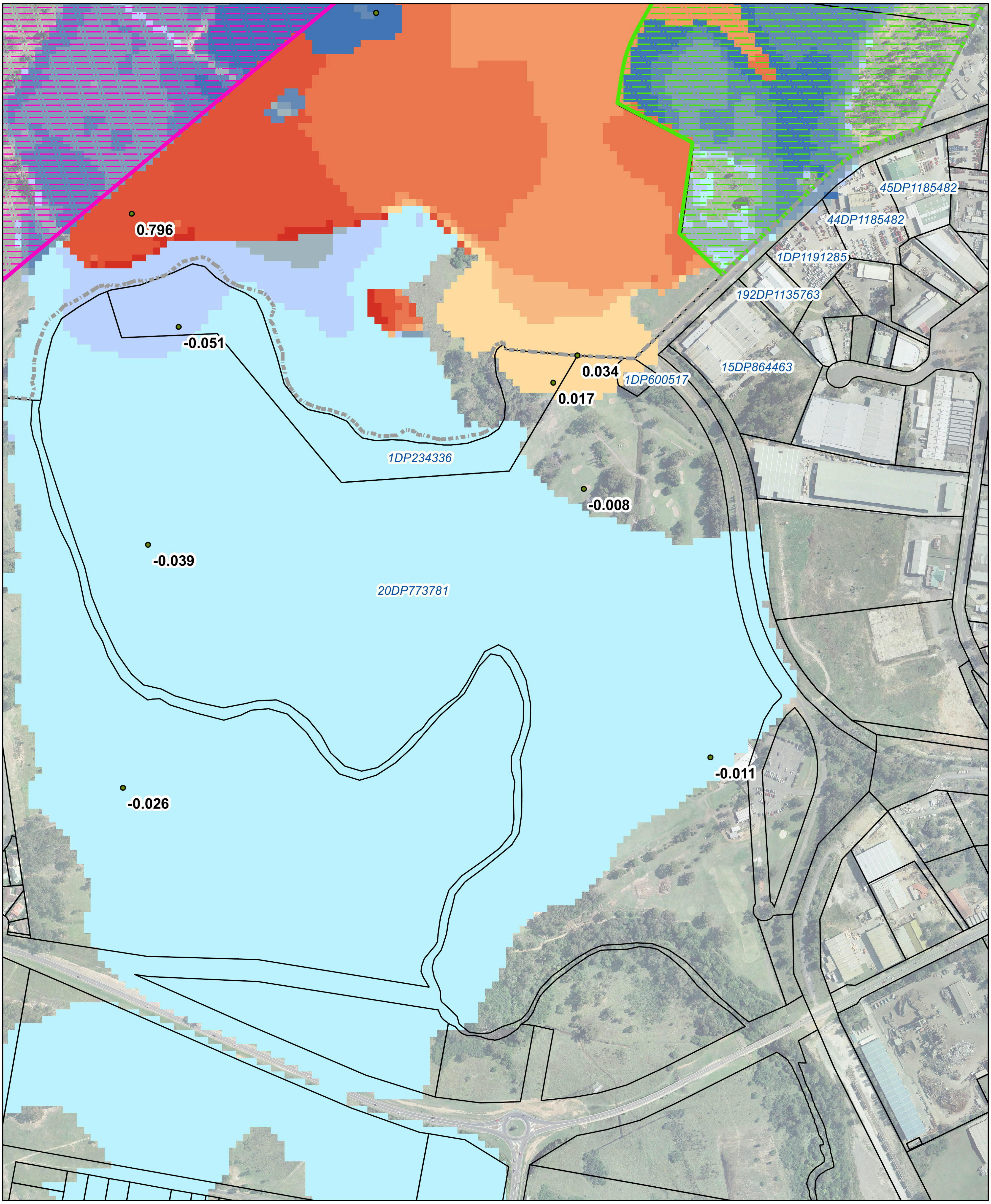
* Impact in 1% AEP Regional TW event (D301).

Upstream impacts are substantially limited to within the Dunheved Golf Course. Under existing conditions, the majority of the Golf Course adjoining the site is inundated by water over 1 m deep in the 1% AEP event, with depths of up to 3 m in some areas. The increase in flood levels across the Golf Course is unlikely to change the effects of flooding on the Golf Course. There are no impacts on the buildings or carpark associated with the Golf Course; water levels in this area decrease compared to the existing case. The area of increased flooding on the Golf Course (approximately 1 ha) is also offset by an area (~50 ha) of reduced flooding (10-50 mm decrease in peak water surface level).

The duration of flooding on the Golf Course is unchanged under developed conditions at approximately 20 hours in the regional 1% AEP flood event. Similarly, there is no change in the duration of flooding or the timing of the arrival of flooding at the downstream site boundary in the 1% AEP flood event.

Tanks and plant, but no buildings, were identified on the Sydney Water property (1 DP600517), with what appears to be a pump station elevated above ground level. No site survey was available for the site.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Spot Impacts (m)
- Site Boundary
- Dunheved Precinct
- Central Precinct
- Cadastre

Afflux (m)

- < -1.00
- -1.00 - -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- > 1.00

0 50 100 200 300 400 500 Meters

Scale in A3

Figure 5-5: Upstream Flood Impacts
1% AEP Regional Tailwater
Jacobs Model D301

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Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

Flood impacts at the downstream boundary of the Lendlease site in the 1% AEP event (Appendix F) are 7 mm and 11 mm under regional and local tailwater conditions, respectively. In the regional event, impacts greater than 10 mm are contained within the site boundary. In the local event, Richmond Road has a more pronounced effect on the flood surface, acting as a hydraulic control, meaning little attenuation of the afflux at the downstream site boundary occurs. Downstream of Richmond Road the impacts are less than 10 mm and within the accuracy limit of the model.

These impacts represent less than 1% of the total flood depth in the channel and do not cause a significant increase in flood extent. There are no newly flooded properties upstream or downstream in the developed case for the 1% AEP flood event. That is, the flood impacts do not inundate any properties that are not affected by flooding under existing conditions. No material flood impact is therefore expected at downstream properties.

It is noted that while the local tailwater impacts extend downstream of the site boundary, the peak levels for the regional tailwater event significantly exceed those in the local tailwater event and are therefore critical.

Existing and developed Flood Planning Areas (FPA) were generated based on the modelled peak water surface levels for the 1% AEP Regional tailwater, using WaterRide. It is noted that a newer version of WaterRide was utilised compared to that used in the 2015 body of work. Due to a minor update to the routine WaterRide uses for this process, this has resulted in slight differences to the FPA extents compared to the 2015 report. Both the mapped existing and developed FPA extents have been generated using the new process, and thus a consistent relative comparison is presented here.

Council provided Jacobs with their FPA for the Lendlease site and upstream area as an ESRI shapefile format on 30 April 2015. A comparison was undertaken between the Council's FPA and the FPA estimated based on the existing (E078) Jacobs flood modelling. Figure 5.6 presents this comparison, as well as the developed FPA. This comparison showed good agreement between the two FPA layers, with the two FPA lines generally within 10-20 m of each other, except for on Lot 13 DP31908 which is identified as not flooded and not within the FPA area in the Jacobs model due to the incorporation of detailed survey.

To identify the potential for property impacts based on changes to the FPA and associated Section 149, the existing and developed FPAs were intersected with the cadastre (2015) and the area affected by the FPA calculated for each property. Properties with a change in the area affected by the FPA were then identified.

Under the developed case, there are no additional properties affected by the FPA compared to existing conditions.

Several properties have been identified with a negligible increase or negligible decrease in area affected by the FPA. A negligible change has been defined as less than 5% of the total area AND less than 3 grid cells affected. Changes of this magnitude are within the tolerance of the analysis techniques.

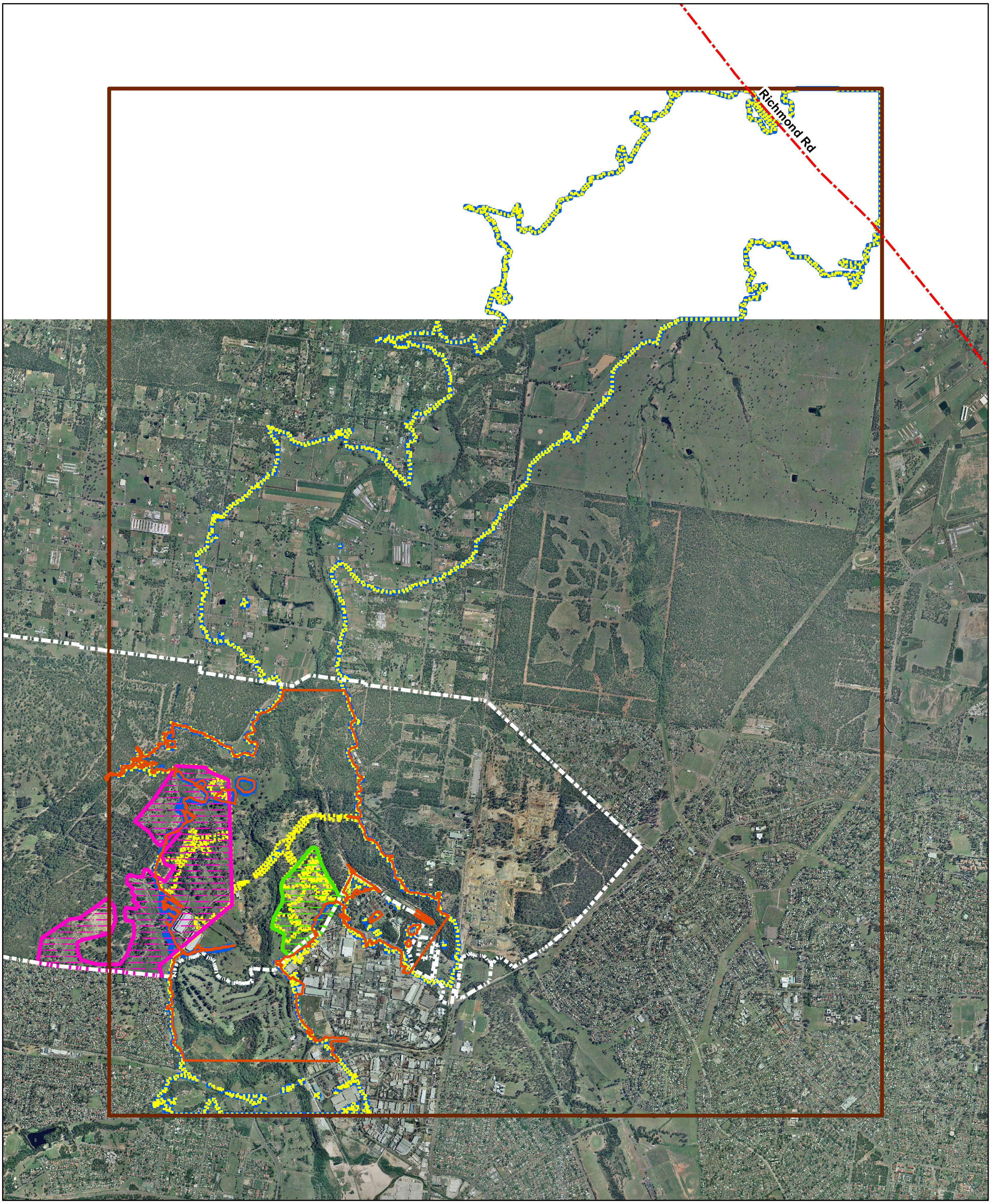
Four (4) properties have been identified upstream of the Lendlease site that will potentially be affected by a change in the area affected by the FPA, with all four impacted by an increased FPA extent. These properties are all industrial properties located upstream of the Lendlease site on Links Road.

Table 5.7 and Figure 5.7 present the details of these impacted lots.

Table 5.7 Summary of lots impacted by increase in area affected by the FPA

Lot	Plan	Description	Total Lot Area (Ha)	Area Affected by FPA (Ha)		% Area Affected by FPA	
				Existing	Developed	Existing	Developed
192	DP1135763	Industrial	0.56	0.01	0.33	2%	59%
1	DP1191285	Industrial	0.90	0.14	0.44	15%	49%
44	DP1185482	Industrial	1.15	0.32	0.44	28%	38%
45	DP1185482	Industrial	1.09	0.01	0.04	1%	4%

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Roads
- Site Boundary
- MIKEFlood Extent
- Council Existing FPA
- Dunheved Precinct
- Central Precinct
- Existing Model FPA (E078)
- Developed Model FPA (D301)

0 300 600 1,200 1,800 2,400 3,000 Meters

Figure 5-6: Flood Planning Area (FPA) Comparison - Overview

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Last Modified: 29/01/2018
By: S Watt

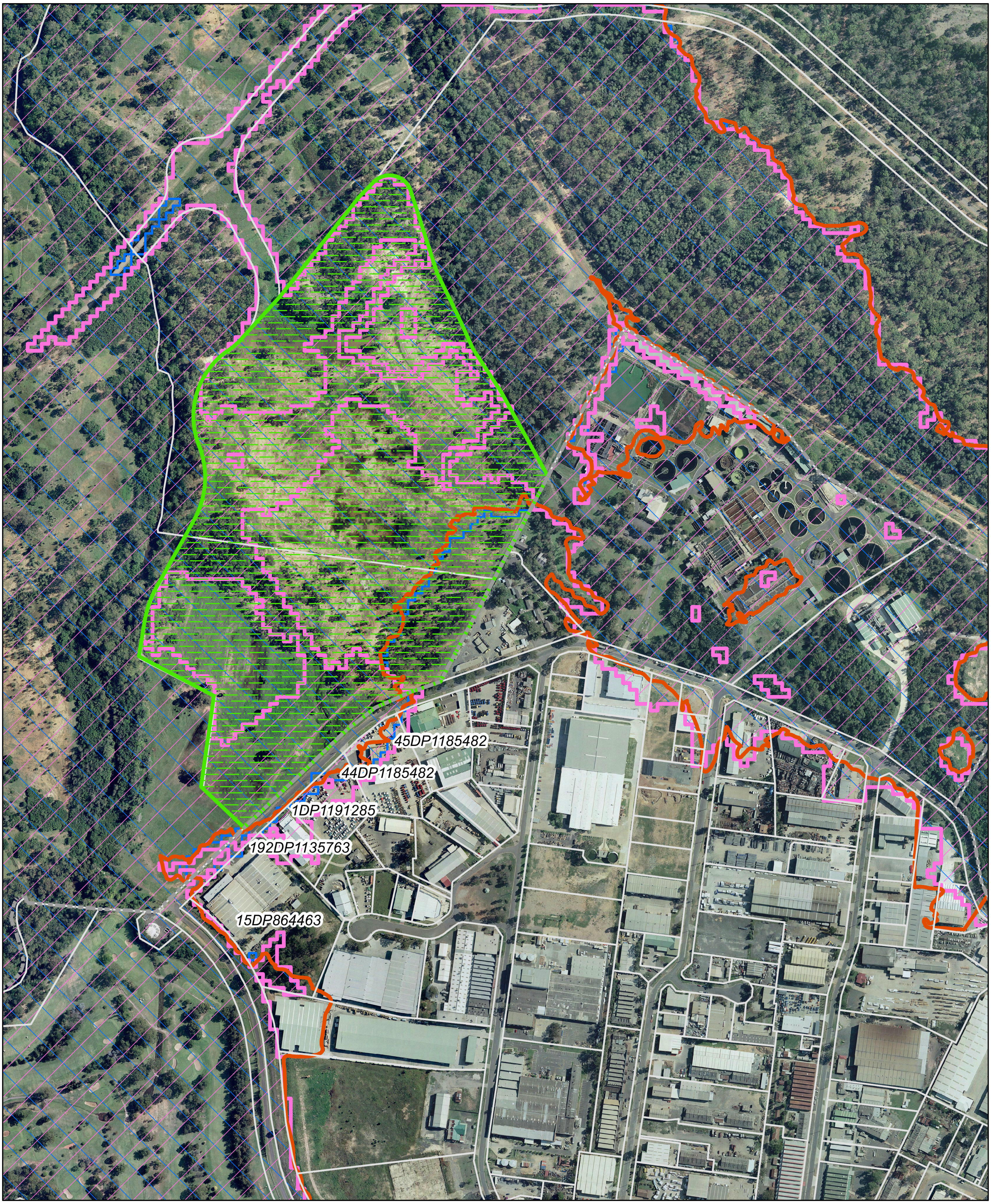

Figure 5-7: Flood Planning Area (FPA) Comparison - Upstream

Legend

- Site Boundary
- Dunheved Precinct
- Cadastre
- Council Existing FPA
- Developed Model FPA (D301)
- Existing Model FPA (E078)

0 50 100 200 300 400 500 Meters

Scale in A3

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Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8148709
Version: 1, Version Date: 19/04/2018

Maps detailing the changes in velocity are provided in Appendix G of this report. Velocity mapping for the existing and developed scenarios can be found in Appendix B and Appendix D respectively.

In the 1% AEP event, existing peak velocities at the downstream site boundary vary between 0.8-1.2 m/s within the channel and are generally less than 0.8 m/s on the floodplain. This same velocity profile is maintained under developed conditions with a maximum velocity increase of 0.002 m/s under developed conditions (local and regional tailwater conditions). These velocity changes at the downstream boundary of the site represent less than a 1% increase.

At the upstream site boundary, there is a minor change to the velocity profile due to the increased conveyance along the western bank of South Creek where the Old Munitions Road embankment and abutment will be removed, and where floodplain flow is constricted between the ROS fill areas. The Old Munitions Road embankment is currently acting as a localised levee, limiting flow on the western bank. When it is removed, this causes increases on the western bank of up to 0.7 m/s in the 1% AEP Event. There are also minor increases up to 0.3 m/s in South Creek adjacent to the southern-most ROS fill area in the 1% AEP event.

5.4.2 Comparison with previously reported impacts

A comparison of the impacts reported within the previous Bulk Earthworks DA to the impacts of the design presented within this report was undertaken;

- Consistent with previous reporting, the presented design does not cause flooding of properties in the developed case that were not affected by flooding under existing conditions
- The previous reporting indicated impacts on 5 lots, with this decreased to 4 lots with the current design.
- Maximum afflux on the upstream boundary decreases compared to previous reporting (from 38 mm to 34 mm in the 1% AEP Regional Tailwater event)
- Maximum afflux on the downstream boundary decreases compared to previous reporting (from 11 mm to 7 mm in the 1% AEP Regional Tailwater event)
- Consistent with previous reporting, the presented design does not change the duration of flooding on the Golf Course upstream of the site
- Analysis indicates an increase in area affected by the FPA for 4 lots. This is consistent with the previous Bulk Earthworks DA reporting, which indicated 4 lots would be impacted by an increase in FPA area, and one impacted by a decrease.
- Consistent with previous reporting, changes to velocity at the upstream and downstream boundaries are minimal.

5.4.3 Hydraulic Category Mapping

The NSW Government's *Floodplain Development Manual* (2005) (the Manual) identifies three hydraulic categories within the floodplain:

- Floodways, defined as "*areas conveying a significant proportion of the flood flow … where partial blocking will adversely affect flood behaviour to a significant and unacceptable extent.*"
- Flood storage areas, defined as "*areas outside floodways which, if completely filled with solid material, would cause peak flood levels to increase anywhere by more than 0.1m and/or would cause the peak discharge anywhere downstream to increase by more than 10%.*"
- Flood fringe areas, defined as "*the remaining area affected by flooding*".

The definition of these hydraulic categories provides a guide for best practice floodplain risk management. However, the Manual does not prohibit filling within the floodway or flood storage area. It advocates a merit-based approach which takes into consideration social, economic and ecological factors, as well as flooding characteristics.

The *South Creek Flood Study* (Worley Parsons, 2015) included hydraulic category mapping for the South Creek floodplain through an iterative process based on Velocity X Depth product mapping and encroachment analysis.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

Parts of the Central Precinct and Dunheved fill platforms lie within areas identified by this study as floodway or flood storage.

The NSW Government's *Floodplain Risk Guideline – Floodway Definition* (2007) identifies that approximate limits of the floodway can be identified through an iterative method by modelling altered cross-sections (simulating filling of the floodplain) and examining whether:

- There is a significant affect [sic] on upstream flood levels; and/or
- There is a significant diversion to an existing flowpath; and/or
- A significant new flowpath or floodway develops due to the change.

While this process is aimed at identifying the extents of the floodway, it can equally be applied to identifying whether filling of the floodplain constitutes acceptable encroachment or not.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

It was identified in the 2015 assessment that without mitigation, the filling of the Central Precinct and Dunheved areas would constrict the floodplain and produce impacts in excess of 100 mm upstream of the site boundary. A number of hydraulic improvements to the floodway were proposed to partially counter the loss of conveyance due to filling in the floodway areas. These mitigation measures have been further refined as part of the design process and now include:

- removal of Old Munitions Road embankment;
- removal of stockpiles on the western floodplain;
- increased waterway area through the South Creek and Ropes Creek bridges; and
- additional culverts under the western section of the EWC road.

An analysis of the conveyance of South Creek upstream, downstream and through the site has been undertaken. This assessment demonstrates that the proposed measures included within the development to manage encroachment in the floodplain would maintain the conveyance capacity through the South Creek floodplain.

The unit flow (Velocity X Depth Product) was plotted for a series of cross-sections along South Creek. A comparison of the existing (E078) and developed (D301) unit flow across the floodplain demonstrates that the conveyance upstream and downstream of the site is not impacted by the proposed development. Within the site, the analysis demonstrates that the reduction in conveyance through the fill platforms would be partially offset by the increased conveyance provided through the compensatory measures detailed above.

The other key issue relevant to merit-based consideration of filling in a floodway area is cumulative fill based on assumptions regarding possible future filling scenarios. The Lendlease site encompasses the width of the South Creek floodplain through this reach. The Central Precinct and Dunheved fill areas form part of a larger regional plan which includes handover of the residual floodplain areas to the NSW Government to manage as Regional Park. Therefore, future filling and further encroachment within this section of South Creek is highly unlikely. Hence, this assessment can be considered to be a cumulative assessment of the total fill possible in this reach of the floodplain.

This analysis for the proposed development scenario (D301) has shown that:

- There is NOT a significant affect [sic] on upstream flood levels; and
- There is a NOT a significant diversion to an existing flowpath; and
- A significant new flowpath or floodway DOES NOT develop due to the change.

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

6. Conclusions and recommendations

The following conclusions and recommendations are made from this investigation.

- The MIKFLOOD hydraulic model utilised in the Bulk Earthworks DA was updated to effectively assess the impacts of the refined East West Connector .
- The refined MIKEFLOOD model produced design event peak flood levels consistent with those produced by the Worley Parsons RMA-2 model for existing flooding conditions.
- The model was used to assess the refined proposed developed scenario. Compared to the previously approved scenario from the Bulk Earthworks DA, the refined developed scenario included upgrades to the East West Connector and Link Connector Road, inclusion of pipes under the Links Connector Road in place of an M-lock bridge, widening of the South Creek and Ropes Creek Bridges, addition of high flow culverts on South Creek west bank, inclusion of a backwater prevention control in the Dunheved Precinct riparian corridor.
- This modelling takes into account the proposed filling of the Central Precinct together with the approved filling of the North and South Dunheved Precincts.
- The proposed development in its current form produces water level impacts limited to 34 mm at the upstream site boundary and 7 mm at the downstream site boundary in the 1% AEP regional tailwater event.
- The impacts of the proposed development meet PCC’s Development Control Plan (DCP) requirements of afflux not exceeding 100 mm at the upstream boundary (noting that the DCP is not explicitly applicable), and is within the previous reported impacts approved in the Bulk Earthworks DA.
- Upstream impacts are limited to the Sydney Water Recycled Water Project site, the Dunheved Golf Course, which is already inundated under existing conditions, and the Links Rd road reserve.
- The preferred developed scenario does not inundate any additional buildings in the 1% AEP event.
- No additional properties are affected by the Flood Planning Area in the developed scenario. Four (4) upstream industrial properties on Links Road will potentially be affected by an increase in the area affected by the FPA.
- Impacts at the downstream boundary are 7 mm and 11 mm in the regional and local tailwater scenarios. The characteristics of the floodplain result in relatively little attenuation, meaning these small impacts propagate for a significant distance downstream in the local tailwater event. However, these impacts do not cause a significant increase in flood extent, or result in inundation of additional properties. No material flood impact is therefore expected at downstream properties.
- The predicted impacts are consistent with those approved as part of the Bulk Earthworks DA and considered by Worley Parsons independent peer review by Worley Parsons to be *“minor for all areas outside of the Lendlease site.”*

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

7. References

DHI (2011) *MIKE11 Reference Manual*

DHI (2011) *MIKE21 Reference Manual*

Jacobs (2015), *Central Precinct of St Mary's Project Development: Flood Assessment Report (Final)* 20 July 15

NSW Government (2005) *Floodplain Development Manual: the management of flood liable land*

NSW Government (2007) *Floodplain Risk Management Guideline – Floodway Definition*

SKM (May 2009) St Marys Project – Central Precinct Plan, Water, Soils, and Infrastructure Report

SKM (30 Mar 2007) *Dunheved Precinct Development Application, Flood Impact Assessment*

SKM (18 Dec 2007) *Dunheved Precinct Development Application Flood Impact Assessment Addendum*

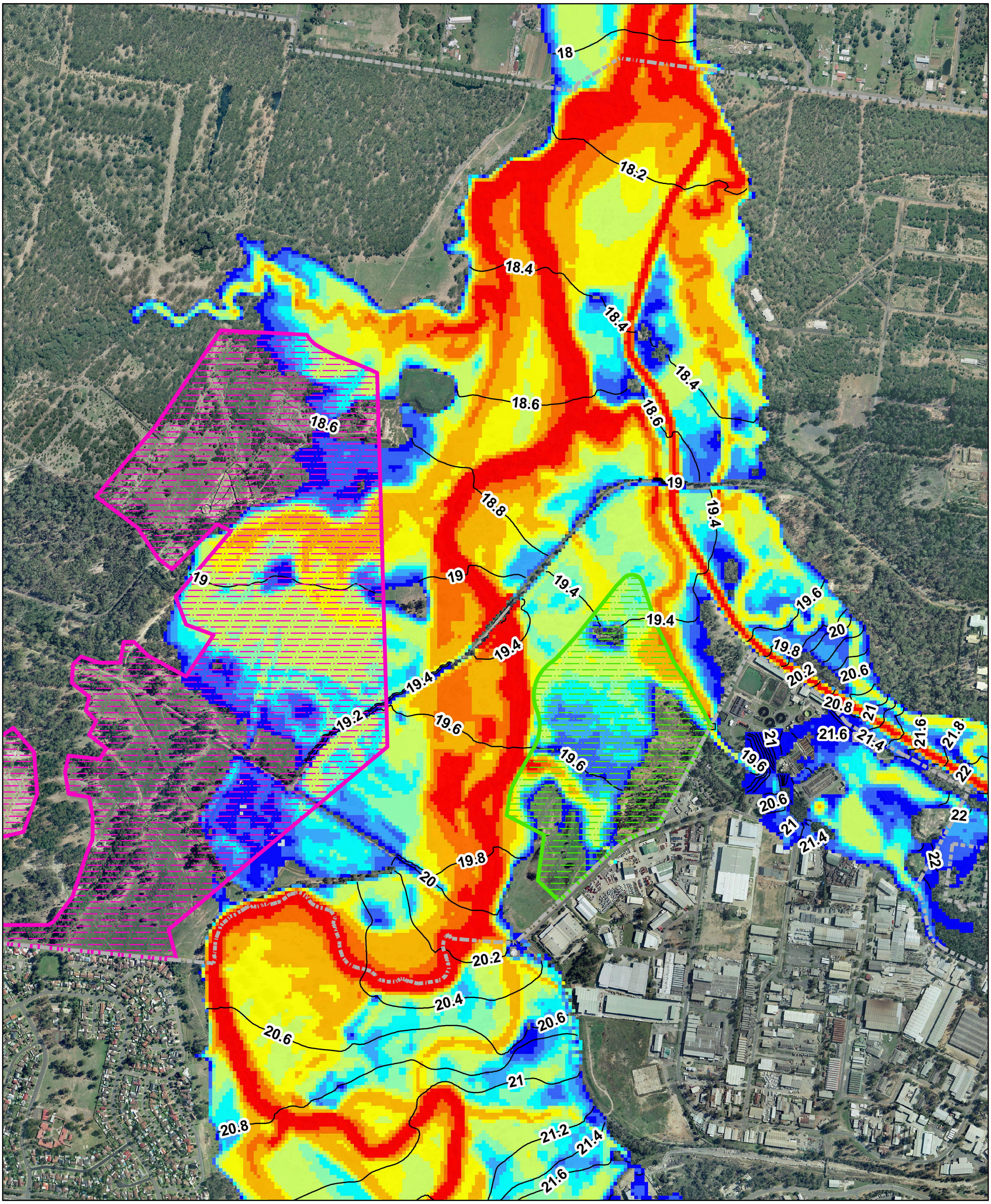
Worley Parsons (2013) *South Creek Flood Study: Provision of DRAFT Results at ADI Site, St Marys*

Worley Parsons (2015) *St Marys Central Precinct Flood Impact Assessment: Peer Review* 3 July 2015

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

Appendix A. Existing flood mapping

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct
- Flood Contour (mAHD)

Peak Flood Depth (m)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- > 4.0

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure A-1: Peak Flood Inundation

5% AEP Local Tailwater

Existing Conditions - E078

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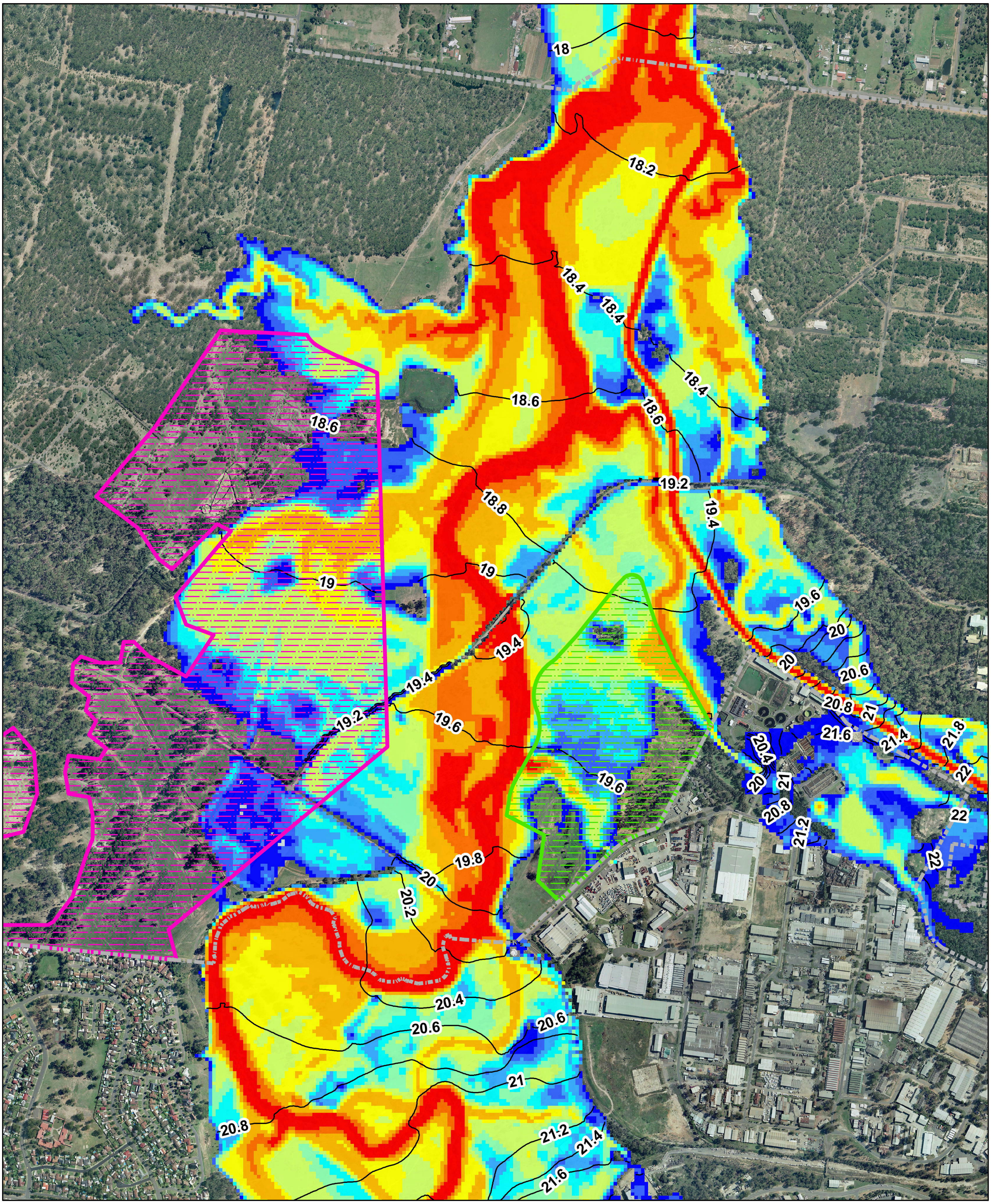
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary
Dunheved Precinct
Central Precinct
Flood Contour (mAHD)

Peak Flood Depth (m)

< 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 3.0
3.0 - 4.0
> 4.0

0 100 200 400 600 800 1,000 Meters
Scale in A3

Figure A-2: Peak Flood Inundation
5% AEP Regional Tailwater
Existing Conditions - E078

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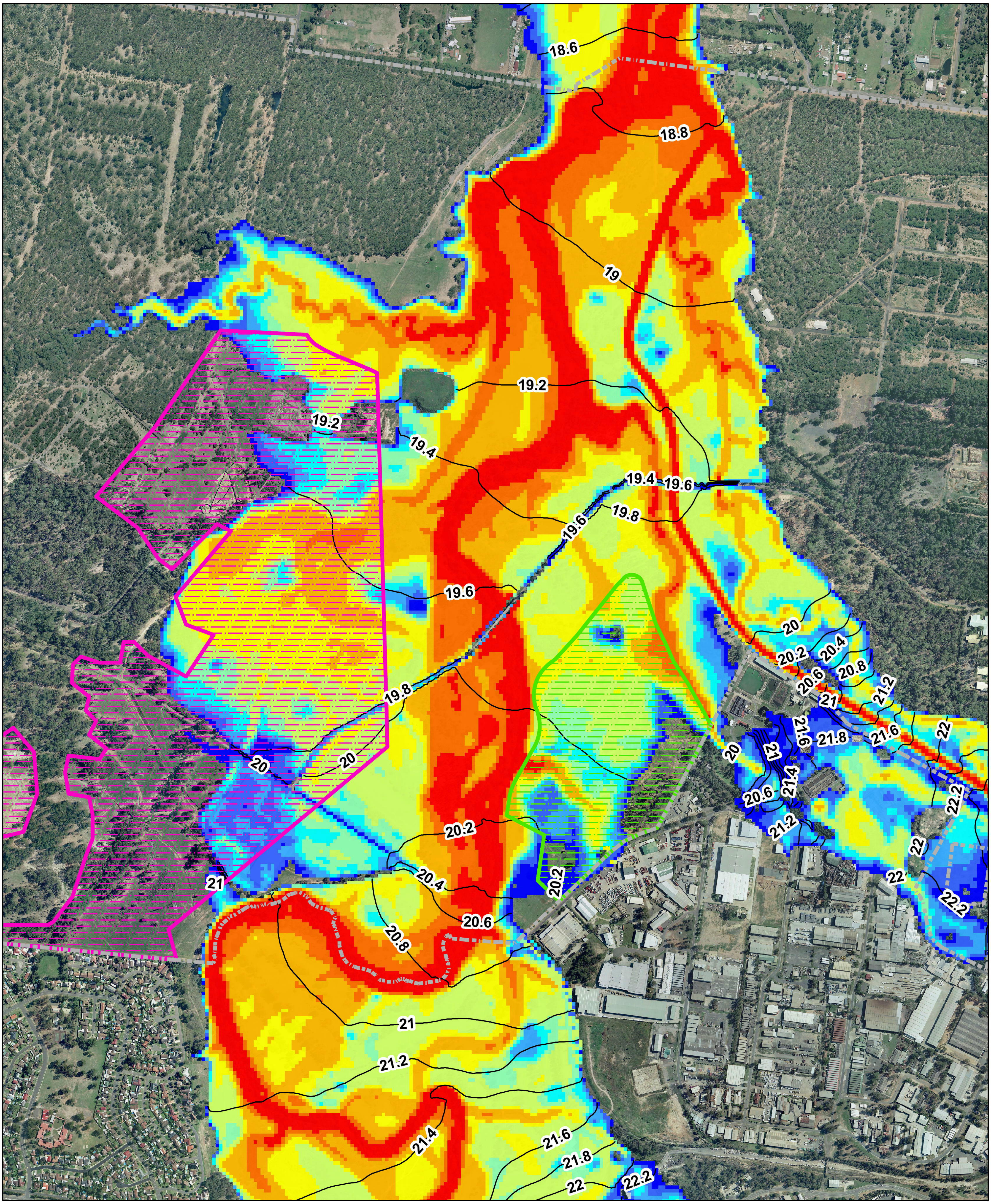

Legend

Site Boundary
Dunheved Precinct
Central Precinct
Flood Contour (mAHD)

Peak Flood Depth (m)

< 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 3.0
3.0 - 4.0
> 4.0

0 100 200 400 600 800 1,000 Meters
Scale in A3

Figure A-3: Peak Flood Inundation
1% AEP Local Tailwater
Existing Conditions - E078

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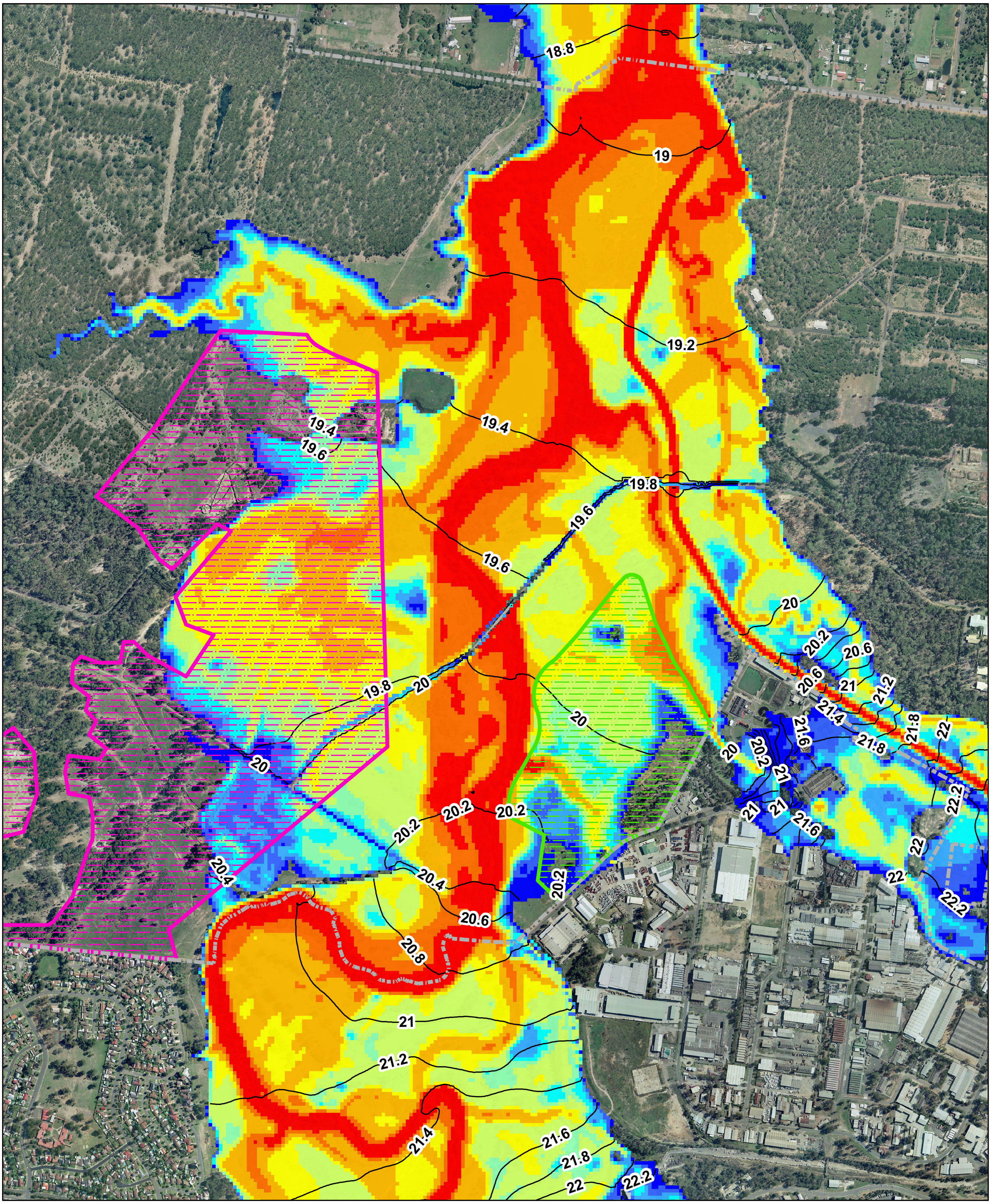

Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct
- Flood Contour (mAHD)

Peak Flood Depth (m)

< 0.2	0.6 - 0.8
0.2 - 0.4	0.8 - 1.0
0.4 - 0.6	1.0 - 1.5
	1.5 - 2.0
	2.0 - 3.0
	3.0 - 4.0
	> 4.0

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure A-4: Peak Flood Inundation

1% AEP Regional Tailwater

Existing Conditions - E078

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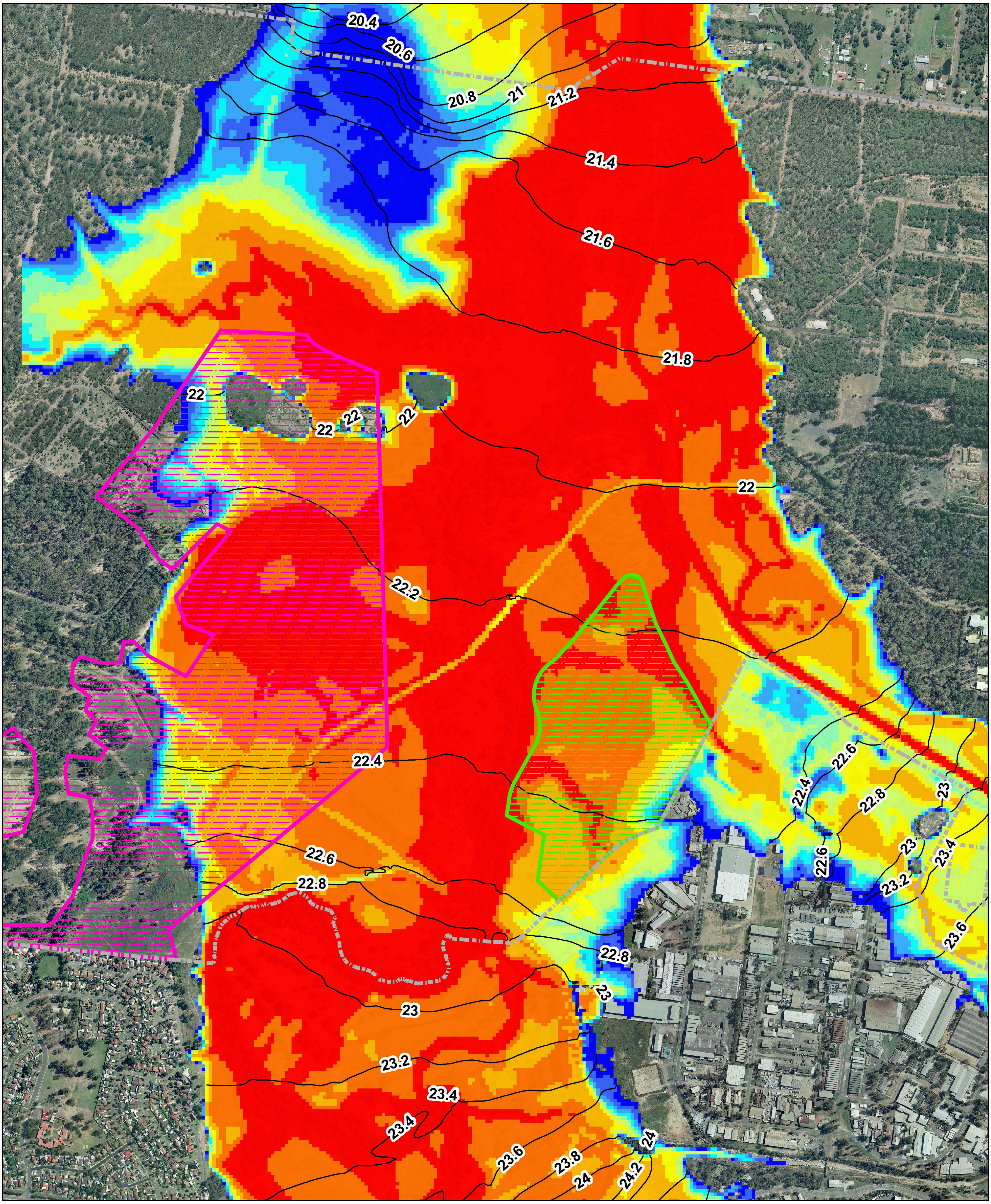

Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct
- Flood Contour (mAHD)

Peak Flood Depth (m)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- > 4.0

Figure A-5: Peak Flood Inundation
Probable Maximum Flood Local Tailwater
Existing Conditions - E078

0 100 200 400 600 800 1,000 Meters

Scale in A3

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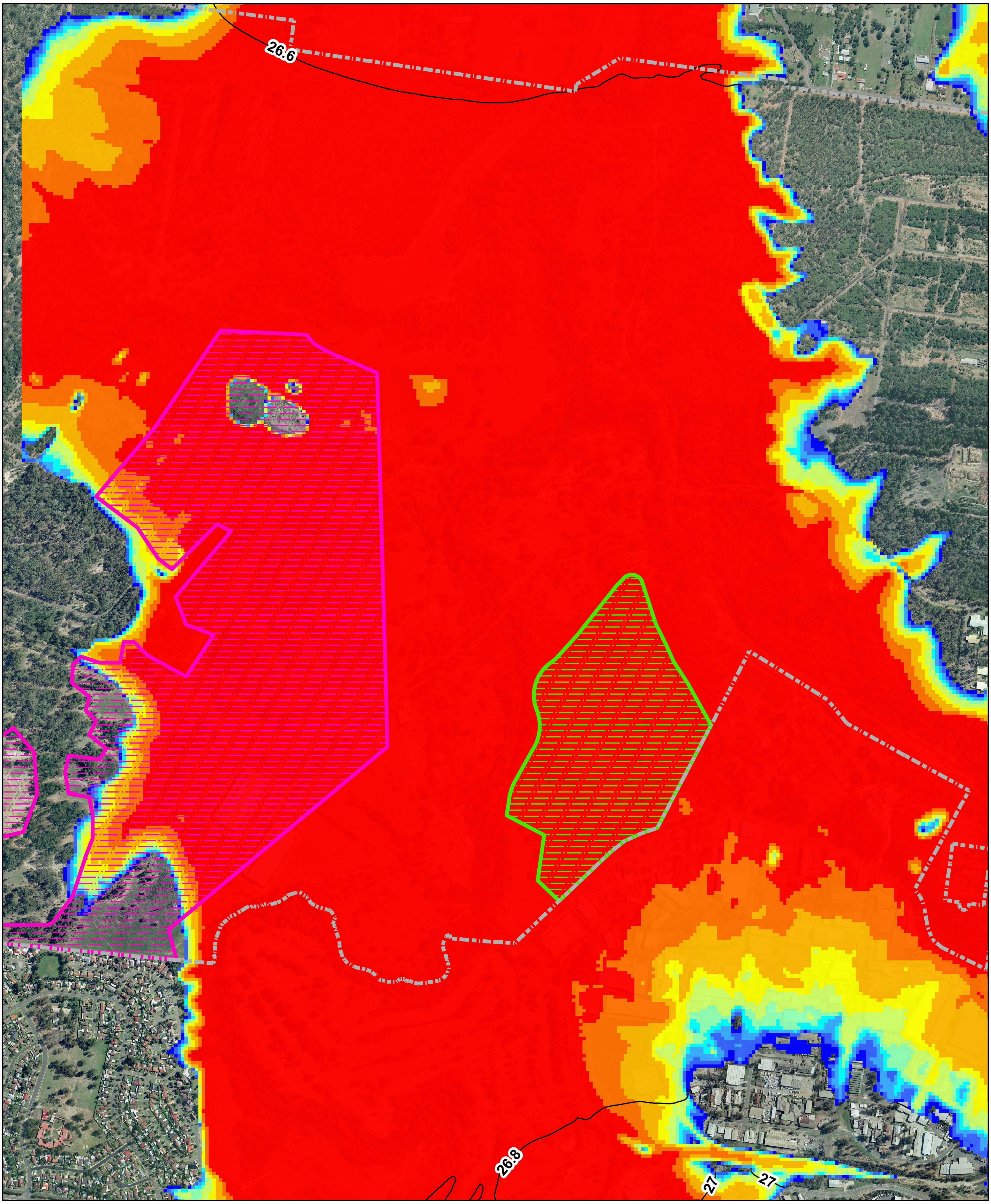

Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct
- Flood Contour (mAHD)

Peak Flood Depth (m)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- > 4.0

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure A-6: Peak Flood Inundation
Probable Maximum Flood Regional Tailwater
Existing Conditions - E078

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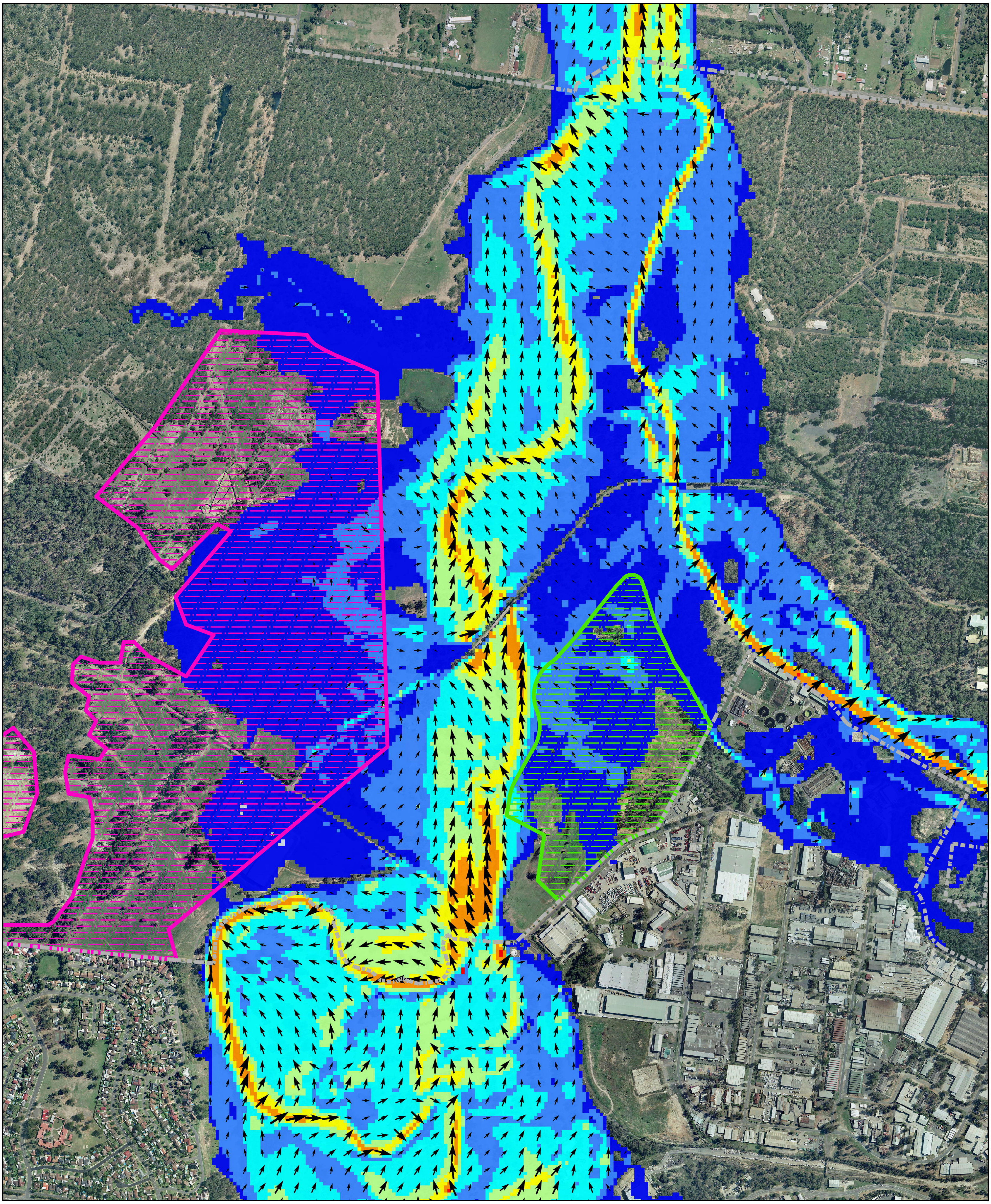
Appendix B. Existing velocity mapping

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct

Peak Velocity (m/s)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- >1.5

Velocity Vectors (m/s)

- Less than 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- Greater than 1

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure B-1: Peak Flood Velocity
5% AEP Local Tailwater
Existing Conditions - E078

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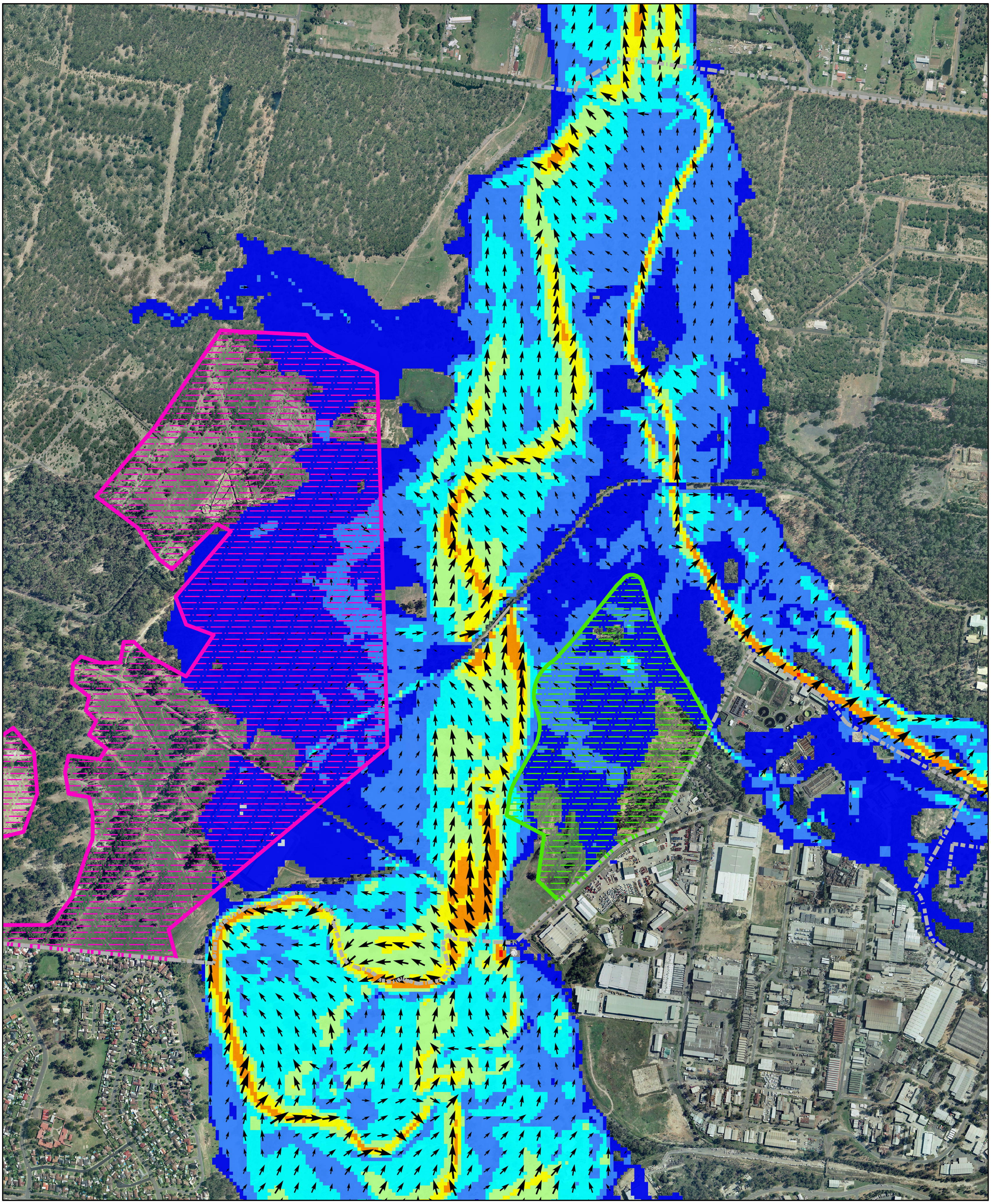
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary
Dunheved Precinct
Central Precinct

Peak Velocity (m/s)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- >1.5

Velocity Vectors (m/s)

- Less than 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- Greater than 1

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure B-2: Peak Flood Velocity
5% AEP Regional Tailwater
Existing Conditions - E078

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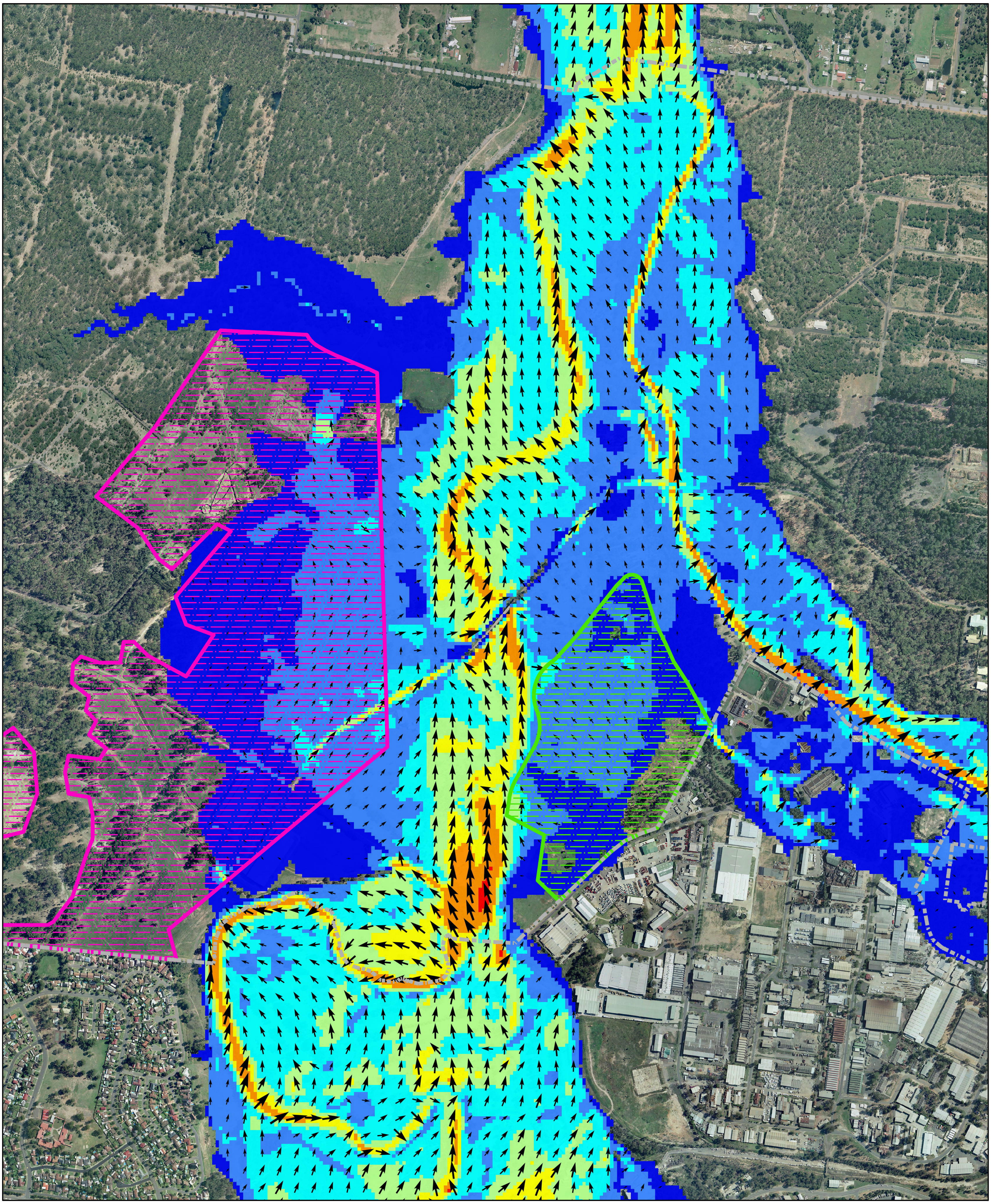
Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary
Dunheved Precinct
Central Precinct

0.8 - 1.0
1.0 - 1.5
>1.5

Peak Velocity (m/s)

< 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8

Velocity Vectors (m/s)

Less than 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
Greater than 1

Figure B-3: Peak Flood Velocity
1% AEP Local Tailwater
Existing Conditions - E078

0 100 200 400 600 800 1,000 Meters
Scale in A3

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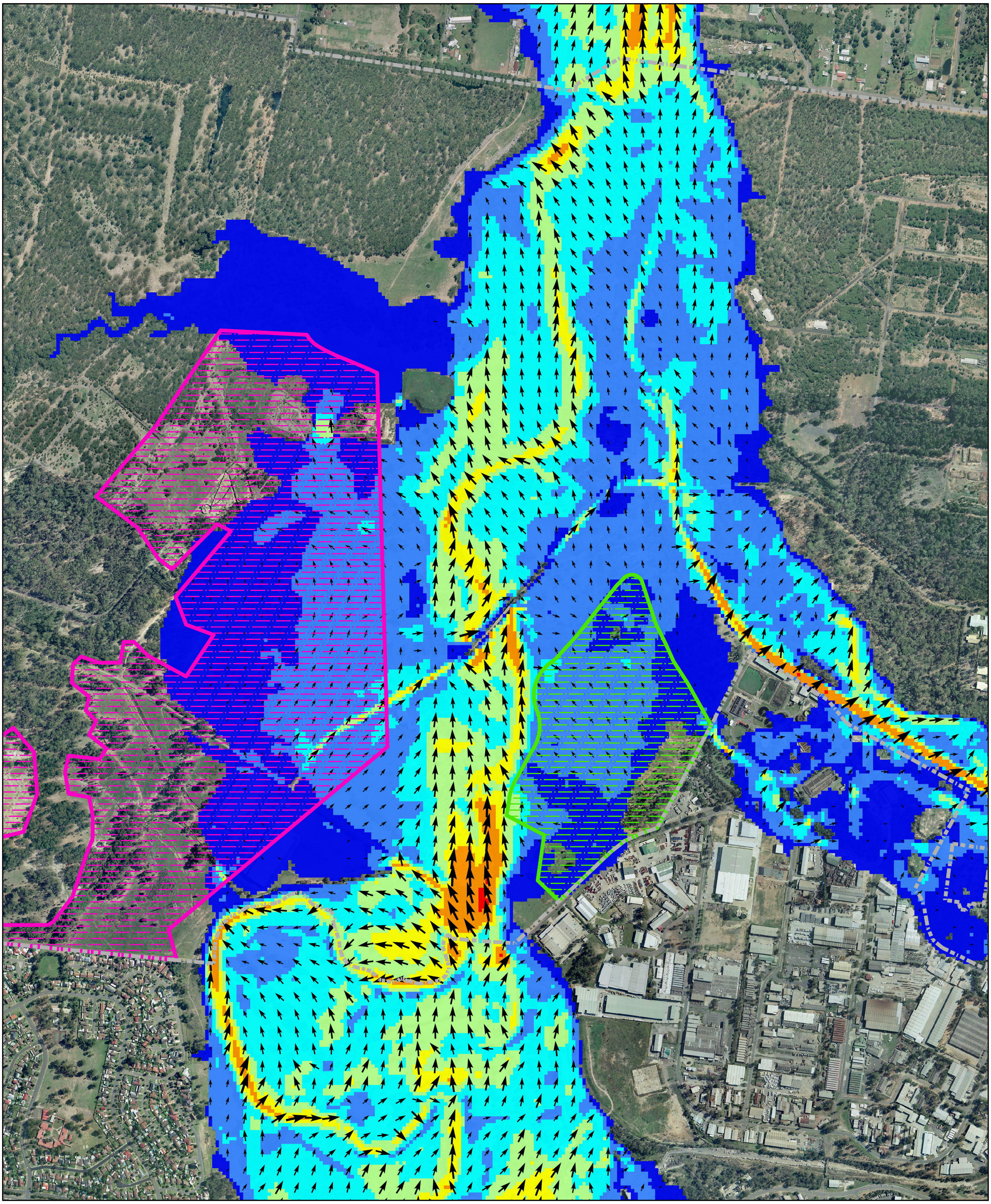
Document Set ID: 8106709
Version: 1, Version Date: 19/04/2018



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct

Peak Velocity (m/s)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- >1.5

Velocity Vectors (m/s)

- Less than 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- Greater than 1

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure B-4: Peak Flood Velocity
1% AEP Regional Tailwater
Existing Conditions - E078

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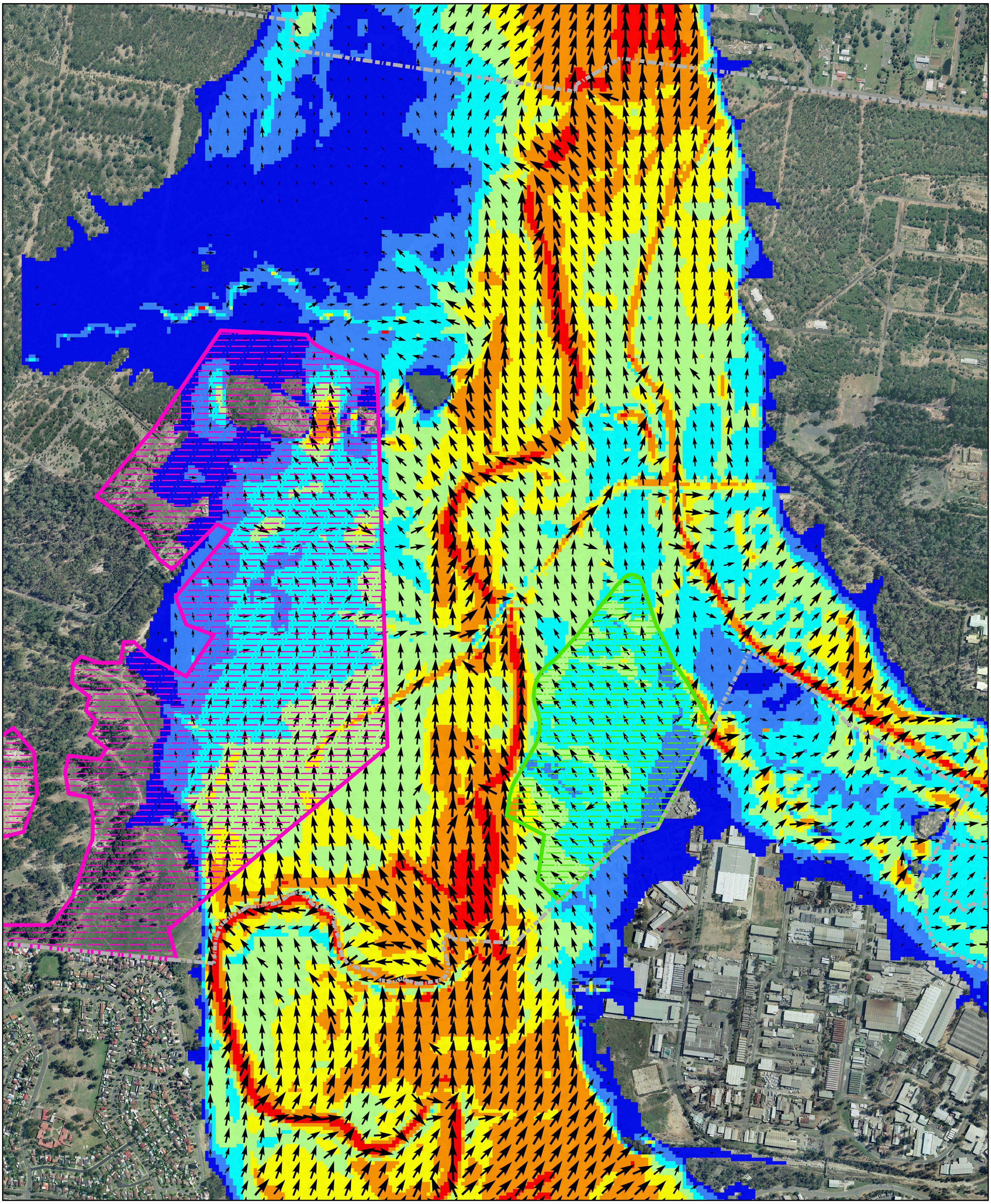
Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct

Peak Velocity (m/s)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- >1.5

Velocity Vectors (m/s)

- Less than 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- Greater than 1

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure B-5: Peak Flood Velocity
Probable Maximum Flood Local Tailwater
Existing Conditions - E078

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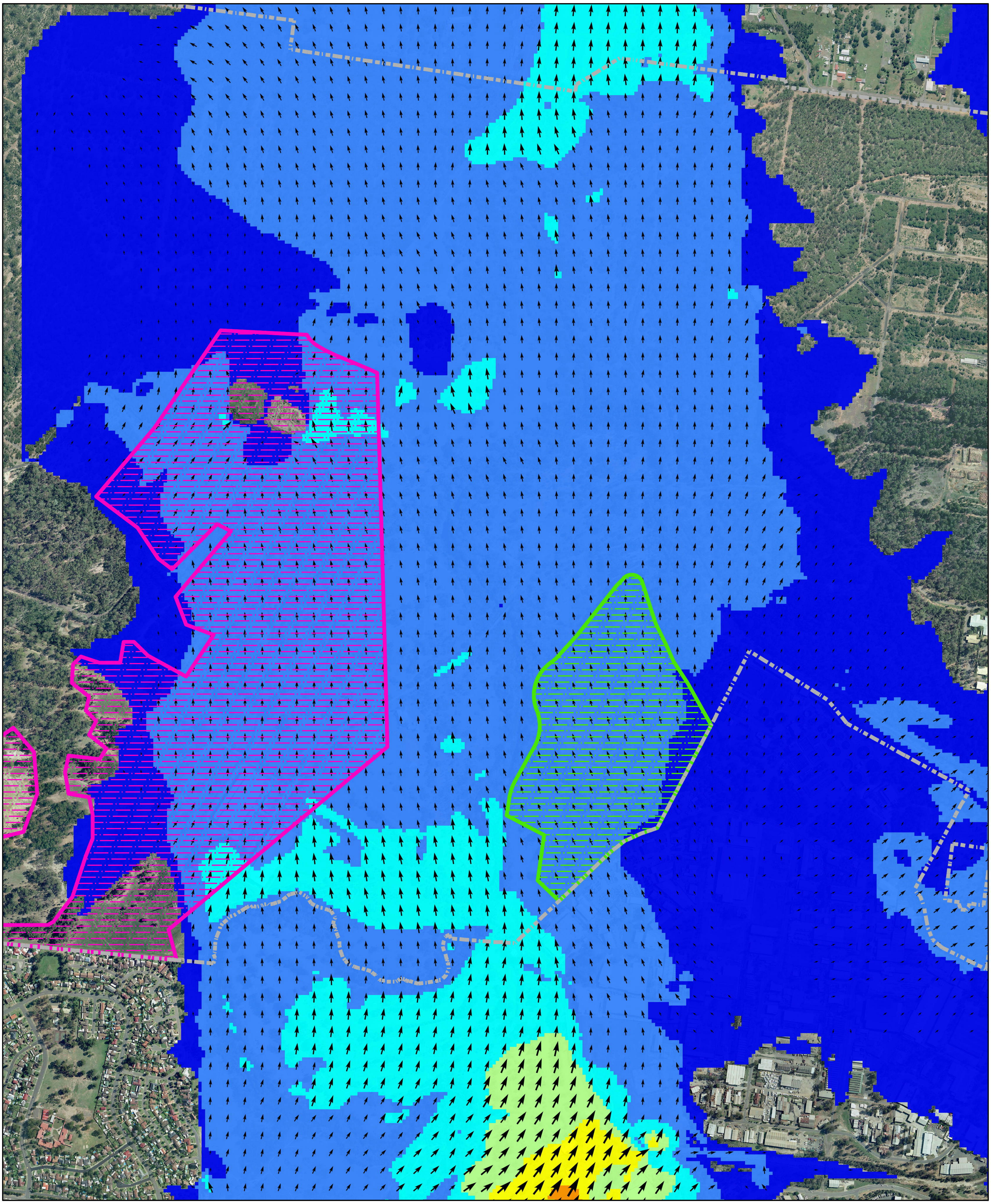
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary

Dunheved Precinct

Central Precinct

0.8 - 1.0

1.0 - 1.5

>1.5

Peak Velocity (m/s)

< 0.2

0.2 - 0.4

0.4 - 0.6

0.6 - 0.8

Velocity Vectors (m/s)

Less than 0.2

0.2 - 0.4

0.4 - 0.6

0.6 - 0.8

0.8 - 1.0

Greater than 1

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure B-6: Peak Flood Velocity
Probable Maximum Flood Regional Tailwater
Existing Conditions - E078

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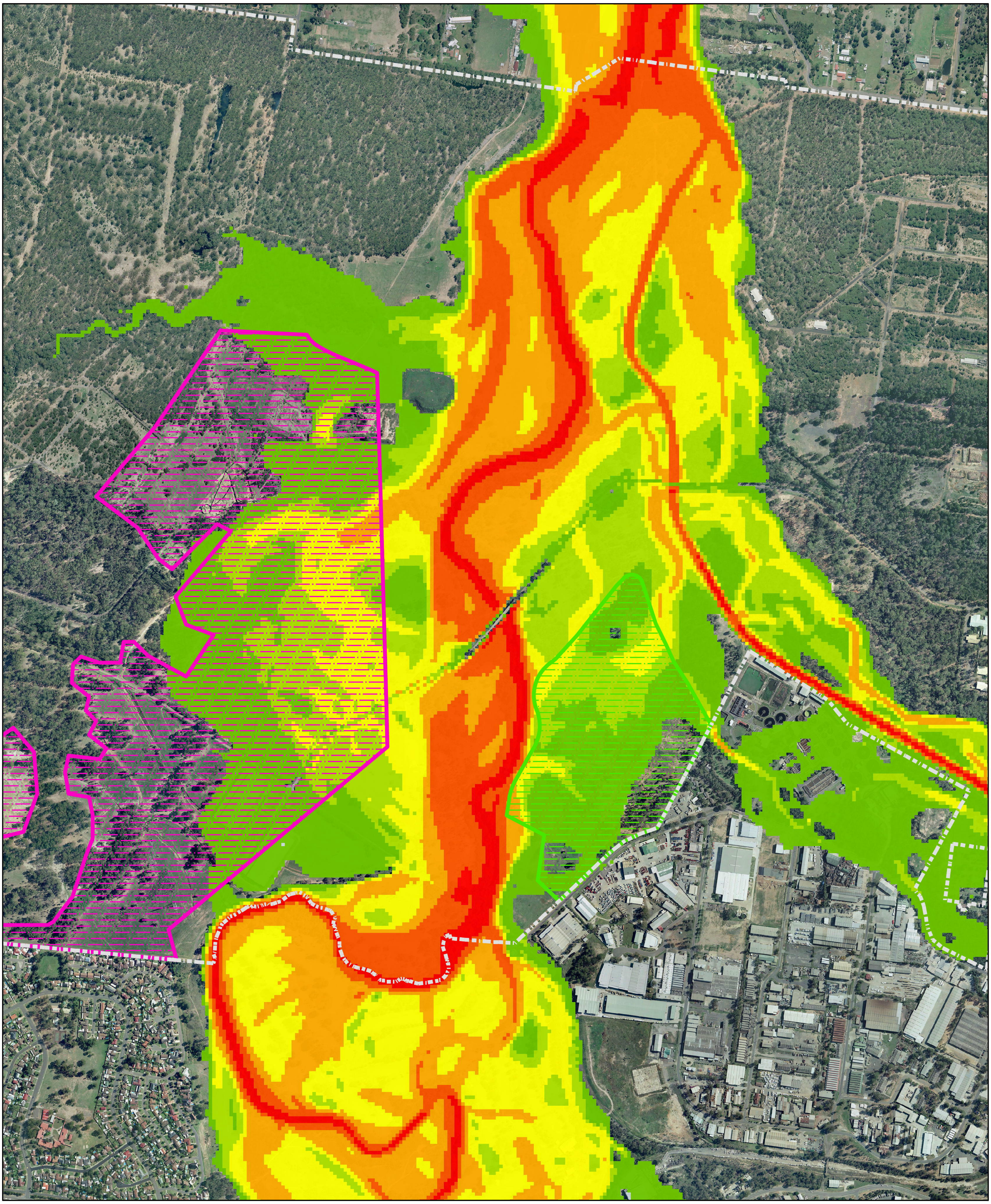
Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

Appendix C. Flow Intensity (Velocity Depth Product) mapping

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary
Dunheved Precinct
Central Precinct

Velocity Depth Product (m2/s)

0
<0.3
0.3 - 0.5
0.5 - 1
1 - 2
2 - 5
>5

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure C-1: Flow Intensity (Velocity-Depth Product)
1% AEP Regional Tailwater
Existing Conditions - E078

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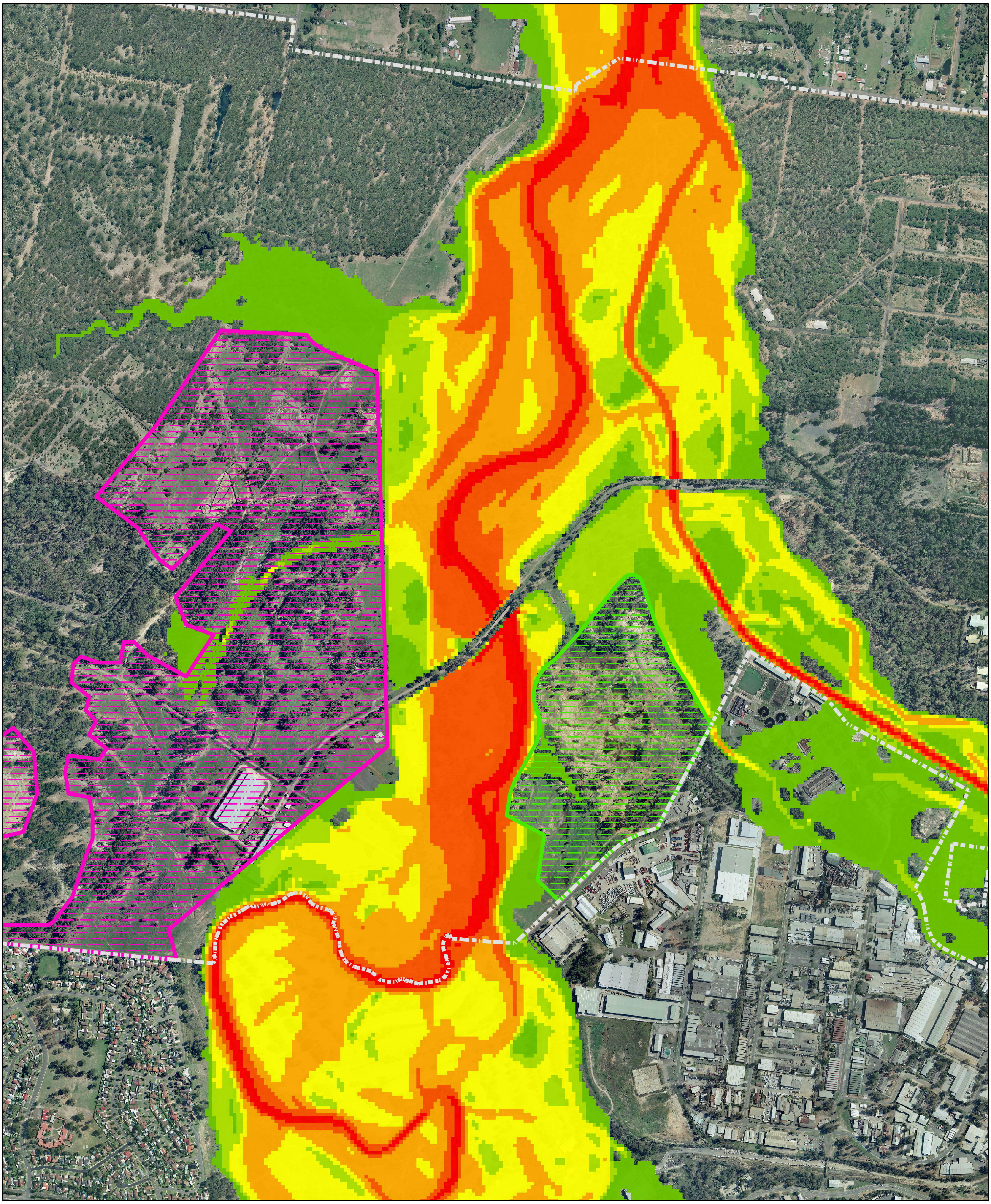
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct

Velocity Depth Product (m2/s)

- 0
- <0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- >5

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure C-2: Flow Intensity (Velocity-Depth Product)
1% AEP Regional Tailwater
Developed Conditions - D301

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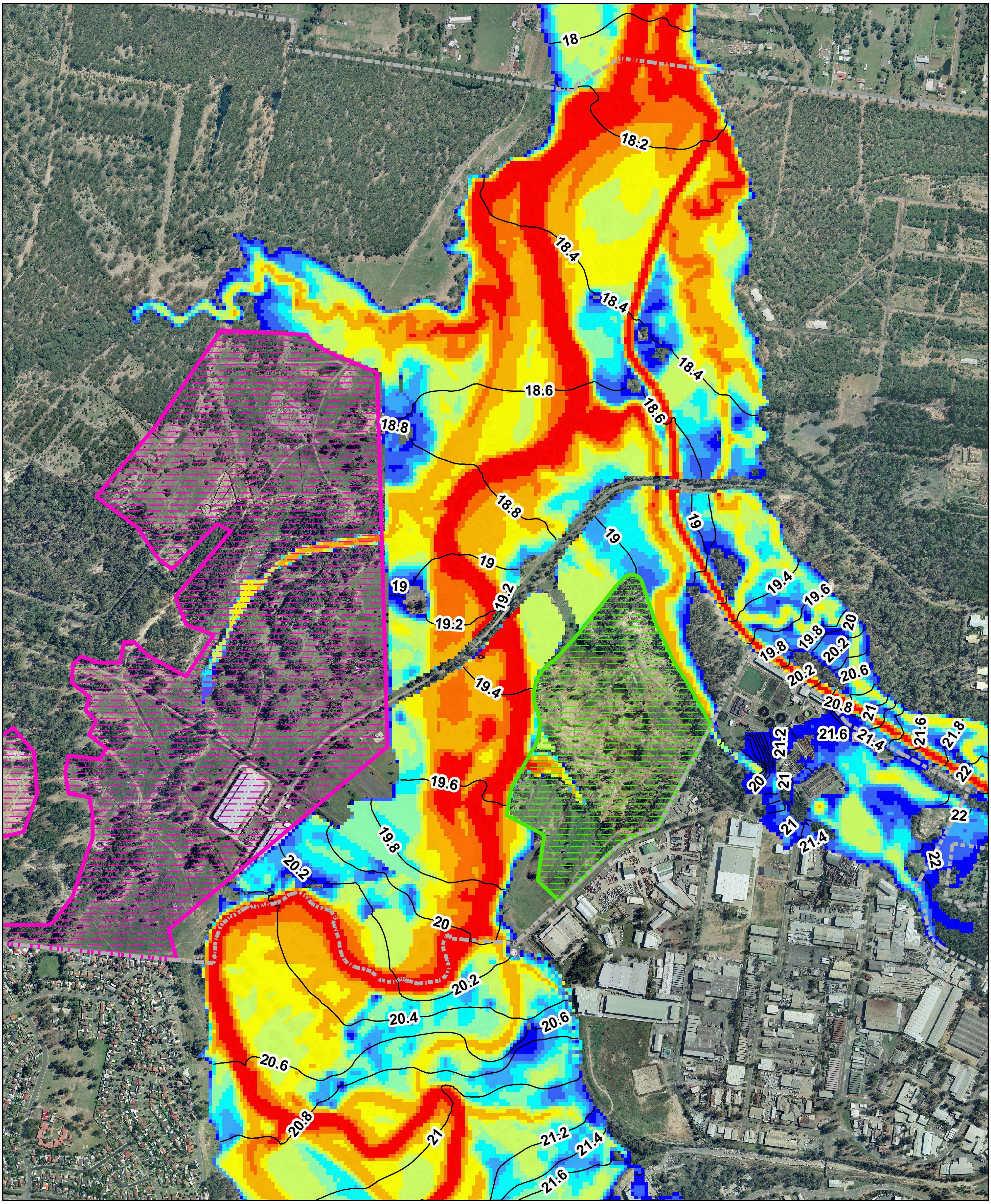
Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018

Appendix D. Developed case flood mapping

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary
Dunheved Precinct
Central Precinct
Flood Contour (mAHD)

Peak Flood Depth (m)

< 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 3.0
3.0 - 4.0
> 4.0

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure D-1: Peak Flood Inundation
5% AEP Local Tailwater
Jacobs Model D301

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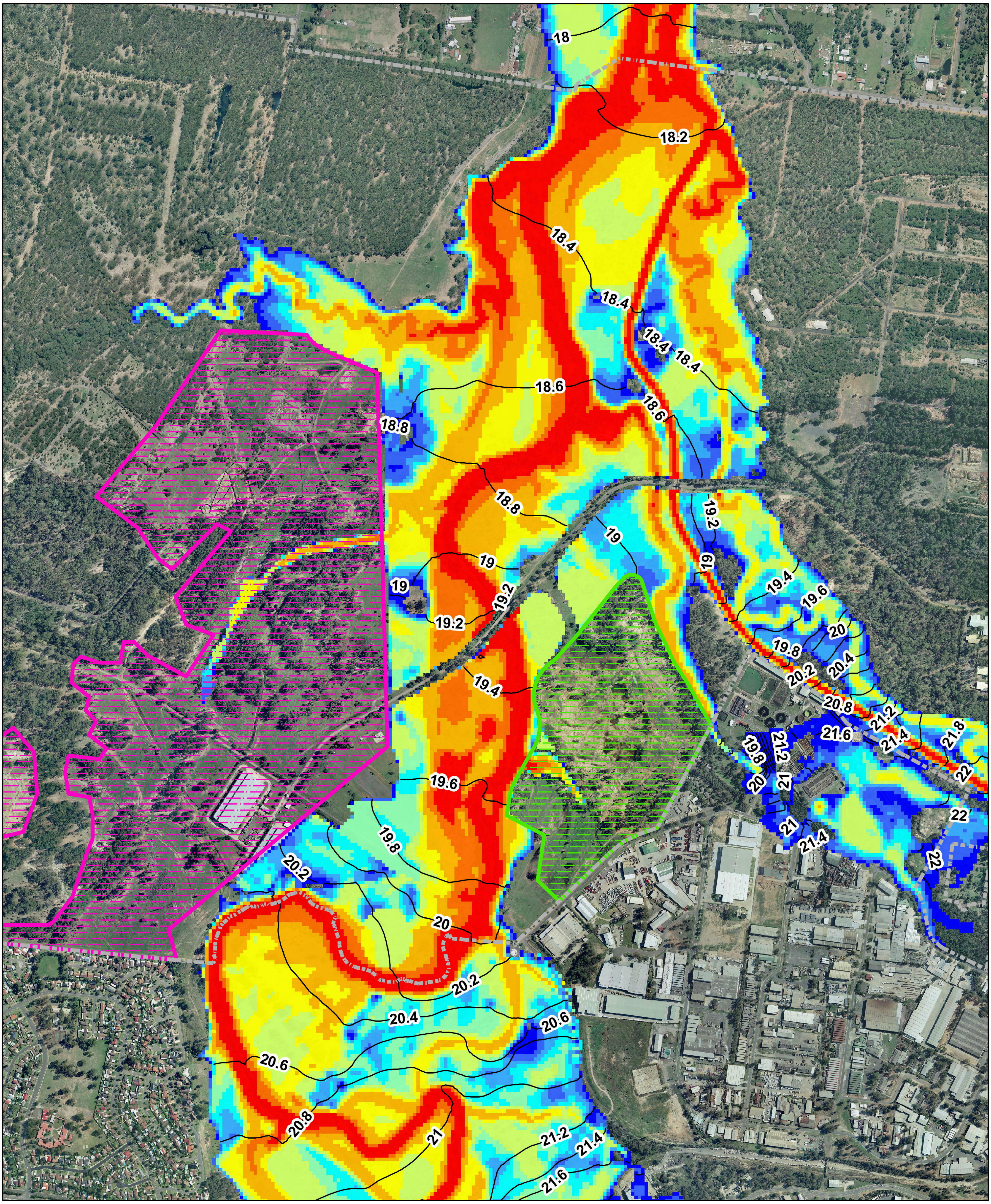
Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8106709
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary	0.6 - 0.8
Dunheved Precinct	0.8 - 1.0
Central Precinct	1.0 - 1.5
Flood Contour (mAHD)	1.5 - 2.0
Peak Flood Depth (m)	2.0 - 3.0
< 0.2	3.0 - 4.0
0.2 - 0.4	> 4.0
0.4 - 0.6	

Figure D-2: Peak Flood Inundation

5% AEP Regional Tailwater

Jacobs Model D301

0 100 200 400 600 800 1,000 Meters

Scale in A3

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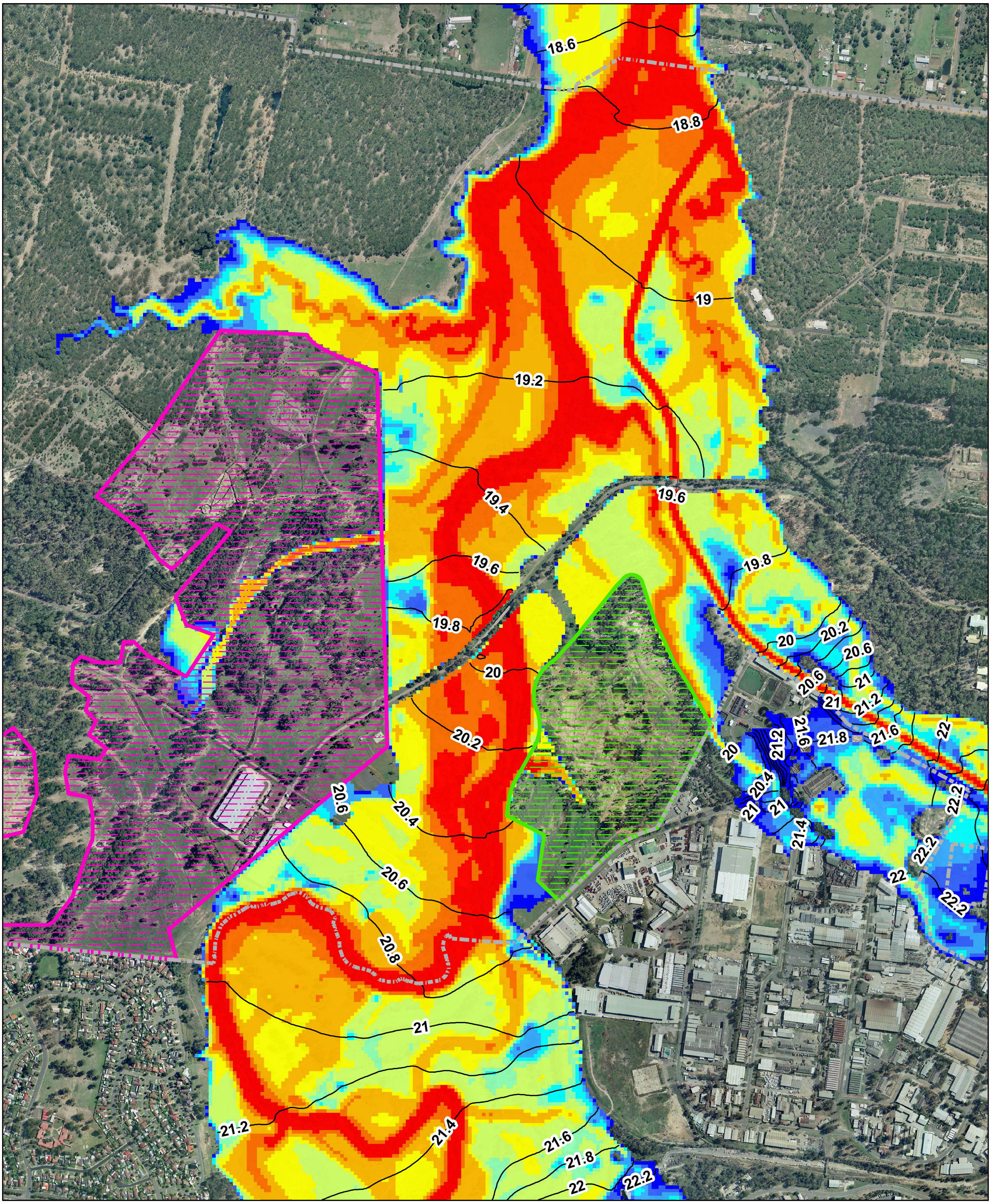

Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct
- Flood Contour (mAHD)

Peak Flood Depth (m)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- > 4.0

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure D-3: Peak Flood Inundation
1% AEP Local Tailwater
Jacobs Model D301

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8416709
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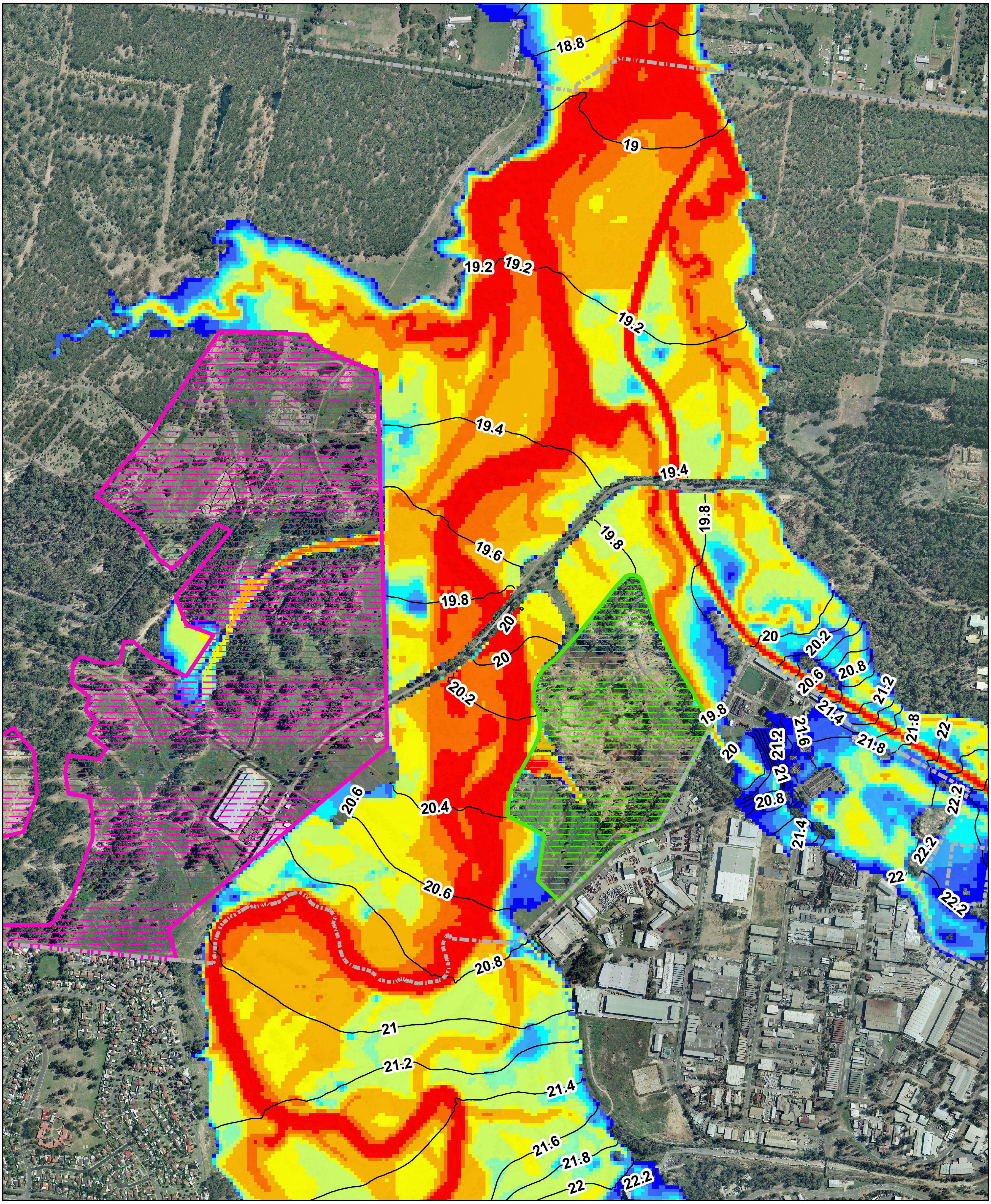


Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct
- Flood Contour (mAHD)

Peak Flood Depth (m)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- > 4.0

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure D-4: Peak Flood Inundation

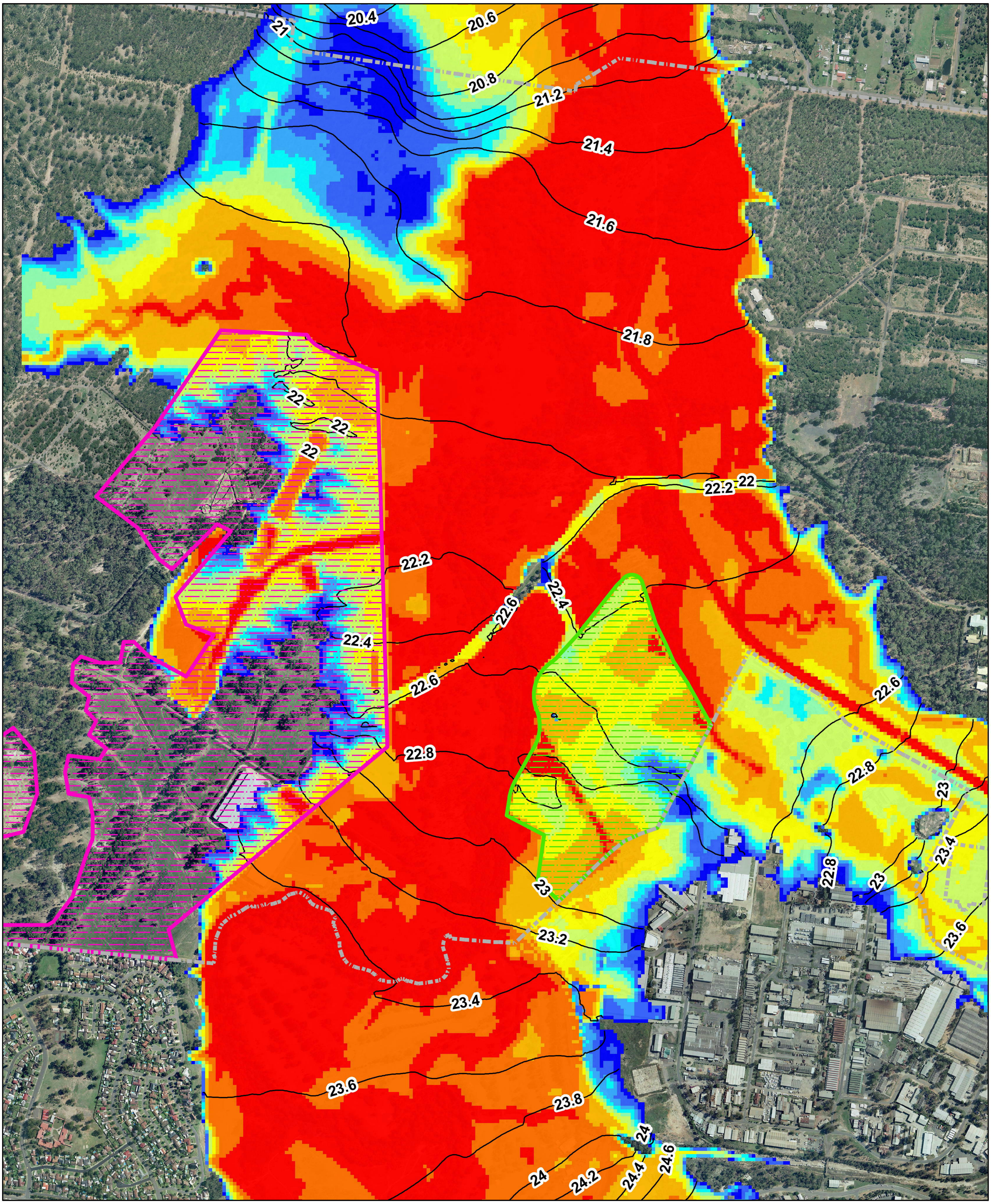
1% AEP Regional Tailwater

Jacobs Model D301

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8406709
Version: 1, Version Date: 19/04/2018



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct
- Flood Contour (mAHD)

Peak Flood Depth (m)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- > 4.0

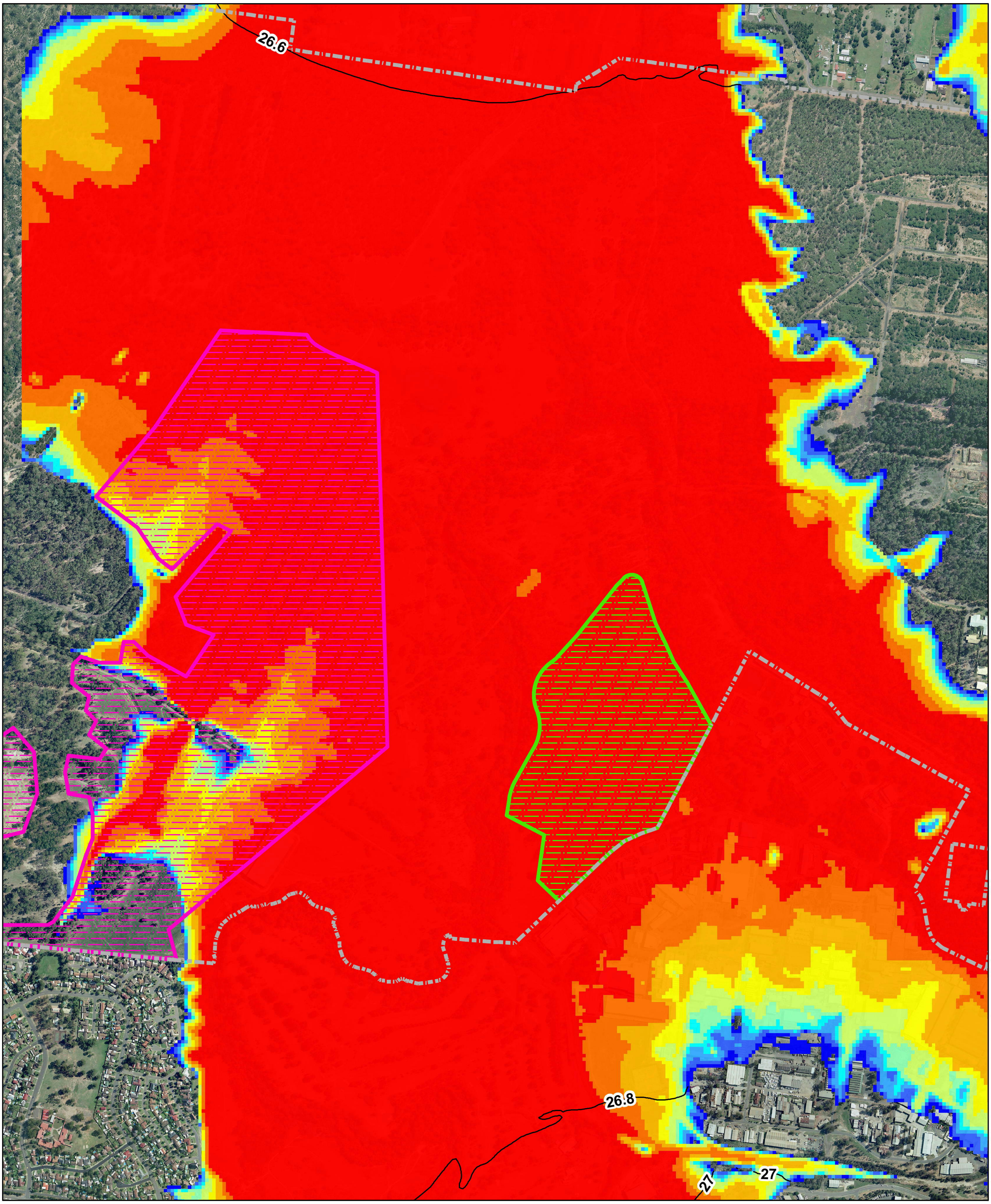
0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure D-5: Peak Flood Inundation
Probable Maximum Flood Local Tailwater
Jacobs Model D301

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct
- Flood Contour (mAHD)

Peak Flood Depth (m)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- > 4.0

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure D-6: Peak Flood Inundation
Probable Maximum Flood Regional Tailwater
Jacobs Model D301

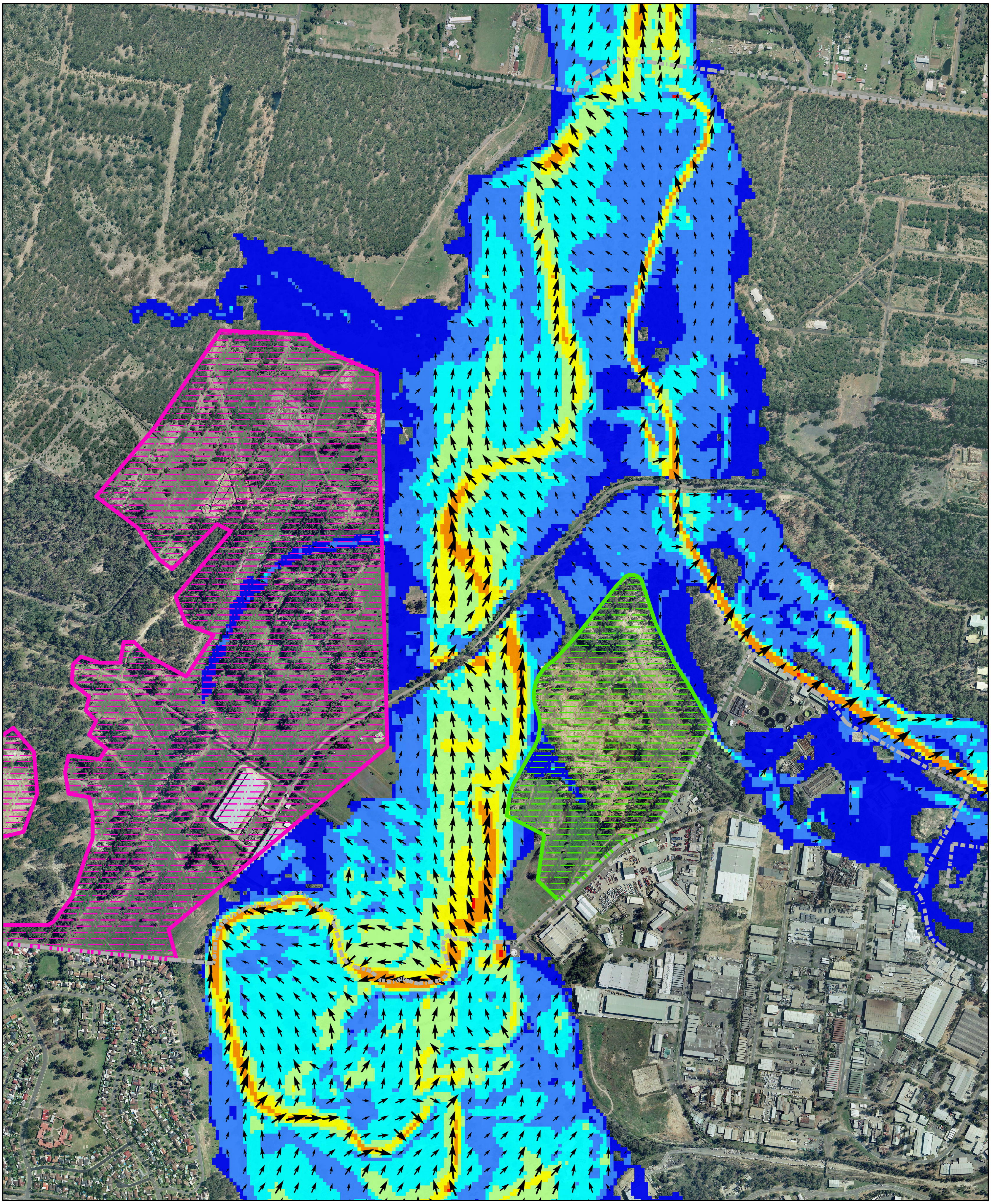
JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8106709
Version: 1, Version Date: 19/04/2018

Appendix E. Developed case velocity mapping

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct

Peak Velocity (m/s)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- >1.5

Velocity Vectors (m/s)

- Less than 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- Greater than 1

0 100 200 400 600 800 1,000 Meters

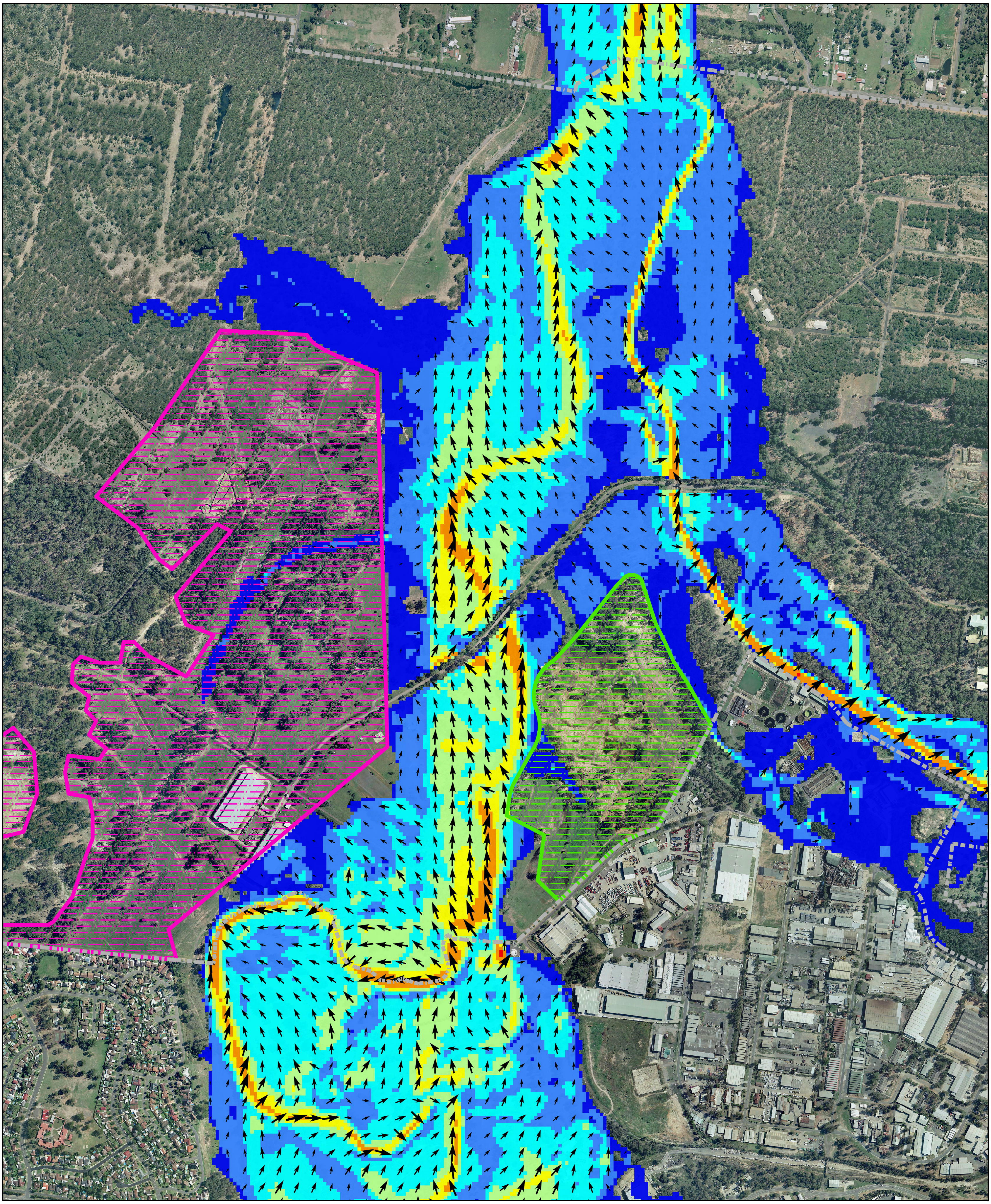
Scale in A3

Figure E-1: Peak Flood Velocity
5% AEP Local Tailwater
Jacobs Model D301

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8110709
Version: 1, Version Date: 19/04/2018



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct

Peak Velocity (m/s)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- >1.5

Velocity Vectors (m/s)

- Less than 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- Greater than 1

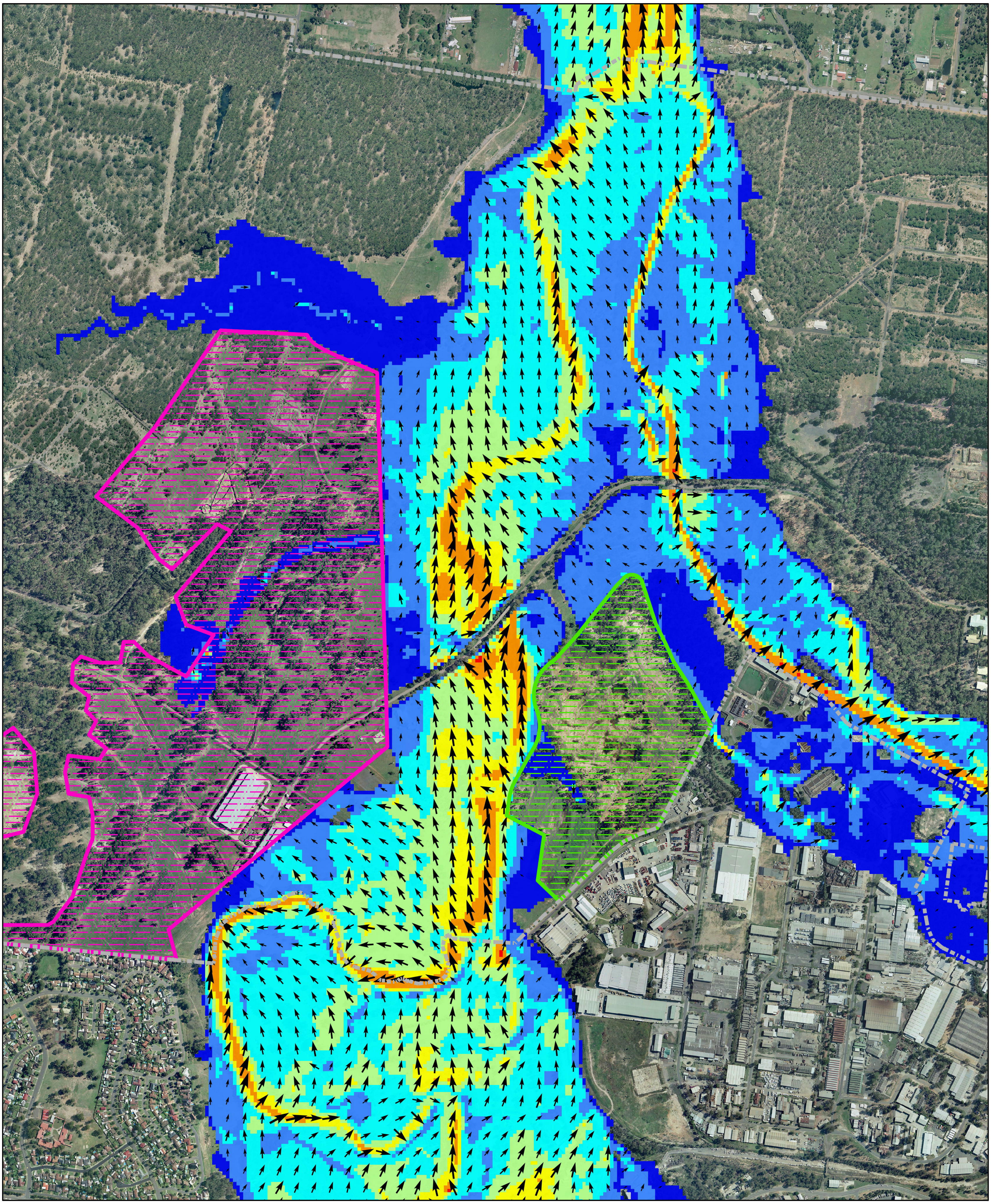
0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure E-2: Peak Flood Velocity
5% AEP Regional Tailwater
Jacobs Model D301

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt



Legend

Site Boundary
Dunheved Precinct
Central Precinct

Peak Velocity (m/s)

< 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
1.0 - 1.5
>1.5

Velocity Vectors (m/s)

Less than 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
Greater than 1

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure E-3: Peak Flood Velocity
1% AEP Local Tailwater
Jacobs Model D301

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

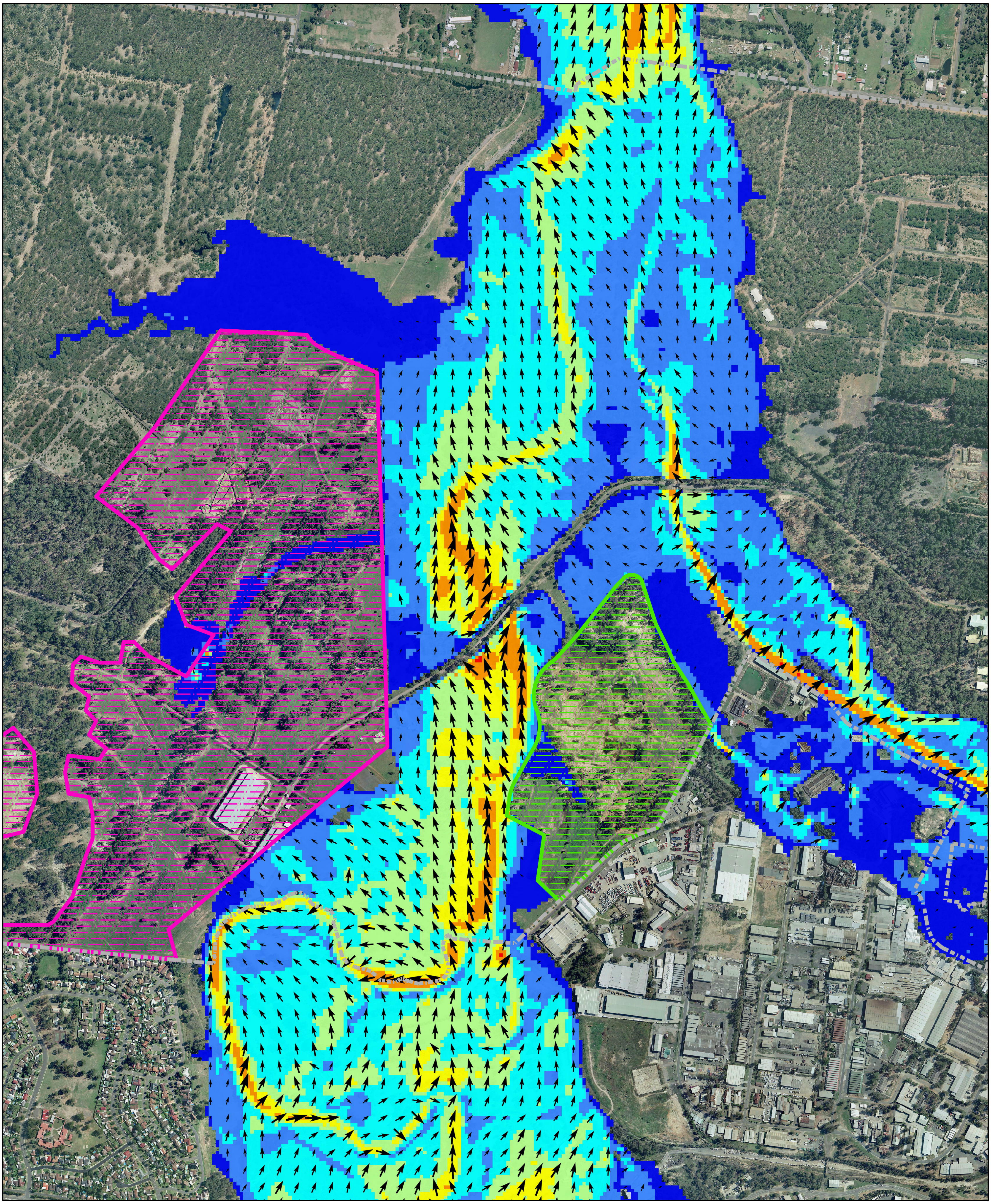


Figure E-4: Peak Flood Velocity
1% AEP Regional Tailwater
Jacobs Model D301

Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct

Peak Velocity (m/s)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- >1.5

Velocity Vectors (m/s)

- Less than 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- Greater than 1

0 100 200 400 600 800 1,000 Meters

Scale in A3

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Job No: EN04189
Last Modified: 29/01/2018
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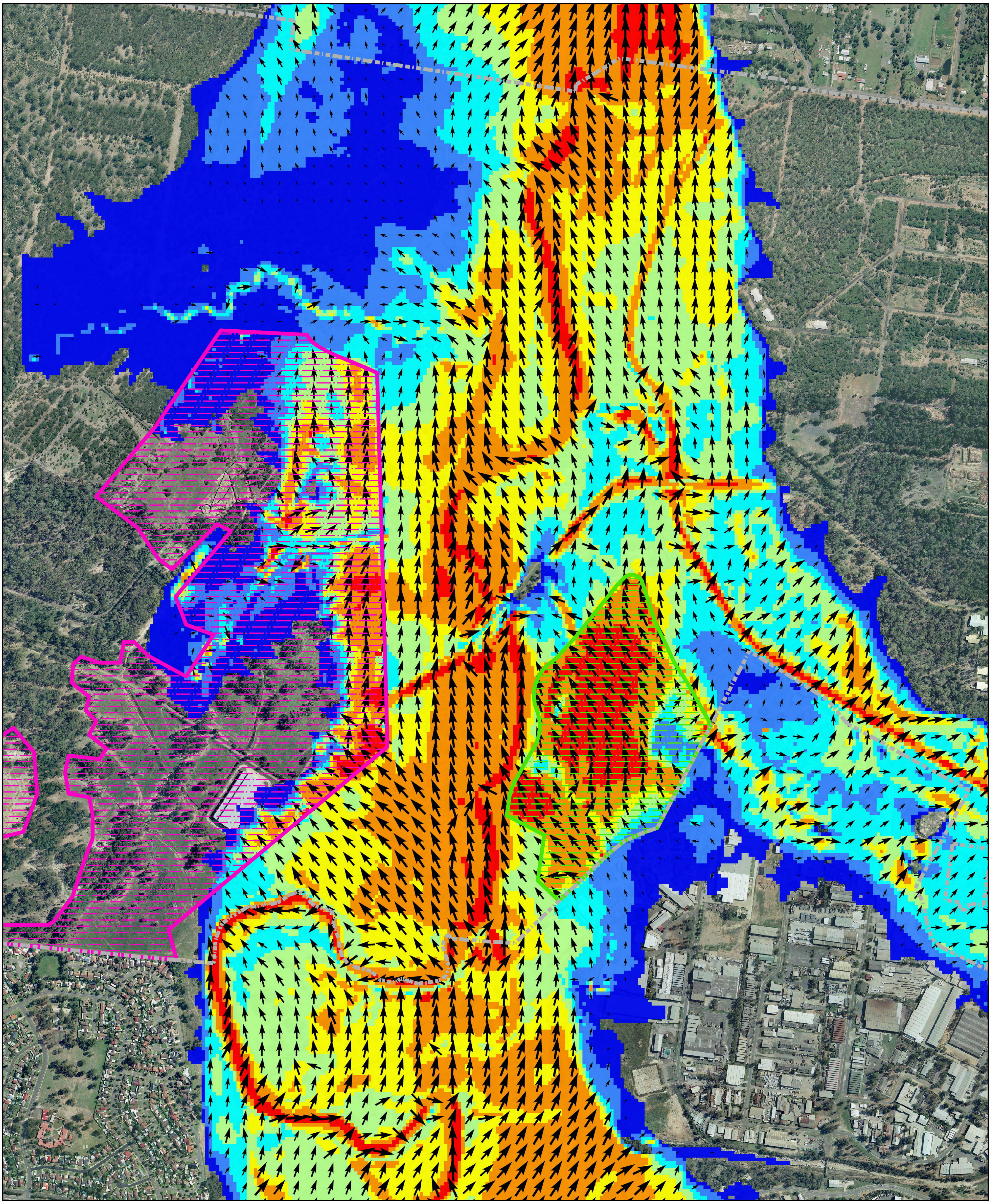
Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct

Peak Velocity (m/s)

- < 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- >1.5

Velocity Vectors (m/s)

- Less than 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- Greater than 1

Figure E-5: Peak Flood Velocity
Probable Maximum Flood Local Tailwater
Jacobs Model D301

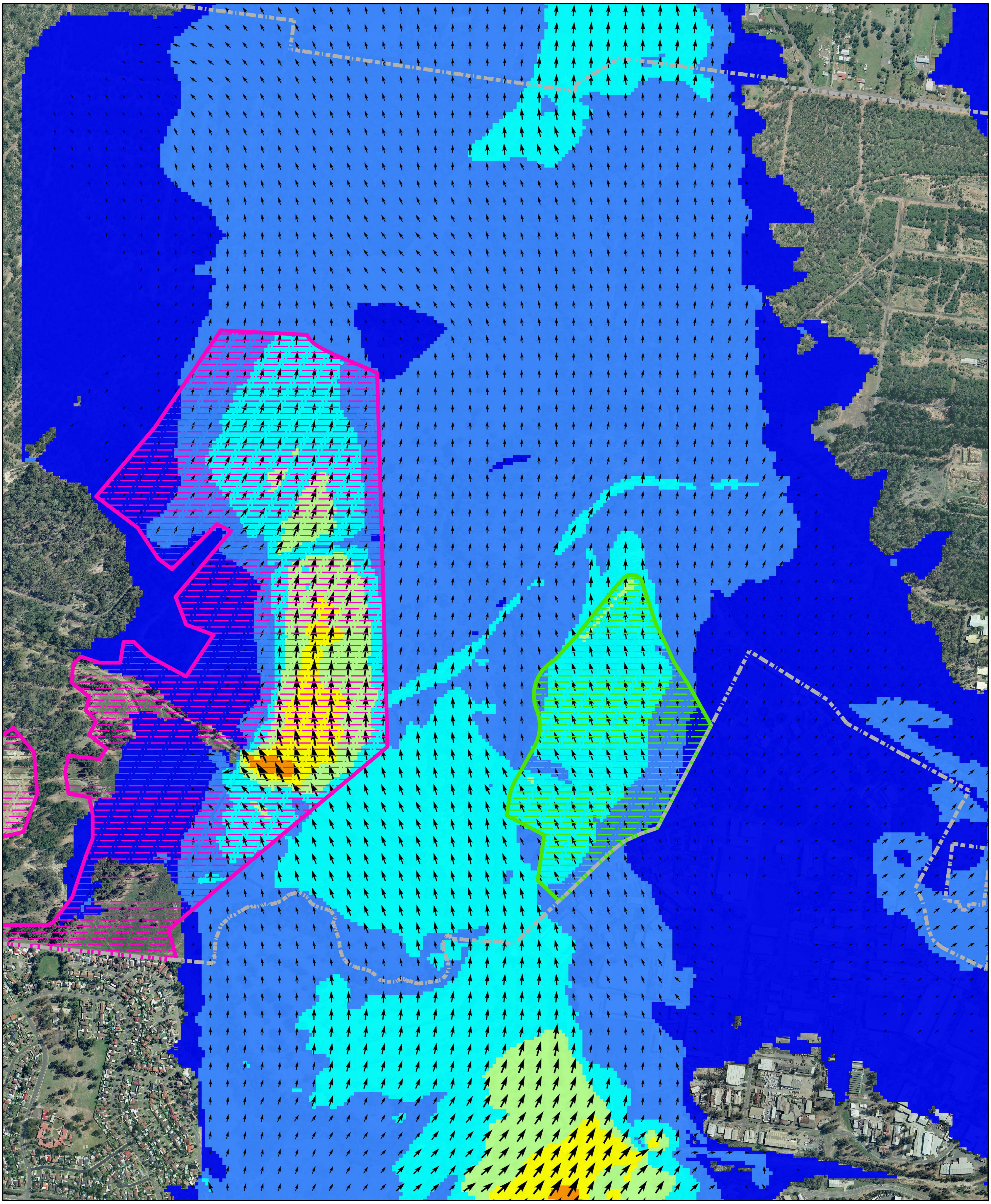
0 100 200 400 600 800 1,000 Meters

Scale in A3

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8106709
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary
Dunheved Precinct
Central Precinct

0.8 - 1.0
1.0 - 1.5
>1.5

Peak Velocity (m/s)

< 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8

Velocity Vectors (m/s)

Less than 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
Greater than 1

0 100 200 400 600 800 1,000 Meters
Scale in A3

Figure E-6: Peak Flood Velocity
Probable Maximum Flood Regional Tailwater
Jacobs Model D301

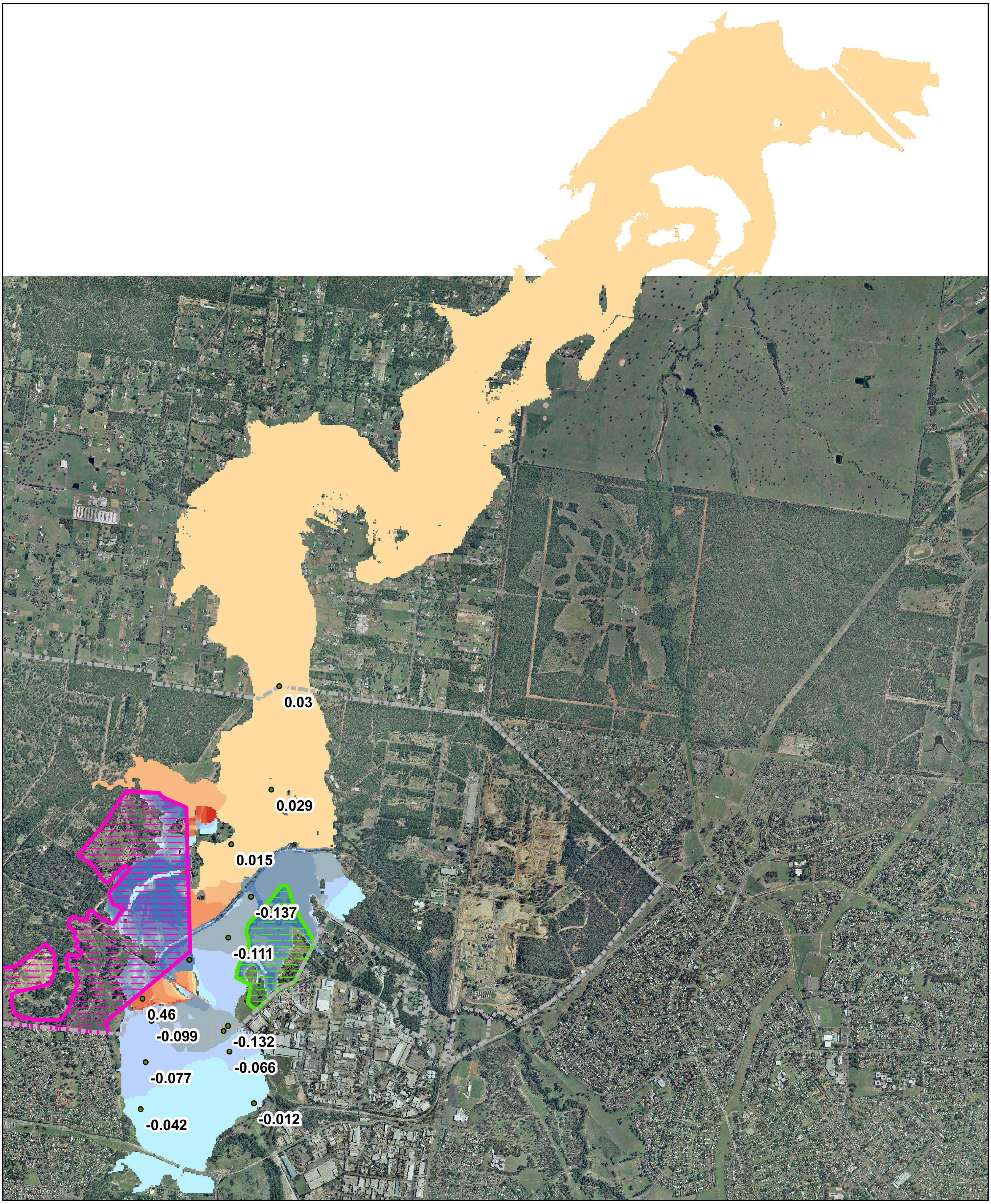
JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8106709
Version: 1, Version Date: 19/04/2018

Appendix F. Developed case impact maps

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

Spot Impacts (m)
Site Boundary
Dunheved Precinct
Central Precinct

Afflux (m)

< -1.00
-1.00 - -0.50
-0.50 - -0.20
-0.20 - -0.10
-0.10 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.10
0.10 - 0.20
0.20 - 0.50
0.50 - 1.00
> 1.00

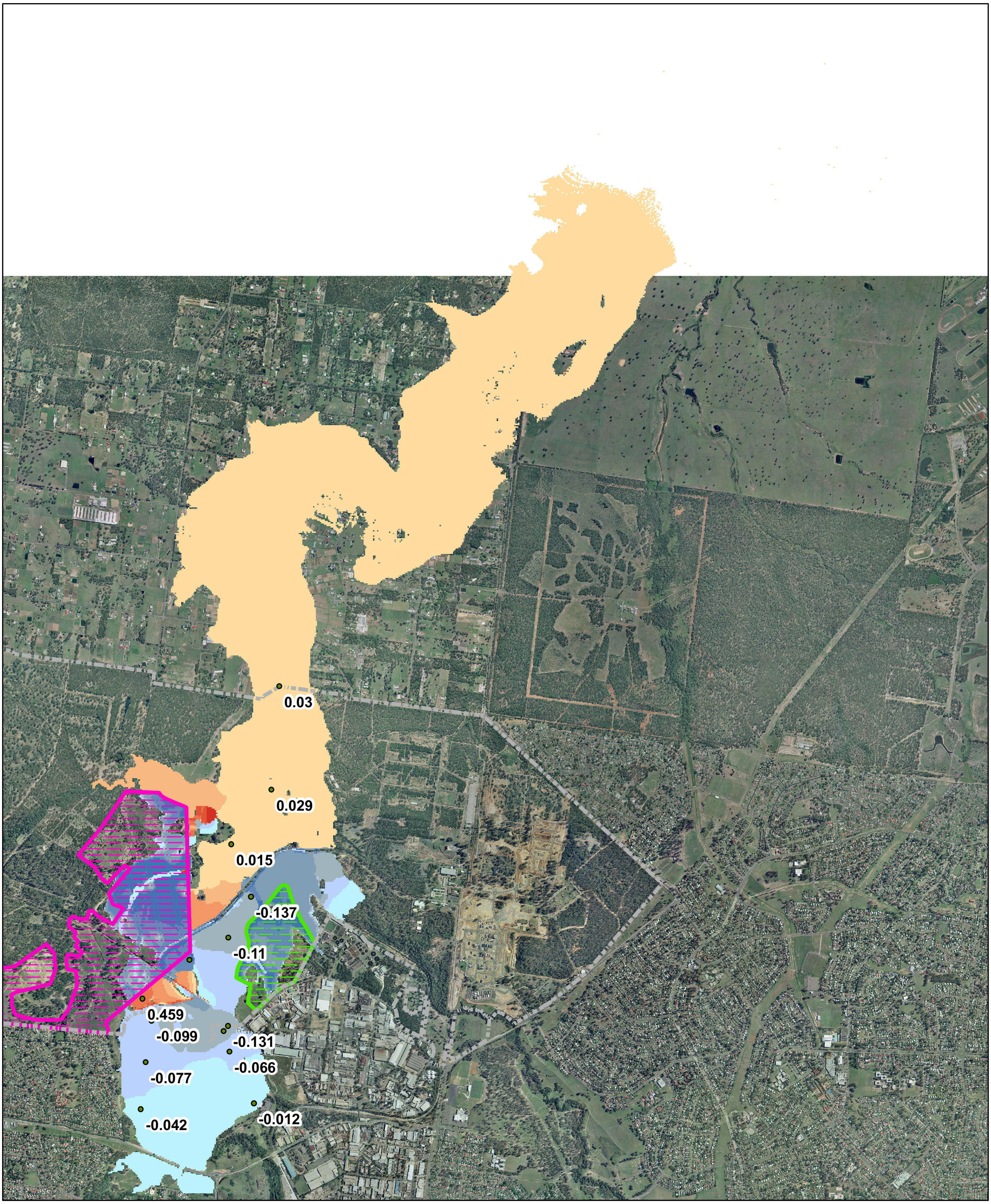
0 270 540 1,080 1,620 2,160 2,700 Meters

Scale in A3

Figure F-1: Change in Water Surface Level
5% AEP Local Tailwater
Jacobs Model D301

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt



Legend

- Spot Impacts (m)
- Site Boundary
- Dunheved Precinct
- Central Precinct

Afflux (m)

- < -1.00
- -1.00 - -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- > 1.00

Figure F-2: Change in Water Surface Level
5% AEP Regional Tailwater
Jacobs Model D301

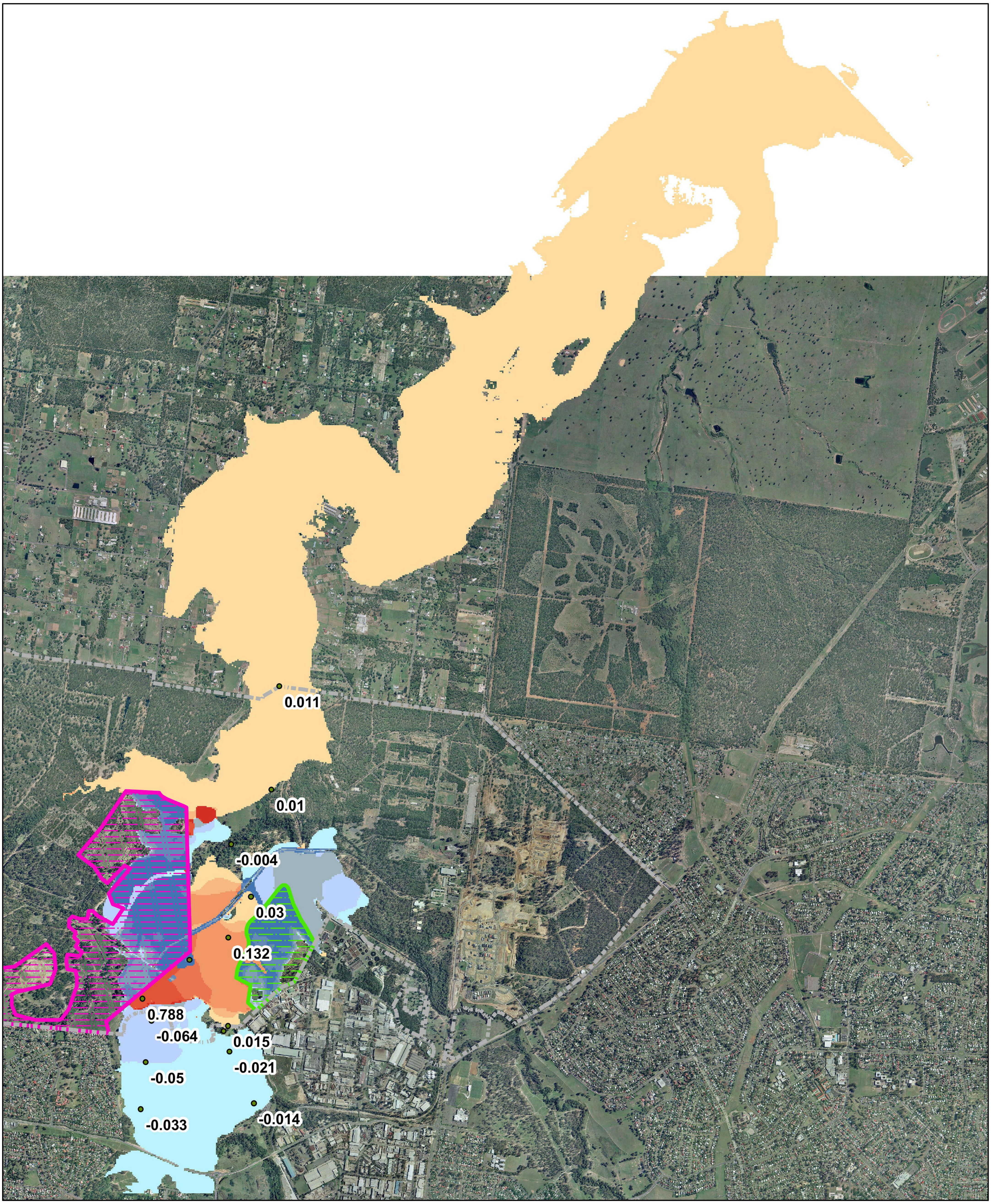
0 270 540 1,080 1,620 2,160 2,700 Meters

Scale in A3

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8140709
Version: 1, Version Date: 19/04/2018



Legend

- Spot Impacts (m)
- Site Boundary
- Dunheved Precinct
- Central Precinct

Afflux (m)

- < -1.00
- -1.00 - -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- > 1.00

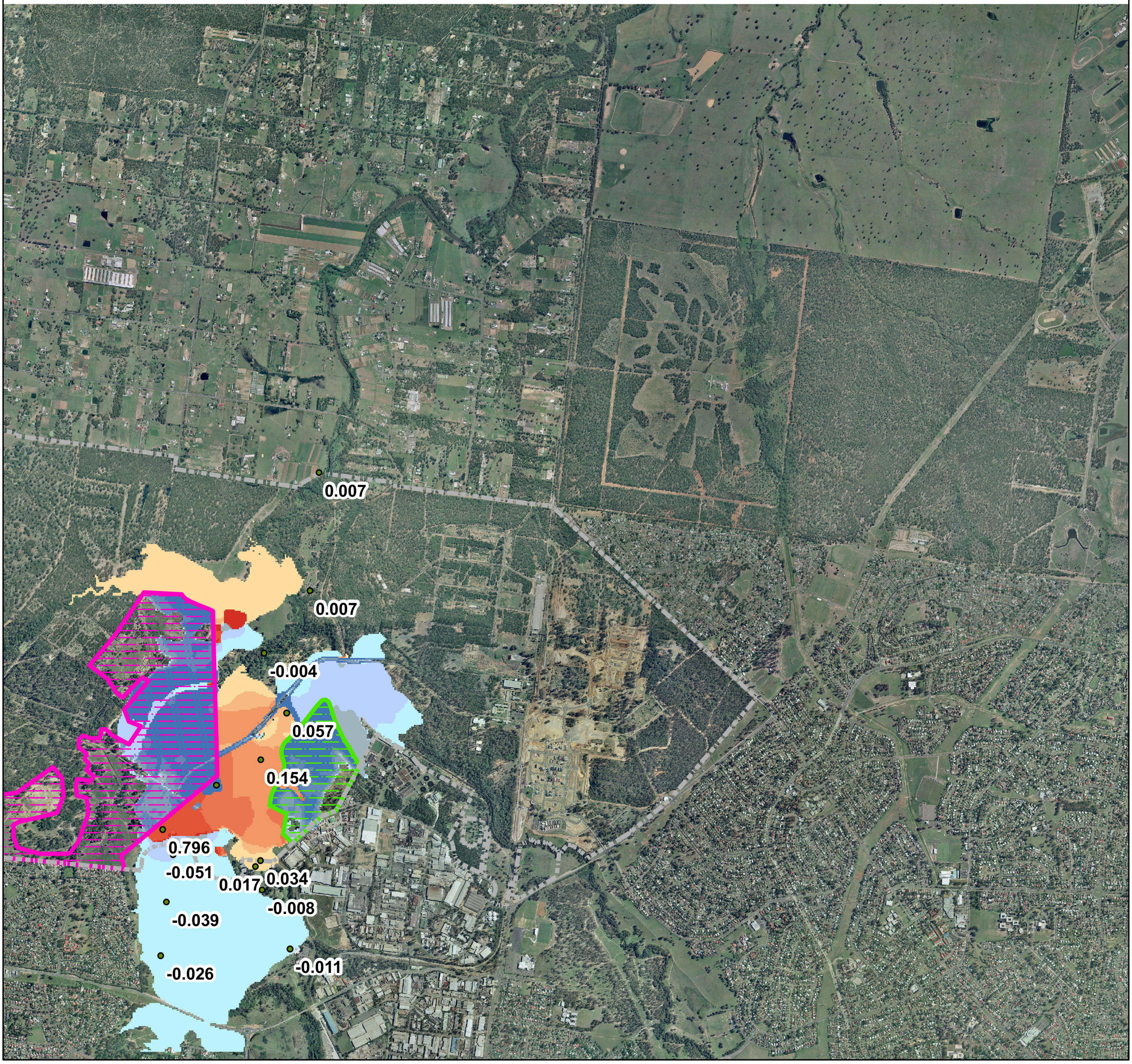
Figure F-3: Change in Water Surface Level
1% AEP Local Tailwater
Jacobs Model D301

0 270 540 1,080 1,620 2,160 2,700 Meters

Scale in A3

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt



Legend

- Spot Impacts (m)
- Site Boundary
- Dunheved Precinct
- Central Precinct

Afflux (m)

- < -1.00
- -1.00 - -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- > 1.00

Figure F-4: Change in Water Surface Level

1% AEP Regional Tailwater

Jacobs Model D301

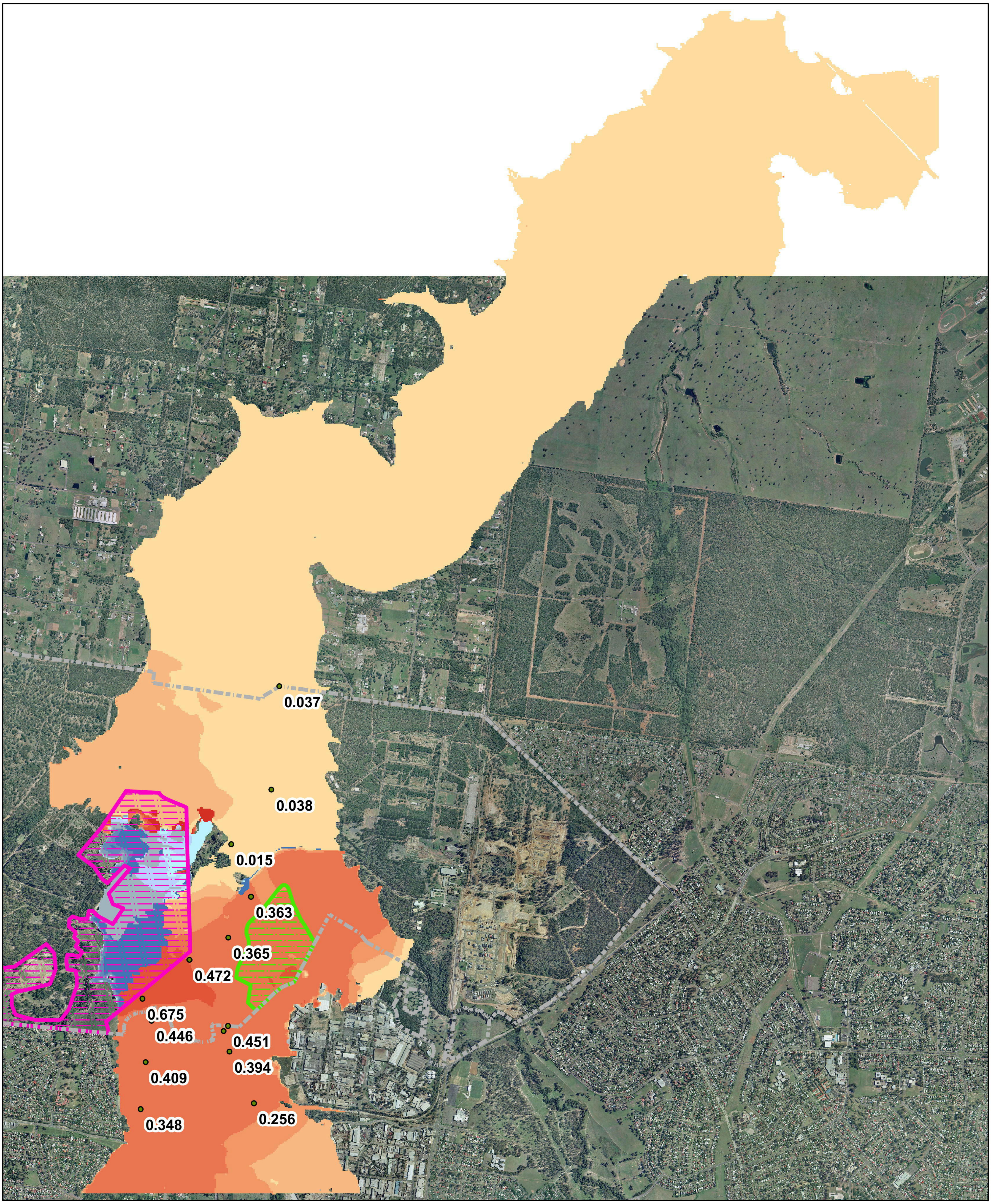
0 270 540 1,080 1,620 2,160 2,700 Meters

Scale in A3

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Spot Impacts (m)
- Site Boundary
- Dunheved Precinct
- Central Precinct

Afflux (m)

- < -1.00
- -1.00 - -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- > 1.00

Figure F-5: Change in Water Surface Level Probable Maximum Flood Local Tailwater Jacobs Model D301

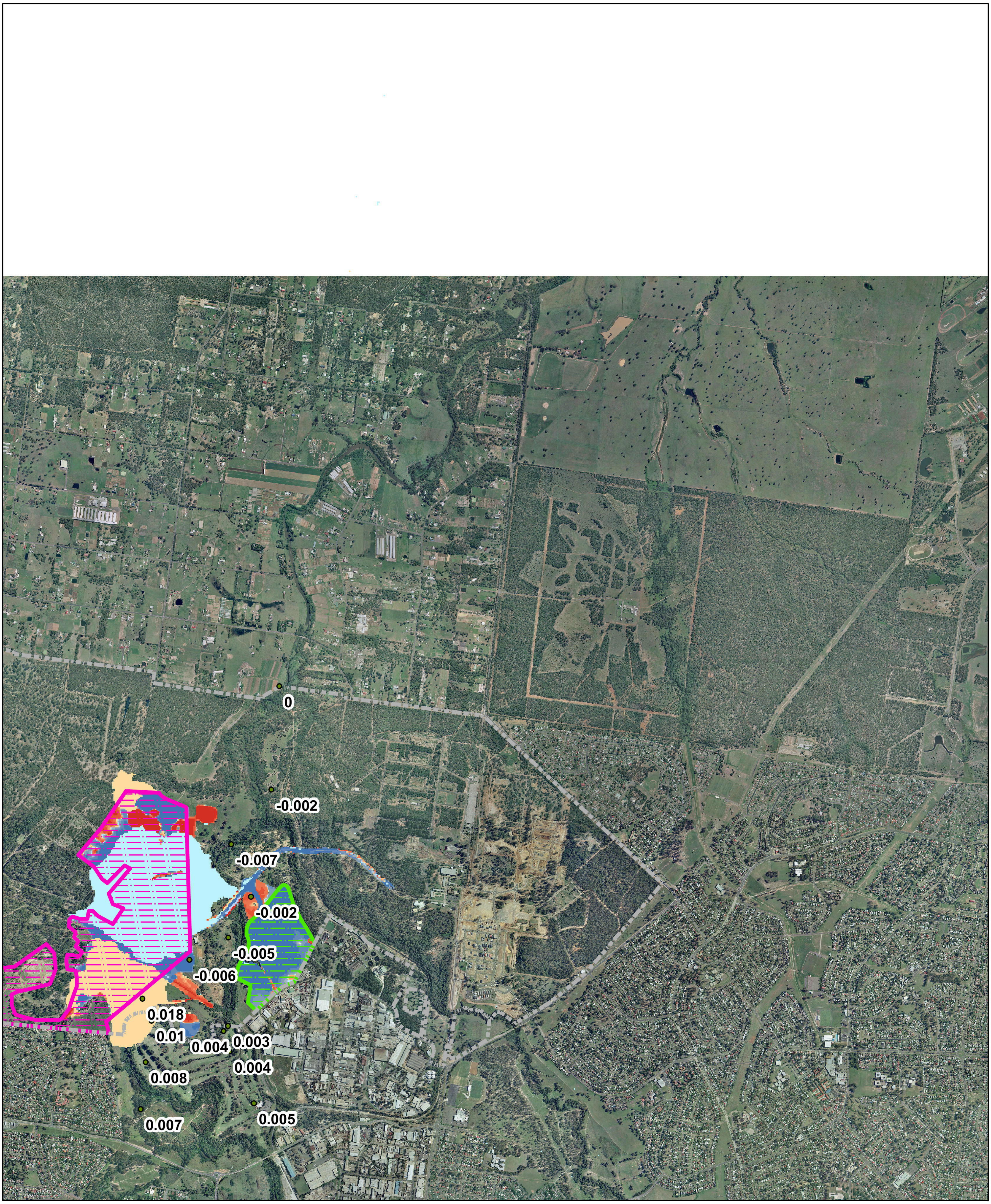
0 270 540 1,080 1,620 2,160 2,700 Meters

Scale in A3

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Spot Impacts (m)
- Site Boundary
- Dunheved Precinct
- Central Precinct

Afflux (m)

- < -1.00
- -1.00 - -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- > 1.00

Figure F-6: Change in Water Surface Level
Probable Maximum Flood Regional Tailwater
Jacobs Model D301

0 270 540 1,080 1,620 2,160 2,700 Meters

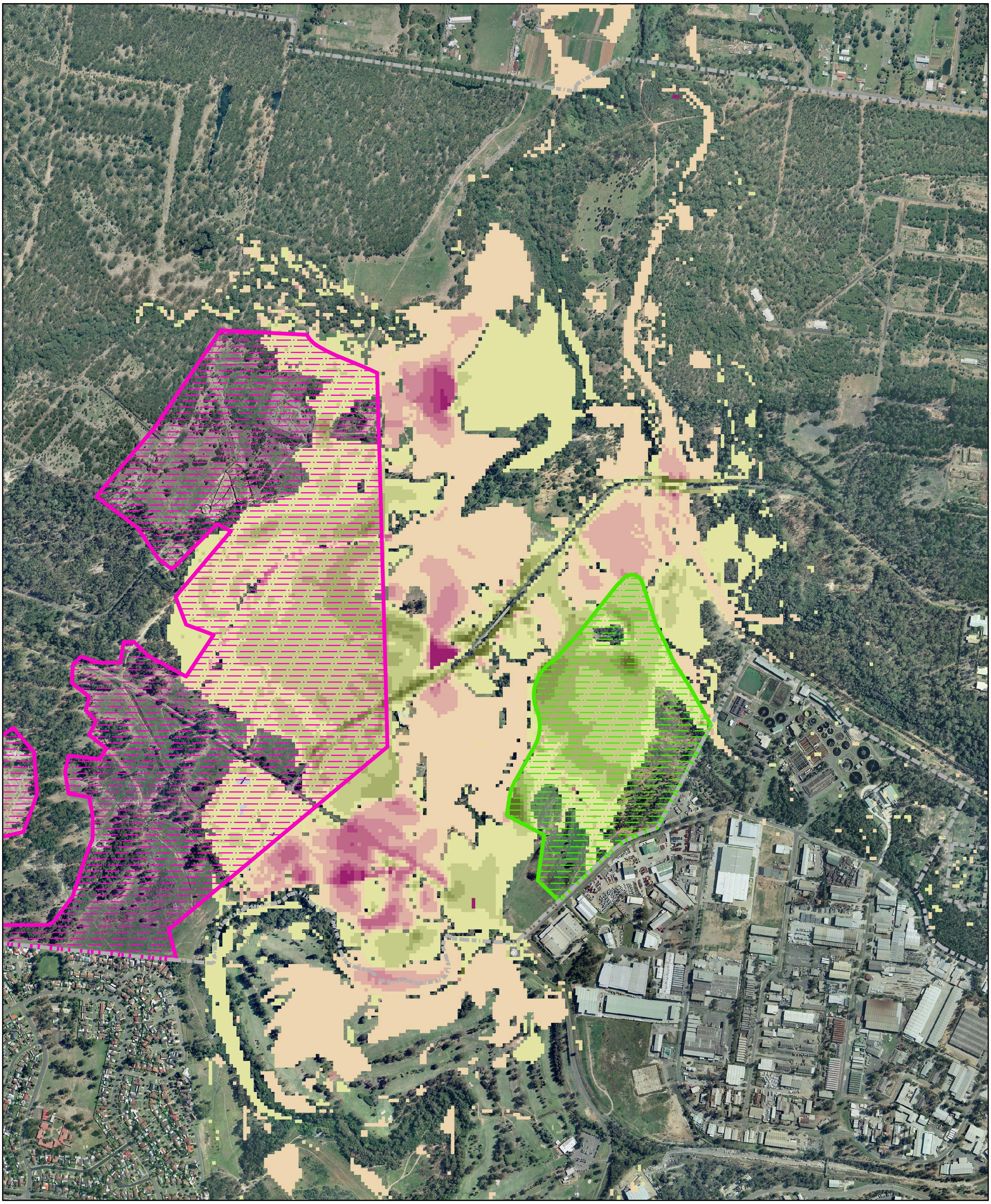
Scale in A3

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Appendix G. Developed case velocity impact maps

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

Site Boundary
Dunheved Precinct
Central Precinct

Change in Velocity (m/s)

- < -0.5
- -0.5 - -0.4
- -0.4 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- > 0.5

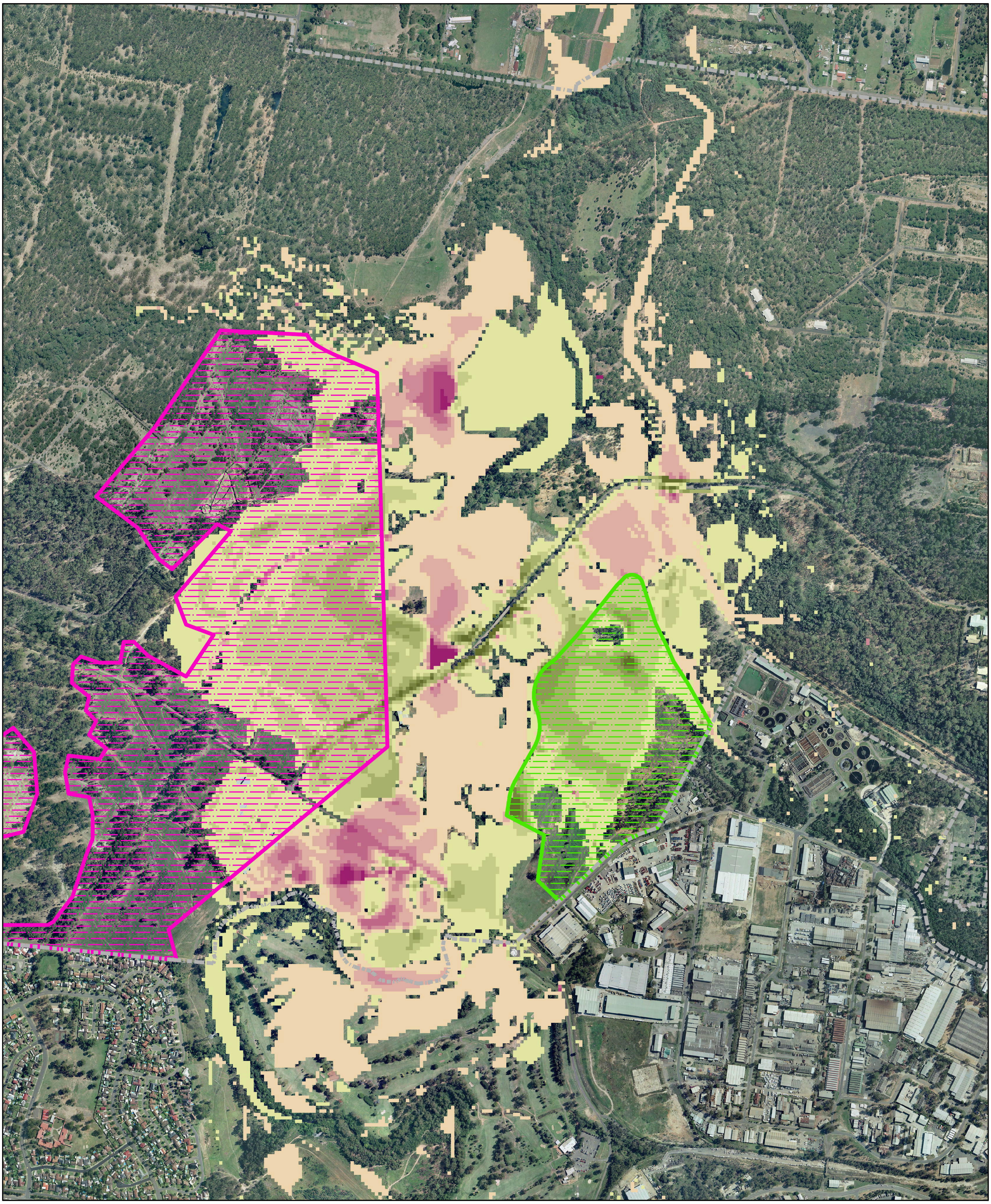
Figure G-1: Change in Velocity
5% AEP Local Tailwater
Jacobs Model D301

JACOBS

0 100 200 400 600 800 1,000 Meters
Scale in A3

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct

Change in Velocity (m/s)

- < -0.5
- -0.5 - -0.4
- -0.4 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- > 0.5

0 100 200 400 600 800 1,000 Meters

Scale in A3

Figure G-2: Change in Velocity

5% AEP Regional Tailwater

Jacobs Model D301

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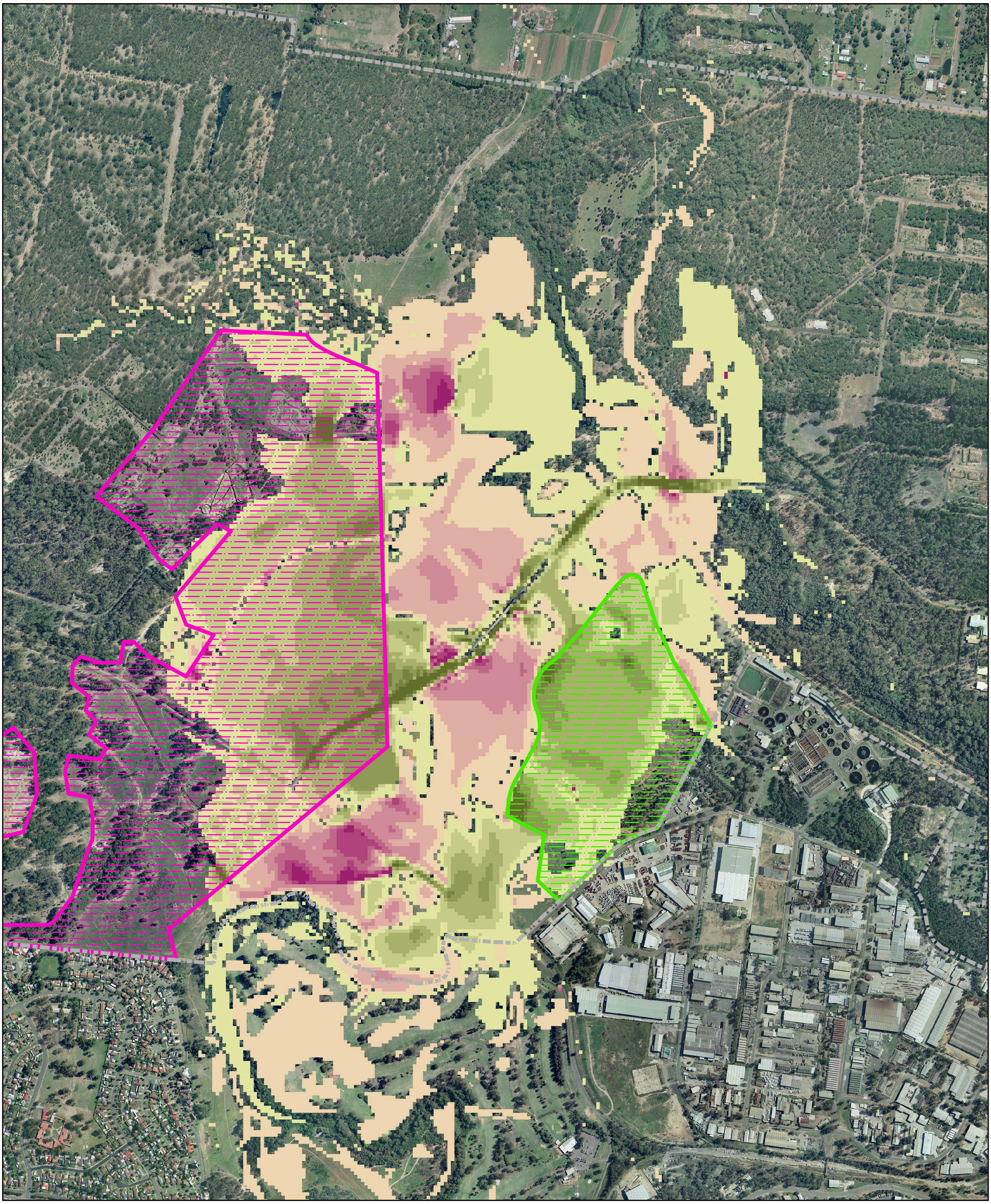
Job No: EN04189
Last Modified: 29/01/2018
By: S Watt



Legend

Site Boundary
Dunheved Precinct
Central Precinct

Change in Velocity (m/s)

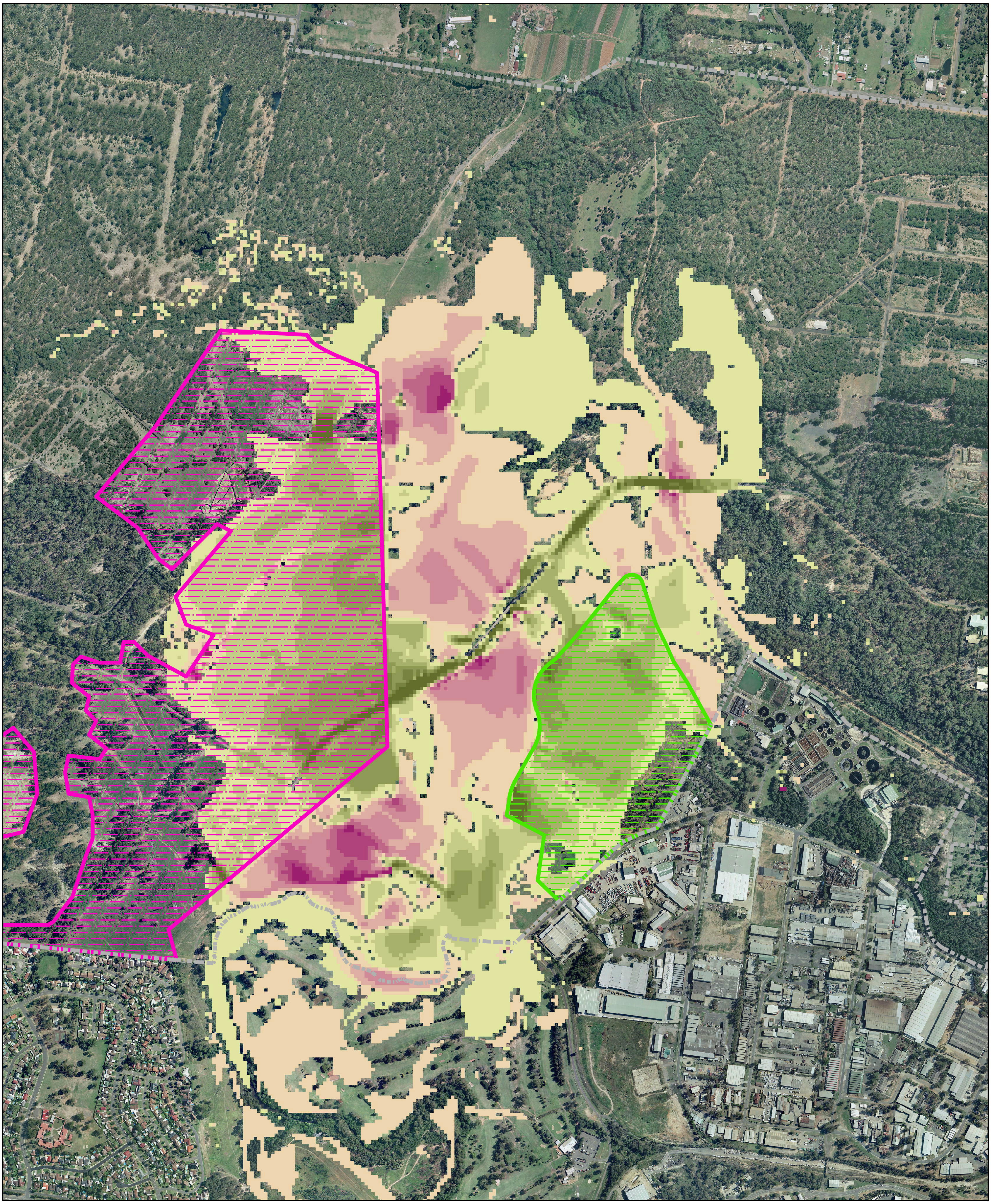
- < -0.5
- -0.5 - -0.4
- -0.4 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- > 0.5

Figure G-3: Change in Velocity
1% AEP Local Tailwater
Jacobs Model D301

0 100 200 400 600 800 1,000 Meters
Scale in A3

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt



Legend

Site Boundary	
Dunheved Precinct	
Central Precinct	

Change in Velocity (m/s)

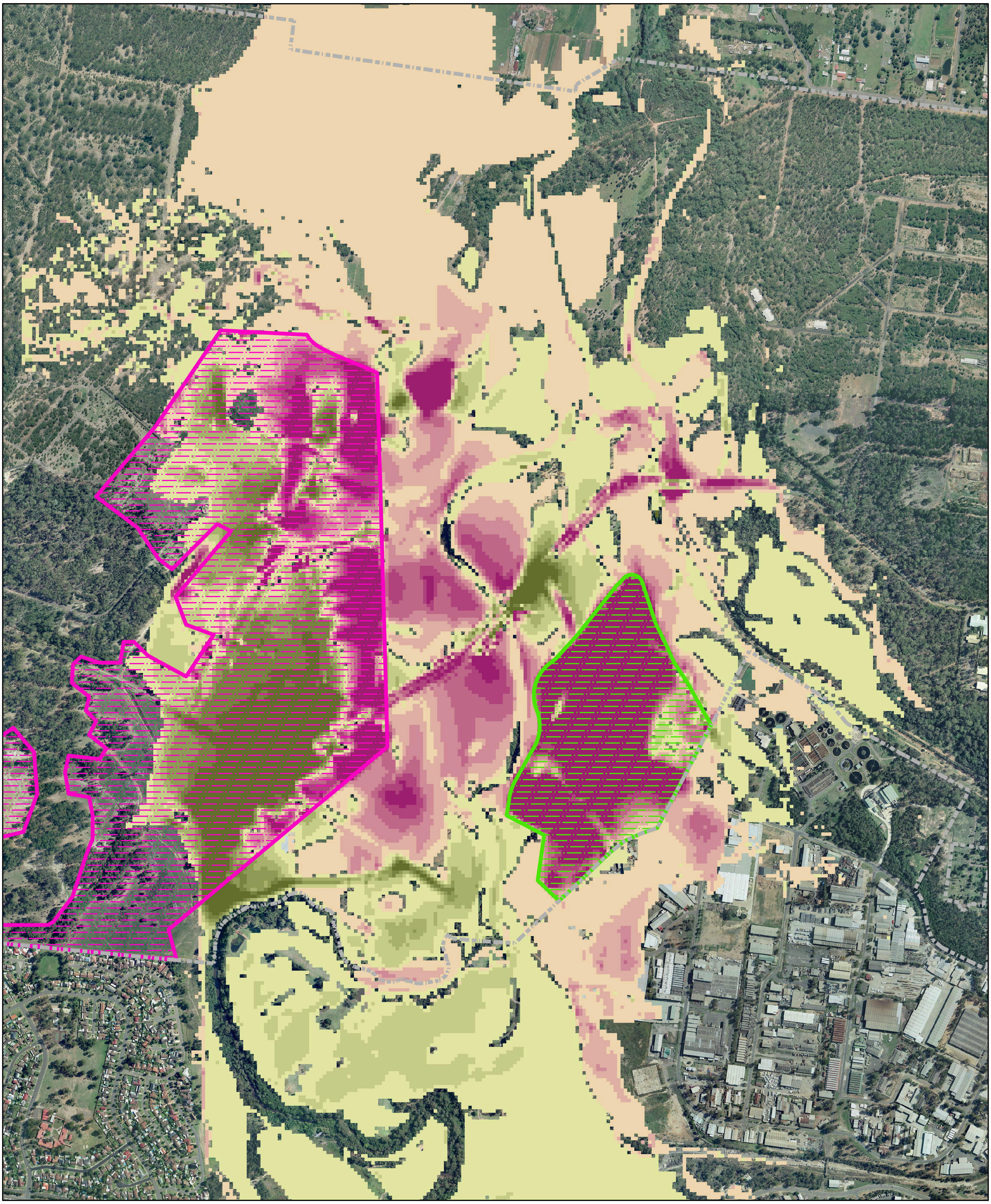
- < -0.5
- -0.5 - -0.4
- -0.4 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- > 0.5

Figure G-4: Change in Velocity
1% AEP Regional Tailwater
Jacobs Model D301

JACOBS

0 100 200 400 600 800 1,000 Meters
Scale in A3

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt



Legend

Site Boundary

Dunheved Precinct

Central Precinct

Change in Velocity (m/s)

- < -0.5
- -0.5 - -0.4
- -0.4 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- > 0.5

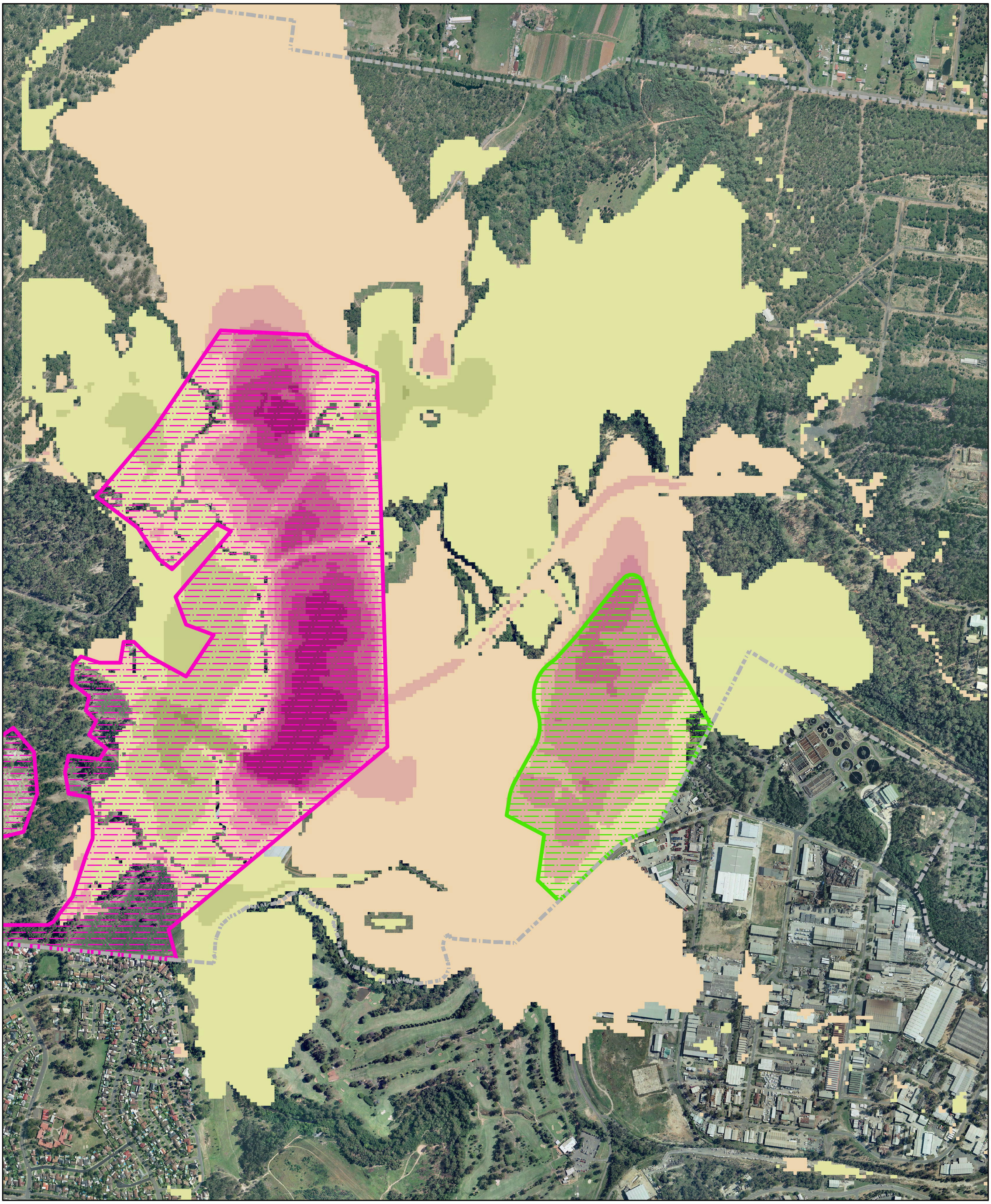
Figure G-5: Change in Velocity
Probable Maximum Flood Local Tailwater
Jacobs Model D301

0 100 200 400 600 800 1,000 Meters

Scale in A3

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt



Legend

- Site Boundary
- Dunheved Precinct
- Central Precinct

Change in Velocity (m/s)

- < -0.5
- -0.5 - -0.4
- -0.4 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- > 0.5

Figure G-6: Change in Velocity
Probable Maximum Flood Regional Tailwater
Jacobs Model D301

0 100 200 400 600 800 1,000 Meters

Scale in A3

JACOBS

Job No: EN04189
Last Modified: 29/01/2018
By: S Watt

Document Set ID: 8146709
Version: 1, Version Date: 19/04/2018