QANTAS GROUP FLIGHT TRAINING CENTRE

FLOOD IMPACT ASSESSMENT

Prepared for: Qantas Airways Limited

By: enstruct group pty ltd

August 2019

enstruct

QANTAS FLIGHT TRAINING & SIMULATOR CENTRE

FLOOD IMPACT ASSESSMENT

ISSUE AUTHORISATION

PROJECT: Qantas Group Flight Training Centre

Project No: 5728

Rev	Date	Purpose of Issue / Nature of Revision	Prepared by	Reviewed by	Issue Authorised by
1	18/07/19	Issue for Information	TH	PL	PL
2	25/07/19	Issue for Information	TH	PL	PL
3	7/08/19	Issue for Information	TH	PL	PL
4	9/08/19	Issue for Information	TH	PL	PL
5	12/08/19	Issue for Information	TH	PL	PL
6b	12/08/19	Issue for Information	TH	PL	PL

Executive Summary

This flood impact assessment outlines the flood modelling methodology and results for the Qantas Group Flight Training Centre and Multi-storey Car Park project.

The TUFLOW model developed by WMA Water Ltd and provided by Bayside Council has been updated to reflect the changes to the area in recent years, and to utilise field survey data in and around the site.

Flood modelling shows no impact beyond the site boundaries. Buildings in the proposed development have adequate freeboard.

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Contents

1 The Project

1.1 Project Description

Safety is Qantas' first priority. The flight training centre is a key pillar of this value. The facility enables pilots and flight crews to undertake periodic testing to meet regulatory requirements by simulating both aircraft and emergency procedural environments. The Project plans to construct and operate of a new flight training centre, and a multi-deck car park. The Project is comprised of the following uses:

Flight Training Centre

The proposed flight training centre will occupy the southern portion of the site. It is a multi-storey level building that comprises of 14 flight training bays, emergency procedures halls, and associated office spaces.

Multi-Deck Car Park

The proposed multi-deck car park will be located to the north-east of the flight training centre and adjacent the existing Qantas catering facility and tri-generation plant. The car park is 14 levels and will provide 2059 spaces for Qantas staff. Vehicle access to the car park will be provided via King Street, Kent Road and from Qantas Drive via the existing catering bridge.

2 Flooding

2.1 Site description

The site is part of the Alexandria Canal catchment which consists of industrial and commercial developments in the Mascot area. The catchment consists mainly of a piped drainage system with developed flow paths through the urban areas.

Bayside Council have provided correspondence advising that a portion of the site is being affected by the 1% AEP. This correspondence was based on a previous flood study entitled Mascot, Roseberry & Eastlakes Flood Study undertaken by WMA Water Ltd in 2015.

Based on information provided by Bayside Council the northern portion of the site is subject to inundation due to flooding from overland flow in the 1% AEP events.

The information provided was based on the TUFLOW model developed by WMA Water Ltd in 2015.

2.2 Model Update

2.2.1 Terrain adjustments

The TUFLOW model developed by WMA Water Ltd. was acquired by enstruct in February of 2019 for revision. The survey in the existing model was based on LiDAR data flown in April

2013. enstruct added the latest detailed survey of the existing site to the model to improve the accuracy of the model to include all the changes in surface as well as the building locations.

The existing TUFLOW model has been updated to incorporate most recent surveyed data prepared by Land Partners dated 21/03/2019 (SY074560), as well as additional buildings in the area which have been developed after the original model was prepared.

2.2.2 1D Channel adjustments

As part of the update, the channel sections and culvert dimensions within the site were reviewed and adjusted to meet the field survey data. Changes to the geometry in this regard were fairly minor in nature.

2.2.3 Hydrology

Feedback from Council noted that ponding in the northern carpark under existing conditions was not reflected in the model results. The model has been reformulated in this regard by adjusting the catchment boundaries in the vicinity of the site to provide a better reflection of the hydrologic conditions. The resultant hydrographs were input to the hydraulic model such that the low point in the northern car park was correctly showing ponding in the model results.

Following the model updates by enstruct, the model represents the conditions on the ground at the time of this report.

2.3 Proposed Conditions Model

The model was further updated to model the proposed development. The design pavement surface and proposed buildings were added to the model to determine the impact of the development on flood levels through the site and on nearby properties.

2.4 Results

The results of the flood modelling are shown in Appendix A.

In general, during a 1% AEP storm, there is some impact on flood levels within the Qantas site. This is limited to approximately 35mm in one location.

In the 1% AEP event there is an increase in flood level of up to 55mm north of the catering building, where the flood depth remains below 300mm. The adjacent properties are approximately 1.2m above the ground level (Figure 1 and Figure 2), giving a freeboard of approximately 900mm in a 1% AEP event. There is no adverse impact on adjoining properties here.

Figure 1 Northern Boundary

Figure 2 Northern Boundary

There are areas in the car park on the south side of the channel where the redirection of overland flow changes flood behaviour. These changes are considered to be localised impacts. The civil design and site grading includes appropriate falls and site drainage to manage on-site stormwater.

Outside of the site, there is no impact on flood levels or behaviour. There is no impact on the ARTC corridor.

2.5 Floor levels and flood freeboard

A summary of the proposed finished floor levels and the modelled flood levels is presented in Table 1.

Table 1 Finished floor levels and flood freeboard

Location	Finished floor level (mAHD)	1% AEP flood level (mAHD)	Freeboard (m)
Northern car park lower ground level	4.33	3.9	0.43
Northern car park upper ground level	5.83	4.30	1.53
Flight training centre	5.70	4.30	1.40

Figure 3 1% AEP Flood Levels

2.6 Flood Storage

The original model supplied by Council shows the existing car park north of the channel to be flood affected. As this is a localised depression, the model shows this area acts as a flood storage area.

The model update includes the development of Qantas head office in 2013-14 (10 Bourke Road) and the development of 185 O'Riordan Street in 2016-17 to the west of the subject site. These developments have minimised the overland flow from Bourke Road through to the existing northern car park. As part of the model upgrade, the hydrology around the area was refined to reflect surveyed ground conditions.

There is some ponding in the northern car park from a combination of local sub-catchment rainfall and overflow from Bourke Road in the 1% AEP event.

The proposed development includes filling of the northern car park area. This has been shown to have no impact on flooding beyond the site boundaries.

Increases in flood levels between the proposed multi-storey car park and the existing tri-gen plant can be attributed to the proposed increase in ground levels in this location. This re-grading allows overflows from Bourke Road to pass through the site without being trapped in a sag point. The depth of flow along this path is limited to approximately 90mm in a 1% AEP event. The overland flow will be within the kerbs of this access road and will not impact on the existing or proposed infrastructure.

2.7 Flood Hazard

Sydney Water has requested a Flood Hazard Management Plan:

> For State significant developments the applicant is also required to submit a Flood Hazard Management Plan as per Floodplain Development Manual. The flood models need to assess 5, 20, 100 and 100 year plus climate change year storm events.
>
> Sydney Water requires the models to be 1 D/2D models. Models should be simple and easy to read illustrating in maps:
> - Flood levels
> - Velocities
> - Hazards
>
> Sydney Water needs to ensure that developments do not adversely impact on people, properties and infrastructure.

We note that the Floodplain Development Manual does not make reference to a Flood Hazard Management Plan. Provisional Flood Hazard Categories have been mapped in Appendix A in accordance with the Floodplain Development Manual.

Overland flow on the site is categorised as low hazard. The Sydney Water Channel is categorised as high hazard. This site is not flood affected in a 1% AEP event beyond local overland flow paths, including when considering future climate scenarios.

In extreme flood events such as the PMP, we recommend site occupants shelter in place until flood waters recede, noting that the critical duration storm is between 1-2 hours. The Probable Maximum Precipitation (PMP) is defined as ‘the theoretical greatest depth of precipitation that is physically possible over a particular catchment’. This has an annual exceedance probability of rarer than 1 in 2000 (0.05% AEP). In other words, there is a less than 0.05% chance of such an event in any given year.

3 Future Scenarios

3.1 Sydney Water trunk drainage upgrade

At the request of Ray Parsell and Jeya Jayadevan of Sydney Water, enstruct tested the capacity of the Sydney Water channel for increased peak flow rates under a potential future scenario where works upstream of the channel result in the substantial increase in flow in the channel. Modelling a flow increase from the current 7.2m^3/s in a 1% AEP event to a flow rate of 13.3m^3/s in the channel showed there is additional capacity in the channel. The design of the development is robust in that it will achieve freeboard to flood events under potential future scenarios.

The letter outlining the above modelling and results is included in Appendix B

3.2 Climate Change

To review the impact of climate change with respect to flooding on the site, the WMA model scenarios of 10%, 20% and 30% increase in rainfall intensities, and 2050 and 2100 sea levels were run for the proposed conditions model. The maximum increase in flood levels in the Sydney Water channel is approximately 30mm. The proposed development has adequate freeboard for these scenarios.

4 Conclusion

enstruct has undertaken flood modelling based on Council's flood model, up-to-date survey and the proposed works on the site. It was demonstrated that there is no negative impact on surrounding properties with respect to flooding

The development has adequate freeboard under both the proposed conditions and future trunk drainage upgrade and climate change scenarios.

APPENDIX A FLOOD MAPPING

1% AEP Existing Conditions

1% AEP Proposed Conditions

1% AEP Flood Impact

1% AEP Existing Conditions Velocity

1% AEP Proposed Conditions Velocity

1% AEP Existing Provisional Flood Hazard

1% AEP Proposed Flood Hazard

5% AEP Existing Conditions

5% AEP Proposed Conditions

20% AEP Existing Conditions

20% AEP Proposed Conditions

PMP Existing Conditions

PMP Proposed Conditions

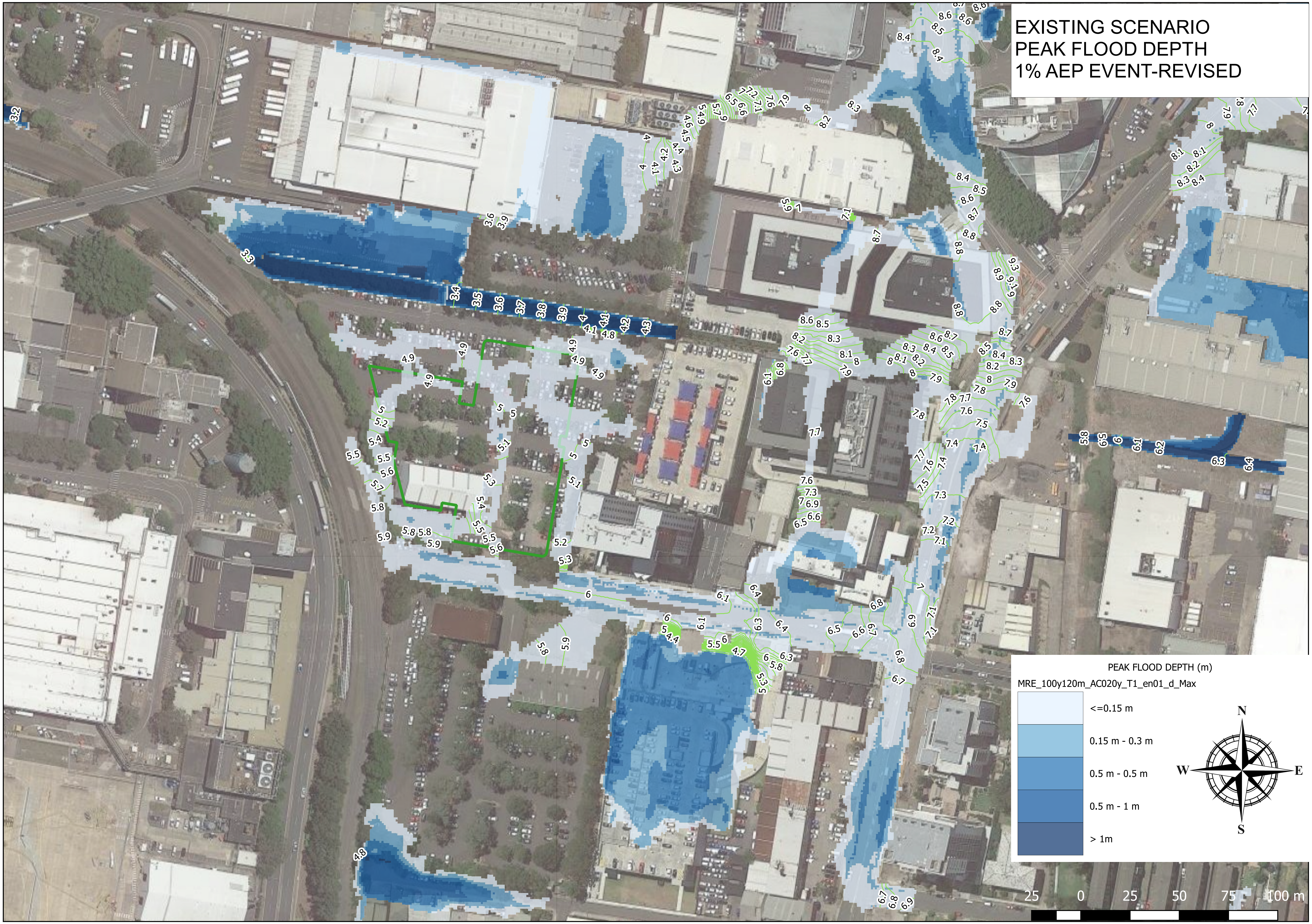
1% AEP Proposed Conditions with 10% rainfall intensity increase

1% AEP Proposed Conditions with 20% rainfall intensity increase

1% AEP Proposed Conditions with 30% rainfall intensity increase

1% AEP Proposed Conditions with 2050 sea level rise

1% AEP Proposed Conditions with 2100 sea level rise


EXISTING SCENARIO
PEAK FLOOD DEPTH
1% AEP EVENT-REVISED
PEAK FLOOD DEPTH (m)
MRE_100y120m_AC020y_T1_en01_d_Max
<=0.15 m
0.15 m - 0.3 m
0.5 m - 0.5 m
0.5 m - 1 m
> 1m
N
E
S
W
25
0
25
50
75
100 m

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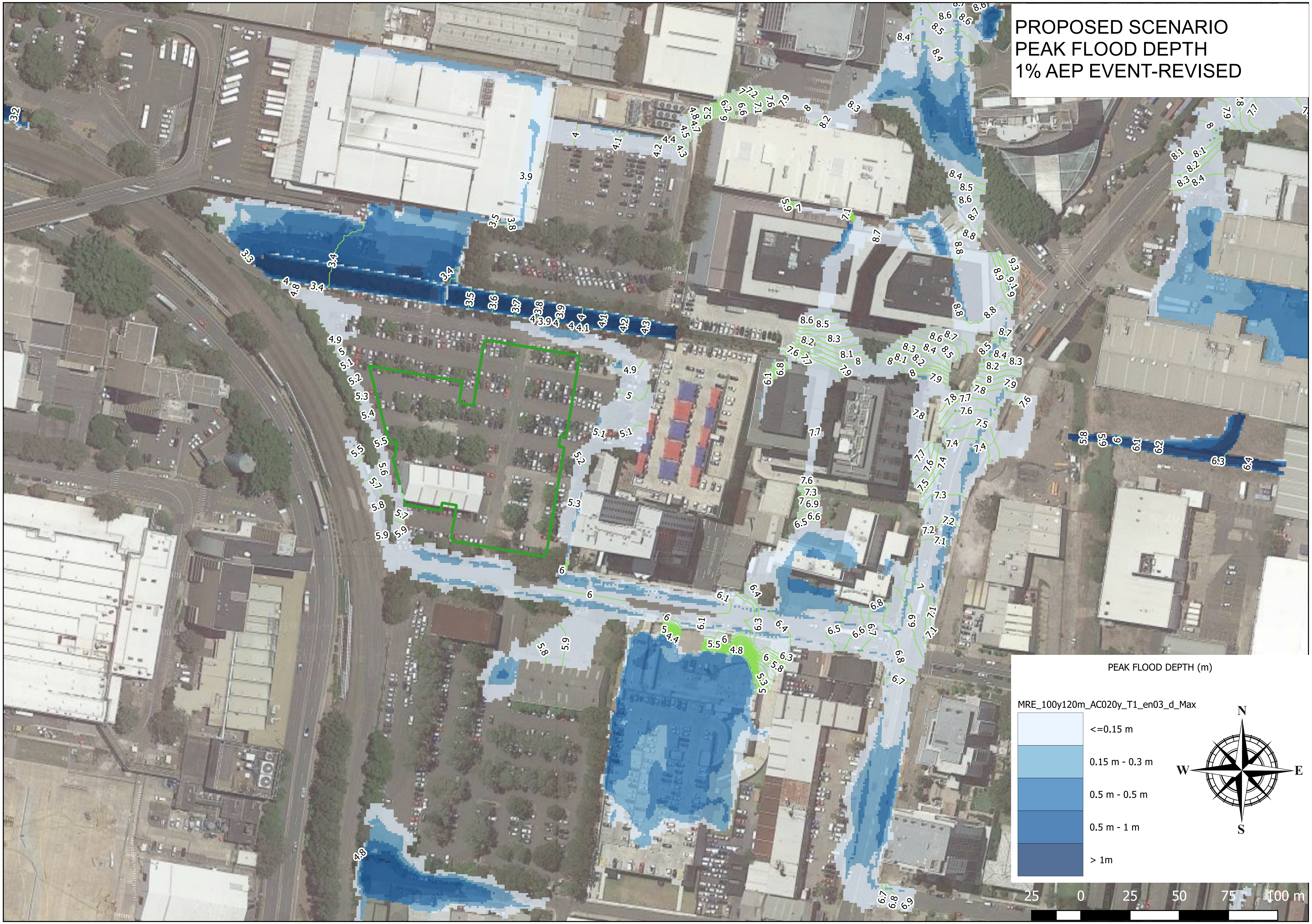

PROPOSED SCENARIO
PEAK FLOOD DEPTH
1% AEP EVENT-REVISED
PEAK FLOOD DEPTH (m)
MRE_100y120m_AC020y_T1_en03_d_Max
<=0.15 m
0.15 m - 0.3 m
0.5 m - 0.5 m
0.5 m - 1 m
> 1m
N
W
E
S
25 0 25 50 75 100 m

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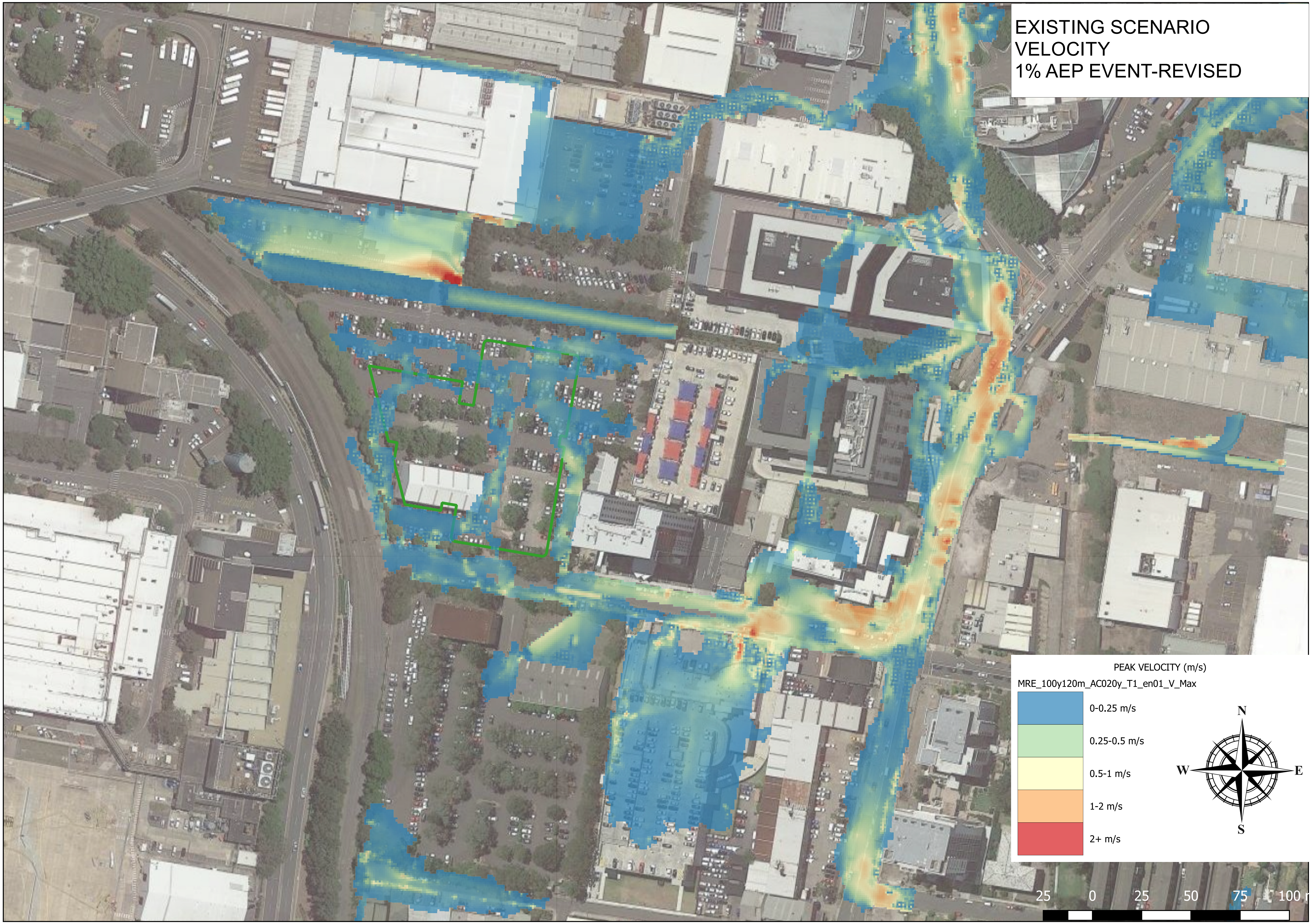
FLOOD IMPACT
1% AEP EVENT-REVISED
FLOOD IMPACT
100y_en03_impact
more than 1m lower
15mm to 1m lower
less than 15mm change
15-30mm increase
30-60mm increase
more than 60mm increase
N
W
E
S
25
0
25
50
75
100 m



EXISTING SCENARIO
VELOCITY
1% AEP EVENT-REVISED
PEAK VELOCITY (m/s)
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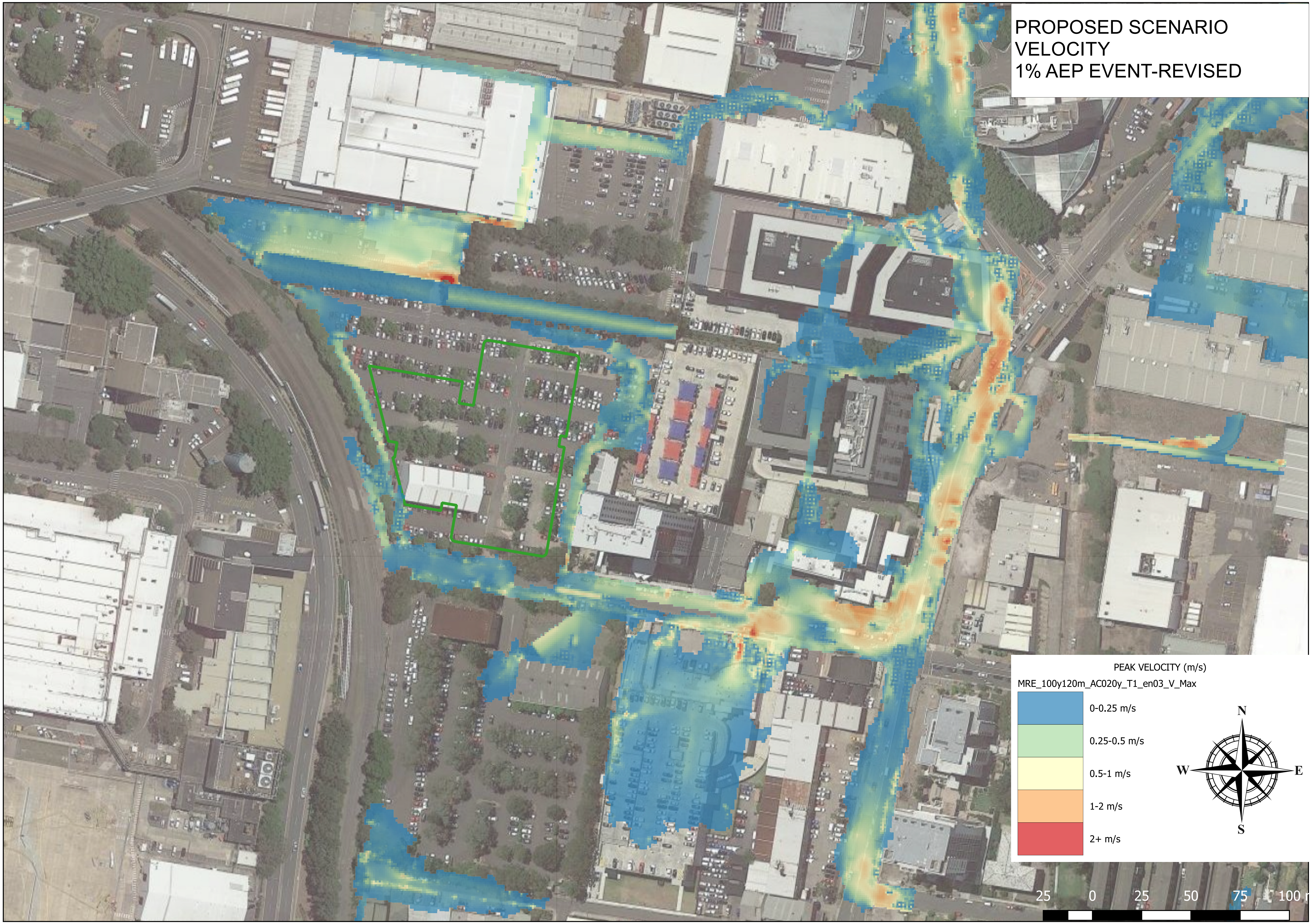
0-0.25 m/s
0.25-0.5 m/s
0.5-1 m/s
1-2 m/s
2+ m/s
N
W
E
S
25
0
25
50
75
100 m

enstruct



PROPOSED SCENARIO
VELOCITY
1% AEP EVENT-REVISED
PEAK VELOCITY (m/s)
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0-0.25 m/s
0.25-0.5 m/s
0.5-1 m/s
1-2 m/s
2+ m/s
N
W
E
S
25
0
25
50
75
100 m

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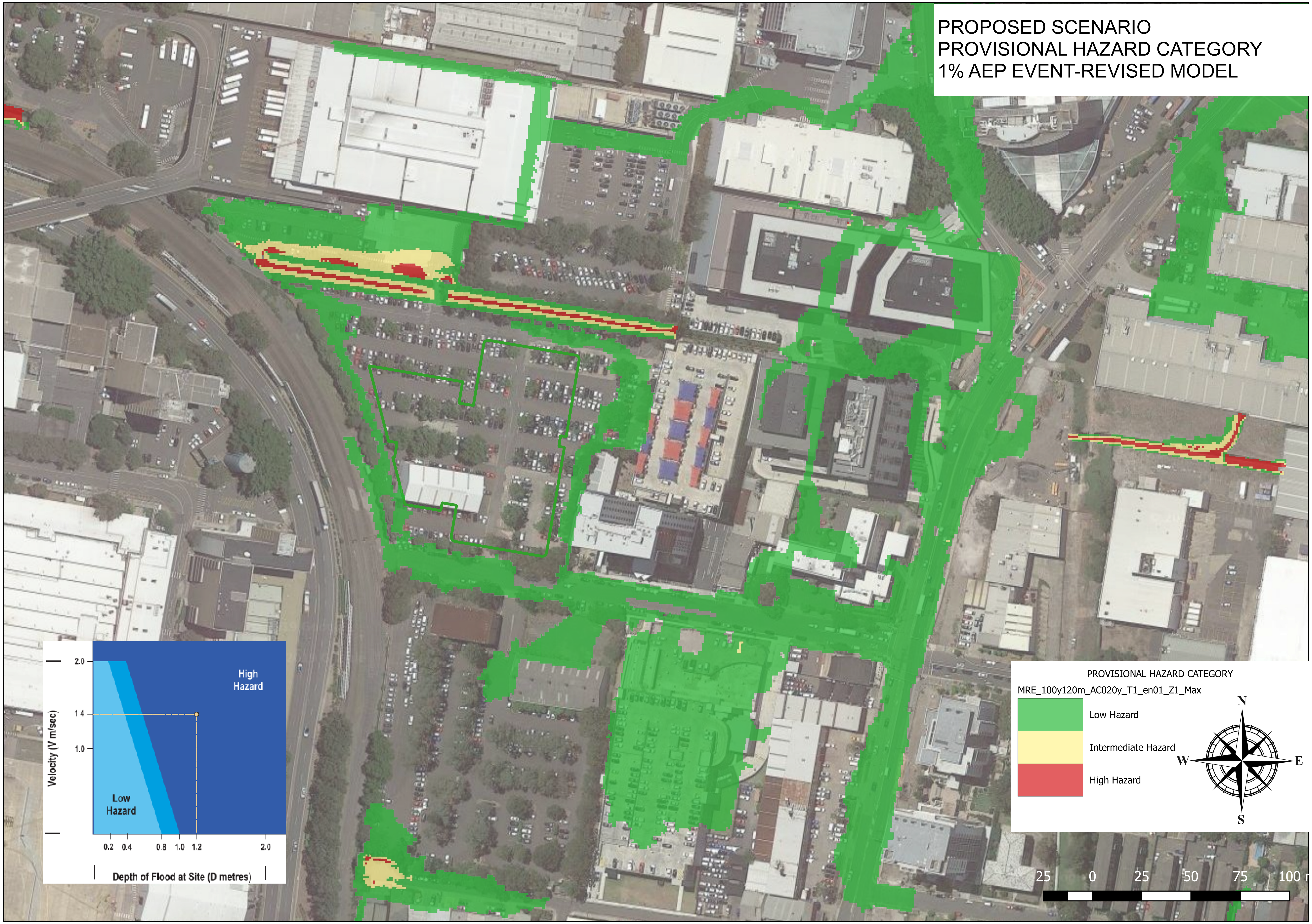
EXISTING SCENARIO
PROVISIONAL HAZARD CATEGORY
1% AEP EVENT-REVISED MODEL
PROVISIONAL HAZARD CATEGORY
MRE_100y120m_AC020y_T1_en01_Z1_Max
Low Hazard
Intermediate Hazard
High Hazard
N
S
E
W
25 0 25 50 75 100 m
High Hazard
Low Hazard
Velocity (V m/sec)
2.0
1.4
1.0
0.2 0.4 0.8 1.0 1.2 2.0
Depth of Flood at Site (D metres)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PROVISIONAL HAZARD CATEGORY
1% AEP EVENT-REVISED MODEL
PROVISIONAL HAZARD CATEGORY
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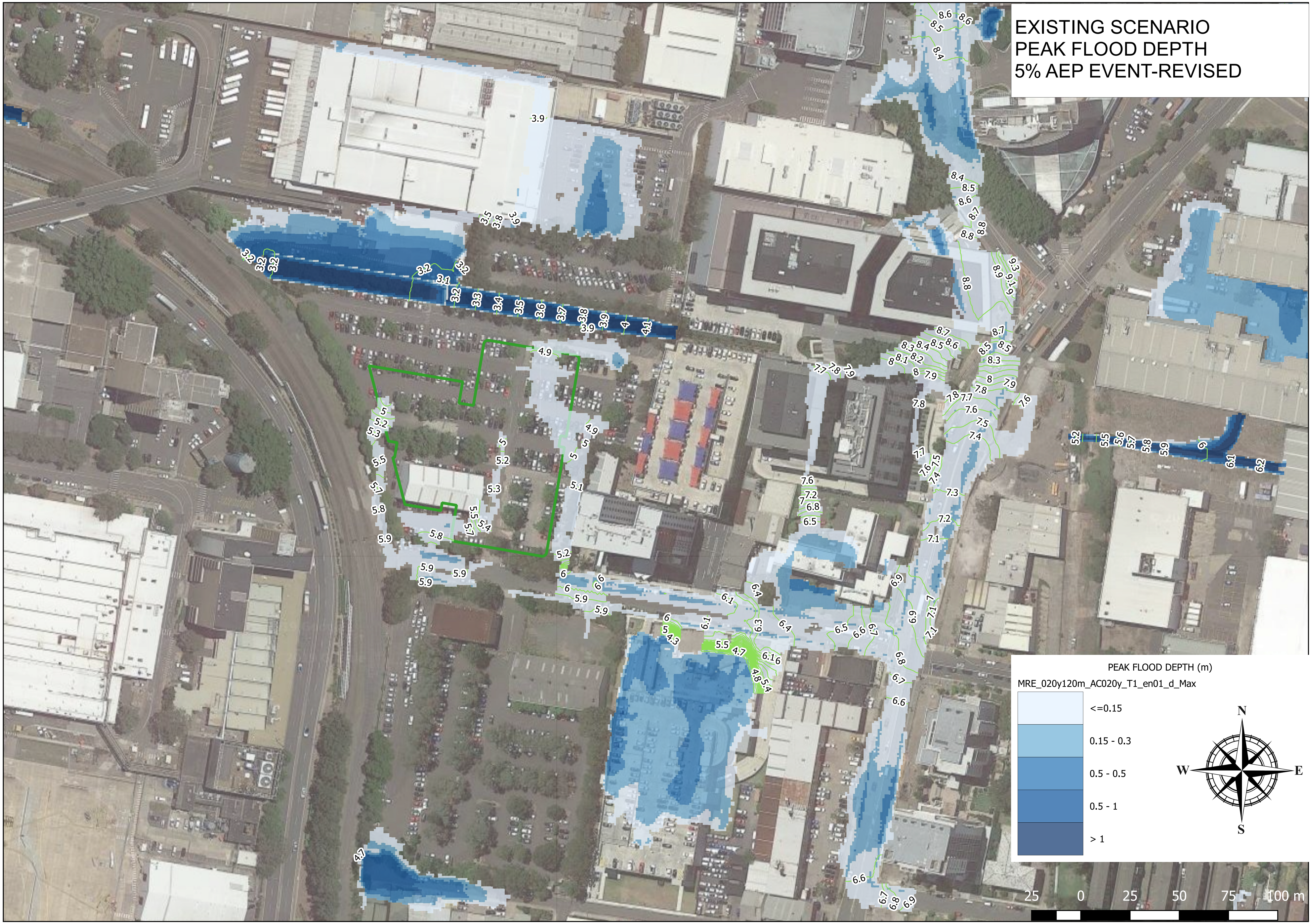
Low Hazard
Intermediate Hazard
High Hazard
N
S
E
W
25
0
25
50
75
100
High Hazard
Low Hazard
Velocity (V m/sec)
2.0
1.4
1.0
0.2
0.4
0.8
1.0
1.2
2.0
Depth of Flood at Site (D metres)



EXISTING SCENARIO
PEAK FLOOD DEPTH
5% AEP EVENT-REVISED
PEAK FLOOD DEPTH (m)
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<=0.15
0.15 - 0.3
0.5 - 0.5
0.5 - 1
> 1
N
S
W
E
25
0
25
50
75
100 m

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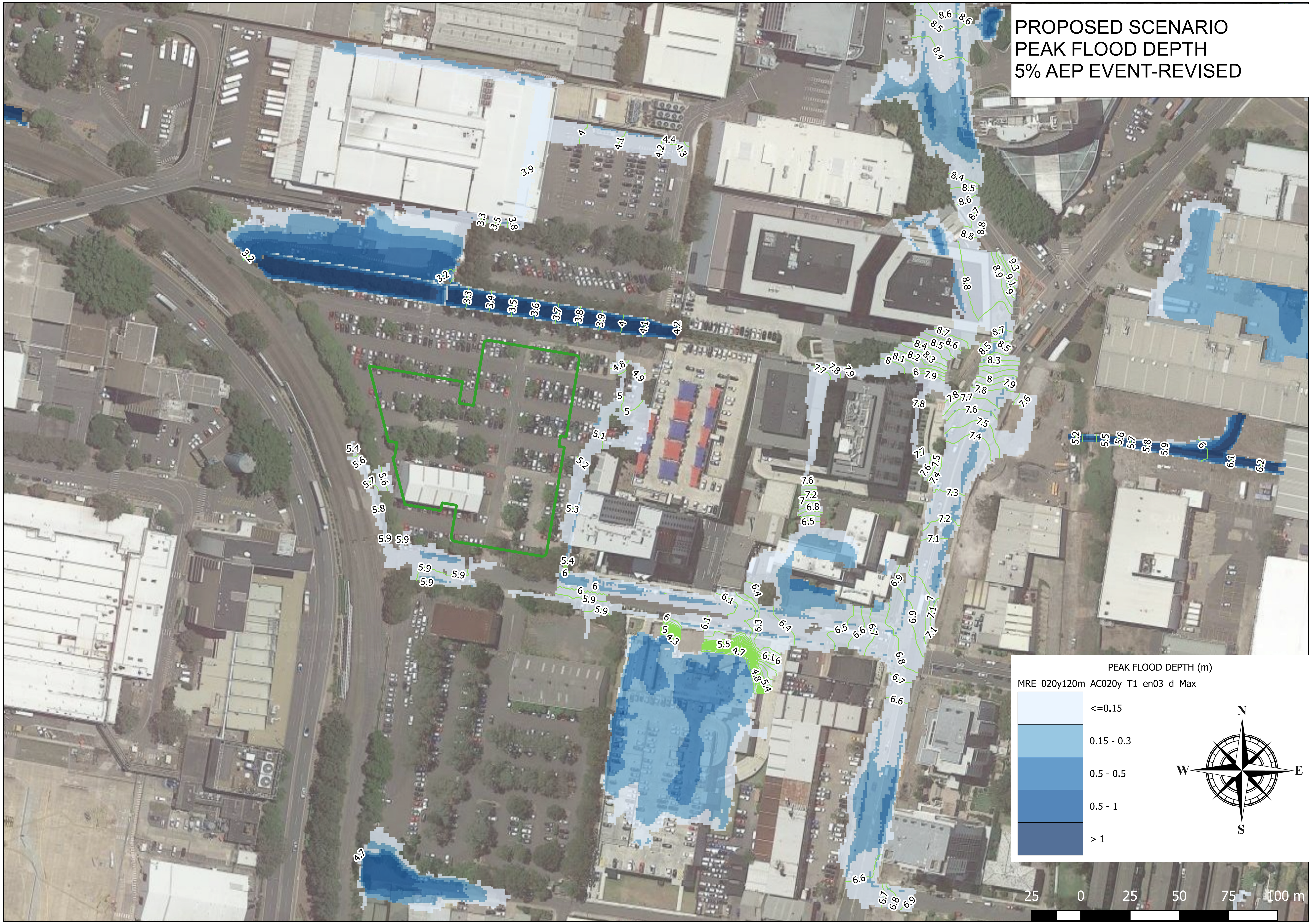
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5% AEP EVENT-REVISED
PEAK FLOOD DEPTH (m)
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<=0.15
0.15 - 0.3
0.5 - 0.5
0.5 - 1
> 1
N
S
W
E
25
0
25
50
75
100 m

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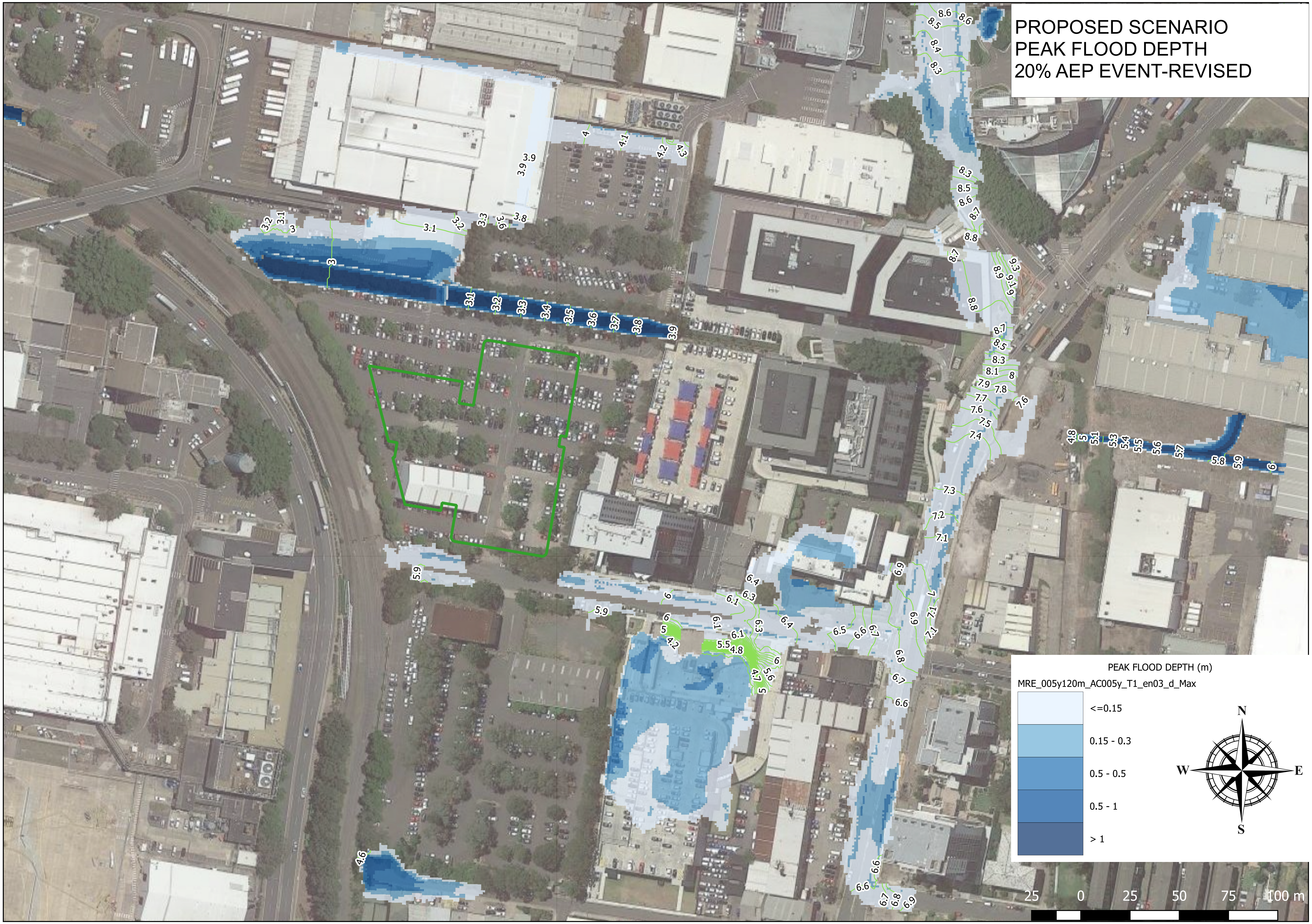
EXISTING SCENARIO
PEAK FLOOD DEPTH
20% AEP EVENT-REVISED
PEAK FLOOD DEPTH (m)
MRE_005y120m_AC005y_T1_en01_d_Max
<=0.15
0.15 - 0.3
0.5 - 0.5
0.5 - 1
> 1
N
E
S
W
25
0
25
50
75
100 m

enstruct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20% AEP EVENT-REVISED
PEAK FLOOD DEPTH (m)
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<=0.15
0.15 - 0.3
0.5 - 0.5
0.5 - 1
> 1
N
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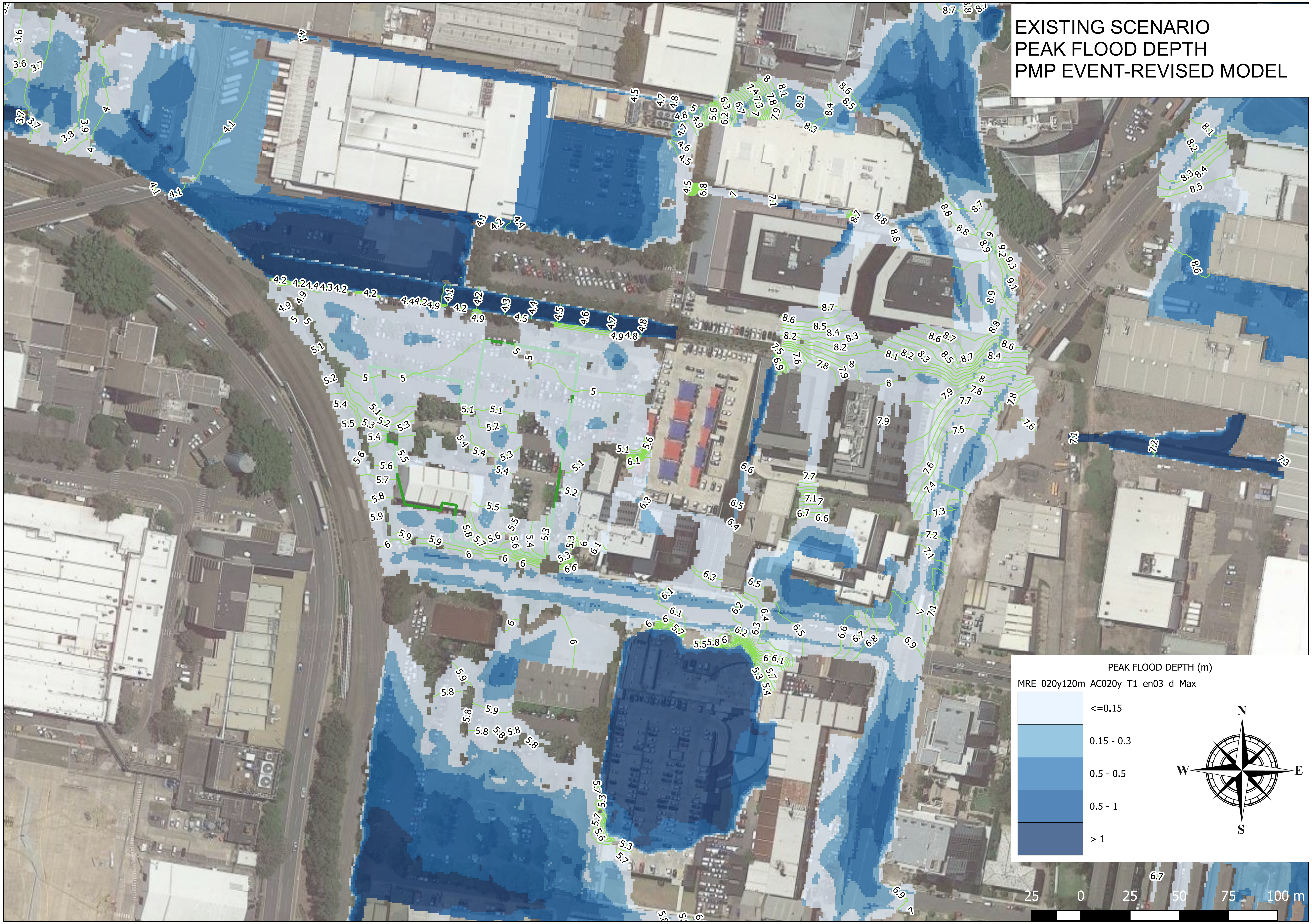
25
50
75
100 m

enstruct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PMP EVENT-REVISED MODEL
PEAK FLOOD DEPTH (m)
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<=0.15
0.15 - 0.3
0.5 - 0.5
0.5 - 1
> 1
N
W
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25
50
75
100 m

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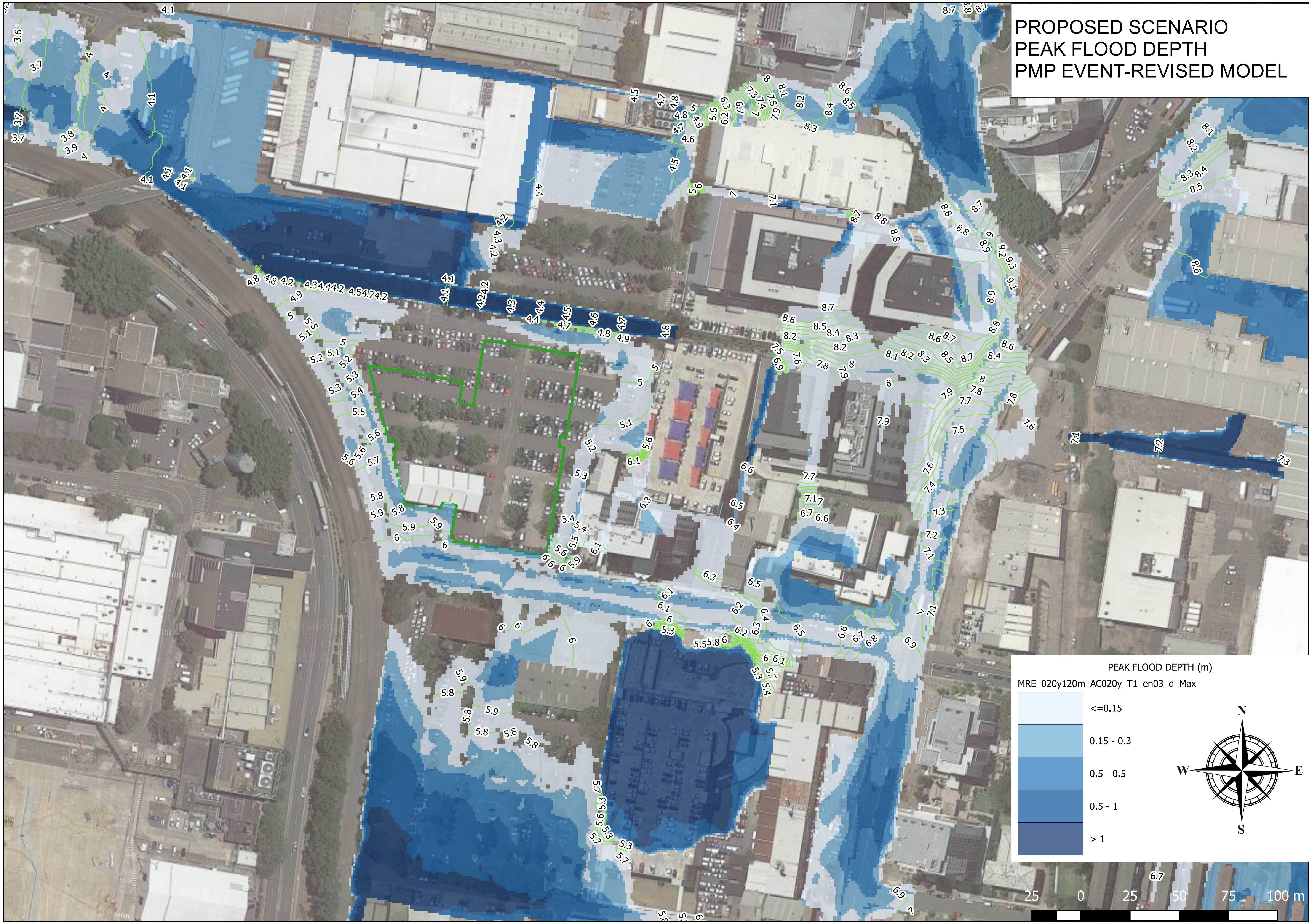
PROPOSED SCENARIO
PEAK FLOOD DEPTH
PMP EVENT-REVISED MODEL



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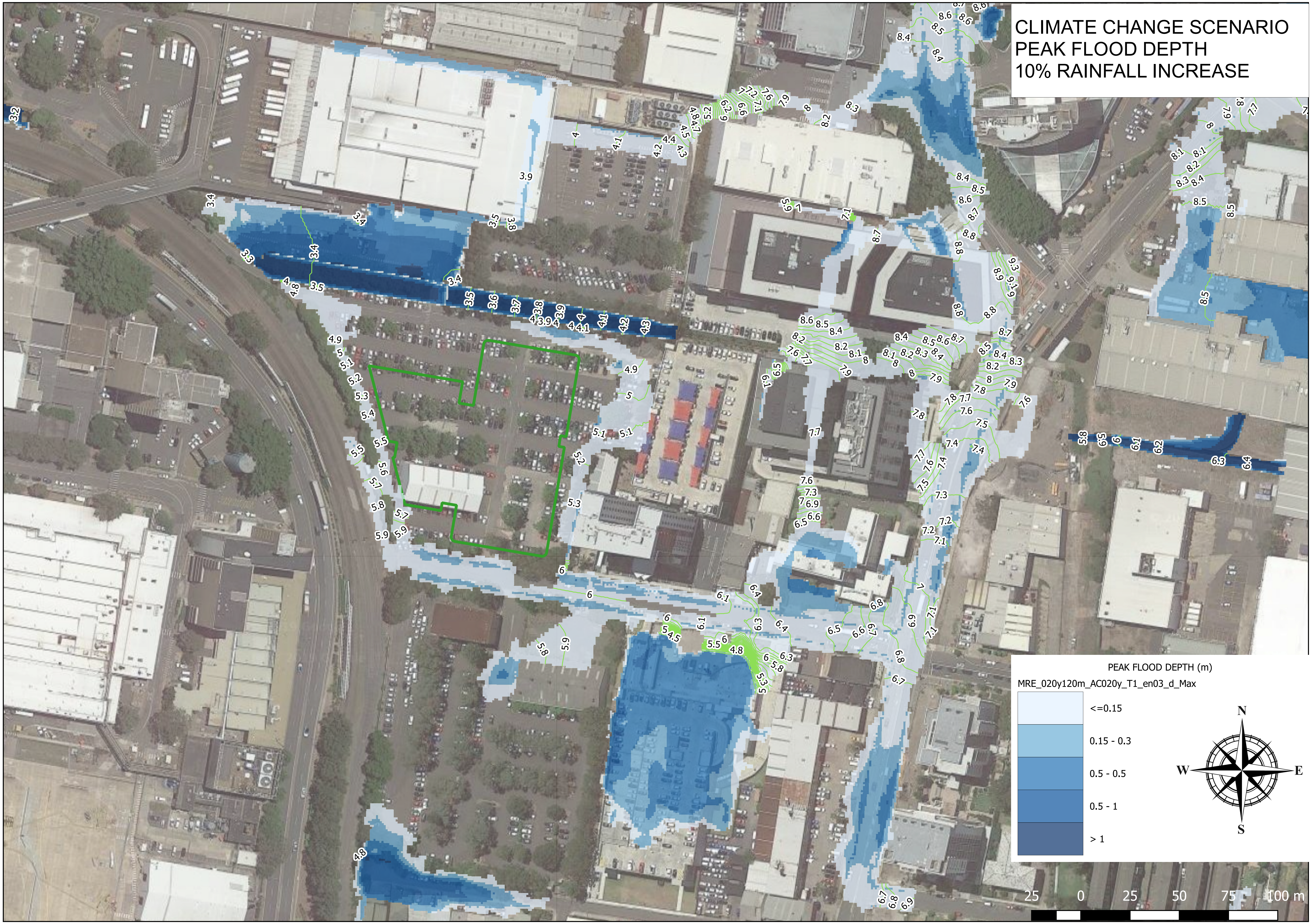
CLIMATE CHANGE SCENARIO
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10% RAINFALL INCREASE
PEAK FLOOD DEPTH (m)
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0.5 - 0.5
0.5 - 1
> 1
N
S
W
E
25 0 25 50 75 100 m

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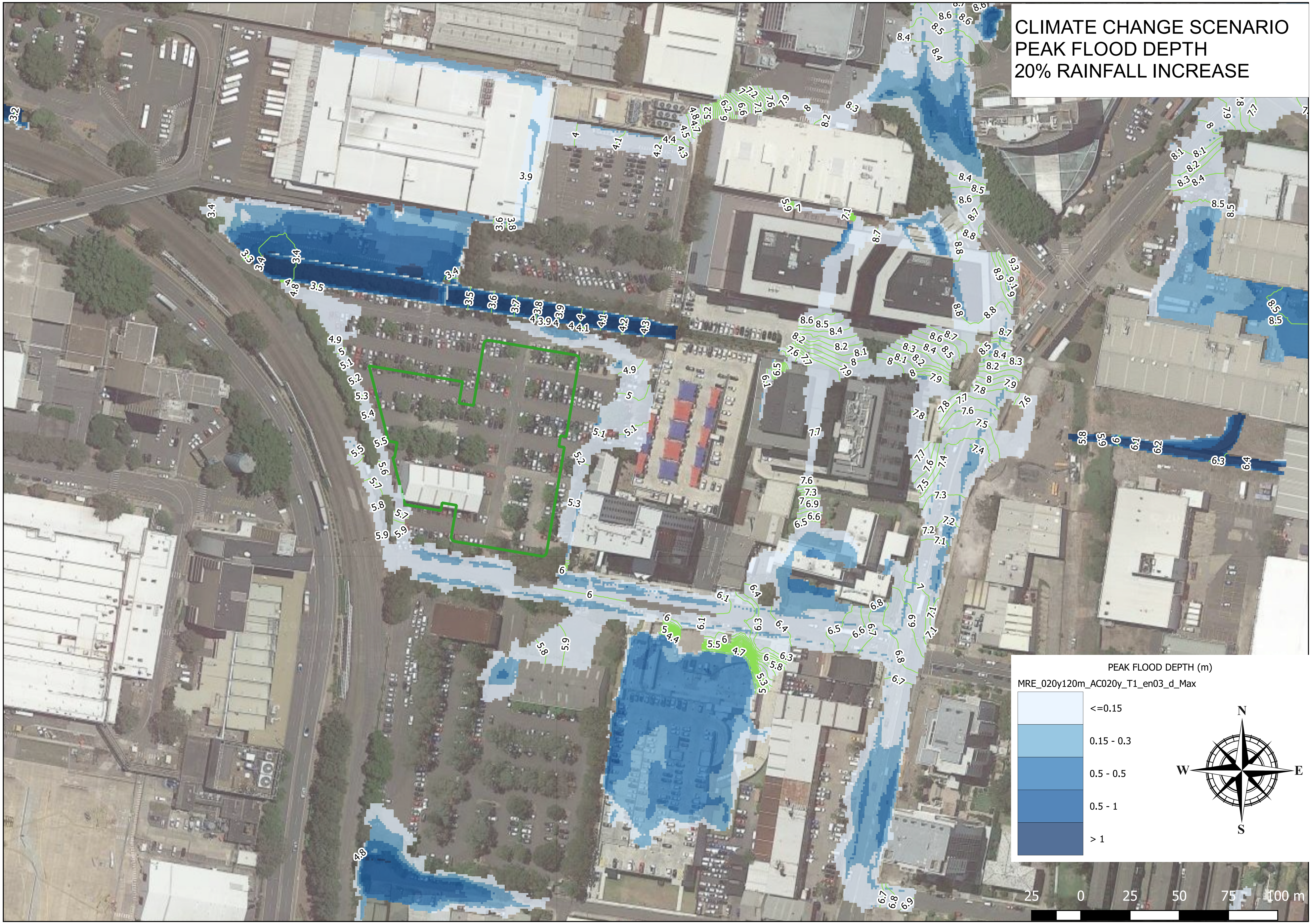
CLIMATE CHANGE SCENARIO
PEAK FLOOD DEPTH
20% RAINFALL INCREASE
PEAK FLOOD DEPTH (m)
MRE_020y120m_AC020y_T1_en03_d_Max
<=0.15
0.15 - 0.3
0.5 - 0.5
0.5 - 1
> 1
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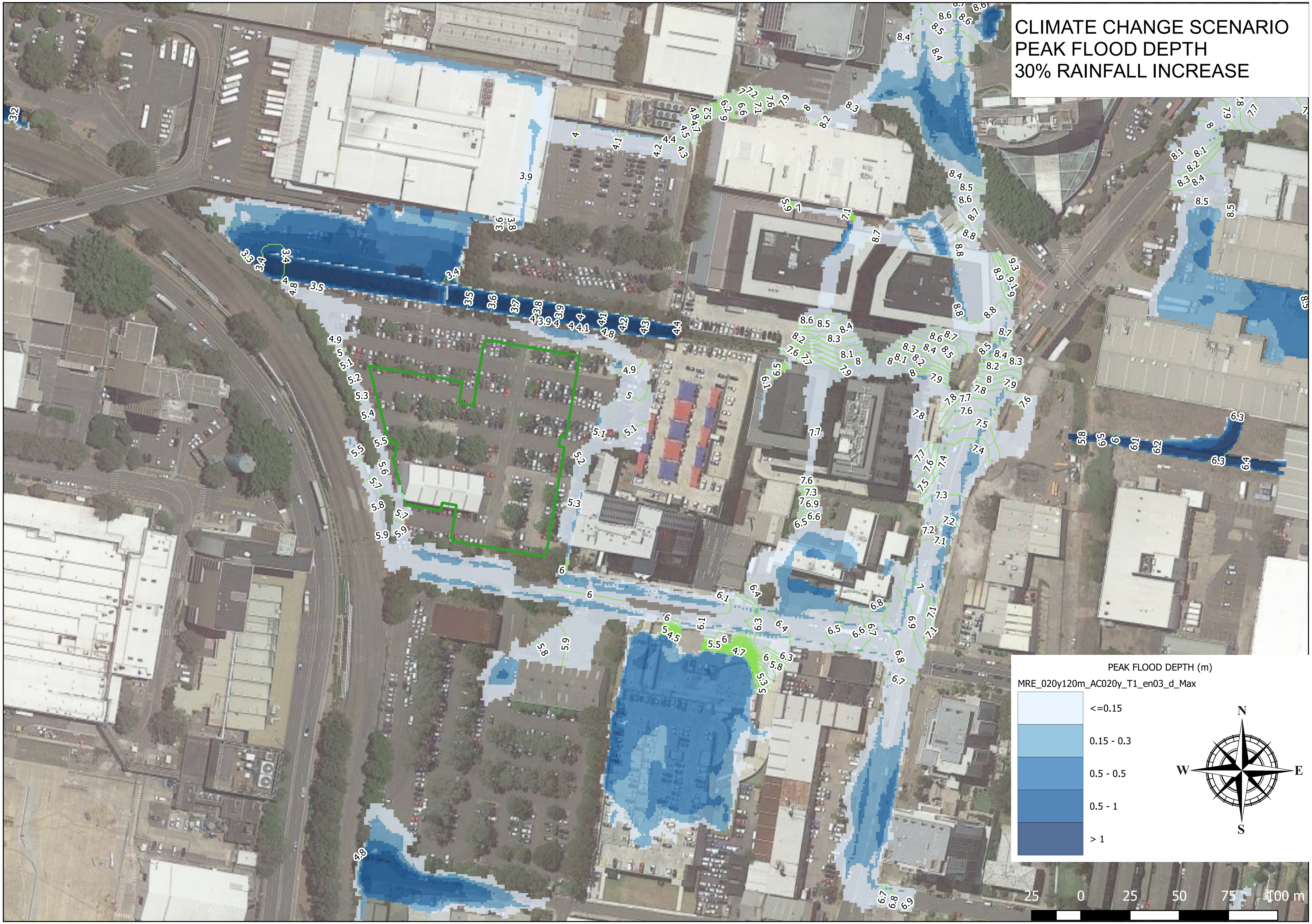
100 m

enstruct


CLIMATE CHANGE SCENARIO
PEAK FLOOD DEPTH
30% RAINFALL INCREASE
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0.15 - 0.3
0.5 - 0.5
0.5 - 1
> 1
N
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75
100 m

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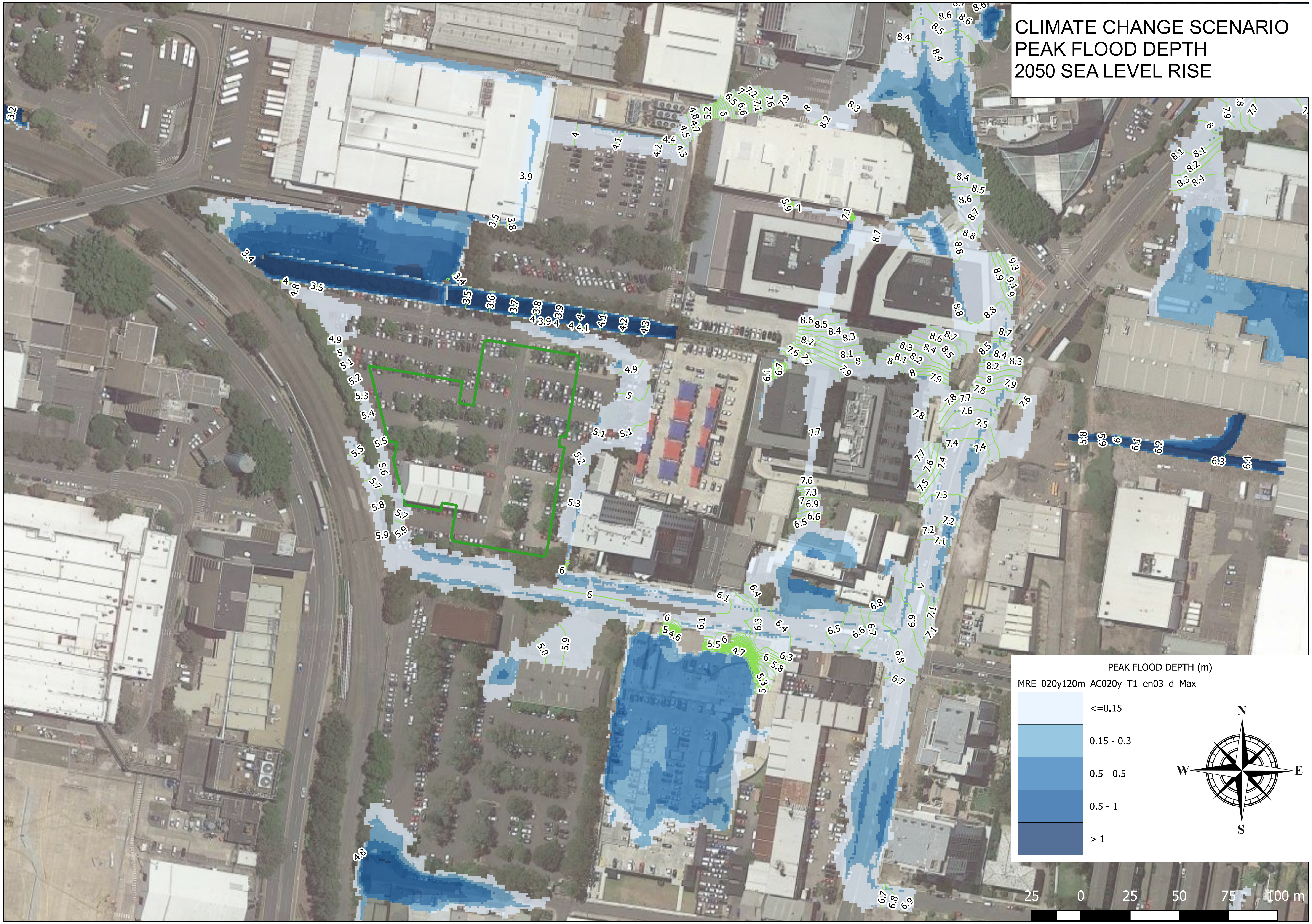
CLIMATE CHANGE SCENARIO
PEAK FLOOD DEPTH
2050 SEA LEVEL RISE



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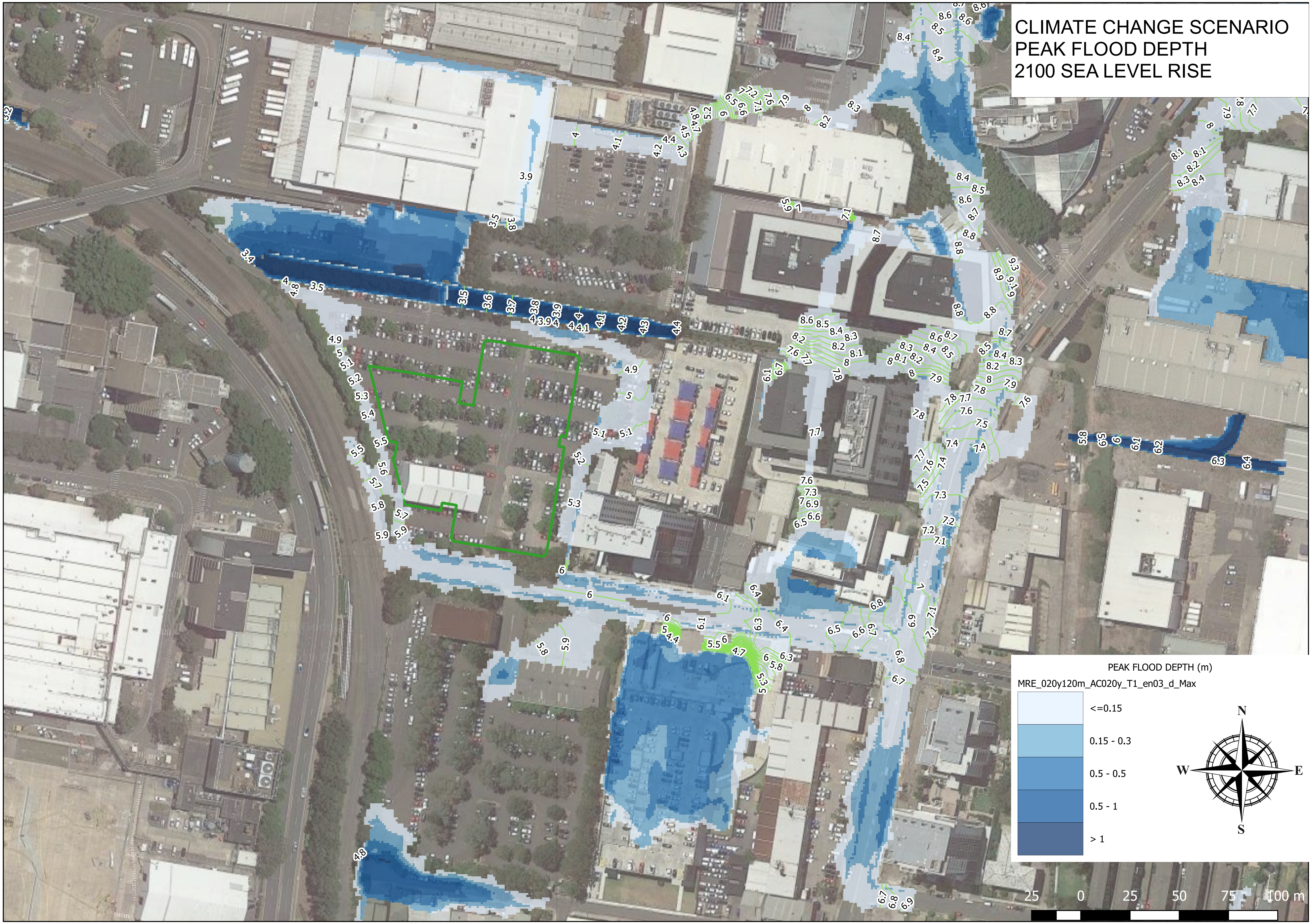

CLIMATE CHANGE SCENARIO
PEAK FLOOD DEPTH
2100 SEA LEVEL RISE
PEAK FLOOD DEPTH (m)
MRE_020y120m_AC020y_T1_en03_d_Max
<=0.15
0.15 - 0.3
0.5 - 0.5
0.5 - 1
> 1
N
E
S
W
25 0 25 50 75 100 m

APPENDIX B

Review of Flood Levels for 297 King Street, MASCOT (Lot 133 DP 659434, Lot B DP 164829, Lot 1, 2, 3 4 & 5 DP 234489)

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NSW, 2061,
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17th May 2019 Job: 5728

Sydney Water Corporation,
1 Smith Street,
Parramatta,
NSW 2150

For the attention of: - Jeya Jeyadevan

Dear Jeya,

Review of Flood Levels for 297 King Street, MASCOT (Lot 133 DP 659434, Lot B DP 164829, Lot 1, 2, 3 4 & 5 DP 234489)

Introduction

Following our meeting of Monday 13/05/2019, we have investigated the capacity of the Sydney Water channel that runs through the Qantas site at 297 King Street, Mascot.

As discussed at the meeting, the channel may be used in the future as part of a drainage upgrade masterplan. As such, any design for the development of the land around the channel should consider the impact of increased flow in the channel.

This letter has been prepared to analyse the impact on increased flow rates on the flood levels within the channel.

Figure 1: Site Location Plan (Source: Six Maps NSW 2018)

Existing Geometry

The culvert that conveys flow from the O'Riordon Street to the upstream end of the channel is 1675mm wide x 1300mm high. The longitudinal grade is 0.9%.

The open channel through the site is a brick lined channel approximately 1.3m wide at the base and 1.3m deep, before transitioning to 2.0m wide and 1.5m deep. The batters above the brick side walls vary between 1 : 3 and 1 : 1.3. There are two bridges over the channel. Refer to Figure 2.

There is a headwall at the downstream end of the channel that feeds a culvert 2m wide, 2.2m high. The culvert has a longitudinal grade of 0.74%.

Figure 2 Existing Sydney Water Channel

Analysis

A flood study of the catchment was undertaken by WMA Water Ltd. on behalf of Bayside Council. The TUFLOW model developed by WMA Water Ltd. was acquired by Enstruct under the Council's license (*Ref: F18/397*) in February of 2019.

The existing TUFLOW model has been updated to incorporate most recent surveyed data such as levels, sections of the channel and building outlines of the area that surrounds the site.

The flow rate the in channel was extracted from both the TUFLOW model output and from a simple DRAINS model to determine un-attenuated flow for the 57ha catchment. A summary is included in Table 1 below.

Table 1 Channel flow rates

Source	AEP	Flow Rate
Tuflow model output	1%	7.2 m³/s
Un-attenuated catchment flow (DRAINS)	1%	19.2 m³/s
Un-attenuated catchment flow (DRAINS)	10%	13.3 m³/s
Un-attenuated catchment flow (DRAINS)	20%	11.5 m³/s

The difference in flow rate between the models is attributable to attenuation within the flood model, and some flow being diverted to other catchments.

The channel was modelled in HEC-RAS to quickly determine the capacity of the channel and the impact of increased flow on flood levels in the channel.

Table 2: Flood Levels

LOCATION	1%AEP tuflow	20% AEP un-attenuated	10% AEP un-attenuated	1% AEP un-attenuated
upstream bridge1	3.93 mAHD	3.97 mAHD	3.38 mAHD (supercritical)	3.34 mAHD (supercritical)
upstream bridge 2	3.55 mAHD	3.81 mAHD	3.95 mAHD	4.59 mAHD
Downstream culvert entry	3.38 mAHD	3.38 mAHD	3.38 mAHD	3.38 mAHD

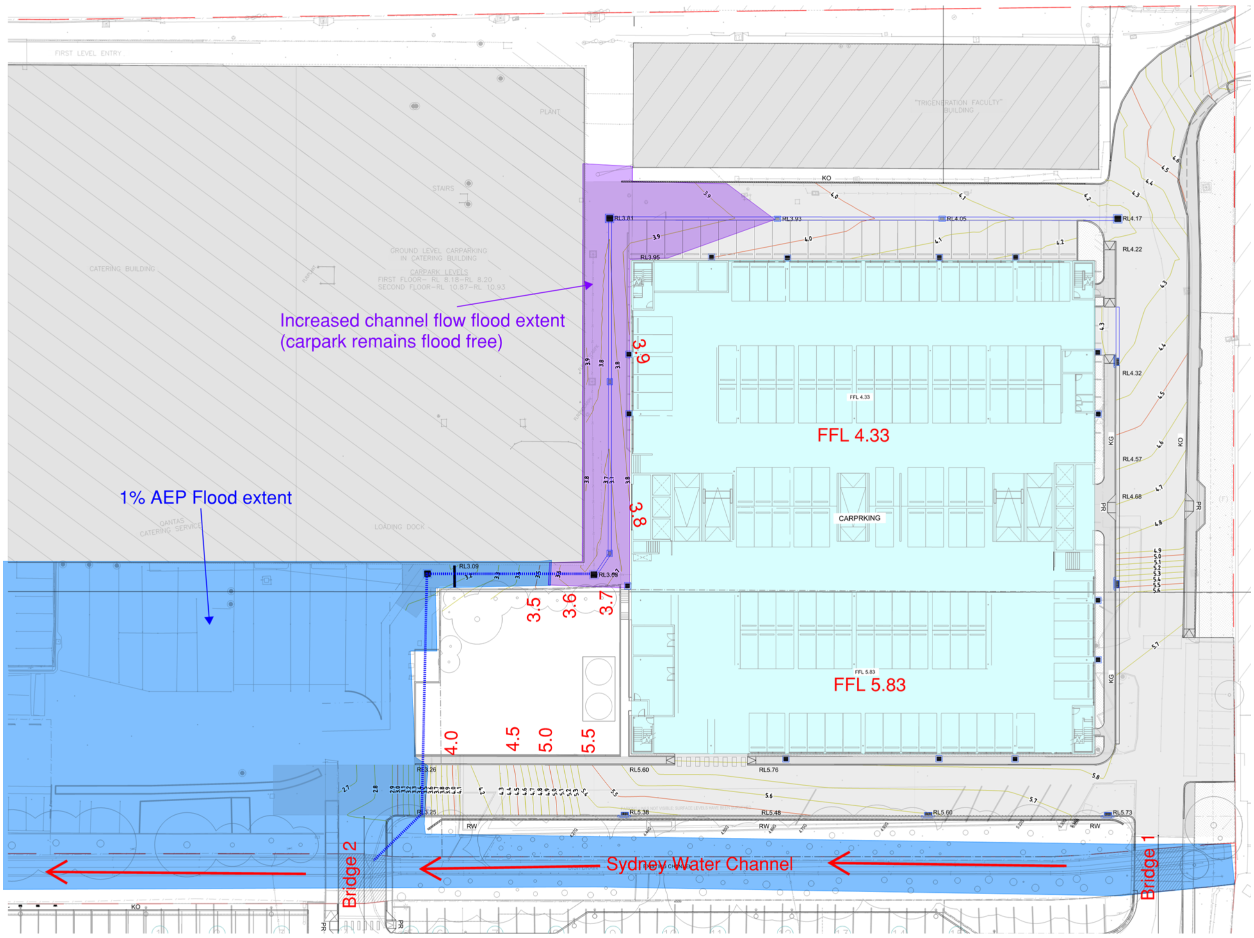


Figure 3 Site Plan

Overland Flow

The catchment wide flood model shows that in a 1% AEP event, there is no overland flow from Bourke Road/O'Riorden Street to the site. In the event that overland flow does enter the site from the northeast or via the drainage easement, overland flow routes are included in the design to direct flood water around the proposed car park and into the channel.

Discussion

The discharge location for the new works is at bridge 2. Under the existing conditions, the tailwater at this point will back up into the site access way in a 1% AEP event. The floor level of the car park is set at 4.33 mAHD, which gives 780mm freeboard to the flood level.

If the flow in the channel was increased from 7.2m3/s to 13.3m3/s, the increase in flood level would increase flood affectation of the access way, and reduce the car park freeboard to 380mm. The proposed work is resilient to possible future increasing flow in the channel.

Upstream of bridge 2, the site remains flood free in the event of increases to the flood level. The design ground levels are a minimum of 4.60 mAHD on the southern side of the channel and 5.4 mAHD on the northern side of the channel.

Should future plans look to increase the flow rate in the channel beyond the un-attenuated 10% AEP flow rate, some channel widening within the drainage easement could be undertaken without impacting on the proposed works.

Conclusion

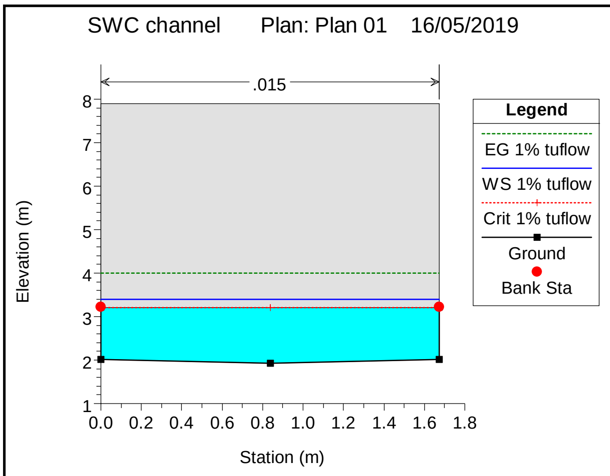
- The site has been designed with provisions for overland flow around the car park
- The car park has been designed to provide freeboard to existing flood levels in the Sydney Water Channel running through the site.
- The site is resilient to future masterplans for stormwater drainage upgrades in the catchment. The channel has the capacity to carry more flow than it sees under the existing conditions.

Yours Sincerely,

for
enstruct group pty ltd

Phillip Lambley
Civil Director

APPENDIX A – Channel Sections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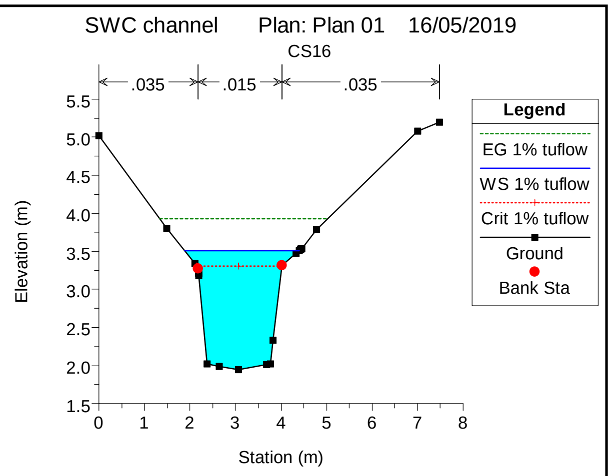
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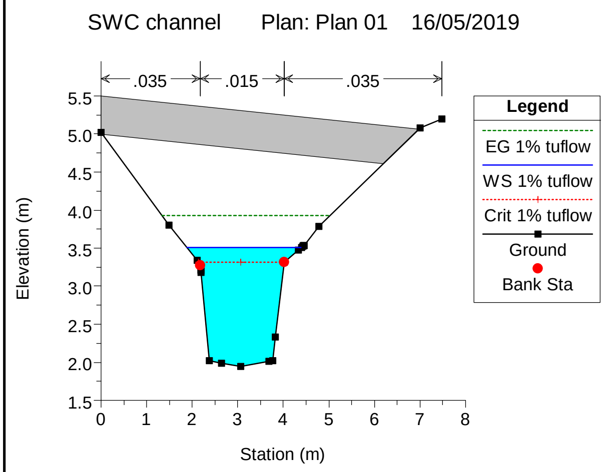
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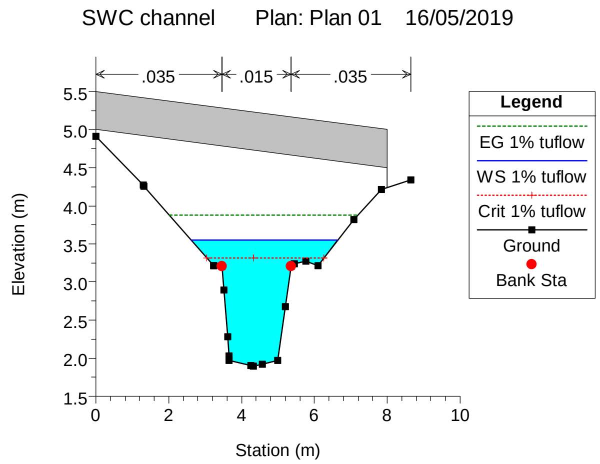
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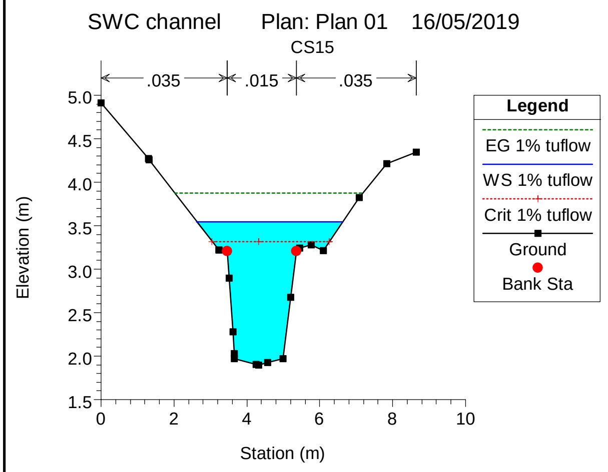
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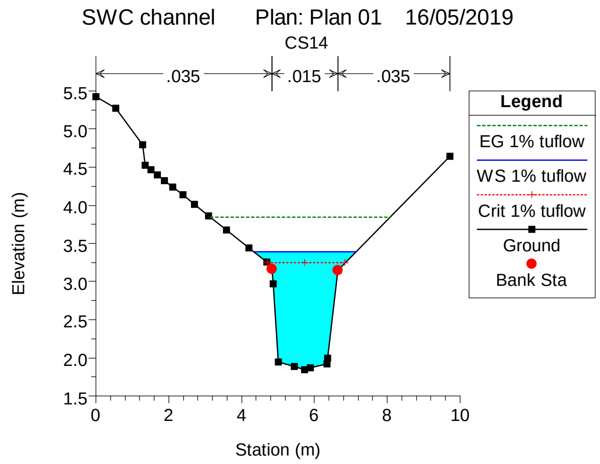
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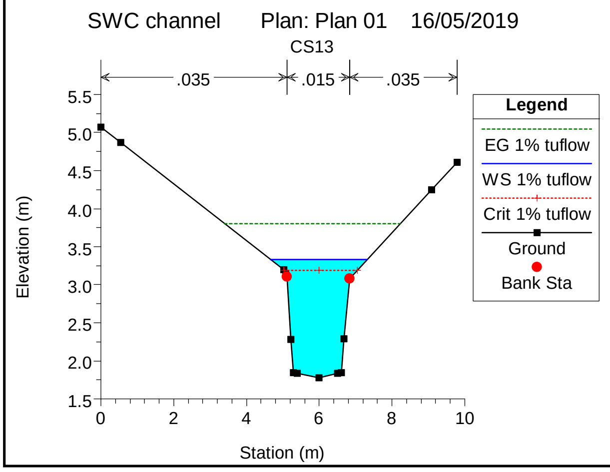
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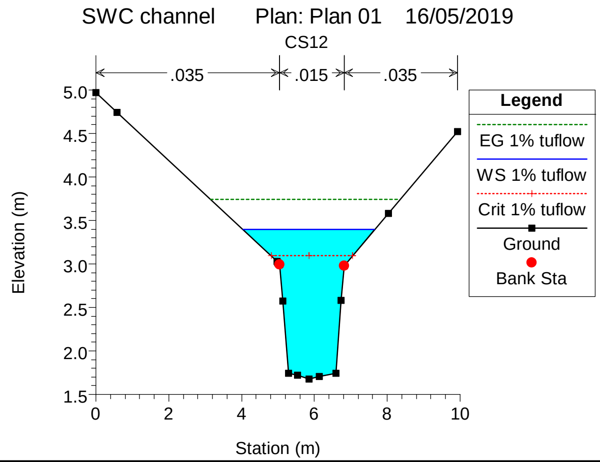
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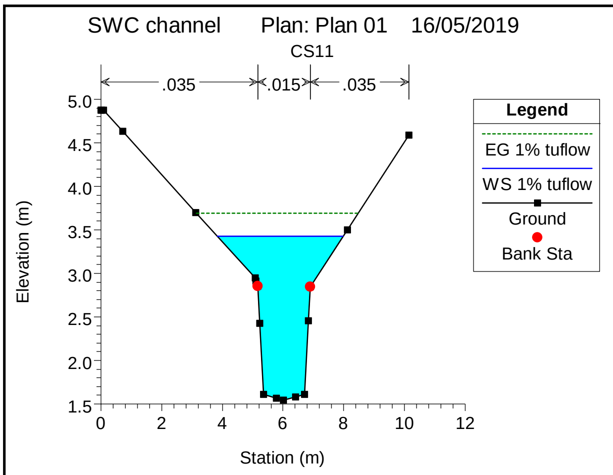
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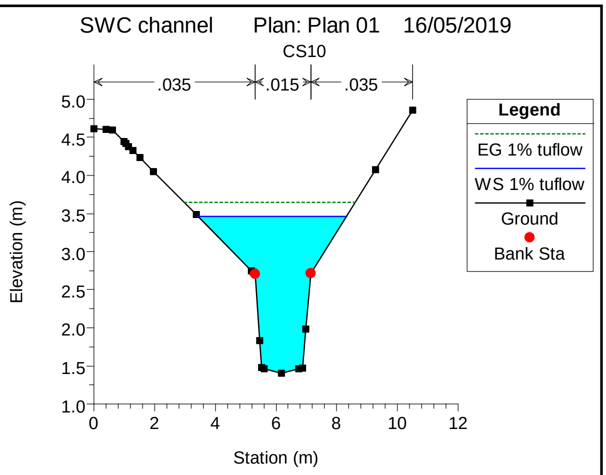
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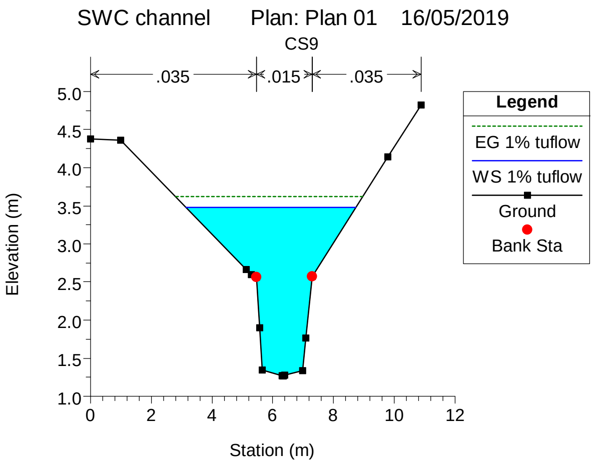
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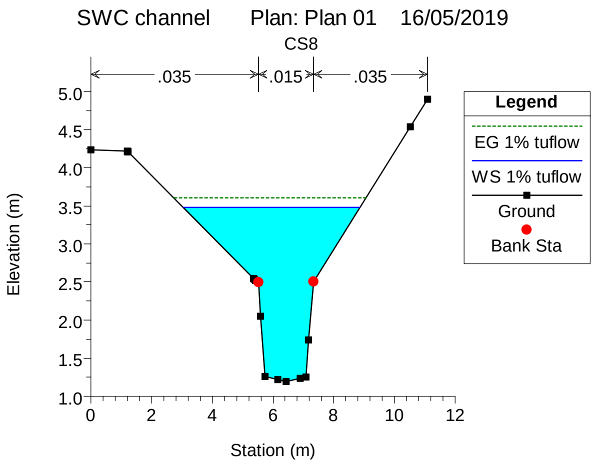
Bank Sta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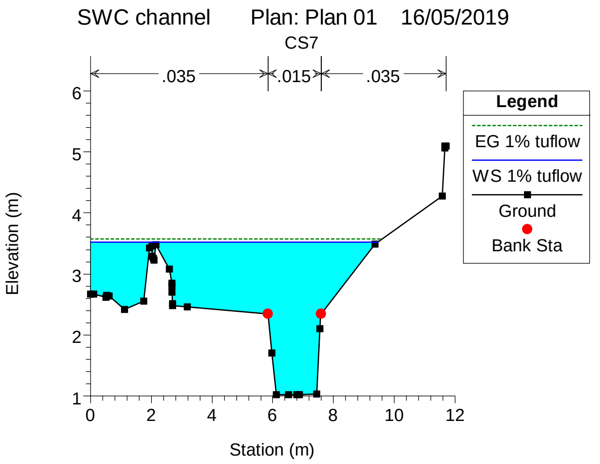
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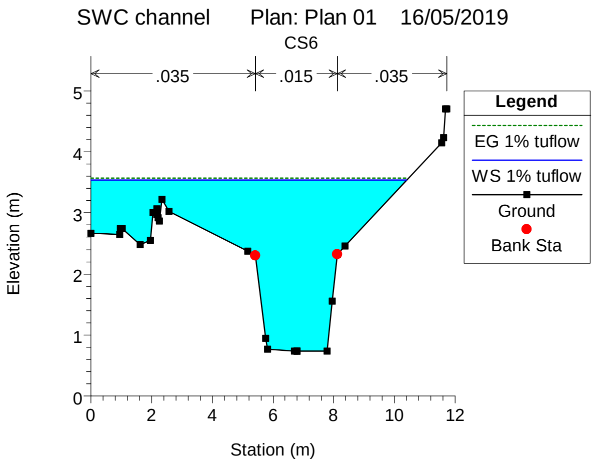
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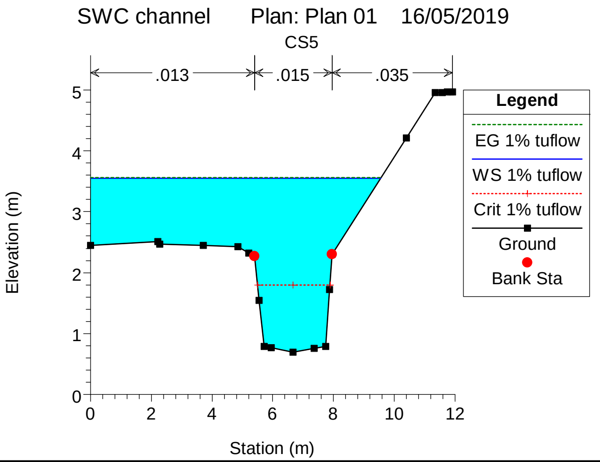
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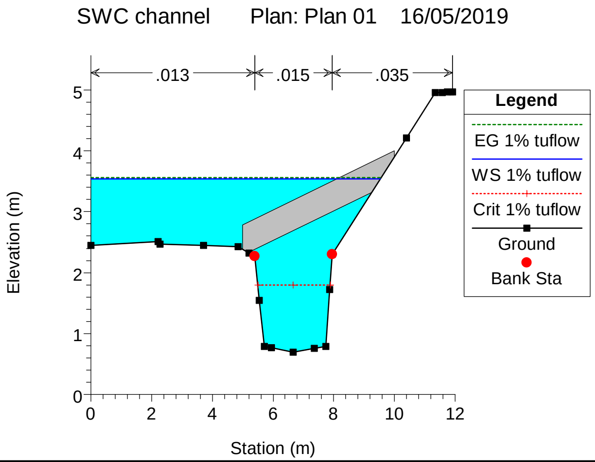
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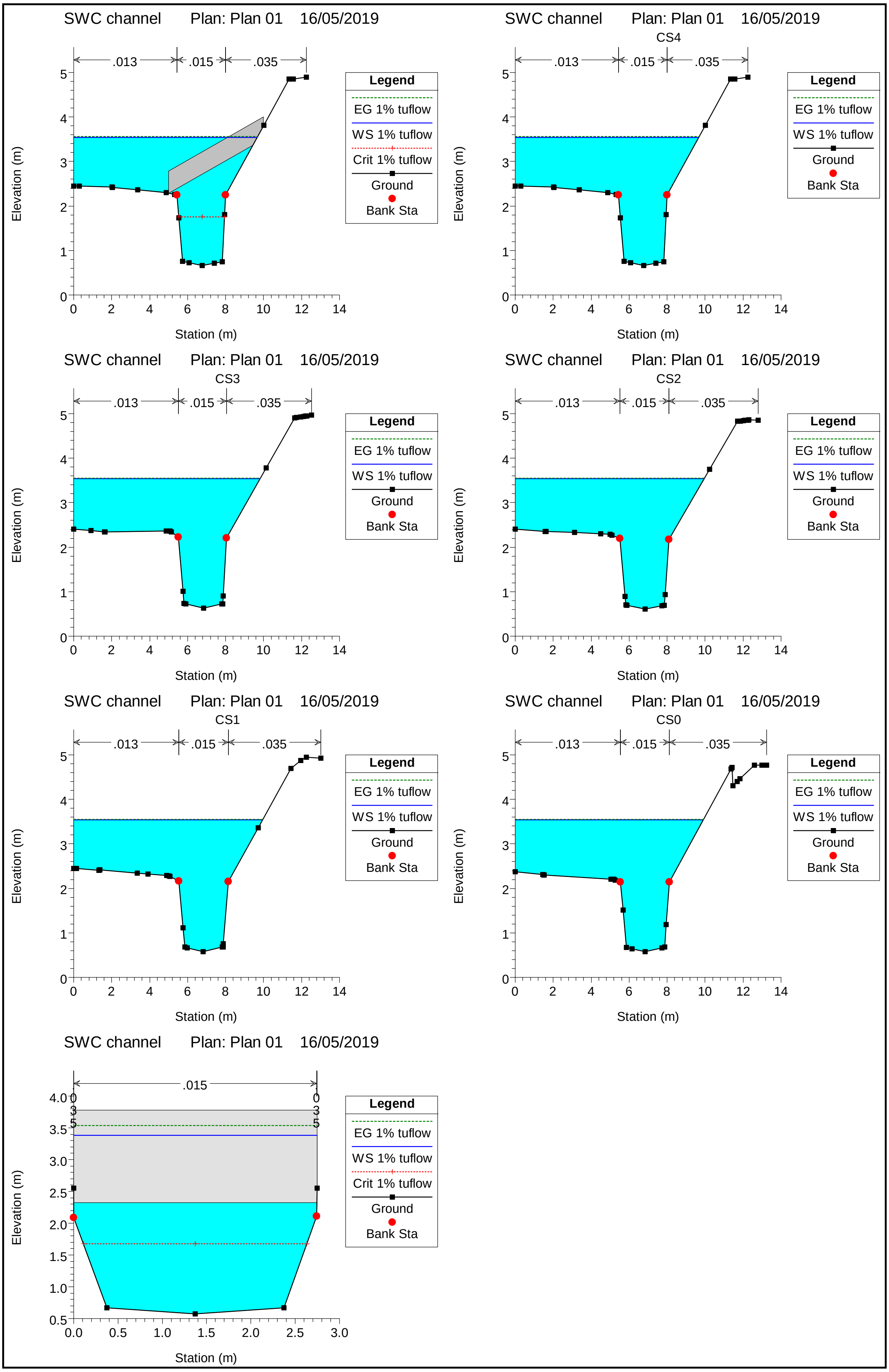

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Elevation (m)
Station (m)
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SWC channel Plan: Plan 01 16/05/2019
CS4
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Elevation (m)
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Legend
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SWC channel Plan: Plan 01 16/05/2019
CS3
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Elevation (m)
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Station (m)
Legend
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Station (m)
Legend
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Elevation (m)
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SWC channel Plan: Plan 01 16/05/2019
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Ground
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APPENDIX C

QANTAS Group Flight Training Centre
Peer Review of TUFLOW Model

Catchment Simulation Solutions

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13 Weatherburn Place
BRUCE ACT 2617
(02) 6251 0002
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Mr Phillip Lambley
enstruct
Level 4, 2 Glen Street
Milsons Point NSW 2061

6th August, 2019

Dear Phillip,

QANTAS Group Flight Training Centre
Peer Review of TUFLOW Model

I refer to recent discussions regarding the proposed QANTAS Group Flight Training Centre. Based on these discussions, we understand that enstruct prepared a flood impact assessment to support the proposed development. The flood impact assessment was prepared with the assistance of a TUFLOW hydraulic model that was original developed as part of the "Mascot, Rosebery & Eastlakes Flood Study" (WMAwater, 2015).

However, we understand that Bayside Council has requested that an independent, detailed peer review of the TUFLOW model be completed to ensure the TUFLOW model updates that were completed as part of the flood assessment reflect modern best practice. Accordingly, Catchment Simulation Solution (CSS) has completed the peer review of the TUFLOW model and is pleased to present the outcomes of the review below.

TUFLOW Model Reviewers

The qualifications and experience of the CSS staff that undertook the TUFLOW model review are provided below. More detailed curriculum vitae can be provided on request.

David Tetley

David Tetley is a civil engineer and Director of Catchment Simulation Solutions with 18 years of experience in flood studies and floodplain risk management investigations in Australia. He graduated from the University of Wollongong with first class honours and the University Medal in 2001. He has experience with a range of hydrologic software as well as 1, 2 and 3-dimensional hydraulic software (including TUFLOW and Drains). David has been involved in the preparation of over 40 Government-funded flood and floodplain risk management studies in NSW and has also prepared several papers on floodplain management (this includes a highly commended paper award at the 2014 NSW Floodplain Management Australia Conference). David is also a member of the consultants' advisory group for the revision of the NSW Government's Floodplain Development Manual.

Daniel Fedczyna

Daniel Fedczyna is a civil and environmental engineer that graduated from the University of Wollongong in 2008 with Honours. During his 9 years with CSS, Daniel has become a highly proficient hydrologic and hydraulic modeller with a particular focus on TUFLOW, XP-RAFTS and WBNM. He has also been exposed to a range of other 1D and 2D hydraulic software including DRAINS, HEC-RAS and RMA-2 as well as GIS software (MapInfo and ArcGIS). Daniel was also awarded best poster presentation at the 2014 Floodplain Management Australia Conference. Daniel has been the principal hydraulic modeller for over 10 government funded flood and floodplain risk management studies in NSW.

Review Outcomes

The TUFLOW model review focussed on the updates that were completed by enstruct to Council's adopted flood study TUFLOW model. That is, a complete review of Council's "base" TUFLOW model was not completed.

The outcomes of the TUFLOW model review are documented in **Attachment A**. The following general comments are made with regard to the following model update components.

- Terrain and building updates for existing conditions: Revised terrain information for the site and adjoining areas was incorporated within the TUFLOW model. The survey information was reviewed and is considered to provide an improved description of local variations in terrain relative to the 2013 LiDAR that was used in the original TUFLOW model. Modifications to the representation of buildings was also completed in the local vicinity and is considered to provide an improved representation of contemporary catchment conditions.
- Boundary conditions: Modifications to several subcatchments (including one additional subcatchment) was completed in the vicinity of the site to provide a better representation of hydrologic conditions and allow more precise application of flows to the TUFLOW model. Rectification of a "split" subcatchment from the flood study model was also incorporated and is considered reasonable.
- Terrain and building updates to reflect "post-development" conditions: The proposed "design" terrain has been included within the post-development scenario together with an overland flowpath around the northern and western extent of the proposed carpark. Modifications to include the new flight training facility have also been implemented. All updates are considered to provide a reliable reflection of post-development conditions.

Overall, the outcomes of the review indicate that all TUFLOW model updates are reasonable and reflect modern best practice.

I trust that this document provides a suitable summary of the TUFLOW model review that was completed. However, if you have any questions or require anything further on this matter, please do not hesitate to contact David Tetley (*ph: 8355 5501 email: david.tetley@csse.com.au*) or Daniel Fedczyna (*ph: 5355 5503 email: daniel.fedczyna@csse.com.au).*

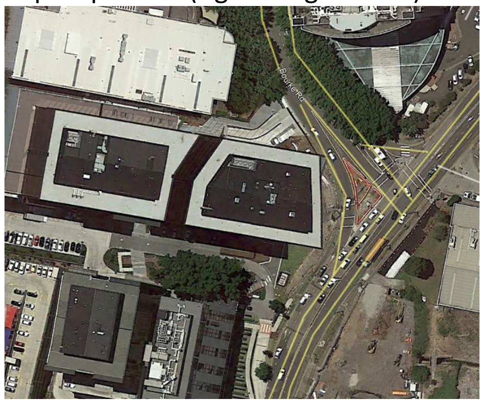
Kind Regards,

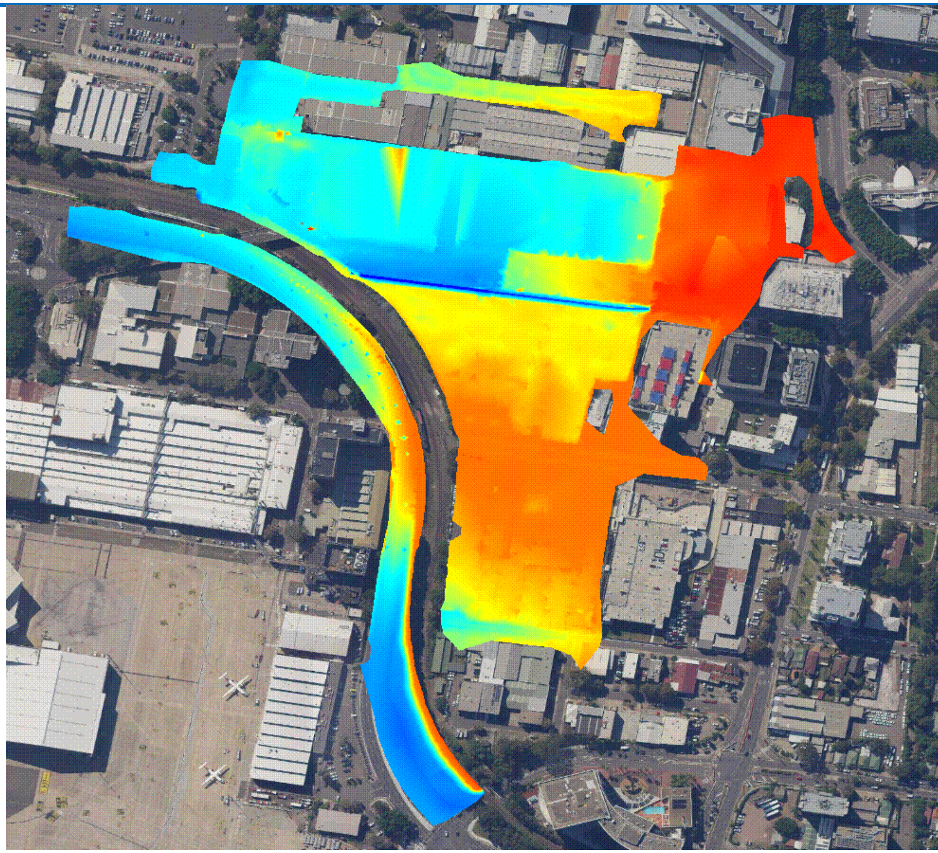
David Tetley
Catchment Simulation Solutions

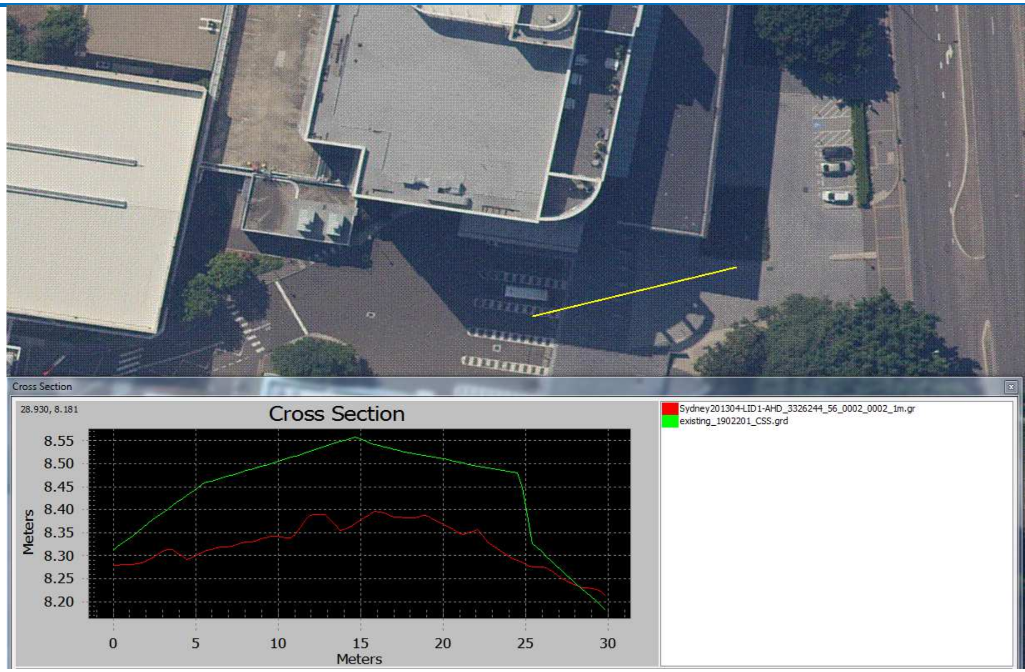
Attachment A:
TUFLOW Model Review Outcomes

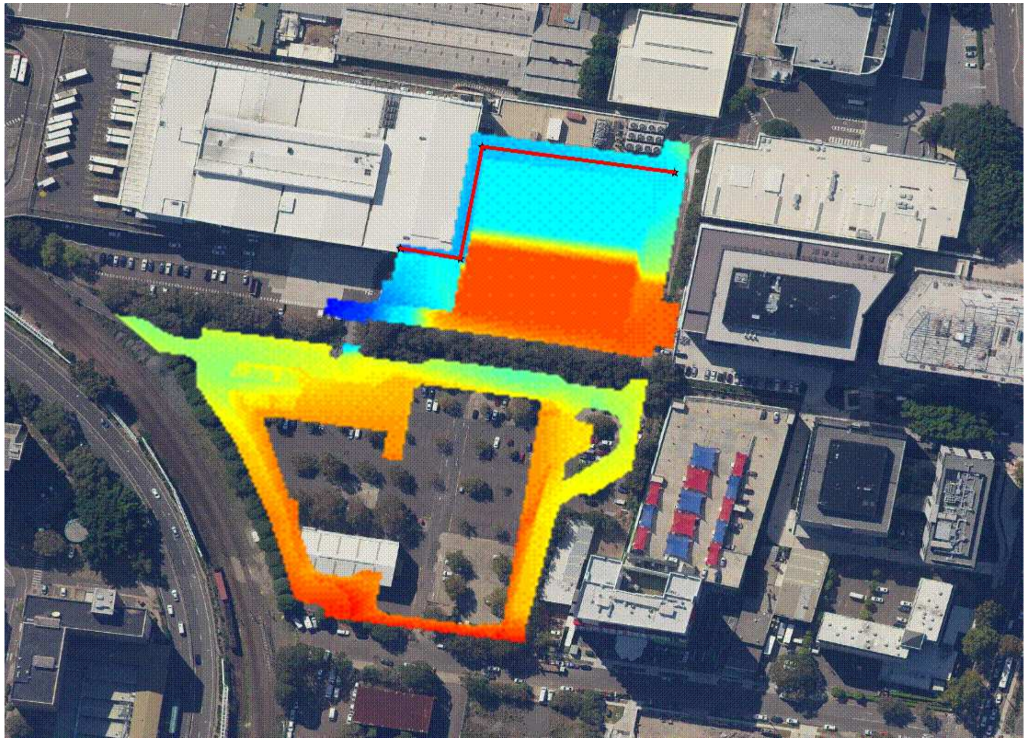
QANTAS Flight Training Facility TUFLOW Model Review

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
General	Version of TUFLOW model used	• TUFLOW 2018-03-AC-iSP-w64 used for both existing and post development scenarios. "Defaults == PRE 2013" has been used to retain backward compatibility with original flood model for the Mascot, Rosebery & Eastlakes (MRE) Flood Study (WMAwater, 2015)	Nil	
Model Setup	TUFLOW Control and other files	• Folder structure is in accordance with the TUFLOW User Manual 2017-09.	Nil	
	Timestep	Specified timesteps in MRE_Timestep.tcf file: • 2D Model timestep = 0.5 seconds. This is considered suitable as it is in the order of the recommended timestep value of ¼ of the model grid size (i.e., ¼ x 2 = 0.5 seconds). • 1D Timestep = 0.5 seconds (defaults to minimum 2D timestep)	Nil	
Model Configuration	Model Configuration (1D, 2D or 1D/2D?)	• 1D representation of major watercourses and drainage structures dynamically linked to 2D representation of floodplain and overland flow areas	Nil	
	1D representation	• Major conveyance areas that would not be well represented in 2D (e.g., major drainage channels) are represented as a 1D domain. The geometry within the 1D domain is defined using cross-sections at an average spacing of 10-15 metres. As the channel geometry is relatively consistent along each "branch", this spacing is considered to be appropriate	Nil	
	2D representation	• 2 metre grid size • 2 metre grid size is commonly adopted for urban/overland flood studies and is considered sufficiently detailed to represent major topographic and drainage features (not represented as 1d elements) in an urban catchment	Nil	

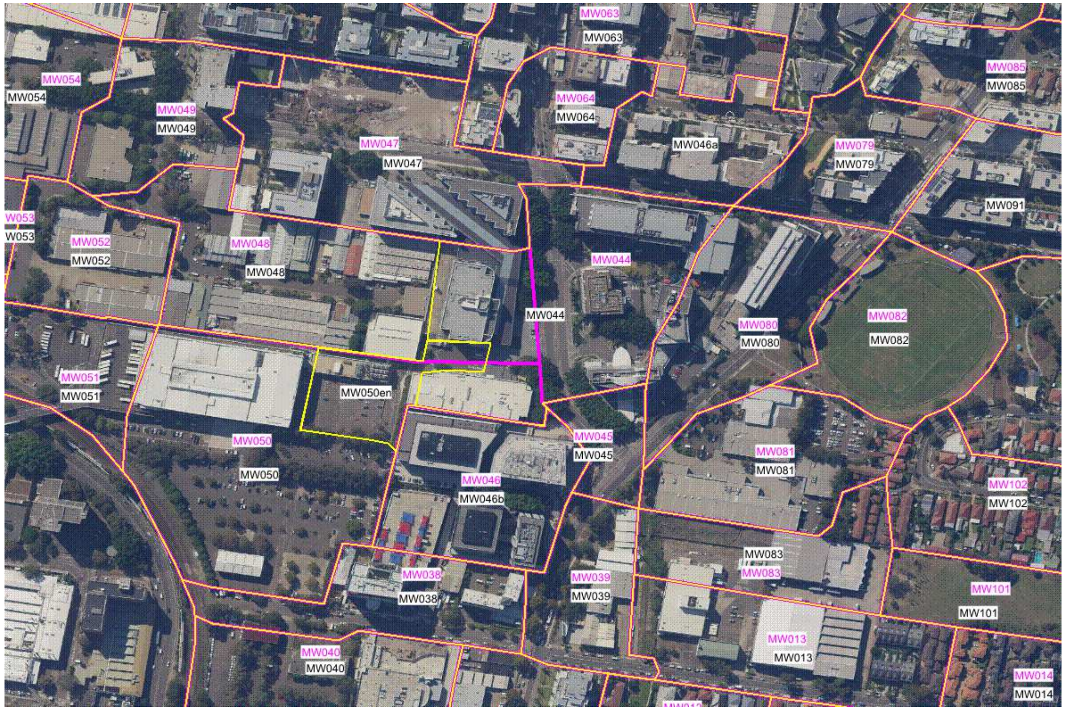
ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
Extent of Model	2D Model Extent	- Active 2D domain extent set by 2d_code_StudyArea_003 Subject site located sufficiently within active domain to ensure appropriate representation of upstream and downstream flood conditions	Nil	
	1D Model Extent	- Major open creek channels and structures within the catchments including channel adjacent subject site. Cross section geometry agrees well with detailed site survey, and is a significant improvement over the LiDAR representation, justifying the use of 1d elements.	Nil	
Terrain Data (2D)	Source of DEM data	- Catchment wide terrain assigned through z-points populated from 2013 LiDAR data (2d_zpt_MRE). - Additional zshp (2d_zsh_en_terrain_fix) included to ‘fix’ terrain where topography has changed since data collection, ie: a building on corner of Bourke Rd and O’Riordan St which was an open carpark (left image below) at the time of LIDAR collection, and now has a large building complex present (right image below).   - Detailed survey DEM (existing_190220.asc) included across and around the development site (extent shown below).	Nil	

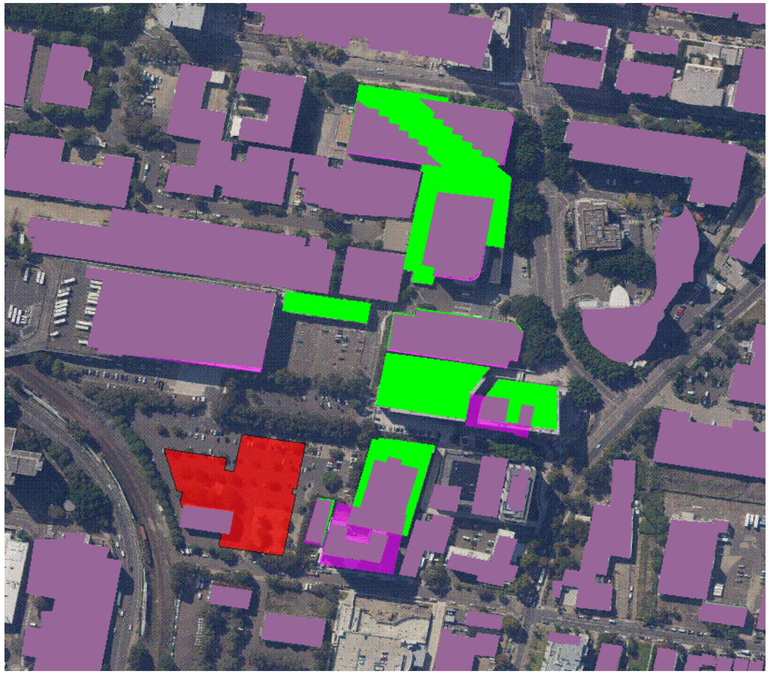
ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
		 • For the most part, there appears to be a good agreement between the 2013 LiDAR terrain and the detailed site survey (generally within 0.05m). However, a location ~50m west from the Bourke Road frontage of the site demonstrates a more significant difference of 0.15 metres, where the detailed survey is higher than the 2013 LiDAR DEM (see section provided below). The detailed survey appears to better reflect the crest of the driveway and has been collected more recently, using more accurate ground survey techniques. As a result, it is considered that the ground survey information is superior to the LiDAR and is more suitable for use in the TUFLOW model across this area.		

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
		 • The post development scenario includes a proposed terrain DEM (190716-proposed.asc), and a zshp (2d_zsh_en_north_olf_L , 2d_zsh_en_north_olf_P) to enforce an overland flowpath on the site that allows water movement along the northern and western extents of the proposed carpark (extent of proposed DEM shown below, and overland flowpath z shape shown as a red line)		

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
				
Cross-section Data (1D)	Source of cross-section data	Unchanged from original MRE Flood Study model, integrity of which has not been reviewed	Nil	
Hydraulic Structures	General	Unchanged from original MRE Flood Study model, integrity of which has not been reviewed	Nil	
	Blockage	Blockage has not been applied to hydraulic structures. Although this is not in accordance with modern best practice as outlined in ARR2019, it was common practice at the time the original MRE Flood Study was prepared. Furthermore, the hydraulic structures that span the channel adjoining the development site are single span structures where there is minimal potential for blockage.	Nil	

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
Stormwater Network	Representation	• The TUFLOW model includes a representation of the stormwater drainage system within the catchment. However, a number of stormwater pipes at the top of drainage lines have been set to "ignored". This appears to be unchanged from the original MRE Flood Study model and is assumed to be intentional.	Nil	
Boundary Conditions	Inflow boundary conditions -	• Inflows to the TUFLOW model have been defined using flow hydrographs generated by a DRAINS model and are applied to the 2D domain based on a 2d_SA layer with 'Local' inflow hydrographs applied. • The subcatchments/SA polygons in the vicinity of the site have been compared between that used within the original MRE Flood Study and that used within the current study. It has been identified within the current study, and verified within this review, that subcatchment "MW046" was originally representing two geographically separate catchment areas as a single subcatchment. As a result, flows were being inappropriately distributed to the 2D domain. This appears to be rectified within the current study by separating the two subcatchments in the DRAINS model, re-naming them MW046a and MW046b and applying the flows from both subcatchments separately to the TUFLOW model. The updates within the DRAINS model to facilitate this update have been reviewed and appear reasonable. • A refinement of the subcatchments, MW044, MW048 and MW050, which are in the vicinity of the study site, have also been made to better reflect the surveyed topography (particularly across the high point identified in the review of the detailed survey DEM). It has also allowed a more detailed and reliable application of local flows in the immediate vicinity of the site. The updates within the DRAINS model to facilitate this update have been reviewed and appear reasonable. Note that the underlying model hydrology has not been reviewed. • Subcatchment MW044 was also enlarged (in a westerly direction) to the high ground identified in the detailed site survey. MW048 and MW050 were reduced to balance the expanded subcatchment MW044. A new subcatchment was added within MW050, (named MW050en) to allow more detailed application of flow within the site (e.g., the low point in the car park for the existing scenario). The SA polygon boundaries and labels from the original MRE Flood Study are shown in pink and the	Nil	

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
		yellow boundaries and black text represents the modified subcatchment boundaries used in the current study.  - The flow application location from the refined subcatchment MW050en has been altered between the "existing" conditions and "proposed" conditions models to account for the location of the proposed carpark. In the proposed conditions model, this is applied directly to the overland flowpath skirting around the carpark. As this will be the lowest point in the area, this is reasonable.		
	Downstream boundary conditions	- Unchanged from original MRE Flood Study model. Located a sufficient distance downstream of site to not impact directly on results at the site itself.	Nil	
Flowpath Obstructions	Buildings	- Buildings have been represented within in the model as complete flow obstructions by complete removal of the 2d cells contained within building footprints.	Nil	

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
and Constrictions		• Buildings in the vicinity of the site have been modified to better reflect contemporary conditions. Green buildings are from the original flood model, pink/purple are overlaid from the modified existing conditions model, and the red polygons are the modified buildings for the post development scenario. The modified location and extents of buildings for both existing and post development scenarios as part of this study are considered appropriate for use. 		
Model Parameters	Roughness (Manning's 'n') values	• Unchanged from original MRE Flood Study model. All Manning's 'n' values are within reasonable ranges. • Material polygons implemented as part of post-development model are unchanged compared to existing conditions. As the modified carpark is currently a carparking area, and the new flight training facility building is represented as null 2d cells, it is considered reasonable to retain the existing material definition in the post development scenario.	Nil	

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
Checks, Warnings and Errors	Outputs in the _messages layer	The _messages layer was checked for the "MRE_100y120m_AC020y_T1_en03" simulation. No major problems are identified, particularly relating to the model changes made as part of the current study.	Nil	