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25 November 2022

Clarence Valley Council

Attention: James Hamilton

Dear James,

RE: WEST YAMBA FLOOD MODELLING

Background

In November 2021 BMT submitted a Flood Impact Assessment (FIA) for the proposed development of Yamba Gardens (the Site) within the wider West Yamba Urban Release Area (WYURA). The FIA assessed the potential for the Site to change or alter the flood behaviour during regional, Clarence River, flood events.

In September 2022, BMT was supplied with a copy of a peer review report[1] undertaken on the Yamba Gardens FIA. The peer review was prepared by an independent third party, WMAwater. The peer review was undertaken on BMT's FIA, which assessed regional Clarence River flooding, and on a Yamba Gardens Stormwater Management Plan, prepared by a third party (BIOME) and which is separate to the BMT assessment.

The peer review found the modelling to be industry standard, sufficiently detailed and reasonable. It made a number of comments and recommended actions for BMT, BIOME and Council. For the BMT assessment these were mostly in relation to provision of additional modelling outputs. Ultimately the peer review recommended that development consent not be granted as it did not meet LEP Clause 5.21 (2-b) and (2-c) which relate to adverse flood impacts and consideration of climate change respectively.

This letter responds to the WMAwater peer review for issues in relation to BMT's FIA. Other issues highlighted in the peer review concerning aspects of the BIOME study or addressed to Council (such as considering the development and adoption of a comprehensive West Yamba drainage strategy or masterplan) are outside the scope of BMT's response and are not covered in this letter.

This letter begins by setting out the scope of our assessment and is followed by responses to the WMAwater peer review.

Scope of BMT Yamba Gardens FIA

BMT has prepared a number of flood impact assessments for development sites within the WYURA over the last 10 years. In all cases the BMT assessments have been for regional (Clarence River) flood events and assess the potential for the development to impact on these regional events. The Yamba Gardens FIA followed the same general approach.

[1] West Yamba Urban Release Area – Yamba Gardens – Flood Impact Assessment Review, Final Report dated September 2022

BMT was provided with a letter[2] from Council to Gerrard Building Pty Ltd which set out additional information required by Council in relation to the Yamba Gardens Development Application. This included matters in relation to the flood modelling along with clarification requests addressed to BMT. The letter required that an Option 1 and Option 2 be modelled with Option 1 being all approved and current applications and Option 2 considering filling of all lots within the WYURA.

Before commencing the assessment, BMT provided a letter[3] to Clarence Valley Council (Council) which set out our modelling methodology including the events that would be modelled, how developments would be represented in the model (clarification of the options) and how the Yamba Bypass would be represented.

Council responded with some further clarification queries for BMT including what parameters would be assumed for the floodway[4]. BMT provided a response to these queries in a letter dated 28 October 2021.

BMT then proceeded with the assessment on the understanding that all of Council's queries with the proposed approach and methodology were resolved.

Response to Peer Review

The WMAwater peer review contains comments/actions within both the text of the peer review and additional tabulated actions, which have been allocated an item number. Not all WMAwater comments were allocated an item number. In our response below we have mirrored the same section headings as used by WMAwater for ease of cross checking.

Integrated assessment of local flooding and riverine flooding

A peer review comment was made in relation to the regional model only investigating the impact of riverine floods from major river systems. It recommends that detail of local runoff generation behaviour is added to the model to allow consideration of both local flooding and riverine flooding for short and long duration design storms.

BMT Response

The scope of the BMT modelling has always been to assess riverine flooding and the model, in its current form, is not suitable for modelling local drainage. It is understood that a local drainage model (developed by BIOME) has been used for this purpose and that this model gives consideration to the joint probability of riverine and local flooding.

Whilst it is possible to adapt the BMT model to apply and model local catchment inflows, the benefit of doing so would seem limited given that this is covered under a separate assessment.

It should be noted that the revision to the Wooloweyah local catchment inflow documented in our report, and highlighted by WMAwater in their peer review, has not resulted in any change to the inflow rate/volume applied in the model. The change was made to apply the inflow within Lake Wooloweyah i.e. upstream of West Yamba, as the adopted Council model lumped this inflow into the main Clarence River channel downstream of West Yamba. Our concern was that by not doing this, peak flood levels may be understated in Lake Wooloweyah. It is therefore considered an improvement to the model.

[2] Letter dated 27 May 2021.
[3] Letter dated 31 August 2021.
[4] Letter dated 7 October 2021.

Yamba Bypass representation

The peer review notes that the modelled investigation of the Bypass is considered appropriate but recommends that the entire Yamba Bypass is modelled, as only part of the Bypass is currently modelled.

BMT Response

Our initial modelling methodology did not include representation of the Yamba Bypass as this was not initially requested by Council and designs for the Bypass were not available. At the request of Council BMT assessed an additional development option (Option 3) which included the Bypass. As specified by Council BMT represented the Bypass *to the same extent and parameters as the January 2018 Flood Model previously prepared*.[5] We understand that there is currently no design for the Yamba Bypass and that our modelling of the bypass is consistent with Council's expectations.

Flood Impacts

The peer review quotes the BMT FIA as showing above floor impacts of between 30mm to 80mm. This is consistent with what is presented in the BMT report. WMAwater suggest using a conservative minimum reporting value of 10mm as opposed to 30mm used by BMT. The peer review also notes that impacts were only tabulated for Option 2 (not Option 1 or 3). Furthermore, the review strongly recommends assessing less frequent design storms including the 0.2% (1 in 500) AEP, the 0.5% (1 in 200) AEP and the PMF along with the smaller events of the 10% (1 in 10) and 20% (1 in 5) AEP events.

The review also recommends that other impact variables should be assessed including potential changes to velocity and time of inundation.

BMT Response

For mapping and reporting purposes we maintained an impact reporting threshold of 30mm. This is to maintain consistency with all previous West Yamba assessments and allow all developments to be assessed in a consistent and fair manner. We note too that this is lower than the value of 50mm adopted for the Pacific Highway Upgrade which also used the lower Clarence flood model as the basis of its assessment.

With regards to the different flood events, Council's adopted model (Lower Clarence Flood Model Update 2013), includes the following AEPs: 1 in 5, 1 in 20, 1 in 50, 1 in 100 along with an extreme event. Council therefore does not have adopted events for the 1 in 500 and 1 in 200 AEPs. We note that the previous Council flood study, undertaken in 2004, did include the 1 in 500 AEP (referred to as the 500 year ARI event). To address the peer review comment we have modelled the 1 in 500 AEP event based on the 2004 flood study inputs and assumptions. The 1 in 500 AEP main Clarence River inflow has been sourced from a study BMT is currently preparing for Council and is based on an updated flood frequency analysis at Grafton. The 1 in 500 AEP peak flow is similar to that from the original 2004 study[6]. We have assessed the 1 in 500 AEP event for flood impacts and presented results within Annex A, B and C.

We have also additionally modelled the 1 in 50 AEP event and assessed this event for impacts.

[5] Requested by Council in their letter to BMT dated 28 October 2021.
[6] The 1 in 500 peak inflow at Grafton is 20,590m3/s in the updated study (in preparation) compared to 20,000m3/s in the 2004 Flood Study Review.

We have not assessed any events with a smaller magnitude than the 1 in 20 AEP event as the 1 in 20 AEP event showed minimal impacts. It is assumed the comment regarding assessment of the 1 in 5 and 1 in 10 AEP events is more targeted for local catchment runoff assessment which is outside the scope of this assessment.

To assist Council in interpreting the impacts and to address the peer review comments we have undertaken the following for each assessed AEP event and for Option 1 and 2:

- Mapped peak flood level impacts for additional AEPs (1 in 50, 1 in 500 and 1 in 100 with climate change) – presented in Annex A.
- Mapped peak flood velocity impacts – presented in Annex B
- Mapped peak flood hazard category impacts – presented in Annex C
- Presented plots showing potential changes in flood duration at impacted locations – presented in Annex D
- Presented updated tables of above floor level impacts for Options 1 and 2. The updated information includes additional details on whether or not a property is flooded above floor level in the base case and to what depth – presented in Annex E.

Results show no notable impacts above those presented in the BMT report including when considering the larger magnitude events of the 1 in 500 AEP and the 1 in 100 AEP with climate change (1 in 100CC AEP). There are some additional dwellings shown to have impacts of 30mm or more in the 1 in 500 and 1 in 100CC AEP events (see Annex E) but the higher Base Case flood levels in these events means that these same dwellings are also inundated above floor level in the Base Case.

As noted by WMAwater, there are some increases in peak velocity on Carrs Drive within the WYURA, for example in the 1 in 100 AEP under Option 2 (see Map B-6). However, there is a decrease in flood hazard along Carrs Drive at the same locations showing these velocity increases (see map C-6). This is due to the increased height of Carrs Drive as part of the development resulting in lower flood depths. The flood hazard (which is a function of both depth and velocity) shows an overall reduction.

There is no meaningful change in flood duration for all events modelled under both Option 1 and Option 2 (see Annex D).

The analysis of impacts greater than 30mm at residential dwellings shows no properties impacted above floor level for the 1 in 50 AEP for both Options 1 and 2. As shown in Annex E, in the 1 in 100 AEP there is one dwelling impacted by 30mm or more above floor level for Option 1 and two additional dwellings impacted in Option 2 (3 in total). Of these three dwellings impacted by 30mm or more, only one at 28 Golding Street is not inundated above floor level in the 1 in 100 AEP Base Case but is inundated above floor level under Option 2. It is noted that this dwelling is located within the land identified as floodway in the WYURA.

In both the 1 in 500 AEP event and the 1 in 100 AEP event with climate change, there are two dwellings impacted by 30mm or more above floor level under Option 1 and a further four dwellings impacted by 30mm or more above floor level under Option 2 (6 in total). In all cases the dwellings are inundated above floor level in the Base Case although at 28 Golding Street, the Base Case inundation depth above floor is very shallow.

Flood Hazard

The peer review requested that maps of flood hazard should be presented.

BMT Response

Maps of classified flood hazard (classified in accordance with AIDR[7]) have been included in Annex C along with maps showing increases in the hazard category. It was beyond the scope of the BMT study to undertake an evacuation assessment.

Further Detailed Comments

Table 1.2 of the peer review lists a further five itemised comments/actions. This table is replicated in Table 1.1 below with BMT responses appended below the comment/action.

Table 1.1 Further Detailed Peer Review Comments

Item	Section	Comment/Actions
1	5.2	It would be helpful to clarify whether the current and future development plans are limited to the West Yamba Urban Release Area (WYURA – Figure 5.3) or to the entire West Yamba Development area (Figure 3-4). The modelled Development Options are within WYURA. Any developments outside of this area should be also assessed as suggested in Section 4.1 ***BMT Response*** The developments assessed as part of the Options are shown in Figure 5-1 to Figure 5-3 of the BMT FIA. The development Options were specified by Council.
2	5.3	To complete the assessment and better understand flood risk, we recommend presenting the downstream impacts on velocity and hazard categories. It was noted there is an increase in the velocities in the corridor between the developments (Miles Street and Carrs Drive). We found that this is a requirement under the DCP Schedule D4. ***BMT Response*** Velocity and hazard category impacts have been presented within this letter (see Annex B and Annex C). Whilst there is an increase in velocity on Carrs Drive and Miles Street, there is a decrease in the flood hazard as the level of the roads has increased resulting in a lower flood depth.
3	5.3	It would be beneficial to document any benefit and/or impacts as a result of the proposed flood way. ***BMT Response*** Options 1, 2 and 3 all include the flood way and so the impacts presented for those options include for any impacts/benefits of the floodway. For the most part the floodway is not a proposed feature but rather an area of natural low lying land which will remain unchanged.
4	5.3	Please comment on the changes in the flood duration time as a result of the proposed development. For example, along the main road out of the development area. ***BMT Response***

[7] Australian Institute of Disaster Resilience Handbook 7: managing the floodplain: best practice in flood risk management in Australia (AIDR, 2017)

Item	Section	Comment/Actions
		Changes in flood duration have been included in this letter (Annex D), on Carrs Drive and Yamba Road. This has been assessed for the 1 in 50, 1 in 100, 1 in 500 and 1 in 100CC AEP events (smaller events did not cause extensive inundation on Yamba Road and did not show any impact as the result of the development). In all cases there is no noticeable change in flood duration on Yamba Road. At the northern end of Carrs Drive there is a very minor change (increase) in duration in the 1 in 50 AEP event of approximately 30 minutes. The overall duration of flooding for the 1 in 50 AEP at this location is around 6 hours. This increase is not seen on Yamba Road.
5	5.3	Assessment of the changes in downstream velocity as a result of the new development area, may give an indication of erosion potential or flood hazard in the downstream areas/surrounds. The DCP Clause 5.2 requires investigating velocities. It would be necessary to investigate this to comply with the DCP. ***BMT Response*** Changes in flood velocity have been included in this letter (Annex B) and commented on in text above.

Review against relevant LEP and DCP sections

Table 1.5 of the peer review lists three comment/actions in relation to a review of the flood study against the LEP and DCP. These comments are provided in Table 1.2 below along with a BMT response.

Table 1.2 Peer Review Comments on Review against Relevant LEP and DCP Sections

Item	Report/Section	Comment/Actions
1	Flood Study / General	The development consent must not be granted as it does not meet LEP Clause 5.21. (2-b) and (2-c). As also discussed in Section 4.2.1, the modelled options adversely affect other properties by increasing flood level. These options also have an impact on the Yamba Road and the proposed Yamba Bypass. Therefore, they adversely affect safe evacuation of people relying on these roads. ***BMT Response*** This letter expands the presentation of flood impacts to cover additional (larger) flood events and to include changes in peak flood velocity, hazard and duration in addition to level. Overall, the impacts are considered minor except at a limited number of identified dwellings, and for which all but one are inundated in the equivalent Base Case simulation. The impacts do not result in any notable change to velocity or flood hazard categorisation along Yamba Road.
2	Flood Study / General	LEP Clause 5.21 objective 1-b and Clause 3-a requires taking into account projected changes as a result of climate change and enabling the safe occupation and efficient evacuation of people in the event of a flood. The flood study does not provide assessment of climate change impacts or evacuation plans for the development area. Consideration needs to be given to the flood emergency evacuation plan for the new developments as the main access roads to the development are

Item	Report/Section	Comment/Actions
		inundated in small sections for the 20% AEP event. The houses are above 1% AEP but the area becomes an island for events over 20% AEP. If a flood higher than the 1% AEP event occurs any people remaining in this area may be at high risk. Noted that Part X of the DCP Natural and environmental hazards states that at an accessible refuge area must be provided above the PMF at 3.8 mAHD. The management of this risk needs to be explicitly addressed in the development application, including addressing Schedule D4 of the DCP. ***BMT Response*** The assessment has been expanded to include an assessment of the 1 in 100 AEP event with a 10% increase in rainfall. This rainfall increase was applied for climate change simulations in the 2013 flood study update. The 1 in 100 AEP storm tide applied in the model has a peak of 2.6mAHD. This is widely regarded to be a highly conservative value and the Yamba Floodplain Risk Management Study notes that it could be argued that this boundary already includes a component that could allow for a climate change increase. Furthermore, preliminary storm tide levels being developed for council as part of their coastal management program indicate a year 2100 storm tide peak level of 2.43mAHD under the more severe RCP8.5 emissions scenario. The climate change simulation for the West Yamba assessment has therefore retained the conservative storm tide boundary of 2.6mAHD and applied a 10% increase in rainfall. An evacuation assessment was beyond the scope of the BMT assessment. However, it is noted that there are no notable changes to the flood hazard categorisation from the Base Case under Options 1 and 2 for any modelled event except for locations such as within the floodway.
3	Flood Study / General	LEP Clause 7.4. objectives are to (a) "…enable evacuation of land subject to flooding in events exceeding the flood planning level", and (b) "to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events". This clause applied to land between the flood planning area and the line indicating the level of the probable maximum flood and land surrounded by the flood planning area. The clause restricts certain developments on land to which this clause applies. Given that no flood modelling is conducted for storm events rarer than 1% AEP, the flood study does not investigate if the conditions of this clause are satisfied. ***BMT Response*** A flood evacuation assessment was outside the scope of BMT's report. The flood modelling has now considered a 1 in 500 AEP event which shows no notable change to the flood hazard categorisation outside of the floodway. For all events modelled, up to an including the 1 in 500 AEP event, there are no notable changes in flood level, velocity, hazard or duration which are considered to be significant enough to have impact on existing flood evacuation.

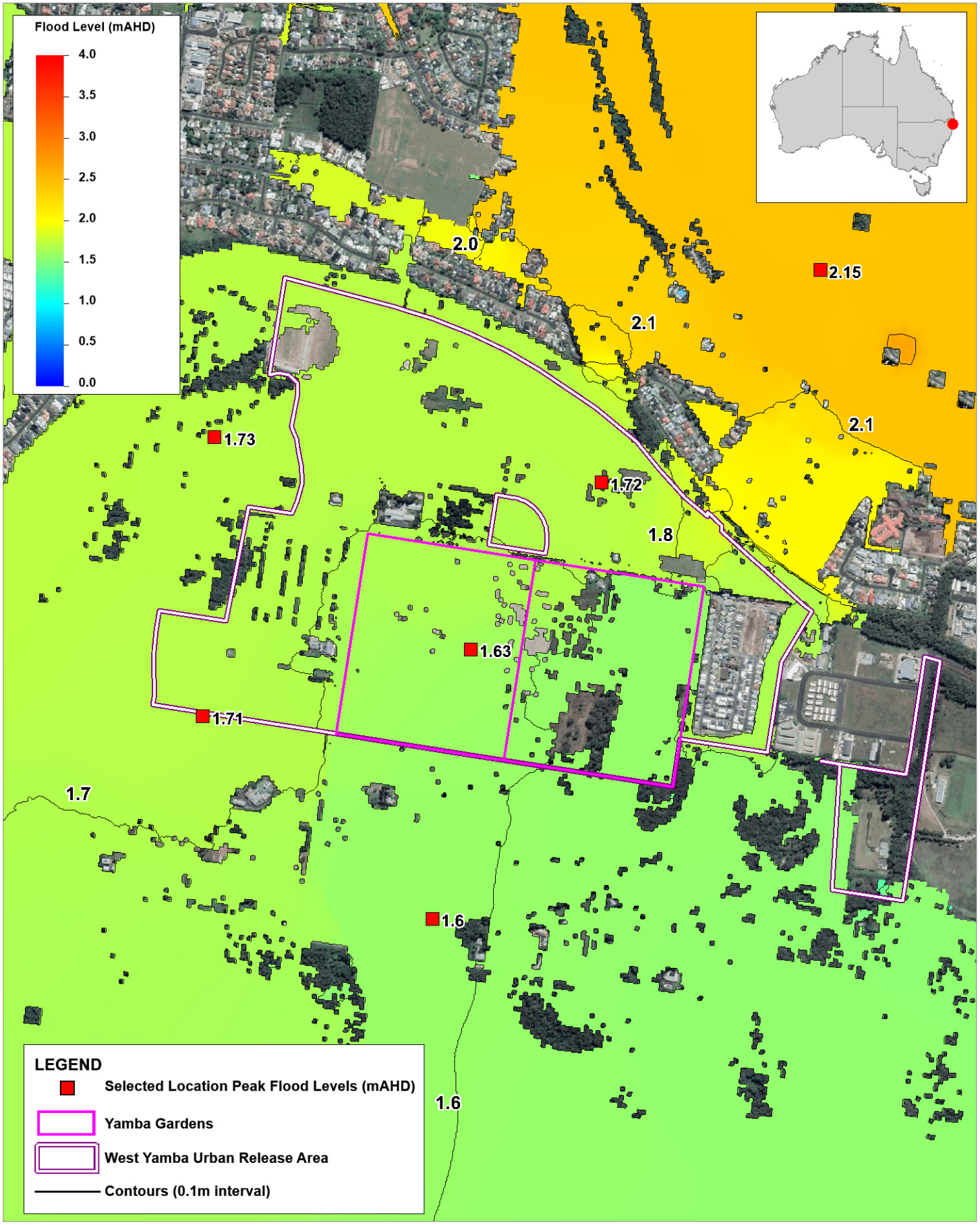
Conclusions

BMT has responded to all comments/actions raised in the WMAwater peer review in relation to the BMT FIA. A substantial amount of additional information has been presented in this letter to further assess the potential for flood impacts, including for larger flood events than previously assessed. It is considered that all peer review comments in relation to the BMT FIA have been addressed.

Yours Faithfully

Barry Rodgers
Principal (Flooding)
BMT

Annex A Additional Peak Flood Level and Peak Flood Level Impacts



Title:

1 in 50 AEP Base Case Peak Flood Elevations

Figure: A-1

Rev: A

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Approx.Scale

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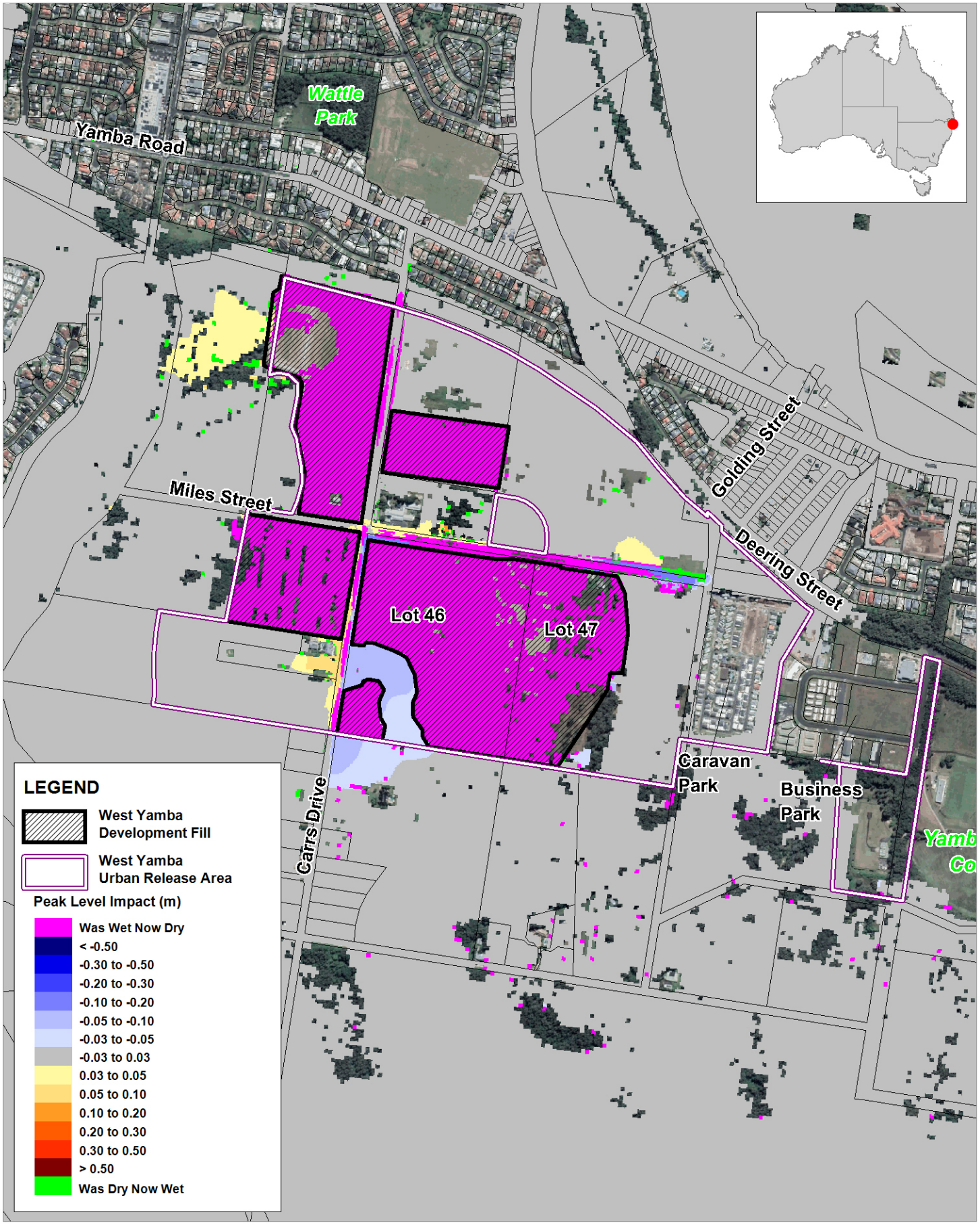

Title:

Model Scenario 'Option 1' - 1 in 50 AEP Peak Flood Level Impact

Figure: A-2

Rev: A

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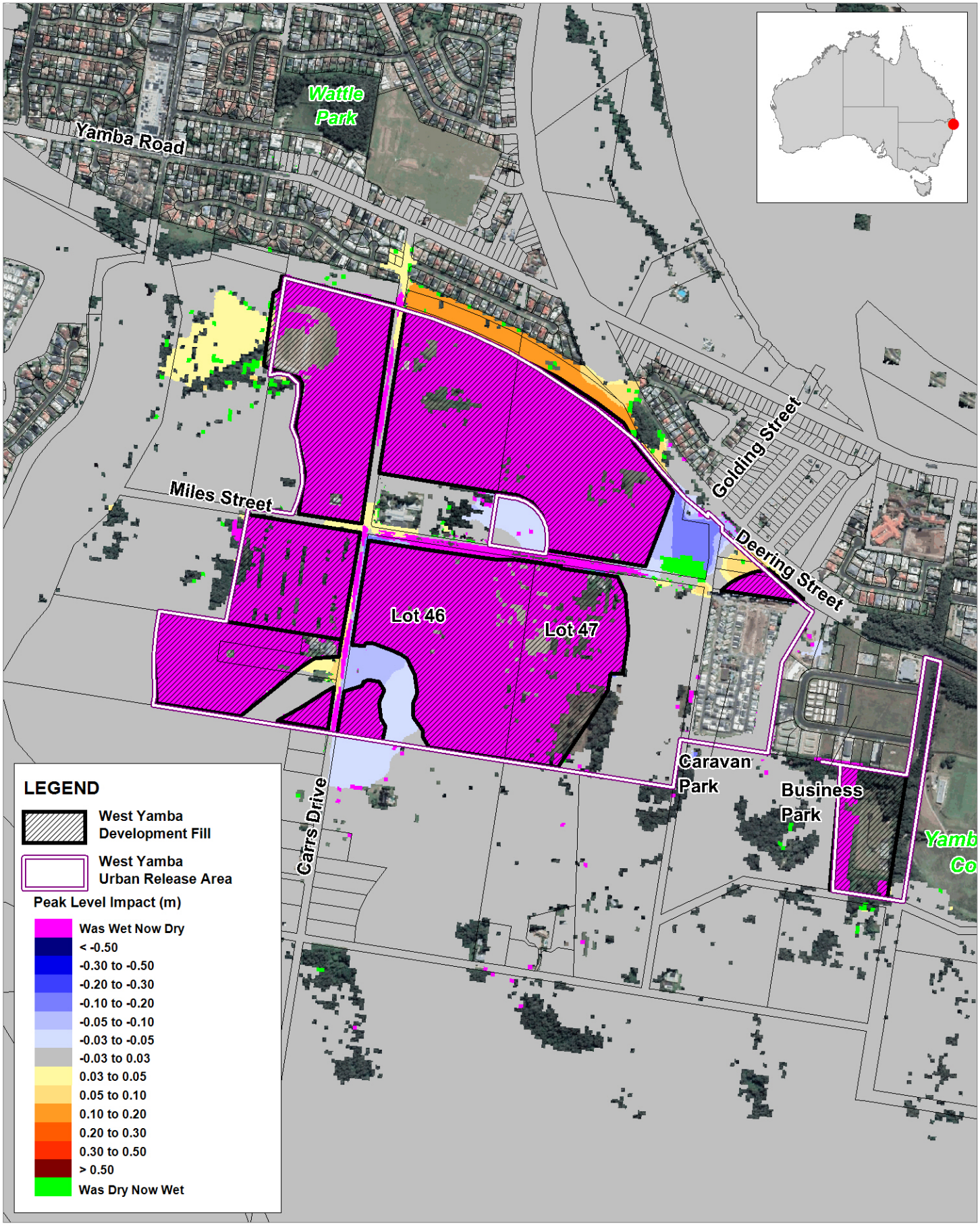

Title:

Model Scenario 'Option 2' - 1 in 50 AEP Peak Flood Level Impact

Figure: A-3

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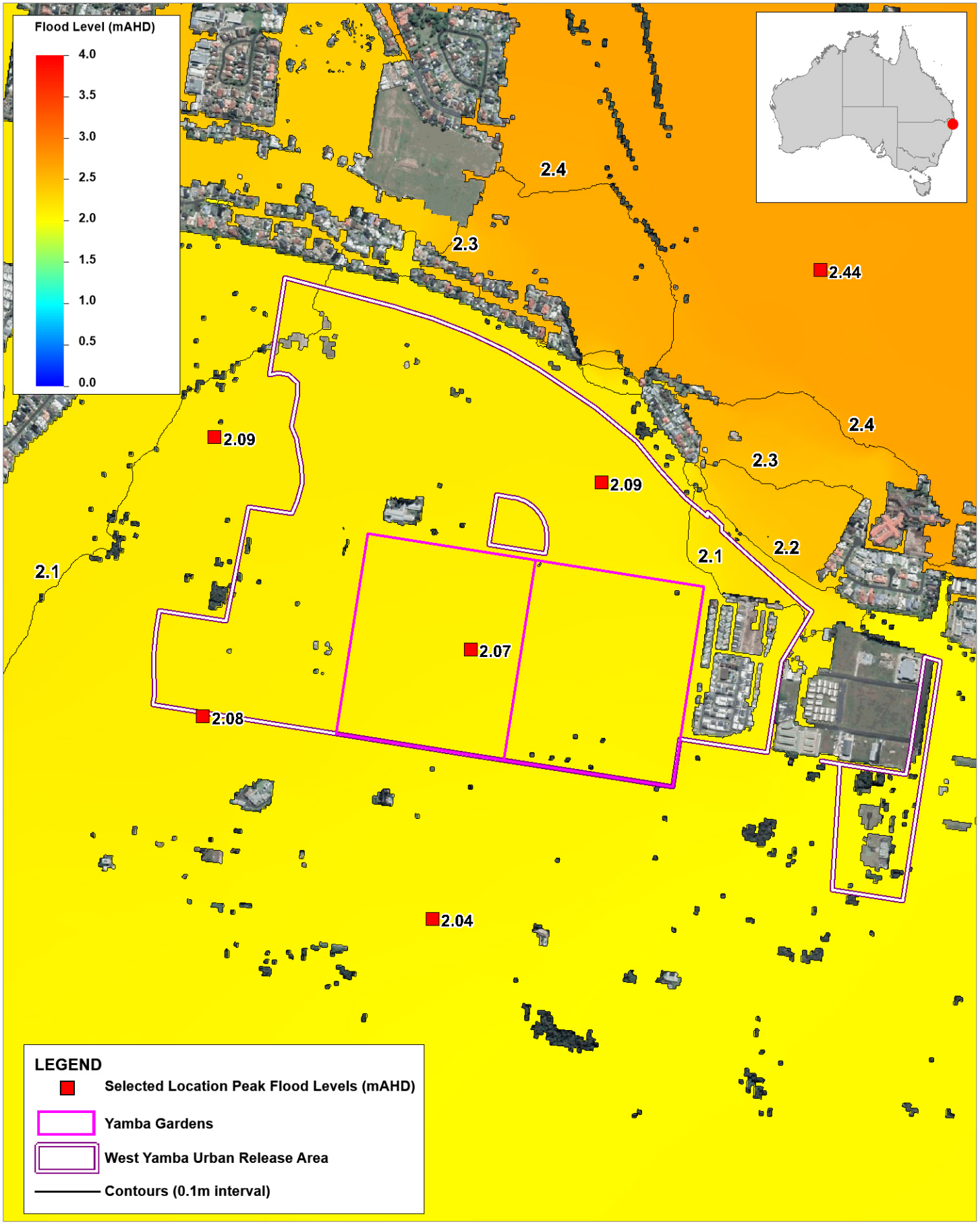

Title:

1 in 500 AEP Base Case Peak Flood Elevations

Figure: A-4

Rev: A

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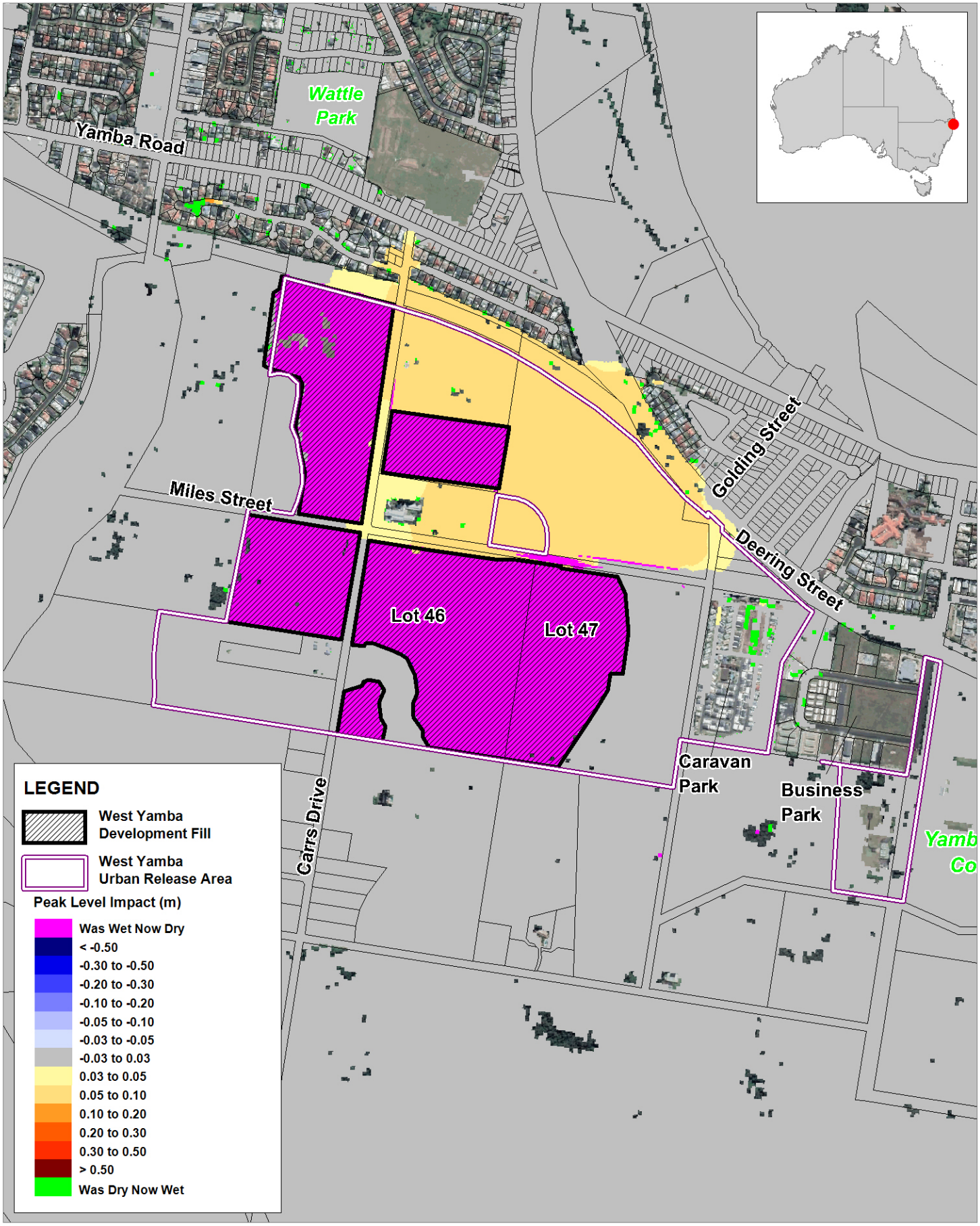

Title:

Model Scenario 'Option 1' - 1 in 500 AEP Peak Flood Level Impact

Figure: A-5

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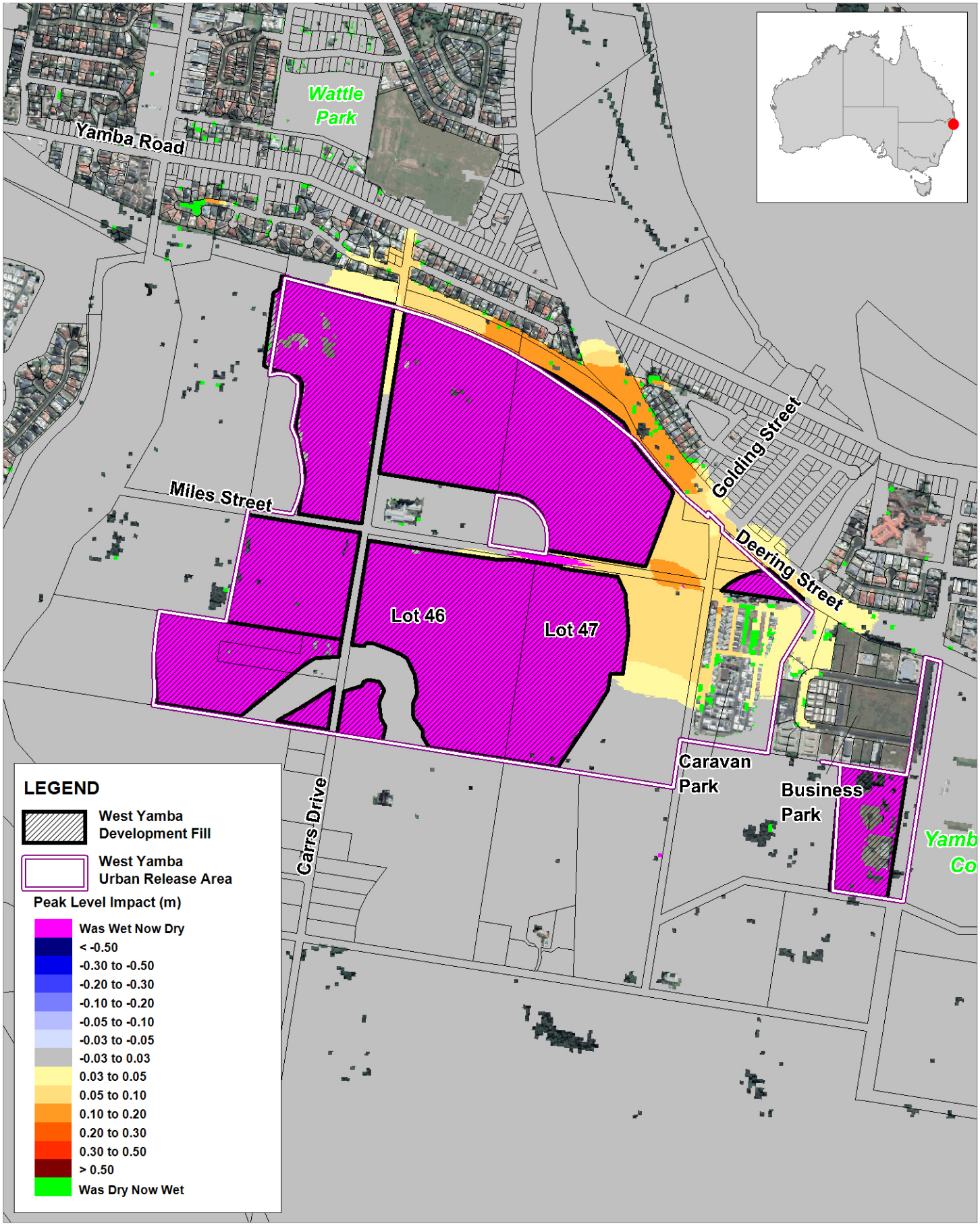

Title:

Model Scenario 'Option 2' - 1 in 500 AEP Peak Flood Level Impact

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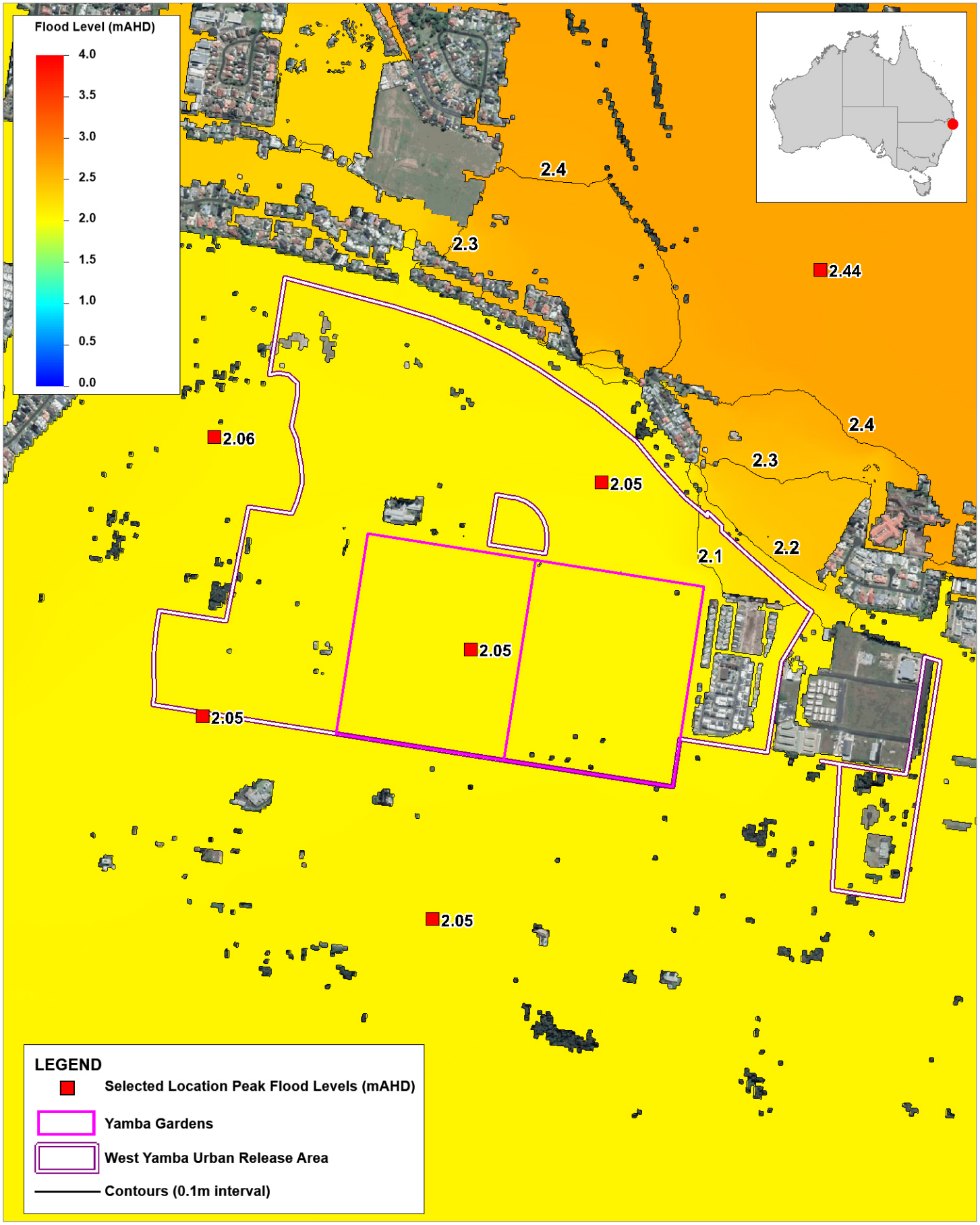

Title:

1 in 100CC AEP Base Case Peak Flood Elevations

Figure: A-7

Rev: A

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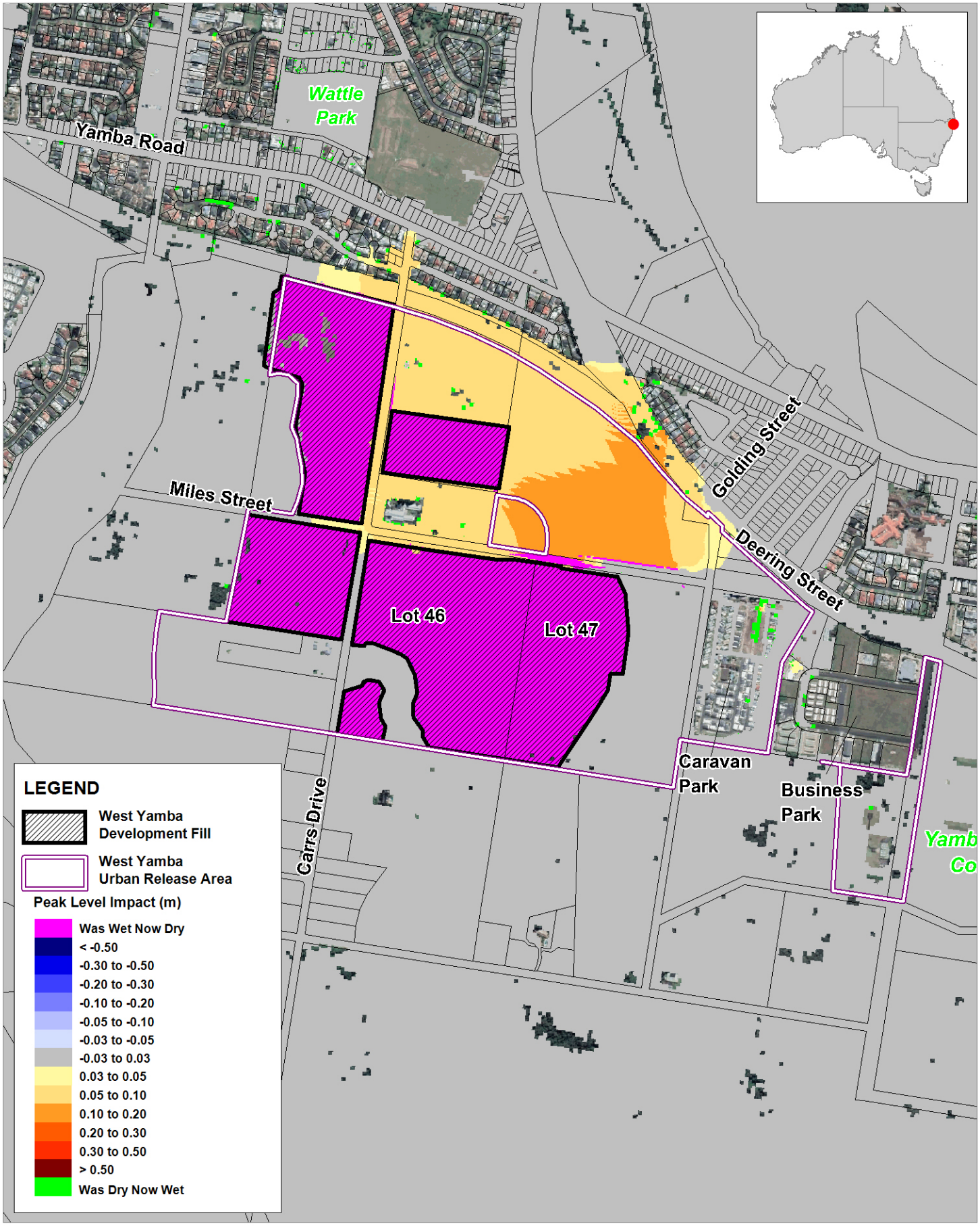

Title:

Model Scenario 'Option 1' - 1 in 100CC AEP Peak Flood Level Impact

Figure: A-8

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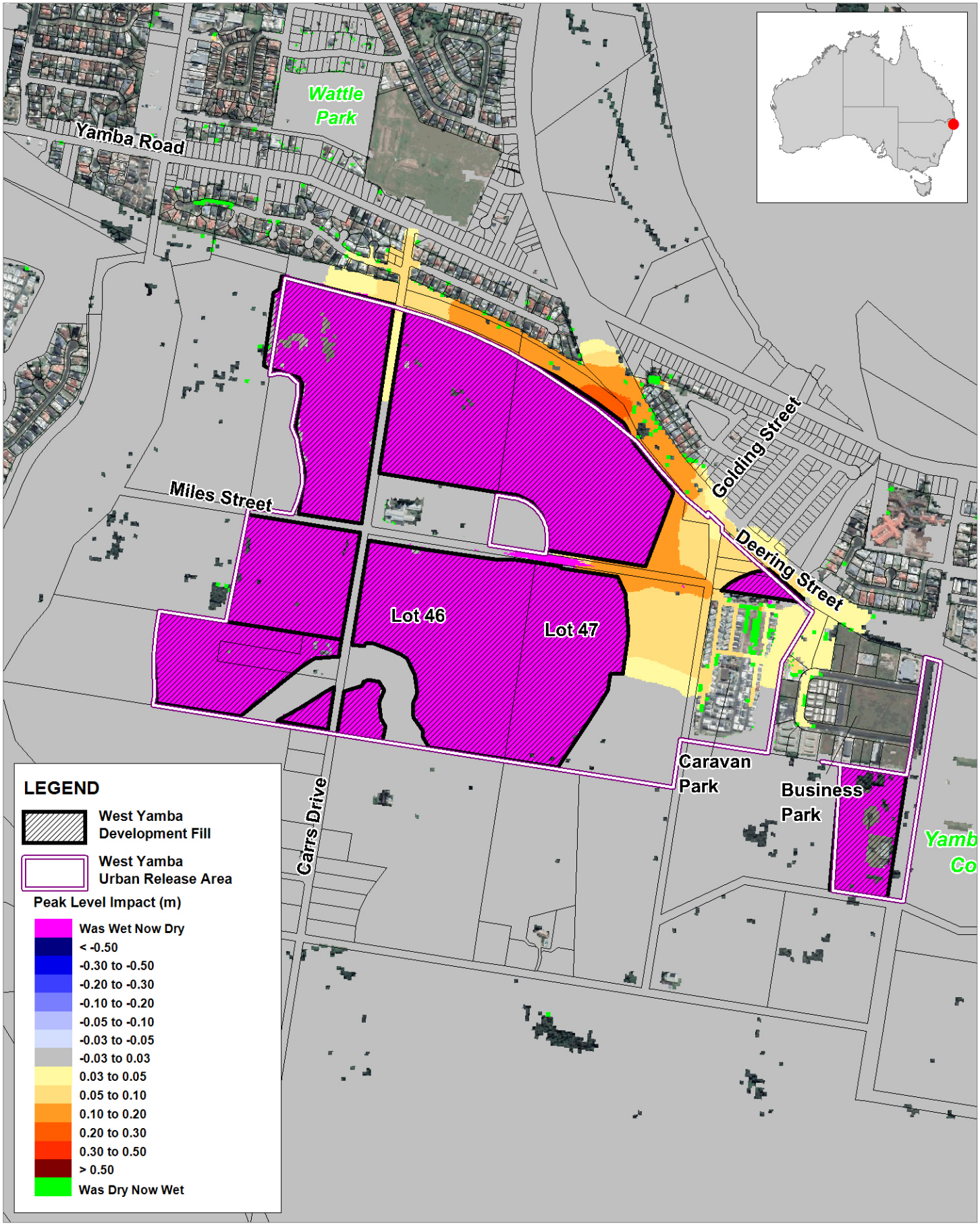

Title:

Model Scenario 'Option 2' - 1 in 100CC AEP Peak Flood Level Impact

Figure: A-9

Rev: A

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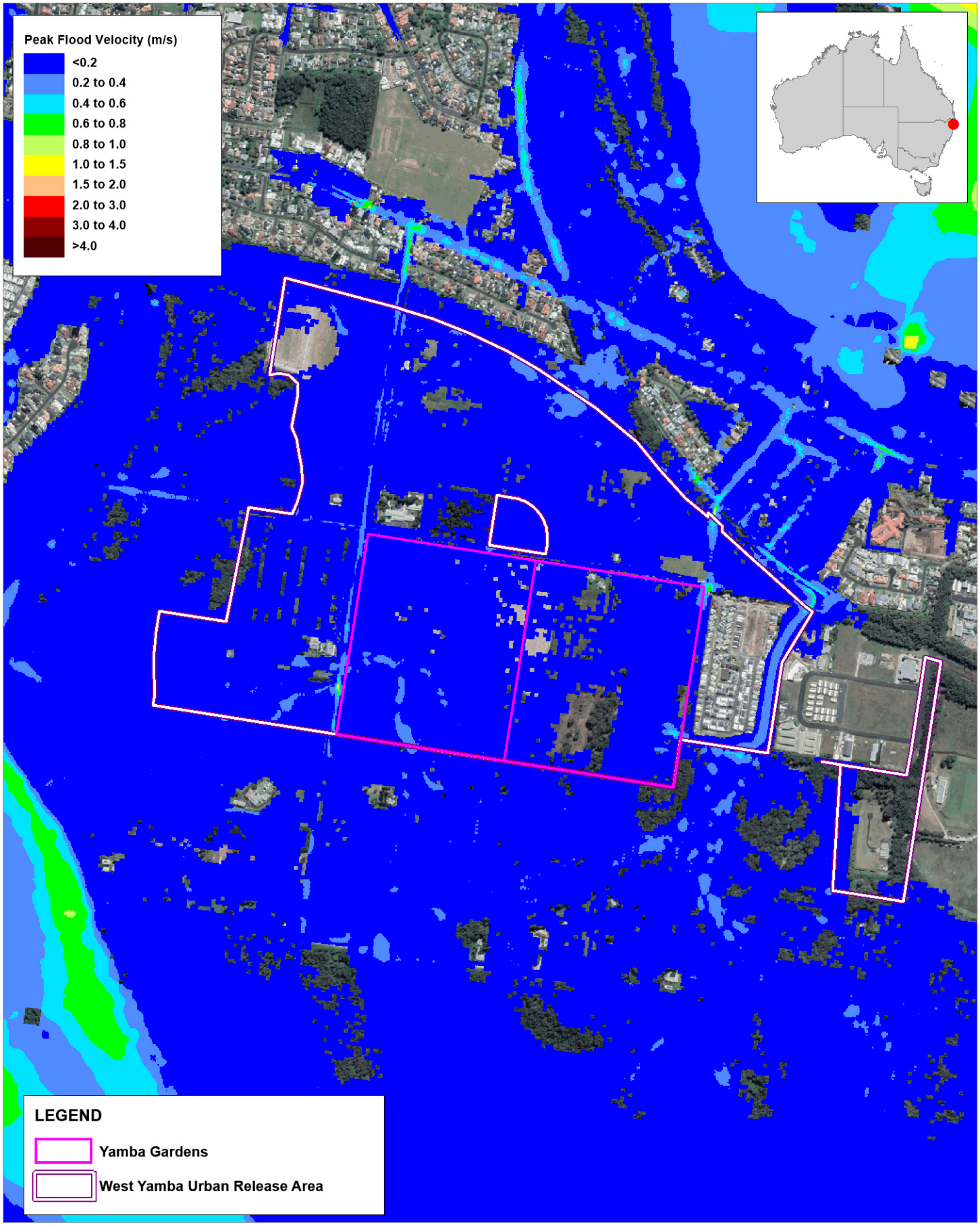
Annex B Peak Flood Velocity and Peak Flood Velocity Impacts



Title:

1 in 50 AEP Base Case Peak Flood Velocity

Figure: **B-1**

Rev: **A**

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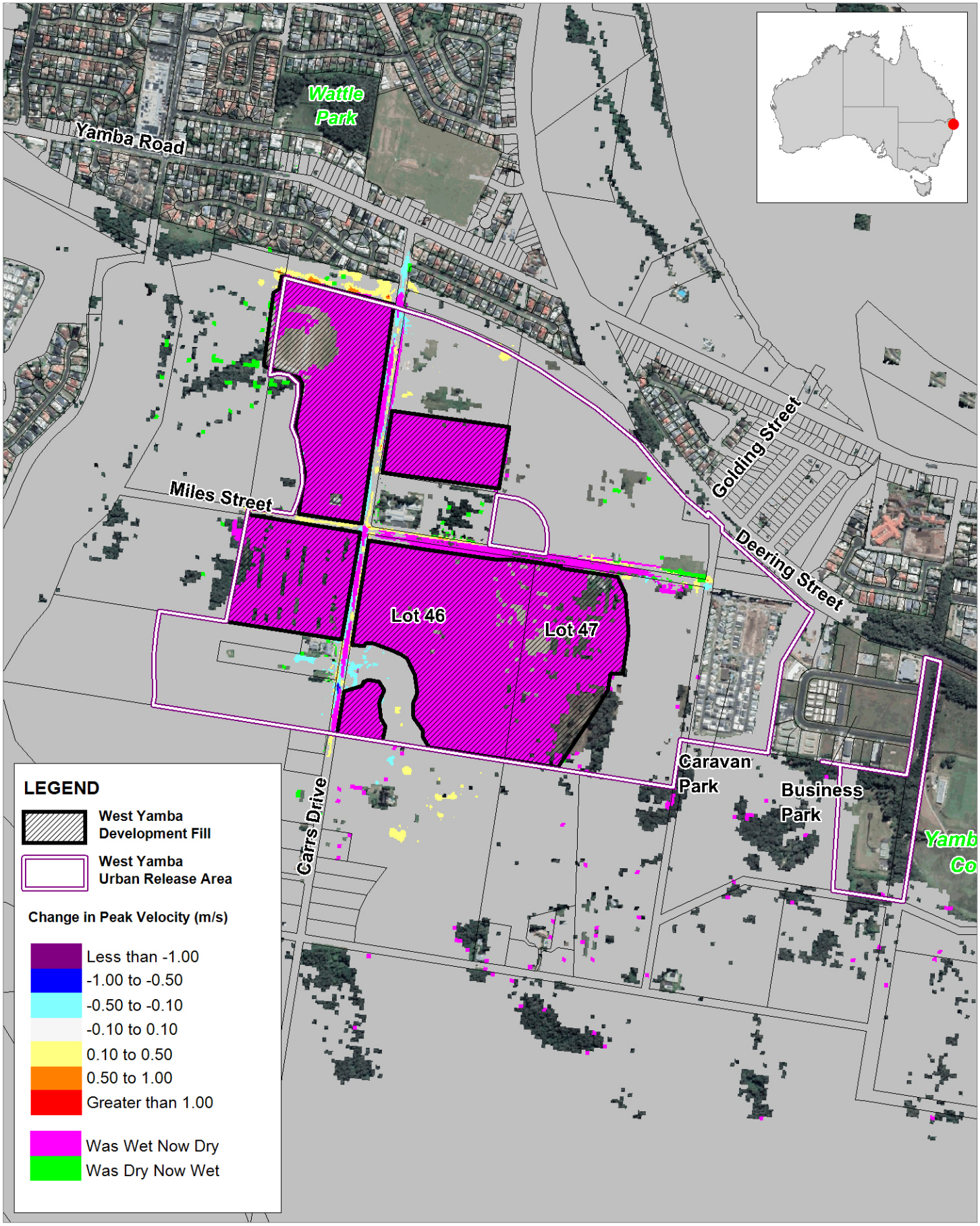

Title:

Model Scenario 'Option 1' - 1 in 50 AEP Peak Flood Velocity Impact

Figure: B-2

Rev: A

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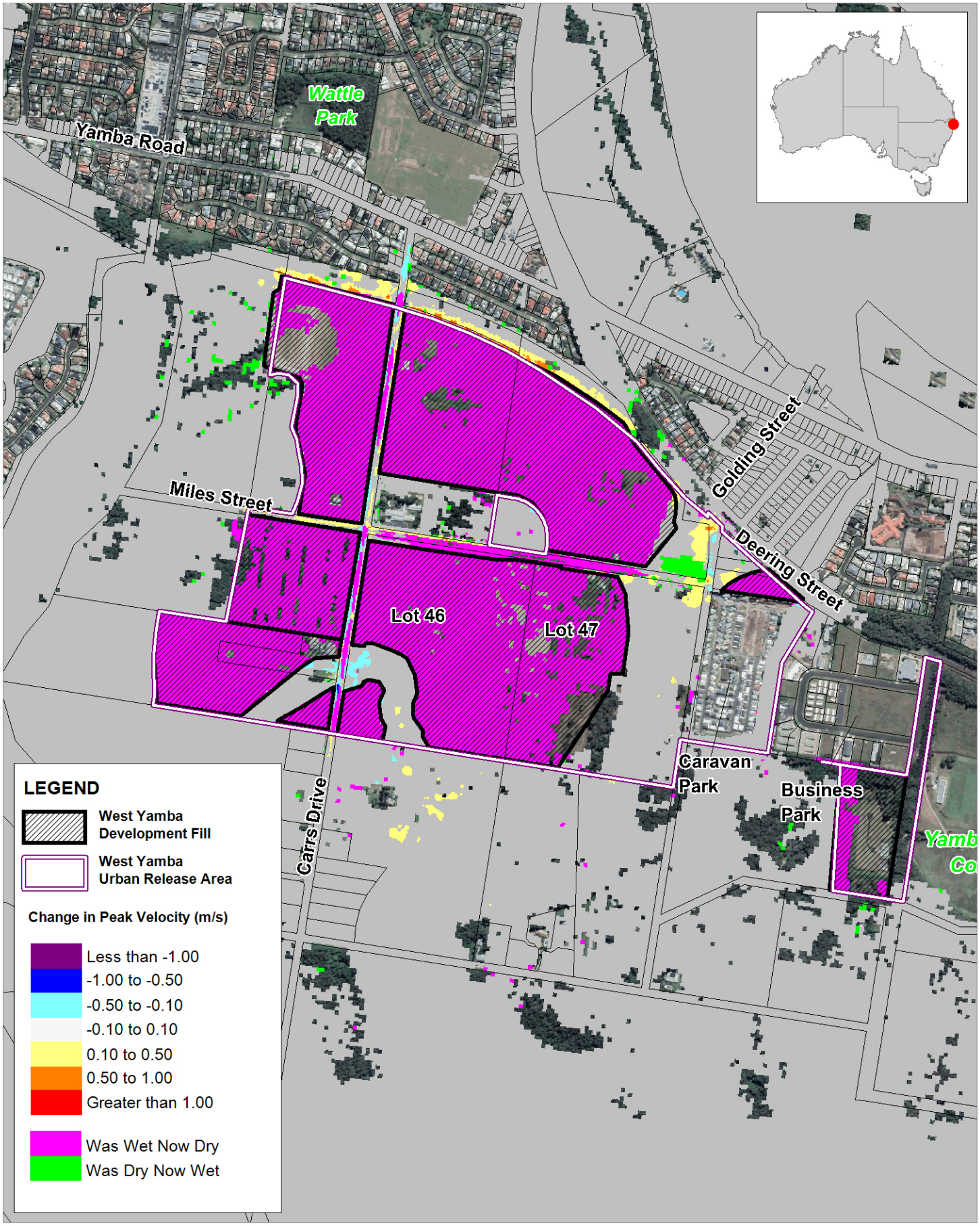

Title:

Model Scenario 'Option 2' - 1 in 50 AEP Peak Flood Velocity Impact

Figure: B-3

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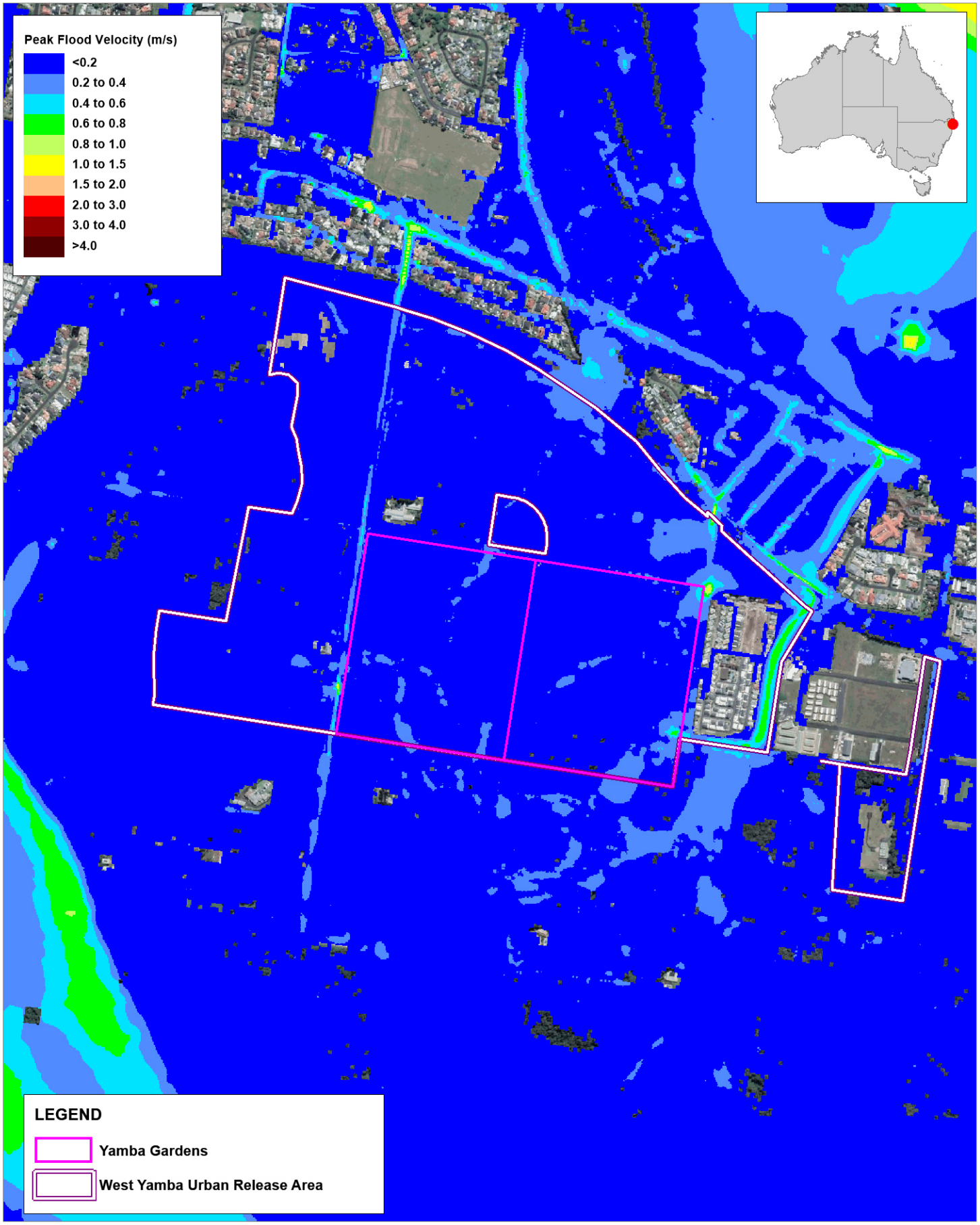

Title:

1 in 100 AEP Base Case Peak Flood Velocity

Figure: **B-4**

Rev: **A**

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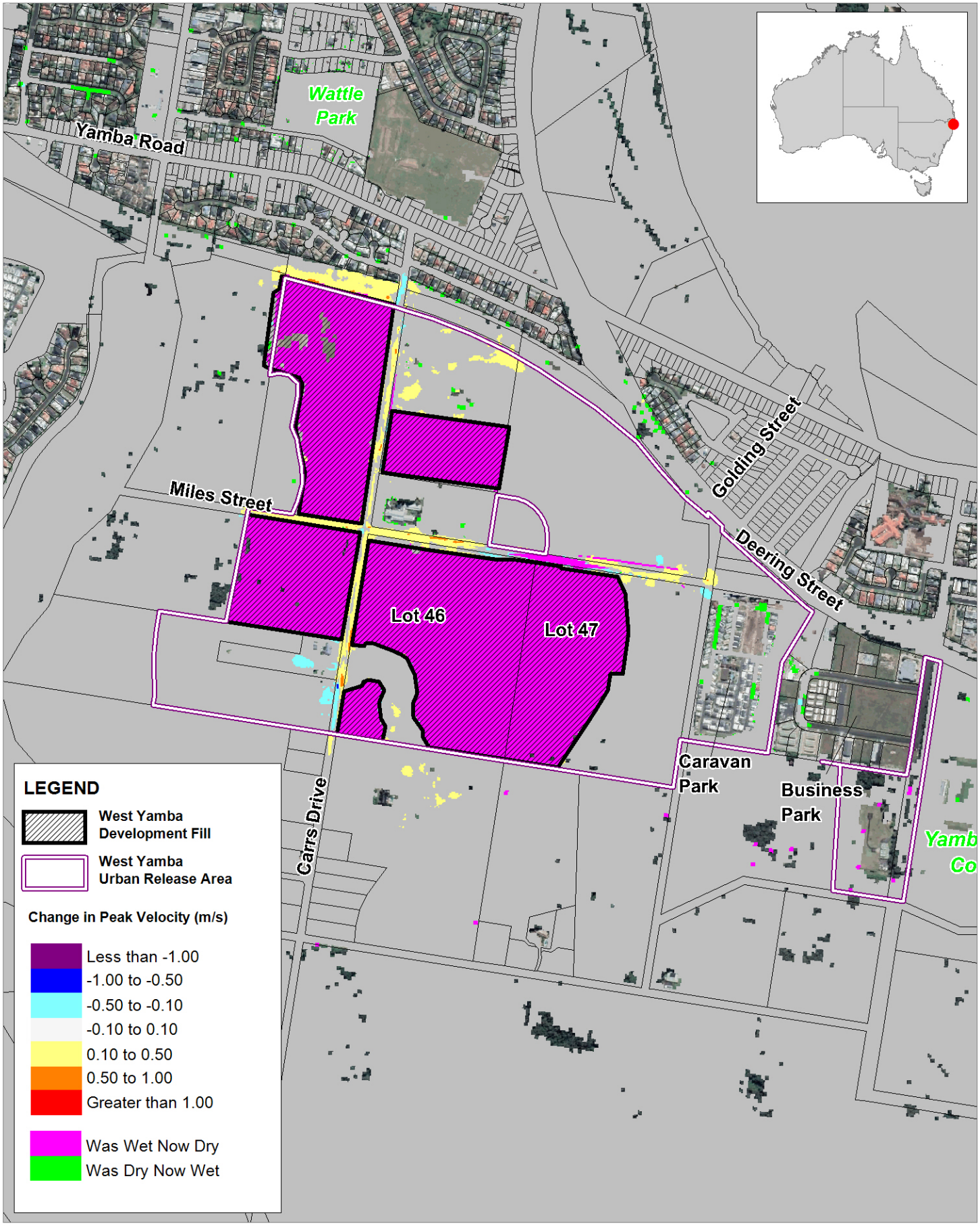

Title:

Model Scenario 'Option 1' - 1 in 100 AEP Peak Flood Velocity Impact

Figure: B-5

Rev: A

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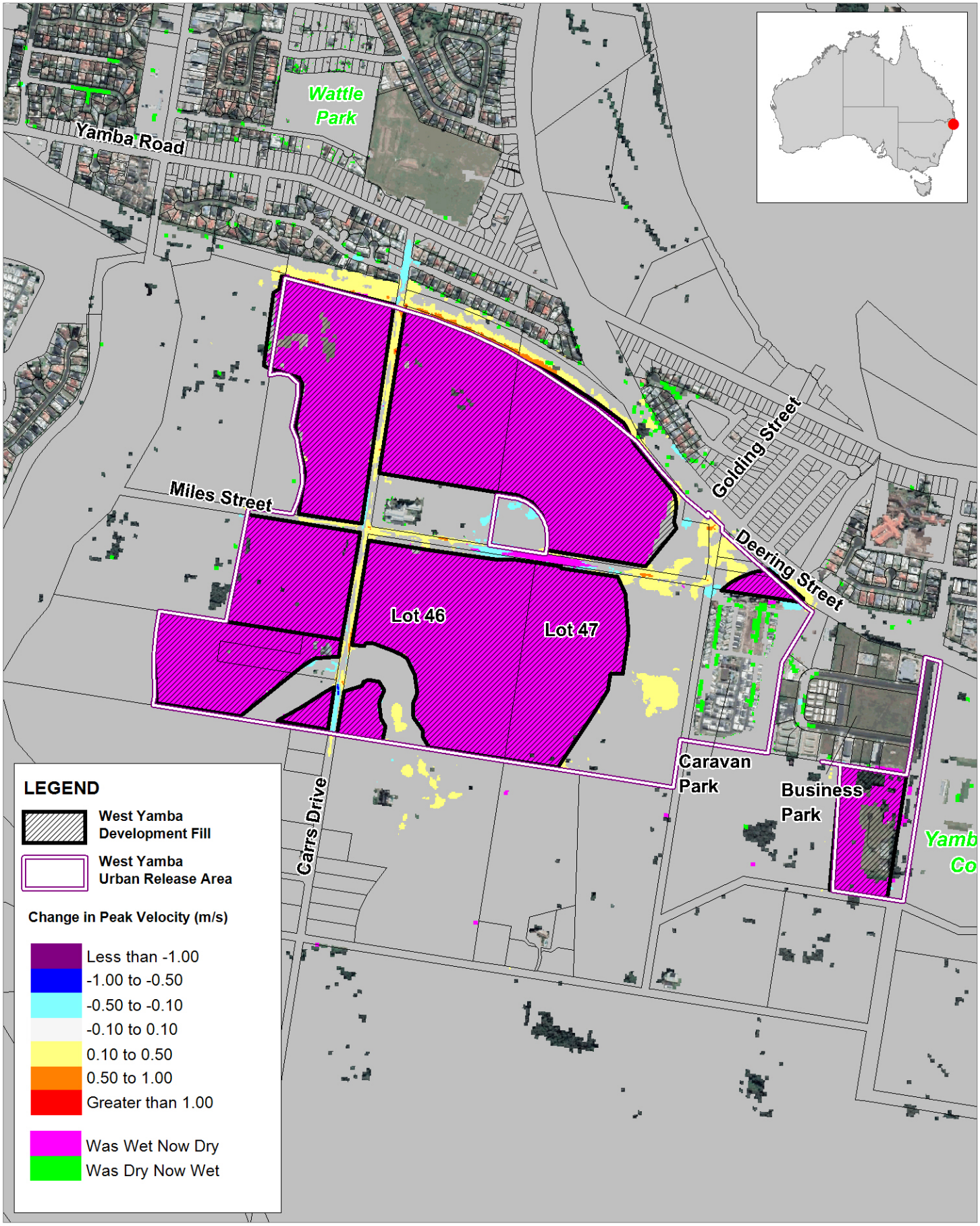

Title:

Model Scenario 'Option 2' - 1 in 100 AEP Peak Flood Velocity Impact

Figure: B-6

Rev: A

N

0 200 400m

Approx.Scale

BMT

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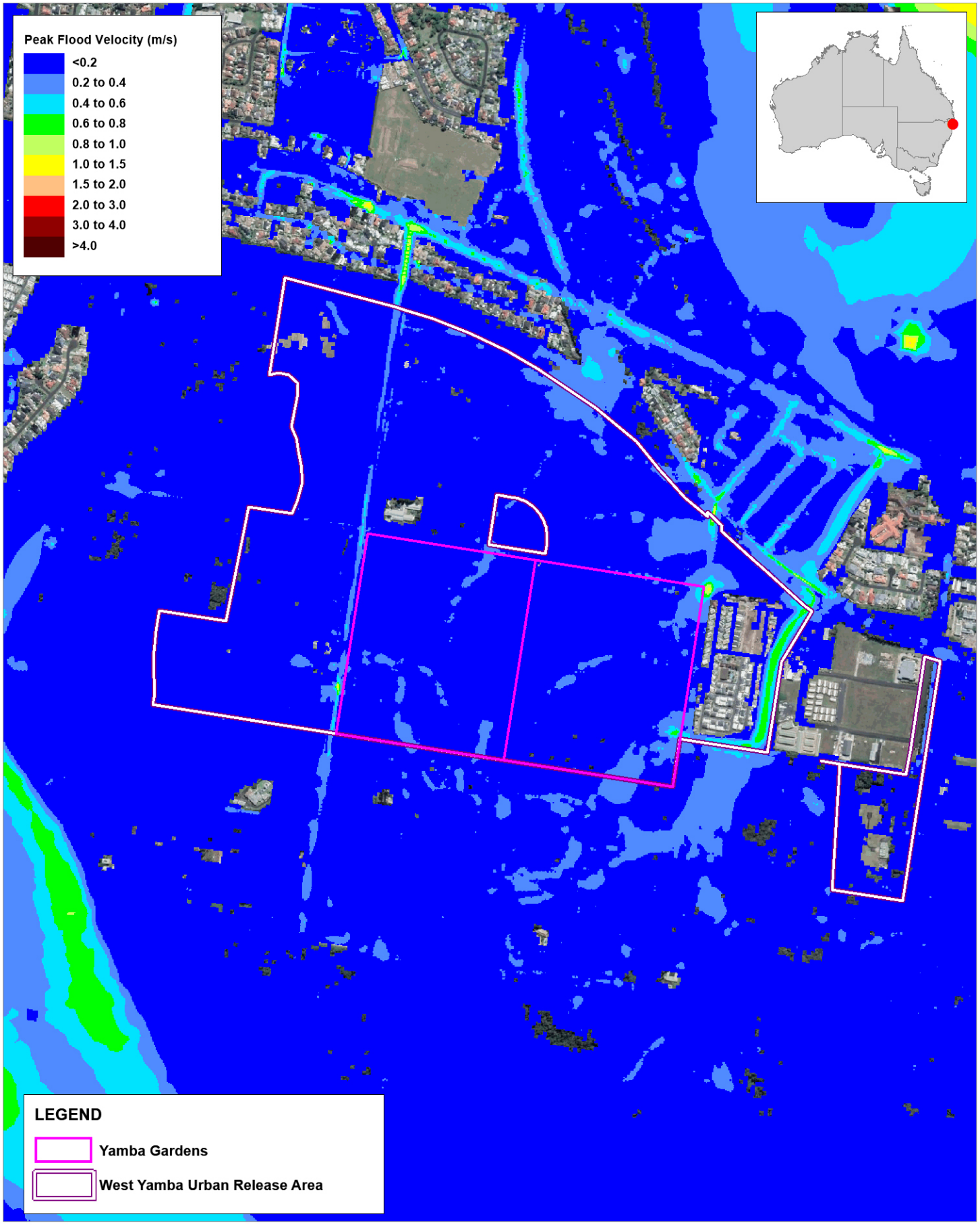

Title:

1 in 500 AEP Base Case Peak Flood Velocity

Figure: **B-7**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 200 400m

Approx.Scale

BMT

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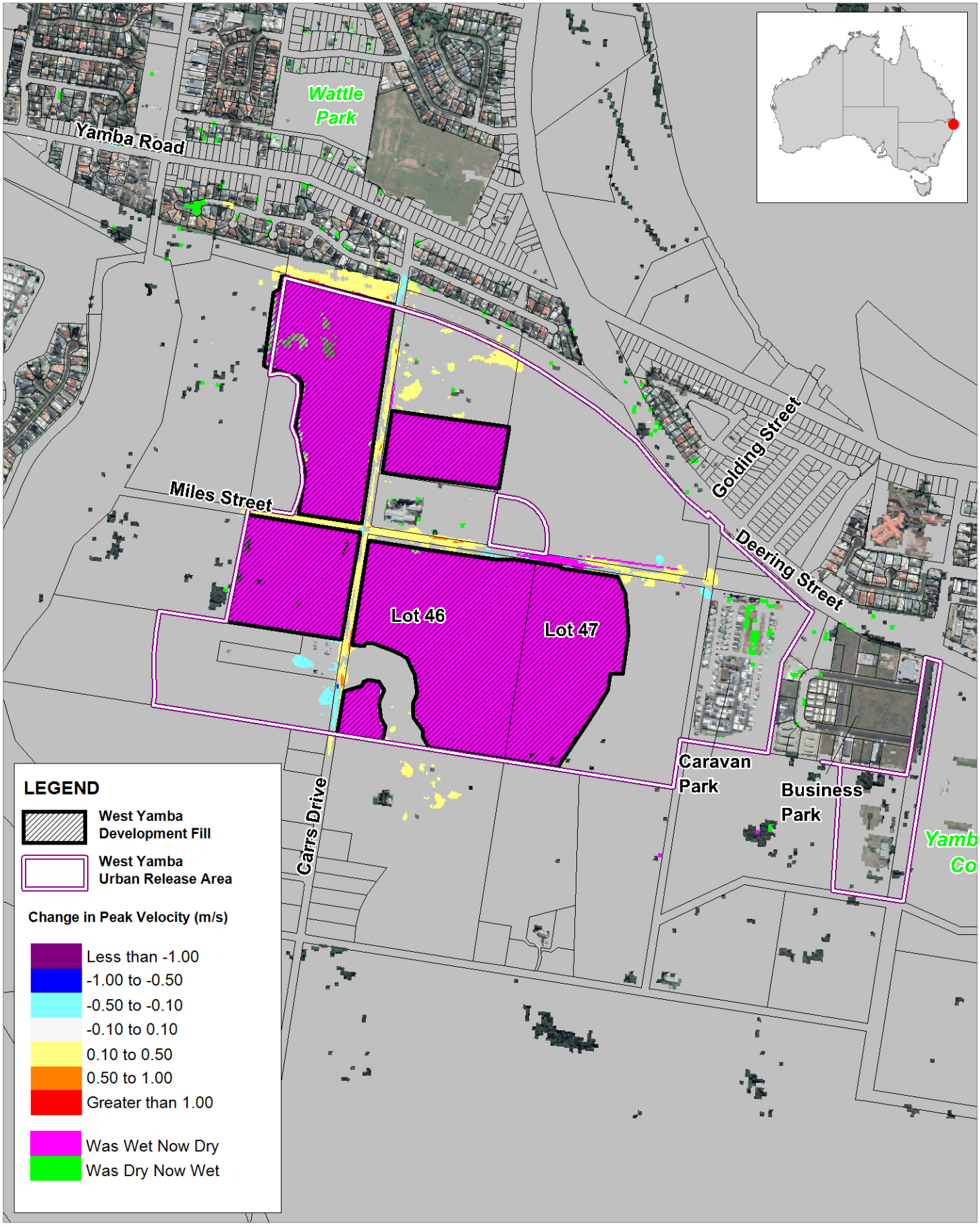
Filepath: "I:\A11309.i.br_West_Yamba\Drg\FLD_048_20221025_500yr_Base_Case_Velocity.wor"



Title:

Model Scenario 'Option 1' - 1 in 500 AEP Peak Flood Velocity Impact

Figure: B-8

Rev: A

N

0 200 400m

Approx.Scale

BMT

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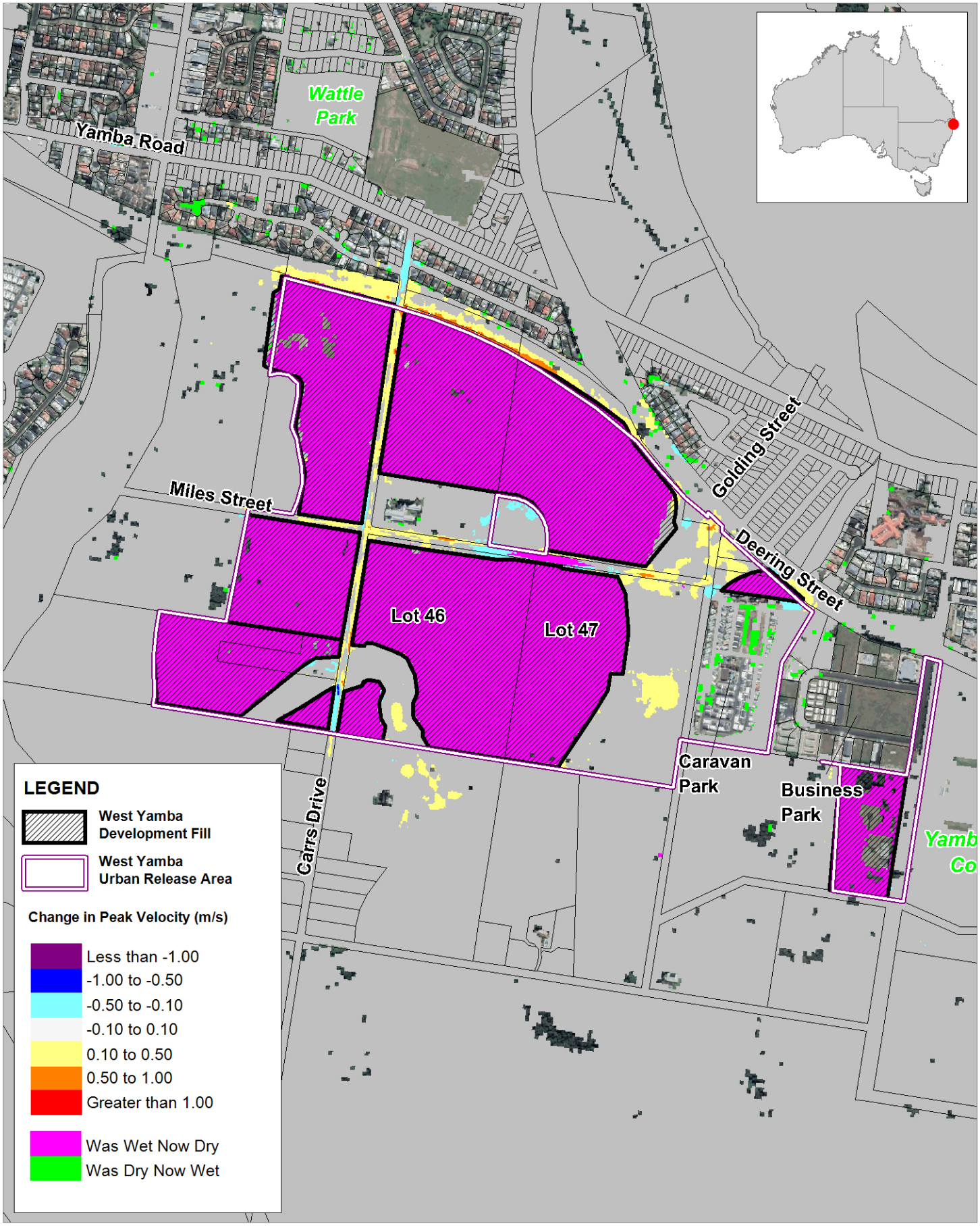

Title:

Model Scenario 'Option 2' - 1 in 500 AEP Peak Flood Velocity Impact

Figure: B-9

Rev: A

N

0 200 400m

Approx.Scale

BMT

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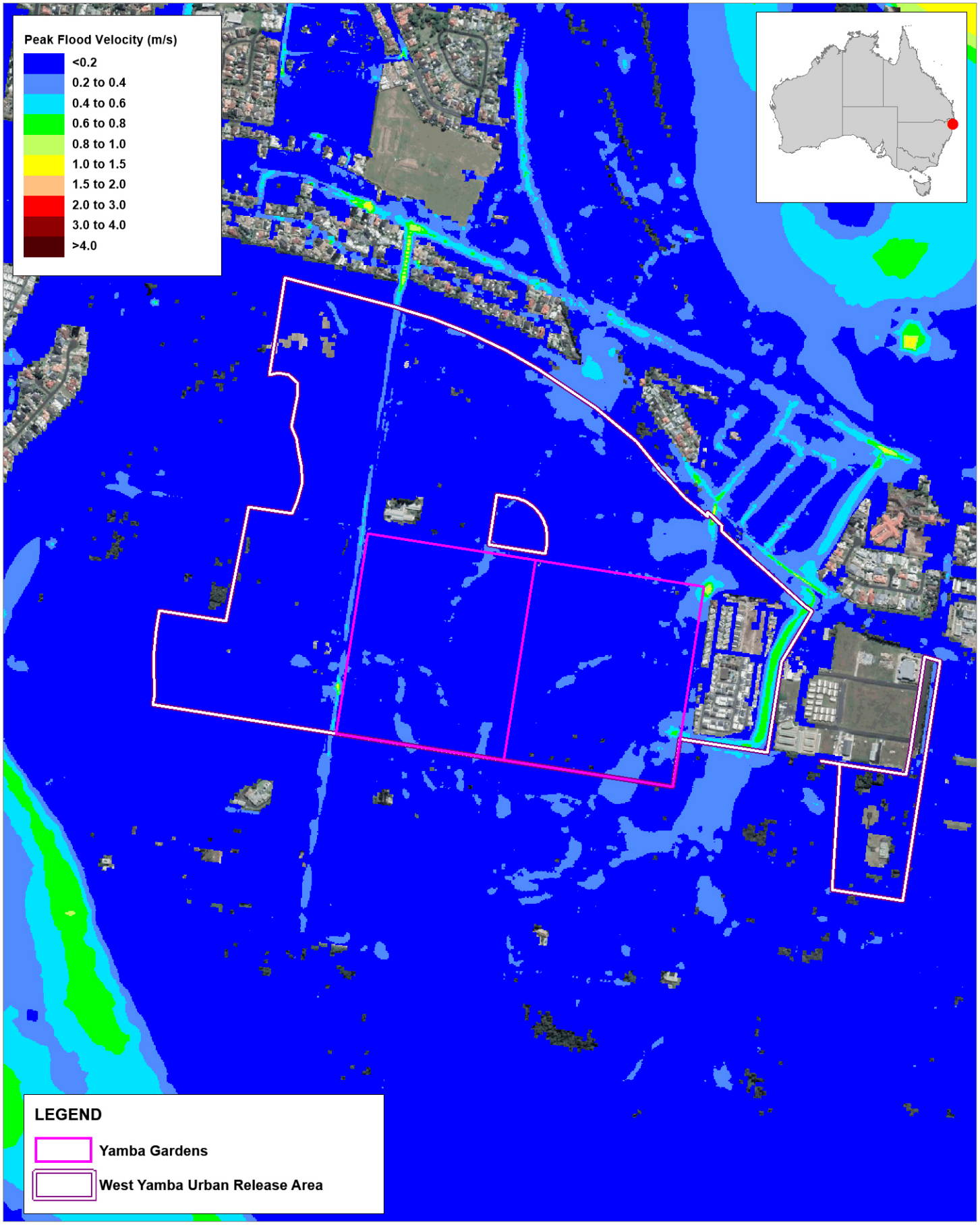
Filepath: "I:\A11309.i.br_West_Yamba\Drg\FLD_031_20221026_WY_dV_Opt2_Q500.wor"



Title:

1 in 100CC AEP Base Case Peak Flood Velocity

Figure: **B-10**

Rev: **A**

N

0 200 400m

Approx.Scale

BMT

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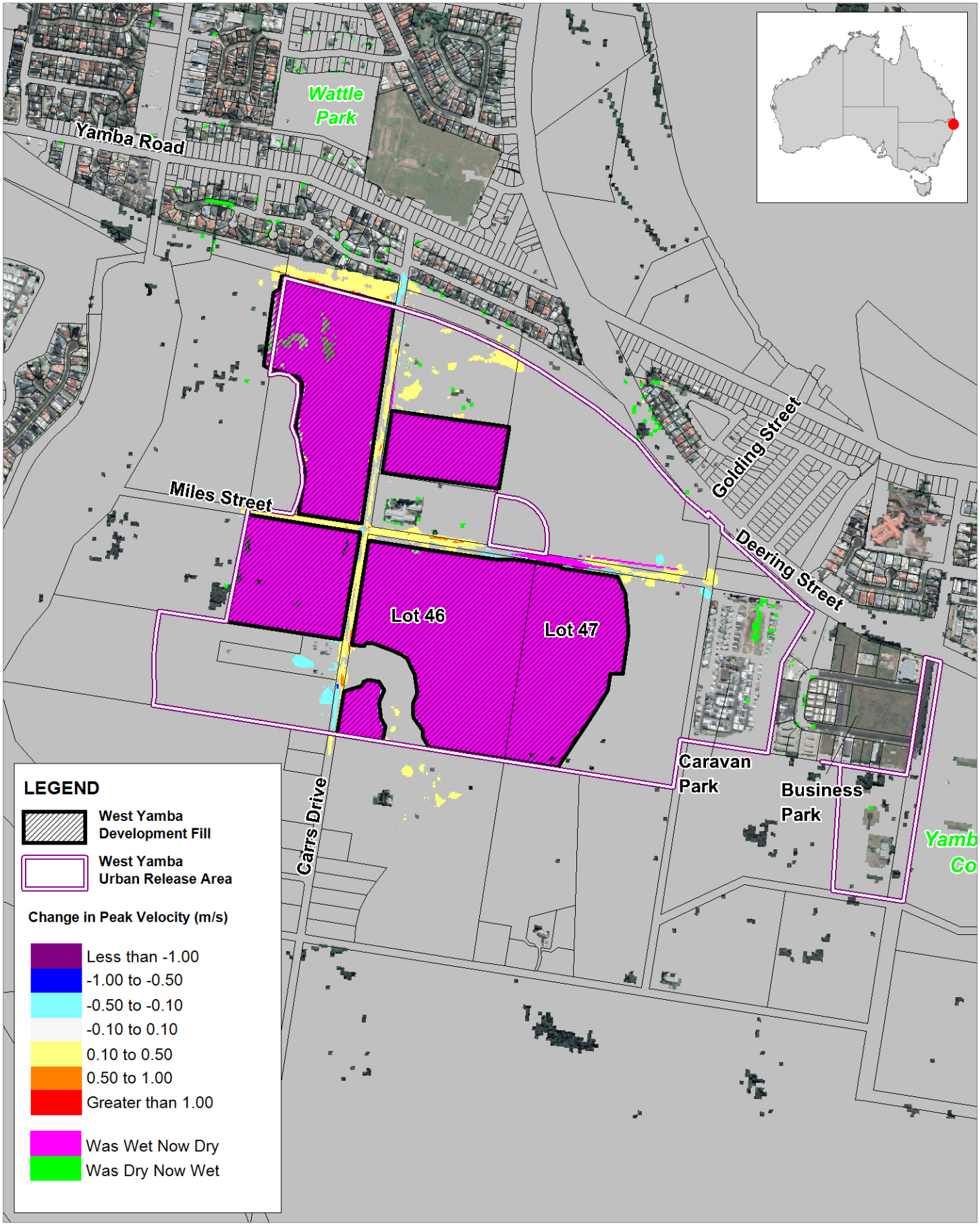
Filepath: "I:\A11309.i.br_West_Yamba\Drg\FLD_049_20221025_100CCyr_Base_Case_Velocity.wor"



Title:

Model Scenario 'Option 1' - 1 in 100CC AEP Peak Flood Velocity Impact

Figure: B-11

Rev: A

N

0 200 400m

Approx.Scale

BMT

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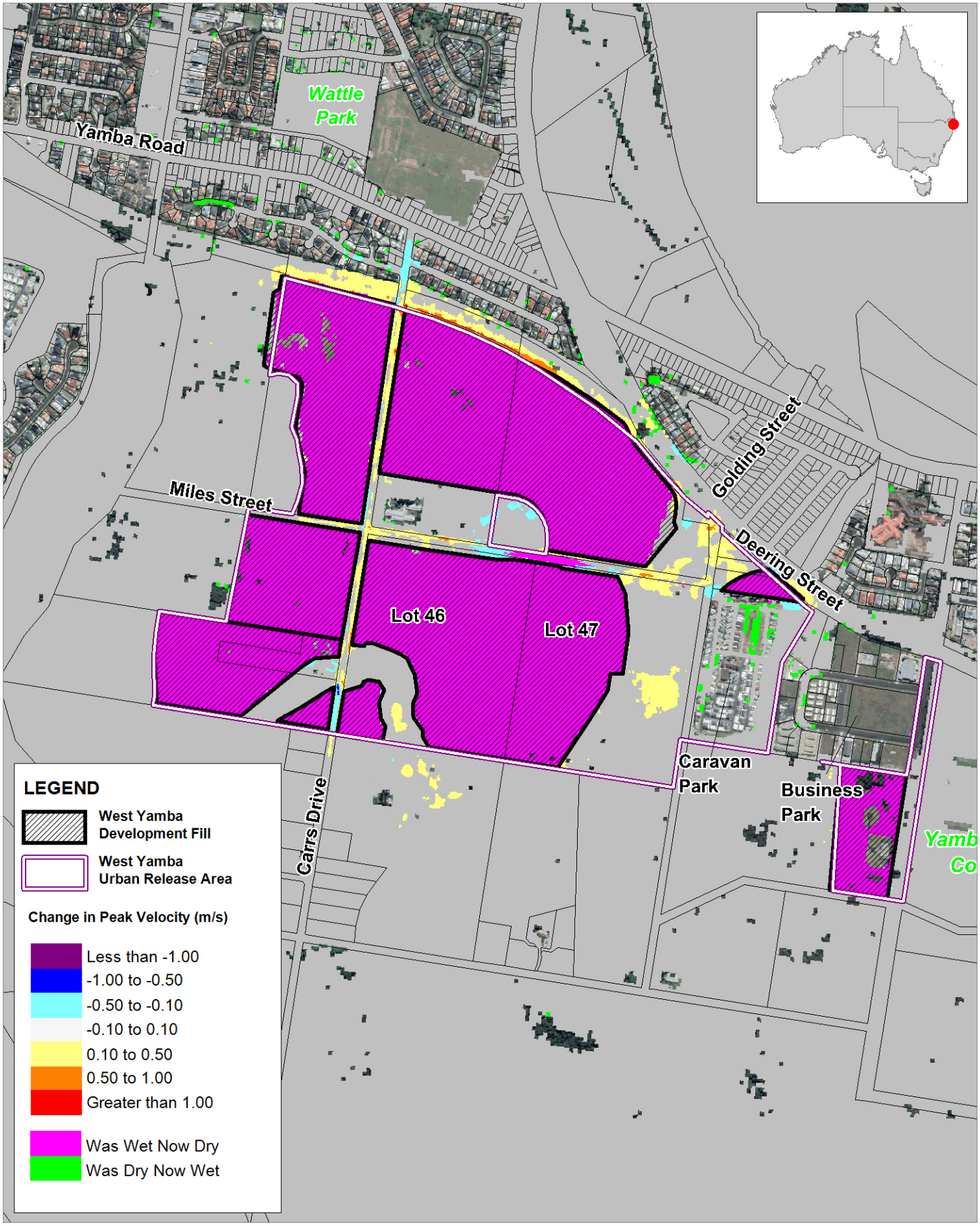

Title:

Model Scenario 'Option 2' - 1 in 100CC AEP Peak Flood Velocity Impact

Figure: B-12

Rev: A

N

0 200 400m

Approx.Scale

BMT

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Filepath: "I:\A11309.i.br_West_Yamba\Drg\FLD_037_20221026_WY_dV_Opt2_Q100CC.wor"

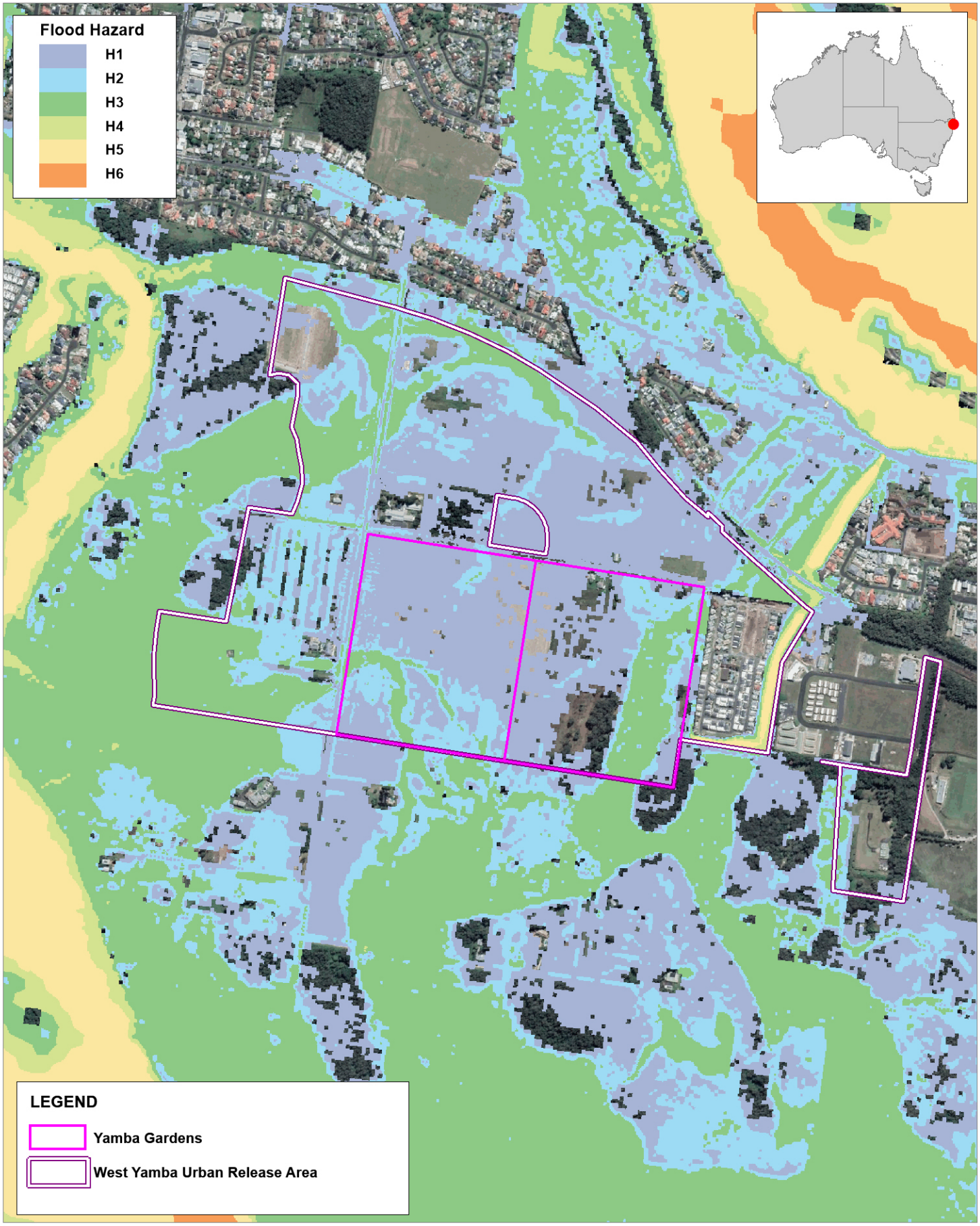
Annex C Peak Flood Hazard and Change in Peak Flood Hazard Category

Flood hazard output has been classified in accordance with general guidance from the Australian Institute for Disaster Resilience (AIDR, 2017)[8]. Six hazard vulnerability categories are defined based on different combinations of flood depth and velocity. The categories increase in severity from category H1 to H6. The combinations of depth and velocity that define the categories are shown below.

Table C.1. Hazard vulnerability thresholds

Hazard Classification	Description
H1	Generally safe for vehicles, people and buildings.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles, children and the elderly.
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

[8] Australian Institute of Disaster Resilience Handbook 7: managing the floodplain: best practice in flood risk management in Australia.



Title:

1 in 50 AEP Base Case Flood Hazard

Figure: C-1

Rev: A

N

0 200 400m

Approx.Scale

BMT

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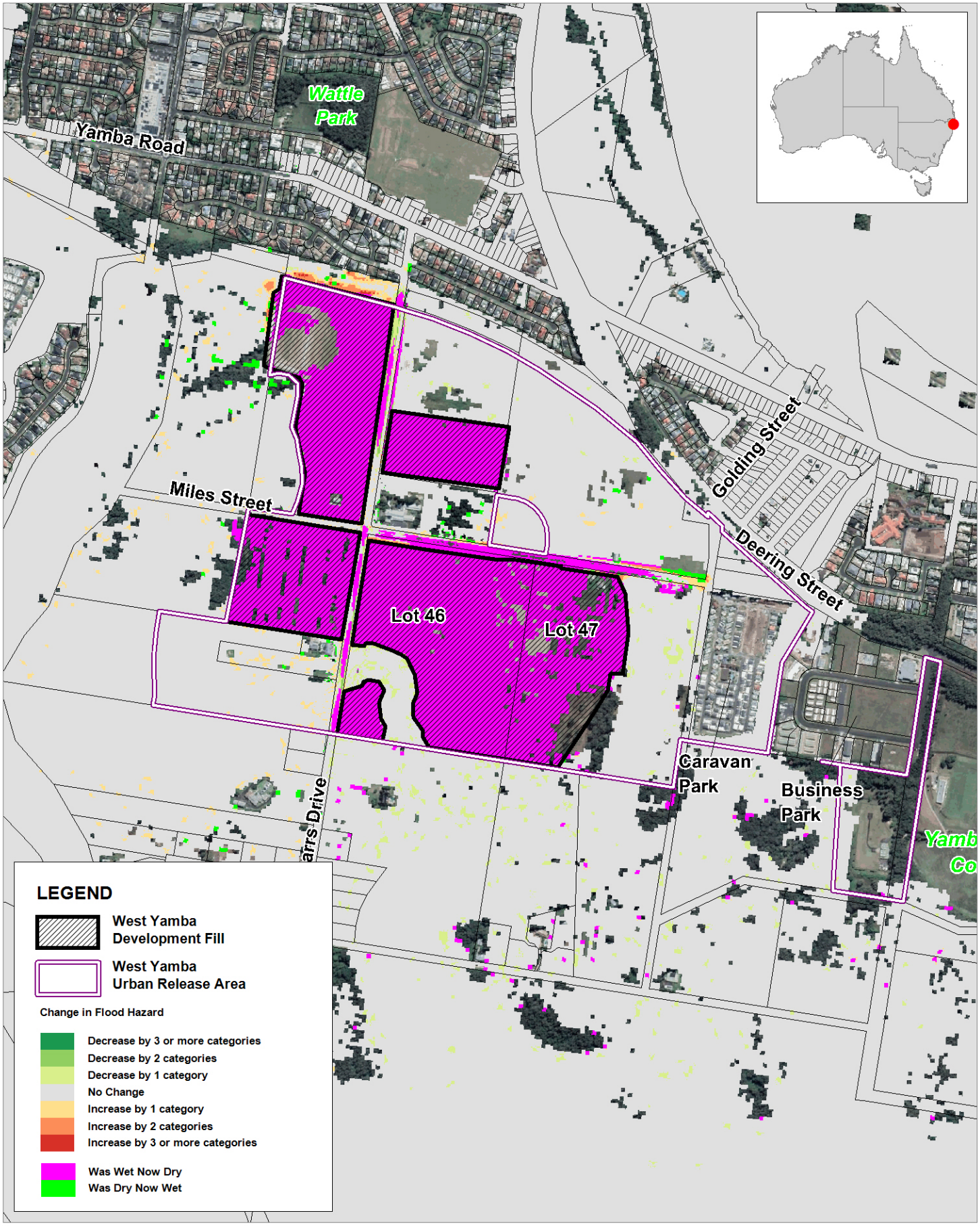
Filepath: "I:\A11309.i.br_West_Yamba\Drg\FLD_033_20221025_50yr_Base_Case_Hazard.wor"



Title:

Model Scenario 'Option 1' - 1 in 50 AEP Change in Flood Hazard Category

Figure: C-2

Rev: A

N

0 200 400m

Approx.Scale

BMT

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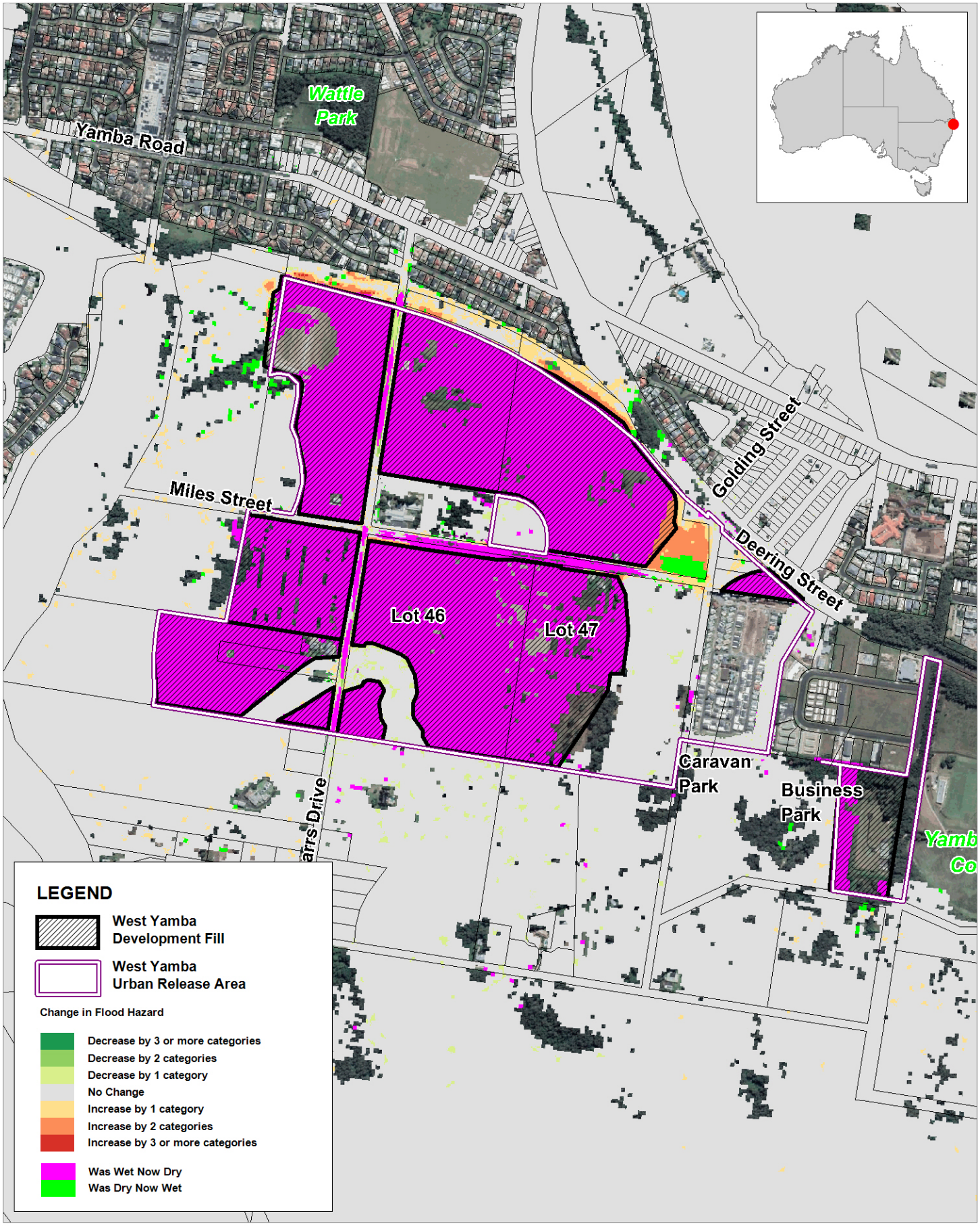
Filepath: "I:\A11309.i.br_West_Yamba\Drg\FLD_038_20221026_WY_dZAEM_Opt1_Q50.wor"



Title:

Model Scenario 'Option 2' - 1 in 50 AEP Change in Flood Hazard Category

Figure: C-3

Rev: A

N

0 200 400m

Approx.Scale

BMT

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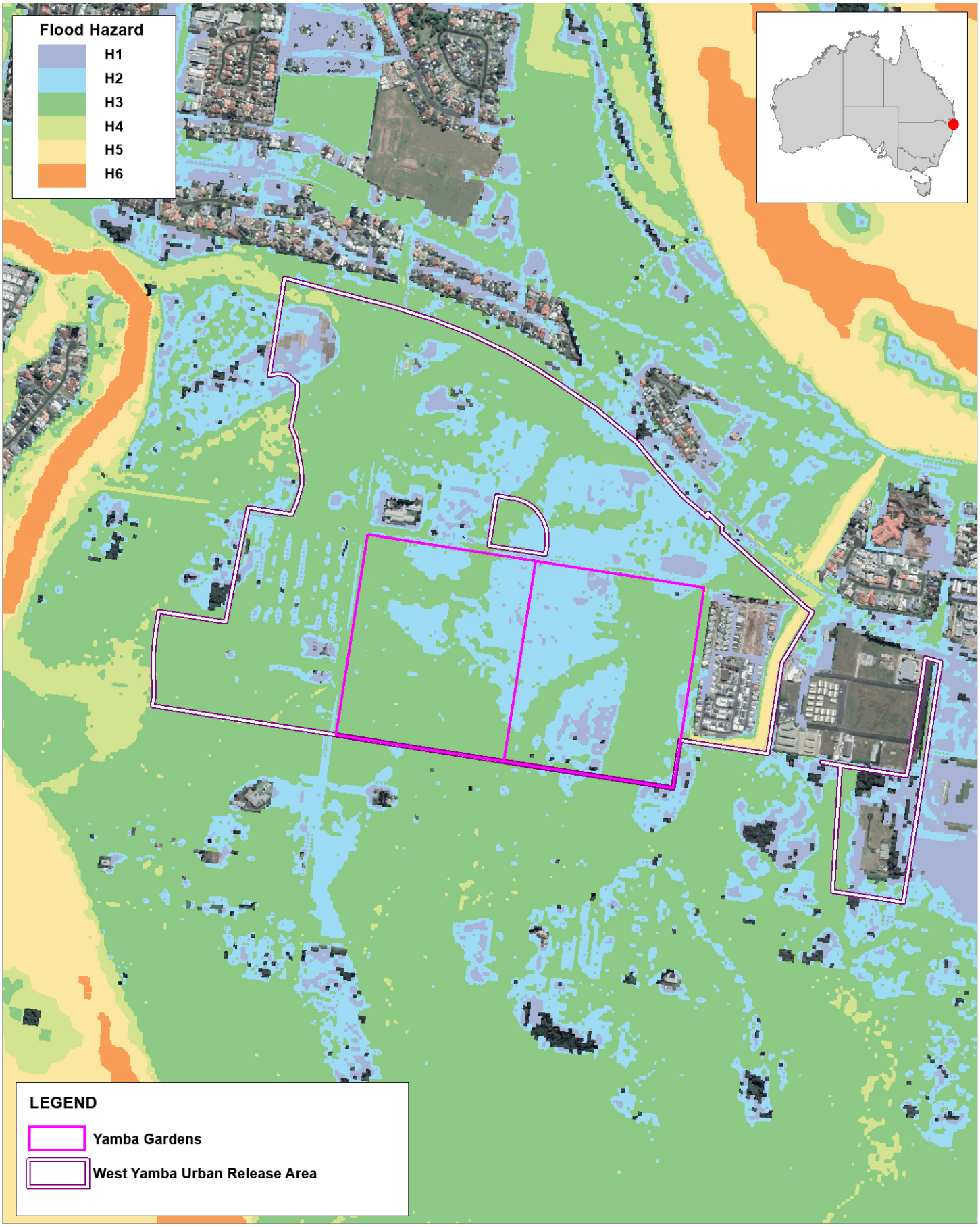
Filepath: "I:\A11309.i.br_West_Yamba\Drg\FLD_039_20221026_WY_dZAEM_Opt2_Q50.wor"



Title:

1 in 100 AEP Base Case Flood Hazard

Figure: C-4

Rev: A

N

0 200 400m

Approx.Scale

BMT

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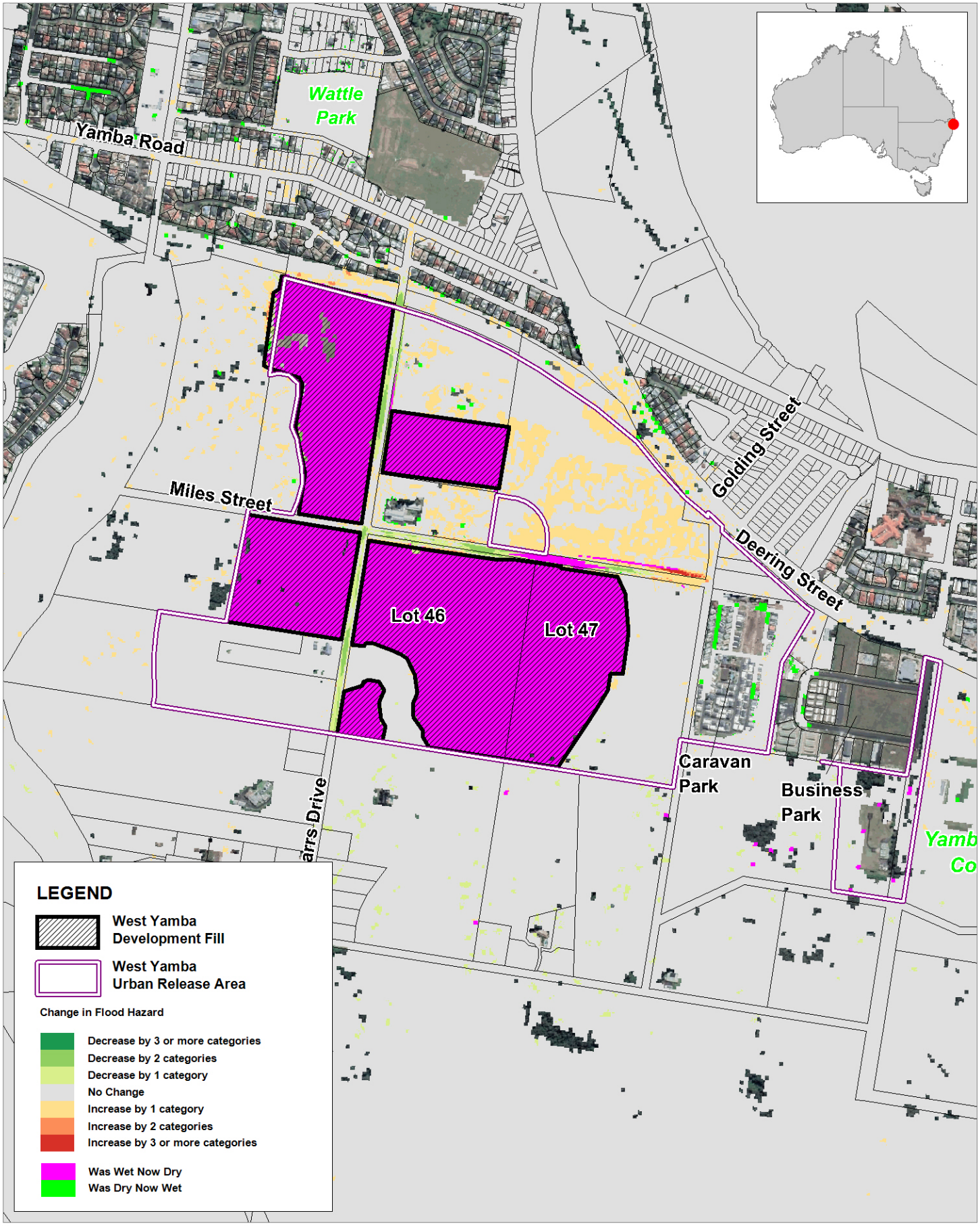


Title:

Model Scenario 'Option 1' - 1 in 100 AEP Change in Flood Hazard Category

Figure: C-5

Rev: A

N

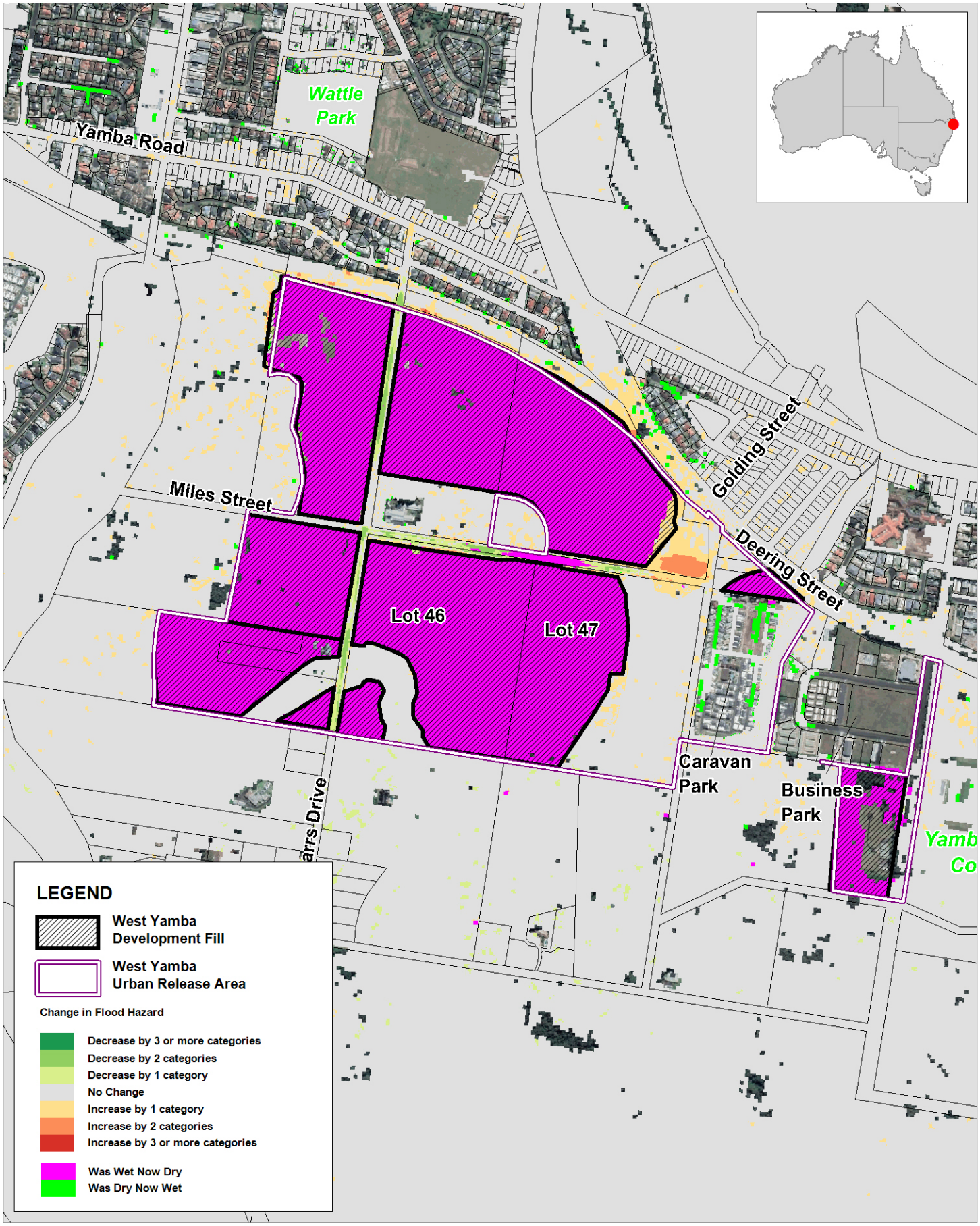
0 200 400m

Approx.Scale

BMT

www.bmt.org

Filepath: "I:\A11309.i.br_West_Yamba\Drg\FLD_040_20221026_WY_dZAEM_Opt1_Q100.wor"



Title:

Model Scenario 'Option 2' - 1 in 100 AEP Change in Flood Hazard Category

Figure: C-6

Rev: A

N

0 200 400m

Approx.Scale

BMT

www.bmt.org

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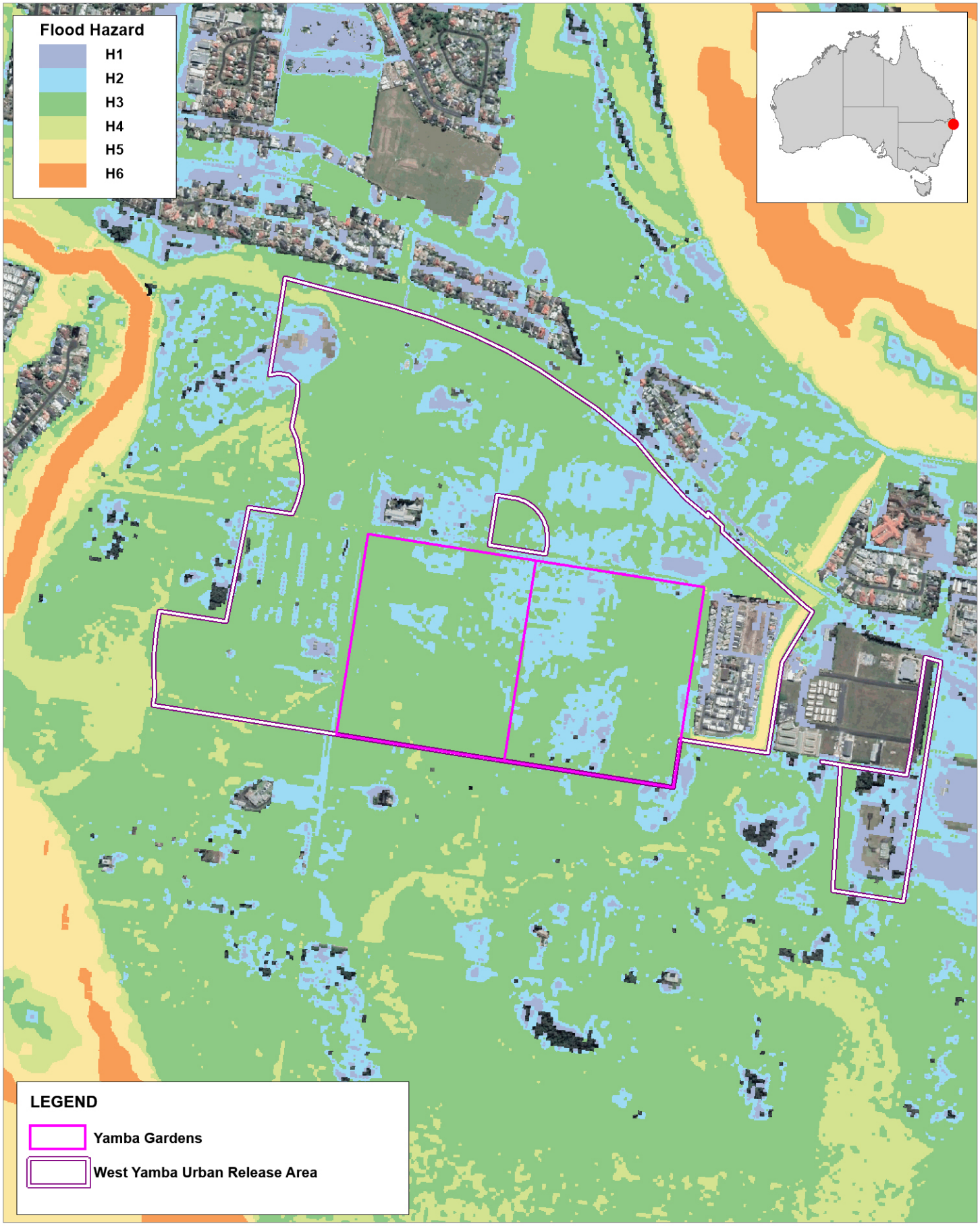


Title:

1 in 500 AEP Base Case Flood Hazard

Figure: C-7

Rev: A

N

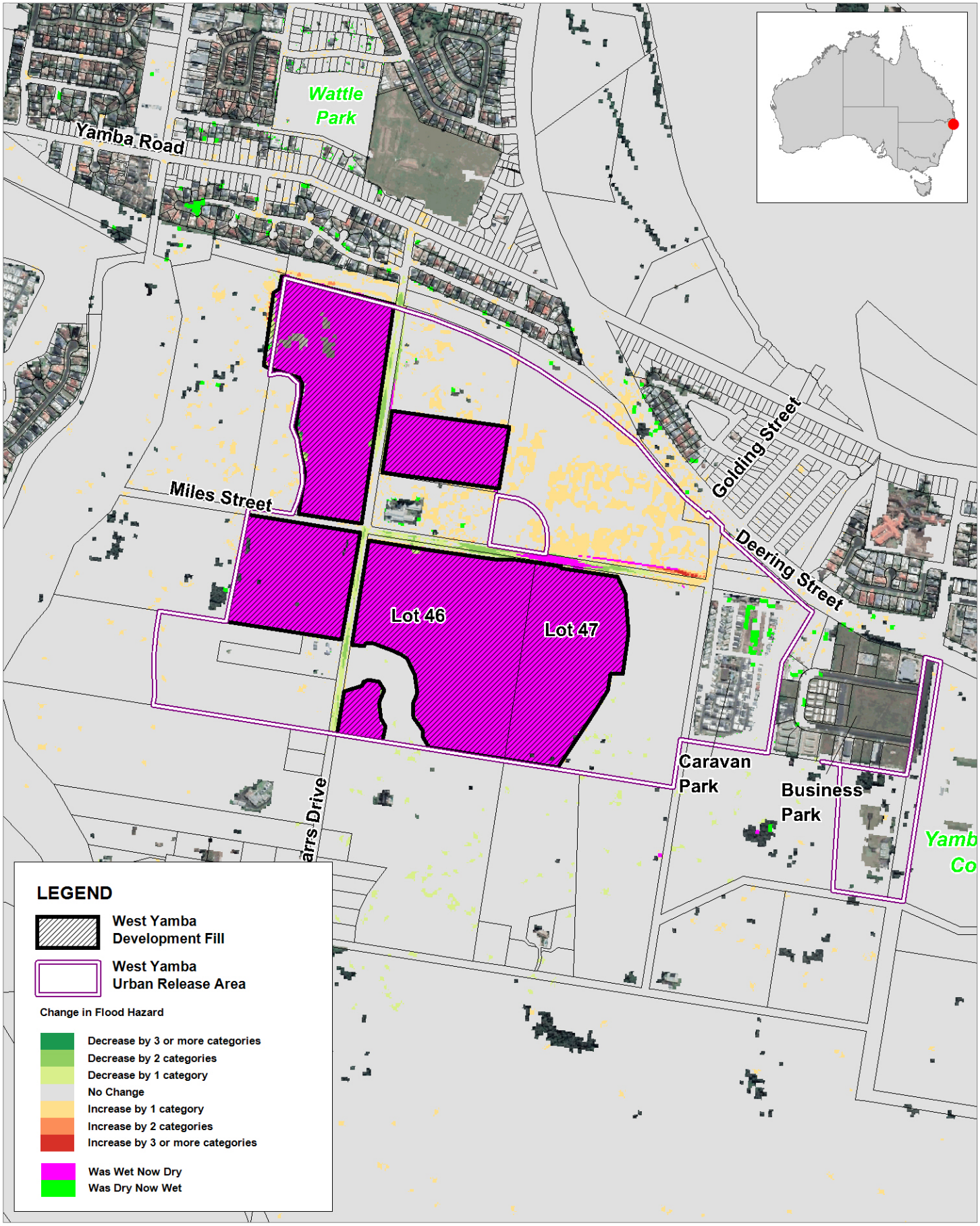
0 200 400m

Approx.Scale

BMT

www.bmt.org

Filepath: "I:\A11309.i.br_West_Yamba\Drg\FLD_035_20221025_500yr_Base_Case_Hazard.wor"



Title:

Model Scenario 'Option 1' - 1 in 500 AEP Change in Flood Hazard Category

Figure: C-8

Rev: A

N

0 200 400m

Approx.Scale

BMT

www.bmt.org

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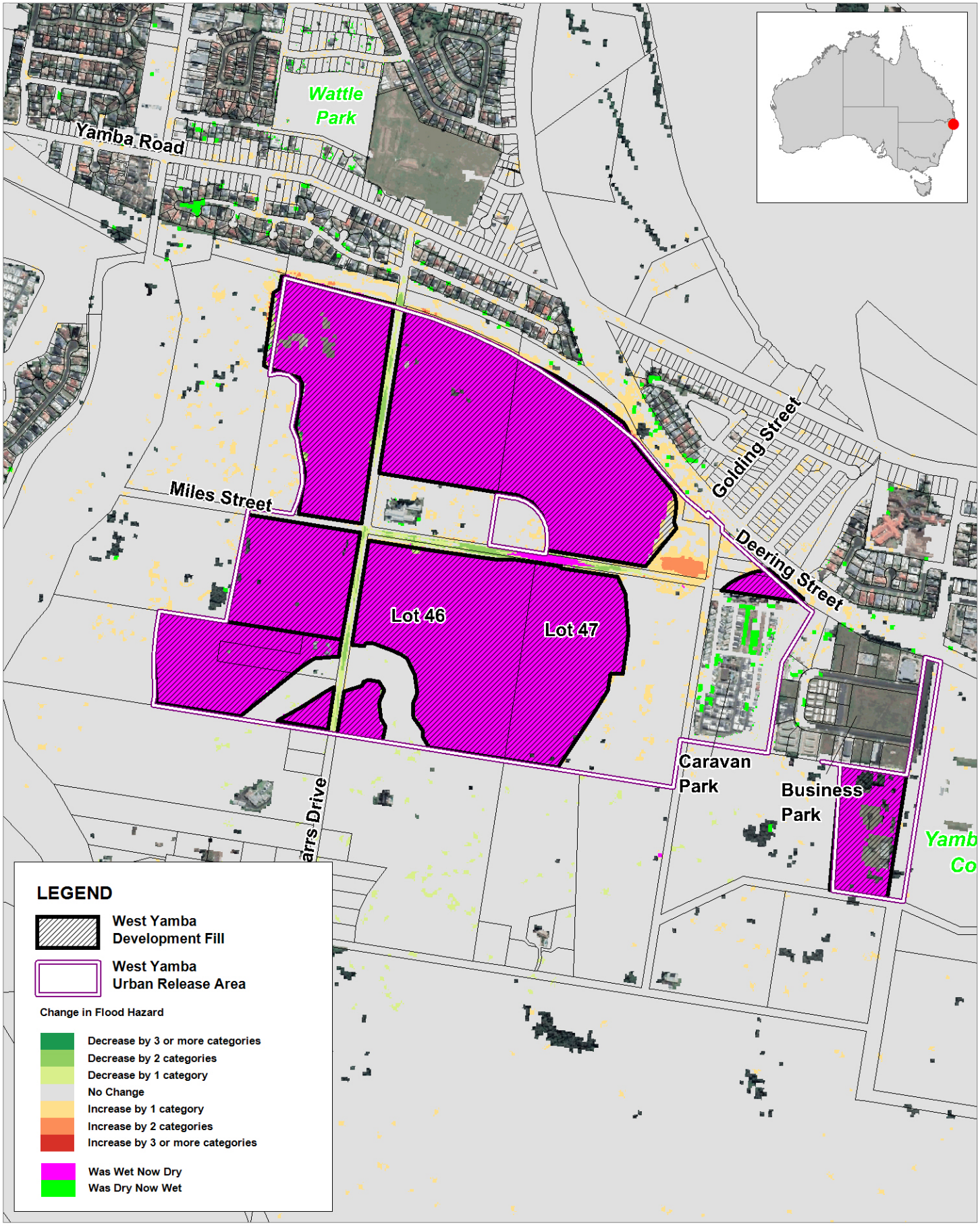

Title:

Model Scenario 'Option 2' - 1 in 500 AEP Change in Flood Hazard Category

Figure: C-9

Rev: A

N

0 200 400m

Approx.Scale

BMT

www.bmt.org

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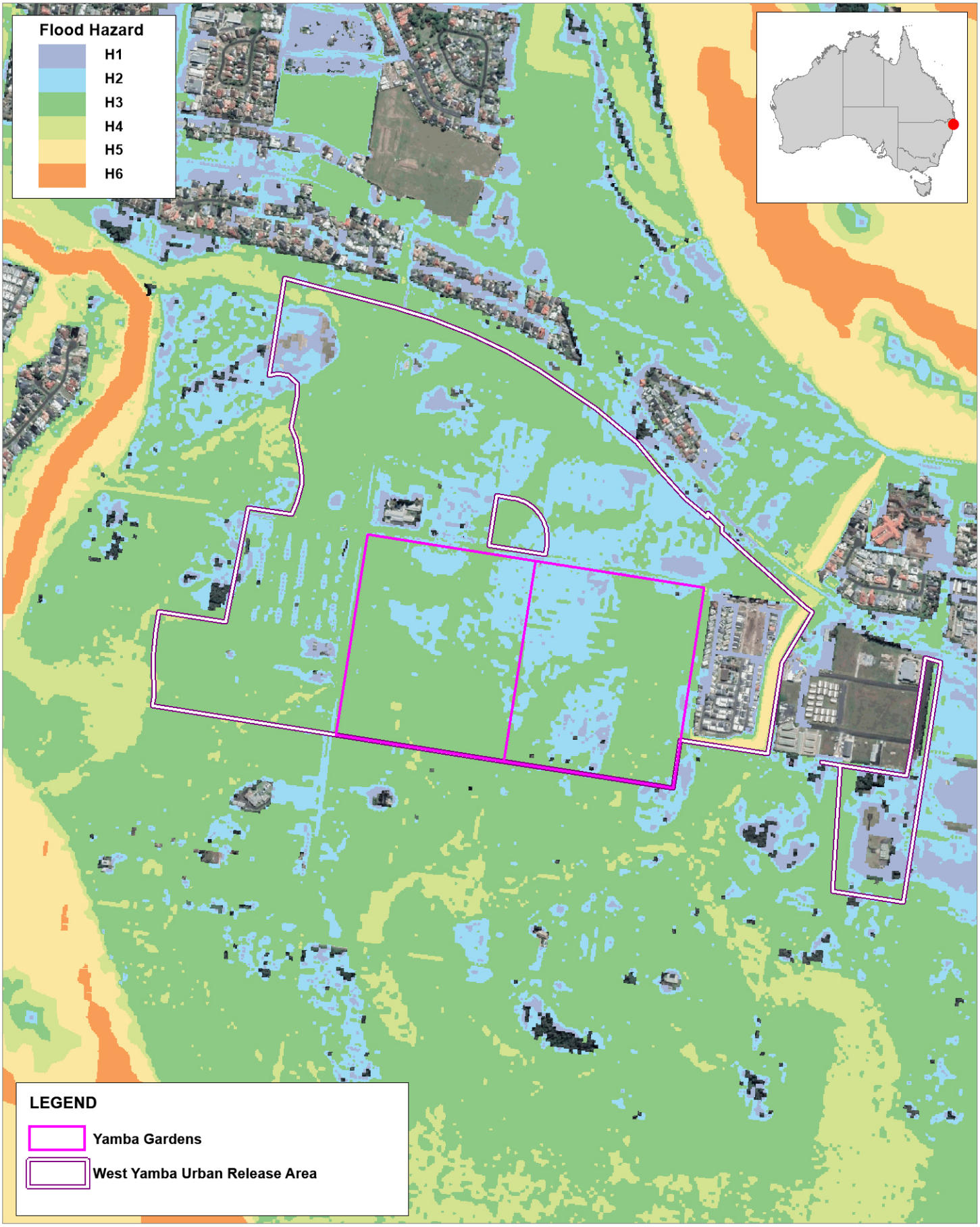

Title:

1 in 100CC AEP Base Case Flood Hazard

Figure: C-10

Rev: A

N

0 200 400m

Approx.Scale

BMT

www.bmt.org

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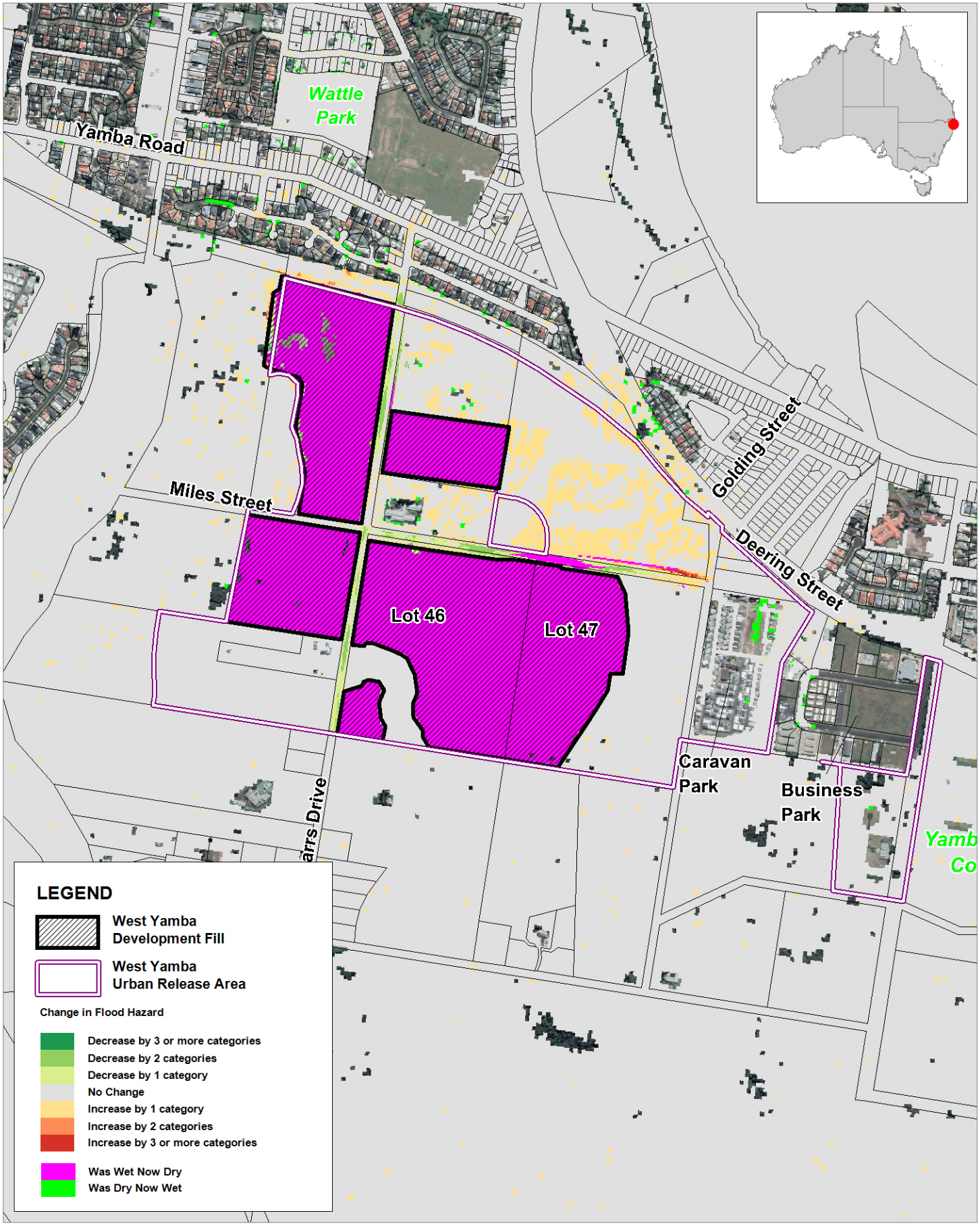

Title:

Model Scenario 'Option 1' - 1 in 100CC AEP Change in Flood Hazard Category

Figure: C-11

Rev: A

N

0 200 400m

Approx.Scale

BMT

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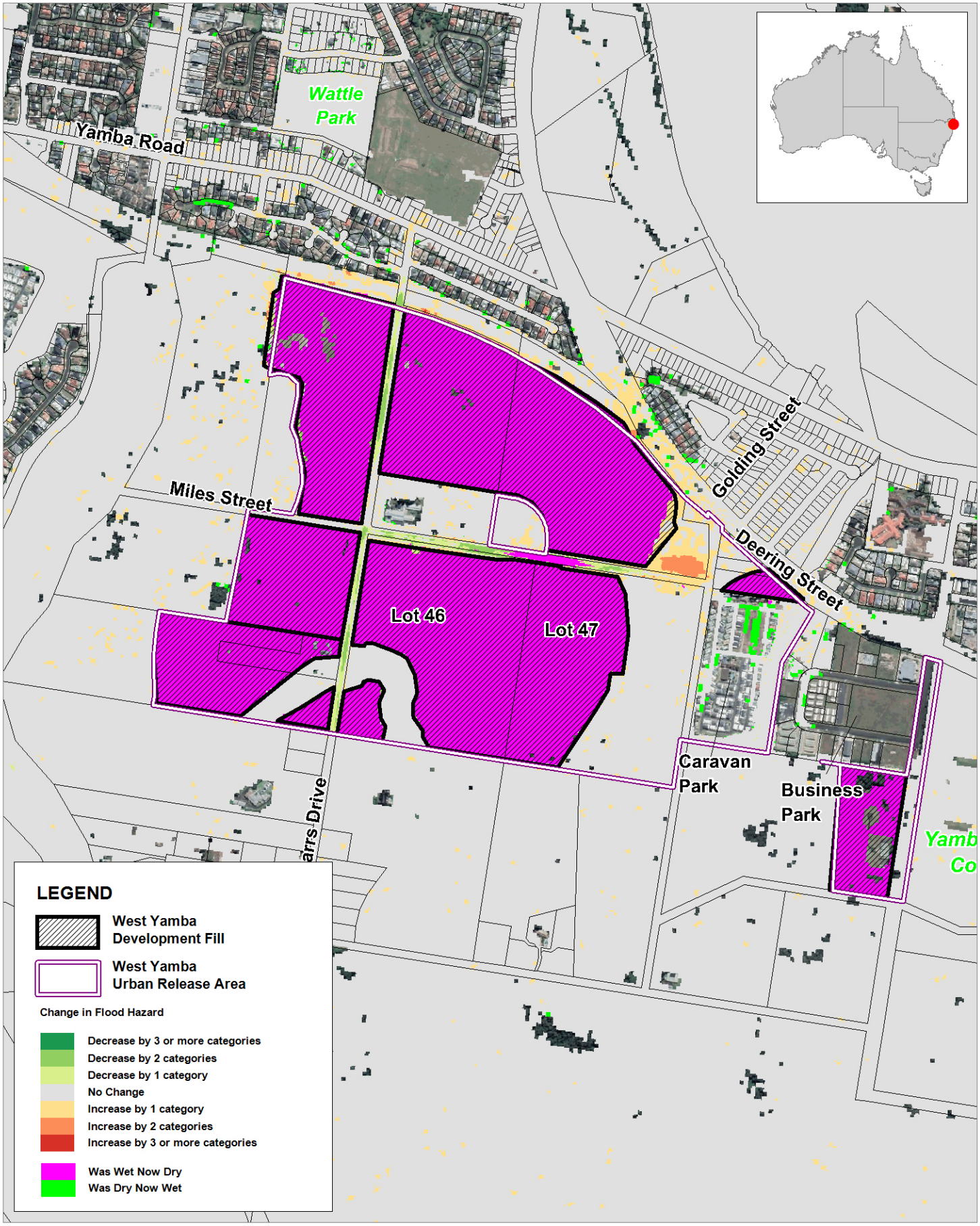

Title:

Model Scenario 'Option 2' - 1 in 100CC AEP Change in Flood Hazard Category

Figure: C-12

Rev: A

N

0 200 400m

Approx.Scale

BMT

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Filepath: "I:\A11309.i.br_West_Yamba\Drg\FLD_045_20221026_WY_dZAEM_Opt2_Q100CC.wor"

Annex D Flood Duration Plots

Plots showing the peak flood level over time at the three locations shown in Figure D.1 are presented. Each plot contains the Base Case flood level along with the flood level for Options 1 and 2. Each plot shows a separate AEP and a separate location. The locations were selected as they are within an area shown to have increases in flood level as a result of the development and are in the vicinity of the area referred to by WMAwater for considering potential changes in flood duration.

Figure D.1 Numbered locations used for flood duration plots

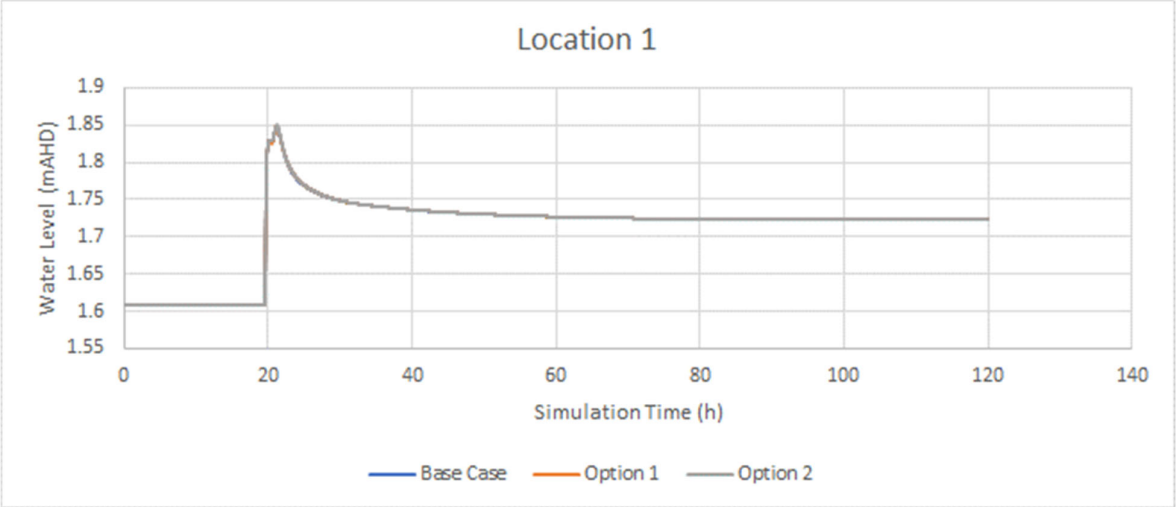

Figure D.2 Flood Level over Time 1 in 50 AEP: Location 1

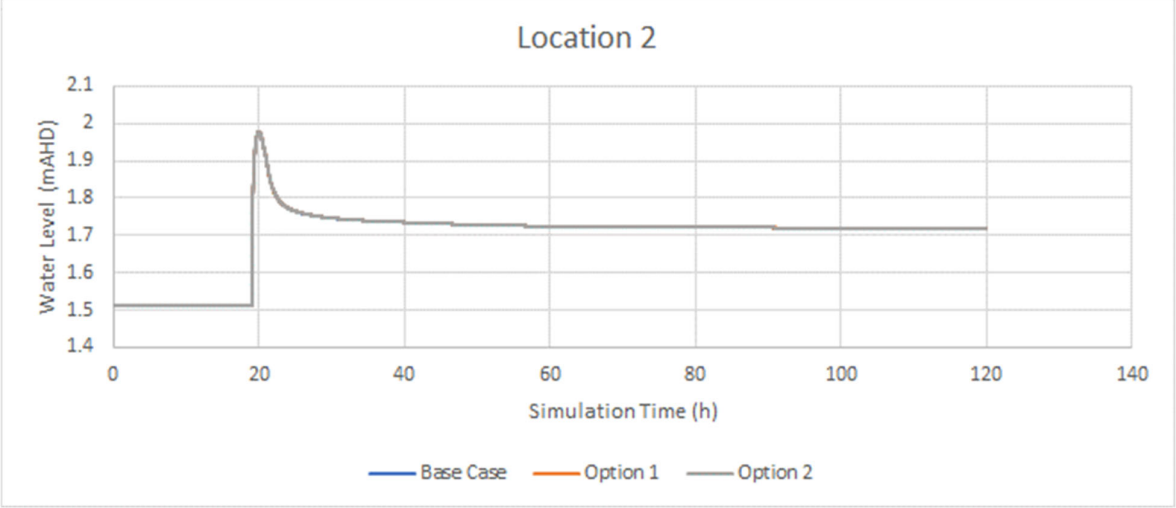

Figure D.3 Flood Level over Time 1 in 50 AEP: Location 2

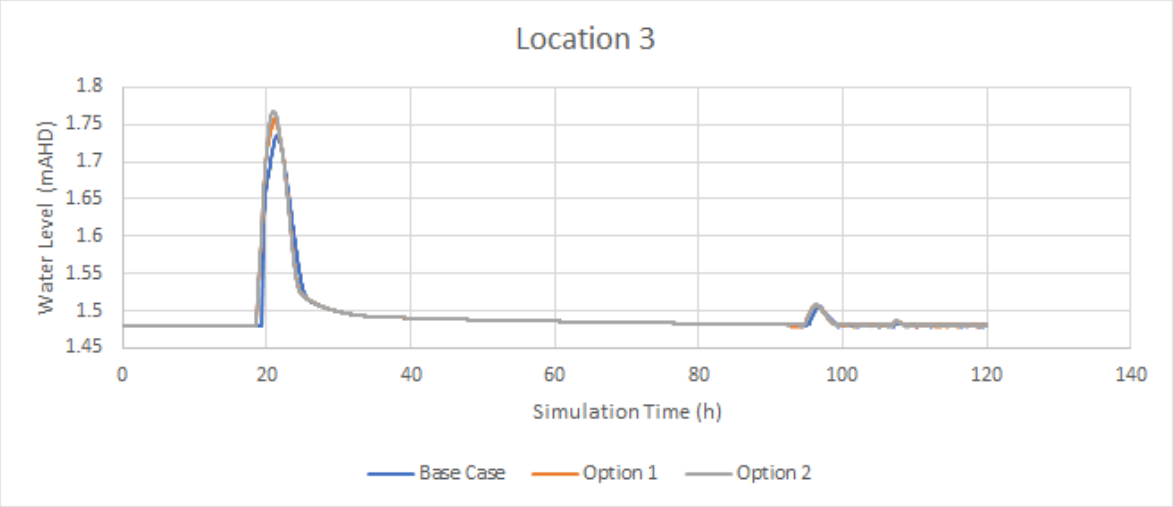

Figure D.4 Flood Level over Time 1 in 50 AEP: Location 3

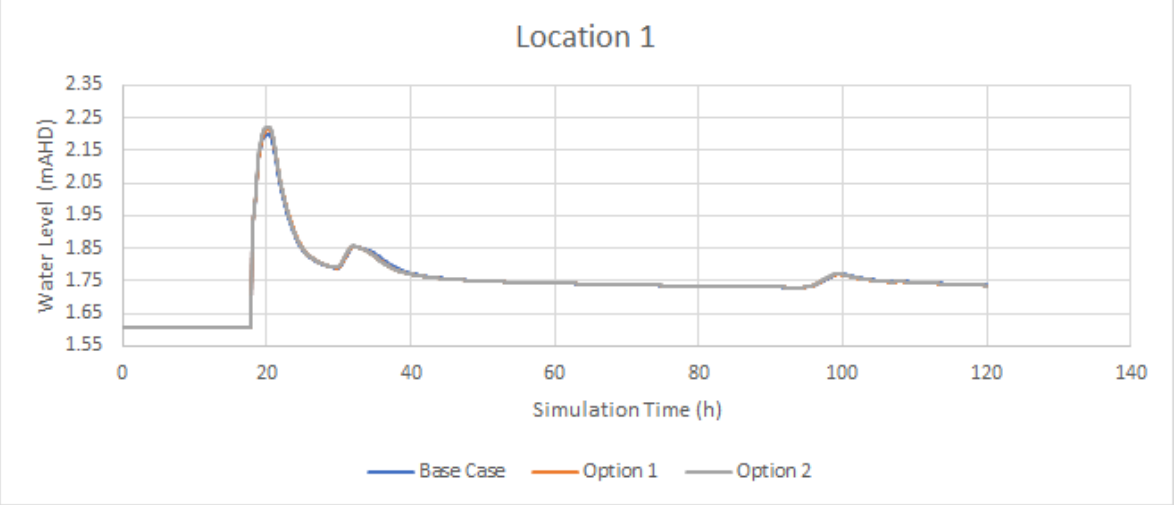

Figure D.5 Flood Level over Time 1 in 100 AEP: Location 1

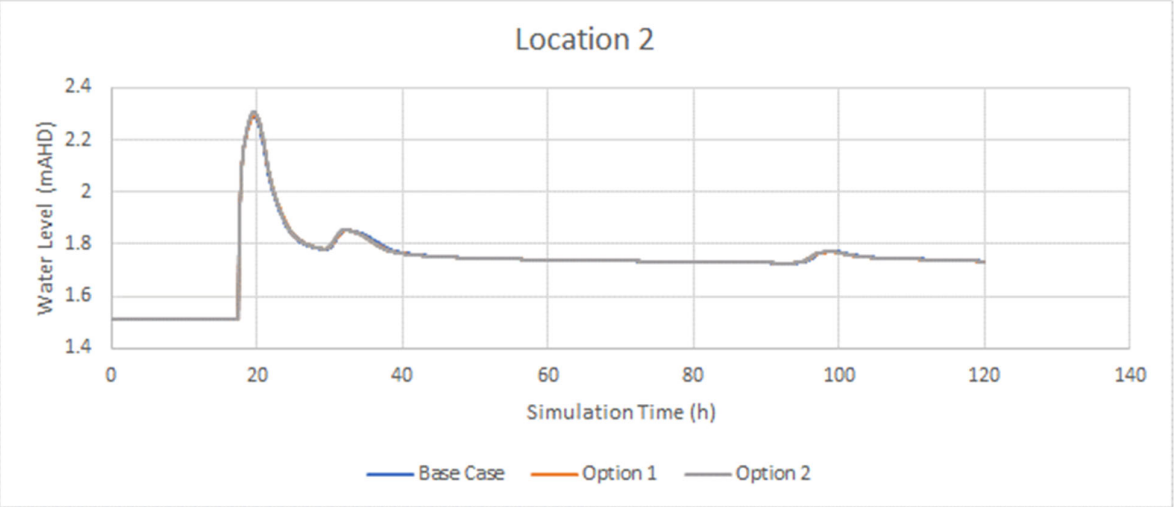

Figure D.6 Flood Level over Time 1 in 100 AEP: Location 2

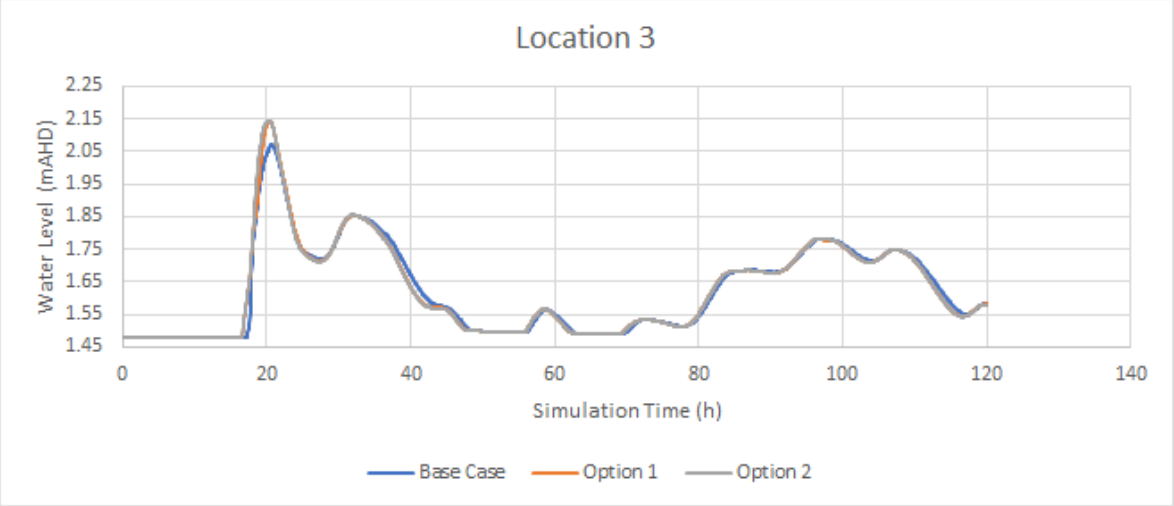

Figure D.7 Flood Level over Time 1 in 100 AEP: Location 3

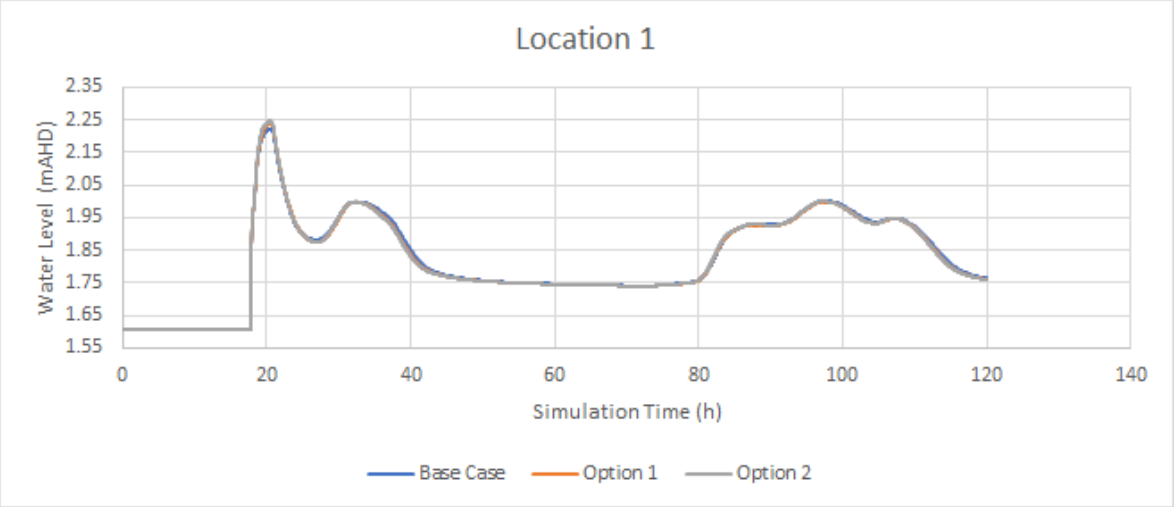

Figure D.8 Flood Level over Time 1 in 500 AEP: Location 1

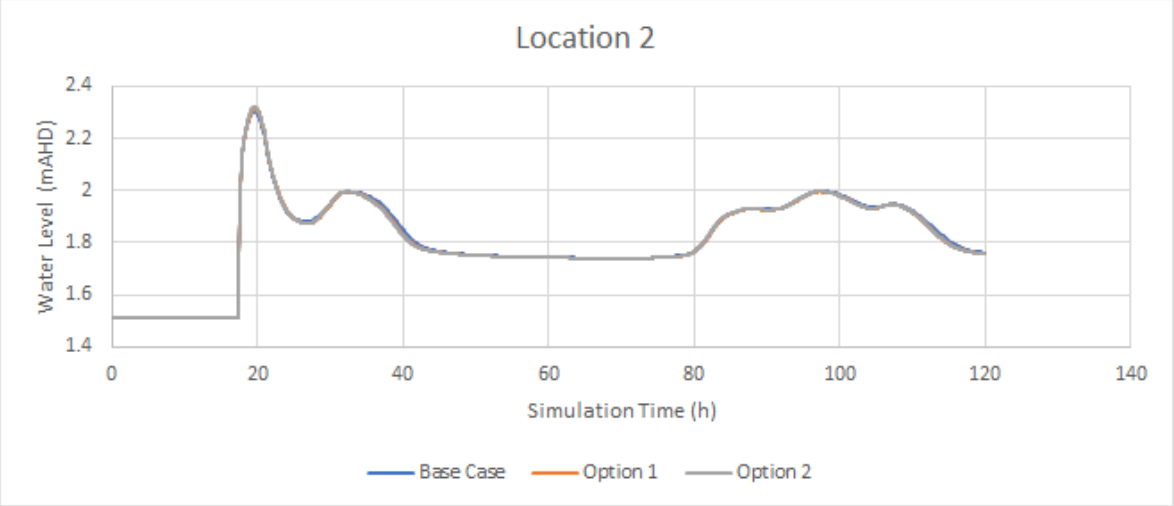

Figure D.9 Flood Level over Time 1 in 500 AEP: Location 2

Figure D.10 Flood Level over Time 1 in 500 AEP: Location 3

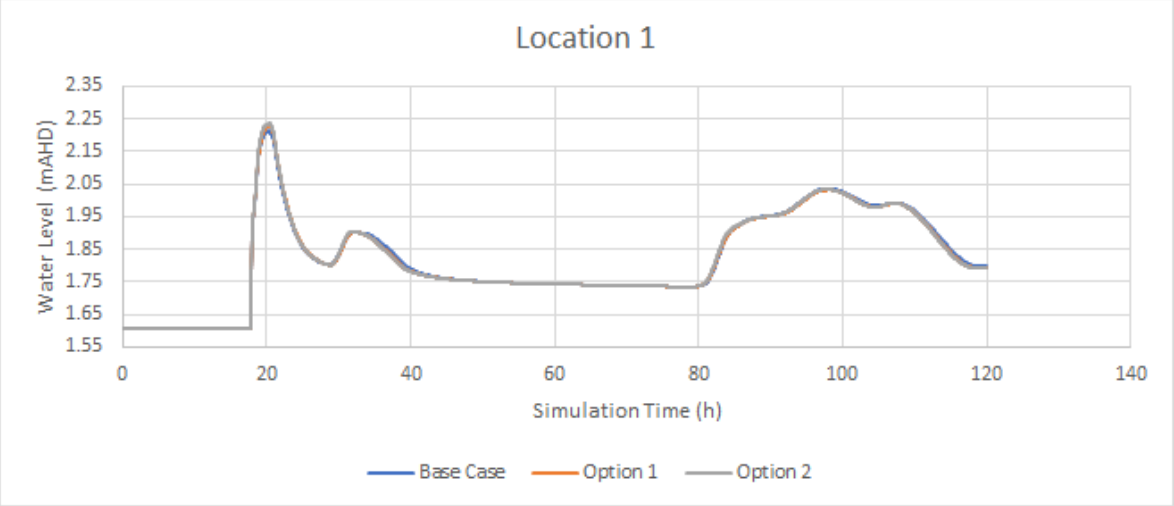

Figure D.11 Flood Level over Time 1 in 100CC AEP: Location 1

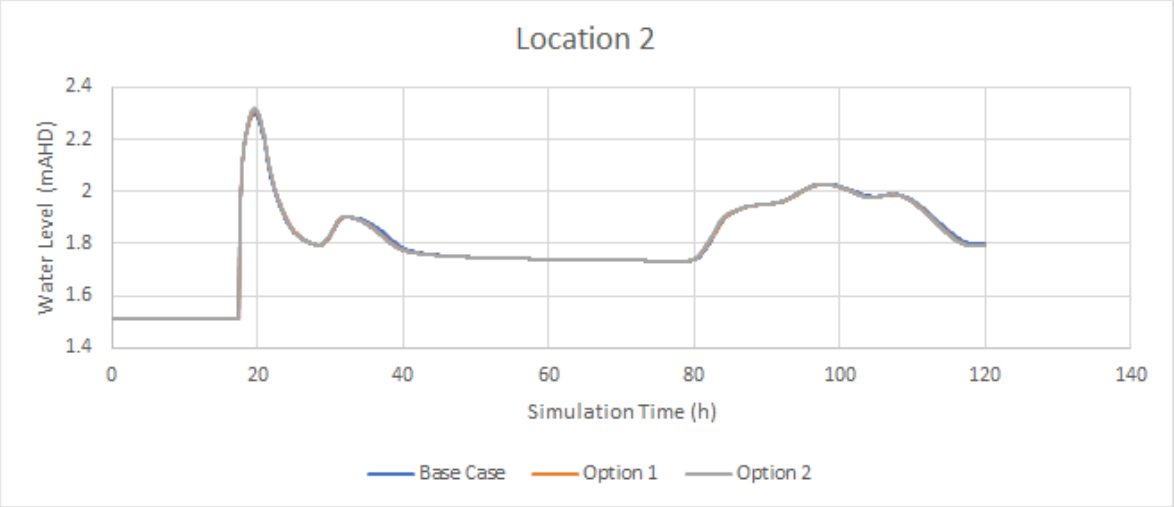

Figure D.12 Flood Level over Time 1 in 100CC AEP: Location 2

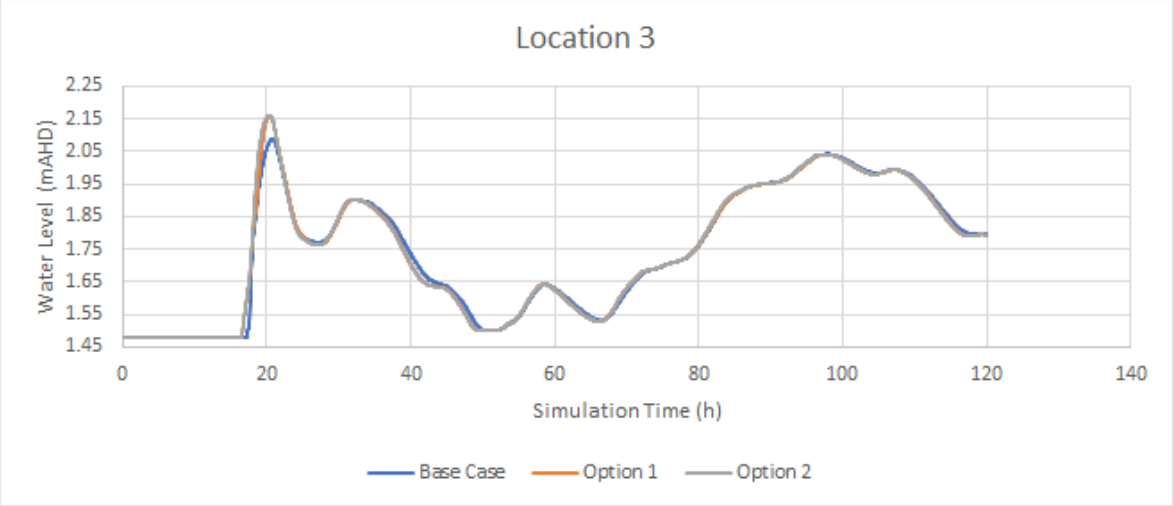

Figure D.13 Flood Level over Time 1 in 100CC AEP: Location 3

Annex E Impacts at Dwelling

Tables E1 to E6 list the residential dwellings identified as having an impact (increase in peak water level) of 30mm or greater. The tables provide details on whether the impact is above floor level or not and if that dwelling was flooded in the Base Case. If the dwelling has an above floor level impact and was flooded in the Base Case, the Base Case depth of flooding above floor level is included.

For the 1 in 50 AEP and more frequent events, no above floor impacts greater than 30mm were identified. Therefore, the tables present the information for the 1 in 100, 1 in 500 and 1 in 100CC AEPs, for both Option 1 and Option 2. The tables highlight in orange, any dwelling for which the impact is above floor level.

Table E.1. 1 in 100 AEP Impacted Dwellings: Option 1

Street Number	Street Name	Street Type	Floor Level (mAHD	Survey Source	Peak Flood Level (mAHD)		Impact (m)	Inundated in Base Case?	Impact Above Floor?	Depth in Base Case (m)
					Base Case	Option 1				
6	Carrs	Drive	1.92	WYLOC	2.07	2.14	0.07	Y	Y	0.15
26	Golding	Street	2.295	WYLOC	2.12	2.15	0.03	N	N	
30	Coonawara	Ct	2.492	WYLOC	2.11	2.19	0.08	N	N	
4	Harold Tory	Drive	2.7	CVC	2.07	2.14	0.07	N	N	
2	Harold Tory	Drive	2.7	CVC	2.07	2.14	0.08	N	N	

Table E.2. 1 in 100 AEP Impacted Dwellings: Option 2

Street Number	Street Name	Street Type	Floor level (mAHD)	Survey Source	Peak Flood Level (mAHD)		Impact (m)	Inundated in Base Case?	Impact Above Floor?	Depth in Base Case (m)
					Base Case	Option 2				
6	Carrs	Drive	1.92	WYLOC	2.07	2.14	0.08	Y	Y	0.15
23	Cox	Street	2.265	WYLOC	2.18	2.22	0.04	N	N	
25	Cox	Street	2.13	WYLOC	2.17	2.23	0.05	Y	Y	0.04
27	Cox	Street	2.61	WYLOC	2.20	2.24	0.05	N	N	
26	Golding	Street	2.295	WYLOC	2.12	2.17	0.05	N	N	
28	Golding	Street	2.12	WYLOC	2.11	2.17	0.06	N	Y	not flooded
30	Golding	Street	2.285	WYLOC	2.10	2.16	0.06	N	N	
25	Endeavour	Street	2.56	WYLOC	2.24	2.27	0.03	N	N	
30	Endeavour	Street	3.305	WYLOC	2.24	2.28	0.03	N	N	
30	Coonawara	Ct	2.492	WYLOC	2.11	2.27	0.17	N	N	
	Caravan Park		2.791	CVC	2.00	2.09	0.09	N	N	
	Caravan Park		2.783	CVC	2.00	2.09	0.09	N	N	
	Caravan Park		2.804	CVC	2.00	2.09	0.09	N	N	
	Caravan Park		2.63	CVC	2.03	2.07	0.04	N	N	
	Caravan Park		2.49	CVC	2.03	2.07	0.04	N	N	
	Caravan Park		2.515	CVC	1.99	2.04	0.04	N	N	
4	Harold Tory	Drive	2.7	CVC	2.07	2.14	0.08	N	N	
2	Harold Tory	Drive	2.7	CVC	2.07	2.14	0.08	N	N	

Table E.3. 1 in 500 AEP Impacted Dwellings: Option 1

Street Number	Street Name	Street Type	Floor level (mAHD)	Survey Source	Peak Flood Level (mAHD)		Impact (m)	Inundated in Base Case?	Impact Above Floor?	Depth in Base Case (m)
					Base Case	Option 1				
6	Carrs	Drive	1.92	Wendy	2.09	2.16	0.07	Y	Y	0.167
26	Golding	Street	2.295	Andrew	2.13	2.17	0.04	N	N	
28	Golding	Street	2.12	Andrew	2.12	2.15	0.03	Y	Y	0.002
30	Coonawara	Ct	2.492	Andrew	2.12	2.22	0.10	N	N	
4	Harold Tory	Drive	2.7	CVC	2.09	2.16	0.07	N	N	
2	Harold Tory	Drive	2.7	CVC	2.09	2.16	0.07	N	N	

Table E.4. 1 in 500 AEP Impacted Dwellings: Option 2

Street Number	Street Name	Street Type	Floor level (mAHD)	Survey Source	Peak Flood Level (mAHD)		Impact (m)	Inundated in Base Case?	Impact Above Floor?	Depth in Base Case (m)
					Base Case	Option 2				
6	Carrs	Drive	1.92	WYLOC	2.09	2.16	0.07	Y	Y	0.17
23	Cox	Street	2.265	WYLOC	2.19	2.23	0.04	N	N	
25	Cox	Street	2.13	WYLOC	2.18	2.24	0.06	Y	Y	0.05
27	Cox	Street	2.61	WYLOC	2.21	2.25	0.05	N	N	
25	Golding	Street	2.105	WYLOC	2.24	2.27	0.03	Y	Y	0.13
24	Golding	Street	3.885	WYLOC	2.24	2.27	0.03	N	N	
26	Golding	Street	2.295	WYLOC	2.13	2.18	0.06	N	N	
28	Golding	Street	2.12	WYLOC	2.12	2.18	0.06	Y	Y	0.002
30	Golding	Street	2.285	WYLOC	2.11	2.18	0.07	N	N	
28	Cook	Street	2.07	WYLOC	2.25	2.28	0.03	Y	Y	0.18
28	Endeavour	Street	1.795	WYLOC	2.26	2.29	0.03	Y	Y	0.47
25	Endeavour	Street	2.56	WYLOC	2.25	2.28	0.03	N	N	
30	Endeavour	Street	3.305	WYLOC	2.25	2.29	0.03	N	N	
30	Coonawara	Ct	2.492	WYLOC	2.12	2.30	0.17	N	N	
	Caravan Park		2.791	CVC	2.05	2.10	0.05	N	N	
	Caravan Park		2.783	CVC	2.05	2.10	0.05	N	N	
	Caravan Park		2.804	CVC	2.05	2.10	0.05	N	N	
	Caravan Park		2.63	CVC	2.05	2.09	0.04	N	N	
	Caravan Park		2.49	CVC	2.05	2.09	0.04	N	N	
	Caravan Park		2.86	CVC	2.03	2.09	0.06	N	N	
4	Harold Tory	Drive	2.7	CVC	2.09	2.16	0.07	N	N	
2	Harold Tory	Drive	2.7	CVC	2.09	2.16	0.07	N	N	

Table E.5. 1 in 100CC AEP Impacted Dwellings: Option 1

Street Number	Street Name	Street Type	Floor Level (mAHD	Survey Source	Peak Flood Level (mAHD)		Impact (m)	Inundated in Base Case?	Impact Above Floor?	Depth in Base Case (m)
					Base Case	Option 1				
6	Carrs	Drive	1.92	WYLOC	2.12	2.17	0.06	Y	Y	0.20
26	Golding	Street	2.295	WYLOC	2.14	2.18	0.04	N	N	
28	Golding	Street	2.12	WYLOC	2.13	2.17	0.04	Y	Y	0.01
30	Coonawara	Ct	2.492	WYLOC	2.14	2.23	0.09	N	N	
4	Harold Tory	Drive	2.7	CVC	2.12	2.17	0.06	N	N	
2	Harold Tory	Drive	2.7	CVC	2.12	2.17	0.06	N	N	

Table E.6. 1 in 100CC AEP Impacted Dwellings: Option 2

Street Number	Street Name	Street Type	Floor level (mAHD)	Survey Source	Peak Flood Level (mAHD)		Impact (m)	Inundated in Base Case?	Impact Above Floor?	Depth in Base Case (m)
					Base Case	Option 2				
6	Carrs	Drive	1.92	WYLOC	2.12	2.18	0.06	Y	Y	0.20
23	Cox	Street	2.265	WYLOC	2.19	2.24	0.04	N	N	
25	Cox	Street	2.13	WYLOC	2.18	2.24	0.06	Y	Y	0.05
27	Cox	Street	2.61	WYLOC	2.21	2.26	0.05	N	N	
25	Golding	Street	2.105	WYLOC	2.24	2.27	0.03	Y	Y	0.13
24	Golding	Street	3.885	WYLOC	2.24	2.27	0.03	N	N	
26	Golding	Street	2.295	WYLOC	2.14	2.19	0.06	N	N	
28	Golding	Street	2.12	WYLOC	2.13	2.19	0.06	Y	Y	0.01
30	Golding	Street	2.285	WYLOC	2.12	2.18	0.06	N	N	
28	Cook	Street	2.07	WYLOC	2.25	2.29	0.03	Y	Y	0.18
28	Endeavour	Street	1.795	WYLOC	2.26	2.30	0.03	Y	Y	0.47
25	Endeavour	Street	2.56	WYLOC	2.25	2.28	0.03	N	N	
30	Endeavour	Street	3.305	WYLOC	2.26	2.29	0.03	N	N	
30	Coonawara	Ct	2.492	WYLOC	2.14	2.30	0.16	N	N	
	Caravan Park		2.791	CVC	2.06	2.12	0.06	N	N	
	Caravan Park		2.783	CVC	2.06	2.12	0.06	N	N	
	Caravan Park		2.804	CVC	2.06	2.12	0.05	N	N	
	Caravan Park		2.63	CVC	2.07	2.10	0.03	N	N	
	Caravan Park		2.49	CVC	2.07	2.10	0.03	N	N	
	Caravan Park		2.723	CVC	2.07	2.11	0.04	N	N	
	Caravan Park		2.86	CVC	2.04	2.10	0.07	N	N	
	Caravan Park		2.767	CVC	2.09	2.13	0.03	N	N	
4	Harold Tory	Drive	2.7	CVC	2.12	2.17	0.06	N	N	
2	Harold Tory	Drive	2.7	CVC	2.12	2.17	0.06	N	N	