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Our Ref: DJW: L.T2103.002.docx

5 February 2020
Providence Asset Group
Suite 704, 97-99 Bathurst Street
Sydney NSW 2000
Attention: Jeremy Every

Dear Jeremy

RE: FLOOD IMPACT ASSESSMENT FOR PROPOSED NARROMINE WEST SOLAR FARM, NARROMINE, NSW

Background

Torrent Consulting was engaged to undertake a Flood Impact Assessment to assist in the DA process for the proposed Narromine West Solar Farm at Lot 2221 DP1101864 Dandaloo Road, Narromine, NSW (the Site), as presented in Figure 1. It is understood that Council has identified the site as being at risk of flooding, with existing flood information available in the Narromine Floodplain Risk Management Study and Plan (Lyall & Associates, 2009) and the Narromine River Bank Levee Feasibility Study (Lyall & Associates, 2013).

The Site is located on the right floodplain of Town Cowal, which is a flood runner within the left floodplain of the Macquarie River. The catchment area of the Macquarie River totals some 26 000 km^2 at Narromine. The proposed solar farm is potentially at risk of flooding from rare events on the Macquarie River that generate sufficient flow within the Town Cowal. The floodplain topography is presented in Figure 2, in which the bifurcation of the Macquarie River and Town Cowal can be clearly seen, with the latter traversing the Site.

The assessment includes the development of a TUFLOW model that reproduces the design flood conditions of the Narromine River Bank Levee Feasibility Study for the purposes of flood impact assessment. This model will provide a more detailed understanding of the local flood depths, velocities and hazards at the Site.

Model Development

For this assessment, a TUFLOW model was developed covering the Macquarie River floodplain from around 12 km upstream to 8 km downstream of Narromine. The model also includes around a 20 km length of Backwater Cowal and the entire 12 km length of Town Cowal. The modelled area covers some 166 km^2, as presented in Figure 3.

The model utilised the Geoscience Australia LiDAR and the NSW Spatial Services photogrammetry data products, downloaded via the ELVIS Foundation Spatial Data portal to define the floodplain topography. The LiDAR covers central model area and is available at a 1 m horizontal grid cell resolution. The coverage includes an 11 km reach of the Macquarie River, 10 km of Town Cowal and the surrounding floodplain, including the Site, as presented in Figure 3.

Where LiDAR is unavailable the photogrammetry was used. Torrent Consulting has found the photogrammetric data (which is a 5 m grid cell resolution DEM product) to provide a similar representation of overall floodplain topography to that captured in more detailed LiDAR (Light Detection and Ranging) surveys, when coincidently available. However, the absolute elevation values can often differ to those within the LiDAR data. This is to be expected, given the relative vertical accuracy requirements of the photogrammetry compared to the LiDAR, which are +/- 0.3 m and +/- 1.0 m within a 95% confidence respectively.

The practical application of these elevation data products in previous flood studies has found that LiDAR data typically compares well to traditional ground survey techniques in terms of absolute elevation values. However, the photogrammetry data can present up to around a +/- 0.5 m difference in floodplain elevations when compared to available ground survey data. It is therefore important to make a corrective adjustment when using the photogrammetry data for flood modelling applications. Comparison of the photogrammetry data to the available site survey identified a typical error of -0.2 m. Therefore, the photogrammetry elevations had a +0.2 m corrective adjustment applied within the TUFLOW model.

The TUFLOW model adopted a 20 m horizontal grid resolution, sampling elevation data from the underlying LiDAR and photogrammetry Digital Elevation Models (DEMs). However, the TUFLOW model was locally refined using the TUFLOW QPC quad-tree functionality, which allows an efficient transition between model grid cells of varying resolution. The embankment alignments and areas within a 10 m buffer were assigned a model grid cell resolution of 10 m, with the banks and channel of the irrigation supply canal being assigned a resolution of 5 m. This enables a more accurate representation of flood water conveyance through the canal and the embankment cross-drainage structures. TUFLOW then transitions the surrounding model cells back to the 20 m resolution throughout the broader model.

Key hydraulic controls beyond the resolution of the model grid cell resolution were enforced using the Z Shape functionality. This includes road, rail, canal and levee embankments, for which crest levels were extracted from the DEM data, with an additional 0.2 m being added to the rail embankment to account for the rail tracks.

Some 18 cross-drainage structures were included within the model, represented either a Layered Flow Controls in the 2D domain or as 1D hydraulic elements dynamically linked to the 2D floodplain, depending on the size of structure. The structure dimensions were estimated using a combination of aerial imagery, LiDAR data and Google Street View. However, the cross-drainage structures are only included for completeness, with the actual structure sizes unlikely to have any significant impact on the results of the flood modelling at the Site.

Model inflows were established by generating a composite flood flow hydrograph shape from the August 1990 and December 2010 recorded data and scaling the hydrograph to match the peak design flows provided in the Narromine River Bank Levee Feasibility Study. The Macquarie River inflow is situated upstream of the breakout to Backwater Cowal through Webbs Siding, providing a fully-2D representation of the floodplain flow distribution. Downstream model boundaries are provided on the Macquarie River and Backwater Cowal. The former represents a peak flood level condition estimated from the Narromine River Bank Levee Feasibility Study and local floodplain topography, whilst the latter is a model-generated stage-discharge curve with an assumed hydraulic gradient of 0.05%.

The December 2010 and 1% AEP flood events were simulated and the Manning's 'n' roughness parameters were adjusted to provide a good match to the modelled flood levels in the Narromine River Bank Levee Feasibility Study. The adopted hydraulic roughness values are presented in Table 1.

Table 1 – Modelled Hydraulic Roughness Values

Surface Type	Manning's 'n'
Cleared floodplain	0.050
River channel	0.048
Remnant vegetation	0.100
Urban road reserve	0.030
Urban lots	1.000

Baseline Design Flood Conditions

The TUFLOW hydraulic model was simulated (using the HPC solver) for the adopted design flood hydrology, as presented in Table 2. The Extreme Flood was assumed to be three times the flow of the 1% AEP event.

Table 2 – Modelled Peak Flood Flows

Design Event	Inflow (m^3/s)
5% AEP	1610
2% AEP	2720
1% AEP	4000
0.5% AEP	5800
Extreme Flood	12 000

Figure 4 presents the modelled peak flood extents at the Site for the 5% AEP, 1% AEP and Extreme Flood events. Figure 5, Figure 6, Figure 7 and Figure 8 are presented for additional context and show the modelled peak flood depths and peak flood level contours for the 5% AEP, 1% AEP, 0.5% AEP and Extreme Flood events respectively.

Figure 9, Figure 10, Figure 11 and Figure 12 present the flood hazard classification at the Site for the 5% AEP, 1% AEP, 0.5% AEP and Extreme Flood events respectively. The flood hazards have been determined in accordance with Guideline 7-3 of the Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017). This produces a six-tier hazard classification, based on modelled flood depths, velocities and velocity-depth product. The hazard classes relate directly to the potential risk posed to people, vehicles and buildings, as presented in Chart 1.

The flood hazard mapping is useful for providing context to the nature of the modelled flood risk and to identify potential constraints for development of the Site with regards to floodplain risk management. The principal consideration of good practice floodplain risk management is to ensure compatibility of the proposed development with the flood hazard of the land, including the risk to life and risk to property.

The modelled flood conditions show that the location of the proposed Solar Farm is flood-free at the 5% AEP event and only subject to minor inundation at the 1% AEP event. However, for the 0.5% AEP and rarer events the flood levels at the Site increase significantly, as presented in Table 3. The ground surface level at the northern end of the proposed solar farm footprint is around 237.2 m AHD in the LiDAR data. This gives around a 0.4 m peak flood depth at the 1% AEP event, but a 1.2 m depth at the 0.5% AEP event and almost 2 m for the Extreme Flood event.

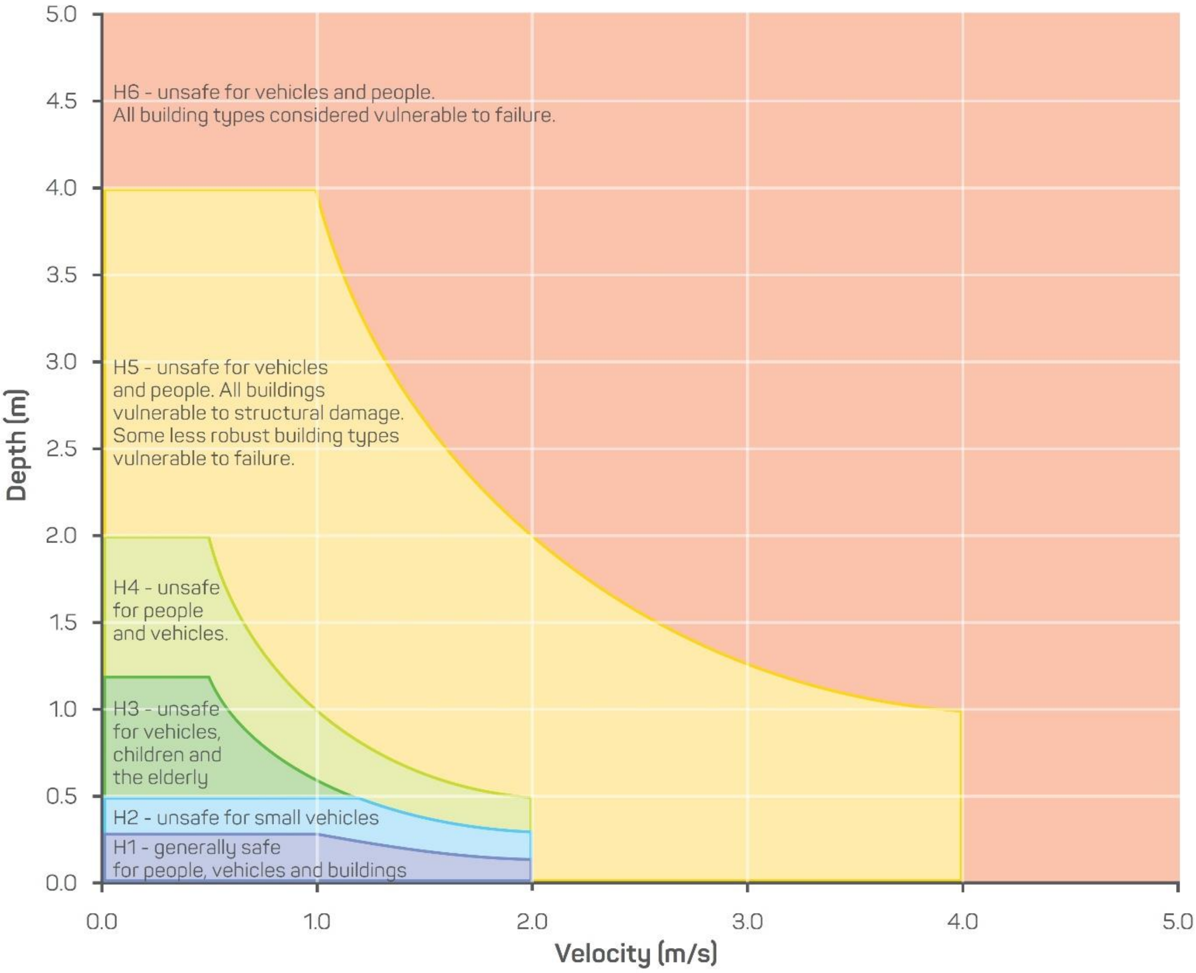

Chart 1 – General Flood Hazard Vulnerability Curves (AIDR, 2017)

Table 3 – Modelled Peak Flood Levels

Design Event	Flood Level (m AHD)
5% AEP	N/A
2% AEP	N/A
1% AEP	237.6
0.5% AEP	238.4
Extreme Flood	239.0 – 239.3

The flood hazard conditions are principally a function of the modelled flood depth, as the peak flood velocities are relatively low, even for the Extreme Flood event. Modelled peak flood velocities within the proposed solar farm footprint are negligible at the 1% AEP event, around 0.2 m/s at the 0.5% AEP event and around 0.6 m/s at the Extreme Flood event. These conditions produce a low flood hazard (H1 and H2) exposure to the proposed solar farm at the 1% AEP event, and a medium flood hazard at the 0.5% AEP (H3) and Extreme Flood event (H4).

Flood Impact Assessment

The principal consideration of good practice floodplain risk management is to ensure compatibility of the proposed development with the flood hazard of the land, including the risk to life and risk to property. Requirements within a Council's LEP (Local Environment Plan) and DCP (Development Control Plan) typically consider the management of flood risk, with the application of an FPL (Flood Planning Level) being the principal control measure. The standard FPL for residential development in NSW is the 1% AEP flood level plus a 0.5 m freeboard. However, requirements for non-residential development can vary significantly.

The objective of the management of risk to property is to minimise the damages that would be incurred in the event of a flood. This includes potential damage to future building structures and their contents, and critical infrastructure and services. Risk to property is typically managed to the 1% AEP design flood event.

The Narromine Flood Policy (Lyall & Associates, 2011) forms part of the Narromine Shire Council DCP and provides guidance on floodplain management measures for approving developments. Reference to the Development Controls Matrix in the Flood Policy indicates that in the Intermediate Floodplain and Outer Floodplain Flood Risk Precincts (in which the proposed solar farm is located) the appropriate FPL for commercial and industrial developments is the 2% AEP flood level plus a 0.5 m freeboard. However, the Site is not inundated at the 2% AEP and so an appropriate FPL cannot be determined. It is therefore reasonable to use the 1% AEP flood level of 237.6 m AHD as the FPL, with buildings and critical infrastructure at the Site be set at or above this level. This includes:

- temporary construction buildings
- O & M building
- power conversion unit
- HV RMU & metering
- PV combiner boxes

It is understood from Providence Asset Group that the standard PV array design can accommodate flood depths of up to 0.5 m. Therefore, the proposed solar farm is compatible with the flood hazard of the land at the 1% AEP event (being up to 0.4 m deep), but not at the 0.5% AEP event. However, it is important to consider that the Narromine River Bank Levee will potentially be constructed in the mid-term future, which would significantly reduce the flood risk exposure of the Site to floods of a 1% AEP and 0.5% AEP probability. The impact of Levee Option 2Ai is presented in the Narromine River Bank Levee Feasibility Study as reducing the flood extent at the proposed solar farm location to around a level of 237.8 m AHD, which would produce a maximum flood depth of around 0.6 m within the solar farm.

The objective of the management of risk to life is to minimise the likelihood of deaths in the event of a flood and is typically considered for rarer flood events than the 1% AEP, up to the PMF. The risk to life exposure at the proposed solar farm location is consistent with that of the broader Narromine township. It is expected that the Site would be unattended most of the time. Therefore, it is unlikely that people would be present on-site in the event of a flood. Further, if the solar farm were to be inundated then Narromine would be subject to a flood evacuation order by the SES and so potential visitors would be unable to access the Site.

In addition to the management of flood risk exposure of the proposed development, the potential for off-site flood impacts to the existing baseline flood conditions also need to be considered to avoid adverse impacts to neighbouring property and infrastructure. The details contained in the site plan (10080-G-GAD-01-1

Narromine SF GA Base (2021.01.29).dwg) were incorporated into the TUFLOW model to assess the potential flood impacts. Assumptions include:

- application of a 50% blockage to flow around the perimeter fencing
- application of a 2% blockage to flow through the PV tracker arrays to account for the piles (PV modules raised above the flood surface).
- raising of the gravel hardstand construction laydown and Site access road to the levels indicated by the design surface contours
- raising above the floodplain of all internal site infrastructure other than the PV trackers
- incorporation of the proposed site stormwater detention bund.

The design flood events were then re-simulated, and the results compared to the baseline results to identify potential flood impacts.

The results of the flood impact assessment are presented in Figure 13 to Figure 14 for the modelled peak flood level impacts and in Figure 15 to Figure 16 for the flood velocity impacts. The results show a negligible impact to the existing peak flood level and velocity conditions. This is expected due to the minimal flood flow velocities and negligible loss of overall floodplain storage.

Conclusion

Torrent Consulting was engaged to undertake a Flood Impact Assessment to assist in the DA process for the proposed Narromine West Solar Farm.

This assessment has included development of a TUFLOW model for the Macquarie River floodplain and has simulated design flood conditions consistent with those presented in the Narromine River Bank Levee Feasibility Study.

Flood mapping has been produced that shows that the proposed solar farm is compatible with the flood hazard of the land at the 1% AEP event. There is a residual flood risk exposure for rarer events than the 1% AEP that is expected to be managed through appropriate Insurances. However, this flood risk exposure to very rare flood events will be significantly reduced with a future construction of the Narromine River Bank Levee scheme.

The provisions of the Narromine Shire Council DCP provide an appropriate FPL of the 2% AEP plus a 0.5 m freeboard. However, the Site is not inundated at the 2% AEP and so it is therefore reasonable to use the 1% AEP flood level of 237.6 m AHD as the FPL, with buildings and critical infrastructure at the Site be set at or above this level. This includes:

- temporary construction buildings
- O & M building
- power conversion unit
- HV RMU & metering
- PV combiner boxes

The risk to life exposure at the proposed solar farm location is consistent with that of the broader Narromine township. It is expected that the Site would be unattended most of the time. Therefore, it is unlikely that people would be present on-site in the event of a flood. Further, if the solar farm were to be inundated then Narromine would be subject to a flood evacuation order by the SES and so potential visitors would be unable to access the Site.

The results of the flood impact assessment show a negligible impact to the existing peak flood level and velocity conditions.

We trust that this report meets your requirements. For further information or clarification please contact the undersigned.

Yours faithfully

Torrent Consulting

Dan Williams
Director

Title:

Study Locality

0 1 2 km

approx. scale

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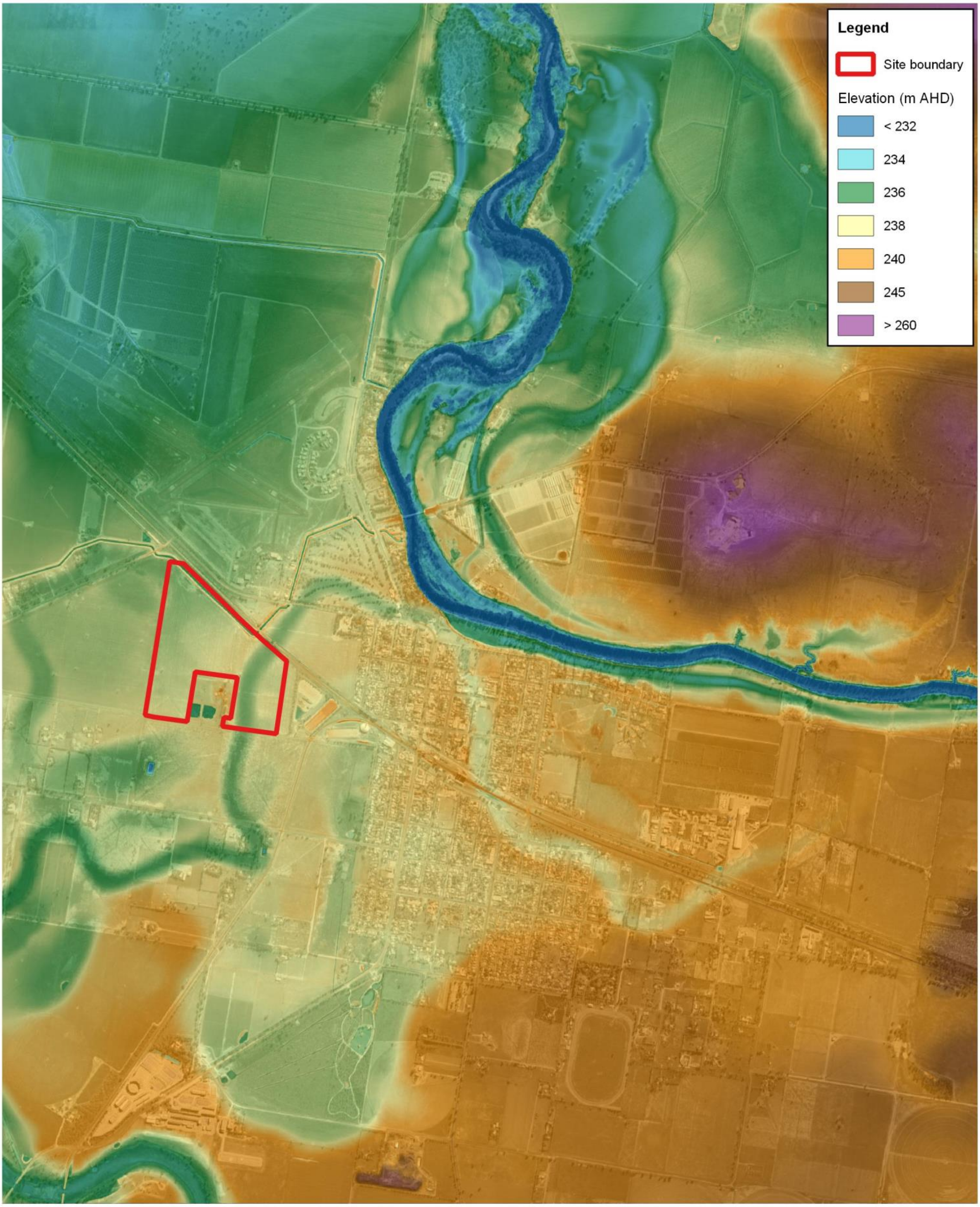

Title:

Local Floodplain Topography

0 0.9 1.8 km

approx. scale

Figure: **2**

Revision: **A**

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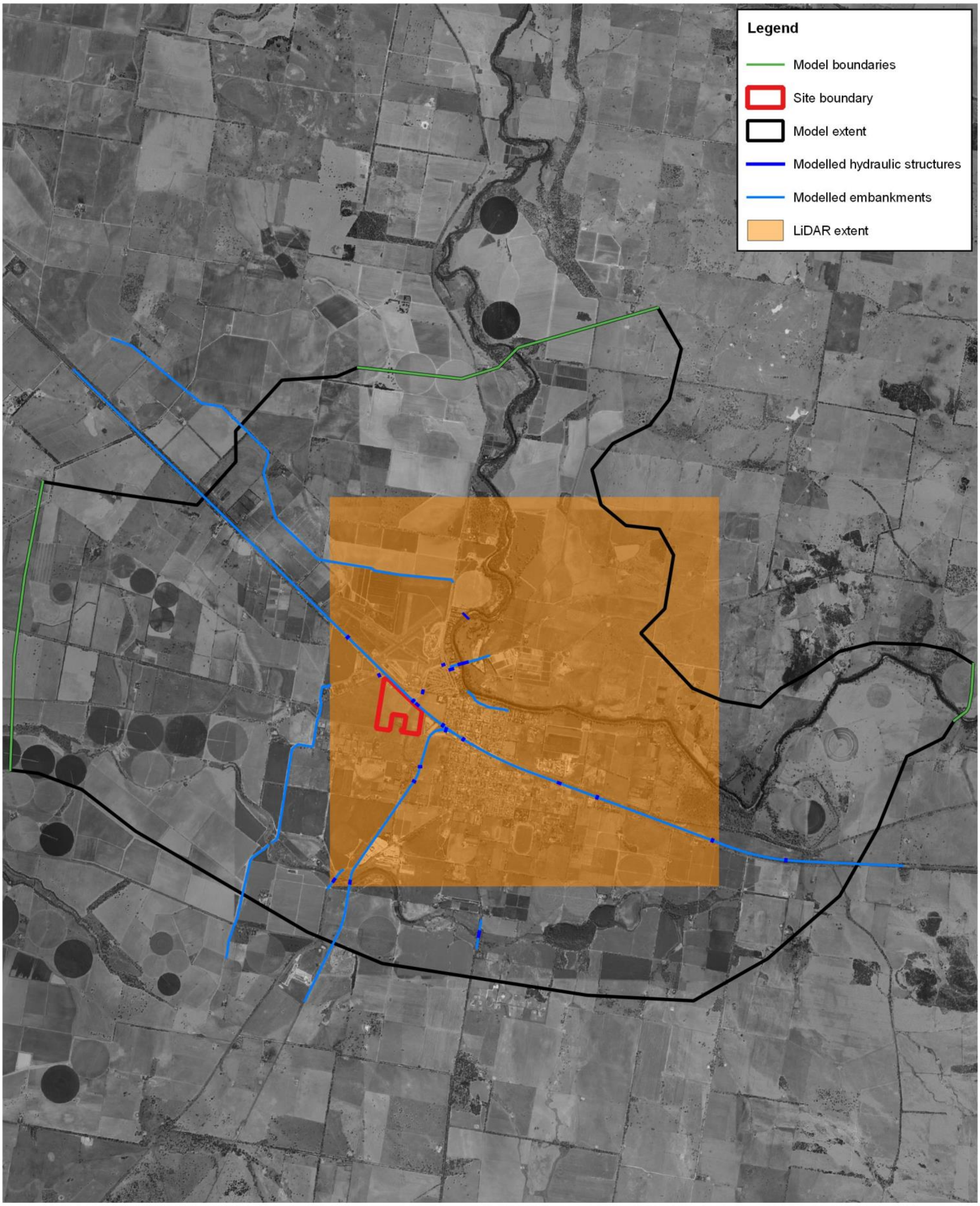

Title:

TUFLOW Model Components

Figure: **3**

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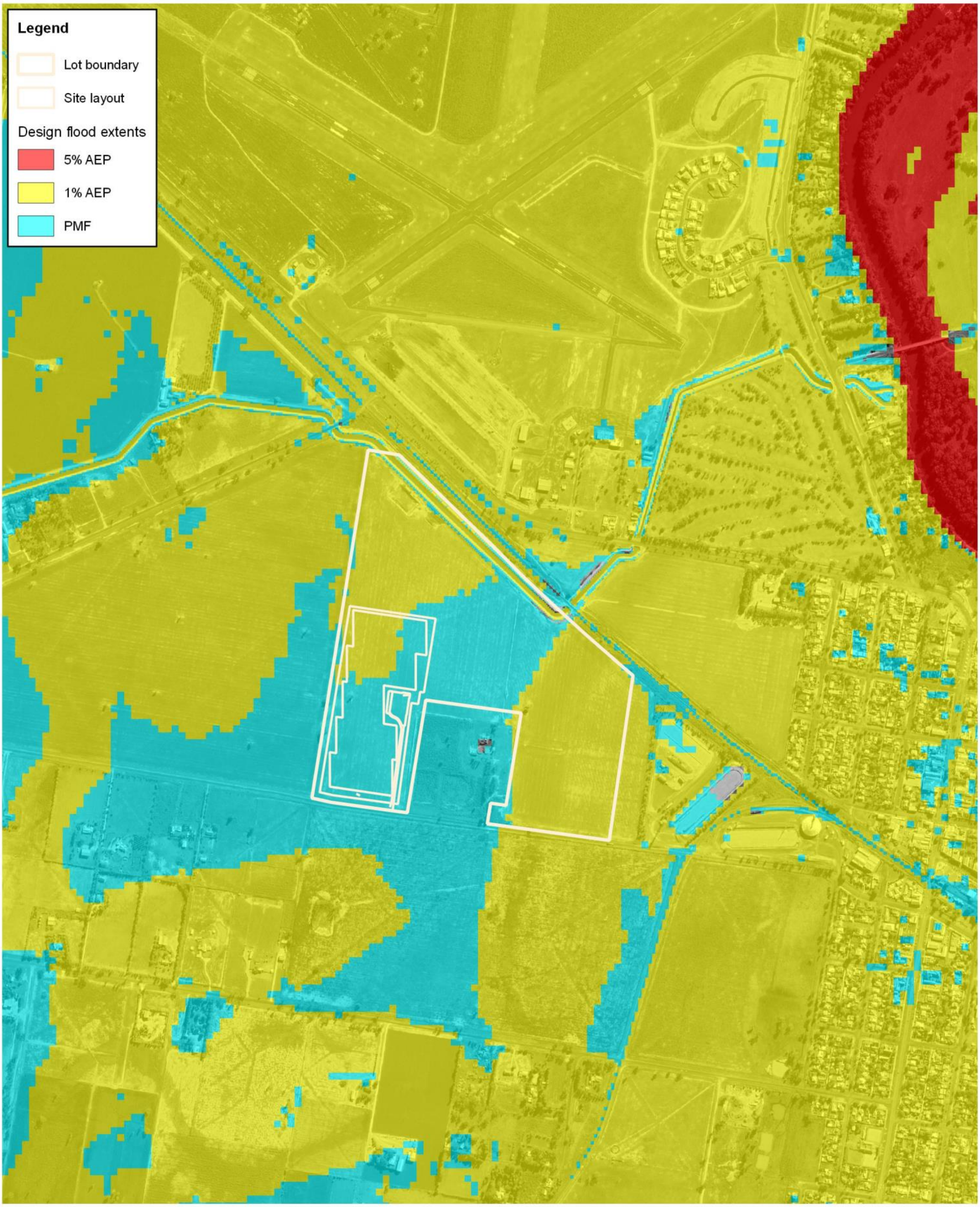

Title:

Modelled Flood Extents and Site Layout

0 400 800 m

approx. scale

Figure:	4
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Title:

Modelled 5% AEP Flood Depths and Levels

Figure: 5

Revision: A

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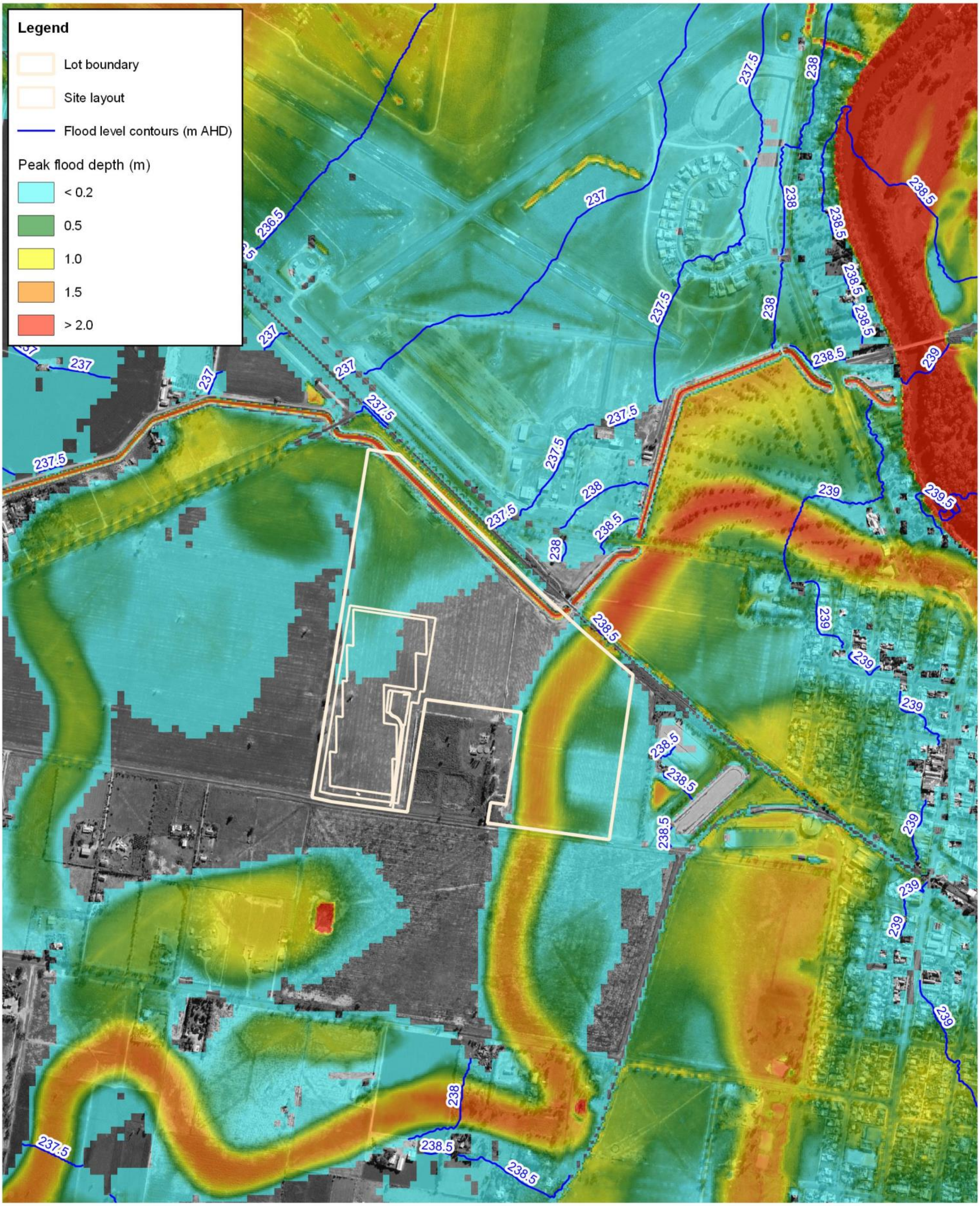

Title:

Modelled 1% AEP Flood Depths and Levels

0 400 800 m

approx. scale

Figure: 6

Revision: A

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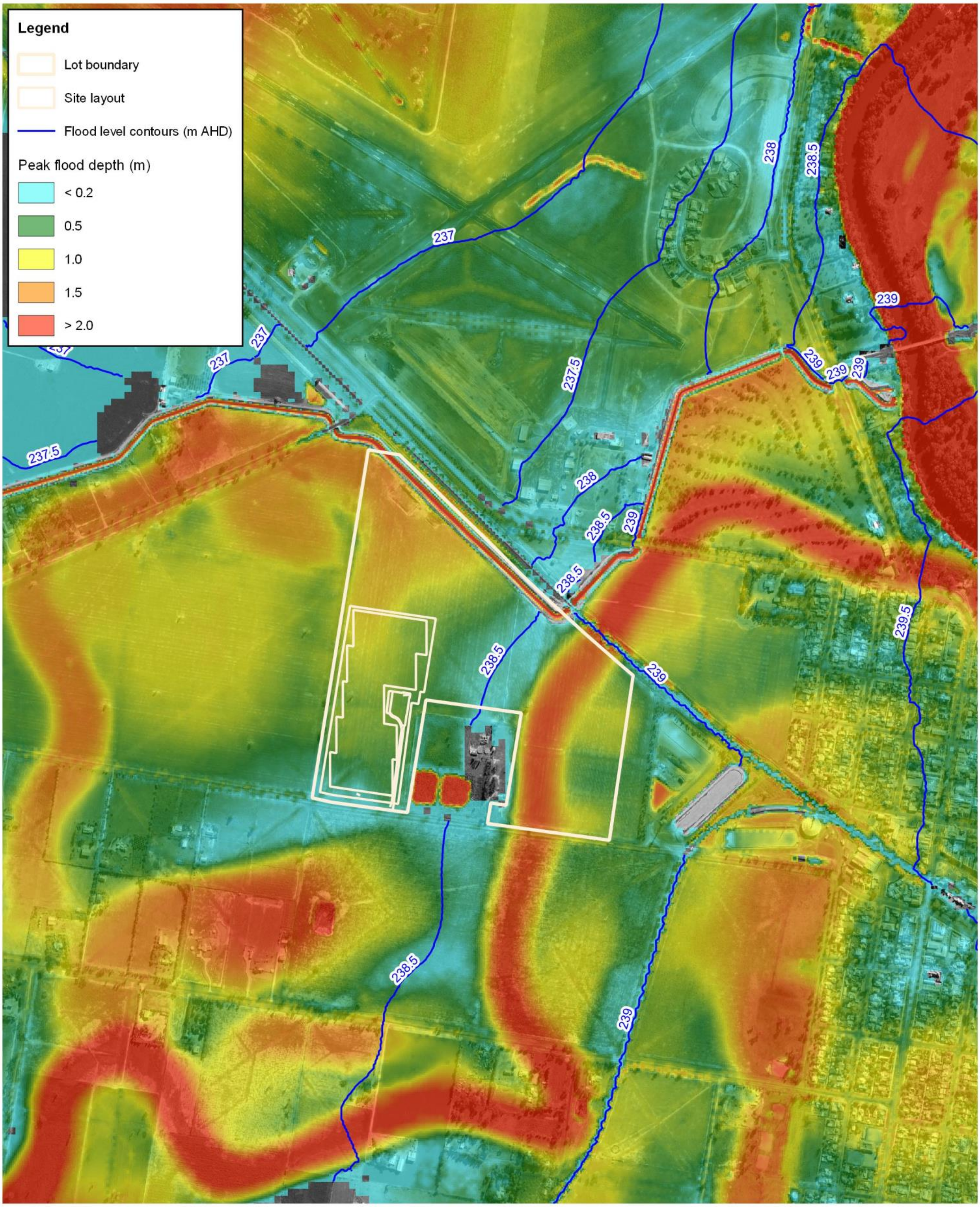

Title:

Modelled 0.5% AEP Flood Depths and Levels

0 400 800 m

approx. scale

Figure:	7
Revision:	A

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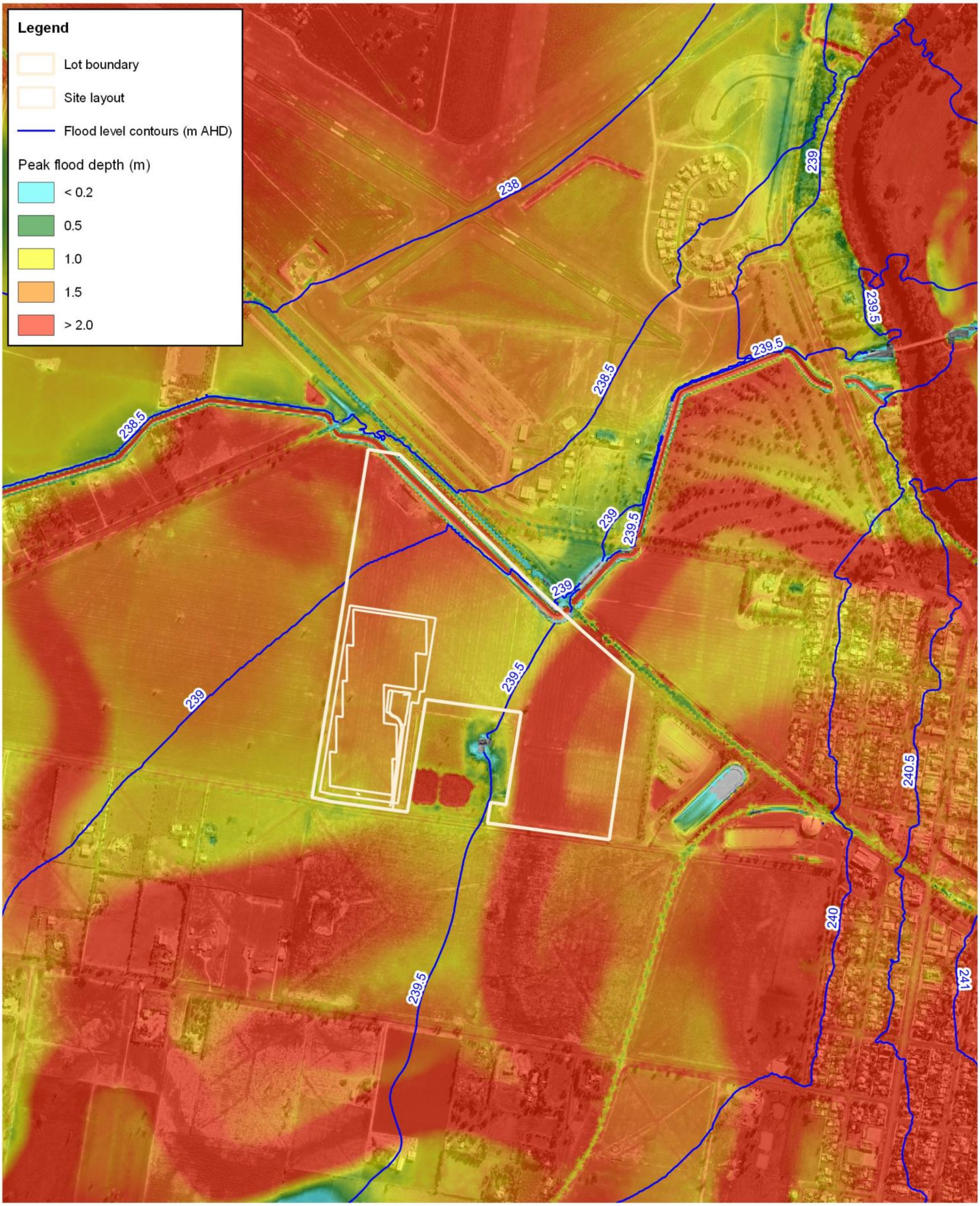

Title:

Modelled Extreme Flood Depths and Levels

0 400 800 m

approx. scale

Figure: **8**

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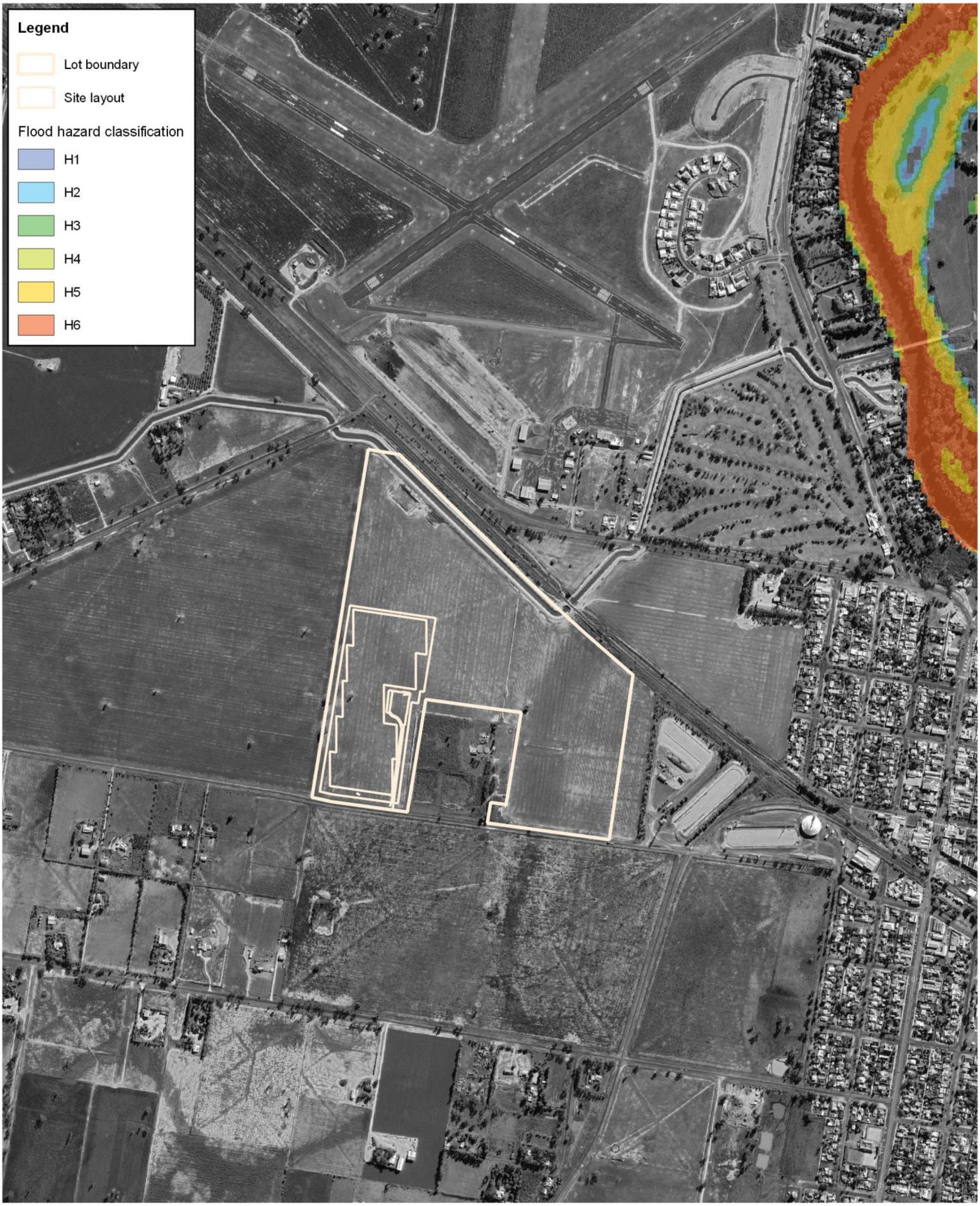

Title:

5% AEP Flood Hazard Classification

0 400 800 m

approx. scale

Figure: 9

Revision: A

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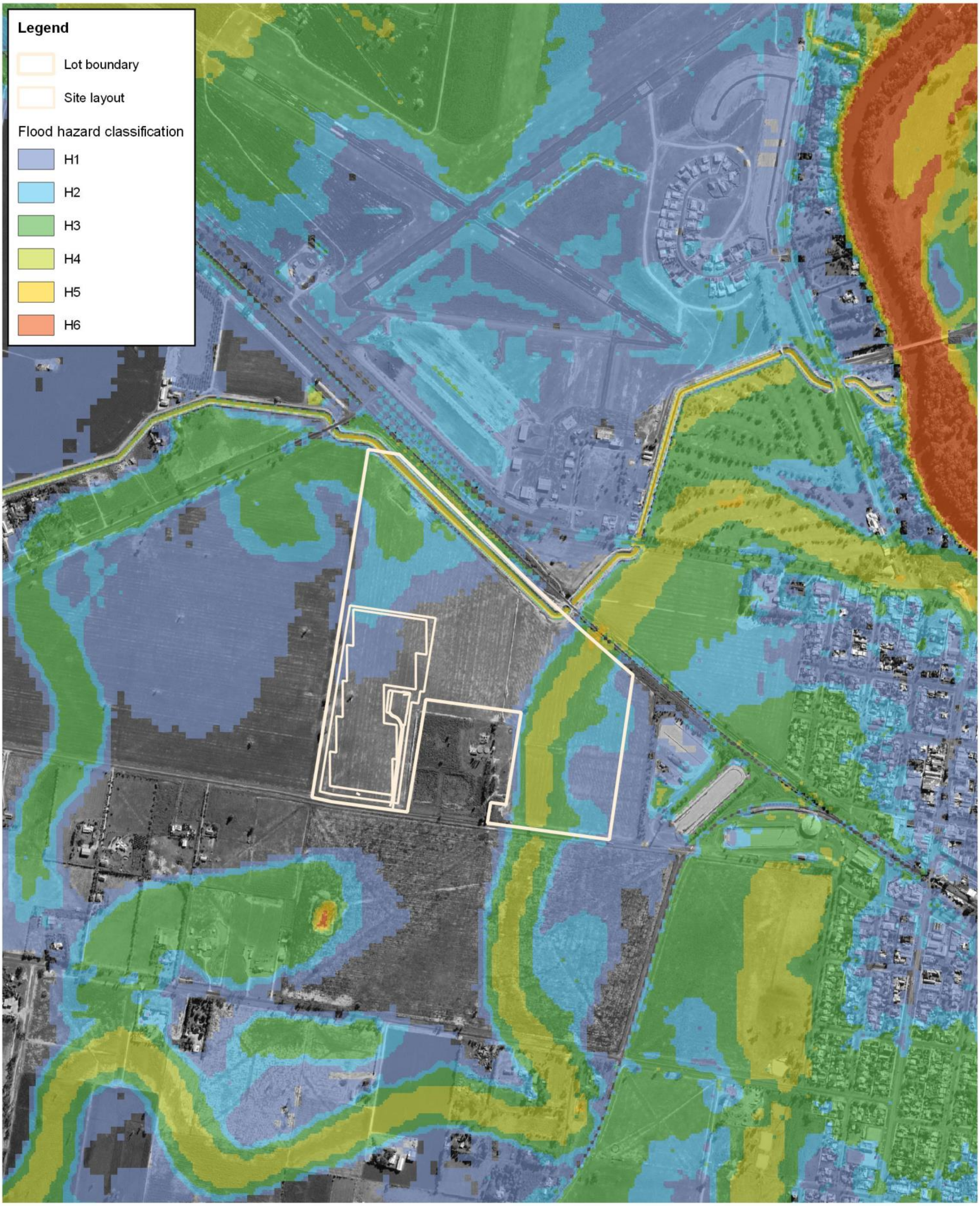

Title:

1% AEP Flood Hazard Classification

0 400 800 m

approx. scale

Figure: 10

Revision: A

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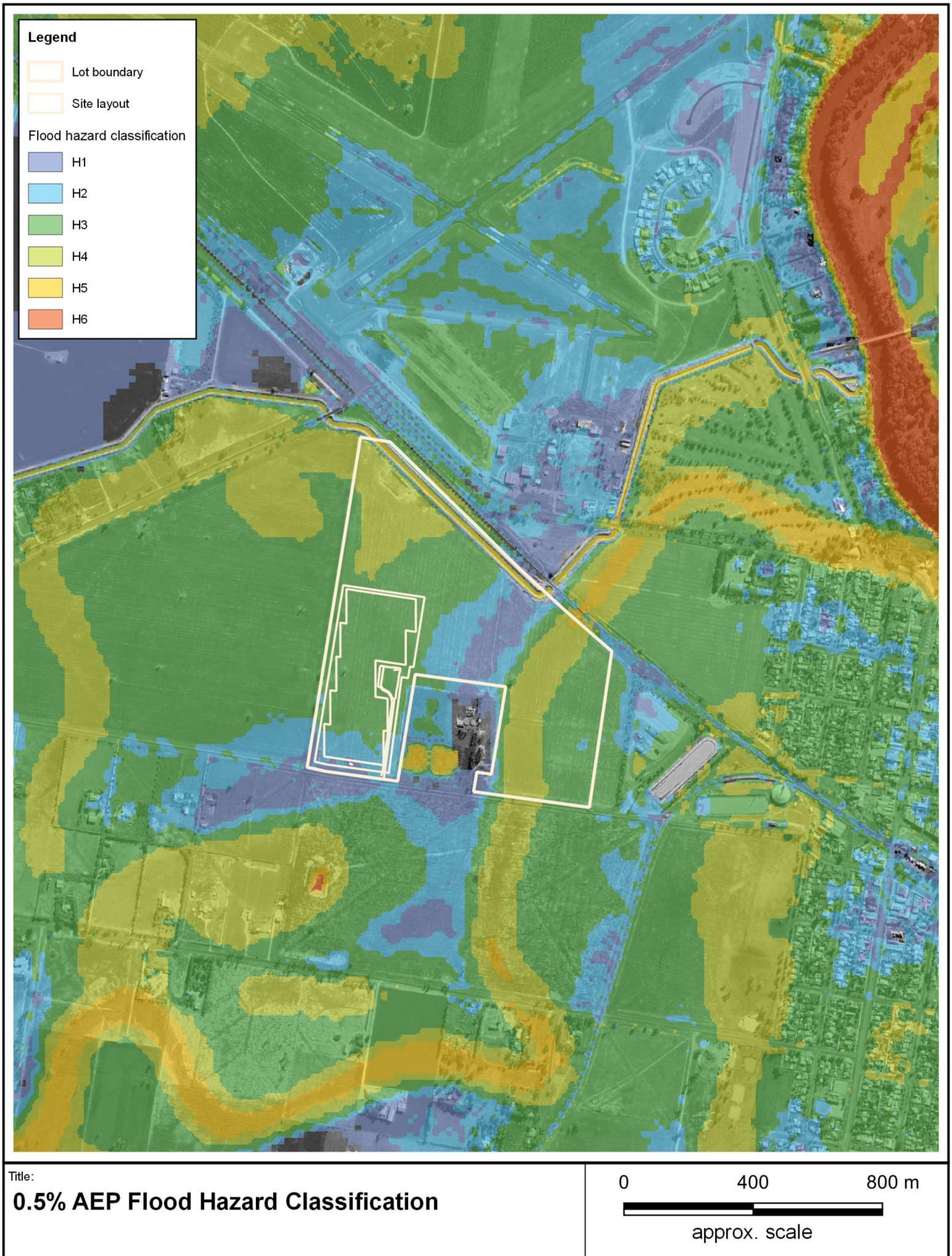

Title:

0.5% AEP Flood Hazard Classification

Figure: 11

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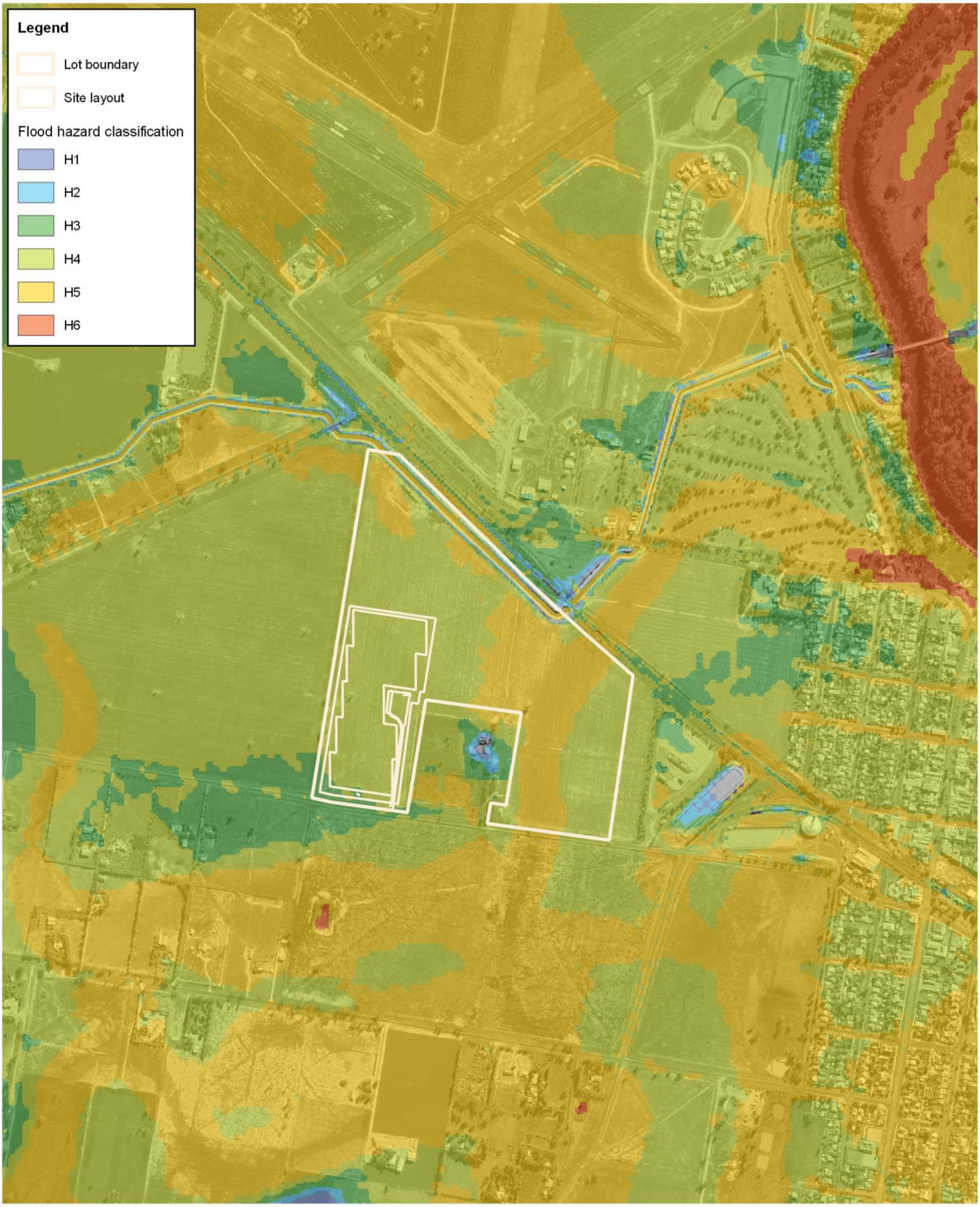

Title:

Extreme Flood Hazard Classification

Figure: **12**

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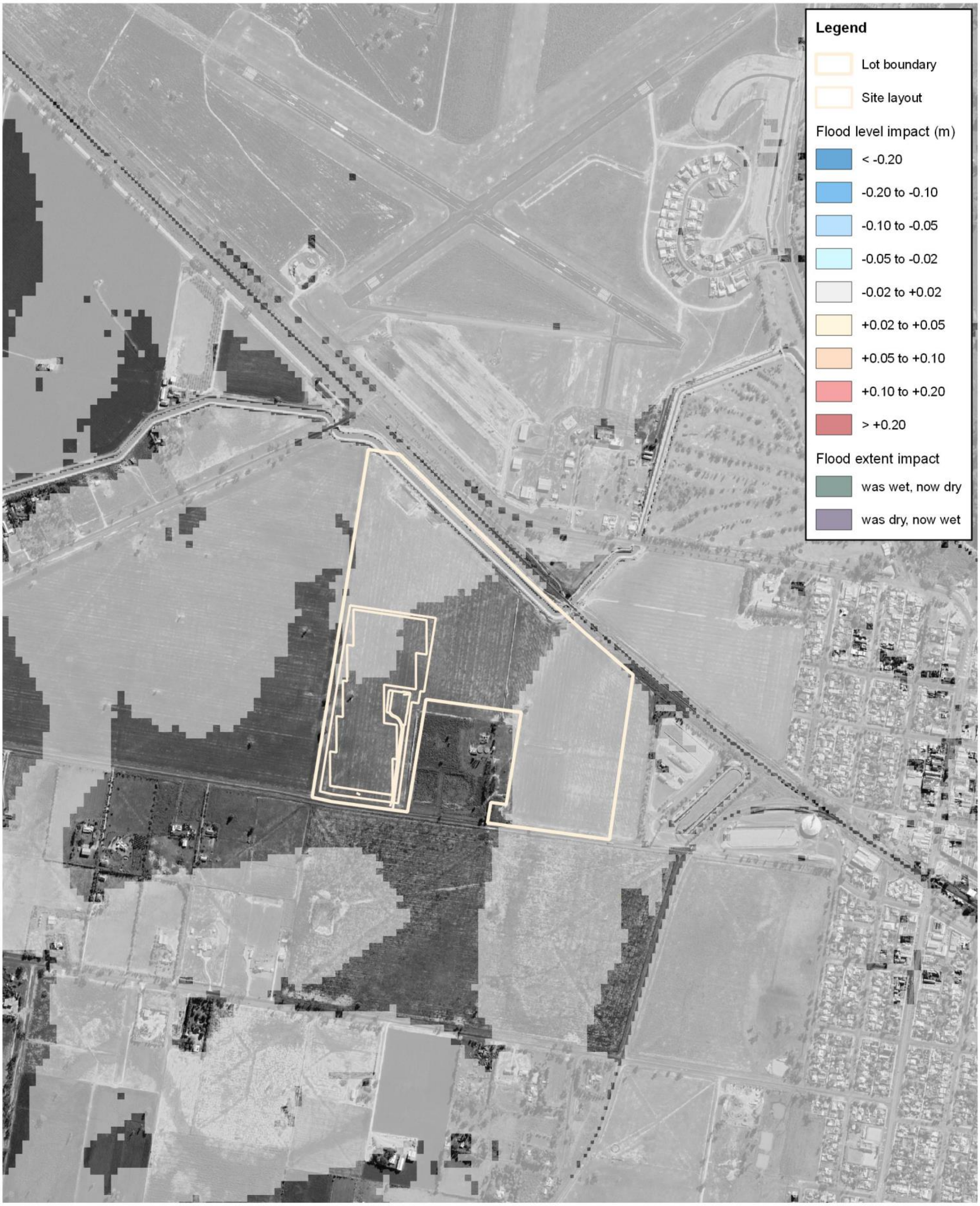

Title:

Modelled 1% AEP Peak Flood Level Impact

Figure: **13**

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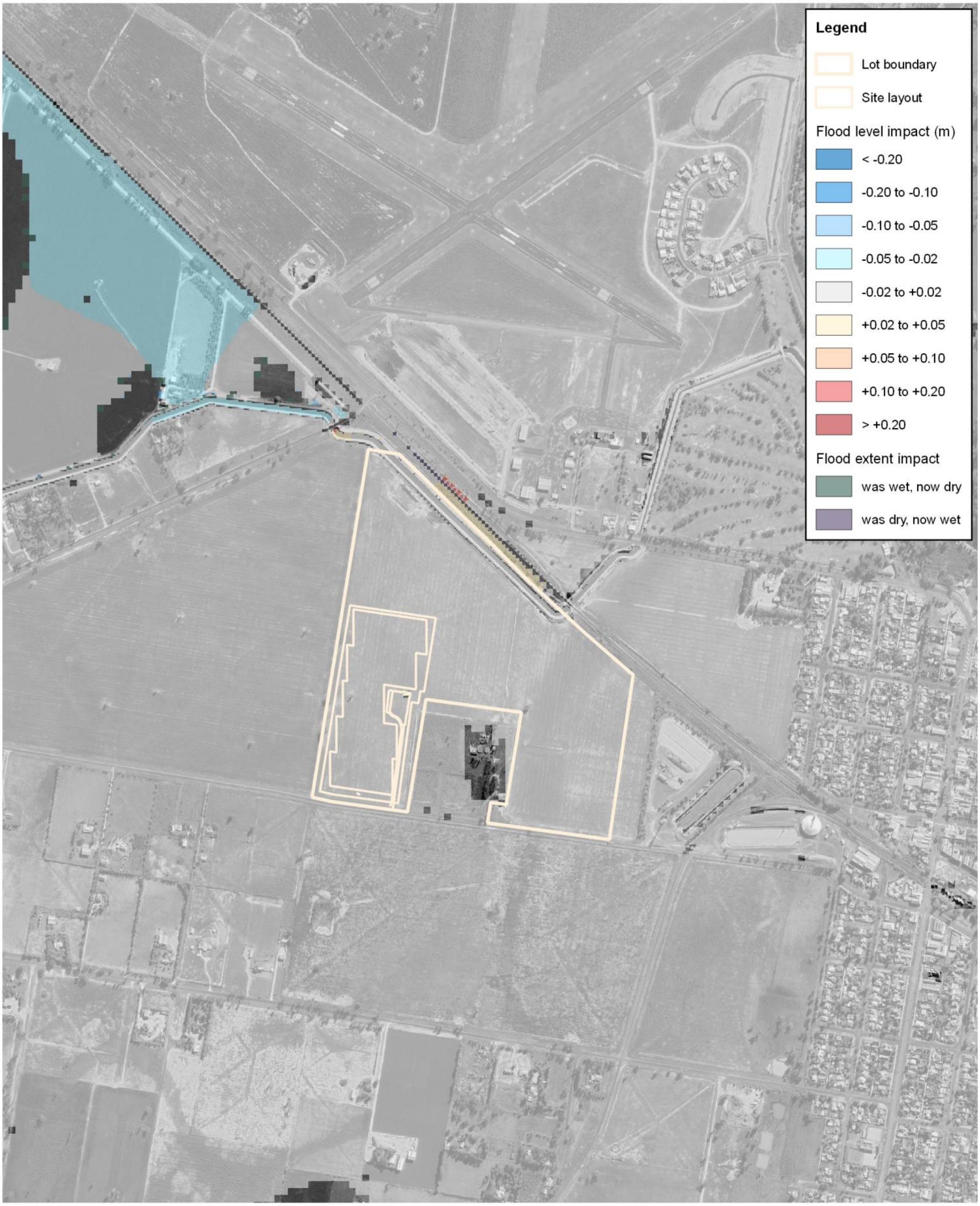

Title:

Modelled 0.5% AEP Peak Flood Level Impact

0 400 800 m

approx. scale

Figure: **14**

Revision: **A**

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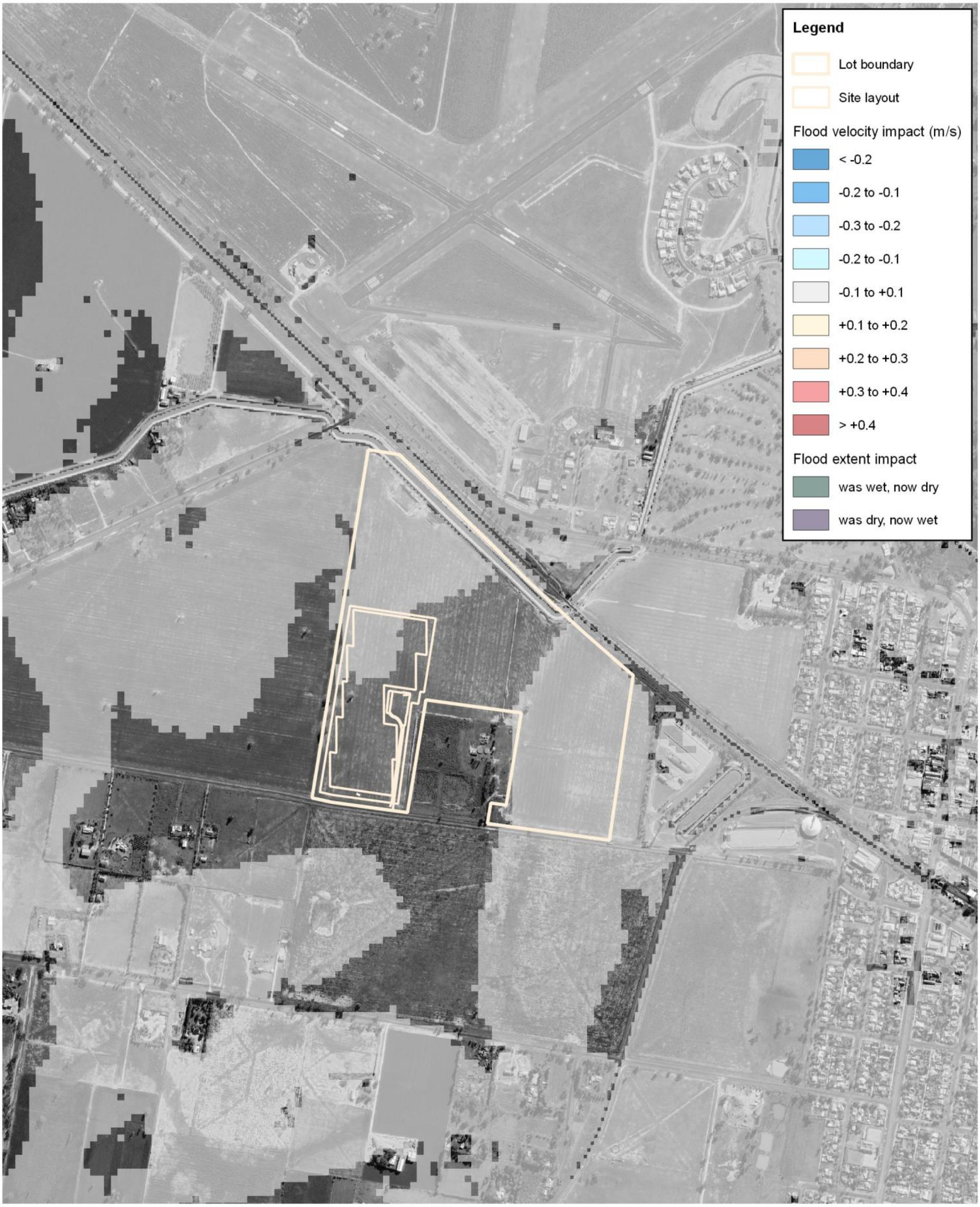

Title:

Modelled 1% AEP Peak Flood Velocity Impact

0 400 800 m

approx. scale

Figure: **15**

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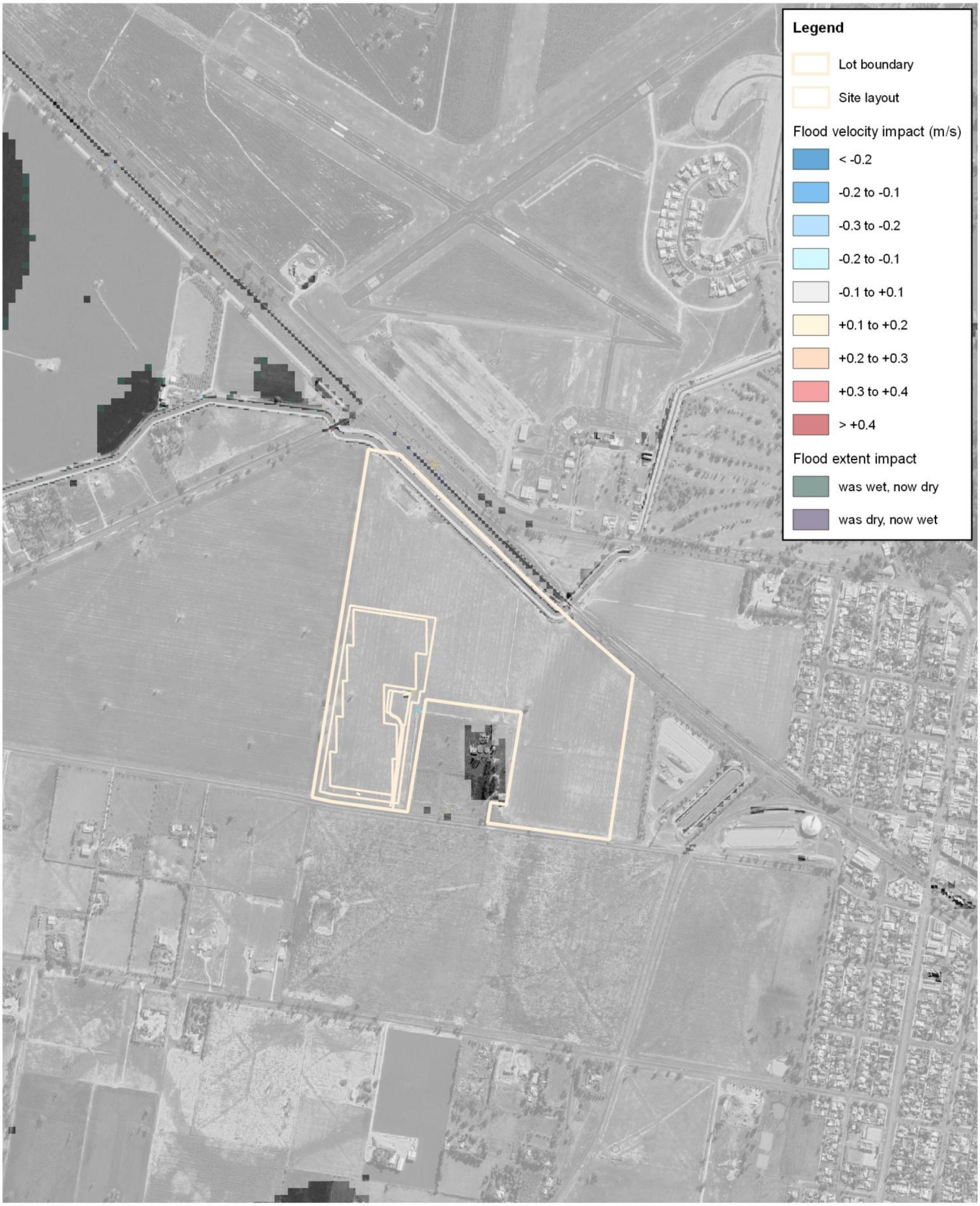

Title:

Modelled 0.5% AEP Peak Flood Velocity Impact

0 400 800 m

approx. scale

Figure: **16**

Revision: **A**

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