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Our Ref: DJW: L.T2104.003.docx

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

Dear Jeremy

RE: FLOOD IMPACT ASSESSMENT FOR PROPOSED NARRABRI SOLAR FARM AT LOT 489 DP754944, AIRPORT ROAD, NARRABRI NSW

Background

Torrent Consulting was engaged to undertake a Flood Impact Assessment to assist in the DA process for the proposed Narrabri Solar Farm at Airport Road (Lot 489 DP754944), Narrabri, NSW (the Site). It is understood that Council has identified the site as being potentially at risk of flooding, with existing flood information available in the Narrabri Flood Study (WRM, 2016) and the Narrabri Floodplain Risk Management Study and Plan (WRM, 2019).

The Site is located at the edge of the right floodplain of Namoi River (as presented in Figure 1), the catchment area of which totals over 25 000 km^2 at Narrabri. The Site is also affected by breakout flows from Horsearm Creek, some 3 km to the north. Local catchment drainage also traverses the northern end of the Site, conveying runoff from the hillslopes to the east through to Horsearm Creek. The local catchment is over 3 km^2 upstream of the Site.

There are no existing design flood conditions for the local catchment at the Site. The assessment therefore includes the development of a TUFLOW model. This model will provide a platform to assess the potential flood impacts associated with the proposed development. It will also enable a more detailed understanding of the local flood depths, velocities and hazards.

Model Development

For this assessment, a TUFLOW hydraulic model was developed covering the site and the local contributing catchment area, which is around 3 km^2. The model utilised the NSW Spatial Services LiDAR data product, downloaded via the ELVIS Foundation Spatial Data portal to define the local topography, as presented in Figure 2.

As the Site is potentially impacted by flooding from the Namoi River, the model extent also includes the right floodplain of the Namoi, as presented in Figure 3. The model was constructed using a 5 m grid cell resolution, sampling elevations from the LiDAR data.

Land use coverage in the catchment was digitised using aerial imagery, to distinguish between cleared land and areas of remnant vegetation. The cleared land was assigned a Manning's 'n' roughness coefficient of 0.06, with areas of remnant vegetation being assigned an 'n' value of 0.12.

The boundaries of the model were configured to reproduce flooding from the Namoi River as presented in the Narrabri Floodplain Risk Management Study and Plan. An upstream inflow boundary was applied to represent floodplain flows within the modelled area, with a downstream boundary to represent tailwater

levels. The flows and levels were estimated using information contained in the Narrabri Floodplain Risk Management Study and Plan. Following initial model simulations these flows and levels were adjusted until the modelled flood extents and levels matched those in the Narrabri Floodplain Risk Management Study and Plan mapping. Direct rainfall input was applied to the upstream hillslopes to the east to simulate catchment runoff and any resultant local flooding.

Design Flood Hydrology

The TUFLOW model was simulated (using the HPC solver) for the 5% AEP, 1% AEP and 0.5% AEP design rainfall events for storm durations ranging from two hours to nine hours. The design rainfall depths were sourced from the BoM IFD (Intensity Frequency Duration) portal. An Areal Reduction Factor (ARF) was applied to the design point rainfall using the contributing catchment area of 3 km^2 upstream of the Site. ARFs calculated in accordance with ARR 2019 for the Central NSW ARF region range from around 0.96 at the 2-hour duration to 1.0 at the 9-hour duration.

Design rainfall losses considered the recent NSW-specific guidance and initial losses of 8-15 mm and 16-18 mm (for the 1% AEP and 5% AEP respectively) and a continuing loss of 0.4 mm/h were adopted accordingly.

The ARR 2019 guidelines ensemble method to design flood hydrology involves the simulation of ten rainfall temporal patterns for each design event magnitude and duration, with the average condition of the ten being adopted for design purposes. The point rainfall temporal patterns provided for the Central Slopes temporal rainfall region were adopted for the ensemble method accordingly.

The TUFLOW model simulations were analysed at the point of discharge next the Site to identify the critical duration, i.e. that which produces the peak flood flows for each design event magnitude. This is undertaken by calculating the average peak flood flow and the peak flood flow variance of the ten simulated hydrographs for each design event duration and magnitude. The 4.5-hour duration was identified as being critical for the 5% AEP event, with the 3-hour being critical for the 1% AEP and 0.5% AEP events. The design temporal pattern IDs 2339 and 2282 were selected for the 5% AEP and 1% AEP events respectively, as producing hydrographs most representative of the mean design condition from the results of the ensemble method.

For the simulation of the PMF (Probable Maximum Flood) condition the Generalised Short Duration Method (GSDM) published by the BoM was adopted. Events for the 15-minute to 2-hour durations were simulated to determine the critical conditions. This found the Probable Maximum Precipitation (PMP) for the 1.5-hour duration to be critical, with a rainfall depth of 480 mm (320 mm/h intensity). The simulated peak design flows discharging from the Site are summarised in Table 1.

Table 1 – Modelled Peak Design Flows (m^3/s)

Design Event	Site Outlet
5% AEP 4.5-hour (2339)	8.0
1% AEP 3-hour (2282)	13.7
0.5% AEP 3-hour (2282)	20.5
PMF 1.5-hour (GSDM)	234

Note: contents of parentheses denote the adopted design temporal pattern ID

Baseline Design Flood Conditions

The TUFLOW hydraulic model was simulated (using the HPC solver) for the adopted design flood hydrology. Figure 4 presents the modelled peak flood extents at the Site for the 5% AEP, 1% AEP and PMF 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 PMF (Extreme Flood Event for the Namoi River floodplain) 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 PMF (Extreme Flood Event for the Namoi River floodplain) 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.

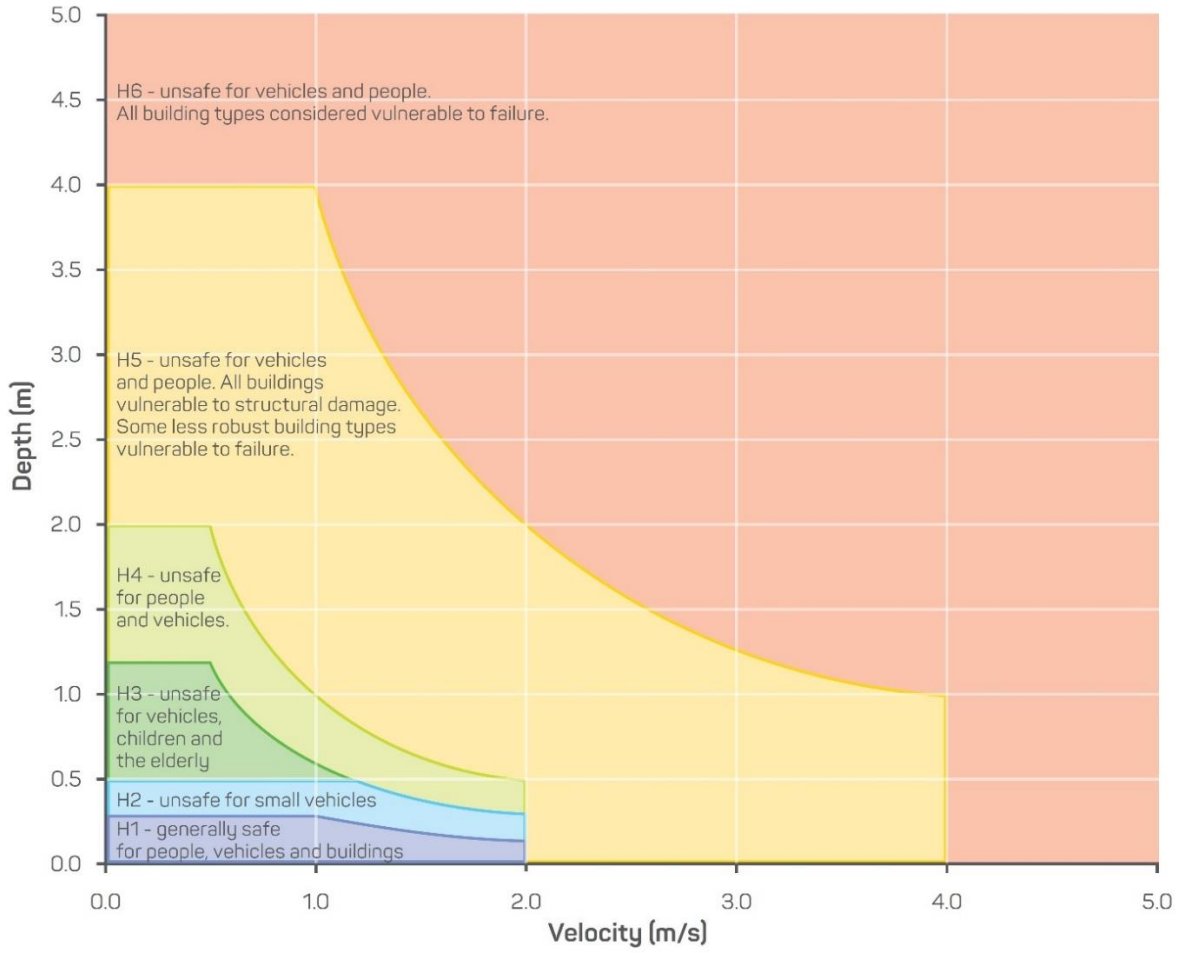


Chart 1 – General Flood Hazard Vulnerability Curves (AIDR, 2017)

The modelled flood conditions show that the Site is unaffected by local catchment flooding. Whilst the northern area of the Lot is flood-prone, the southern area in which the Solar Farm is to be located is flood-free at the 1% AEP and 0.5% AEP events. The Site is not totally free from flood risk, however, as it can potentially become inundated by a local catchment PMF event or an Extreme Flood event of the Namoi River. For an Extreme Flood of the Namoi River the modelled flood hazards would be expected to damage infrastructure. However, for a local catchment PMF event the resultant flood hazard within the proposed Solar Farm footprint is only low (H1 or H2), as presented in Figure 13.

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 flood modelling results show that at the 1% AEP event (and the 0.5% AEP event) the proposed solar farm infrastructure is unaffected by flooding.

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. Ample flood-free refuge is available on-site if people are present during a local catchment flood PMF event. For an Extreme Flood of the Namoi River the entire Site would be inundated. It is advised that the Solar Farm be closed to site visitors in the event of a Major Flood Warning being issued by the BoM for the Namoi River to manage this minimal risk. This course of action is advisable regardless of risk to the Site, as local and regional roads could be flood-affected, preventing Site access.

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. However, as the proposed Solar Farm is only inundated in an extreme flood event, the potential for adverse off-site flood impacts is negligible and therefore further consideration of flood impacts is not required.

Conclusion

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

This assessment has included development of a TUFLOW model for the local catchment runoff and has simulated design flood conditions in accordance with the ARR 2019 guidelines, specifically the ensemble method for design flood hydrology. The main river flood conditions of the Namoi River have also been reproduced, using information contained in the Narrabri Floodplain Risk Management Study and Plan.

Flood hazard mapping has been produced that shows that the Site is of a low flood risk and is suitable for the proposed solar farm.

The flood modelling results show that at the 1% AEP event (and the 0.5% AEP event) the proposed solar farm infrastructure is unaffected by flooding, with the Solar Farm area being flood-free.

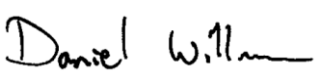
Ample flood-free refuge is available on-site if people are present during a local catchment flood event and all but an Extreme Flood event of the Namoi River, during which the entire Site would be inundated. It is advised that the Solar Farm be closed to site visitors in the event of a Major Flood Warning being issued by the BoM for the Namoi River to manage this minimal risk. This course of action is advisable regardless of risk to the Site, as local and regional roads could be flood-affected, preventing Site access.

As the proposed Solar Farm is only inundated in an extreme flood event, the potential for adverse off-site flood impacts is negligible and therefore further consideration of flood impacts is not required.

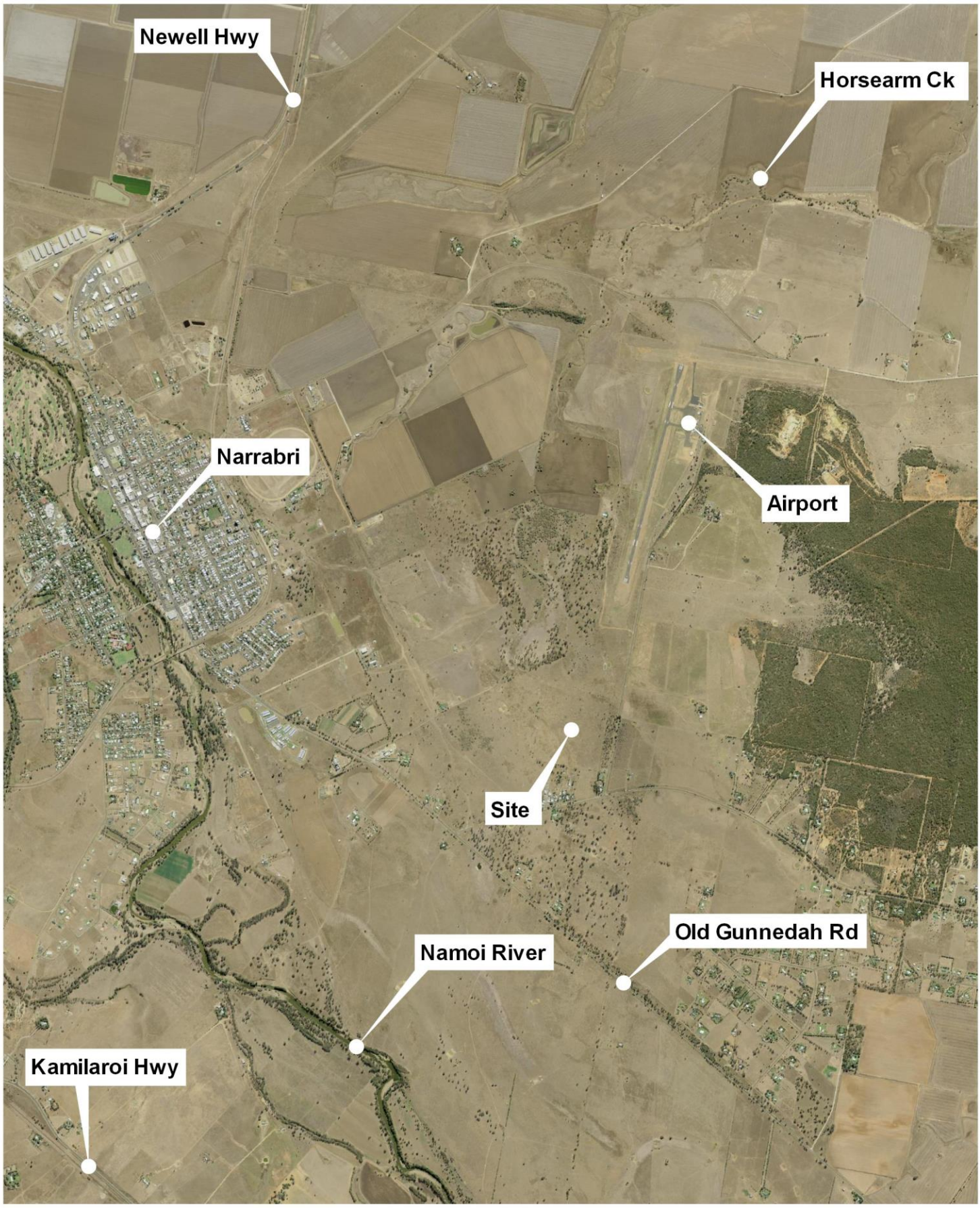
We trust that this report meets your requirements. For further information or clarification please contact the undersigned.

Yours faithfully

Torrent Consulting



Dan Williams
Director



Title:

Study Locality

0 1 2 km

approx. scale

Figure: 1

Revision: A

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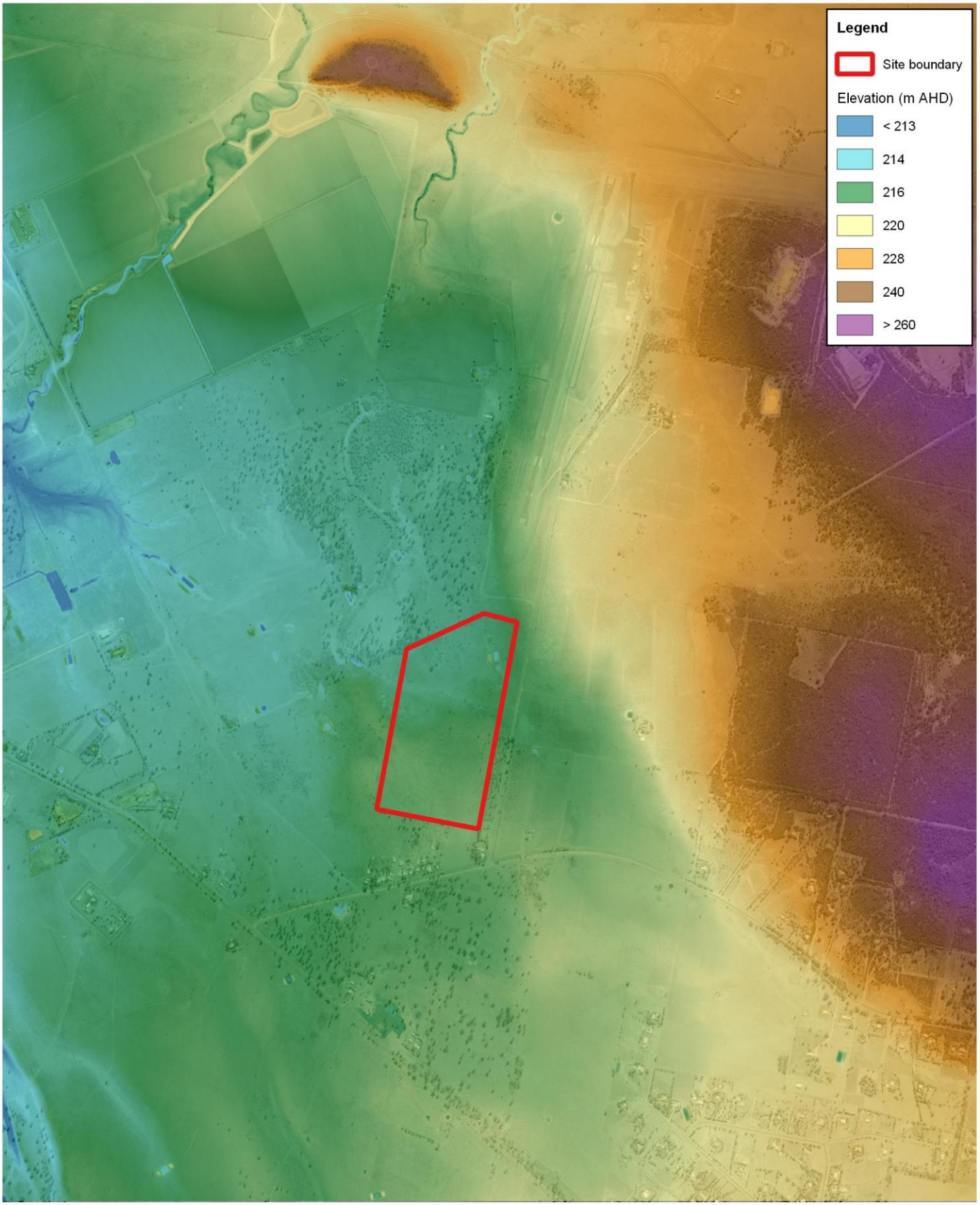

Title:

Local Topography

0 0.6 1.2 km

approx. scale

Figure: 2

Revision: A

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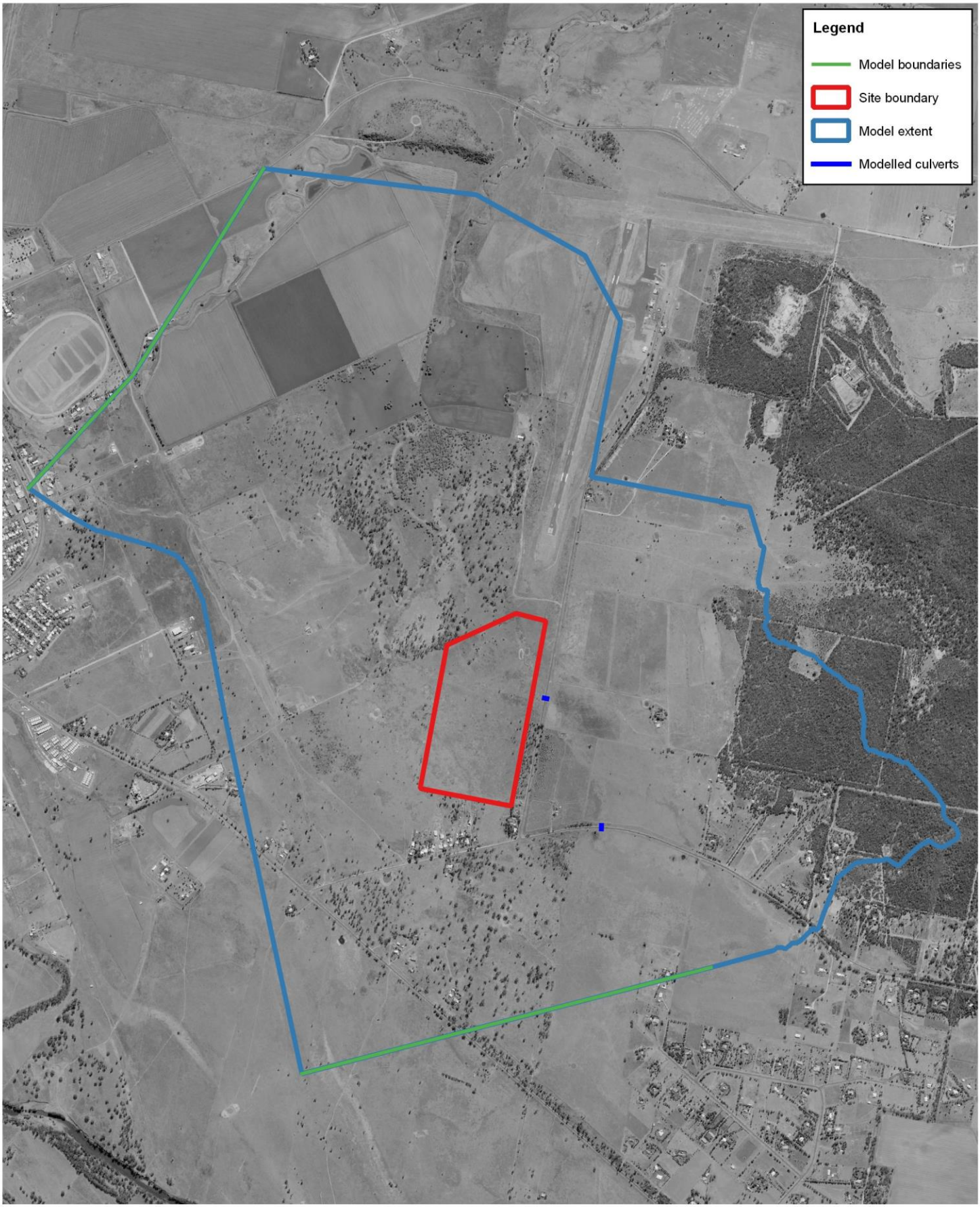

Title:

TUFLOW Model Components

0 0.7 1.4 km

approx. scale

Figure: 3

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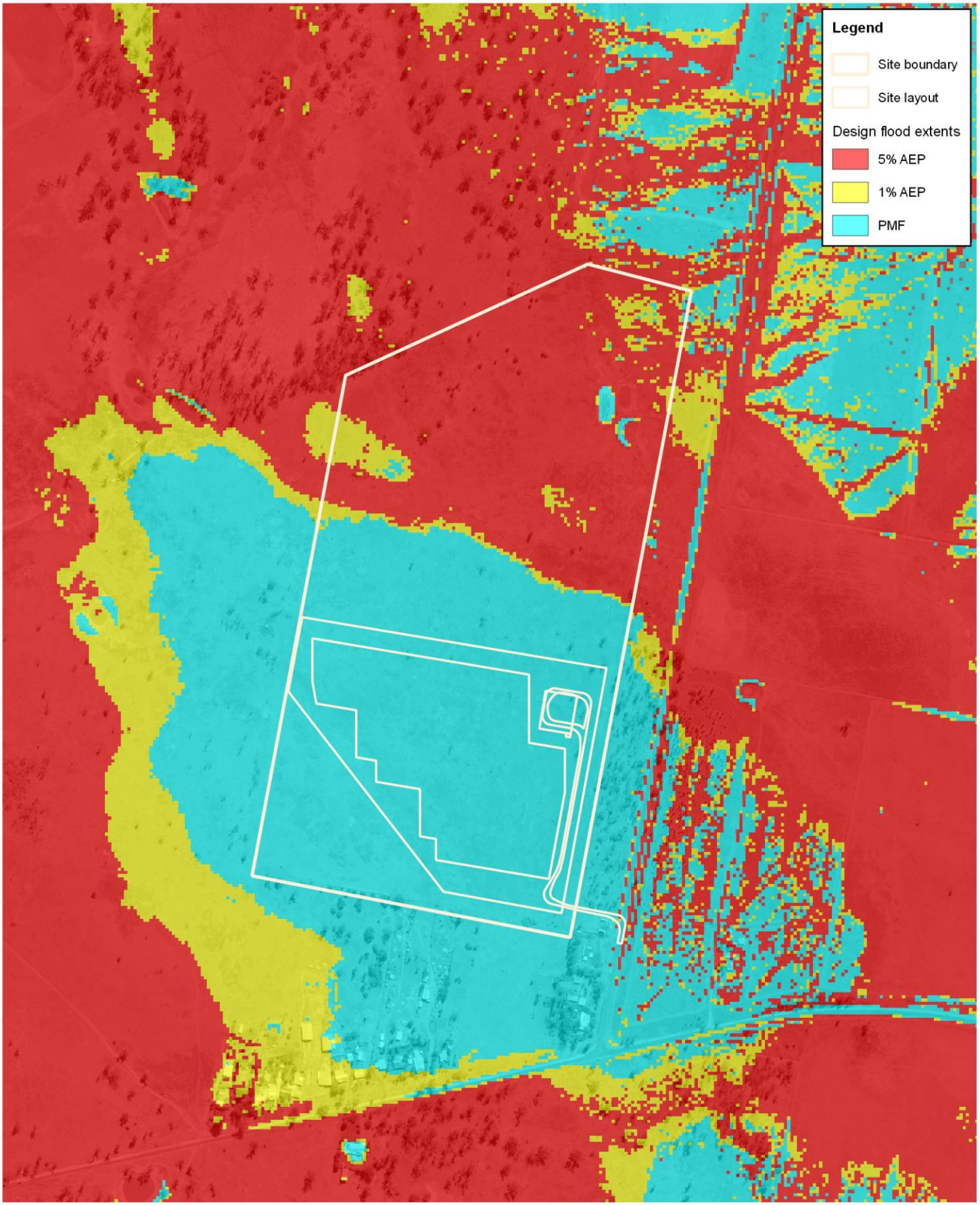

Title:

Modelled Flood Extents and Site Layout

0 200 400 m

approx. scale

Figure: 4

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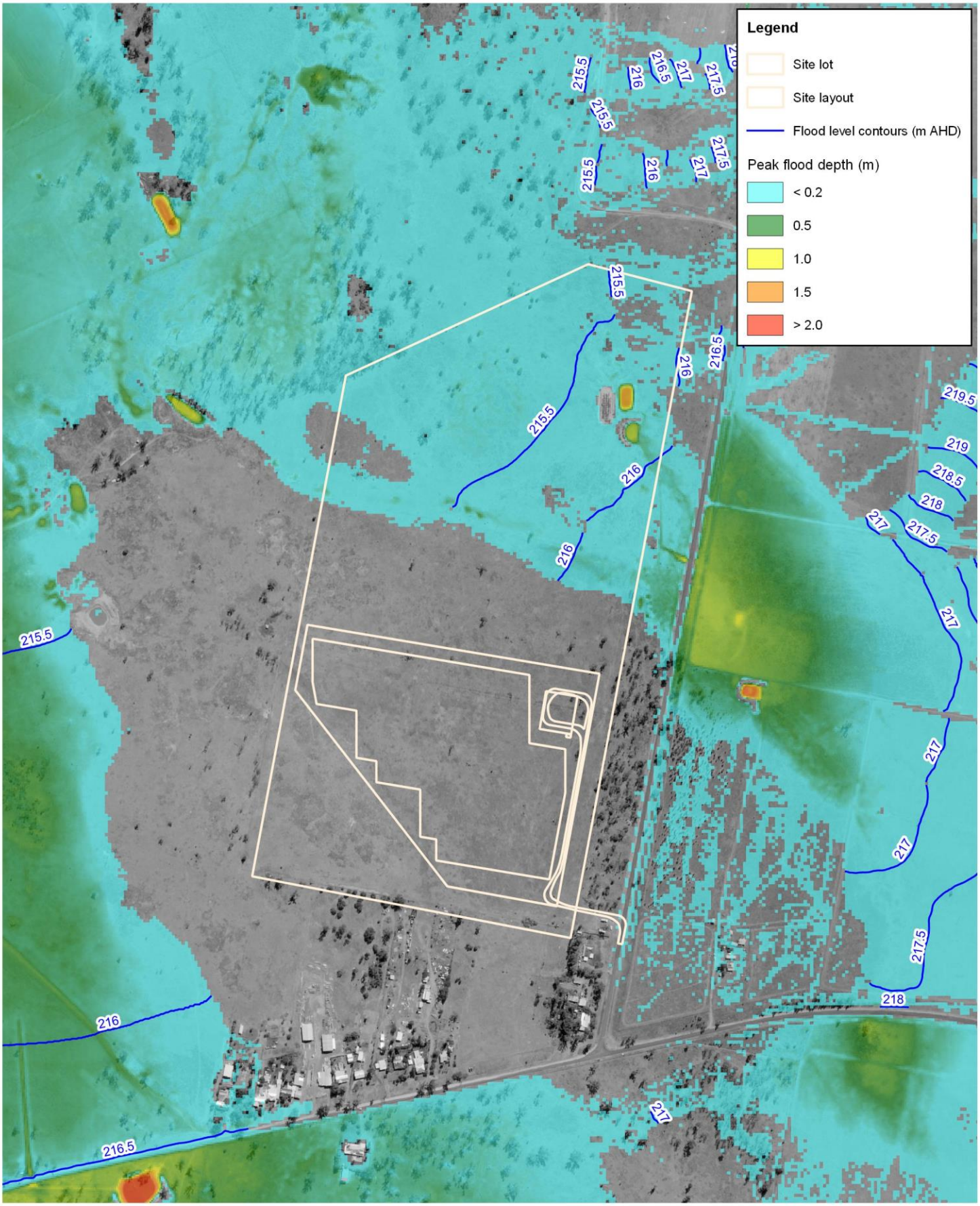

Title:

Modelled 5% AEP Flood Depths and Levels

0 200 400 m

approx. scale

Figure: 5

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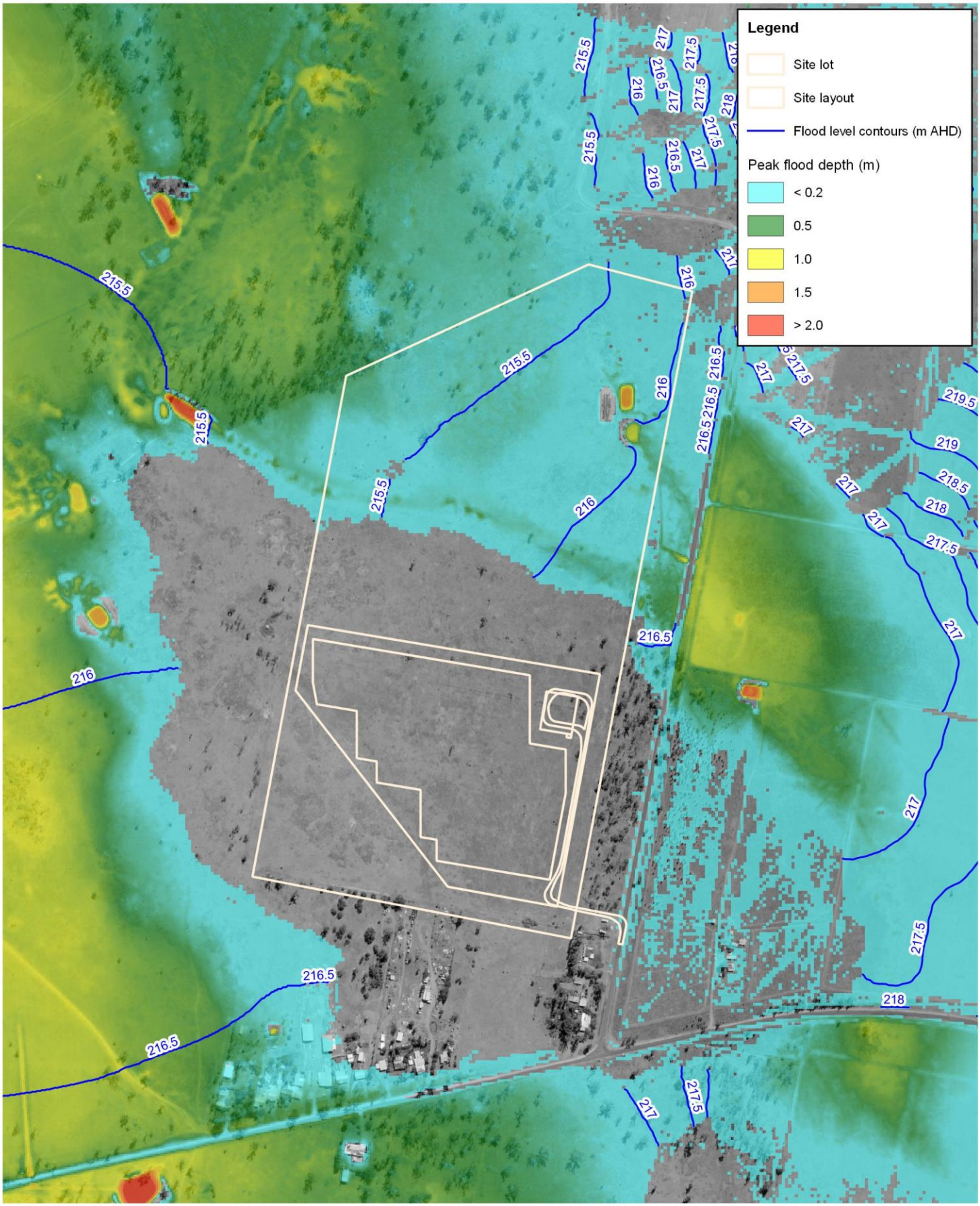

Title:

Modelled 1% AEP Flood Depths and Levels

0 200 400 m

approx. scale

Figure: 6

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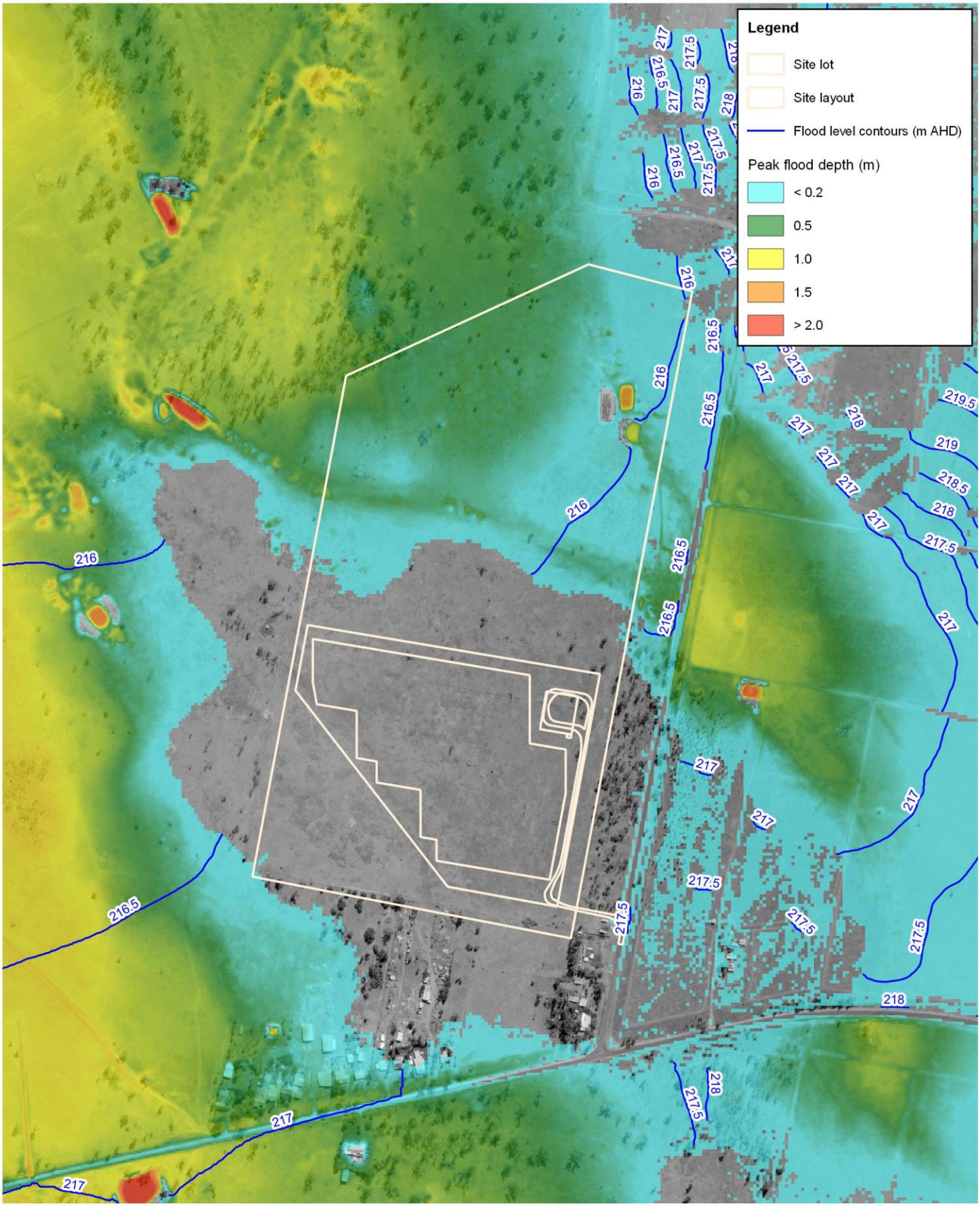

Title:

Modelled 0.5% AEP Flood Depths and Levels

0 200 400 m

approx. scale

Figure: 7

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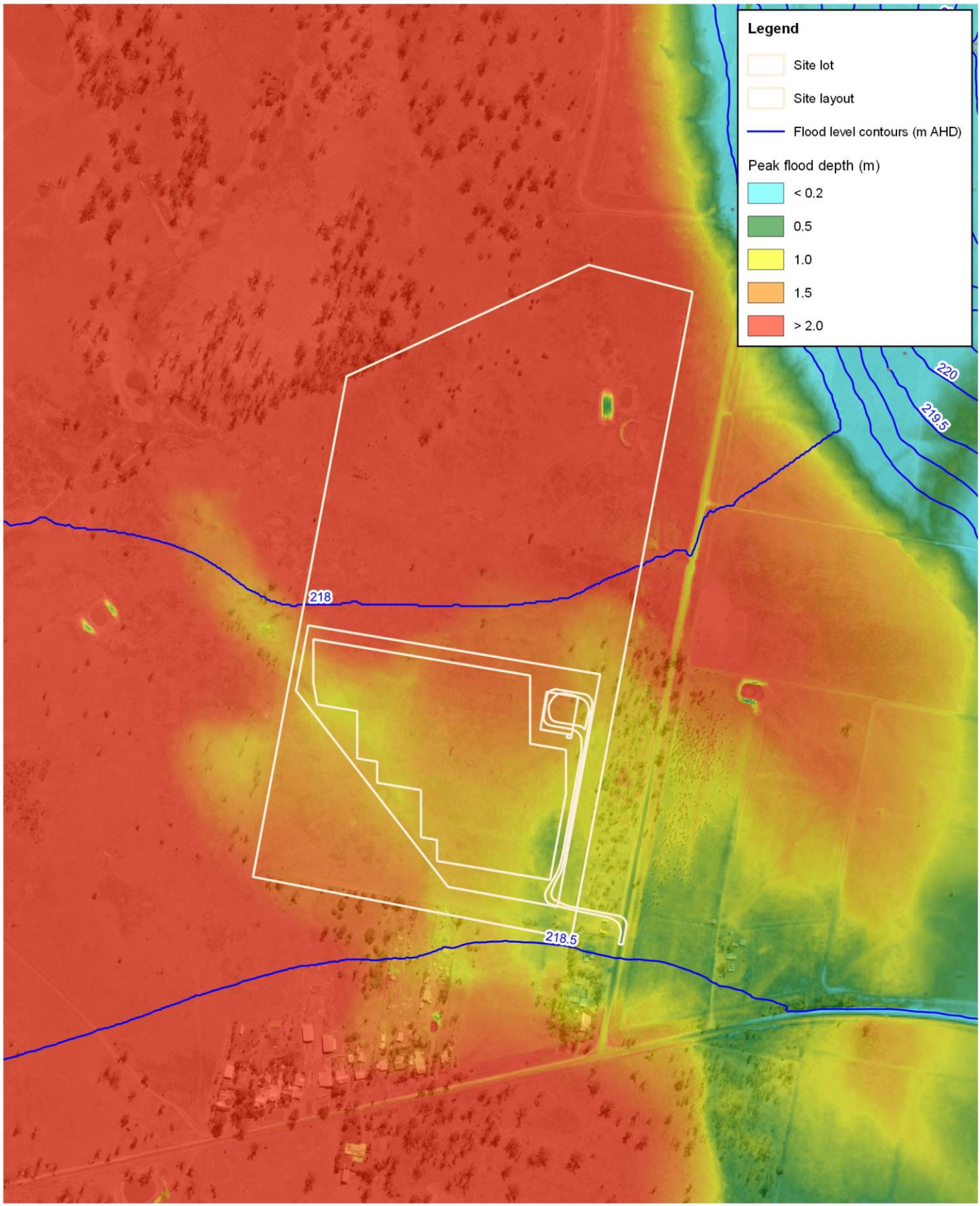

Title:

Modelled PMF/Extreme Flood Depths and Levels

0 200 400 m

approx. scale

Figure: 8

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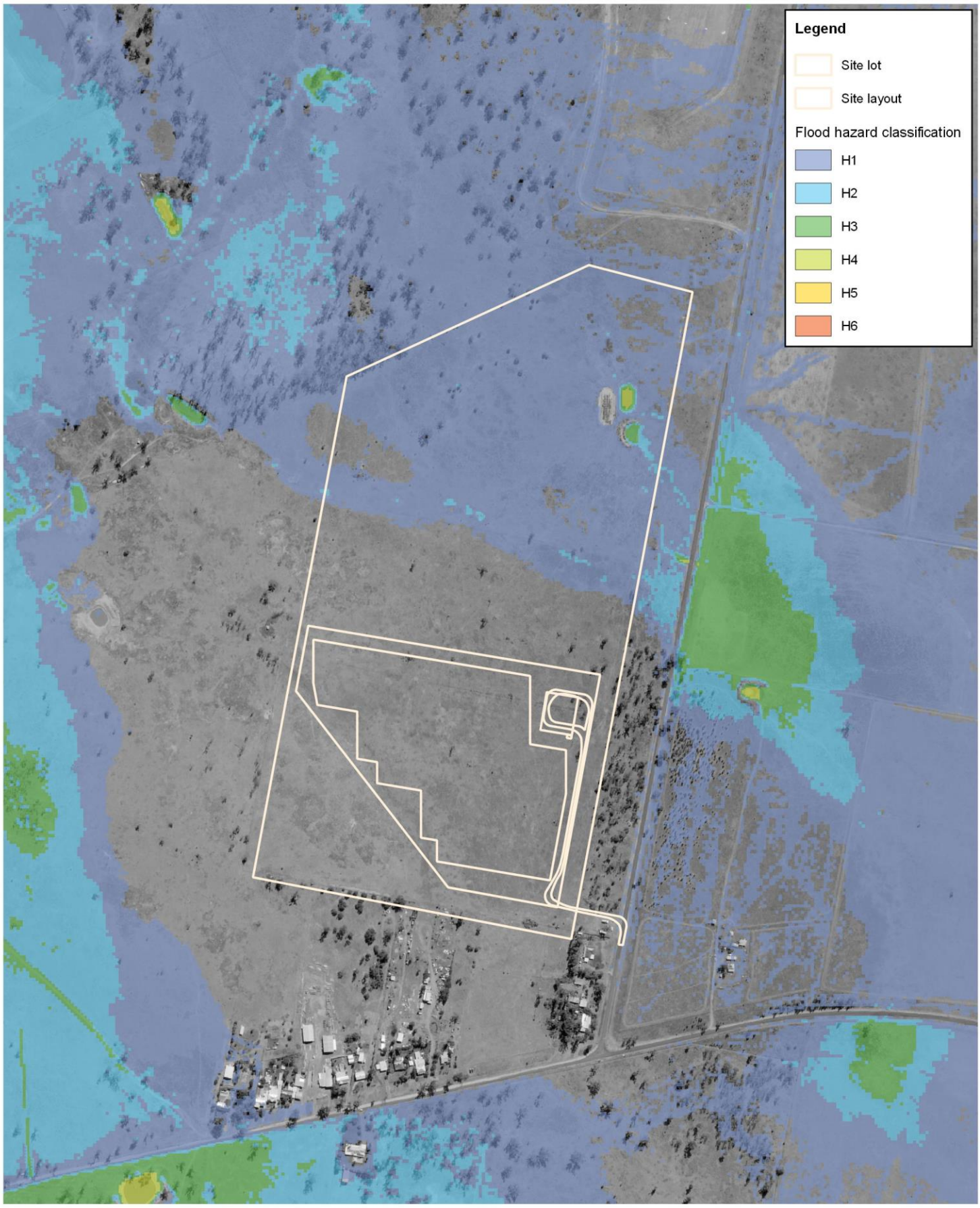

Title:

5% AEP Flood Hazard Classification

0 200 400 m

approx. scale

Figure: 9

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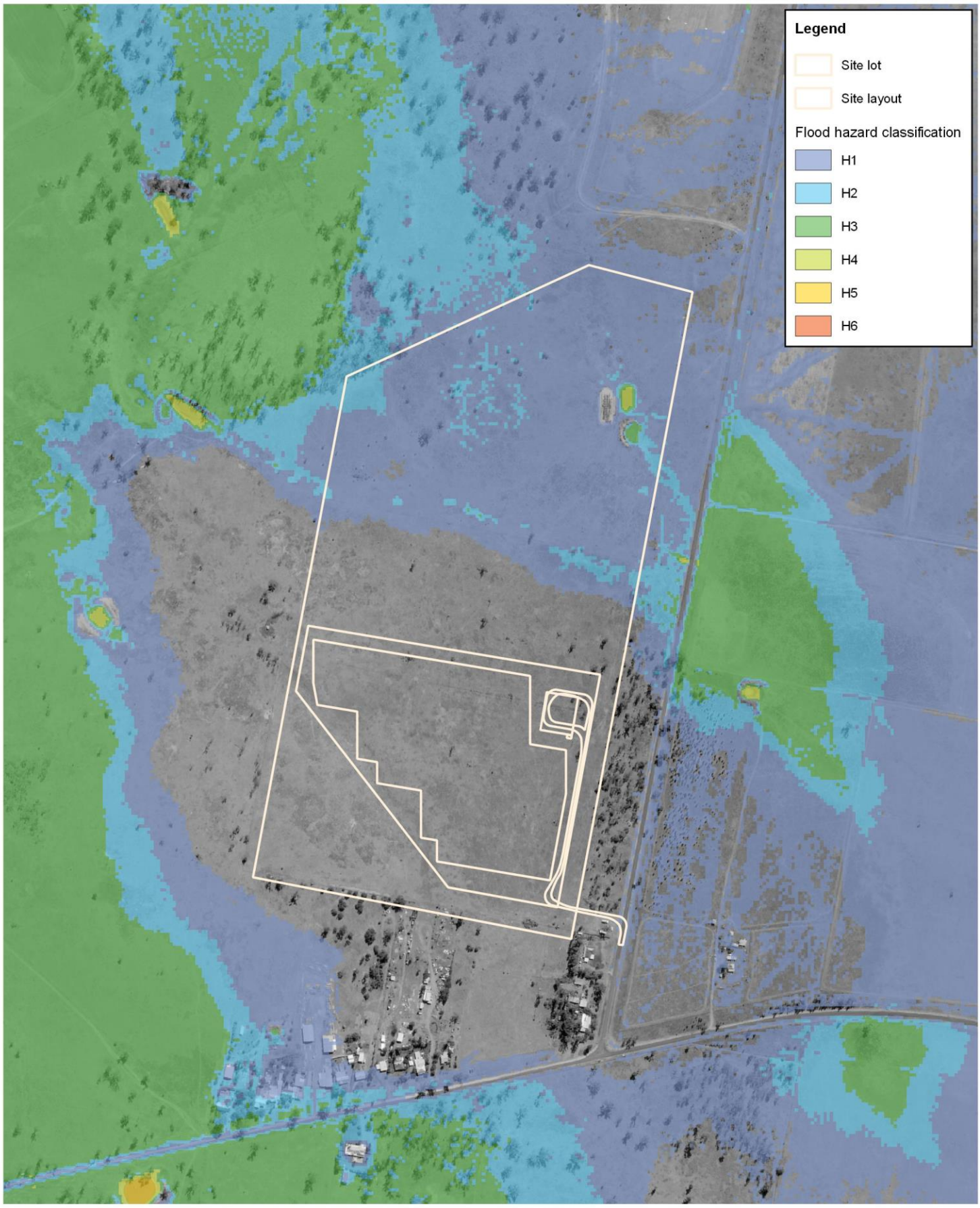

Title:

1% AEP Flood Hazard Classification

0 200 400 m

approx. scale

Figure: 10

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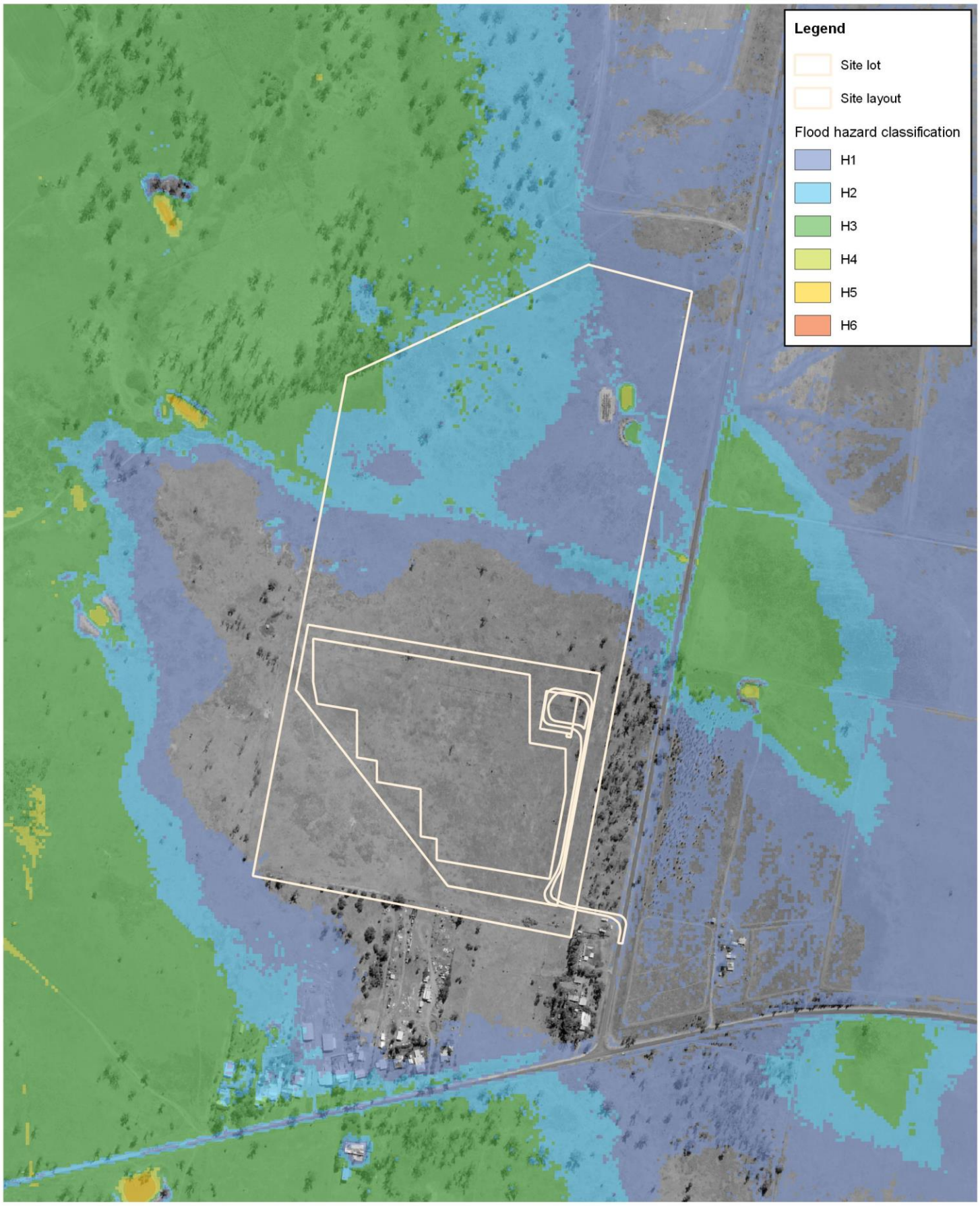

Title:

0.5% AEP Flood Hazard Classification

0 200 400 m

approx. scale

Figure: 11

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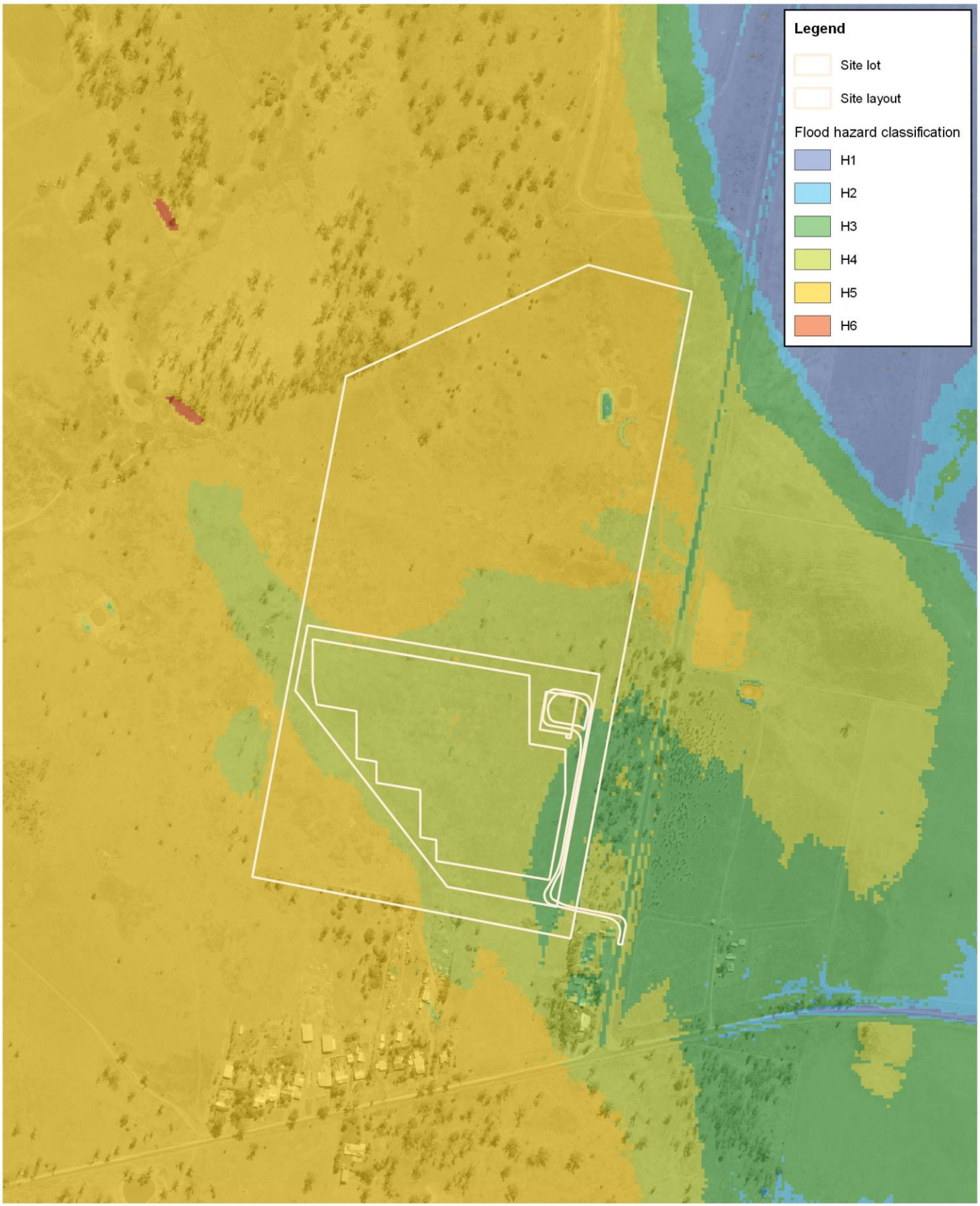

Title:

PMF/Extreme Flood Hazard Classification

0 200 400 m

approx. scale

Figure: 12

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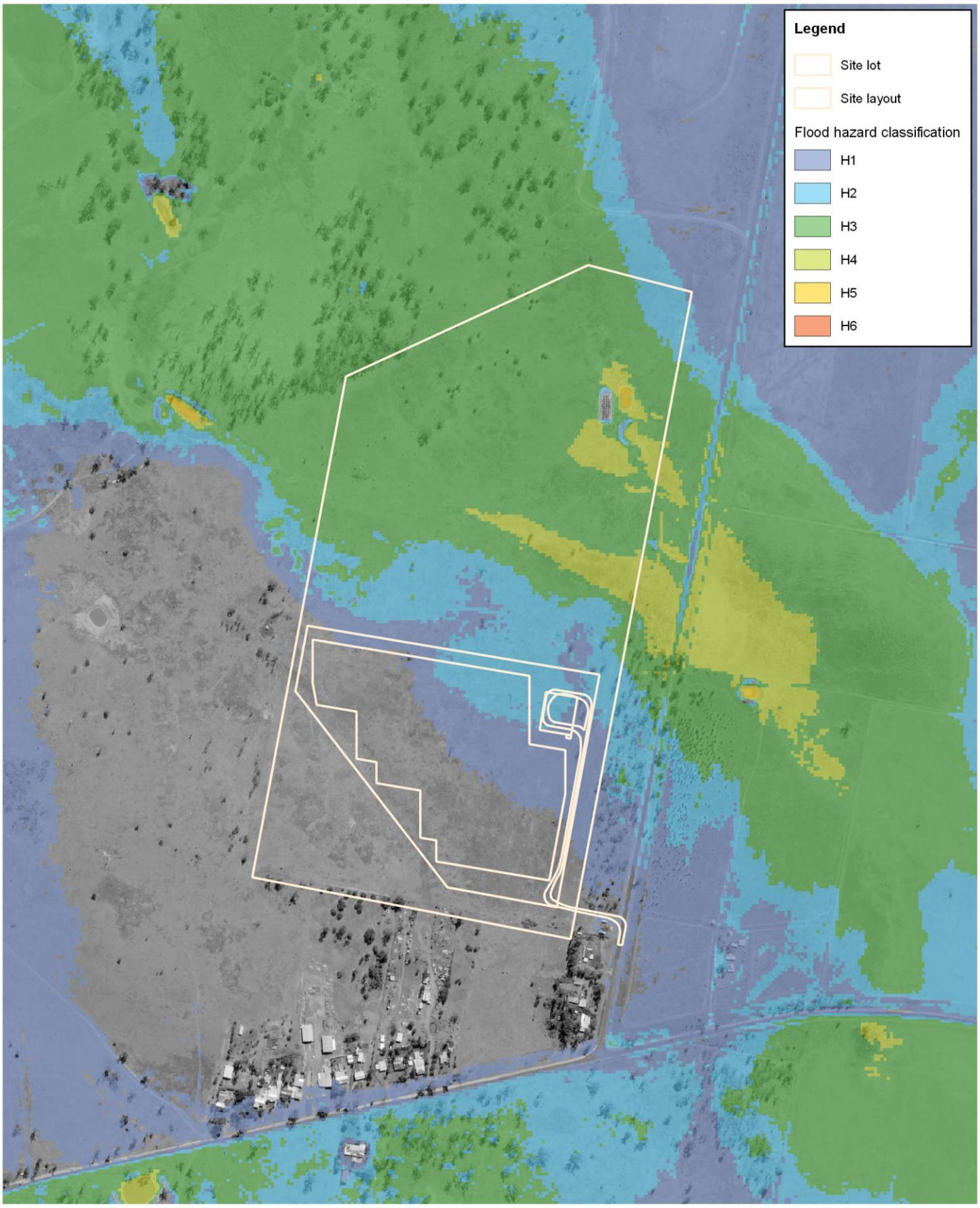

Title:

PMF Local Catchment Flood Hazard Classification

0 200 400 m

approx. scale

Figure: 13

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