BMT (OFFICIAL)

HW10 Pacific Highway / Harrington Road Interchange Upgrade: Flooding Assessment

80% Concept Design Report

Customer	AECOM
Project	A11808
Deliverable	003
Version	03
	30 June 2023

Document Control

Document Identification

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Version Date	30 June 2023
Customer	AECOM
Customer Contact	Jarrod Pettigrew (Project Manager)
Classification	BMT (OFFICIAL)
Synopsis	This report documents the approach and outcomes of the flood assessment undertaken for the CHiP 80% Concept Design in addressing the flood impacts and flood immunity requirements for the Project.

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Amendment Record

The Amendment Record below records the history and issue status of this document.

Version	Version Date	Distribution	Record
00	13 February 2023	AECOM	80% Concept Design Draft Report
01	31 March 2023	AECOM	80% Concept Design Final Report
02	13 April 2023	AECOM	80% Concept Design Final Report
03	30 June 2023	AECOM	80% Concept Design Final Report

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1 Introduction

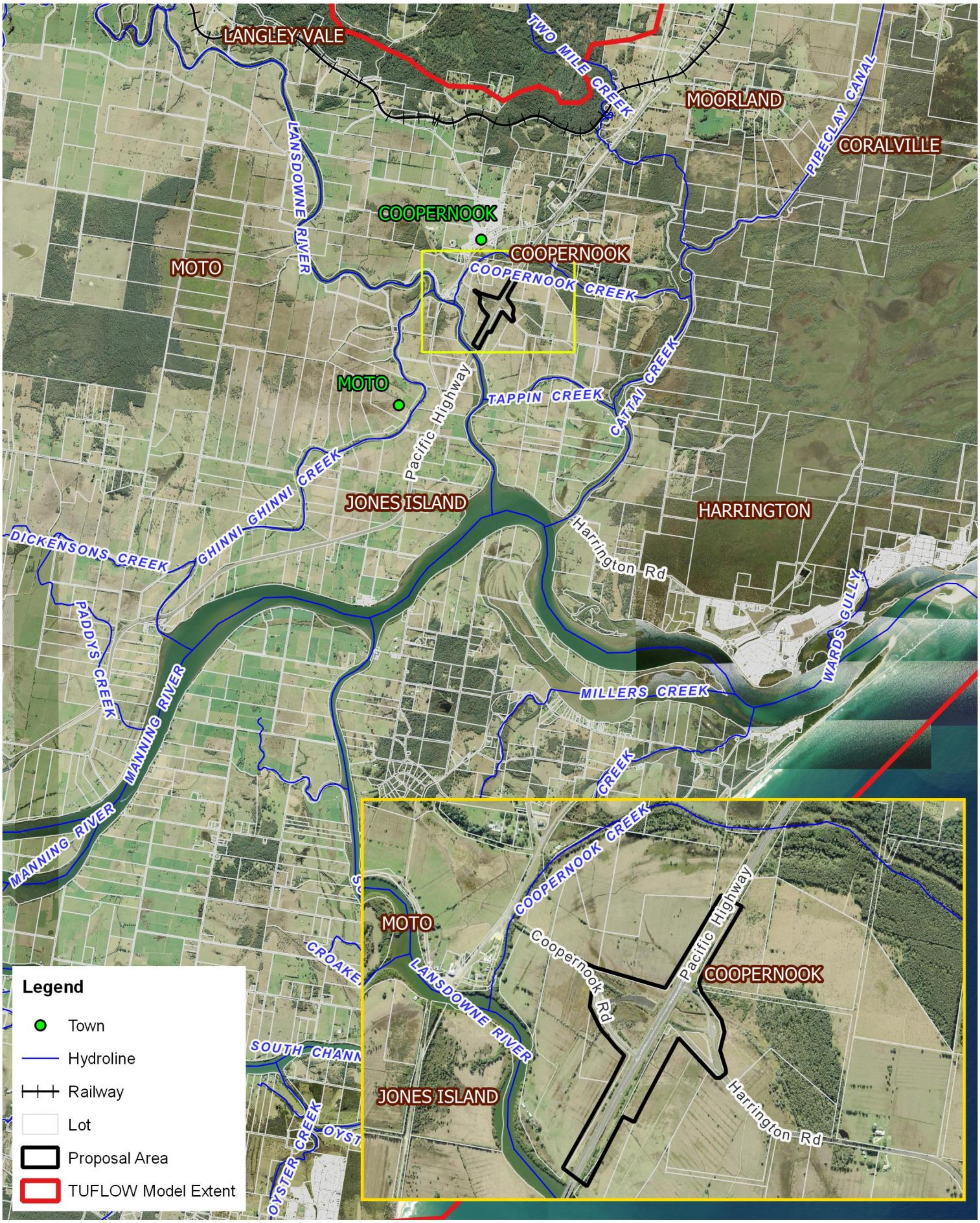
1.1 Project Background

The existing intersections of Harrington Road and Coopernook Road with the Pacific Highway are located approximately 23 km north-east of Taree. These intersections serve to provide access to the highway for the local communities of Coopernook (west of the Pacific Highway) and Harrington (east of the Pacific Highway). Figure 1.1 shows the location of the existing intersections and the site of the proposed interchange upgrade as part of the HW10 Pacific Highway / Harrington Road Interchange Upgrade (CHiP) Project ("Project").

BMT has been engaged to undertake the flood assessment of the Concept Design (CD) of the Project, which is documented in this report herein.

The existing intersections are staggered, at-grade T-intersections which connect with the high-speed, high-volume Pacific Highway. Safety at these at-grade intersections was previously identified as a key issue for further assessment. Difficulty weaving between the two intersections (due to their close proximity, approximately 250 m apart) was one of the key concerns raised by local residents to TfNSW.

TfNSW (then RTA) previously conducted an options analysis for this interchange as part of the Coopernook Bypass EIS (*'Pacific Highway Coopernook Traffic Relief Route Environmental Impact Statement'* (RTA, 1997)). The proposed upgrade consists of an interchange with an overpass bridge, two local road roundabouts and roadway connections to the existing Harrington Road and Coopernook Road. BMT understands that two embankments were constructed in 2005 and 2012 as part of pre-loading of this site for the future construction of an overpass bridge. Figure 1.2 shows the existing topography including the two embankments constructed to tie-in at the future roundabouts on Harrington Road and Coopernook Road. It is noted that this pre-loading is included in the existing TUFLOW model from the *'Manning River Floodplain Risk Management Study and Plan'* (BMT, 2020) and therefore, is assumed to form part of the baseline conditions for the flood assessment of the Project herein.



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Site Locality

Figure: **1-1**

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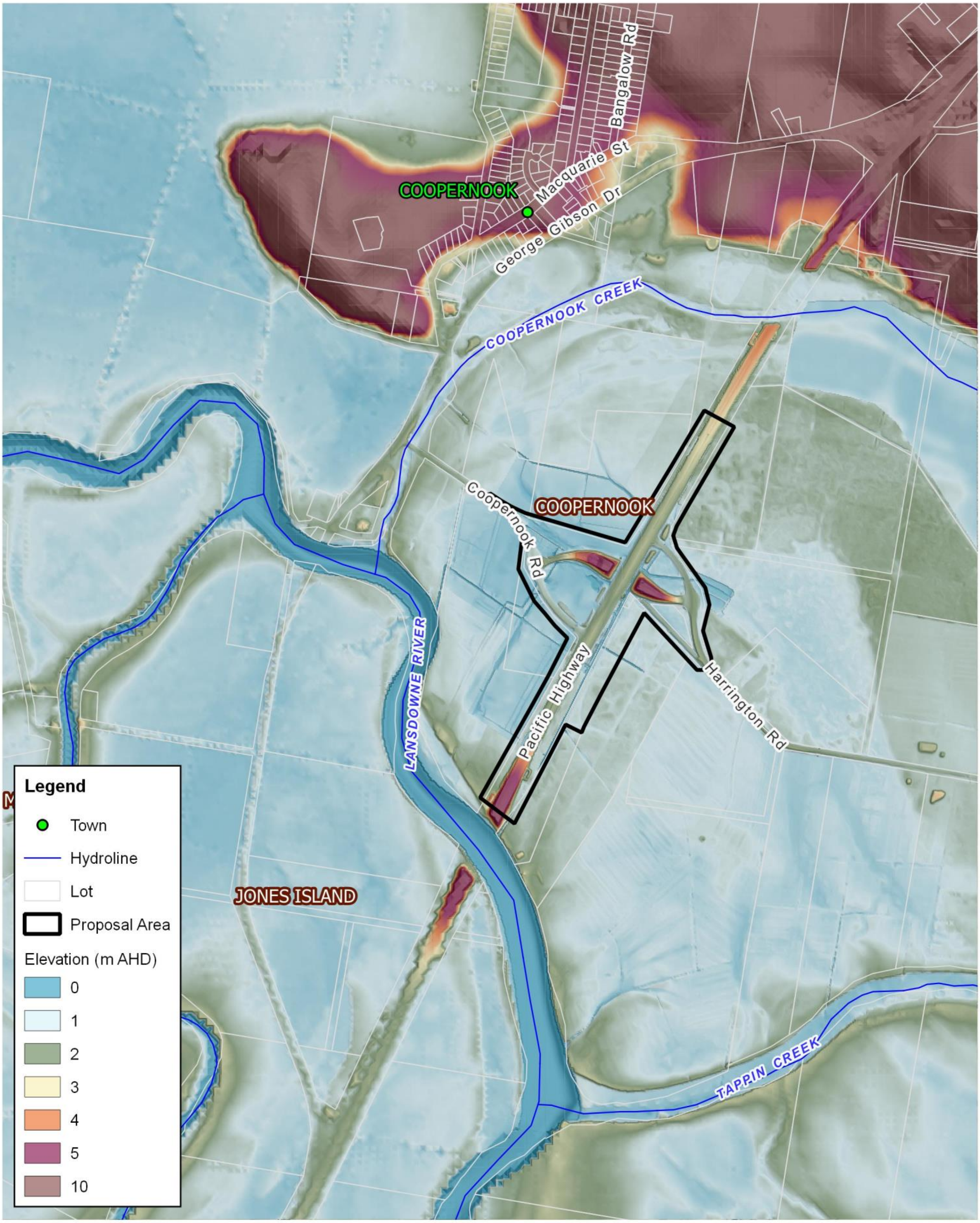

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Site Topography

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1.2 Existing Studies

The Project site is located in the Lansdowne River floodplain and wider lower Manning River floodplain. The Pacific Highway crosses the Lansdowne River via a bridge approximately 2.3 km upstream (north) of the confluence of the Lansdowne River and the Manning River and about 0.5 km south-west of the intersection of Coopernook Road with the Pacific Highway.

Flood behaviour in the lower Manning River floodplain is defined in the *'Manning River Floodplain Risk Management Study and Plan'* (BMT, 2020) and earlier *'Manning River Flood Study'* (BMT WBM, 2016), which were both prepared by BMT for MidCoast Council ("Council"). For the *'Manning River Flood Study'* (BMT WBM, 2016), BMT developed the following models:

- XP-RAFTS hydrologic model of the Manning River catchment;
- Two-dimensional (2D) TUFLOW Classic hydraulic model of the Manning River floodplain from Killawarra to the ocean outlet; and
- TUFLOW-FV model to provide a 2D representation of the ocean entrances at Harrington and Old Bar.

These models were calibrated to historic flood events and used to define existing mainstream flood behaviour within the study area (based on Australian Rainfall and Runoff 1987 (AR&R 87)), assess the impact of climate change in the form of increased rainfall intensity and sea level rise, and develop floodplain risk management measures.

The latest versions of the XP-RAFTS hydrologic model and TUFLOW hydraulic model from the *'Manning River Floodplain Risk Management Study and Plan'* (BMT, 2020) form Council's most current adopted flood models for this area. Council has provided permission to use these models for the flood assessment of the Project.

1.3 Existing Flood Behaviour

The Project site is located in a riverine floodplain area enclosed by a number of watercourses, including the Lansdowne River to the west, Coopernook Creek to the north, Cattai Creek to the east, and Tappin Creek to the south. The junction of the Lansdowne River and Ghinni Ghinni Creek is situated about 1 km upstream of the Lansdowne River crossing of the Pacific Highway.

The results of the modelling from the *'Manning River Floodplain Risk Management Study and Plan'* (BMT, 2020) indicate that:

- The Project site is impacted by mainstream flooding from both the Lansdowne River and Manning River;
- The hydrodynamics in this area of the Manning River floodplain are very complex. For the 1 in 5 Annual Exceedance Probability (AEP) event and greater, breakouts during Manning River flooding are predicted at the confluence with Ghinni Ghinni Creek and further downstream near Croki. These Manning River floodwaters drain north-east towards the Lansdowne River and engage storage within the Lansdowne River floodplain. Floodwaters from the Manning River also backflow into the Lansdowne River during the rising stage of Manning River flooding;
- Given the above, coincident mainstream flooding from the Lansdowne River and Manning River in combination is the dominant flood mechanism in this area. That is, flooding from either the Lansdowne River or Manning River in isolation, is predicted to result in lower peak flood conditions within the Project site. Therefore, the flood assessment herein mainly considers coincident flooding from both rivers;

- In frequent events (e.g. 1 in 5 AEP flood), floodwaters within the reach of the Lansdowne River between Ghinni Ghinni Creek and the Manning River are predominantly contained in-channel with minor breakouts only impacting on the western floodplain (i.e. away from the Project site). During larger AEP events, flood flows breakout of the Lansdowne River channel upstream of the Pacific Highway crossing;
- The Pacific Highway between Coopernook Creek and Lansdowne River is generally flood free for events up to and including the 1 in 20 AEP flood (based on AR&R 87 hydrology). This section of highway is subject to flood inundation during events starting from the 1 in 50 AEP flood; and
- The Project site is located in an area generally classified as “Flood Storage” at the peak of the 1 in 100 AEP flood.

1.4 Report Objectives

This report documents the flood assessment approach undertaken for the Project at the CD stage, as well as the outcomes of the assessment in terms of flood impacts and immunity of the Project. The flood assessment has been undertaken based on the latest Australian Rainfall and Runoff 2019 (ARR 2019) data and methodology. Also, the assessment has been undertaken to address the requirements of TfNSW’s Project brief and specifications including *‘PS261 Bridge and Structure Design’* and *‘PS271 Hydrology and Drainage Design’*.

The flood assessment includes consideration of the following:

- Existing design flood conditions (to be used as the baseline for impact assessment);
- The proposed interchange upgrade and its service/performance requirements;
- Design flood simulations for a range of AEP events;
- Estimation of existing and proposed design flood conditions and the impacts of the Concept Design; and
- Potential flood mitigation and design modifications that may be required to minimise flood impacts.

2 Flood Assessment Approach

2.1 Available Data

The following data and reports are available for the flood assessment herein:

- MidCoast Council's *'Manning River Flood Study'* (BMT WBM, 2016) and associated models;
- MidCoast Council's *'Manning River Floodplain Risk Management Study and Plan'* (BMT, 2020) and associated models;
- For modelling of existing conditions:
  - Recent aerial photography of the Project site dated 23 March 2022;
  - Proposal area and surrounding property cadastre;
  - Project site survey tin[1] received on 29 June 2022;
  - Digital elevation data (1 m LiDAR data) from 'Elevation and Depth - Foundation Spatial Data' ELVIS[2] (NSW Government - Spatial Services), captured in 2012;
  - Existing culverts data and GIS files received on 31 August 2022;
  - Existing bridge general arrangement drawings for the Pacific Highway crossings at Lansdowne River and Coopernook Creek received on 31 August 2022;
- For modelling of proposed 80% Concept Design (80% CD) conditions:
  - Proposed 80% CD site layout received on 19 January 2023;
  - Proposed 80% CD surface tin[3] received on 19 January 2023;
  - Proposed 80% CD bridge concept sketch received on 6 February 2023 (attached in Annex E); and
  - Proposed culverts data and GIS files received on 1 September 2022.

2.2 Assessment Methodology

The flood models developed for Council as part of the *'Manning River Floodplain Risk Management Study and Plan'* (BMT, 2020) were adopted for the flood assessment herein. The Council's TUFLOW model is hereafter referred to as the "regional Manning River TUFLOW model". For this assessment, the original TUFLOW FV model that was used in the simulation of sediment transport processes at the ocean entrances at Harrington and Old Bar during flood events has not been re-simulated (i.e. the boundary assumptions regarding the ocean entrances at Harrington and Old Bar therefore remain unchanged). The regional Manning River TUFLOW model simulates primarily mainstream flood behaviour and does not explicitly model local catchment flooding.

[1] File reference: HV4514 220628 GDA2020 - 12da#3.12da
[2] https://elevation.fsdf.org.au/
[3] File reference: CHiP DESIGN_20220819.12daz

2.2.1 Define Existing (Base Case) Flood Behaviour

Base Case Model Update

The regional Manning River TUFLOW model covers a very large floodplain area extending from Killawarra in the west (upstream) to the ocean outlet at Harrington and Old Bar. Due to this large area coverage, the model employed a relatively coarse grid resolution of 20 m to achieve a reasonable balance between the competing demands of grid resolution and simulation runtimes. Whilst this grid resolution is suitable for a regional scale model, it is considered too coarse for the purpose of detailed representation and assessment of the Project site and proposed works. Accordingly, for the flood assessment herein, the latest version of the TUFLOW HPC module (2020-10-AD-iSP-w64) was employed along with use of TUFLOW's Quadtree feature which allows the model mesh size to be varied. Quadtree was used to specify a finer grid size of 2.5 m around the Project site and its immediate surrounds. Therefore, significant improvement to model run times was achieved whilst higher grid resolution was obtained for the flood assessment of the Project site.

The Digital Elevation Model (DEM) of the regional Manning River TUFLOW model was a 2 m by 2 m gridded DEM derived from the NSW Land and Property Information (LPI) LiDAR survey datasets dated 2012. Since a newer version of the aerial survey was not available, this DEM has been retained for use to define topography where site survey is not available. For the Project site, the available existing site survey information was incorporated into the DEM for the base case flood assessment.

It is noted that the pre-loading of fill at the Project site of the proposed works is already included in the existing DEM (shown in Figure 1.2) and therefore, is assumed to form part of the baseline conditions for this flood assessment.

The TUFLOW model was also updated to include existing cross-drainage structures in the vicinity of the Project site where information is available. As per the requirements outlined in PS271 pertaining to blockage for hydraulic structures, for pipe culverts with hydraulic design capacity less than or equal to 600mm diameter or 600mm height for box culverts, a blockage factor of 50% was applied. This blockage assumption was applied to both existing and proposed pipes/culverts around the Project site.

The definition of the Manning's 'n' roughness values around the Project site was also reviewed and refined to reflect current floodplain conditions, including the cleared areas of the Project site as well as paved roads such as the Pacific Highway, Coopernook Road and Harrington Road. A summary of the roughness values around the Project site is provided in Table 2.1. It should be noted that the roughness values (except for "Paved Road/Abutments" which is added as part of this assessment) have been established following model calibration to historical events undertaken as part of the '*Manning River Flood Study*' (BMT, 2016).

Table 2.1 Manning's 'n' Roughness Values around Project Site

Surface Type	Manning’s ‘n’ Value
Default/Pasture	0.04
Paved Road/Abutments*	0.02
Urban Areas	0.06
Dense Vegetation	0.12
Lansdowne River and nearby creeks	0.02

*** Newly created surface type not found in the original Council’s TUFLOW model**

Council’s TUFLOW model has not included any representation of the existing Pacific Highway bridge crossings at Lansdowne River and Coopernook Creek. The bridge crossing at Lansdowne River is located south of the Project site while the bridge crossing at Coopernook Creek is located north of the Project site. These crossings could potentially influence the existing flood behaviour around the Project site and hence the general arrangement drawings have been obtained from TfNSW to model these bridges in the TUFLOW model. The bridge decks and piers were modelled in TUFLOW using a layered flow constriction shape. This approach involved:

- Representation of the waterway area under the bridge based on the topographic definition of the river/creek bed, banks and bridge abutments in the hydraulic model DEM;
- Multi-layered definition of hydraulic losses associated with the bridge structure in the 2D domain to account for the bridge piers and decks based on the bridge drawings. Values were specified for each layer to represent bridge obvert elevation, waterway blockage by the bridge piers and hydraulic losses. A summary of the modelled parameters is provided in Table 2.2 for the Lansdowne River bridge crossing and Table 2.3 for the Coopernook Creek bridge crossing; and
- The form loss resulting from the bridge piers was determined using the ‘*Hydraulics of Bridge Waterways*’ (U.S. Federal Highway Administration, 1978), with consideration of the skew of bridge piers in the direction of respective river/creek flows.

Table 2.2 Pacific Highway Existing Bridge Crossing Lansdowne River Details in TUFLOW Model

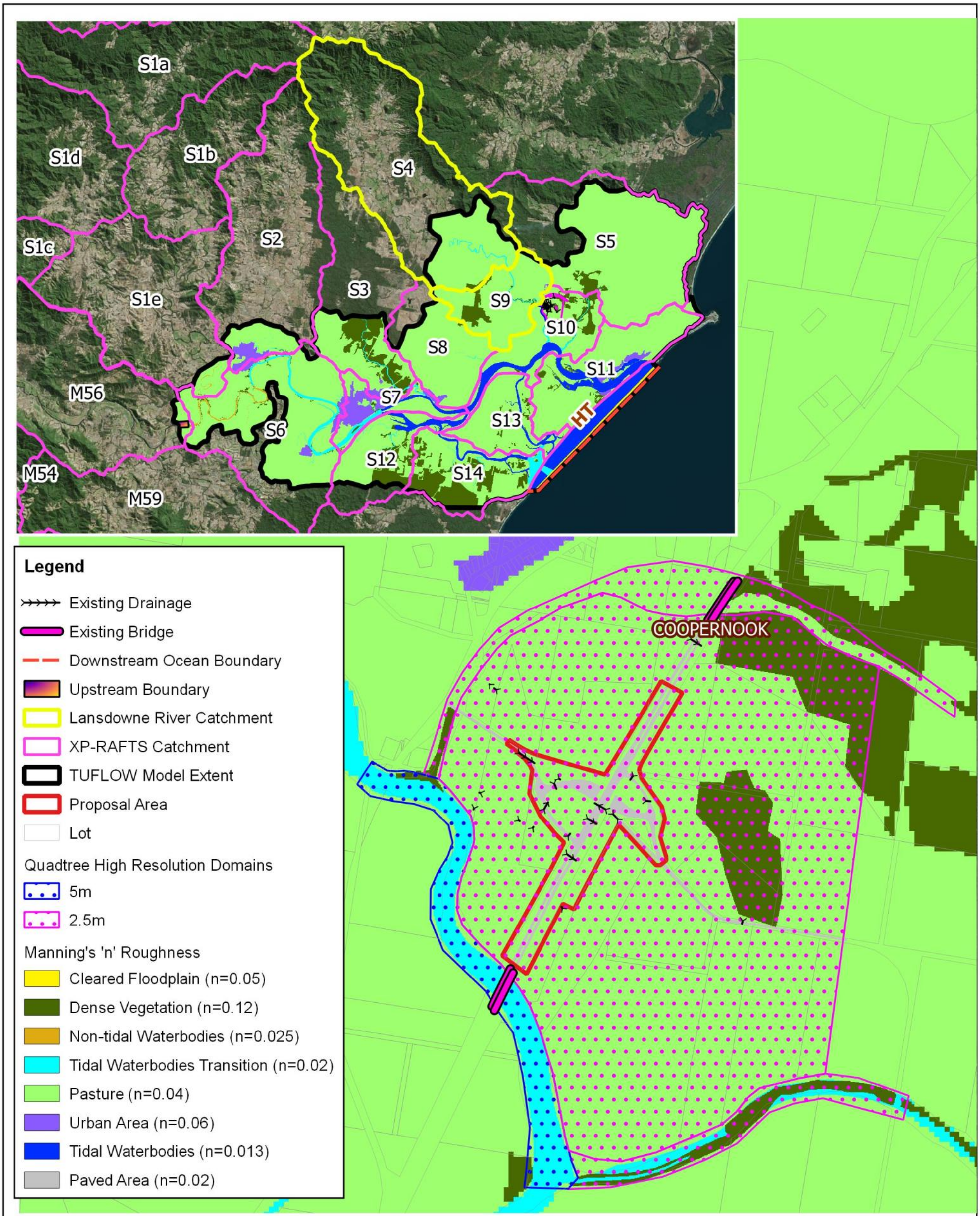
Layer	Obvert (mAHD)	Blockage (%)	Form Loss
Northbound			
L1 (Under Deck)	5.144 – 5.516	7.8	0.15
L2 (Bridge Deck)	7.144 – 7.516	100	1.56
L3 (Above Deck)	8.344 – 8.716	20	0.4
Southbound			
L1 (Under Deck)	5.073 – 5.513	7.8	0.15
L2 (Bridge Deck)	7.073 – 7.513	100	1.56
L3 (Above Deck)	8.273 – 8.713	20	0.4

Table 2.3 Pacific Highway Existing Bridge Crossing Coopernook Creek Details in TUFLOW Model

Layer	Obvert (mAHD)	Blockage (%)	Form Loss
Northbound			
L1 (Under Deck)	2.096 – 2.661	6	0.225
L2 (Bridge Deck)	4.096 – 4.661	100	1.56
L3 (Above Deck)	5.296 – 5.861	20	0.4
Southbound			
L1 (Under Deck)	2.066 – 2.629	6.2	0.23
L2 (Bridge Deck)	4.066 – 4.629	100	1.56
L3 (Above Deck)	5.266 – 5.829	20	0.4

As the regional Manning River TUFLOW model was developed based on GDA94 MGA56 projection, a model conversion has also been undertaken to translate the model into GDA2020 MGA56 projection to match the Project requirements.

The TUFLOW model incorporating the refinements described previously is hereafter referred to as the “Base Case TUFLOW model”. An overview of the model schematisation is shown in Figure 2.1.



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TUFLOW Model Schematisation

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Update XP-RAFTS Model based on ARR 2019

TfNSW requires this assessment to be undertaken based on Australian Rainfall and Runoff 2019 (ARR 2019) guidelines. Therefore, the existing XP-RAFTS hydrologic modelling from the '*Manning River Floodplain Risk Management Study and Plan*' (BMT, 2020) (which was based on AR&R 87) was updated to incorporate ARR 2019 data and methodology. The updates to the XP-RAFTS model were limited to ARR 2019 updates, with no further catchment updates or refinements to the hydrologic inflows application locations undertaken as part of this assessment.

It is noted that the regional Manning River TUFLOW model adopted flood frequency flows for the Manning River at the Killawarra gauge (based on flood frequency analysis (FFA) at this gauge) and XP-RAFTS hydrologic model outputs as inflows for sub-catchments within the TUFLOW model extent. FFA is an approach that is included in ARR 2019 and so the FFA has been retained for this assessment and only the XP-RAFTS model sub-catchment inflows were updated to ARR 2019. Since the procedures for estimating the Probable Maximum Flood (PMF) flows from AR&R 87 apply also to ARR 2019, no modifications to the XP-RAFTS modelling of the PMF, or associated TUFLOW model inflows have been undertaken for the PMF extreme event.

It should also be noted that the 1 in 2000 AEP event has not been simulated in the '*Manning River Floodplain Risk Management Study and Plan*' (BMT, 2020) and as such the 1 in 2000 AEP Manning River flow was extrapolated from the developed flood frequency curves and the XP-RAFTS sub-catchment inflows for this AEP event were developed in accordance with ARR 2019.

ARR 2019 inputs (including storm temporal patterns and climate change factors) were obtained from the ARR Data Hub (attached in Annex D) while the Intensity-Frequency-Duration (IFD) design rainfall grids covering the sub-catchments within the TUFLOW model extent were obtained from the Bureau of Meteorology (BoM) website for a range of storm durations and AEP events. The grids have a grid cell spacing of 0.025 degrees (approximately 2.5 km) and provide the spatial distribution of design rainfall across the sub-catchments. The use of spatial varying design rainfall is adopted for the sub-catchments modelled herein. A summary of the average design rainfall intensities for the simulated storm durations for the Project site (Latitude: -31.834, Longitude: 152.615) is provided in Table 2.4.

Table 2.4 Average Design Rainfall Intensities (mm/hr) based on 2016 BoM IFDs

Storm Duration (hr)	1 in 2 AEP	1 in 5 AEP	1 in 10 AEP	1 in 20 AEP	1 in 50 AEP	1 in 100 AEP	1 in 2000 AEP
12	7.65	10.8	13.2	15.58	18.83	21.50	32.42
18	6.08	8.58	10.4	12.28	14.78	16.78	25.39
24	5.15	7.25	8.76	10.33	12.38	14.04	21.33
30	4.51	6.34	7.66	9.00	10.80	12.23	18.67
36	4.03	5.67	6.84	8.06	9.64	10.92	16.75
48	3.35	4.72	5.7	6.71	8.02	9.06	14.06
72	2.53	3.58	4.33	5.10	6.13	6.93	10.90
96	2.04	2.89	3.51	4.15	4.99	5.66	9.00
120	1.71	2.43	2.96	3.51	4.23	4.81	7.69
144	1.47	2.1	2.56	3.03	3.67	4.18	6.72
168	1.29	1.85	2.25	2.68	3.24	3.70	5.95

Following recommendation by the NSW Office of Environment and Heritage (OEH)[4], a hierarchical approach to loss and pre-burst estimation has been adopted herein. This hierarchy goes from 1 (most preferred) to 5 (least preferred) as indicated in Table 2.5 and also described below:

1. Use the average of calibration losses from the actual study on the catchment if available.
2. Use the average calibration losses from other studies in the catchment, if available and appropriate for the study.
3. Use the average calibration losses from other studies in the similar adjacent catchments, if available and appropriate for the study.
4. Use the NSW FFA-reconciled losses available through the ARR Data Hub. These losses may be used within the catchment in which they were derived (available through the ARR Data Hub) or similar adjacent catchments with appropriate scrutiny. This is used with the unmodified ARR Data Hub initial losses which requires the application of additional scrutiny to the balance between initial loss and pre-burst to ensure it is reflective of flood history and observations for the catchment being investigated in the lead-up to events. This is particularly important in catchments of 100 km^2 or less.
5. Use default ARR Data Hub continuing losses with a multiplication factor of 0.4. This is used with the unmodified ARR Data Hub initial losses which requires the application of additional scrutiny to the balance between initial loss and pre-burst to ensure it is reflective of flood history and observations for the catchment being investigated in the lead-up to events. This is particularly important in catchments of 100 km^2 or less.

The rainfall losses adopted for the assessment were based on Approach (1) as outlined in Table 2.5, which is utilising the average of calibration losses from the actual flood study on the catchment which in this case is the '*Manning River Flood Study*' (BMT, 2016). The losses defined in the calibration of the historical events as part of that study are 10 mm for initial loss and 2.5 mm/hr for continuing loss.

Table 2.5 Hierarchy of Approaches from Most (1) to Least (5) Preferred

Approach	Storm Initial Loss	Pre-Burst (transformational)	IL Burst	Continuing Loss
1	Average Calibration	Not required or back calculated $IL_{Storm} – IL_{Burst}$	Calculated from Equation 1	Average Calibration
2	Average Calibration	Not required or back calculated $IL_{Storm} – IL_{Burst}$	Calculated from Equation 1	Average Calibration
3	Average Calibration	Not required or back calculated $IL_{Storm} – IL_{Burst}$	Calculated from Equation 1	Average Calibration
4	NSW FFA reconciled initial loss (see ARR Data Hub)	Not required or back calculated $IL_{Storm} – IL_{Burst}$	Probability Neutral Burst Loss available through ARR Data Hub	NSW FFA reconciled continuing losses (see ARR Data Hub)
5	ARR Data Hub initial loss	Not required or back calculated $IL_{Storm} – IL_{Burst}$	Probability Neutral Burst Loss available through ARR Data Hub	NSW FFA reconciled continuing losses (see ARR Data Hub)

[4] NSW Specific Data | ARR Data Hub (arr-software.org)

The inputs described previously were applied to the XP-RAFTS model, including the use of areal temporal patterns (for East Coast South) and Areal Reduction Factors (ARFs) considering the Lansdowne River catchment area up to the Project site approximates 204 km^2. The XP-RAFTS model was used to run a range of storm durations (from 12 to 168 hours, in view of the 48-hour critical duration previously determined for the catchment based on AR&R 87 hydrology) and 10 Temporal Pattern (TP) per storm duration.

Based on the XP-RAFTS model results, a subset of durations and temporal patterns were selected (deemed critical for the Project site/Lansdowne River floodplain) to run the Base Case TUFLOW model. The TUFLOW hydraulic model results were then reviewed to select the storm duration/TP that define critical flood conditions for the simulated events at the Project site. The focus was on critical flood levels primarily from the Lansdowne River (since the majority of the Manning River catchment is represented based on FFA flows and not hydrologic modelling outputs). The selected critical storm duration/TP were then applied to the simulation of all design phases within this assessment. The critical duration and TP selected for the 1 in 5 AEP event were also applied to the 1 in 2 AEP and 1 in 10 AEP event for all design phases, with the critical duration and TP selected for the 1 in 100 AEP event also applied to the 1 in 50 and 1 in 2000 AEP events.

The hydrographs from the above critical duration/TP assessment based on the TUFLOW hydraulic model run were subsequently adopted as inflows to simulate the proposed design flood behaviour and to further assess the flood impacts of the proposed works.

Define Existing (Base Case) Flood Behaviour

The Base Case TUFLOW model was used to undertake flood simulations based on ARR 2019 for a range of design events, including the 1 in 2, 1 in 5, 1 in 10, 1 in 20, 1 in 50, 1 in 100, 1 in 2000 AEP and PMF events. This encompasses the range of events required in PS261 and PS271.

BMT considers mainstream flooding to be the dominant flood mechanism at the Project site in terms of both flood impacts and immunity. Therefore, a combined mainstream flood assessment (i.e. considering coincident Manning and Lansdowne River catchment flooding) was undertaken for all design phases. A sensitivity assessment was nevertheless undertaken to assess the modelling of the Manning and Lansdowne River flood mechanisms separately for the 1 in 100 AEP event and ascertain the flooding impacts on the Project site.

Consideration of Climate Change

PS271 requires that potential climate change effects be considered in the modelling in accordance with processes described in the TfNSW Technical Guide ‘*Climate Risk Assessment Guidelines*’.

A dual assessment was adopted for the flood impact assessment and flood immunity assessment as follows:

- Potential afflux caused by the Concept Design be based on current climate conditions.
- Road immunity assessment be based on design flood event with current climate and sensitivity assessment for 1 in 100 AEP with future climate change allowance (an increase in rainfall and sea level rise).

A climate change scenario based on the 1 in 100 AEP event has been modelled and assessed herein, which included an increase in flows (as associated with increased rainfall intensity) and sea level rise. This scenario was based on a combination of flow increase corresponding to RCP 8.5 conditions for the 1 in 100 AEP event and a 0.98 m sea level rise for 2100 climate conditions (as per '*Manning River Flood Study*' (BMT, 2016)), which would represent the most significant future climate conditions currently considered for flood assessments. The RCP 8.5 conditions translate into an approximate 20% rainfall increase for the Project site (based on climate change factors obtained from the ARR Data Hub and included in Annex D), along with an assumed 20% increase in the 1 in 100 AEP flood frequency flow for the Manning River at the Killawarra gauge. The critical storm duration/TP for the 1 in 100 AEP event based on current climate conditions were also adopted for this climate change scenario.

2.2.2 Modelling of Proposed Design Option

The report herein documents the modelling and assessment undertaken for the 80% Concept Design (80% CD) package. BMT understands that the 80% CD is based on the interchange design previously developed as "RTA 2005 Option 1" which was being refined by TfNSW, and includes the existing embankment and highway footprint and levels with a clearance of approximately 5.9 m to the proposed bridge soffit. The following tasks have been undertaken in modelling the 80% CD proposed works:

- Update the Base Case TUFLOW model to incorporate the 3D design (80% CD) DEM for the Project site;
- Represent the proposed bridge deck and piers crossing the existing Pacific Highway as a layered flow constriction shape and model in a similar approach to the existing Pacific Highway bridges as described in Section 2.2.1, using the '*Hydraulics of Bridge Waterways*' (U.S. Federal Highway Administration, 1978). Details of the proposed bridge are provided in Table 2.6 and the proposed bridge drawings are included in Annex E;
- No proposed drainage has been modelled at the 80% CD stage, whereby the proposed drainage has been conservatively assumed as fully blocked. This may be revisited in the Detailed Design;
- Simulate the range of flood events for the afflux and immunity assessment defined herein; and
- Assessment of flood impacts (e.g. impacts on property, infrastructure, duration of flooding, hazard categories).

The TUFLOW model incorporating the proposed 80% CD is hereafter referred to as the "Proposed Case TUFLOW model".

It is assumed that any change in the fraction impervious for the Project site will be mitigated by the Stormwater Management Plan developed (by AECOM) for the Project. Hence, the XP-RAFTS hydrologic model inflows have not been updated for modelling of the design options.

Table 2.6 Proposed Bridge Details in TUFLOW Model

Layer	Obvert (mAHD)	Blockage (%)	Form Loss
L1 (Under Deck)	8.68 – 9.48	20	0.6
L2 (Bridge Deck)	10.13 – 10.98	100	1.56
L3 (Above Deck)	13.13 – 13.98	20	0.4

3 Existing (Baseline) Flood Conditions and Constraints

3.1 Setup for Design Flood Runs

An overview of the adopted model boundary conditions for the range of design flood events simulated herein is presented in Table 3.1. The combination of the different flood mechanisms was based on the approach taken for the '*Manning River Flood Study*' (BMT WBM, 2016). As per the '*Manning River Flood Study*' (BMT WBM, 2016), the TUFLOW model upstream boundary inflows were based on the FFA undertaken for the Manning River flows at the Killawarra gauge while the downstream ocean boundary was based on the ocean tide level time series based on the '*Floodplain Risk Management Guideline: Modelling the Interaction of Catchment Flooding and Oceanic Inundation in Coastal Waterways*' (OEH, 2015). The local inflows for sub-catchments within the TUFLOW model extent were based on the XP-RAFTS hydrologic model outputs. It should be noted that the PMF inflows/boundary conditions have not been altered from the Council's model.

Table 3.1 Design Flood Runs for Coincident Flood Events

Design Flood (AEP)	Killawarra Boundary Peak Inflow (m3/s)	Local Rainfall (AEP)	Ocean Boundary Peak Water Level (m AHD)
1 in 20	6,700 (1 in 20 AEP)	1 in 20	1.03 (HHWS(SS)*)
1 in 50	8,200 (1 in 50 AEP)	1 in 50	1.90 (1 in 20)
1 in 100	9,200 (1 in 100 AEP)	1 in 100	1.90 (1 in 20)
1 in 100 with climate change	11,000 (1.2 x 1 in 100 AEP)	1 in 100 + 20%	1.90 (1 in 20) + 0.98 m
1 in 2000	14,200 (1 in 2000 AEP)	1 in 2000	2.00 (1 in 100)
PMF	27,500 (3 x 1 in 100 AEP)	3 x 1 in 100 AEP	2.00 (1 in 100)

*** High High Water Springs (Solstice Spring)**

3.2 Critical Storm Duration Analysis

The critical storm duration (and its associated temporal pattern) applicable to the Project site was selected through assessment of the modelled peak flood levels across the Project site and its surrounds. This analysis was undertaken for the 1 in 20 AEP and 1 in 100 AEP events. The XP-RAFTS hydrologic model was used to run a range of storm durations in order to narrow down the storm durations deemed critical for the Project site and subsequently run in the TUFLOW hydraulic model along with the ensemble of temporal patterns. Based on the results from the TUFLOW model, the critical storm duration which yields the peak flood levels in the vicinity of the Project site was determined. For the critical storm duration, the temporal pattern producing the peak flood level above the mean peak flood level of the ensemble of 10 temporal patterns was also determined.

A summary of the critical storm durations and selected temporal patterns for the Project site is provided in Table 3.2.

Table 3.2 Critical Storm Durations and Temporal Patterns for the Project Site

Design Storm (AEP)	Critical Storm Duration (hour)	Areal Temporal Pattern
1 in 20	36	284
1 in 50*	36	285
1 in 100	36	285
1 in 100 with climate change*	36	285
1 in 2000*	36	285
PMF	48	N/A

*** Assumed the same critical duration and areal temporal pattern as the 1 in 100 AEP event**

The Base Case TUFLOW model was used to simulate coincident flooding from the Manning and Lansdowne River, i.e. the "worst case" mainstream flood scenario for the Project site, based on the critical storm durations and associated temporal patterns. It is primarily this worst-case flood scenario that was subsequently considered in the flood impact and immunity assessment for all design phases of the Project.

3.3 Comparison of Flood Levels against Council's Study

The simulated flood behaviour (i.e. peak flood levels) around the Project site produced by the Base Case TUFLOW model was compared against the Council's model results for the *'Manning River Floodplain Risk Management Study and Plan'* (BMT, 2020). As described previously, the Base Case TUFLOW model incorporates refinements introduced as part of the assessment herein, e.g. use of Quadtree mesh for the Project site, inclusion of Project site survey, update to utilise ARR 2019 data and methodology etc. Therefore, minor differences to the predicted peak flood levels are expected. Comparison of the peak flood levels is provided in Table 3.3, based on the reporting locations shown in Figure 3.1. It was found that the peak flood levels predicted by the Base Case TUFLOW model are generally higher (in the order of 0.1 m) than those derived from Council's model, which is driven primarily by the higher ARR 2019 design rainfall intensities around the lower Manning River catchment compared to those for AR&R 87. The results for the PMF event are largely similar since the PMF inflows/boundary conditions have not been altered from the Council's model. Based on the model results comparison, the Base Case TUFLOW model was deemed to be suitable for the subsequent flood assessment of the Project.

Table 3.3 Comparison of Predicted Peak Flood Levels (mAHD) around Project Site

ID	1 in 20 AEP		1 in 50 AEP		1 in 100 AEP		PMF	
	Council's Model	Current Base Case	Council's Model	Current Base Case	Council's Model	Current Base Case	Council's Model	Current Base Case
H01	1.86	1.97	2.46	2.54	2.69	2.76	5.33	5.32
H02	1.76	1.93	2.41	2.51	2.66	2.75	5.32	5.30
H03	1.86	1.97	2.46	2.54	2.69	2.76	5.34	5.32
H04	-	1.93	2.41	2.51	2.67	2.75	5.32	5.30
H05	-	-	-	-	2.37	2.77	5.33	5.32
H06	1.82	1.94	2.43	2.53	2.68	2.76	5.32	5.31
H07	1.88	1.97	2.45	2.53	2.69	2.76	5.33	5.32
H08	1.85	1.97	2.46	2.54	2.69	2.76	5.35	5.33
H09	1.86	1.97	2.46	2.54	2.69	2.76	5.34	5.32
H10	1.86	1.97	2.46	2.54	2.69	2.76	5.33	5.31
H11	1.48	1.93	2.42	2.51	2.67	2.75	5.31	5.30
H12	1.76	1.93	2.41	2.51	2.66	2.75	5.32	5.30
H13	1.76	1.93	2.41	2.51	2.66	2.74	5.28	5.27
H14	-	-	2.45	2.54	2.68	2.76	5.32	5.31
H15	-	-	-	2.51	2.67	2.75	5.32	5.31

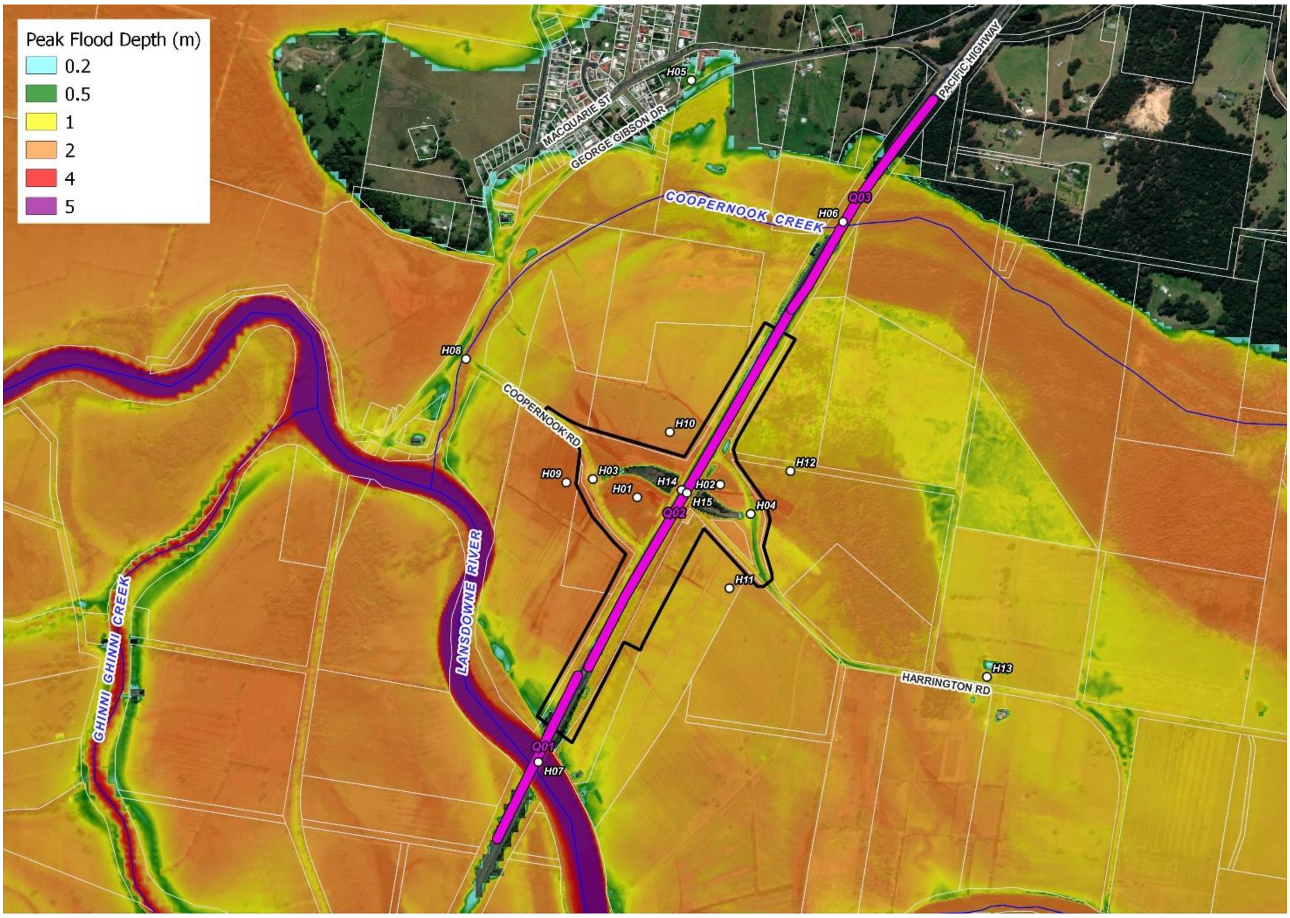

Figure 3.1 Reporting Locations

3.4 Existing Conditions Flood Modelling Results

The flood simulations were used to define existing flood behaviour, such as peak flood levels, depths, velocities, flows, hazard categories and inundation duration. The existing conditions flood maps for the range of design flood events simulated are included in Annex A.

The flood hazard for the Project site and its surrounding floodplain has been defined based on the composite six-tiered hazard classification in the '*Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*' (AIDR, 2017) and reproduced in Figure 3.2. These hazard classifications are based on adopted thresholds of flood depth, velocity and velocity-depth product that identify when flood conditions are likely to present a risk to people, vehicles and buildings. A description of each hazard threshold is provided in Table 3.4.

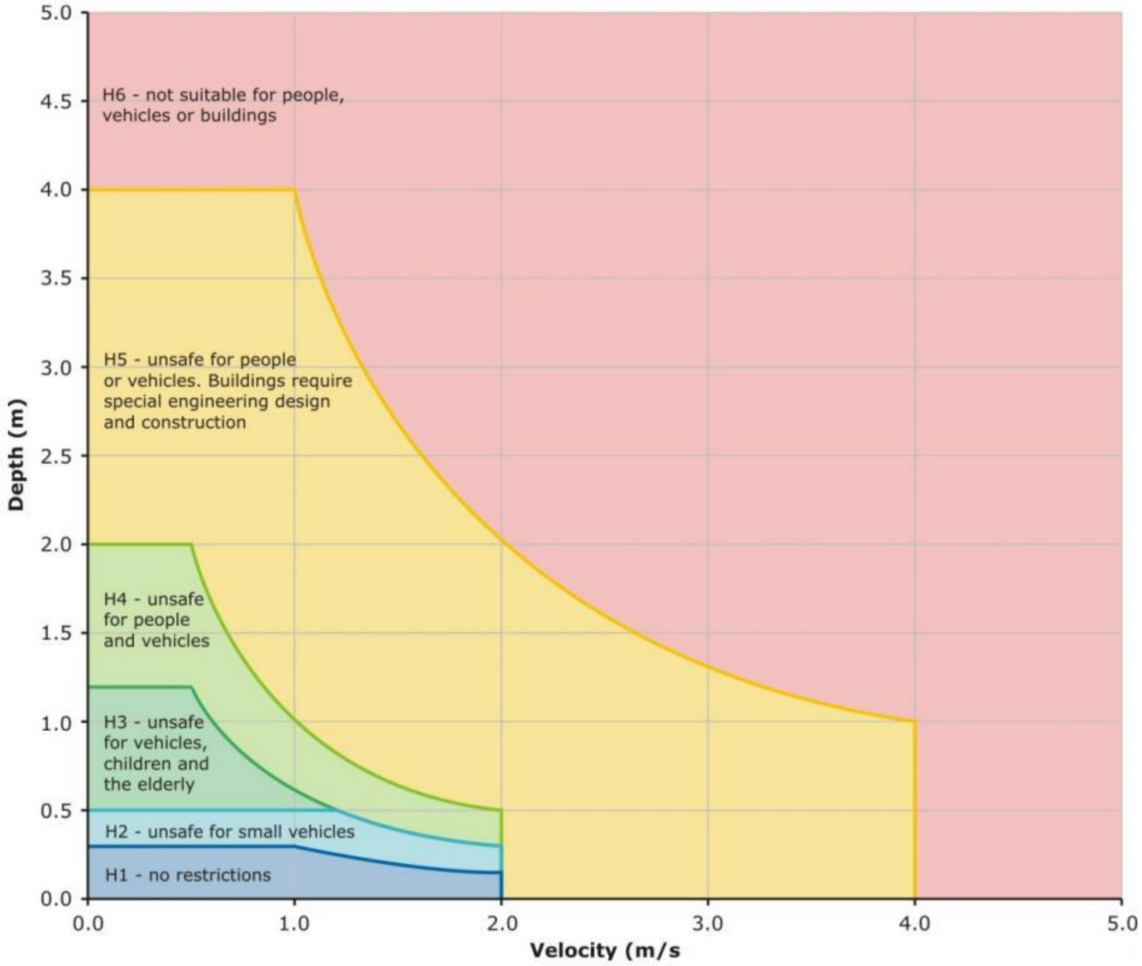

Figure 3.2 Flood Hazard Curves (AIDR, 2017)

Table 3.4 Flood Hazard Classification Thresholds (AIDR, 2017)

Hazard Classification	Description
H1	Relatively benign flow conditions. No vulnerability constraints.
H2	Unsafe for small vehicles.
H3	Unsafe for all vehicles, children and the elderly.
H4	Unsafe for all people and vehicles.
H5	Unsafe for all people and vehicles. Buildings require special engineering design and construction.
H6	Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building types considered vulnerable to failure.

Based on the flood modelling results, the following observations can be made of the existing flood conditions around the Project site:

- The Project site is significantly impacted by mainstream flooding originating from the Lansdowne River and Manning River for the 1 in 20 AEP event and greater, with the 1 in 20 AEP peak flood depths generally in excess of 0.5 m on the adjacent floodplain and in excess of 1.0 m for the 1 in 100 AEP event and greater;
- Floodwaters from the Manning River would backflow into the Lansdowne River during the rising stage of Manning River flooding, thus contributing to flooding on the Lansdowne River floodplain;
- Breakouts are predicted to occur along the Lansdowne River banks for the 1 in 20 AEP event and greater, including upstream of the Pacific Highway crossing at Lansdowne River which cause flooding around the Project site. The floodwaters from the river generally flow in the easterly direction toward the Pacific Highway and fill up the storage areas found on the floodplain;
- Coincident mainstream flooding from the Lansdowne River and Manning River in combination is the dominant flood mechanism around the Project site. That is, flooding from either the Lansdowne River or Manning River in isolation, is predicted to result in lower peak flood conditions within the Project site;
- The existing Pacific Highway between Coopernook Creek and Lansdowne River is generally flood free for events up to and including the 1 in 20 AEP design flood. There would be some minor encroachment of floodwaters on the northbound Pacific Highway carriageway (up to 0.2 m depth on the outside lane) between the Coopernook Road and Harrington Road intersections for the 1 in 20 AEP event. Nevertheless, this section of highway would only be overtopped and completely subject to flood inundation during events starting from the 1 in 50 AEP flood;
- Flood immunity of the smaller roads accessing the Pacific Highway is generally lower with Coopernook Road and Harrington Road subject to flood inundation in the 1 in 20 AEP event and greater;
- The elevated sections of the pre-loading at the Project site (closer to the Pacific Highway) remain flood free even in the PMF event;
- Floodwaters around the Project site are generally slow-moving and less than 0.6 m/s even in the PMF extreme event; and
- The flows overtopping the Pacific Highway in the 1 in 50 AEP event are categorised as “H2”, which are flow conditions unsafe for small vehicles. For the 1 in 100 AEP event the flow conditions reach “H3” hazard category, which are unsafe for all vehicles.

4 Flood Assessment of the Concept Design

4.1 Assessment Criteria

The flood assessment has been undertaken to address the criteria outlined in the TfNSW specifications for the Concept Design stage including *'PS261 Bridge and Structure Design'* and *'PS271 Hydrology and Drainage Design'*. The criteria in addressing the flood impacts and flood immunity of the Project have been reviewed by TfNSW and are summarised as follows:

4.1.1 Criteria for Flood Impacts

- Assess flood impacts (both upstream and downstream) of the proposed design on regional flooding for a range of events including the 1 in 20, 1 in 50, 1 in 100 AEP and the PMF events and recommend appropriate flood mitigation measures if required to alleviate any adverse hydraulic effects (PS271). A peak flood level difference mapping threshold of 0.02 m is shown in assessing the flood impact, applicable across the whole Manning River/Lansdowne River floodplain and across all AEP events, which is a similar approach adopted for other TfNSW projects (i.e. *'Singleton Bypass Concept Design Flood Assessment'* (BMT, 2021) and *'Muswellbrook Bypass Concept Design Flood Assessment'* (BMT, 2022)).
- Comparison of the existing and proposed design conditions of flood level, stream velocity, change in flood flow distribution and hazard categories for the 1 in 20, 1in 50, 1 in 100, 1 in 2000 AEP and the PMF events (PS261).
- Assess flood impacts on inundation times due to the proposed design (PS271), by comparing the existing and proposed design flood level hydrographs at critical locations such as the existing Pacific Highway and the nearby Coopernock Township. A peak flood depth threshold of 0.05 m is adopted to discount shallow flooding in the assessment of the inundation duration.
- For each bridge or bridge size culvert opening affected by flooding, confirm serviceability effects of afflux on adjacent properties and the stability of the adjacent road embankment for the 1 in 100 AEP event (PS271). This is undertaken by providing the relevant flood flow information to the Geotechnical Team for assessment.
- Consideration for existing environmental constraints; minimising impacts on areas of wetlands, biodiversity, and heritage value (PS271). Areas of significance value in terms of biodiversity and heritage are to be confirmed with the relevant biodiversity/heritage specialists, whilst the closest wetland to the Project site is the Cattai Wetlands situated to the north-east.

4.1.2 Criteria for Flood Immunity

- Flood immunity and Serviceability Limit State ("SLS") of 1 in 100 AEP for road bridges and structures based on AS 5100.1 Section 11.1: Waterway and flood design – General (PS261). Flood immunity is assessed based on inundation extent up to the shoulder of the road carriageways.
- Minimum AEP applicable to drainage design as outlined in Table 4.1 (Table PS271.A2 in PS271). BMT understands that the Concept Design maintains current carriageway levels and existing flood immunity (e.g. Pacific Highway being flood free up to the 1 in 20 AEP). BMT also understands that the overpass bridge level has been designed to allow for possible future raising of the main carriageway to the 1 in 100 AEP flood level or above.
- Assess the existing immunity of the local roads and take a pragmatic approach to see if it can be improved, but under no circumstances make it worse than existing conditions.

Table 4.1 Minimum AEP for Drainage Design (Table PS271.A2)

Table PS271.A2 – Minimum ARI

Item No.	Item	Minimum ARI
1	Channels and open drains	5 years
2	Piped system (including pits)	10 years
3	Culverts where surcharge is allowable	50 years
4	Structures where surcharge is undesirable	100 years
5	Gross pollutant traps	1 year
6	Pavement drainage wearing surface	10 years
7	Bridge deck drainage	10 years
8	Major storm event checks for no property damage	100 years
9	Major storm event checks for no structural damage	2000 years
10	Cycleway	1 year
11	Temporary Drainage for Road Works	2 years
12	Temporary Working Platform for Bridges – Subject to sensitivity of the crossing	Ranging from 2 to 20 years
13	***General flooding and flood immunity*** ***Flood Plain***	***100 years/PMF[1]*** ***20 years[2]***

[1]The general flooding and flood immunity is to be design for the 100 year ARI with the PMF checked.

[2]The PSC is to maintain the current carriageway levels and flood immunity (i.e. maintain existing immunity)

The PSC is to design the overpass bridge level to allow for future raising of the main carriageway to 1 in 100. i.e. allow enough clearance. If costs or constructability are an issue then we revert back to a minimum clearance based on current carriageway immunity

4.2 80% CD Flood Modelling Results

The flood simulations were used to define the proposed 80% CD flood behaviour, such as peak flood levels, depths, velocities, flows, hazard categories and inundation duration. The proposed 80% CD condition flood maps for the range of design flood events simulated are included in Annex B. The flood information is also presented in tabular format for both existing and proposed 80% CD flood conditions in Table 4.2 to Table 4.6, based on the reporting locations shown in Figure 3.1. Flood level hydrographs at key locations including the proposed eastern and western roundabouts (H03 and H04) as well as nearby residential properties to the east of the Project Site (H13) are presented in Figure 4.1 to Figure 4.3, with the inundation duration at those locations tabulated in Table 4.7.

Table 4.2 Peak Flood Levels (mAHD) around the Project Site

ID	1 in 20 AEP		1 in 50 AEP		1 in 100 AEP		1 in 100 AEP with climate change		1 in 2000 AEP		PMF	
	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop
H01	1.97	1.96	2.54	2.54	2.76	2.76	3.56	3.56	3.9	3.9	5.32	5.32
H02	1.93	1.93	2.51	2.51	2.75	2.75	3.55	3.55	3.9	3.9	5.3	5.3
H03	1.97	-	2.54	2.54	2.76	2.76	3.56	3.56	3.91	3.9	5.32	5.32
H04	1.93	-	2.51	-	2.75	2.75	3.55	3.55	3.89	3.89	5.3	5.3
H05	-	-	-	-	2.77	2.77	3.56	3.56	3.91	3.91	5.32	5.32
H06	1.94	1.94	2.53	2.52	2.76	2.76	3.55	3.55	3.9	3.9	5.31	5.31
H07	1.97	1.96	2.53	2.53	2.76	2.76	3.55	3.55	3.9	3.9	5.32	5.32
H08	1.97	1.96	2.54	2.54	2.76	2.77	3.56	3.56	3.91	3.91	5.33	5.33
H09	1.97	1.96	2.54	2.54	2.76	2.76	3.56	3.56	3.91	3.91	5.32	5.32
H10	1.97	1.96	2.54	2.54	2.76	2.76	3.56	3.56	3.9	3.9	5.31	5.31
H11	1.93	1.93	2.51	2.51	2.75	2.75	3.55	3.55	3.89	3.89	5.3	5.3
H12	1.93	1.93	2.51	2.51	2.75	2.75	3.55	3.55	3.89	3.89	5.3	5.3
H13	1.93	1.92	2.51	2.51	2.74	2.74	3.54	3.54	3.88	3.88	5.27	5.27
H14	-	-	2.54	2.54	2.76	2.76	3.55	3.55	3.9	3.9	5.31	5.31
H15	-	-	2.51	2.51	2.75	2.75	3.55	3.55	3.9	3.9	5.31	5.31

Table 4.3 Peak Flood Depths (m) around the Project Site

ID	1 in 20 AEP		1 in 50 AEP		1 in 100 AEP		1 in 100 AEP with climate change		1 in 2000 AEP		PMF	
	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop
H01	1.58	1.57	2.15	2.15	2.37	2.37	3.17	3.17	3.52	3.52	4.93	4.93
H02	1.21	1.2	1.79	1.79	2.03	2.02	2.83	2.83	3.17	3.17	4.58	4.58
H03	0.56	-	1.13	0.3	1.36	0.53	2.15	1.32	2.5	1.67	3.91	3.08
H04	0.1	-	0.68	-	0.92	0.11	1.72	0.91	2.06	1.25	3.47	2.66
H05	-	-	-	-	0.78	0.78	1.57	1.58	1.92	1.93	3.34	3.34
H06	0.86	0.86	1.45	1.45	1.68	1.68	2.47	2.47	2.82	2.82	4.23	4.23
H07	5.96	5.95	6.52	6.52	6.75	6.75	7.54	7.54	7.89	7.89	9.31	9.31
H08	0.28	0.28	0.86	0.86	1.08	1.08	1.88	1.88	2.23	2.23	3.65	3.65
H09	1.51	1.51	2.08	2.08	2.31	2.31	3.1	3.1	3.45	3.45	4.87	4.87
H10	1.22	1.22	1.8	1.8	2.02	2.02	2.81	2.81	3.16	3.16	4.57	4.57
H11	0.78	0.78	1.37	1.37	1.6	1.6	2.4	2.4	2.74	2.75	4.15	4.15
H12	0.79	0.79	1.37	1.37	1.61	1.61	2.41	2.41	2.76	2.76	4.16	4.16
H13	0.52	0.52	1.1	1.1	1.34	1.34	2.13	2.13	2.47	2.47	3.86	3.86
H14	-	-	0.36	0.36	0.58	0.58	1.38	1.38	1.72	1.72	3.13	3.14
H15	-	-	0.28	0.27	0.52	0.51	1.32	1.32	1.66	1.66	3.07	3.07

Table 4.4 Peak Flood Velocities (m/s) around the Project Site

ID	1 in 20 AEP		1 in 50 AEP		1 in 100 AEP		1 in 100 AEP with climate change		1 in 2000 AEP		PMF	
	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop
H01	0	0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.4	0.4
H02	0	0.1	0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4
H03	0.6	-	0.6	0.1	0.6	0.1	0.7	0.3	0.6	0.3	0.6	0.6
H04	0.1	-	0.2	-	0.2	0	0.3	0.2	0.3	0.3	0.3	0.4
H05	-	-	-	-	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
H06	0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.3
H07	1	1	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.2	1.2
H08	0.2	0.3	0.3	0.5	0.3	0.5	0.4	0.6	0.4	0.5	0.6	0.7
H09	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.4	0.4
H10	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.5	0.5
H11	0	0	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.5	0.5
H12	0	0	0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.4	0.4
H13	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.5	0.5
H14	-	-	0.1	0.1	0.2	0.2	0.3	0.2	0.3	0.3	0.3	0.3
H15	-	-	0.1	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.4	0.4

Table 4.5 Peak Flood Hazard Categories (AIDR, 2017) around the Project Site

ID	1 in 20 AEP		1 in 50 AEP		1 in 100 AEP		1 in 100 AEP with climate change		1 in 2000 AEP		PMF	
	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop
H01	H4	H4	H5	H5	H5	H5	H5	H5	H5	H5	H6	H6
H02	H4	H3	H4	H4	H5	H5	H5	H5	H5	H5	H6	H6
H03	H3	-	H3	H2	H4	H3	H5	H4	H5	H4	H5	H5
H04	H1	-	H3	-	H3	H1	H4	H3	H5	H4	H5	H5
H05	-	-	-	-	H3	H3	H4	H4	H4	H4	H5	H5
H06	H3	H3	H4	H4	H4	H4	H5	H5	H5	H5	H6	H6
H07	H6	H6	H6	H6	H6	H6	H6	H6	H6	H6	H6	H6
H08	H1	H1	H3	H3	H3	H3	H4	H4	H5	H5	H5	H5
H09	H4	H4	H5	H5	H5	H5	H5	H5	H5	H5	H6	H6
H10	H4	H4	H4	H4	H5	H5	H5	H5	H5	H5	H6	H6
H11	H3	H3	H4	H4	H4	H4	H5	H5	H5	H5	H6	H6
H12	H3	H3	H4	H4	H4	H4	H5	H5	H5	H5	H6	H6
H13	H3	H3	H3	H3	H4	H4	H5	H5	H5	H5	H5	H5
H14	-	-	H2	H2	H3	H3	H4	H4	H4	H4	H5	H5
H15	-	-	H1	H1	H3	H3	H4	H4	H4	H4	H5	H5

Table 4.6 Peak Flow Distribution (m^3/s) around the Project Site

ID	1 in 20 AEP		1 in 50 AEP		1 in 100 AEP		1 in 100 AEP with climate change		1 in 2000 AEP		PMF	
	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop
Q01	363.6	359.7	477.4	476.9	504.3	504.2	481.8	482.2	531.3	531.7	566.5	567.2
Q02	0.0	0.0	41.3	36.7	117.9	108.2	424.3	423.2	717.3	716.9	1791.6	1790.9
Q03	23.8	23.5	59.0	59.7	46.7	48.9	76.0	76.8	108.6	109.2	388.7	388.9

Table 4.7 Inundation Duration (hours) around the Project Site

ID	1 in 20 AEP		1 in 50 AEP		1 in 100 AEP		1 in 100 AEP with climate change		1 in 2000 AEP		PMF	
	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop	Exg	Prop
H03	31.5	0	52	18.5	60	27	82+	46	69.5+	46.5	70.5+	63
H04	5.5	0	35	0	41	6.5	67+	33.5	60	36	64.5+	53
H05	0	0	0	0	46+	46+	58+	58+	57+	57+	61.5+	61.5+
H13	52.5+	52+	58+	58+	59.5+	59+	69.5+	69+	65+	65+	66.5+	66.5+

+ Inundation duration up to the end of simulation time of 90 hours

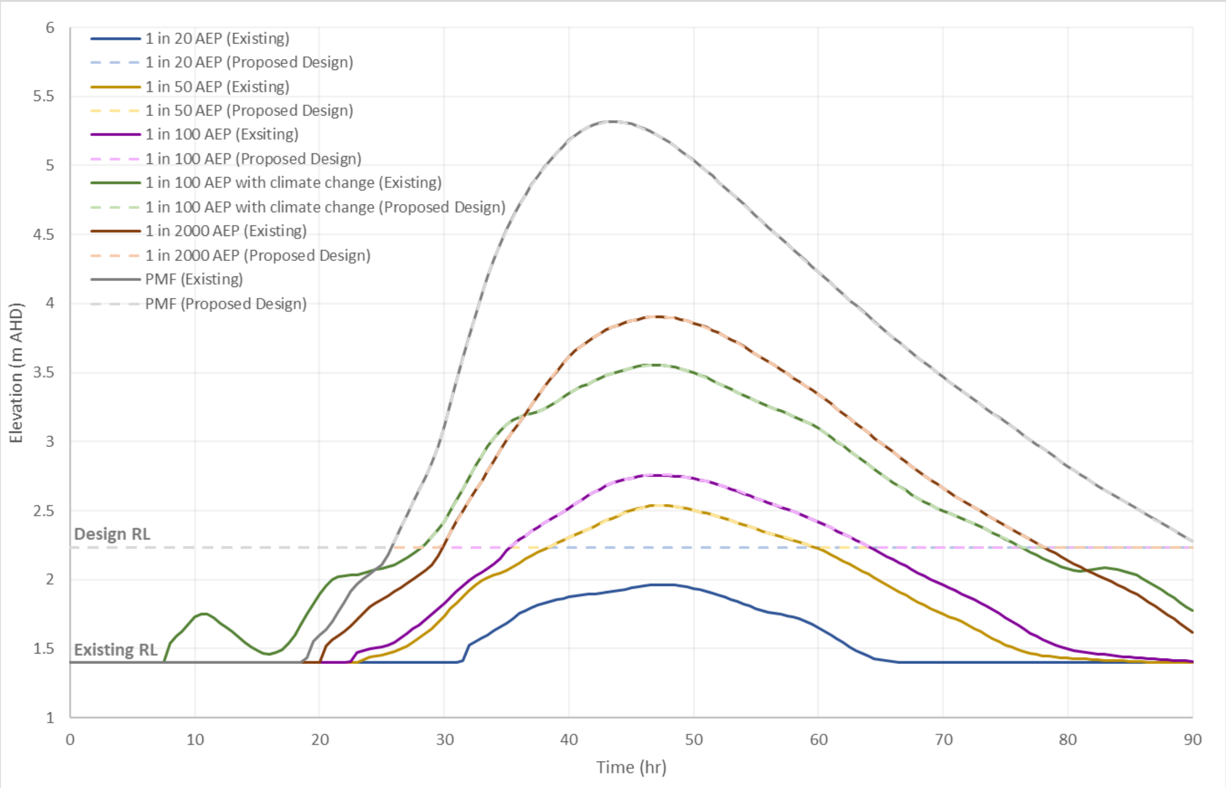

Figure 4.1 Level Hydrographs at Proposed Western Roundabout (H03)

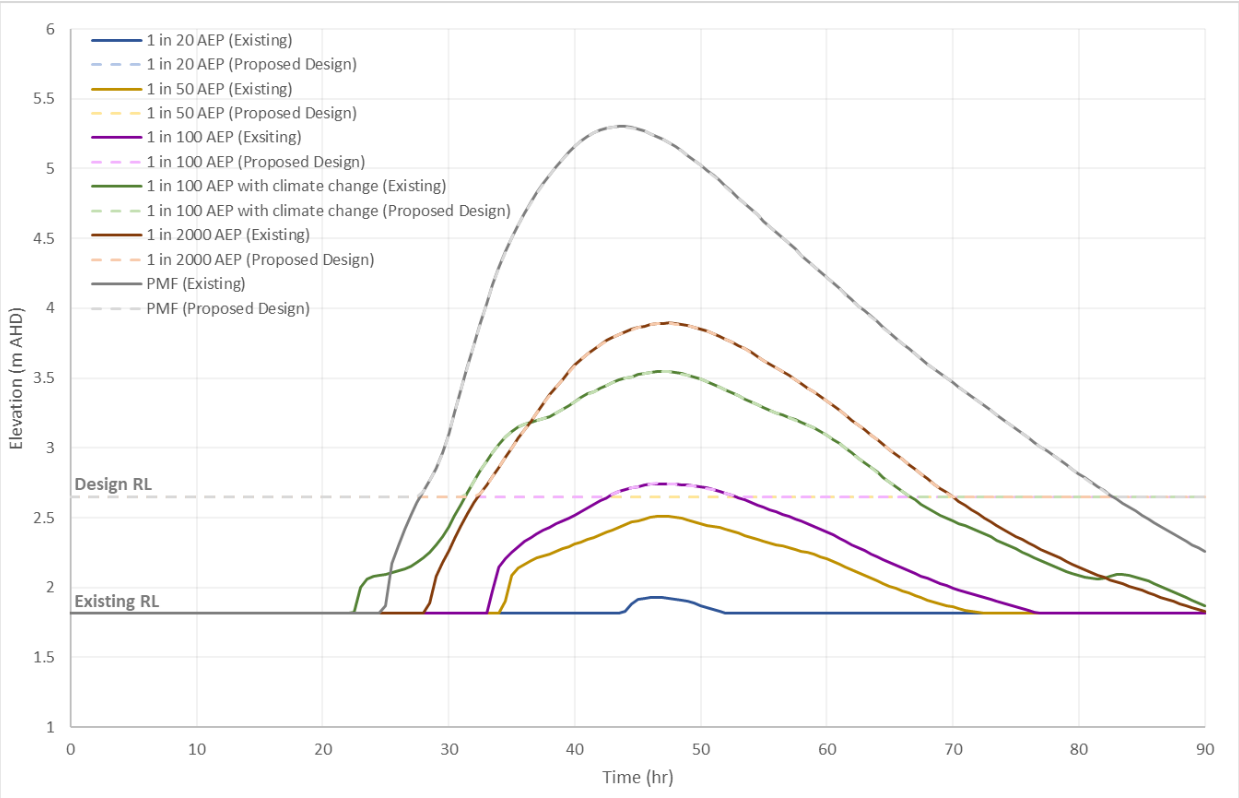

Figure 4.2 Level Hydrographs at Proposed Eastern Roundabout (H04)

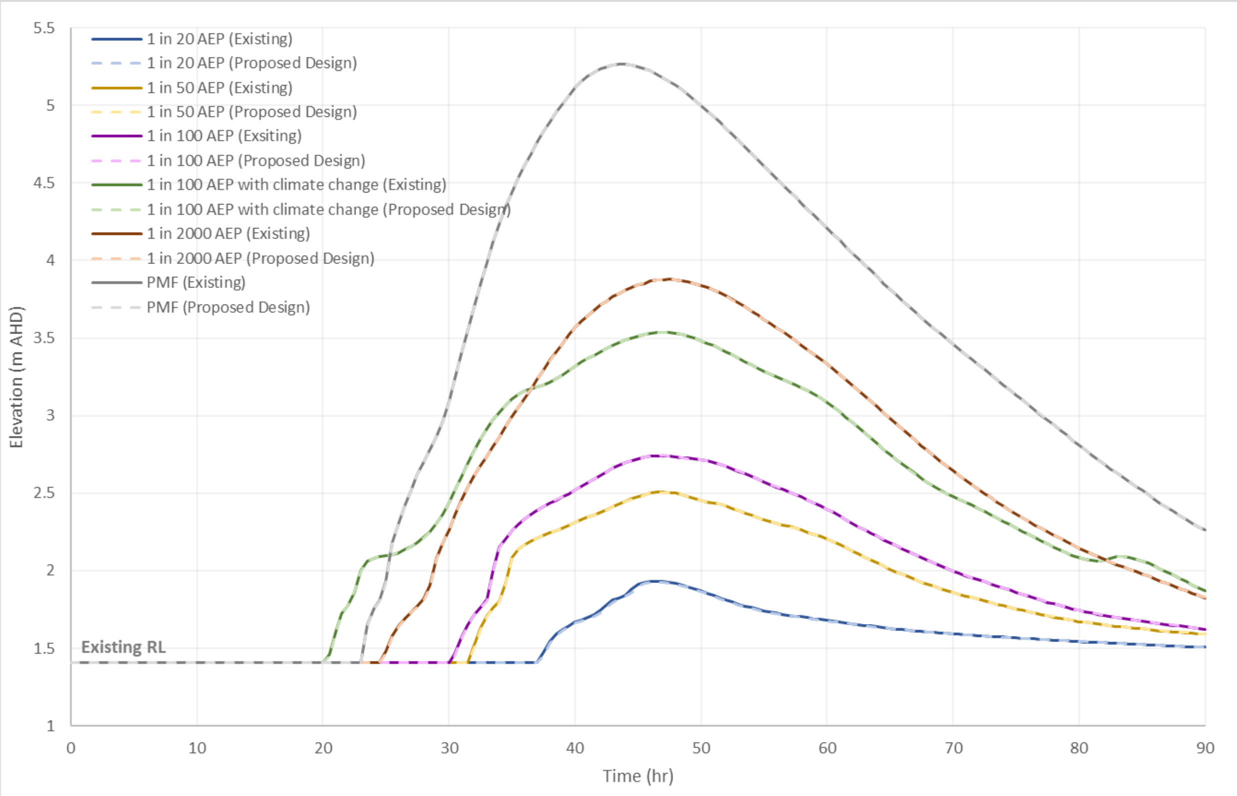

Figure 4.3 Level Hydrographs at Residential Properties East of Project Site (H13)

4.3 Assessment of Flood Impacts

Based on the flood modelling results for the events simulated, the following observations can be made of the impacts of the proposed 80% CD works on the existing flood behaviour around the Project site:

- There is minimal impact to the predicted peak flood levels (no peak flood level increase above mapping threshold of 0.02 m) around the Project site due to the proposed works, with slight reduction in flood extent exhibited within the Proposal area due to the elevation increase of the eastern and western embankments. In the 1 in 20 AEP event a minor increase in flood extent can be seen on the western embankment due to local road lowering in that area;
- There are minor localised increases in peak flood velocity outside of the Proposal area along Coopernook Road to the west of the Project site, though the increases are mostly less than 0.5 m/s and occurring mainly on the Coopernook Road corridor which is subject to slow-moving floodwaters (generally less than 1.0 m/s). Minor increases to velocity are also observed on lands to the immediate east of the eastern embankment;
- There is minimal change to the flood hazard categories in the vicinity of the Project site and surrounding floodplain, other than a reduction in flood hazard for the proposed embankments and roundabouts due to the proposed higher ground elevations;
- There is generally minimal change to the flow distribution across the floodplain (less than 1% difference) based on assessment of Coopernook Creek and Lansdowne River flows, as well as flows overtopping the Pacific Highway. The exception is for the 1 in 50 and 1 in 100 AEP events whereby the peak flow overtopping the Pacific Highway (Q02) is lower under design conditions, which can be attributed to the increase in ground levels along the highway and the western

embankment. It should be noted that the 1 in 50 AEP event is when the Pacific Highway would be overtopped by floodwaters; and

- The inundation duration across the floodplain remains largely unchanged except within the Project site whereby the two proposed roundabouts (refer Figure 4.1 and Figure 4.2), which have proposed ground elevations higher than existing conditions, would have a higher flood immunity and reduced inundation duration (refer Table 4.7).

Considering the minimal flooding impact observed for the proposed 80% CD works on adjacent lands/properties as well as watercourses outside the Proposal area, it can be concluded that flood mitigation measures are not required and the existing flood risks to life and properties around the Project site remain unchanged. There is also minimal flood impact on nearby areas of wetlands, biodiversity and heritage value due to the proposed works. Therefore, in addressing the criteria based on TfNSW specifications outlined in Section 4.1.1, it is concluded that the flood impact results are compliant (i.e. no adverse impacts affecting off-site properties).

4.4 Assessment of Flood Immunity

Based on the flood modelling results, the following observations can be made of the flood immunity of the proposed 80% CD infrastructure and existing roads:

- In view of the minimal change in peak flood levels predicted for design flood events up to the PMF, the flood immunity of nearby existing roads remains unchanged;
- The existing Pacific Highway between Coopernook Creek and Lansdowne River is generally flood free for events up to and including the 1 in 20 AEP design flood. There would be some minor encroachment of floodwaters on the northbound Pacific Highway carriageway (up to 0.2 m depth on the outside lane) between the Coopernook Road and Harrington Road intersections for the 1 in 20 AEP event. Nevertheless, this section of highway would only be overtopped and completely subject to flood inundation during events starting from the 1 in 50 AEP flood;
- The proposed eastern roundabout and embankment would be flood free in the 1 in 20 AEP event, while the proposed western embankment would be partially inundated due to minor overtopping in the same event but not the roundabout. In the 1 in 50 AEP event, the proposed eastern roundabout would be partially inundated and it would be completely inundated in the 1 in 100 AEP event and greater;
- As the PMF level is 5.32 mAHD, the proposed bridge over the Pacific Highway would not be overtopped in the PMF event and the floodwaters would not reach the soffit of the bridge deck (i.e. lowest level at 8.68 mAHD); and
- It was found that the existing pipes/culverts around the Project site are already at full capacity for both existing and proposed 80% CD conditions in the 1 in 20 AEP event. This is to be expected considering the relatively flat topography around the Project site and since the flood behaviour affecting the Project site is categorised as “Flood Storage”, i.e. driven by flood volume rather than conveyance.

Based on these results, the flood immunity criteria based on TfNSW specifications as outlined in Section 4.1.2 are met.

4.5 Sensitivity Assessment of Coincidence and Independence of Flood Mechanisms

A sensitivity assessment was undertaken to assess the difference in predicted flood behaviour around the Project site based on the assumption of a coincident mainstream flooding from the Lansdowne River and Manning River in combination versus flooding from either the Lansdowne River or Manning River in isolation. This was carried out by comparing the 1 in 100 AEP peak flood levels around the Project site and the results are provided in Table 4.8.

It can be noted from Table 4.8 that the flooding at the Project site originates primarily from the Manning River in a coincidental Lansdowne River and Manning River flooding scenario. In an independent Lansdowne River flooding scenario, the 1 in 100AEP peak flood levels are significantly lower (compared to the coincident mainstream flooding scenario) and to a large degree also influenced by the downstream ocean tide. In an independent Manning River flooding scenario, the 1 in 100 AEP peak flood levels are still lower than the coincident mainstream flooding scenario, in the order of 0.1 to 0.2 m. This confirms the coincident mainstream flooding from the Lansdowne River and Manning River in combination is the dominant flood mechanism in this area.

Regardless of the flood mechanisms (either coincident mainstream flooding from the Lansdowne River and Manning River in combination or flooding from the Lansdowne River/Manning River in isolation), the impacts of the proposed 80% CD works on the peak flood levels are shown to be minimal for the 1 in 100 AEP event. For the Landsdowne River only flooding scenario, there is a slight increase in the 1 in 100 AEP peak flood levels to the west of the Project site (H07 and H09) but this is within the 0.02 m mapping threshold.

Table 4.8 1 in 100 AEP Peak Flood Levels (mAHD) for Sensitivity Assessment of Flood Mechanisms

ID	Combined Manning and Lansdowne River Flooding		Lansdowne River Flooding Only		Manning River Flooding Only	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
H01	2.76	2.76	1.66	1.45	2.60	2.60
H02	2.75	2.75	1.14	0.94	2.60	2.60
H03	2.76	2.76	1.66	-	2.60	2.60
H04	2.75	2.75	-	-	2.60	-
H05	2.77	2.77	-	-	-	-
H06	2.76	2.76	1.35	1.31	2.60	2.60
H07	2.76	2.76	1.69	1.70	2.60	2.60
H08	2.76	2.77	-	-	2.60	2.60
H09	2.76	2.76	1.67	1.69	2.60	2.60
H10	2.76	2.76	1.62	1.49	2.60	2.60
H11	2.75	2.75	-	-	2.60	2.60
H12	2.75	2.75	-	-	2.60	2.60
H13	2.74	2.74	-	-	2.60	2.60
H14	2.76	2.76	-	-	2.60	2.60
H15	2.75	2.75	-	-	2.60	2.60

4.6 Construction Flood Impacts

Potential flood impacts due to construction related facilities and activities have not been modelled but commentary is provided below on estimated floor levels and depths at those facilities.

Three Ancillary Facility sites are proposed as part of the construction works (see Figure 4.4). The locations of the Ancillary Facility sites were provided by AECOM and their locations can broadly be described as follows:

- At the intersection of Coopernook Road and George Gibson Drive to the west of the Project site (Ancillary Site 1);
- To the south of the proposed eastern embankment (Ancillary Site 2); and
- At the intersection of Two Mile Creek Road and George Gibson Drive to the north of the Project site (Ancillary Site 3).

Ancillary Sites 1 and 2 will be partially inundated from a 1 in 5 AEP event, with water depths of up to 0.6 m and 0.8 m respectively. Affectation would increase with event rarity, with water depths in the 1 in 20 AEP event of up to 1.0 m at Ancillary Site 1 and 1.5 m at Ancillary Site 2. Both Ancillary Sites 1 and 2 would be fully inundated in the 1 in 100 AEP event, with water depths of up to 1.8 m and 2.2 m respectively. Ancillary Site 3 remains flood free for all modelled events up to and including the Probable Maximum Flood. The potential for Ancillary Sites 1 and 2 to obstruct floodplain flow paths should be considered as part of the detailed design stage.

Given the low flood immunity of Ancillary Sites 1 and 2 it must be acknowledged that the plant and materials located at the Sites would be subject to potential flood risks. Based on historical record, there is not a clearly defined wet/dry season at the locality and flooding has occurred at different times of the year throughout the period of record. An extensive flood warning system is available on the Manning River, including a gauge upstream of the Site at Croki which has a target flood warning time of 12 hours. It is recommended that this flood warning system should be monitored and a plan put in place to reduce the impact of flooding to ancillary works in the event of a warning being issued.

Title:

Construction Facilities - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event Peak Depths

Figure: 4.4

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5 Summary and Conclusions

5.1 Summary and Conclusions

This report documents the approach and outcomes of the flood assessment undertaken for the proposed 80% Concept Design (80% CD) of the HW10 Pacific Highway / Harrington Road Interchange Upgrade (CHiP) Project. The assessment addresses the flood impacts and flood immunity requirements for the Project as per TfNSW's Project brief and specifications. The flood models developed for MidCoast Council as part of the '*Manning River Floodplain Risk Management Study and Plan*' (BMT, 2020) were adopted for the flood assessment, which consider primarily mainstream flood behaviour including the Lansdowne River and Manning River flooding. Refinements were made to the flood models including updating the XP-RAFTS hydrologic model to utilise ARR 2019 data and methodology. Simulations were then undertaken for both the existing (base case) and proposed 80% CD conditions for the 1 in 20, 1 in 50, 1 in 100, 1 in 2000 AEP and PMF events, as well as a 1 in 100 AEP climate change scenario incorporating rainfall increase and sea level rise. The assessment considers mainstream flooding to be the dominant flood mechanism at the Project site in terms of both flood impacts and immunity, therefore a combined mainstream flood assessment (i.e. considering coincident Manning and Lansdowne River catchment flooding) was undertaken.

The following conclusions can be made based on the flood impact results for the simulated flood events:

- There is minimal impact to modelled flood levels (no peak flood level increase above mapping threshold of 0.02 m) around the Project site due to the proposed works. There are slight changes to the flood extent exhibited within the Proposal area which are attributed to the elevation changes along the eastern and western embankments;

- There are minor localised increases in peak flood velocity outside of the Proposal area along Coopernook Road to the west of the Project site, though the increases are mostly less than 0.5 m/s and occurring mainly on the Coopernook Road corridor which is subject to slow-moving floodwaters (generally less than 1.0 m/s);

- There is minimal change to the flood hazard categories for the flow conditions around the Project site and surrounding floodplain, other than reduction in flood hazard for the proposed embankments and roundabouts due to higher proposed ground elevations;

- There is generally minimal change to the flow distribution across the floodplain (less than 1% difference) based on an assessment of Coopernook Creek and Lansdowne River flows, as well as flows overtopping the Pacific Highway. The exception is for the 1 in 50 and 1 in 100 AEP events whereby the peak flow overtopping the Pacific Highway (at model output location Q02) is lower under design conditions, which can be attributed to the increase in ground levels along the highway and the western embankment. It should be noted that the 1 in 50 AEP event is when the Pacific Highway would be overtopped by floodwaters; and

- The inundation duration across the floodplain remains largely unchanged except within the Project site whereby the two proposed roundabouts, which have elevations higher than existing conditions, would have a higher flood immunity and reduced inundation duration when the roundabouts are inundated.

Considering the minimal flooding impact observed for the proposed 80% CD works on adjacent lands/properties as well as watercourses outside the Proposal area, it can be concluded that flood mitigation measures are not required and the existing flood risks to life and properties around the Project site remain unchanged. There is also minimal flood impact for the events assessed on nearby areas of wetlands, biodiversity and heritage value due to the proposed works. Therefore, in addressing the criteria based on TfNSW specifications outlined in Section 4.1.1, the flood impact results are compliant (i.e. no adverse impacts affecting off-site properties).

The following conclusions can be made on the flood immunity of the Project:

- In view of the minimal change in peak flood levels predicted for design flood events up to the PMF, the flood immunity of nearby existing roads remains unchanged;
- The existing Pacific Highway between Coopernook Creek and Lansdowne River is generally flood free for events up to and including the 1 in 20 AEP design flood. There would be some minor encroachment of floodwaters on the northbound Pacific Highway carriageway (up to 0.2 m depth on the outside lane) between the Coopernook Road and Harrington Road intersections for the 1 in 20 AEP event. Nevertheless, this section of highway would only be overtopped and completely subject to flood inundation during events starting from the 1 in 50 AEP flood;
- The proposed eastern roundabout and embankment would be flood free in the 1 in 20 AEP event, while the proposed western embankment would be inundated in the same event but not the roundabout. In the 1 in 50 AEP event, the proposed eastern roundabout would be partially inundated and it would be completely inundated in the 1 in 100 AEP event and greater;
- As the PMF level is 5.31 mAHD, the proposed bridge over the Pacific Highway would not be inundated in the PMF event and the floodwaters would not reach the soffit of the bridge deck (i.e. lowest level at 7.22 mAHD); and
- It was found that the existing pipes/culverts around the Project site are already at full capacity for both existing and proposed 80% CD conditions in the 1 in 20 AEP event. This is to be expected considering the relatively flat topography around the Project site and since the flood behaviour affecting the Project site is categorised as “Flood Storage”, i.e. driven by flood volume rather than conveyance.

Based on these results, the flood immunity criteria based on TfNSW specifications as outlined in Section 4.1.2 are met.

5.2 Limitations and Assumptions

The following are the limitations and assumptions pertaining to the flood assessment undertaken herein:

- BMT has not undertaken a comprehensive review of the Council’s flood models developed as part of the *‘Manning River Floodplain Risk Management Study and Plan’* (BMT, 2020) and earlier *‘Manning River Flood Study’* (BMT WBM, 2016). The general approach and assumptions from these studies were largely retained for this assessment unless otherwise stated herein, such as the ARR 2019 update. It was noted that some existing hydraulic and bridge structures have not been included in the Council’s hydraulic model and where information is available on the structures this has been incorporated into the flood modelling;

- The flood assessment herein considers primarily mainstream flooding including the Lansdowne River and Manning River and does not explicitly simulate the local catchment flooding. Assessment of the local overland flow paths is undertaken as part of the drainage design (by AECOM);

- The original TUFLOW FV model that was used in the simulation of sediment transport processes at the ocean entrances at Harrington and Old Bar during flood events (as part of the *'Manning River Flood Study'* (BMT WBM, 2016)) has not been re-simulated (i.e. the boundary assumptions regarding the ocean entrances at Harrington and Old Bar therefore remain unchanged);
- The regional model used in the assessment accounts for but does not explicitly model local catchment runoff. Proposed highway drainage is also not modelled;
- The flood impact assessment undertaken herein has not considered cumulative impacts from other new developments that are taking place in the same catchment; and
- Development of a Stormwater Management Plan for the Project is outside the scope of the current assessment.

6 References

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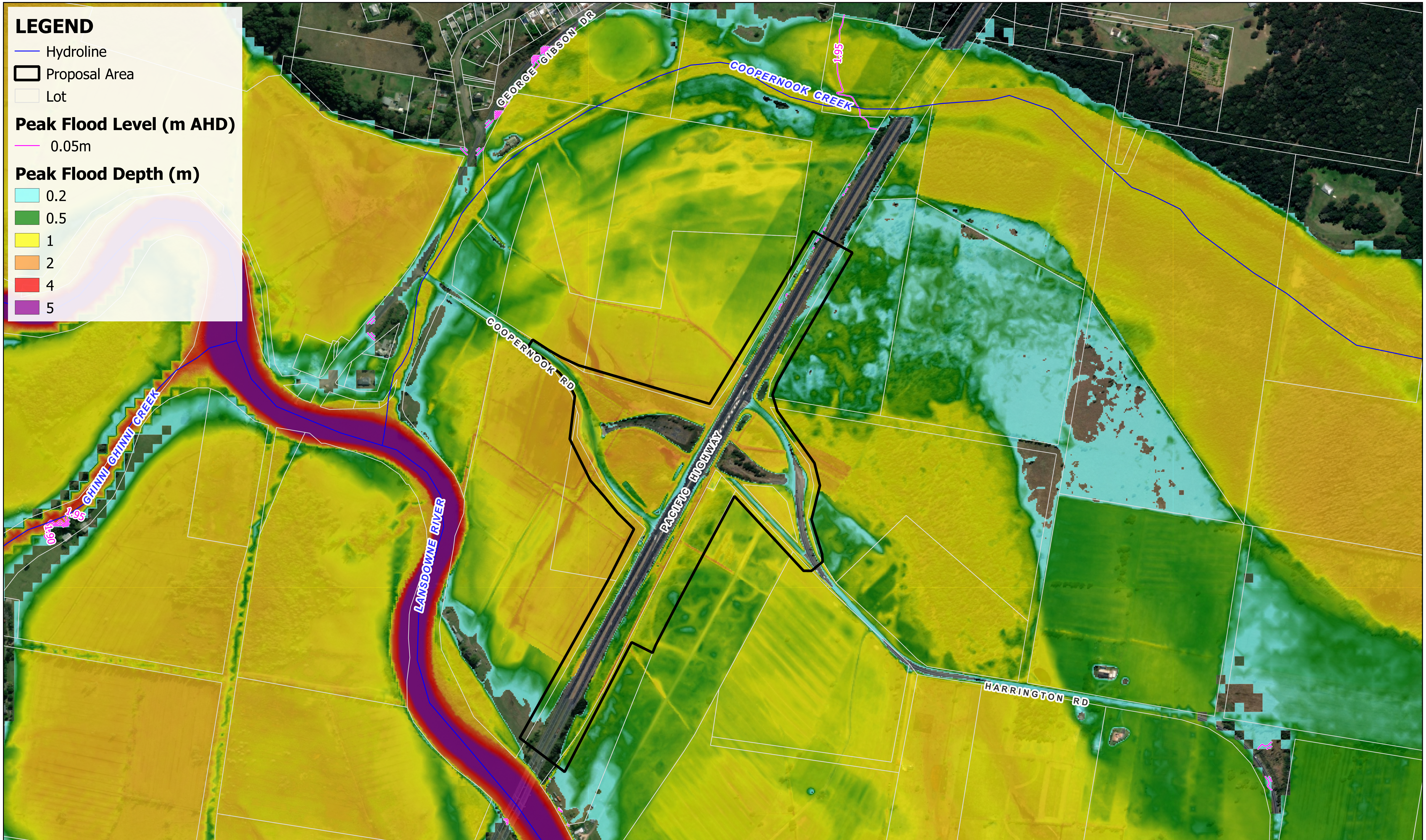
Annex A Existing (Base Case) Conditions Flood Maps



Title:

Peak Flood Depths and Levels - Existing Conditions - 5% (1 in 20) AEP Event

Figure: A-01

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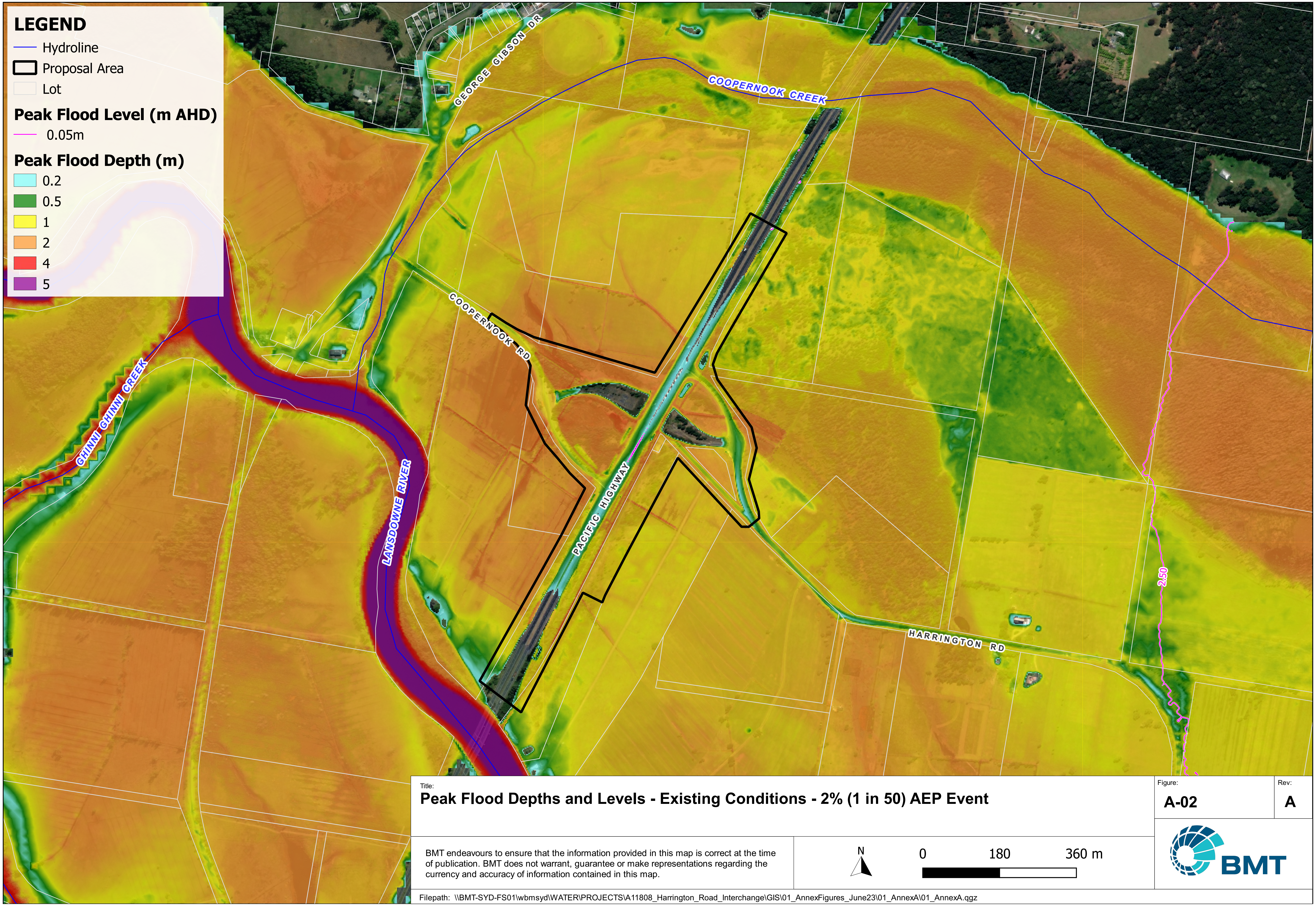

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Peak Flood Depths and Levels - Existing Conditions - 2% (1 in 50) AEP Event

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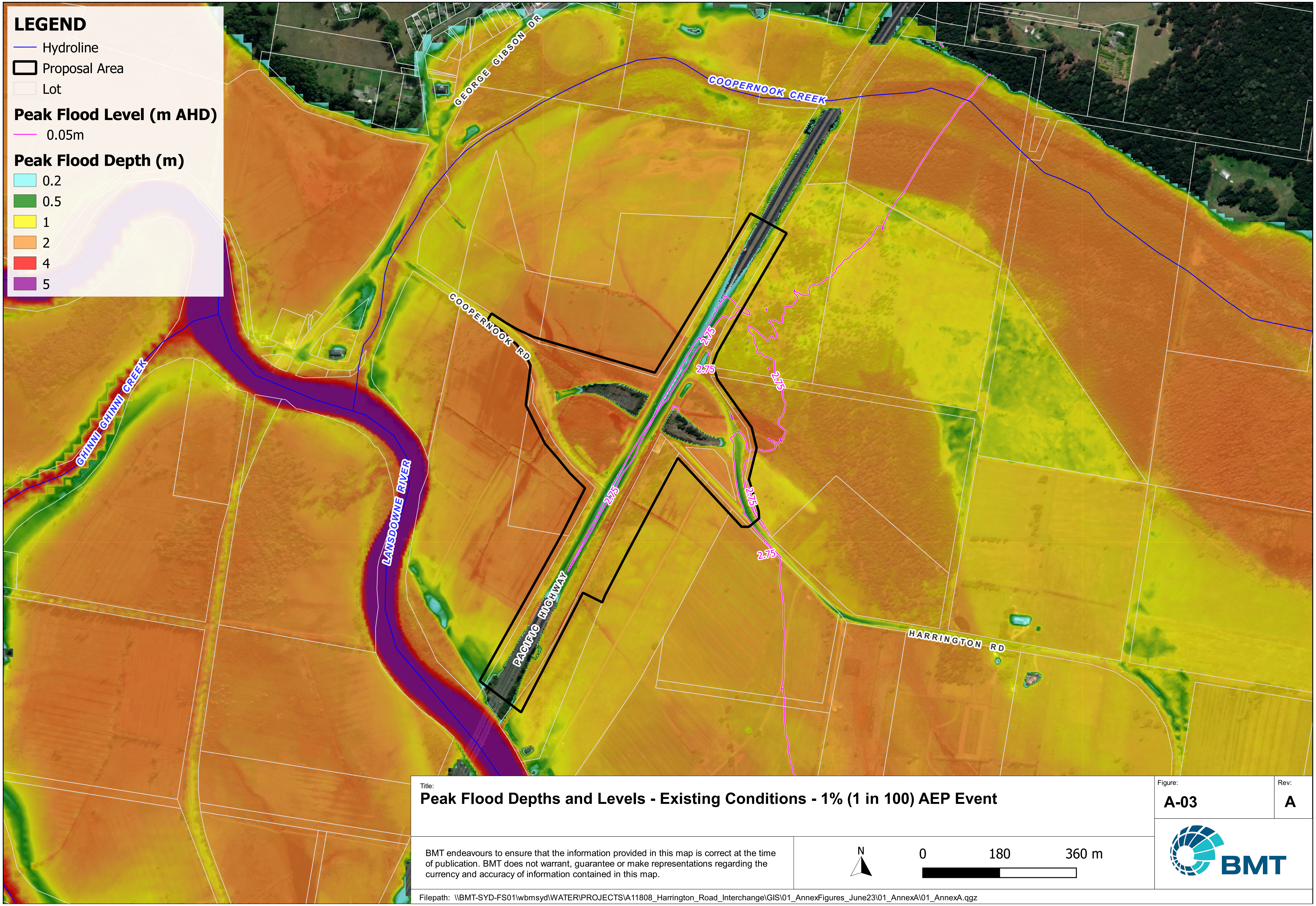

Title:

Peak Flood Depths and Levels - Existing Conditions - 1% (1 in 100) AEP Event

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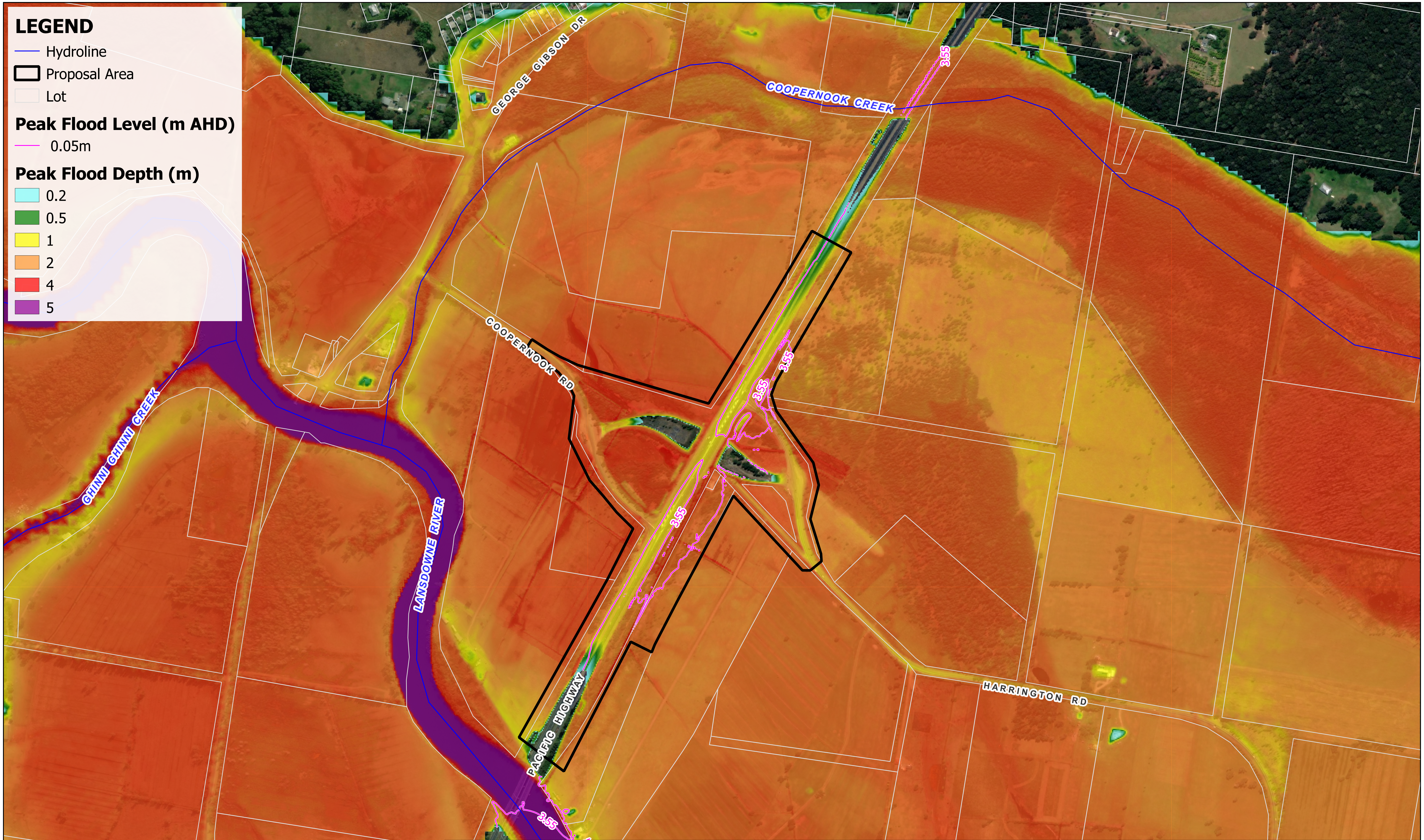

Title:

Peak Flood Depths and Levels - Existing Conditions - 1% (1 in 100) AEP Event with Climate Change

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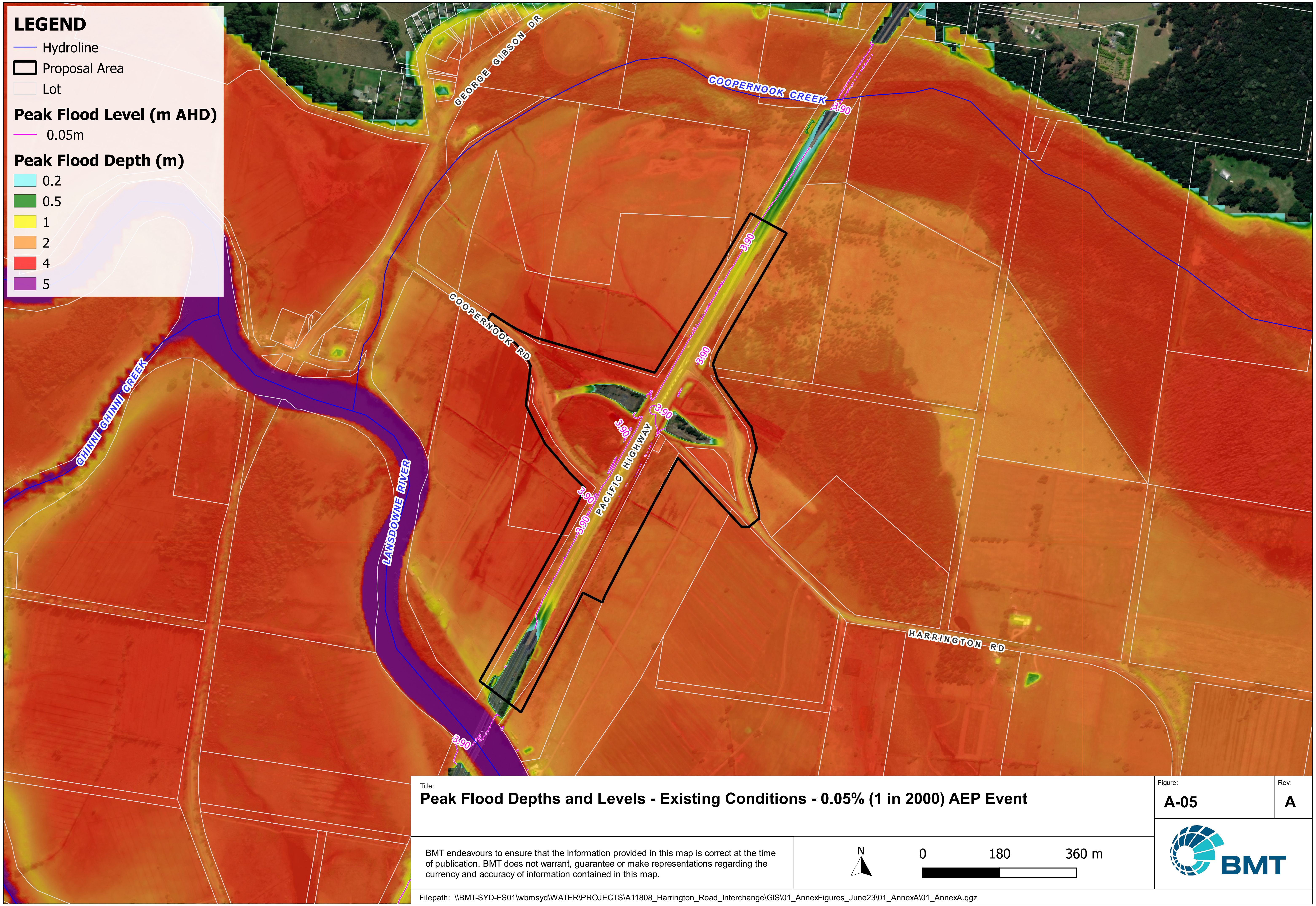

Title:

Peak Flood Depths and Levels - Existing Conditions - 0.05% (1 in 2000) AEP Event

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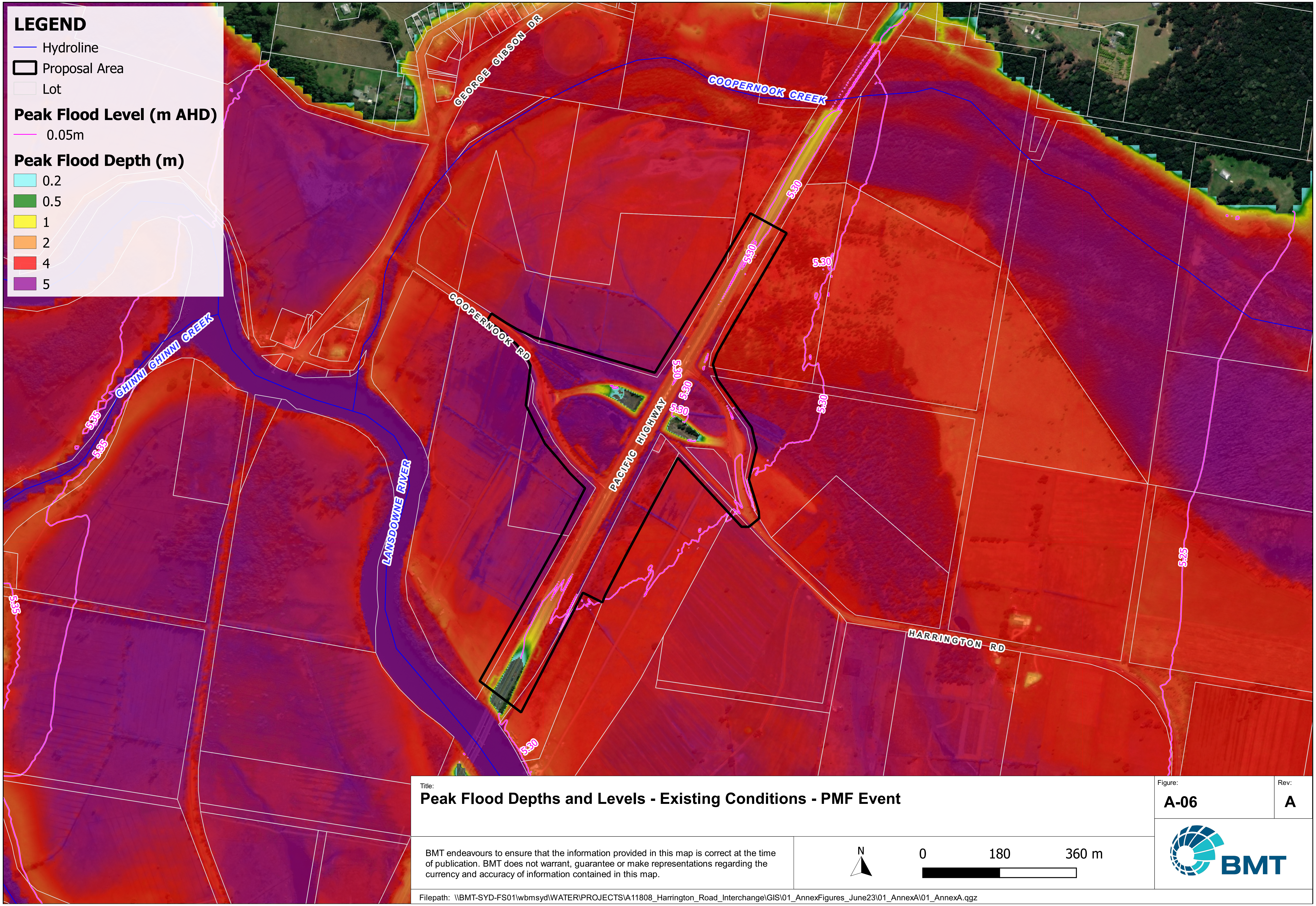

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Peak Flood Depths and Levels - Existing Conditions - PMF Event

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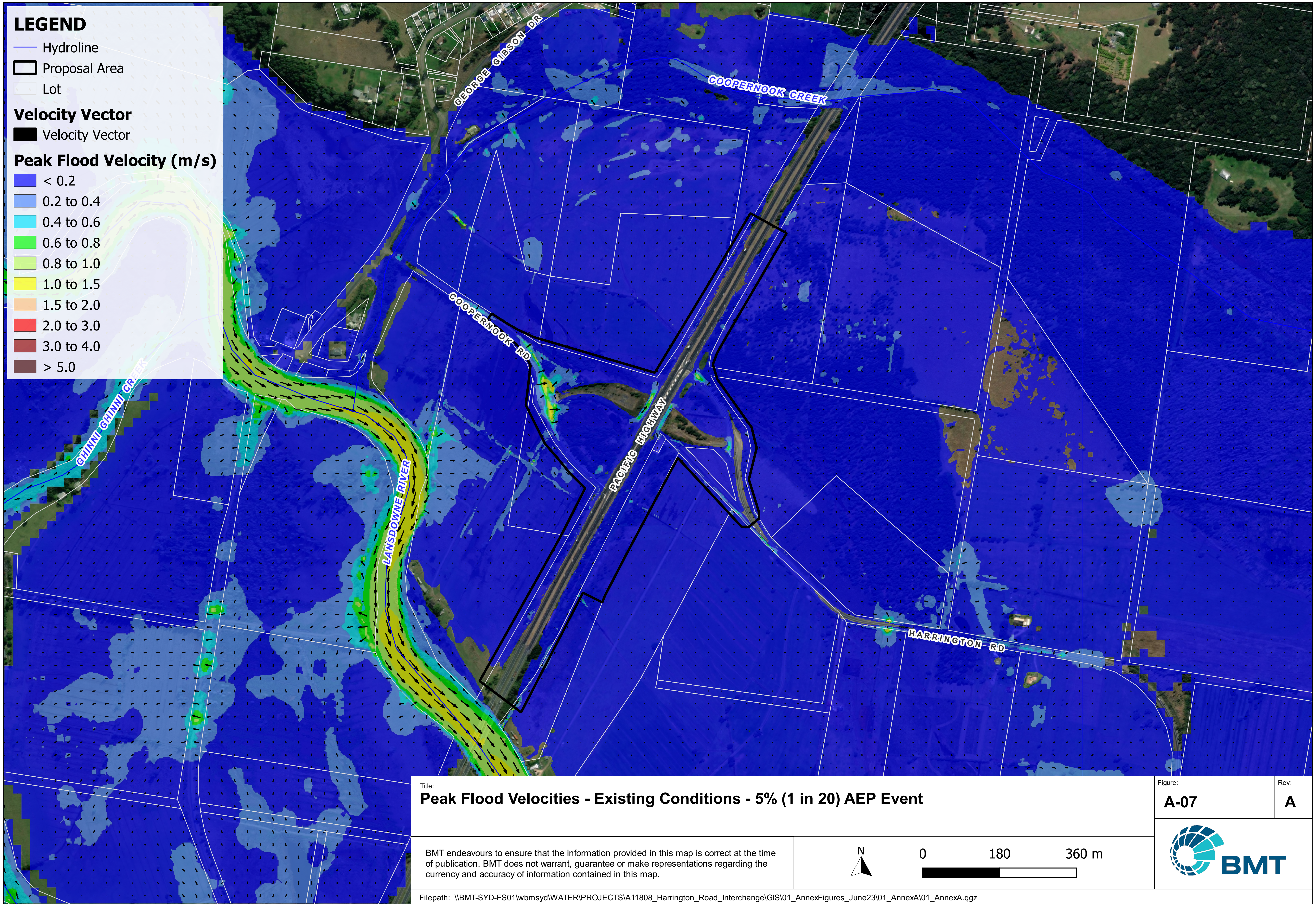

Title:
Peak Flood Velocities - Existing Conditions - 5% (1 in 20) AEP Event

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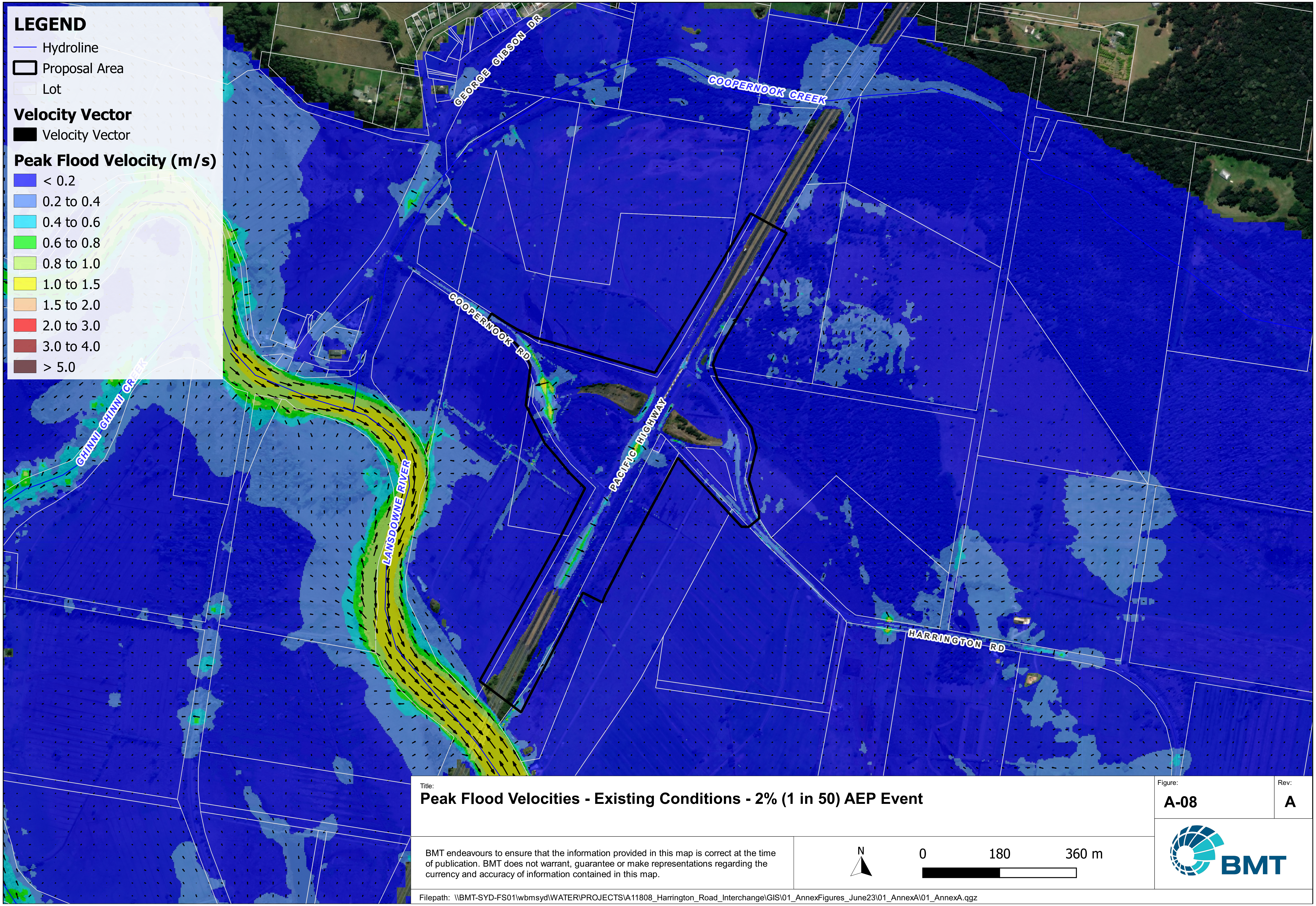

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Peak Flood Velocities - Existing Conditions - 2% (1 in 50) AEP Event

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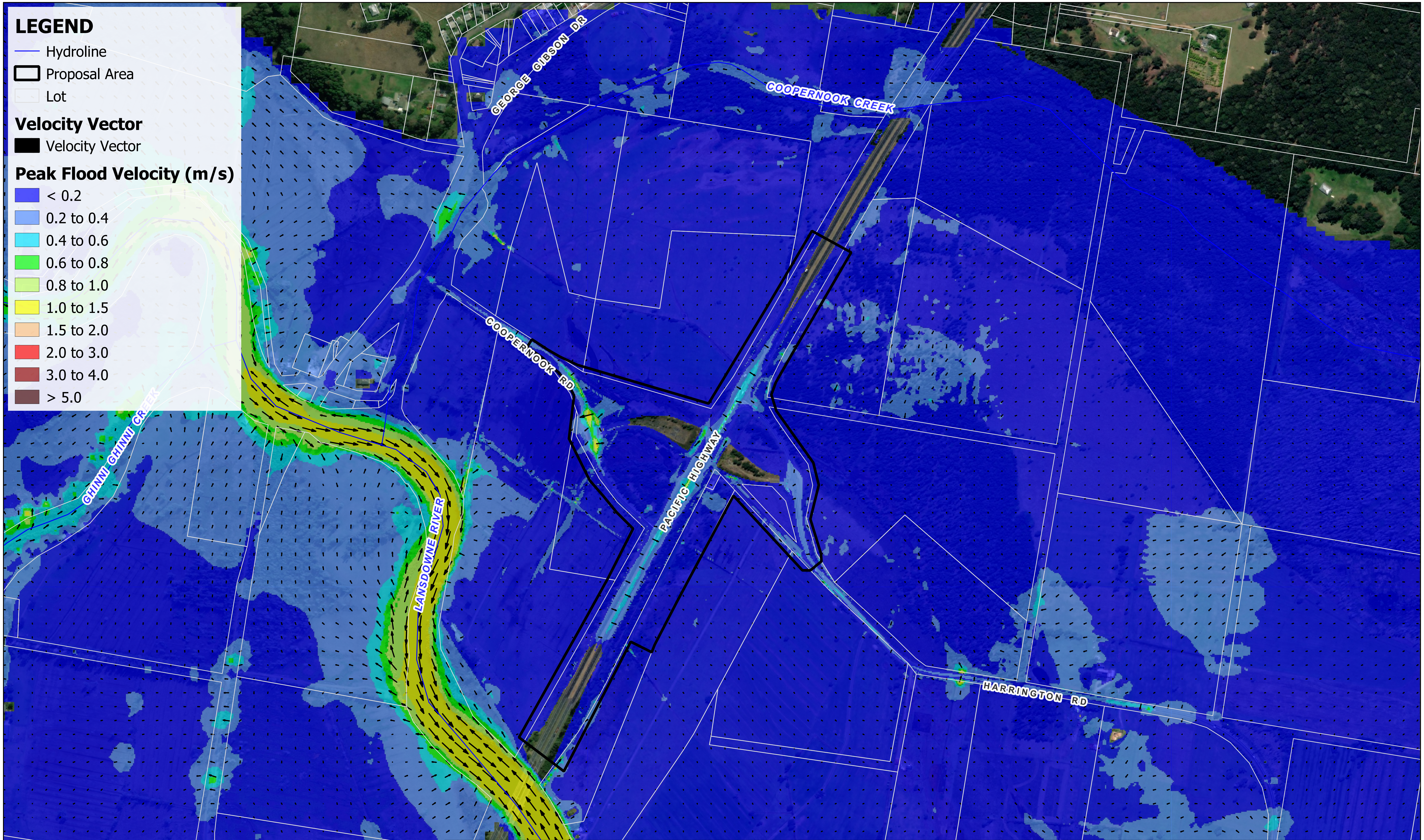

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Peak Flood Velocities - Existing Conditions - 1% (1 in 100) AEP Event

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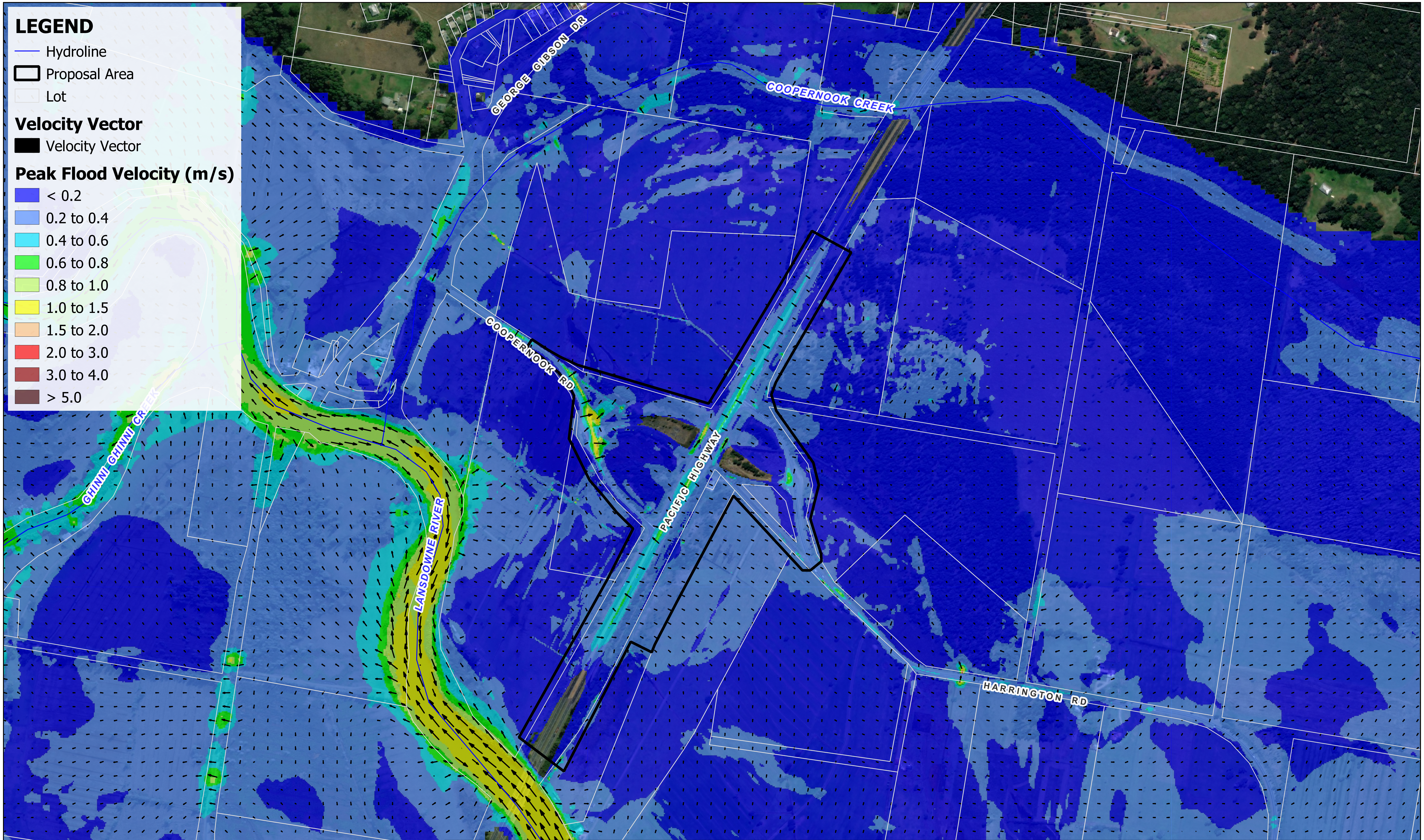

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Peak Flood Velocities - Existing Conditions - 1% (1 in 100) AEP Event with Climate Change

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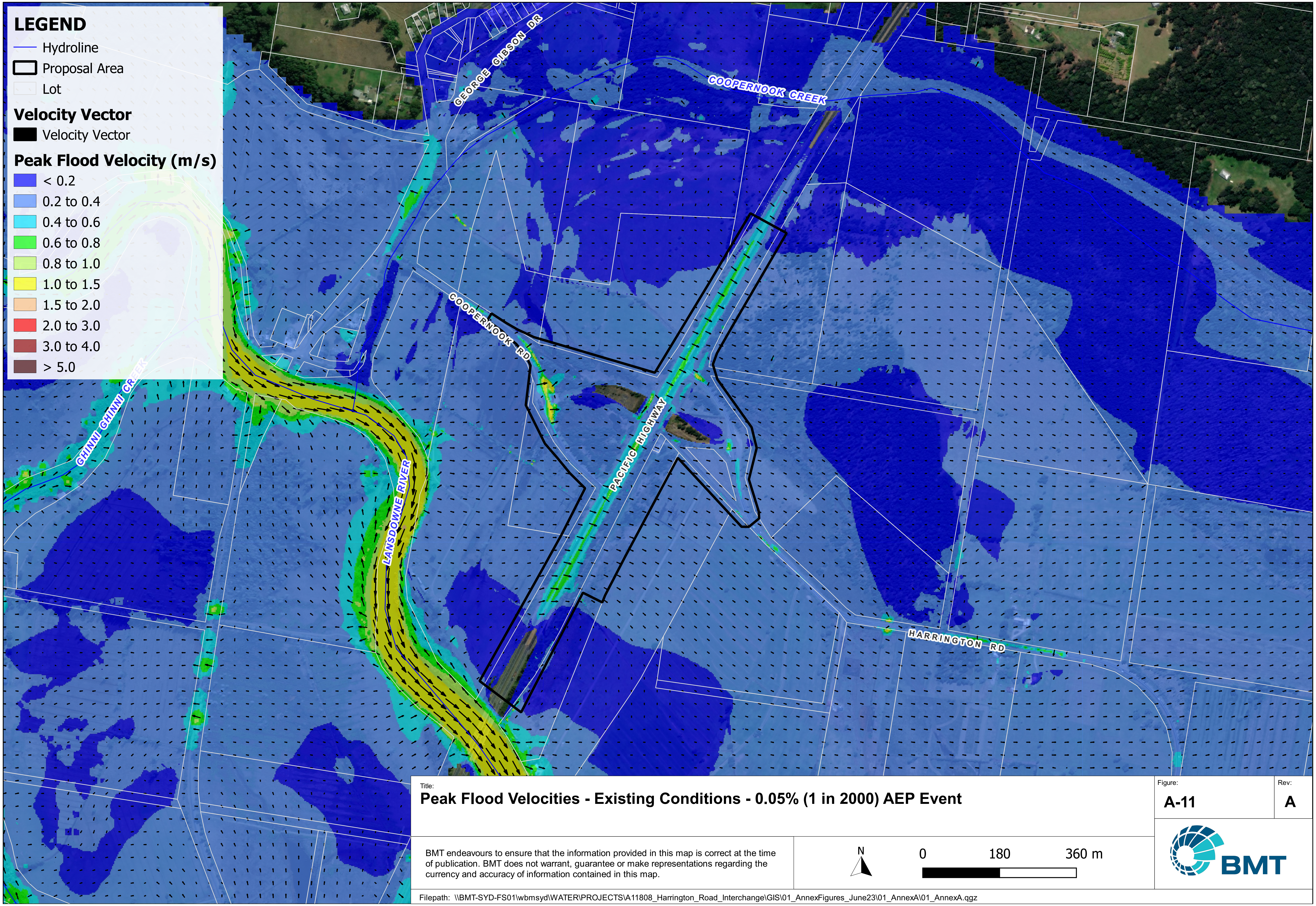

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Peak Flood Velocities - Existing Conditions - 0.05% (1 in 2000) AEP Event

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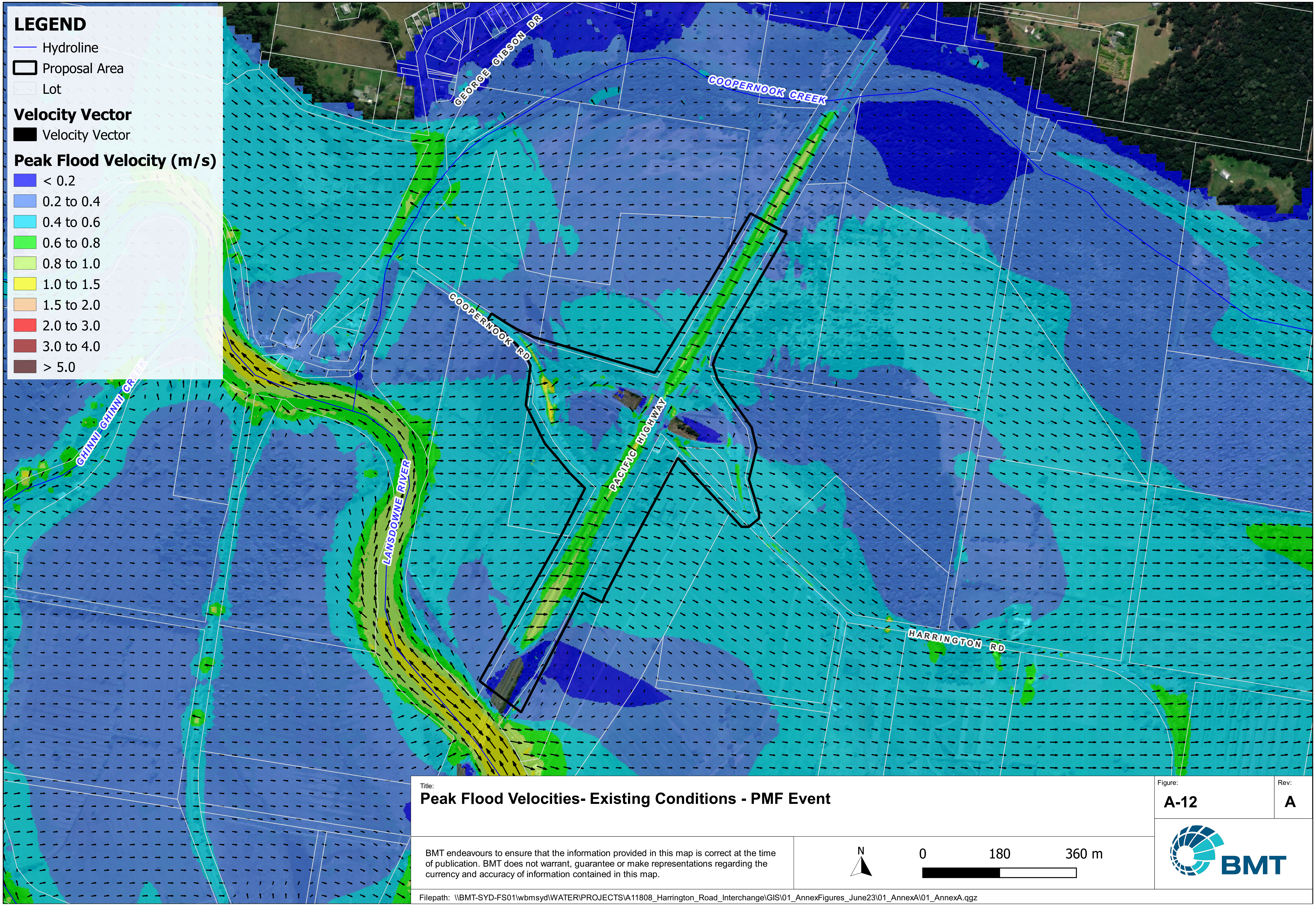

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Peak Flood Velocities- Existing Conditions - PMF Event

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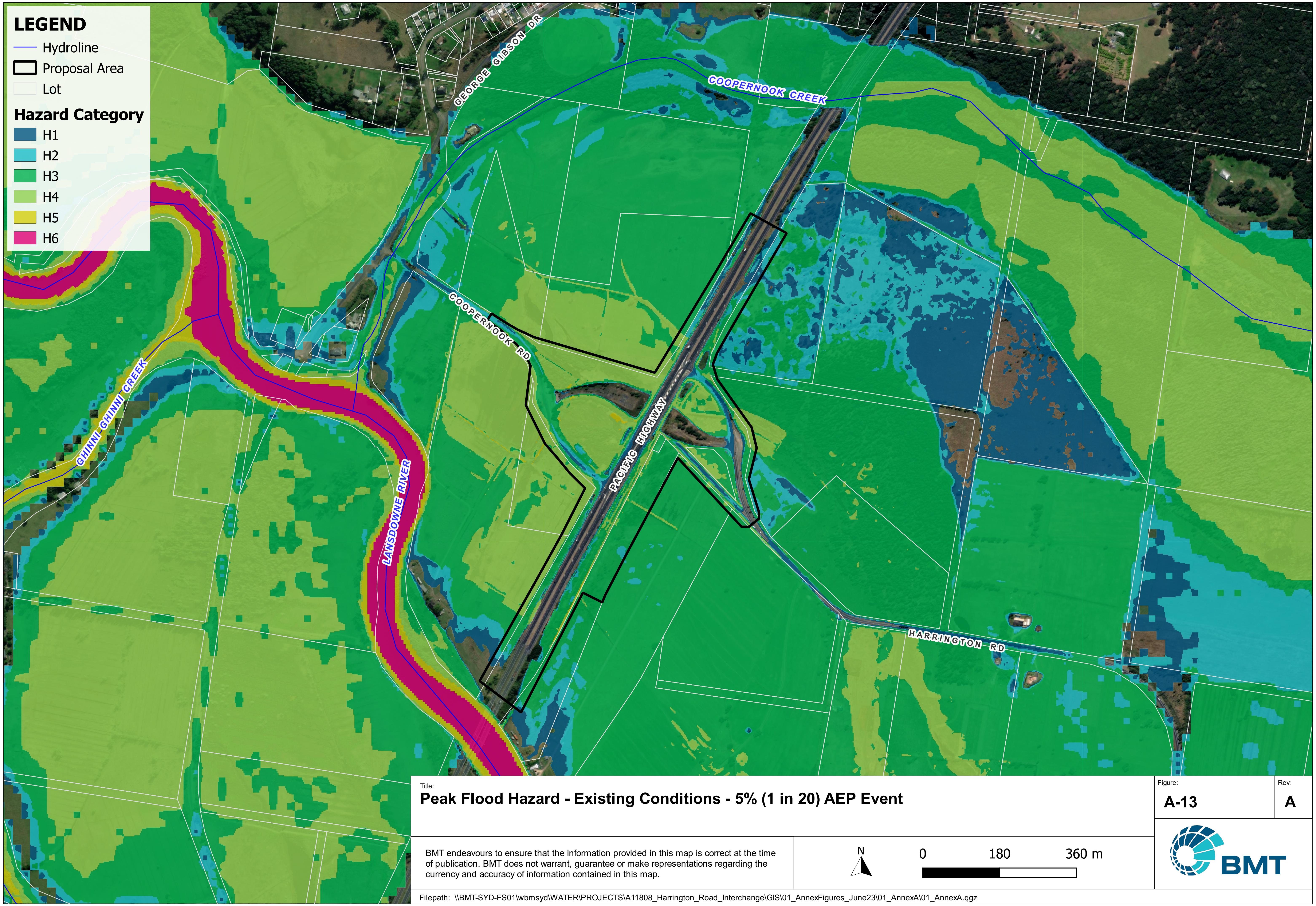

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Peak Flood Hazard - Existing Conditions - 5% (1 in 20) AEP Event

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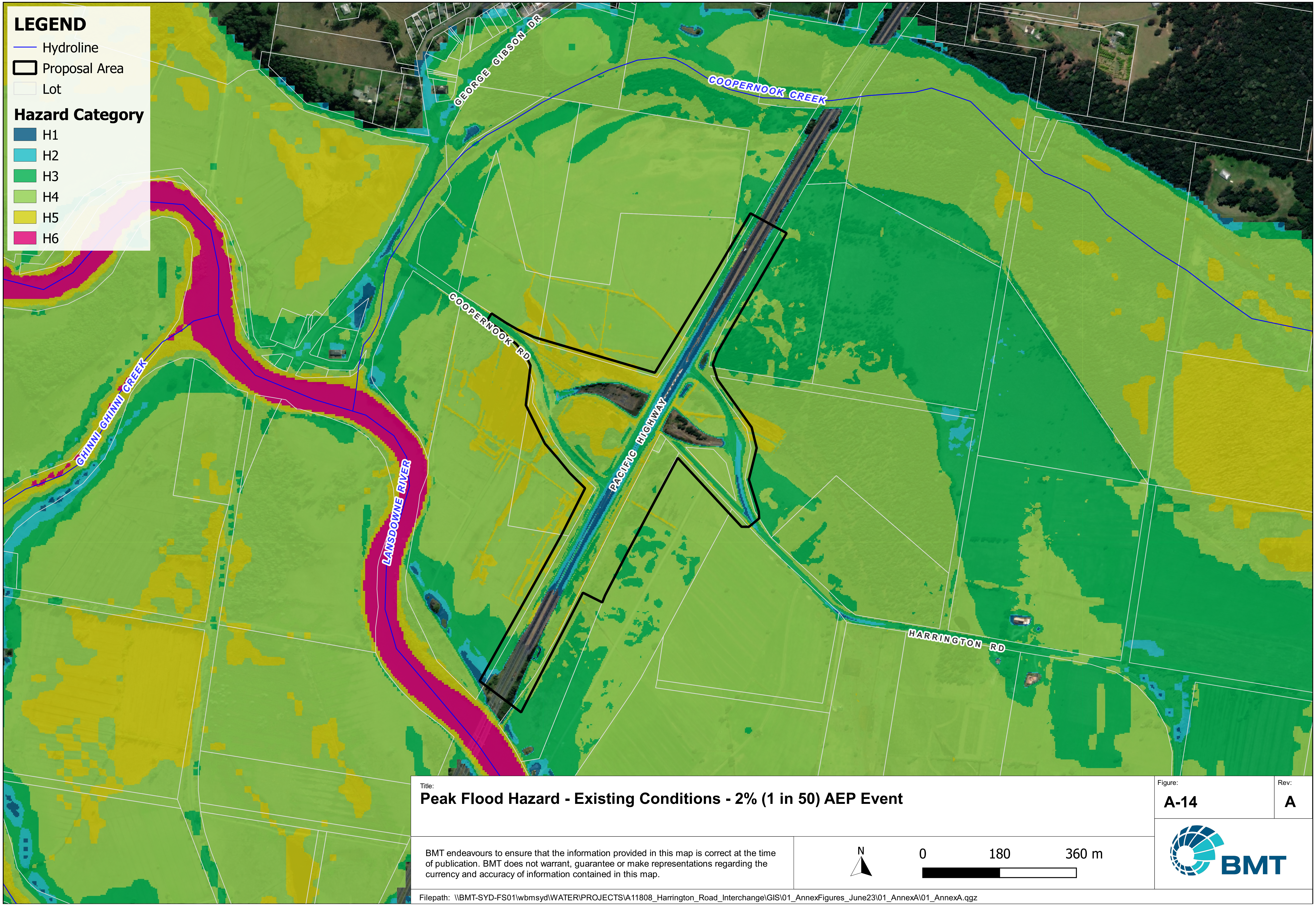

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Peak Flood Hazard - Existing Conditions - 2% (1 in 50) AEP Event

Figure: A-14

Rev: A

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N

0 180 360 m

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Title:

Peak Flood Hazard - Existing Conditions - 1% (1 in 100) AEP Event

Figure: **A-15**

Rev: **A**

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N

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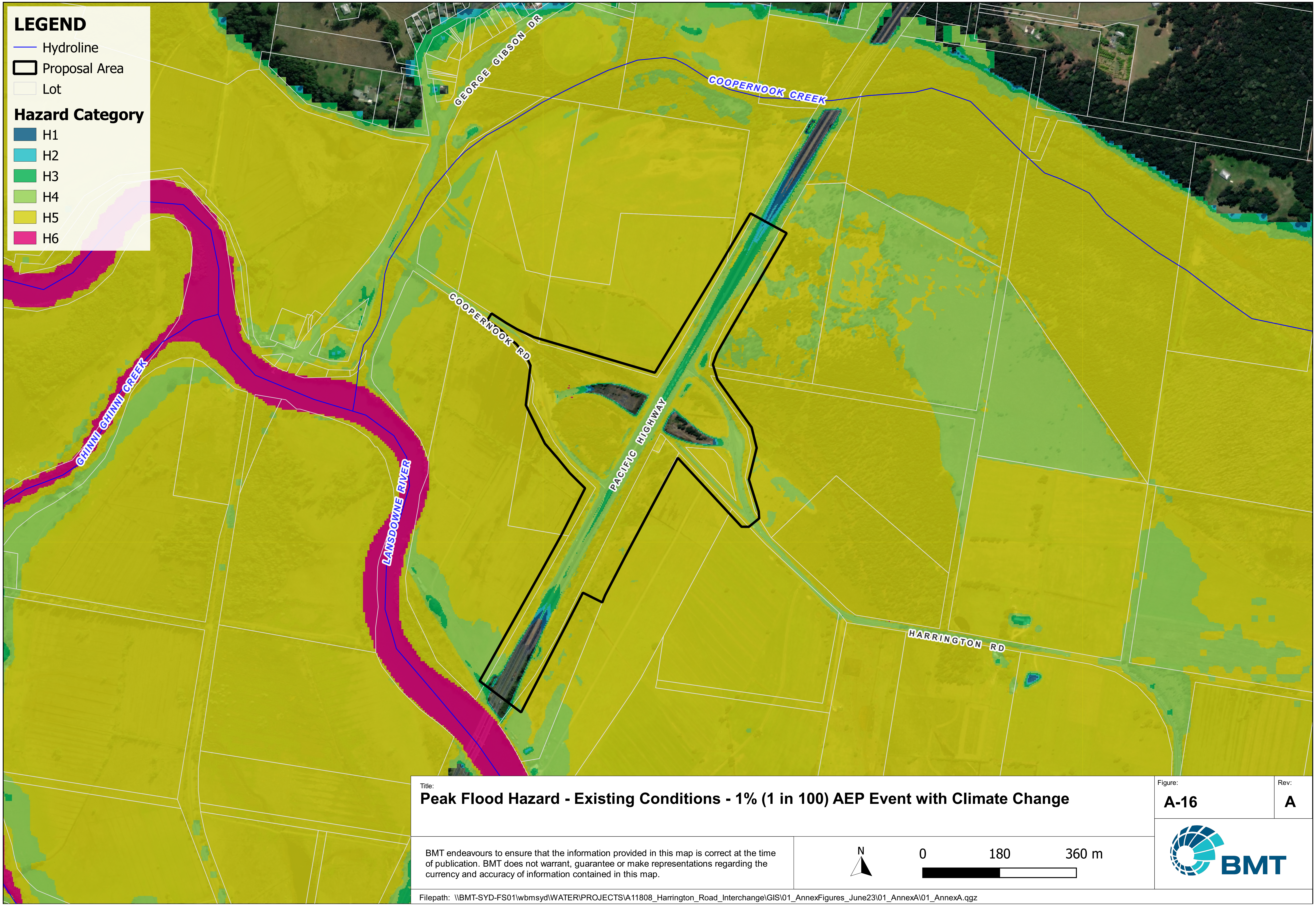

Title:

Peak Flood Hazard - Existing Conditions - 1% (1 in 100) AEP Event with Climate Change

Figure: A-16

Rev: A

BMT

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Title:

Peak Flood Hazard - Existing Conditions - 0.05% (1 in 2000) AEP Event

Figure: A-17

Rev: A

BMT

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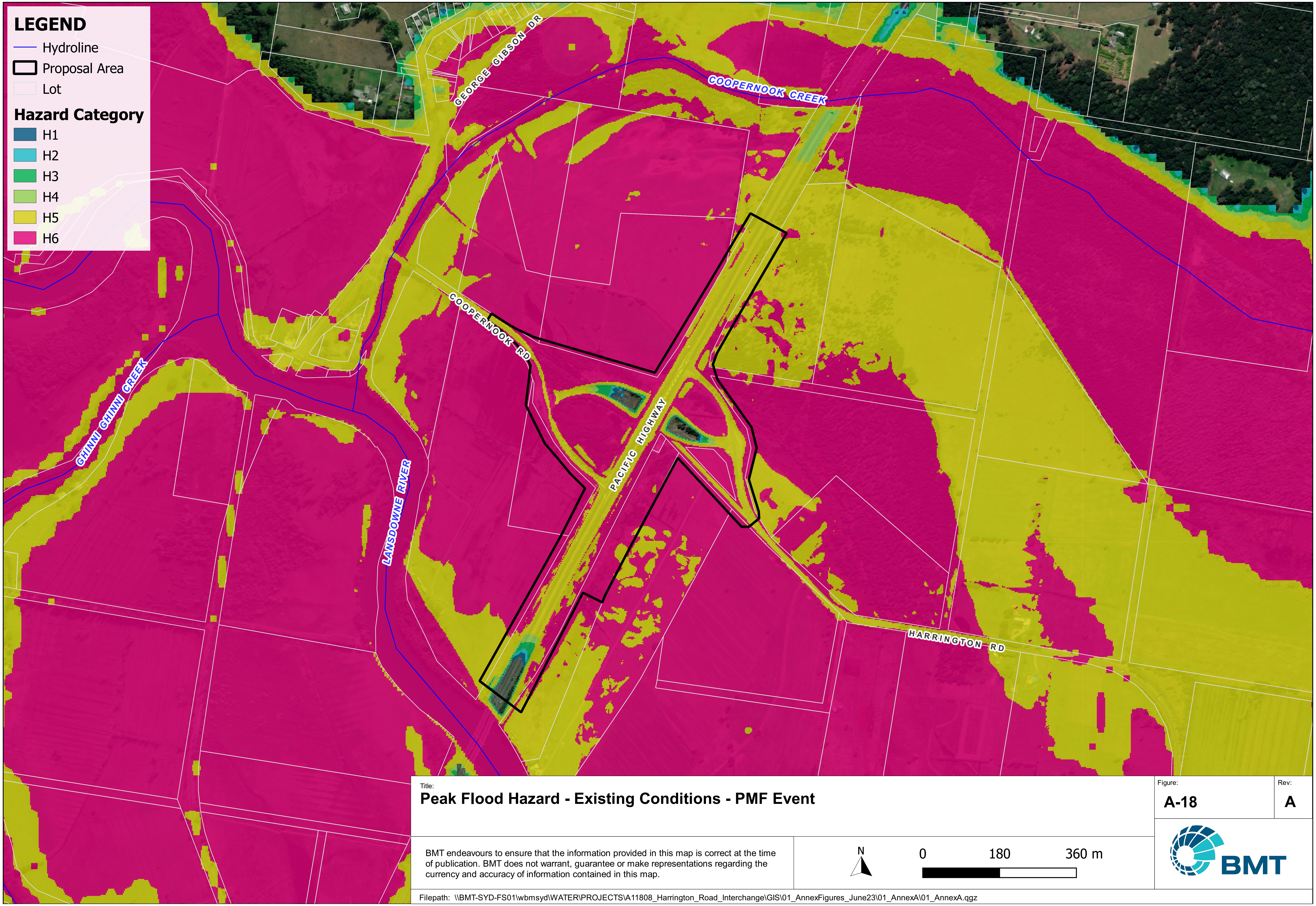


Title:

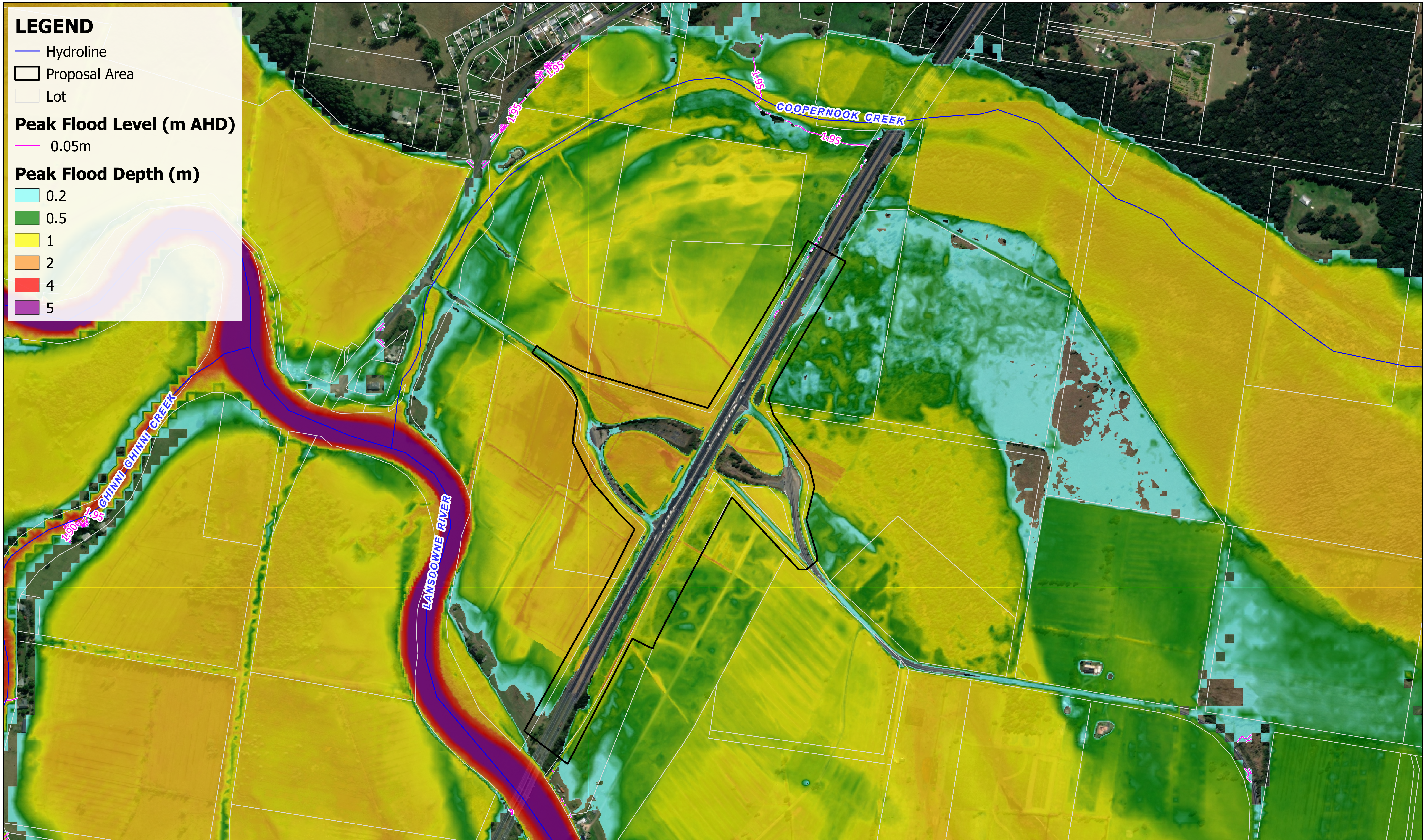
Peak Flood Hazard - Existing Conditions - PMF Event

Figure: A-18

Rev: A

Filepath: \\BMT-SYD-FS01\wbmsyd\WATER\PROJECTS\A11808_Harrington_Road_Interchange\GIS\01_AnnexFigures_June23\01_AnnexA\01_AnnexA.qgz

Annex B Proposed 80% Concept Design Conditions Flood Maps



Title:
Peak Flood Depths and Levels - Proposed 80% CD Conditions - 5% (1 in 20) AEP Event

Figure: B-01

Rev: A

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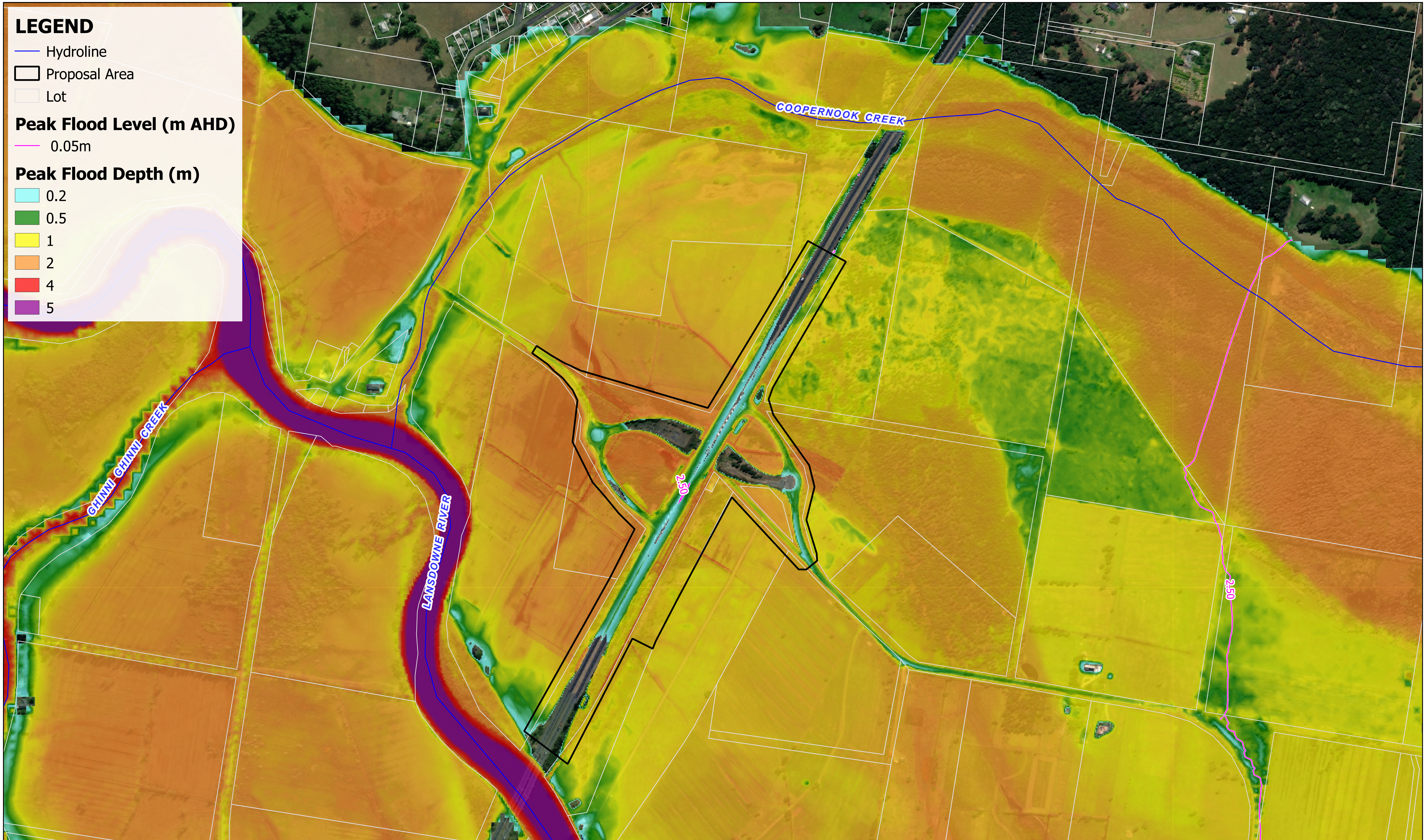

Title:
Peak Flood Depths and Levels - Proposed 80% CD Conditions - 2% (1 in 50) AEP Event

Figure: B-02

Rev: A

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N

0 190 380 m

BMT

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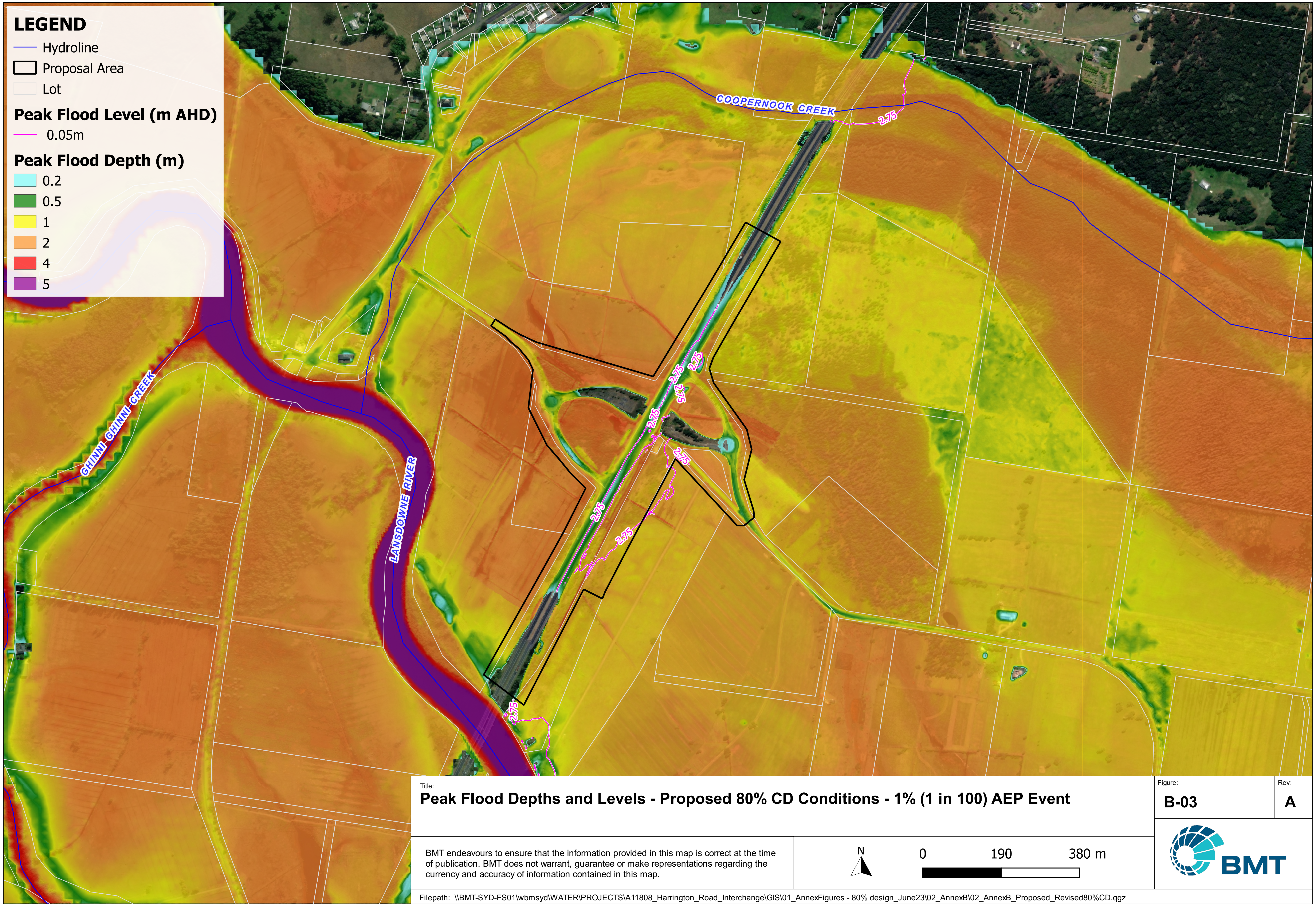

Title:

Peak Flood Depths and Levels - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event

Figure: B-03

Rev: A

BMT

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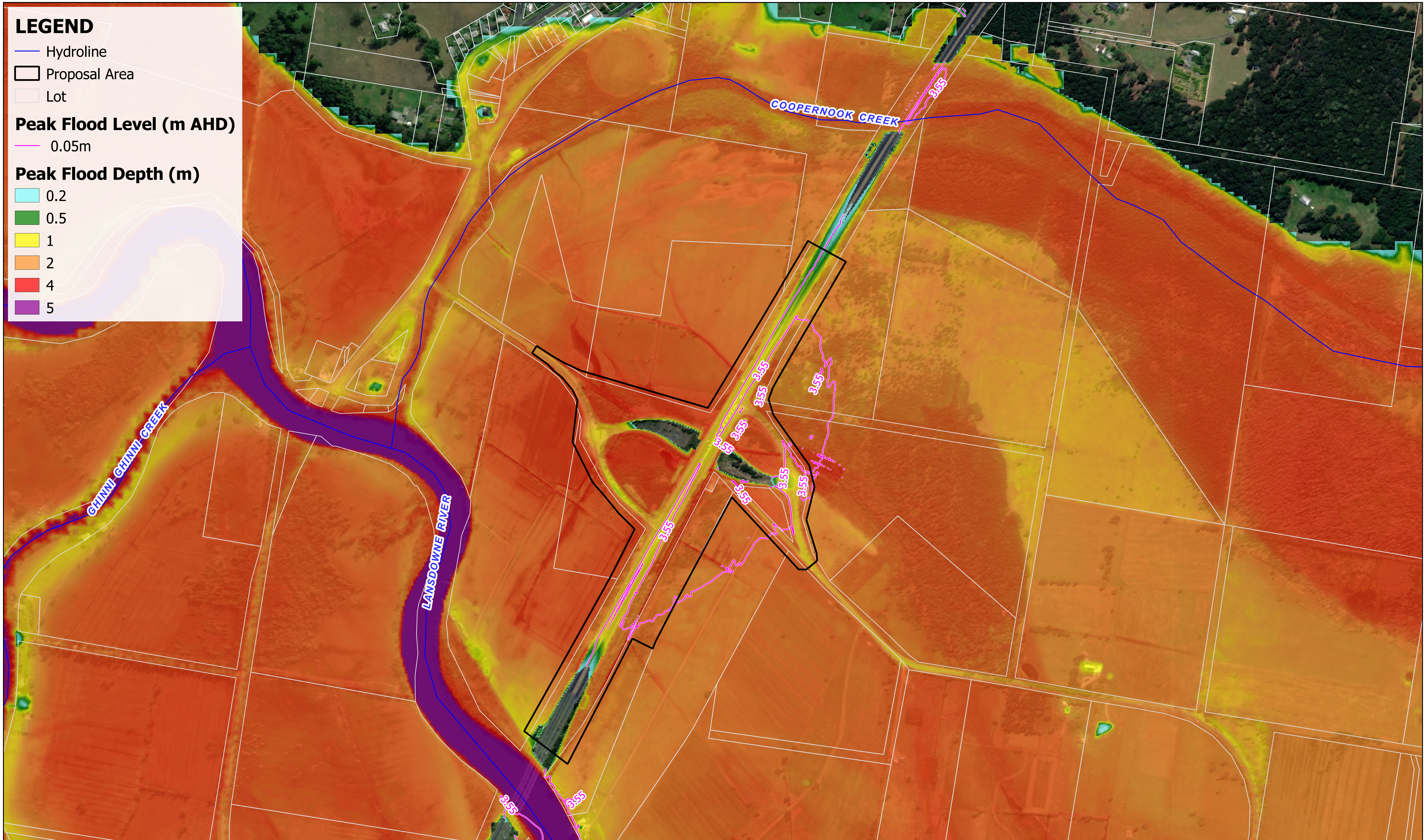

Title:

Peak Flood Depths and Levels - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event with Climate Change

Figure: B-04

Rev: A

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N

0 190 380 m

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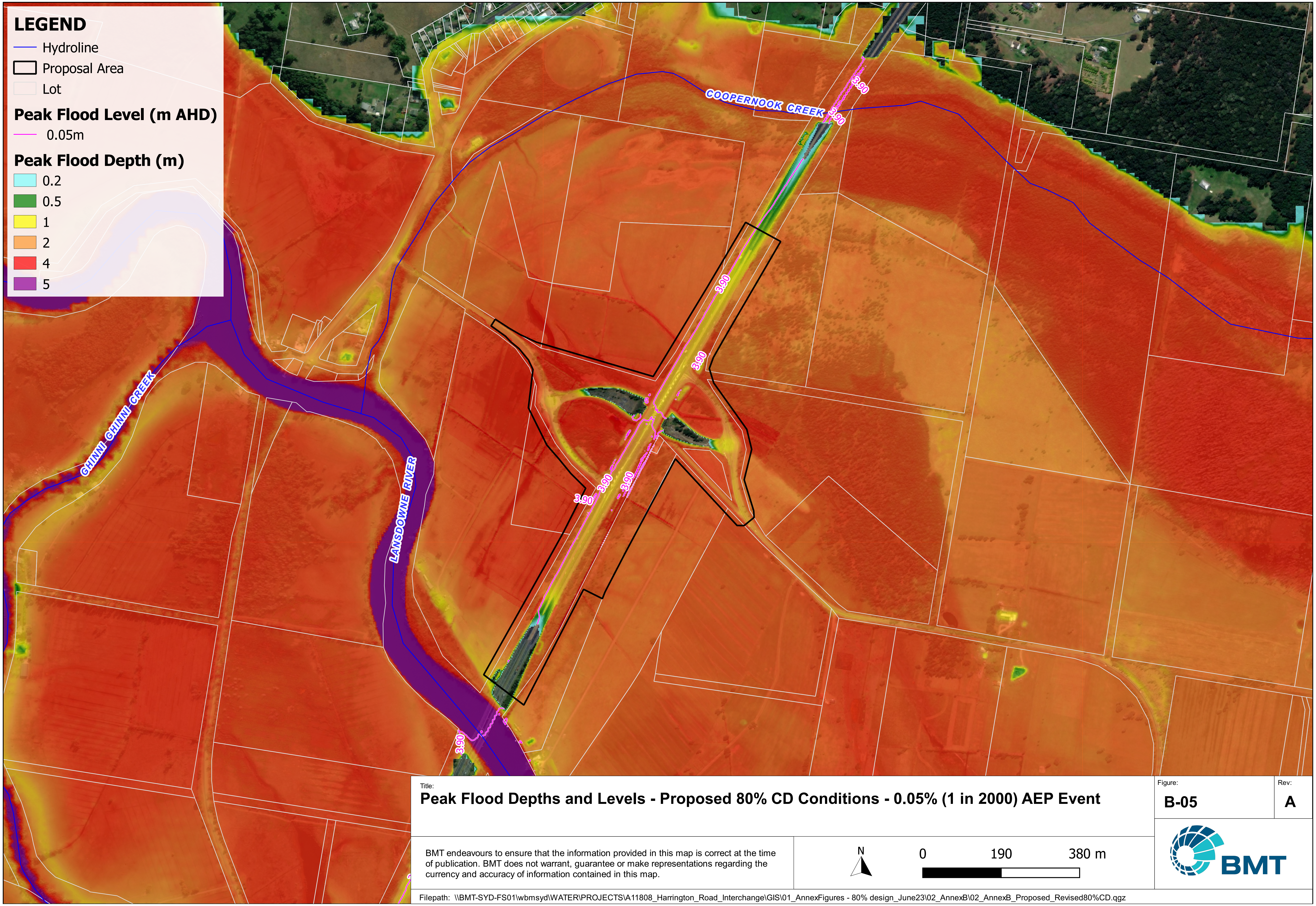

Title:

Peak Flood Depths and Levels - Proposed 80% CD Conditions - 0.05% (1 in 2000) AEP Event

Figure: B-05

Rev: A

BMT

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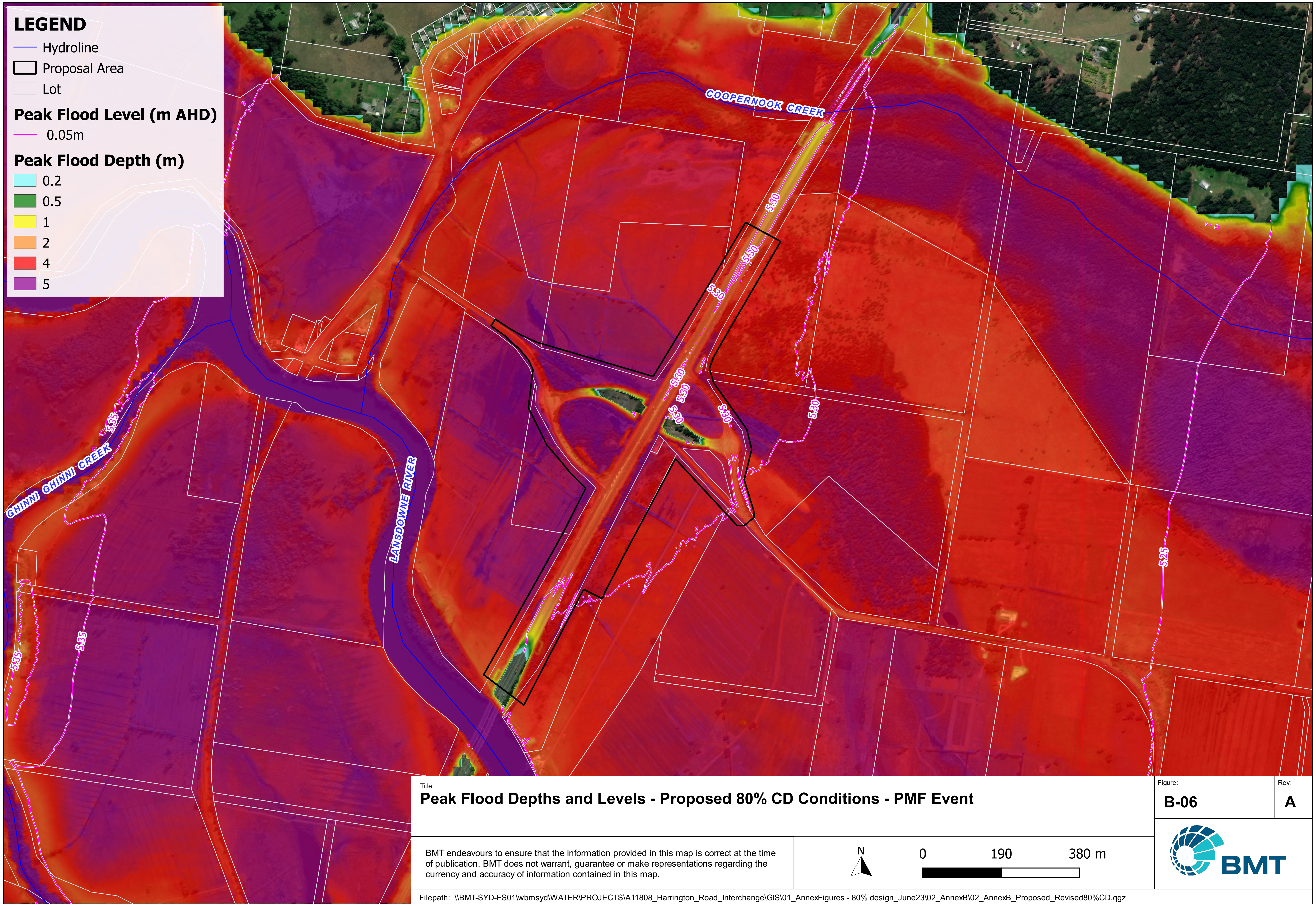

Title:

Peak Flood Depths and Levels - Proposed 80% CD Conditions - PMF Event

Figure: B-06

Rev: A

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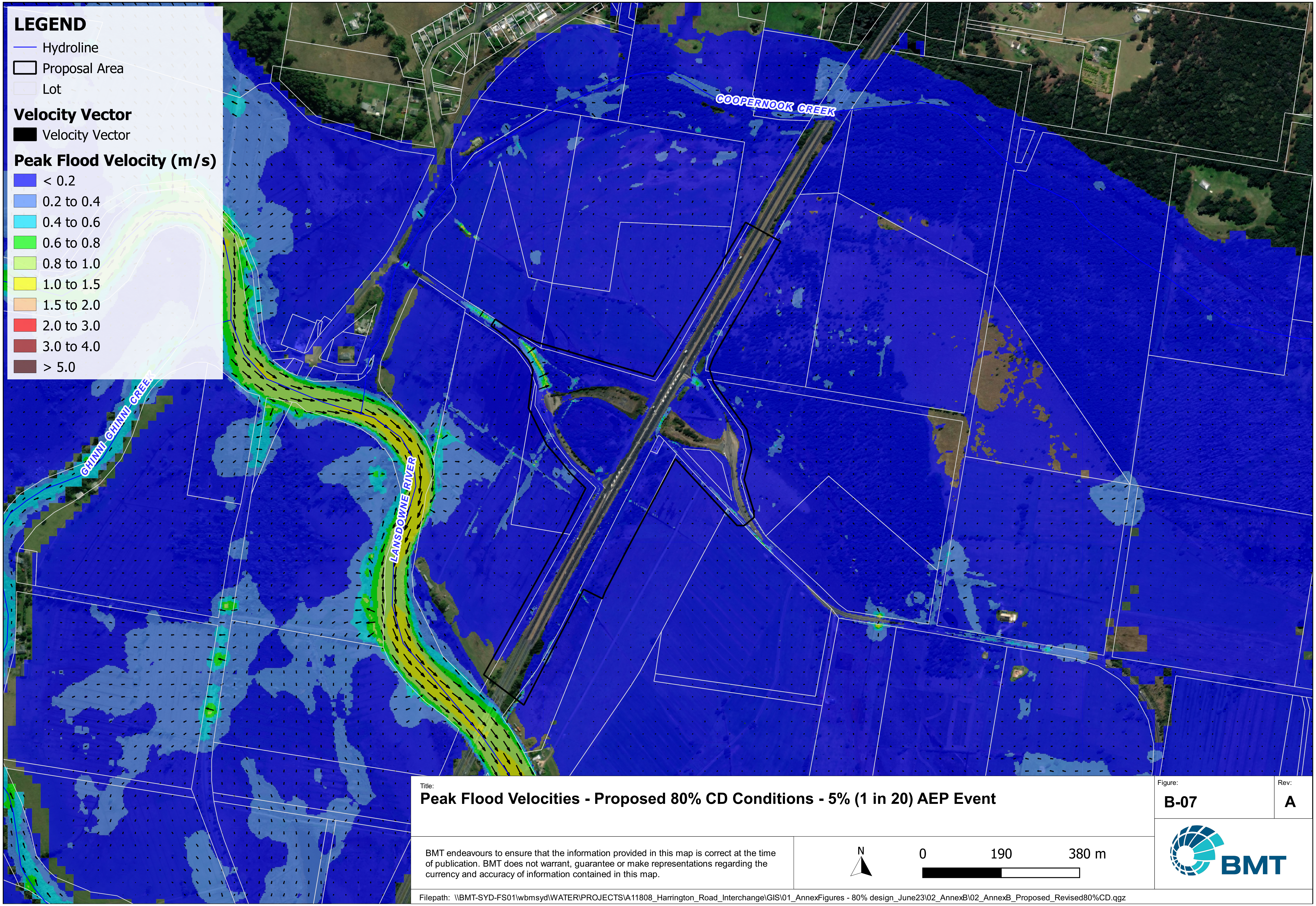

Title:

Peak Flood Velocities - Proposed 80% CD Conditions - 5% (1 in 20) AEP Event

Figure: B-07

Rev: A

BMT

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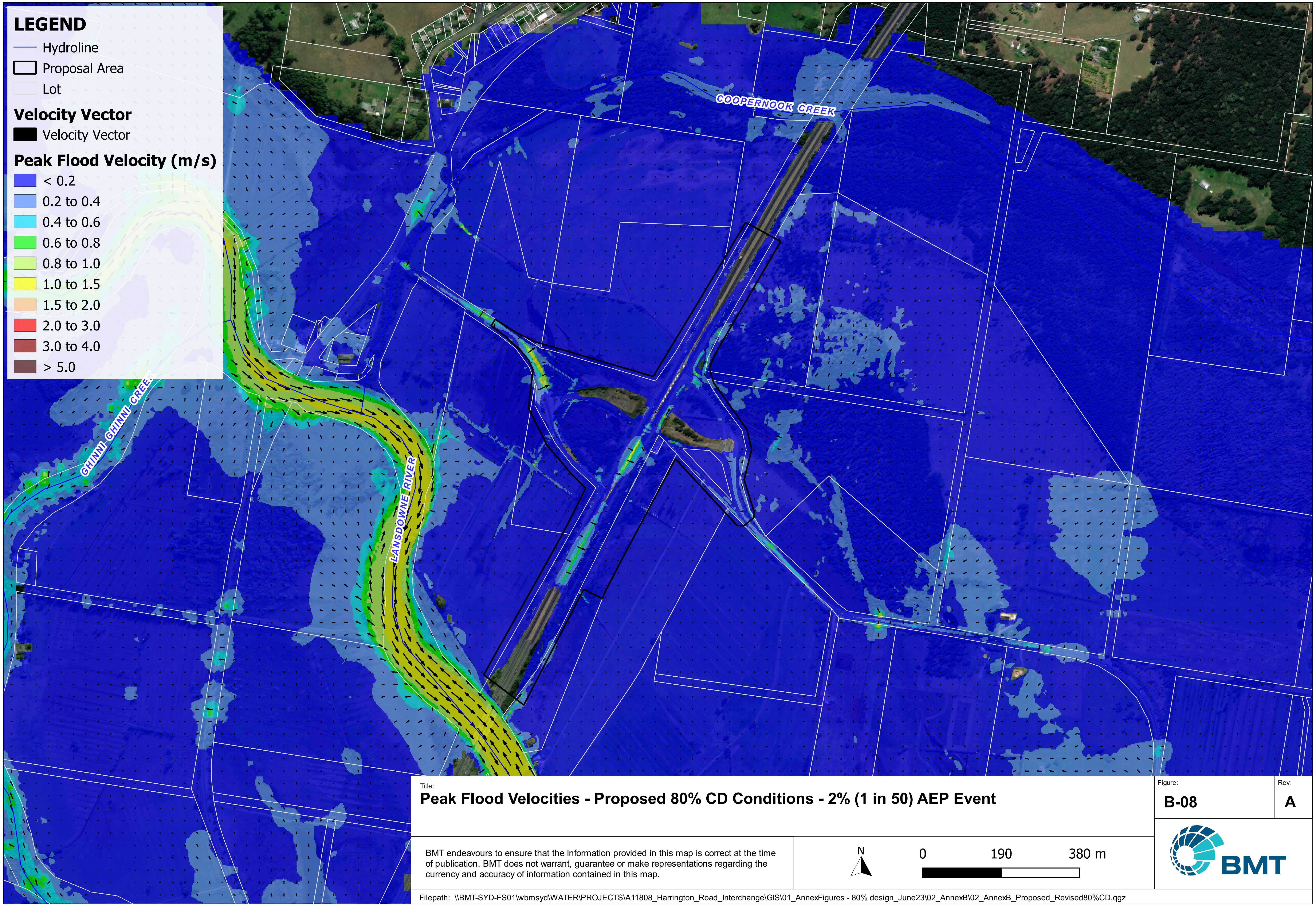

Title:

Peak Flood Velocities - Proposed 80% CD Conditions - 2% (1 in 50) AEP Event

Figure: **B-08**

Rev: **A**

BMT

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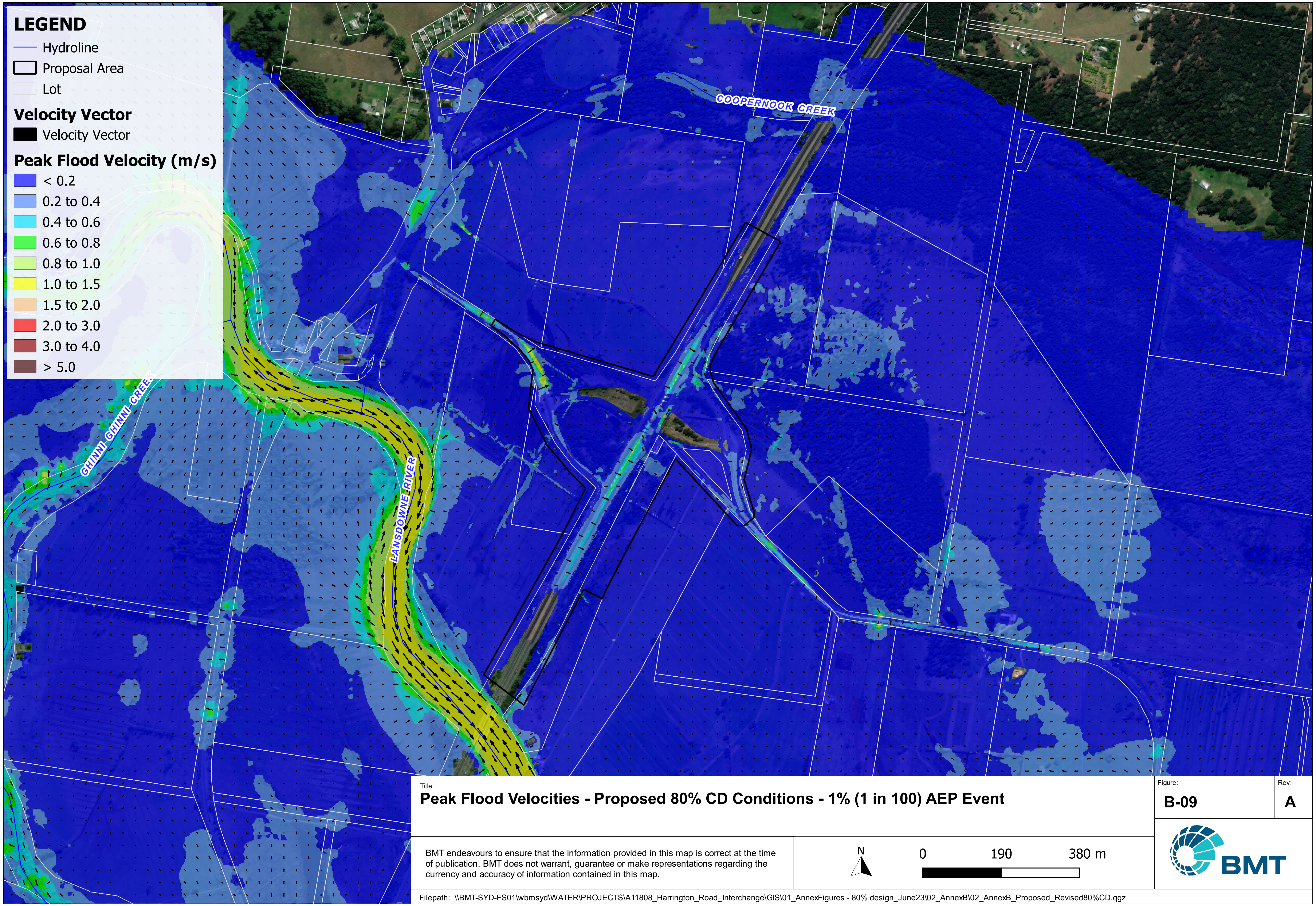

Title:
Peak Flood Velocities - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event

Figure: B-09

Rev: A

BMT

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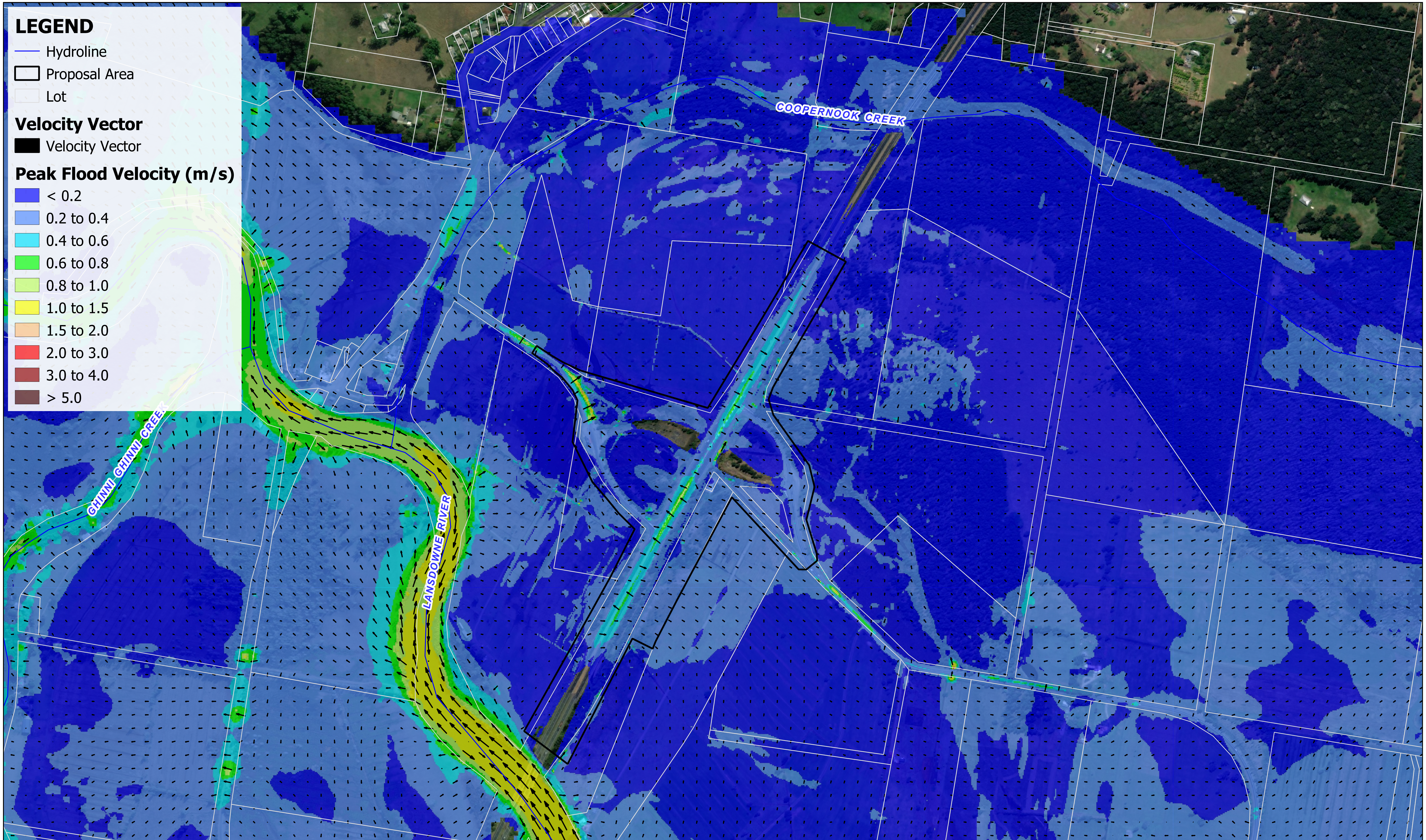

Title:

Peak Flood Velocities - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event with Climate Change

Figure: B-10

Rev: A

BMT

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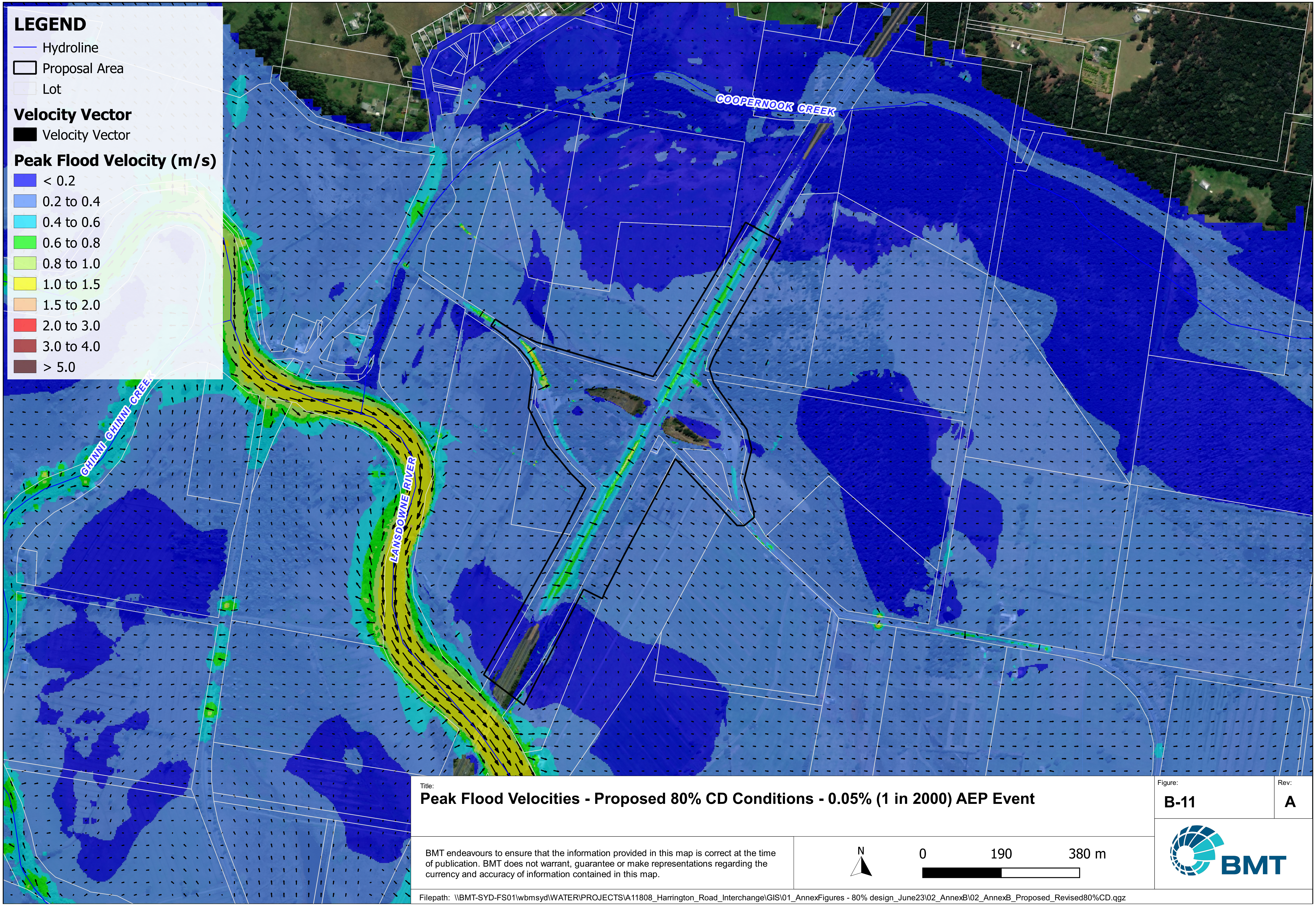

Title:

Peak Flood Velocities - Proposed 80% CD Conditions - 0.05% (1 in 2000) AEP Event

Figure: **B-11**

Rev: **A**

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N

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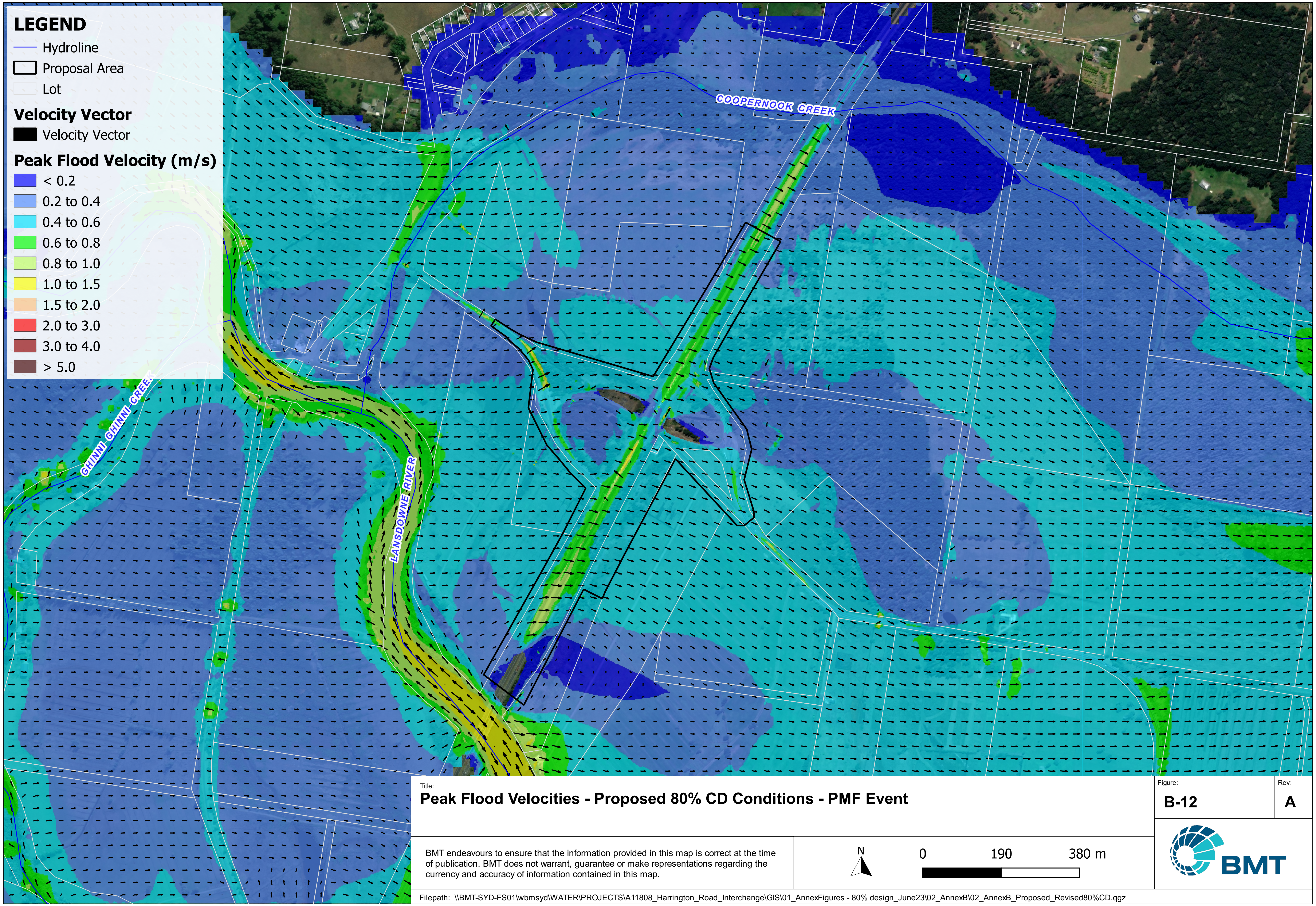

Title:

Peak Flood Velocities - Proposed 80% CD Conditions - PMF Event

Figure: **B-12**

Rev: **A**

BMT

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Title:

Peak Flood Hazard - Proposed 80% CD Conditions - 5% (1 in 20) AEP Event

Figure: B-13

Rev: A

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0 190 380 m

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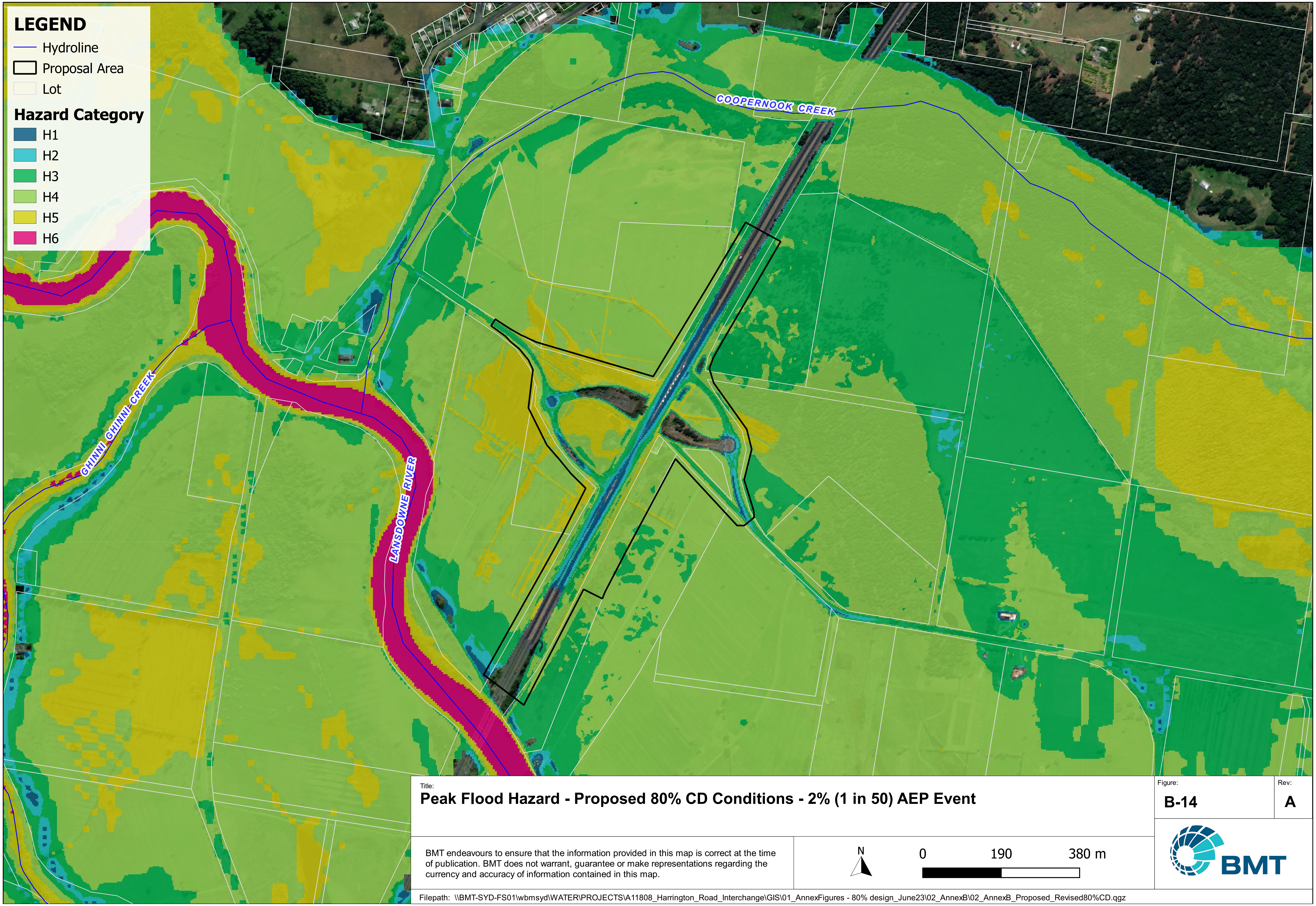

Title:
Peak Flood Hazard - Proposed 80% CD Conditions - 2% (1 in 50) AEP Event

Figure: B-14

Rev: A

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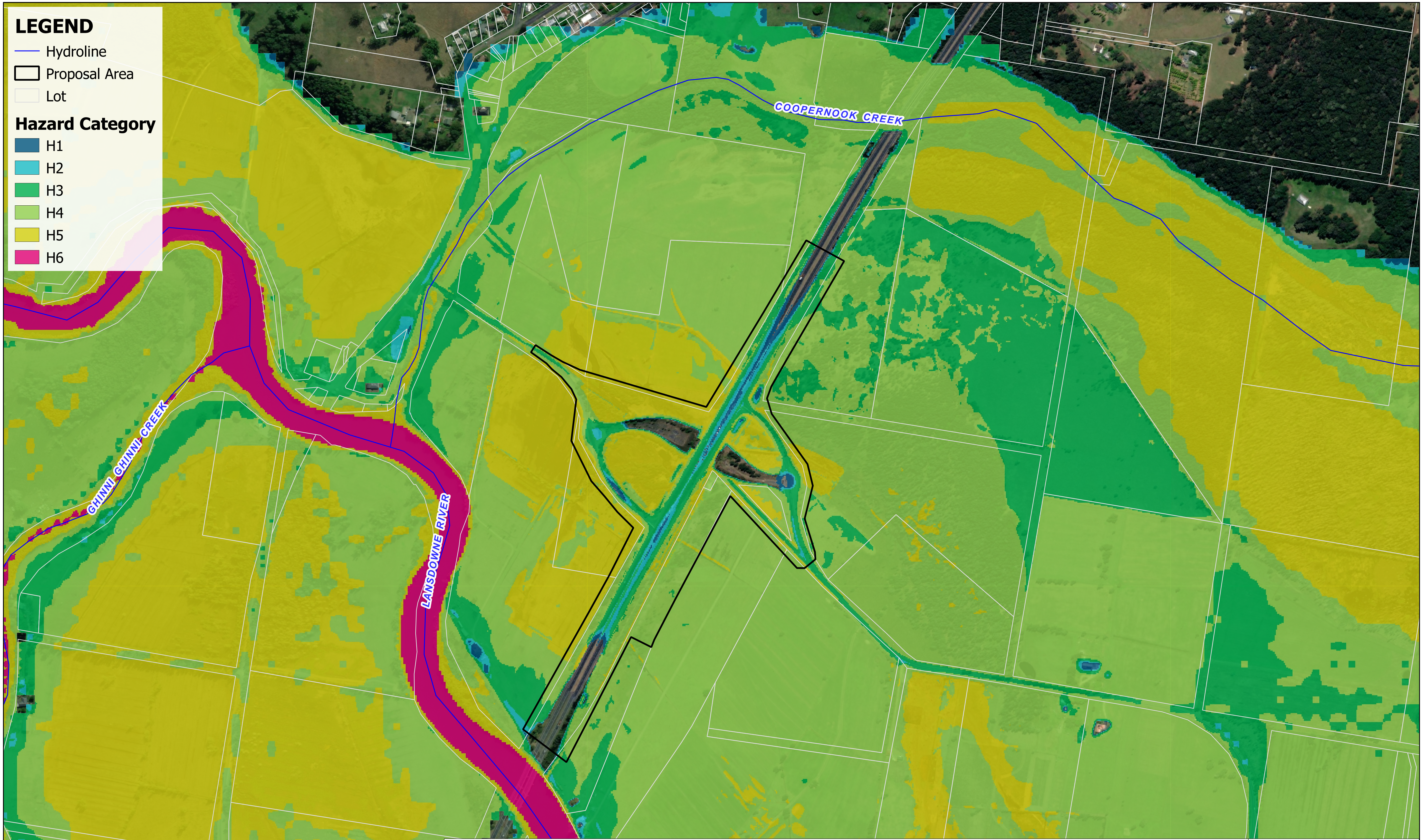

Title:

Peak Flood Hazard - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event

Figure: B-15

Rev: A

N

0 190 380 m

BMT

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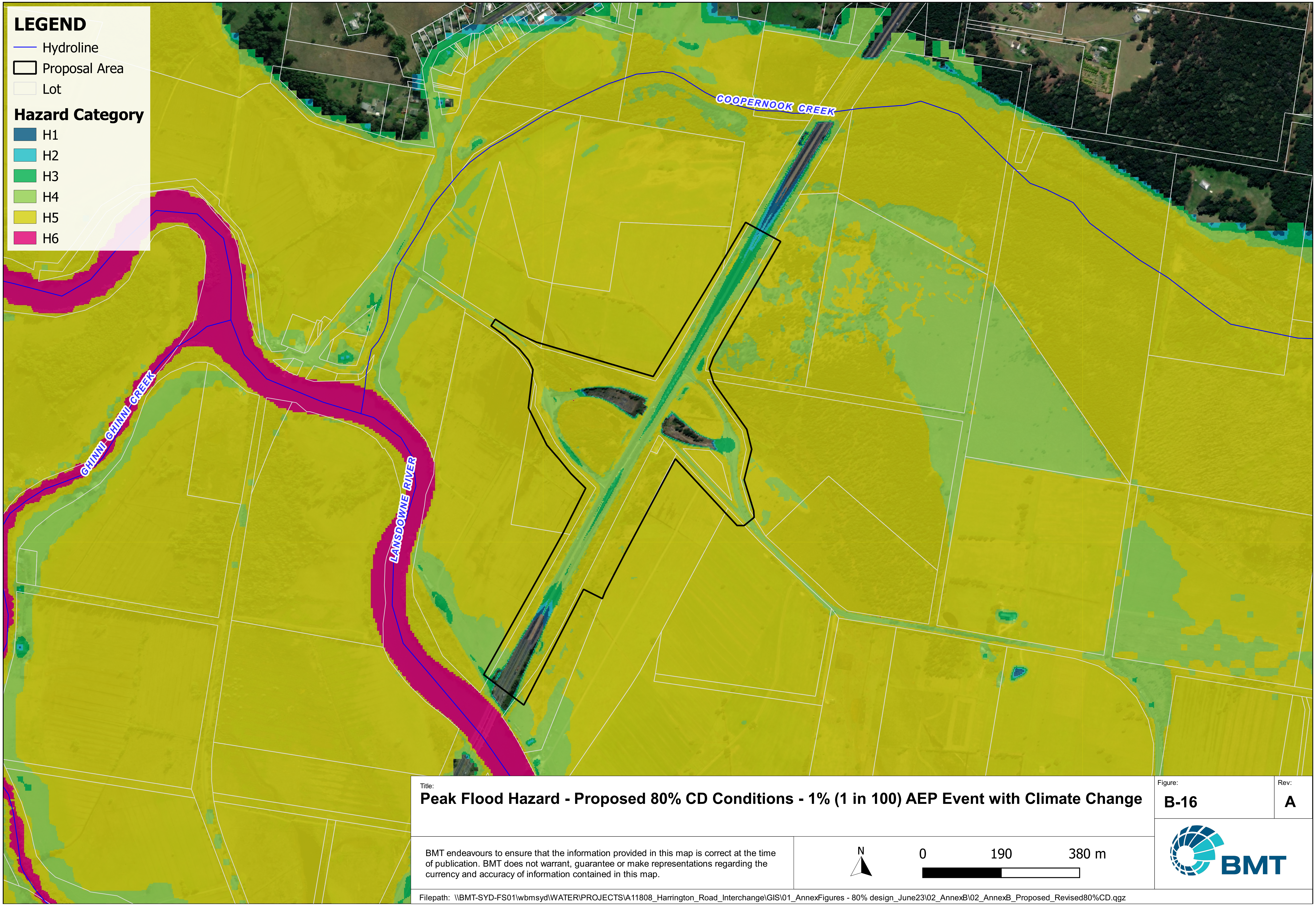

Title:

Peak Flood Hazard - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event with Climate Change

Figure: B-16

Rev: A

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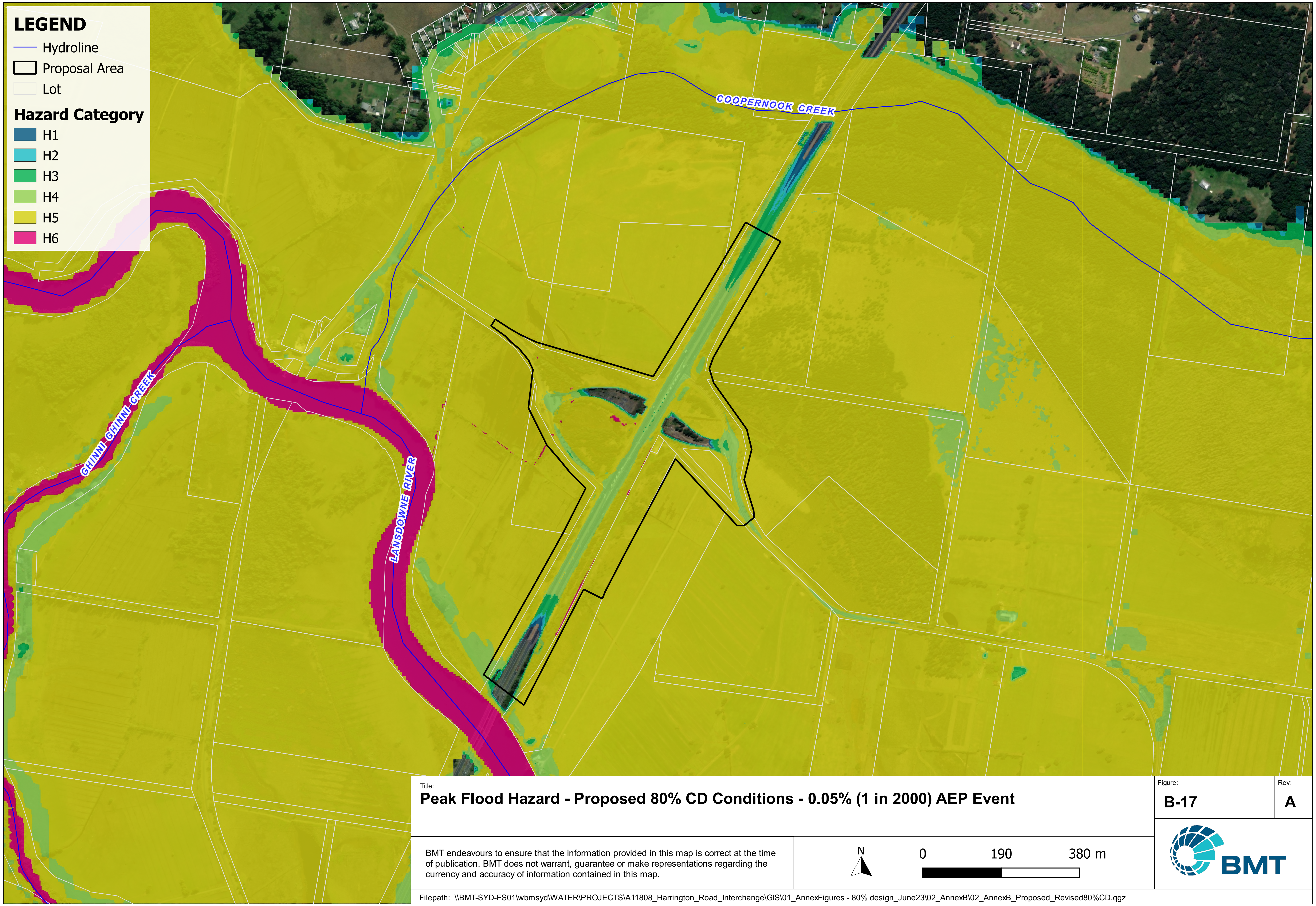

Title:

Peak Flood Hazard - Proposed 80% CD Conditions - 0.05% (1 in 2000) AEP Event

Figure: B-17

Rev: A

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N

0 190 380 m

BMT

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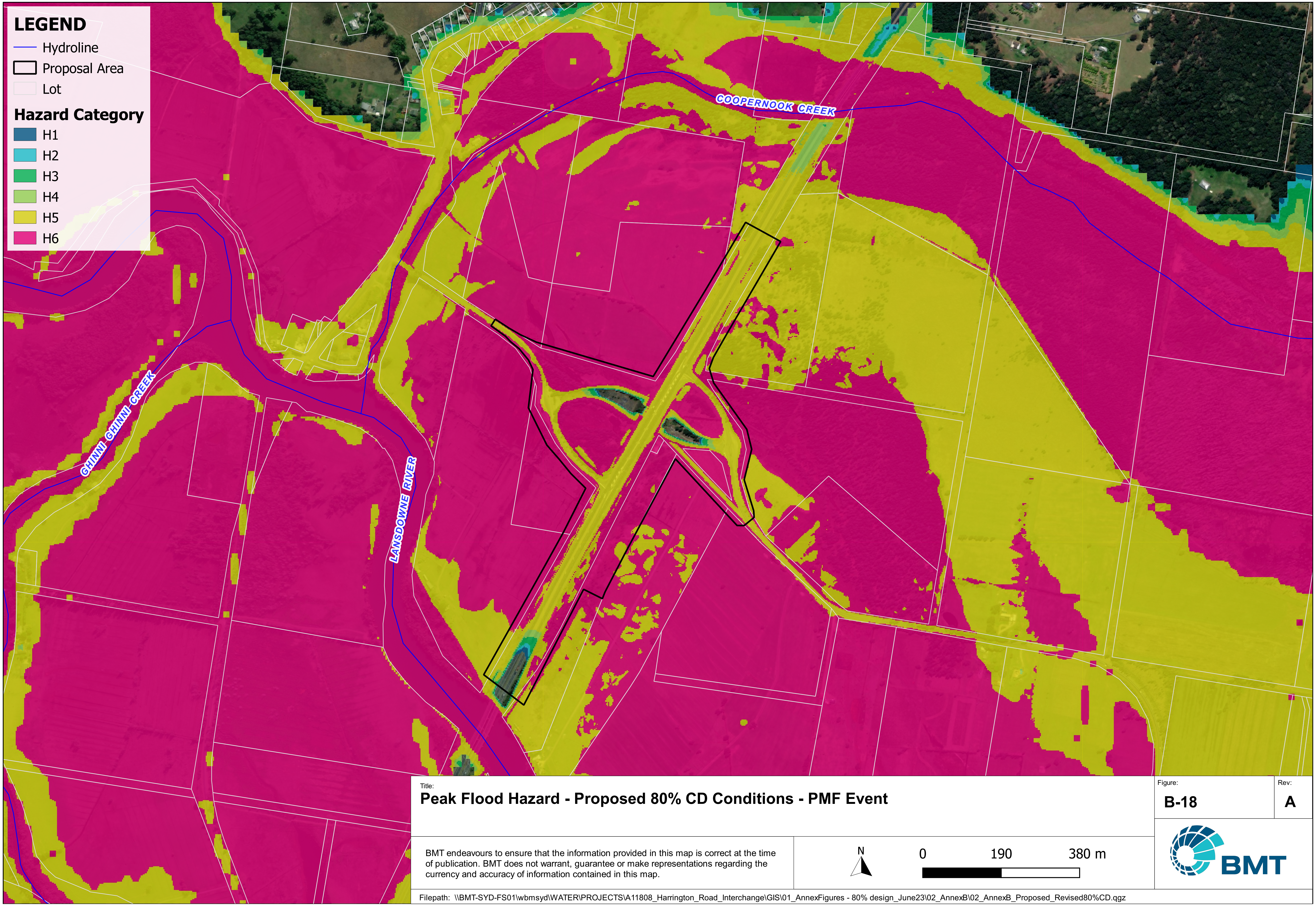

Title:

Peak Flood Hazard - Proposed 80% CD Conditions - PMF Event

Figure: B-18

Rev: A

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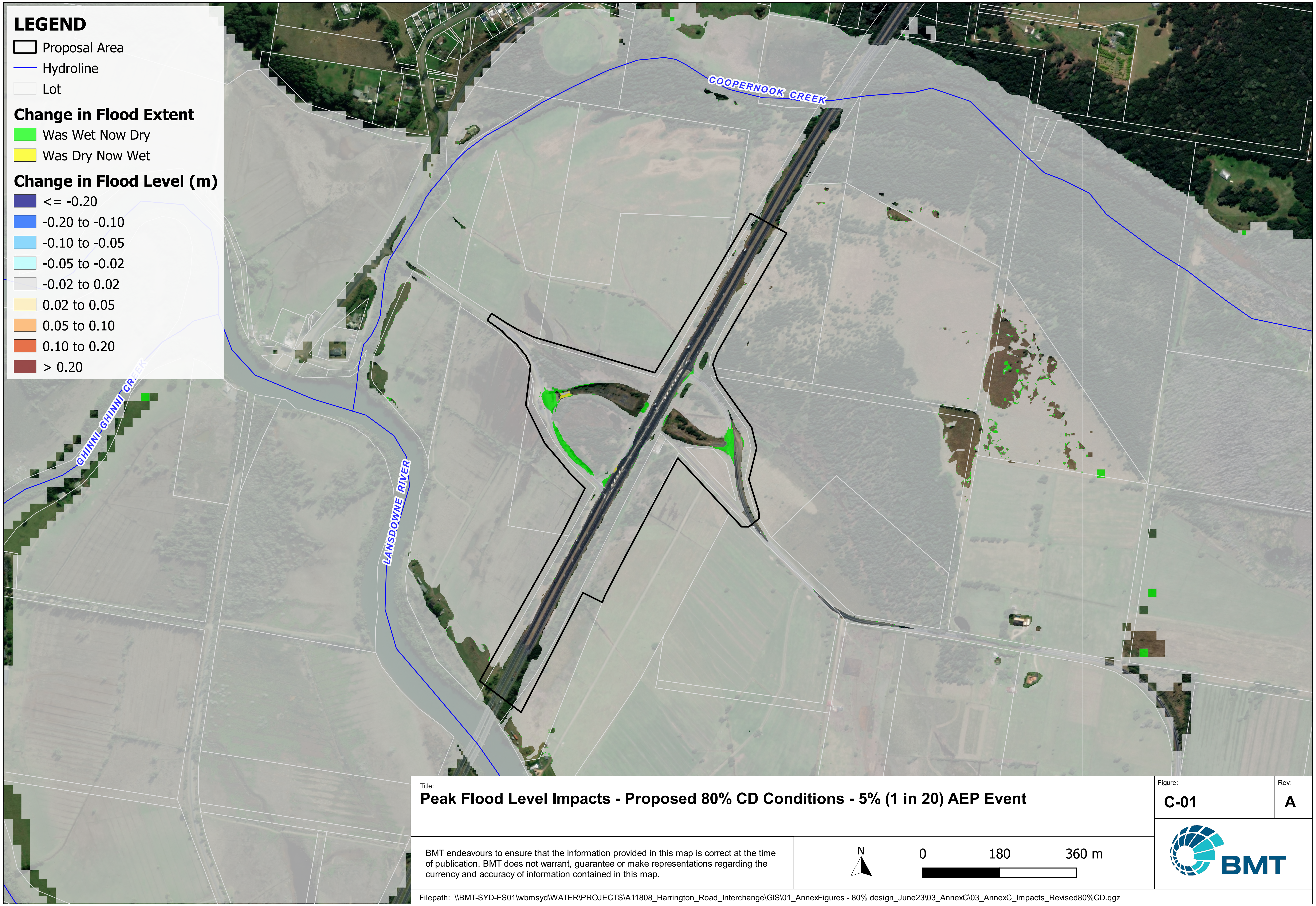
Annex C Flood Impact Maps



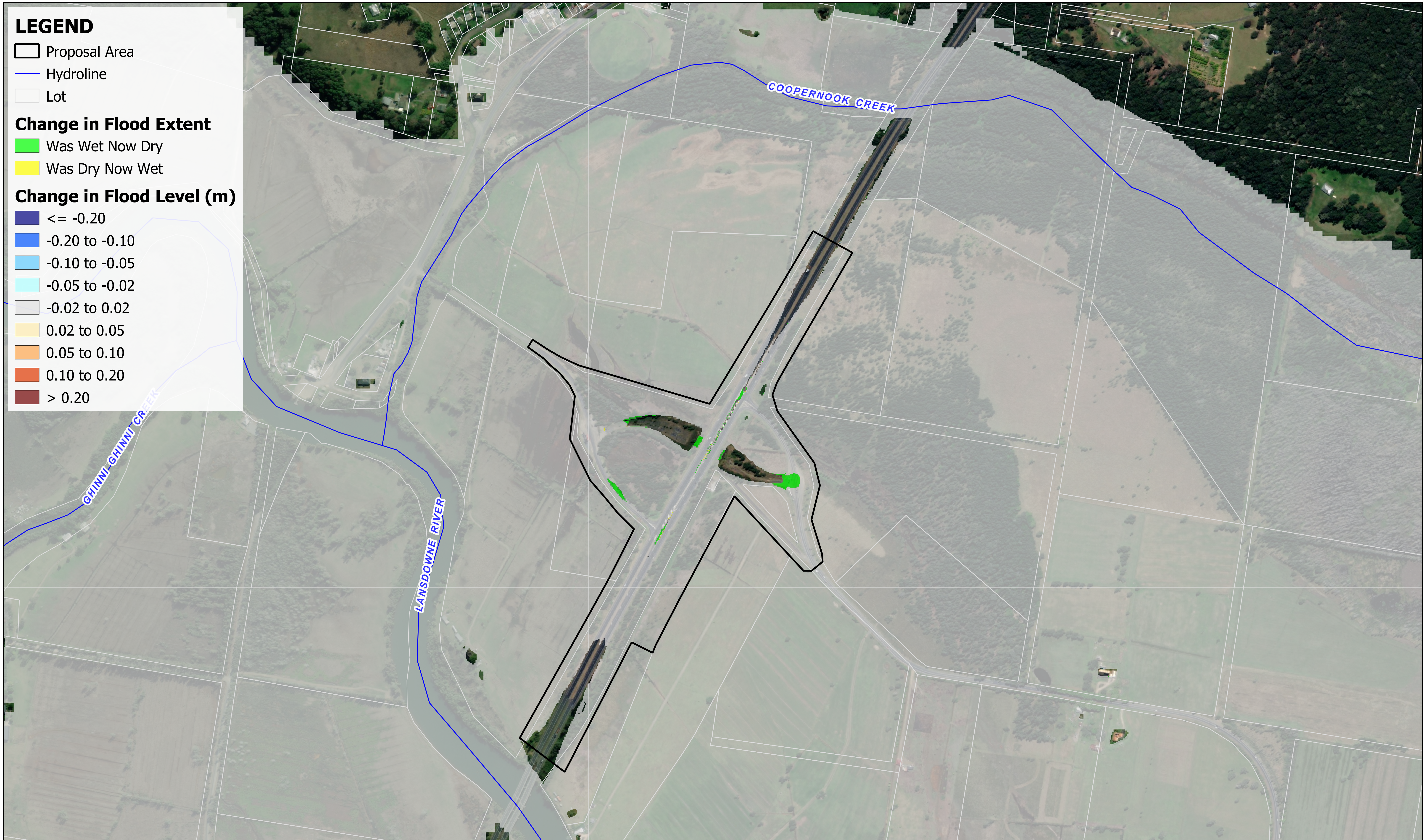
Title:

Peak Flood Level Impacts - Proposed 80% CD Conditions - 5% (1 in 20) AEP Event

Figure: C-01

Rev: A

Filepath: \\BMT-SYD-FS01\wbmsyd\WATER\PROJECTS\A11808_Harrington_Road_Interchange\GIS\01_AnnexFigures - 80% design_June23\03_AnnexC\03_AnnexC_Impacts_Revised80%CD.qgz



Title:

Peak Flood Level Impacts - Proposed 80% CD Conditions - 2% (1 in 50) AEP Event

Figure: C-02

Rev: A

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N

0 180 360 m

BMT

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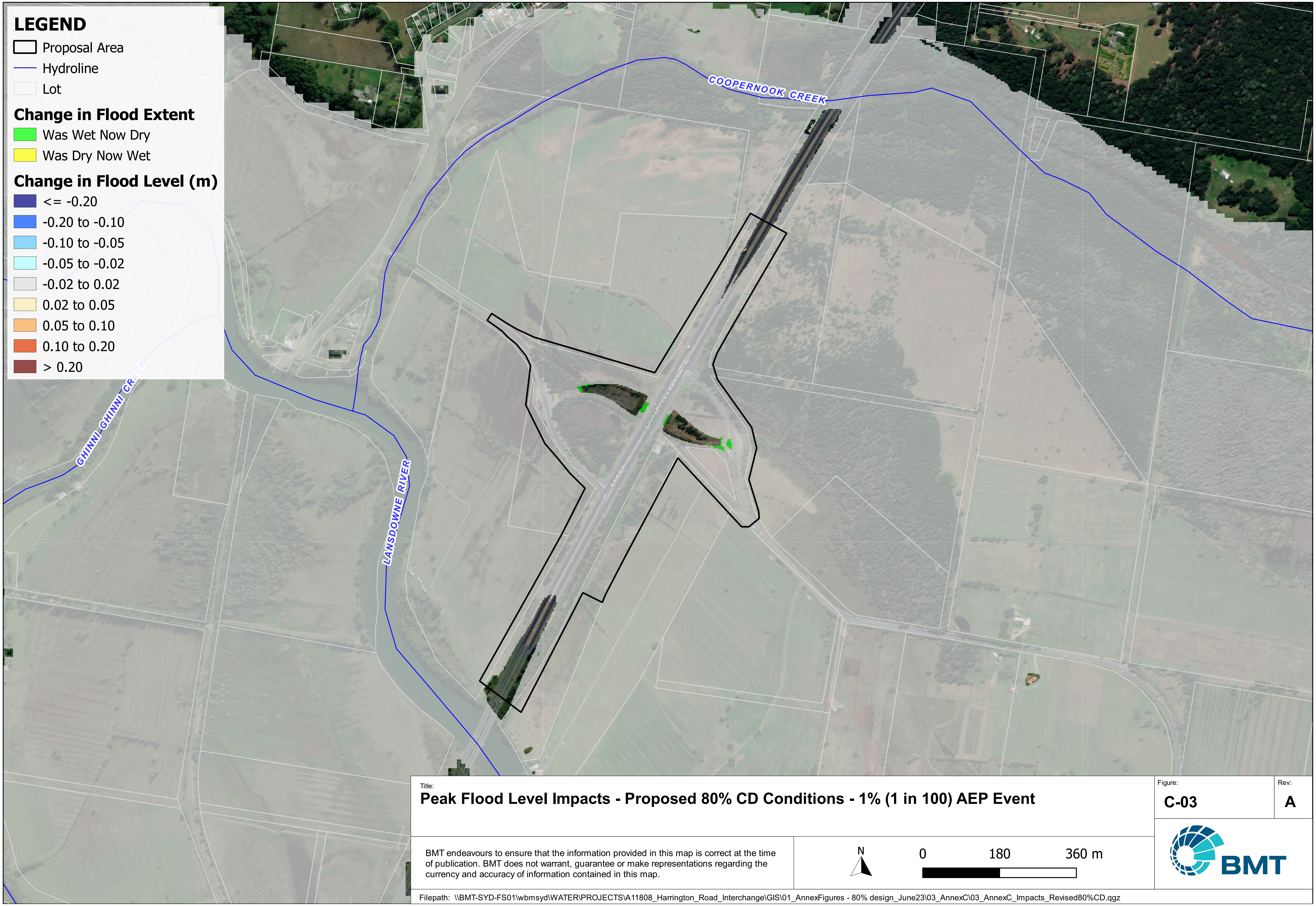

Title:

Peak Flood Level Impacts - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event

Figure: C-03

Rev: A

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Title:

Peak Flood Level Impacts - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event with Climate Change

Figure: C-04

Rev: A

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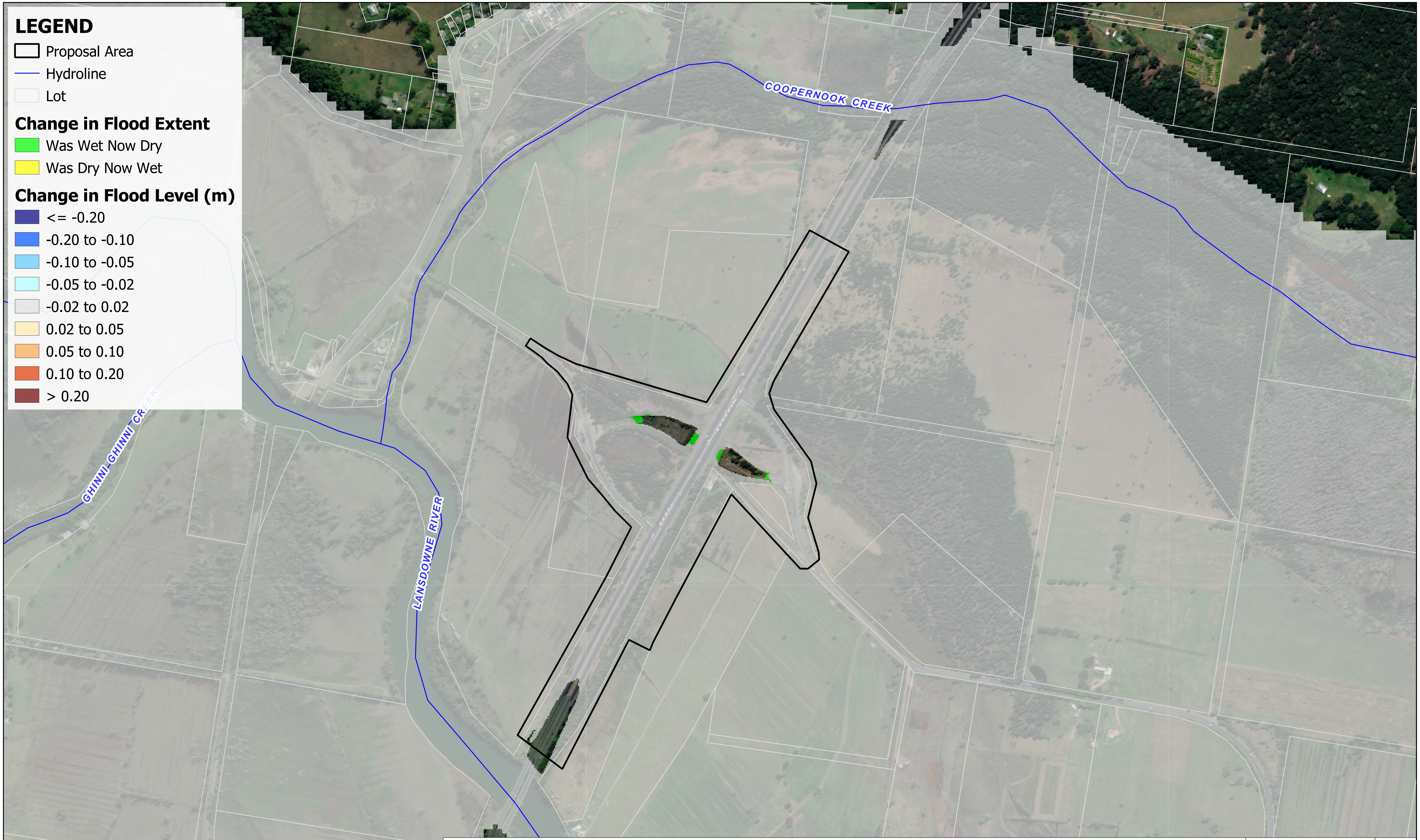

Title:
Peak Flood Level Impacts - Proposed 80% CD Conditions - 0.05% (1 in 2000) AEP Event

Figure: C-05

Rev: A

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N

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BMT

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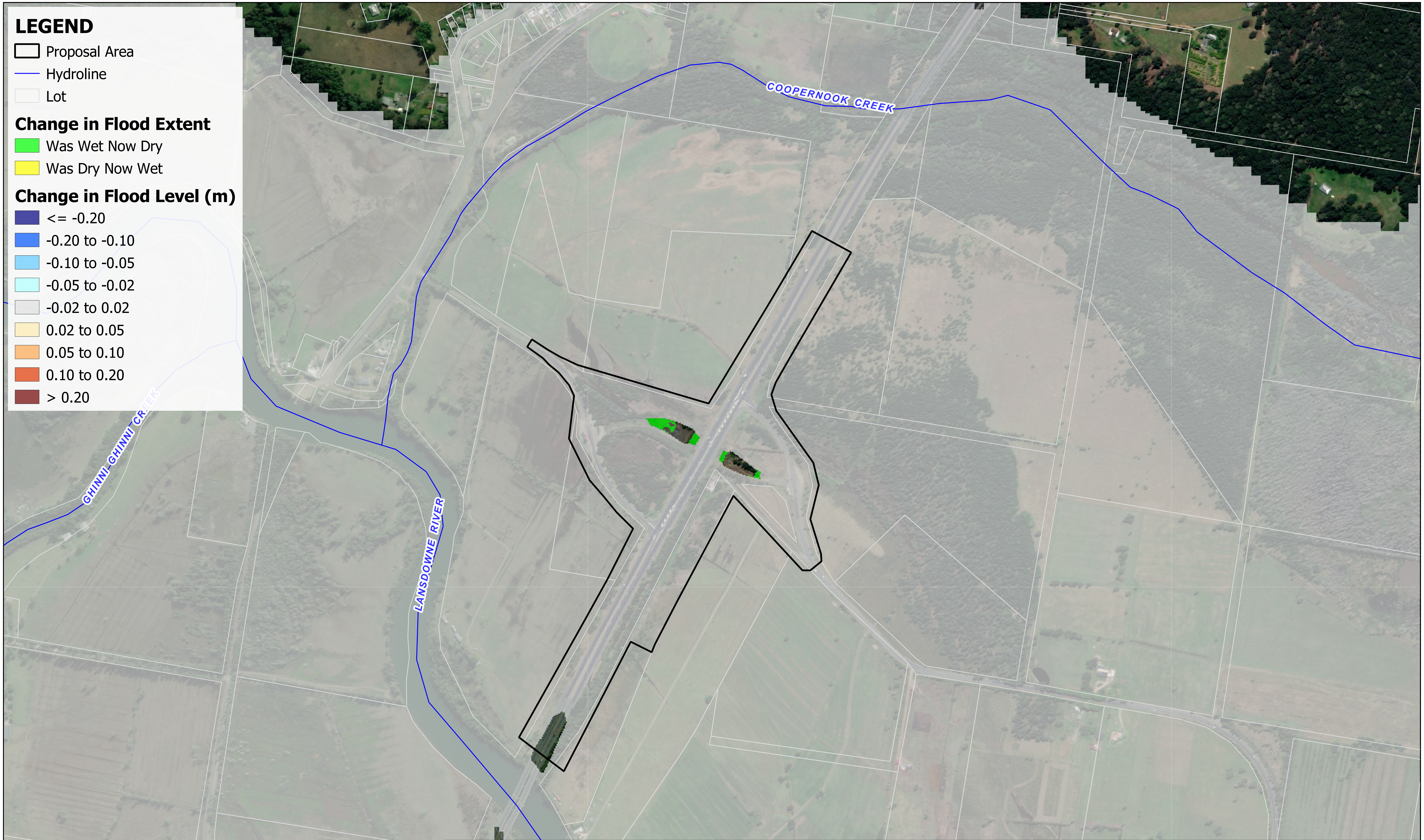

Title:

Peak Flood Level Impacts - Proposed 80% CD Conditions - PMF Event

Figure: C-06

Rev: A

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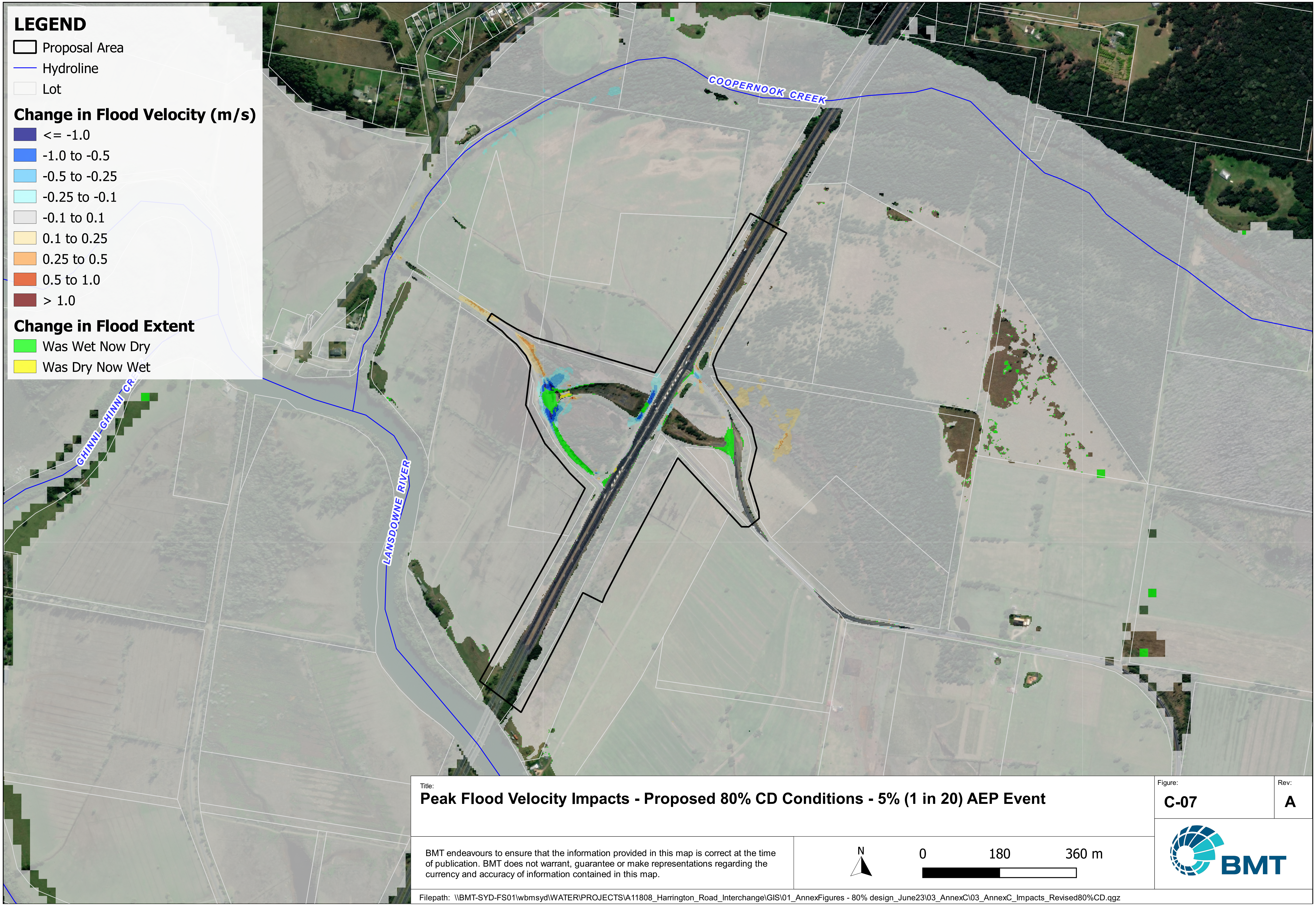

Title:

Peak Flood Velocity Impacts - Proposed 80% CD Conditions - 5% (1 in 20) AEP Event

Figure: C-07

Rev: A

BMT

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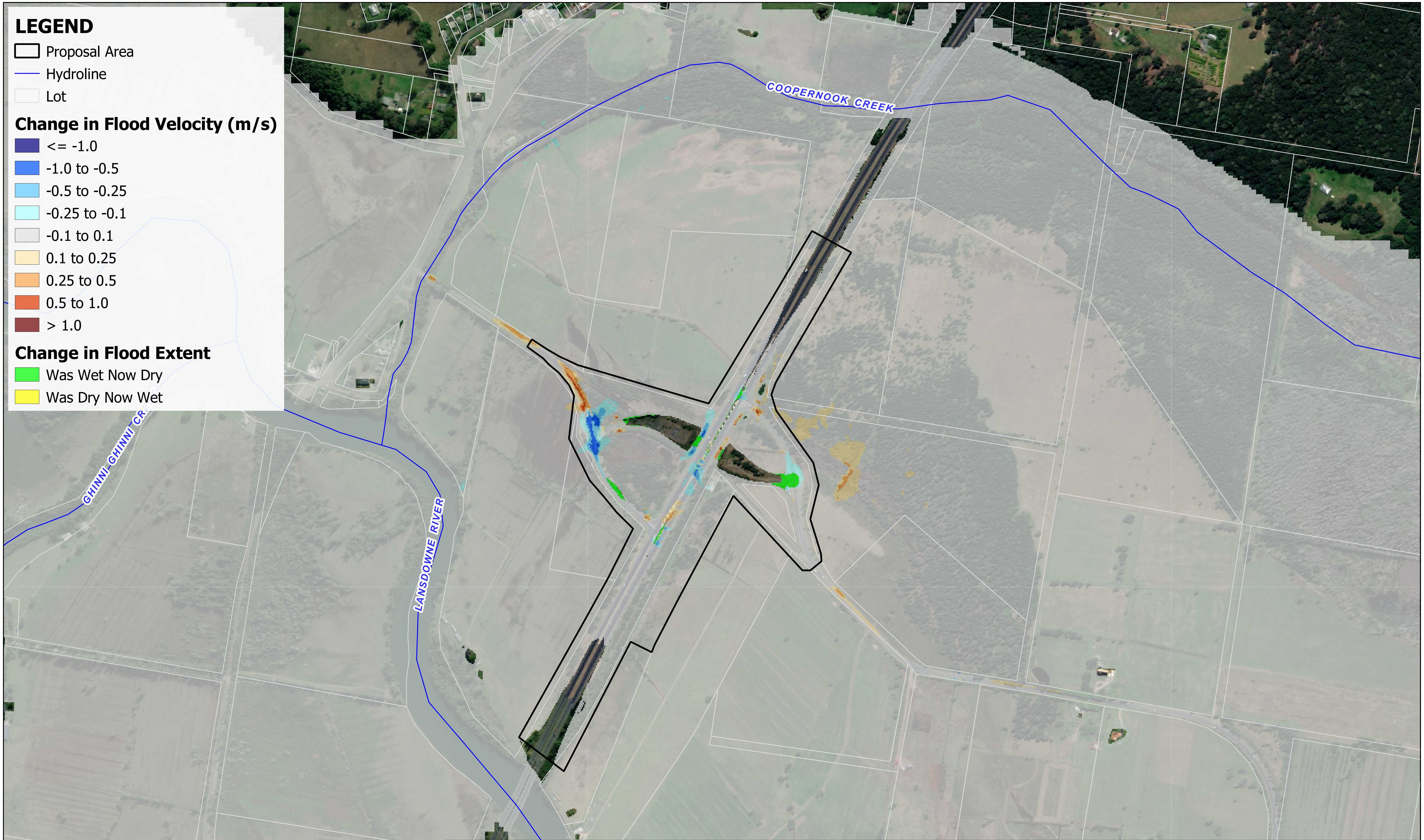

Title:

Peak Flood Velocity Impacts - Proposed 80% CD Conditions - 2% (1 in 50) AEP Event

Figure: C-08

Rev: A

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0 180 360 m

BMT

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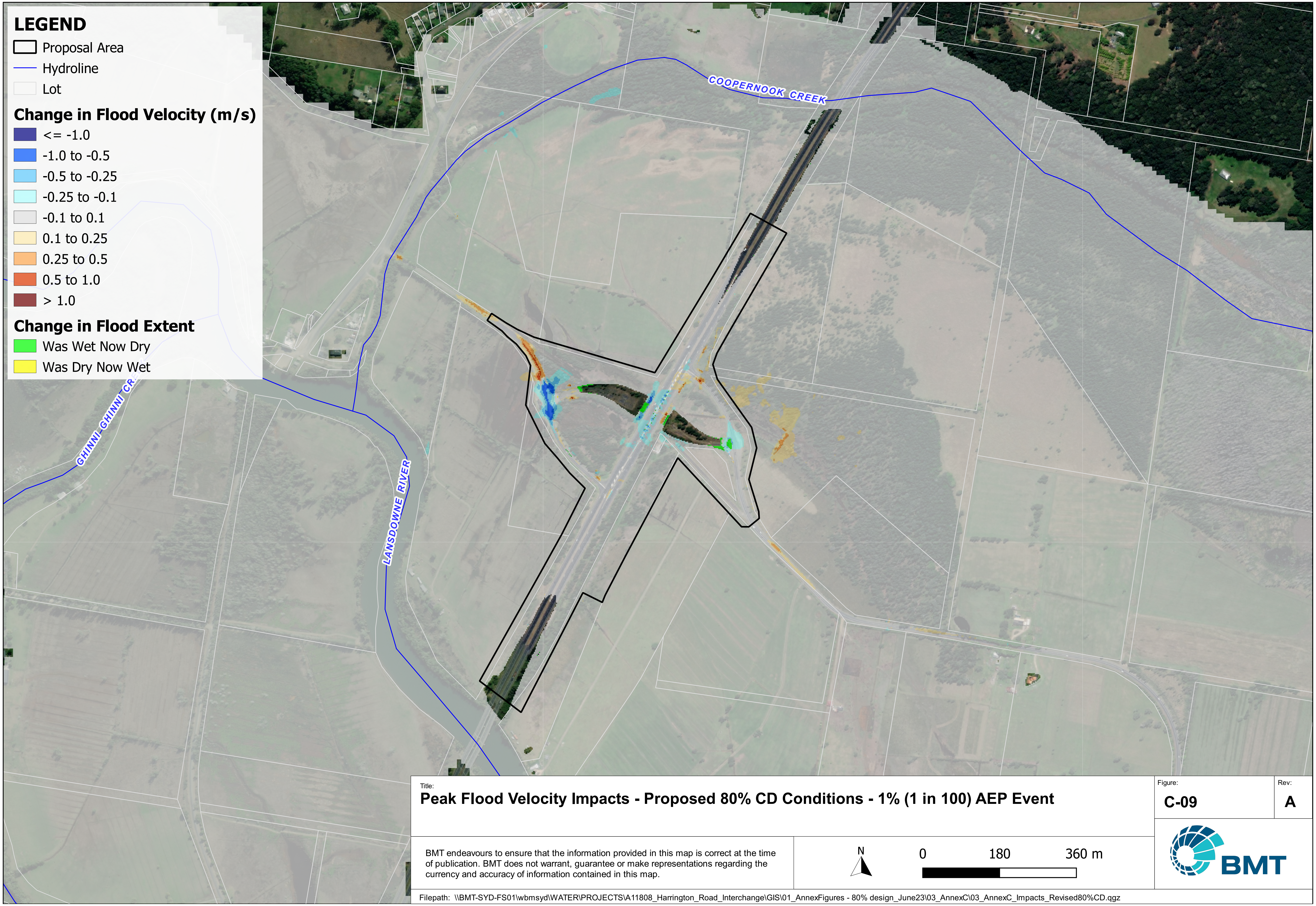

Title:

Peak Flood Velocity Impacts - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event

Figure: C-09

Rev: A

BMT

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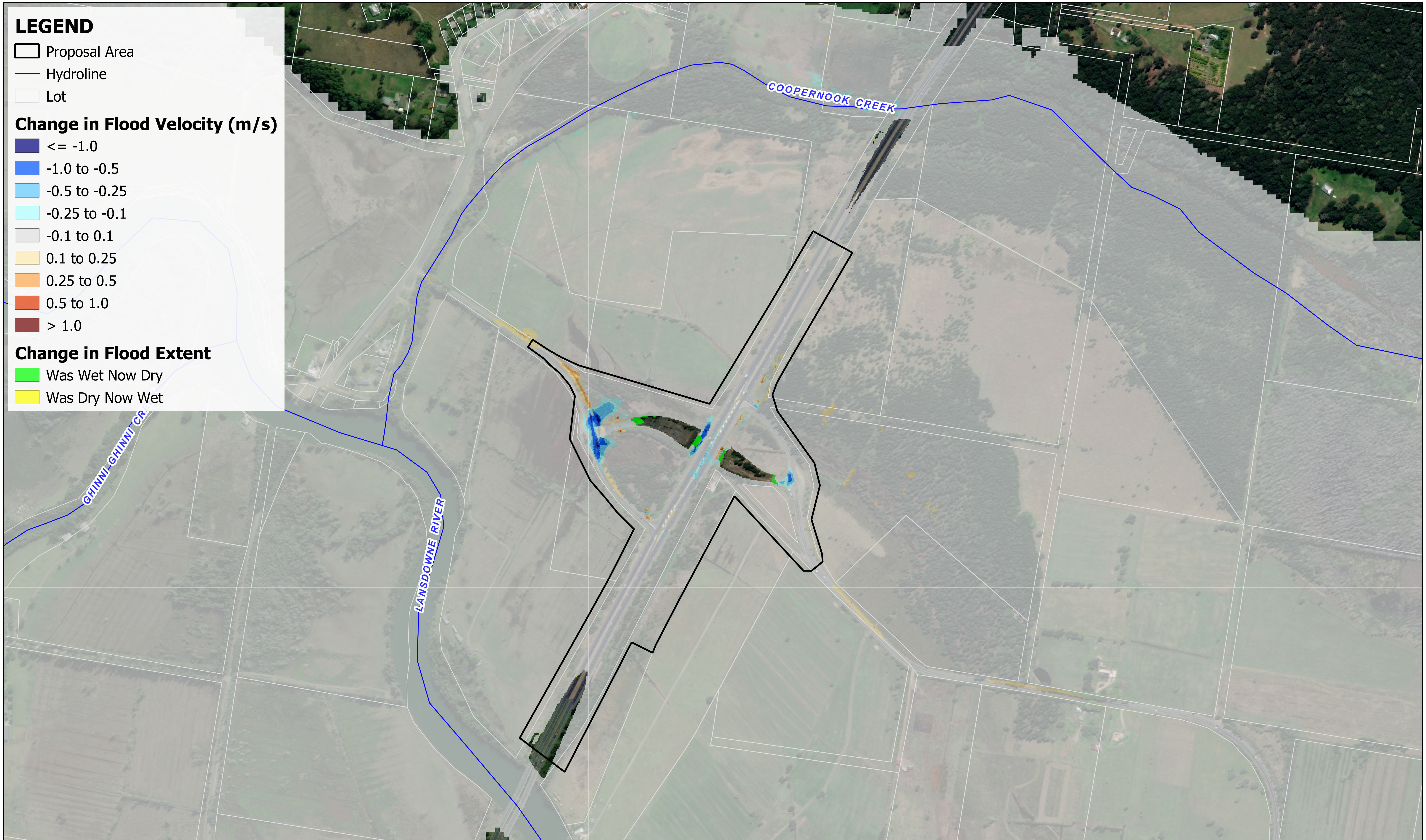

Title:

Peak Flood Velocity Impacts - Proposed 80% CD Conditions - 1% (1 in 100) AEP Event with Climate Change

Figure: C-10

Rev: A

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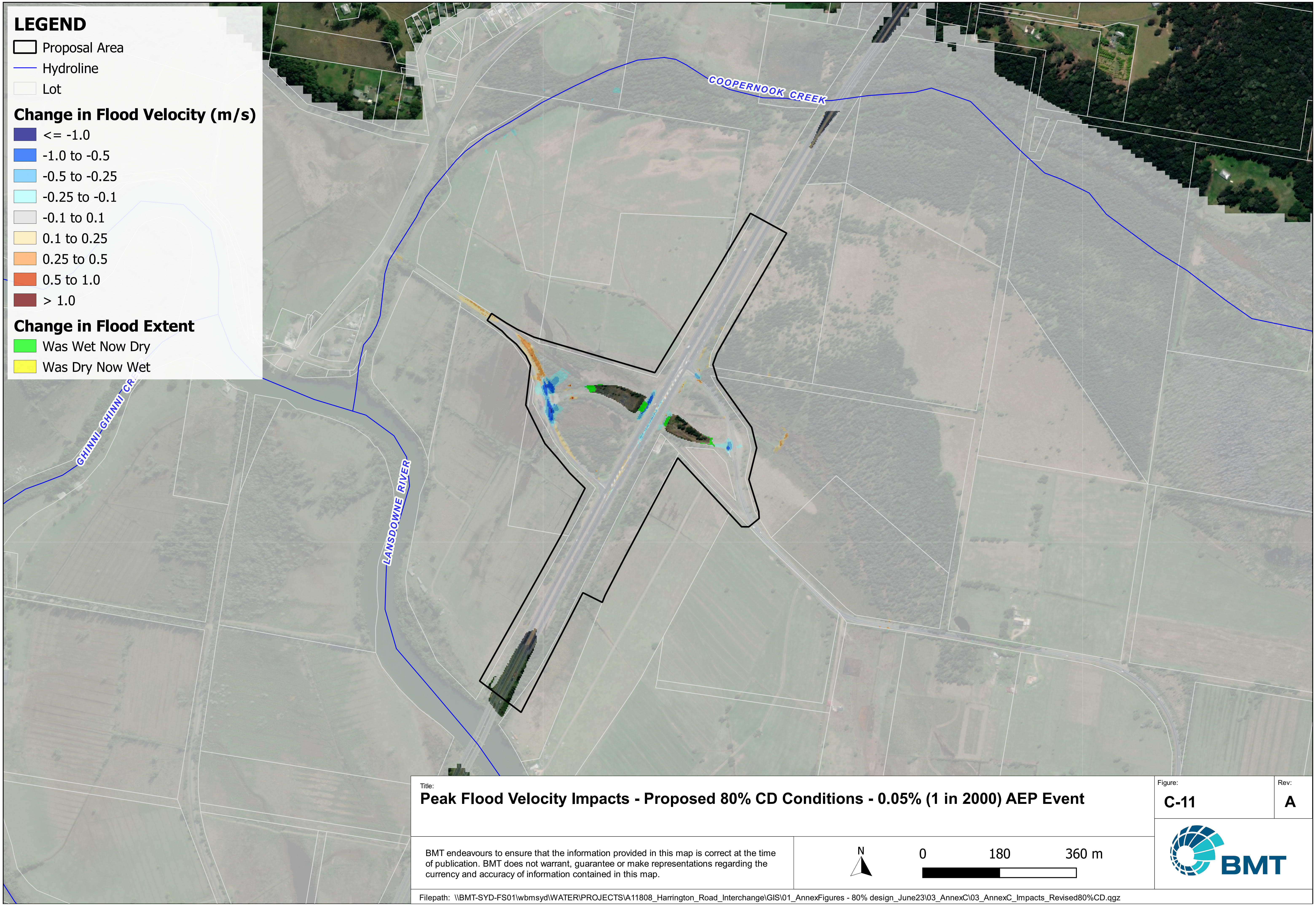


Title:

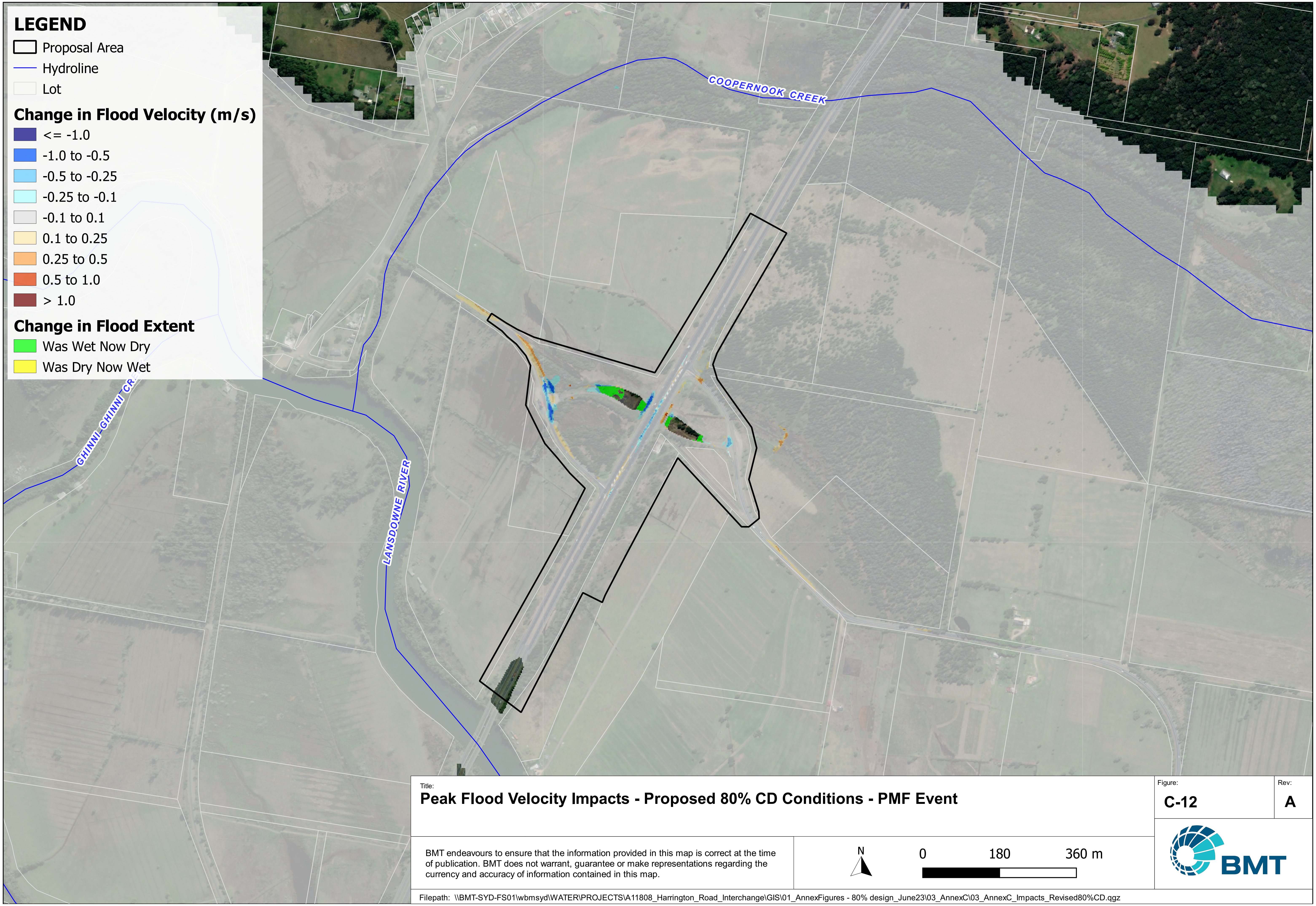
Peak Flood Velocity Impacts - Proposed 80% CD Conditions - 0.05% (1 in 2000) AEP Event

Figure: C-11

Rev: A

BMT

Filepath: \\BMT-SYD-FS01\wbmsyd\WATER\PROJECTS\A11808_Harrington_Road_Interchange\GIS\01_AnnexFigures - 80% design_June23\03_AnnexC\03_AnnexC_Impacts_Revised80%CD.qgz



Title:
Peak Flood Velocity Impacts - Proposed 80% CD Conditions - PMF Event

Figure: C-12

Rev: A

BMT

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.

Filepath: \\BMT-SYD-FS01\wbmsyd\WATER\PROJECTS\A11808_Harrington_Road_Interchange\GIS\01_AnnexFigures - 80% design_June23\03_AnnexC\03_AnnexC_Impacts_Revised80%CD.qgz

Annex D ARR Data Hub Inputs

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	152.615
Latitude	-31.834
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Probability Neutral Burst Initial Loss (./nsw_specific)	show

Data

River Region

Division	South East Coast (NSW)
River Number	8
River Name	Manning River

Layer Info

Time Accessed	23 August 2022 03:40PM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^b - c\log_{10}Duration\right)Duration^{-d} + eArea^f Duration^g \left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
SE Coast	0.06	0.361	0.0	0.317	8.11e-05	0.651	0.0	0.0	0.0

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^2}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Layer Info

Time Accessed	23 August 2022 03:40PM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Note: As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. The continuing storm loss information from the ARR Datahub provided below should only be used where relevant under the loss hierarchy (level 5) and where used is to be multiplied by the factor of 0.4.

ID	20192.0
Storm Initial Losses (mm)	35.0
Storm Continuing Losses (mm/h)	4.2

Layer Info

Time Accessed	23 August 2022 03:40PM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/ECsouth.zip)

code	ECsouth
Label	East Coast South

Layer Info

Time Accessed	23 August 2022 03:40PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_ECsouth.zip)

code	ECsouth
arealabel	East Coast South

Layer Info

Time Accessed	23 August 2022 03:40PM

Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-31.834&longitude=152.615&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	23 August 2022 03:40PM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	3.4 (0.095)	5.8 (0.115)	7.3 (0.121)	8.9 (0.125)	3.9 (0.045)	0.1 (0.001)
90 (1.5)	1.6 (0.039)	3.0 (0.051)	3.9 (0.055)	4.7 (0.057)	7.4 (0.073)	9.4 (0.082)
120 (2.0)	2.5 (0.057)	8.8 (0.137)	12.9 (0.166)	16.9 (0.183)	16.1 (0.143)	15.5 (0.120)
180 (3.0)	3.1 (0.059)	16.3 (0.219)	25.1 (0.276)	33.5 (0.311)	28.1 (0.214)	24.1 (0.159)
360 (6.0)	14.9 (0.219)	24.2 (0.248)	30.3 (0.255)	36.2 (0.257)	51.8 (0.301)	63.4 (0.322)
720 (12.0)	11.9 (0.130)	26.7 (0.205)	36.5 (0.231)	45.9 (0.246)	59.8 (0.265)	70.2 (0.273)
1080 (18.0)	13.9 (0.127)	18.5 (0.120)	21.6 (0.115)	24.5 (0.111)	46.7 (0.176)	63.3 (0.210)
1440 (24.0)	5.3 (0.043)	13.0 (0.075)	18.1 (0.086)	23.0 (0.093)	31.0 (0.104)	37.0 (0.110)
2160 (36.0)	3.2 (0.022)	6.6 (0.032)	8.8 (0.036)	10.9 (0.038)	22.2 (0.064)	30.7 (0.078)
2880 (48.0)	0.0 (0.000)	0.5 (0.002)	0.8 (0.003)	1.2 (0.004)	8.2 (0.021)	13.5 (0.031)
4320 (72.0)	0.0 (0.000)	0.1 (0.000)	0.1 (0.000)	0.2 (0.000)	3.0 (0.007)	5.2 (0.010)

Layer Info

Time Accessed	23 August 2022 03:40PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	23 August 2022 03:40PM

Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.2 (0.005)	0.4 (0.006)	0.5 (0.008)	0.2 (0.003)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.2 (0.003)	0.3 (0.004)	0.4 (0.005)	0.2 (0.002)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.1 (0.001)	0.2 (0.002)	0.2 (0.002)	0.1 (0.001)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.8 (0.009)	1.4 (0.012)	1.9 (0.014)	0.8 (0.005)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	4.0 (0.031)	6.7 (0.042)	9.2 (0.049)	7.4 (0.033)	6.1 (0.024)
1080 (18.0)	0.2 (0.002)	1.5 (0.010)	2.4 (0.013)	3.2 (0.015)	5.2 (0.019)	6.6 (0.022)
1440 (24.0)	0.0 (0.000)	0.4 (0.003)	0.7 (0.003)	1.0 (0.004)	3.7 (0.013)	5.8 (0.017)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.1 (0.000)	0.2 (0.001)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.3 (0.001)	0.6 (0.001)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	23 August 2022 03:40PM
Version	2018_v1

Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	23.9 (0.679)	37.6 (0.752)	46.7 (0.771)	55.4 (0.777)	40.7 (0.473)	29.8 (0.304)
90 (1.5)	20.0 (0.493)	31.0 (0.535)	38.3 (0.544)	45.2 (0.545)	72.3 (0.717)	92.6 (0.804)
120 (2.0)	24.4 (0.544)	46.8 (0.729)	61.6 (0.788)	75.8 (0.819)	103.8 (0.922)	124.9 (0.968)
180 (3.0)	39.8 (0.766)	62.0 (0.833)	76.7 (0.845)	90.8 (0.843)	108.6 (0.826)	121.9 (0.809)
360 (6.0)	56.9 (0.833)	81.8 (0.838)	98.2 (0.826)	114.0 (0.809)	141.1 (0.822)	161.5 (0.820)
720 (12.0)	42.8 (0.466)	67.3 (0.518)	83.6 (0.529)	99.2 (0.531)	119.2 (0.528)	134.3 (0.521)
1080 (18.0)	45.4 (0.414)	57.2 (0.370)	65.0 (0.347)	72.5 (0.329)	96.6 (0.364)	114.6 (0.380)
1440 (24.0)	30.5 (0.246)	47.7 (0.274)	59.1 (0.281)	70.0 (0.283)	86.5 (0.291)	98.8 (0.293)
2160 (36.0)	21.5 (0.148)	33.9 (0.166)	42.1 (0.171)	49.9 (0.172)	73.0 (0.210)	90.3 (0.230)
2880 (48.0)	9.5 (0.059)	17.9 (0.079)	23.5 (0.086)	28.9 (0.090)	52.2 (0.135)	69.6 (0.160)
4320 (72.0)	0.2 (0.001)	8.0 (0.031)	13.2 (0.042)	18.2 (0.050)	41.5 (0.094)	58.9 (0.118)

Layer Info

Time Accessed	23 August 2022 03:40PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	108.5 (3.082)	131.5 (2.629)	146.7 (2.423)	161.3 (2.265)	166.8 (1.938)	170.9 (1.746)
90 (1.5)	60.7 (1.496)	116.4 (2.010)	153.3 (2.179)	188.7 (2.272)	202.6 (2.008)	213.0 (1.848)
120 (2.0)	99.0 (2.207)	163.1 (2.540)	205.5 (2.629)	246.2 (2.662)	255.3 (2.266)	262.1 (2.032)
180 (3.0)	111.8 (2.150)	164.0 (2.201)	198.5 (2.186)	231.7 (2.151)	244.1 (1.857)	253.4 (1.680)
360 (6.0)	113.2 (1.657)	141.3 (1.449)	159.9 (1.346)	177.8 (1.262)	277.2 (1.614)	351.8 (1.787)
720 (12.0)	93.6 (1.019)	127.6 (0.981)	150.1 (0.950)	171.7 (0.919)	192.5 (0.852)	208.2 (0.808)
1080 (18.0)	91.2 (0.833)	122.5 (0.793)	143.2 (0.766)	163.0 (0.739)	188.8 (0.711)	208.2 (0.690)
1440 (24.0)	93.3 (0.754)	116.5 (0.670)	131.9 (0.627)	146.6 (0.592)	173.8 (0.584)	194.2 (0.576)
2160 (36.0)	60.7 (0.418)	86.9 (0.426)	104.3 (0.423)	121.0 (0.417)	129.4 (0.373)	135.7 (0.346)
2880 (48.0)	34.9 (0.217)	57.9 (0.256)	73.1 (0.267)	87.7 (0.273)	113.6 (0.295)	132.9 (0.305)
4320 (72.0)	29.2 (0.160)	33.1 (0.129)	35.7 (0.114)	38.1 (0.104)	77.2 (0.175)	106.5 (0.214)

Layer Info

Time Accessed	23 August 2022 03:40PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	**RCP 8.5**
2030	**0.869 (4.3%)**	0.783 (3.9%)	**0.983 (4.9%)**
2040	**1.057 (5.3%)**	1.014 (5.1%)	**1.349 (6.8%)**
2050	**1.272 (6.4%)**	1.236 (6.2%)	**1.773 (9.0%)**
2060	**1.488 (7.5%)**	1.458 (7.4%)	**2.237 (11.5%)**
2070	**1.676 (8.5%)**	1.691 (8.6%)	**2.722 (14.2%)**
2080	**1.810 (9.2%)**	1.944 (9.9%)	**3.209 (16.9%)**
2090	**1.862 (9.5%)**	2.227 (11.5%)	**3.679 (19.7%)**

Layer Info

Time Accessed	23 August 2022 03:40PM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	50.0	20.0	10.0	5.0	2.0	1.0
60 (1.0)	24.9	14.5	13.4	12.3	12.3	10.5
90 (1.5)	27.5	17.5	15.1	14.2	12.1	6.8
120 (2.0)	23.7	15.5	13.8	12.2	10.9	6.4
180 (3.0)	21.1	14.2	13.5	11.5	11.0	5.8
360 (6.0)	19.2	14.2	13.5	11.5	10.2	3.2
720 (12.0)	22.4	15.5	14.7	12.5	12.6	4.1
1080 (18.0)	23.7	18.6	18.3	15.4	16.0	4.5
1440 (24.0)	27.4	21.0	20.6	17.4	19.3	6.4
2160 (36.0)	31.6	25.2	24.7	23.0	21.3	7.7
2880 (48.0)	37.4	31.3	29.6	30.7	25.1	10.6
4320 (72.0)	40.4	35.3	35.8	38.3	27.3	12.4

Layer Info

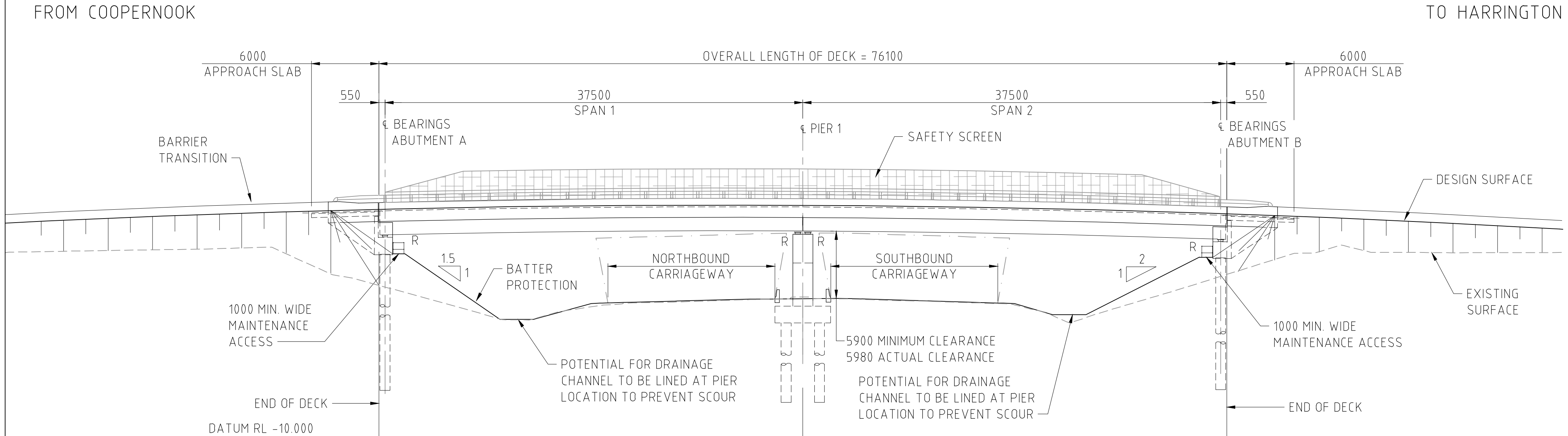
Time Accessed	23 August 2022 03:40PM
Version	2018_v1
Note	As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. Probability neutral burst initial loss values for NSW are to be used in place of the standard initial loss and pre-burst as per the losses hierarchy.

Download TXT (downloads/7ef45054-2948-4e7a-950b-98c814c29acd.txt)

Download JSON (downloads/99966efc-9212-4c77-8547-6af515fdc12c.json)

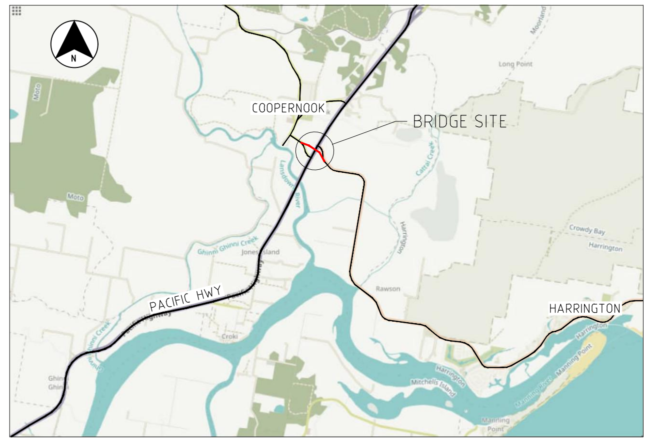
Generating PDF... (downloads/24cf8975-a9aa-455e-afaf-7121fe4b9a87.pdf)

Annex E Proposed 80% CD Bridge Drawings

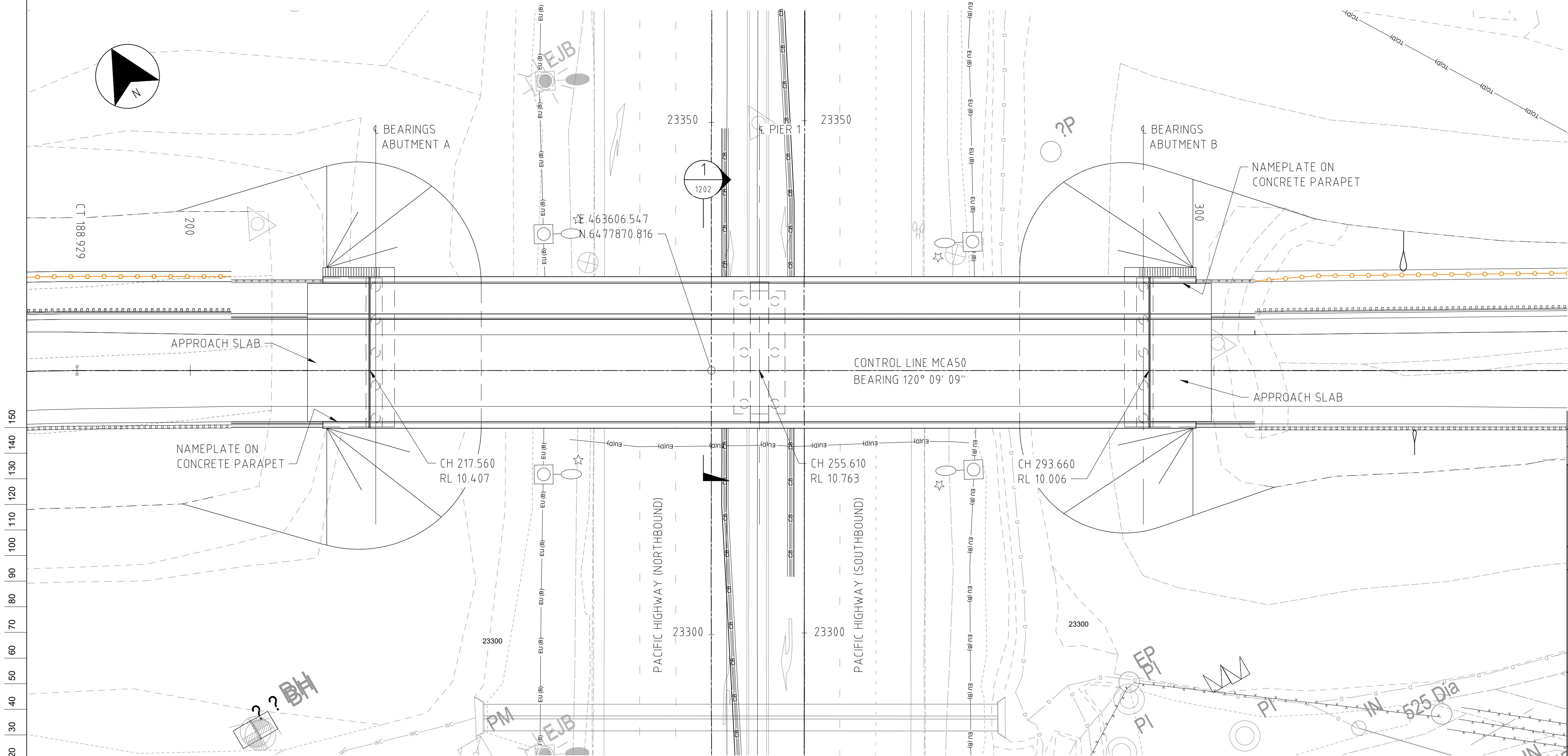


DESIGN SURFACE LEVELS ON CONTROL LINE MCA50	10.407	10.763	10.006
EXISTING SURFACE LEVELS ON CONTROL LINE MCA50	3.63	2.54	4.56
CHAINAGE ON CONTROL LINE MCA50	217.560	255.610	293.660

ELEVATION
SCALE 1:250



LOCALITY PLAN
THE BRIDGE SITE IS APPROXIMATELY
324km BY ROAD FROM SYDNEY
NOT TO SCALE



PLAN
SCALE 1:200

GENERAL NOTES

SCALE 0 5000 10000mm 2500 1250 OR AS SHOWN.

DIMENSIONS ARE IN MILLIMETRES.
CHAINAGES AND REDUCED LEVELS ARE IN METRES.
REDUCED LEVELS ARE RELATED TO AUSTRALIAN HEIGHT DATUM.
ROAD BARRIERS SHOWN INDICATIVELY ONLY.
R DENOTES RESTRAINED BEARING
EJ DENOTES EXPANSION JOINT

REVISION IN PROGRESS

ISSUE	DATE	REVISION	PREP	CHECK	AUTH	WVR
		WORK IN PROGRESS				

HIGHWAY No. 10 MIDCOAST COUNCIL

BRIDGE OVER PACIFIC HIGHWAY
AT HARRINGTON ROAD INTERCHANGE
AT 20.1km NORTH OF TAREE
OPTION 2 CONCEPT - SHEET A

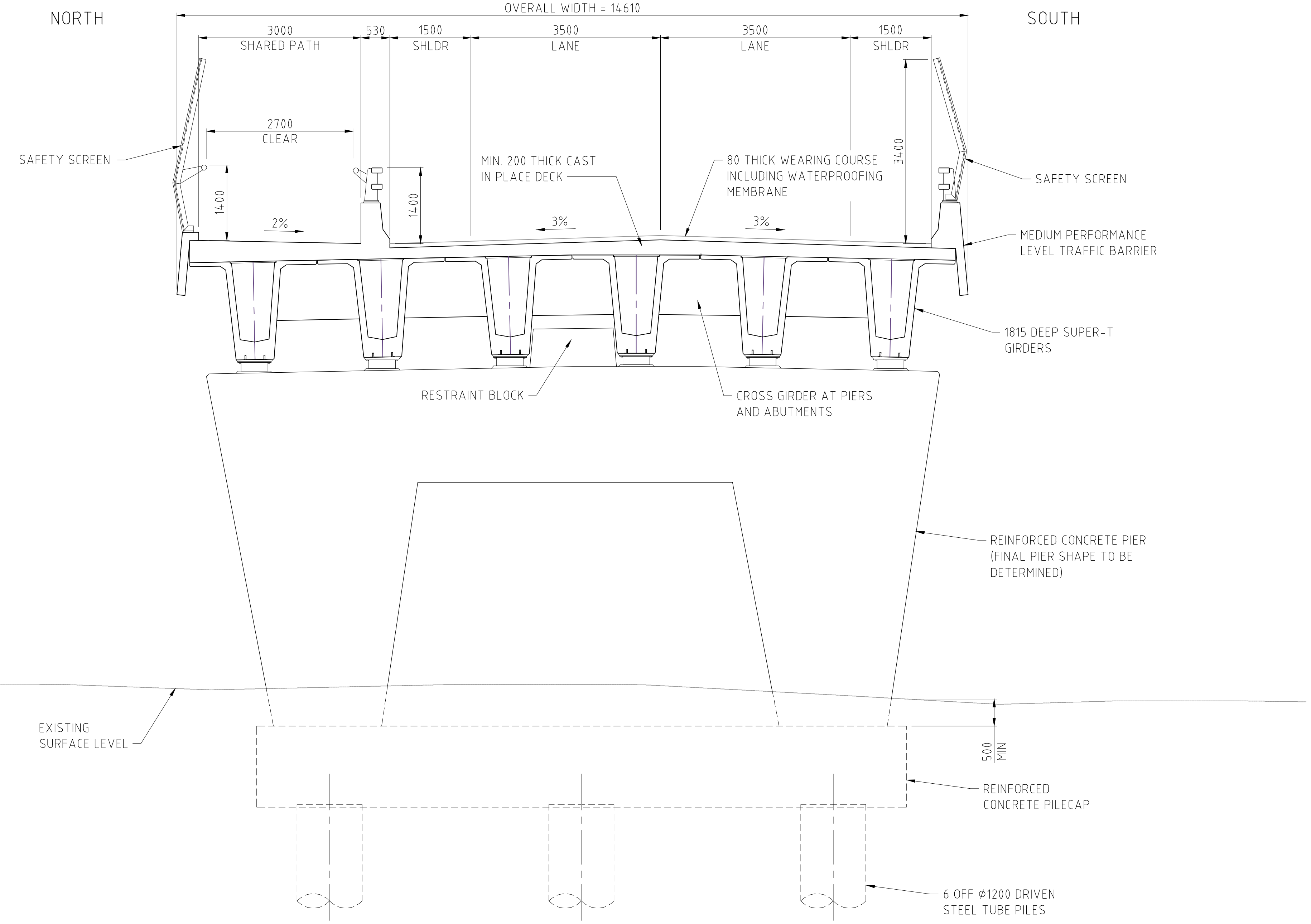
AECOM
AECOM Australia Pty Ltd A.B.N. 20 093 846 925
NSW GOVERNMENT Transport for NSW

PREPARED	CHECKED	REGISTRATION No OF PLANS	
DESIGN D.S.			
DRAWING G.M.R.		BRIDGE NUMBER	BR-1200
APPROVED DESIGN QA RECORDS		ISSUE STATUS: 80% CONCEPT DESIGN	
DIRECTOR		SHEET No 1201	ISSUE 0

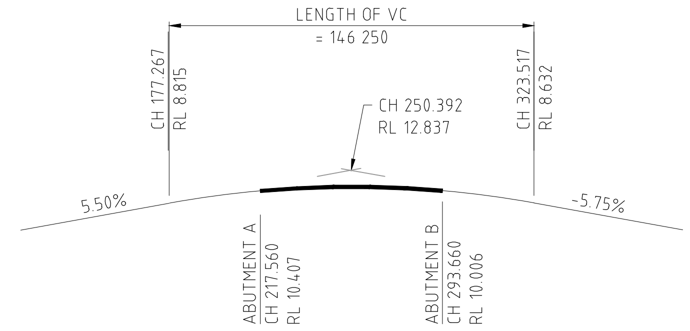
CAD No 60684355-SHT-10-0000-ST-1201

CAD Ref: ProjectWise\60684355-SHT-10-0000-ST-1201.dwg Last modified: 19 Jan 23 - 18:02

150 mm ON ORIGINAL
A1 ORIGINAL



SECTION 1
SCALE 1:50 1201

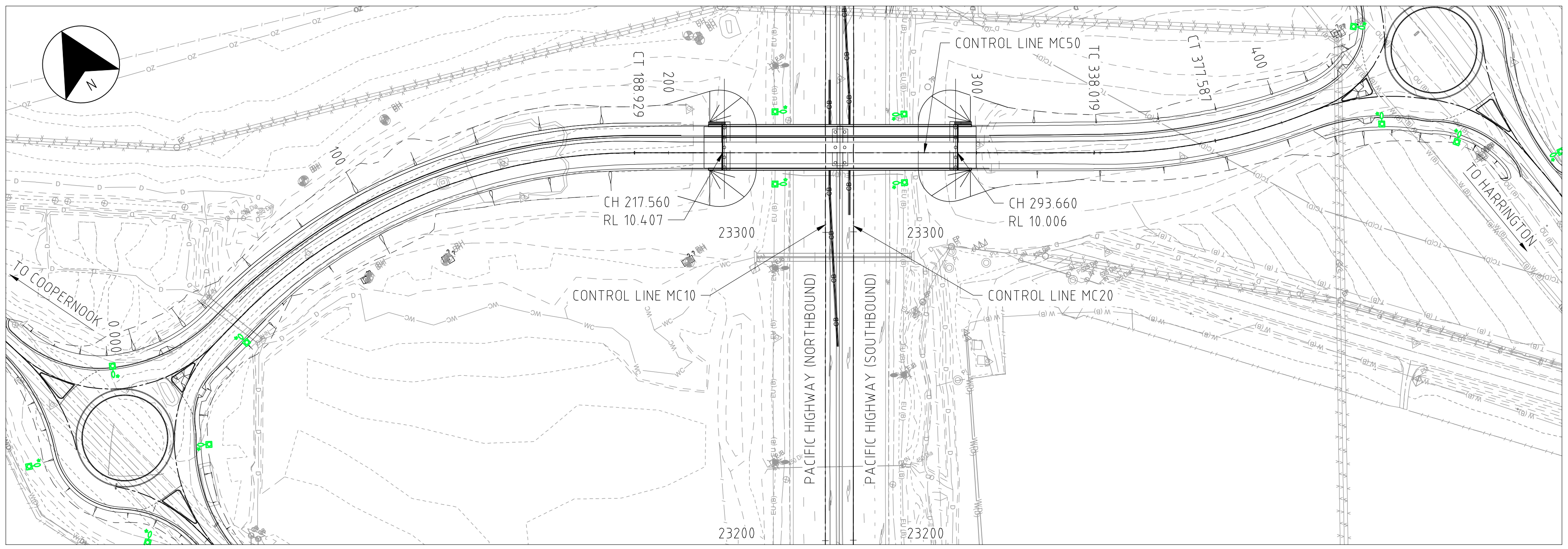


VERTICAL ALIGNMENT
NOT TO SCALE

GENERAL NOTES

SCALE 0 1000 2000mm 500 250 OR AS SHOWN.

DIMENSIONS ARE IN MILLIMETRES.
CHAINAGES AND REDUCED LEVELS ARE IN METRES.
REDUCED LEVELS ARE RELATED TO AUSTRALIAN HEIGHT DATUM.



SITE PLAN
NOT TO SCALE

REVISION IN PROGRESS

ISSUE	DATE	REVISION	PREP	CHECK	AUTH	WVR
		WORK IN PROGRESS				

HIGHWAY No. 10 MIDCOAST COUNCIL

BRIDGE OVER PACIFIC HIGHWAY
AT HARRINGTON ROAD INTERCHANGE
AT 20.1km NORTH OF TAREE
OPTION 2 CONCEPT - SHEET B

AECOM
AECOM Australia Pty Ltd A.B.N. 20 093 846 925

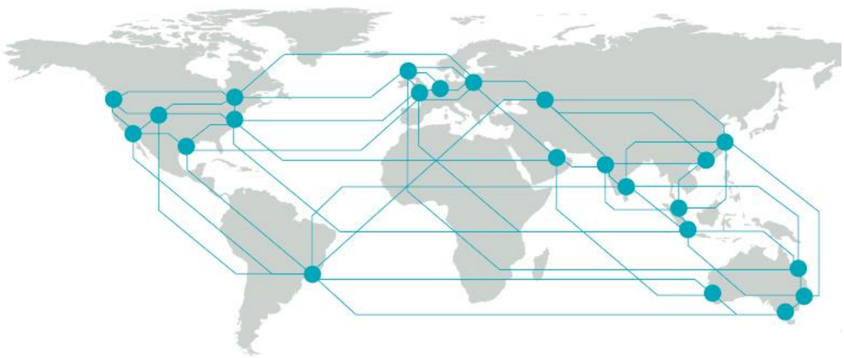
NSW GOVERNMENT Transport for NSW

PREPARED	CHECKED	REGISTRATION No OF PLANS
DESIGN D.S.		
DRAWING G.M.R.		BRIDGE NUMBER: BR-1200
APPROVED DESIGN QA RECORDS		ISSUE STATUS: 80% CONCEPT DESIGN
DIRECTOR		SHEET No 1202 ISSUE 0

CAD No 60684355-SHT-10-0000-ST-1202

CAD Ref: ProjectWise\60684355-SHT-10-0000-ST-1202.dwg Last modified: 19 Jan 23 - 18:02

A1 ORIGINAL 150 mm ON ORIGINAL 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150



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