Singleton bypass

Technical working paper: Surface and Groundwater assessment

Roads and Maritime Services | November 2019

NSW GOVERNMENT

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Roads and Maritime Services | November 2019

Prepared by AECOM Australia Pty Ltd and Roads and Maritime Services

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Approval and authorisation

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Signed:	
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Executive summary

Roads and Maritime proposes to build a New England Highway bypass of Singleton. The proposal includes a new eight kilometre highway bypassing Singleton to the west. The proposed bypass route would depart the New England Highway near Newington Lane in Whittingham then head west over the Main North railway line, across the floodplain over Putty Road. It would continue over the Hunter River, west of Singleton, before crossing the New England Highway west of Gowrie Gates where it would re-join the highway north of McDougalls Hill.

This technical paper assesses surface water and groundwater impacts of the proposal.

Surface water and flooding

An assessment of the surface water quality features and impacts identified construction activities from the proposal represent a risk within local receiving waters, including the Hunter River, Glenridding and Doughboy Hollow floodplains. Primary risks include sediment laden waters, chemicals stored on site, and construction waste as having the potential to mobilise and enter waterways during runoff events or flood conditions. Sediment laden waters and offsite discharge can occur during construction activities including: clearing and grubbing, stockpiling of materials, general earthworks, temporary works (i.e. access roads, compounds, laydown areas and pads), construction of bridge piers and abutments in and adjacent to the Hunter River, instream drainage works, and the placement of fill for embankments.

A number of erosion control and sediment management measures have been identified as part of the assessment with temporary measures to improve the quality of discharged water. This would include using temporary sediment basins and localised treatments such as temporary erosion controls, sediment capture, and separation of on-site and off-site water.

A potential impact to surface water quality during the operation of the proposal would include pollutants and contaminants from the surface of the road (i.e. litter, sediment or oils from vehicles) being conveyed during runoff events to receiving waters. Water quality during operation would be managed through the application of standard design and management measures.

A flood impact assessment was carried out to understand a range of flood magnitudes (20 per cent AEP, 10 per cent AEP, five per cent AEP, two per cent AEP, one per cent AEP, 0.5 per cent AEP and 0.2 per cent AEP) associated with the proposal. The assessment compared the change in peak flood level from existing conditions to the proposed design.

The modelled peak flood level impacts at dwelling locations remote from the proposal are up to a 0.05 metre increase at the one per cent AEP event, 0.07 metres at the 0.5 per cent AEP and 0.08 metres at the 0.2 per cent AEP. At the one per cent AEP and 0.5 per cent AEP events there are reduced peak flood levels through much of Singleton and Glenridding, up to around a 0.1 metre decrease. At the 0.2 per cent AEP event peak flood levels are reduced in Glenridding but largely balanced through Singleton, with some minor local changes of up to 0.05 metres. Peak flood level impacts upstream of the southern interchange are locally over a 0.5 metre increase. However, the impacts are localised and limited to rural property.

Construction activities have the potential to impact on the flood regime and redistribute flows across the floodplain (BMT WBM, May 2018). Potential impacts could occur where temporary access tracks and raised working platforms are placed in flood affected zones. However, flood behaviour of the study area is well understood, with adequate advance flood warning likely to be available to remove staff and equipment and protect the work prior to inundation.

The proposal would be designed to maintain existing stormwater flow paths by providing appropriately sized drainage structures where required. The drainage design would consider transverse drainage, longitudinal drainage, water quality, subsurface drainage, and temporary drainage. Mitigation measures including controlled management of stormwater and drainage patterns, stockpiles located outside the floodplain and drainage lines, flooding evacuation and response protocol and maintained access for all workers, residence and livestock have been proposed to mitigate the potential impact of construction on flooding and stormwater.

Groundwater

Groundwater conditions were assessed using geotechnical information and publicly available groundwater information. The potential for construction impacts from the proposal have been considered with bridge piles identified as a likely impacts. Additional risks include acid sulphate soil disturbance during excavation, however this risk is considered low. Methodology for bridge piles has been developed to minimise any impacts with groundwater. This includes advanced steel casing installation with the pile holes as they are drilled. For most of the alluvial gravel, drilling will be above the water table. Once the casing has been advanced to the bedrock, groundwater is not expected to be encountered.

The geotechnical data (Douglas Partners, 2019) indicates the alluvial gravel aquifer is a coarse-grained granular material that is densely packed. Because of this, the additional loading from the earthworks is not expected to substantially change the intergranular pore spaces that give rise to the high permeability of this aquifer material.

Groundwater dependent ecosystems (GDEs) are not expected to be disturbed by earthworks during construction or operation of the bypass. There is potential for groundwater to be contaminated by accidental spills of substances being conveyed along the bypass if they are not managed. Should a spill occur, it would need to be managed using appropriate emergency response protocols.

The groundwater management plan will consider GDEs that could be impacted by the project. Groundwater levels and quality in these areas will be monitored during the detailed design phase to establish baseline conditions, and during the construction phase to identify unexpected changes that could result in an adverse impact.

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Terms and acronyms used in this technical working paper

Term / Acronym	Description
ACM	asbestos containing material
AECOM	AECOM Australia Pty Ltd
AEP	annual exceedance probability
AHD	Australian height datum
ANZECC	Australian and New Zealand Environmental Conservation Council (ANZECC)
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
ASRIS	Australian Soil Resource Information System
BoM	Bureau of Meteorology
BMT WBM	BMT Group Pty Ltd
CBD	central business district
CEMP	construction environmental management plan
CHPP	coal handling and preparation plant
DA	development application
DO	Dissolved Oxygen
DPIE	Department of Planning, Industry and Environment
EC	electrical conductivity
ESCP	erosion and sediment control plan
EP&A Act	*Environmental Planning and Assessment Act 1979*
GDE	groundwater dependent ecosystem
GNR	geographical name register
HRSTS	Hunter River Salinity Trading Scheme
LEP	Local Environmental Plan. A type of planning instrument made under Part 3 of the EP&A Act.
LGA	local government area
LOR	limit of reporting
NEMP	National Environmental Management Plan
NSW DI - Water	NSW Department of Industry – Water Division
NTU	nephelometric turbidity unit
OEH	NSW Office of Environment and Heritage now Environment, Energy and Science Group, DPIE
POEO Act	*Protection of the Environmental Operations Act 1997*

Term / Acronym	Description
PFAS	per – and poly-fluoroalkyl substances
PFOS	perfluorooctane sulfonate
PFHxS	Perfluorohexane sulfonic acid
REF	review of environmental factors
Roads and Maritime	Roads and Maritime Services
SEPP	State Environmental Planning Policy. A type of planning instrument made under Part 3 of the EP&A Act.
CSWMP	construction surface water management plan
TBA	to be announced
TN	Total Nitrogen
TP	Total Phosphorus
WQO	water quality objectives

1. Introduction

1.1 Proposal identification

Roads and Maritime Services NSW (Roads and Maritime) proposes to build a New England Highway bypass of Singleton (the proposal). The proposal would include eight kilometres of two-lane highway (one lane in each direction) to the west of Singleton and would connect to the New England Highway to the north and south of Singleton.

Located in the Singleton Shire local government area (LGA) in the Hunter Valley, the proposal is 75 kilometres inland from Newcastle, 47 kilometres south-east of Muswellbrook and 200 kilometres from Sydney.

The proposed bypass route departs the New England Highway near Newington Lane in Whittingham then heads west over the Main North railway line, across the floodplain over Putty Road. The route continues over the Hunter River, west of Singleton, before crossing the New England Highway west of Gowrie Gates where it re-joins the highway north of McDougalls Hill.

The proposal, as assessed in this Review of Environmental Factors (REF) includes the following features:

- About eight kilometres of the bypass of Singleton with a single lane in each direction
- Connection with the New England Highway at the southern end of the proposal, including a southbound entry ramp and northbound exit ramp only (the southern connection)
- A 1.7 kilometre bridge over the Main North railway line, Doughboy Hollow floodplain and Putty Road
- Connection to Putty Road including a northbound entry ramp and southbound exit ramp only (the Putty Road connection)
- A 40 metre bridge over the Putty Road entry ramp
- A 100 metre bridge over Rose Point floodway
- A 200 metre bridge over the Hunter River
- A 40 metre bridge over the New England Highway at Gowrie Gates
- Connection with the New England Highway at Gowrie Gates consisting of a southbound entry ramp and northbound exit ramp. The northbound exit ramp would connect to the New England Highway via a new roundabout intersection at Maison Dieu Road
- A 1.7 kilometre northbound climbing lane between Gowrie Gates and the northern connection
- Connection at Magpie Street including access to the nearby industrial area including a northbound entry ramp, southbound exit ramp and southbound entry ramp only (the northern connection).

The Singleton bypass Review of Environmental Factors (AECOM, 2019) provides a detailed description of the proposal inclusive of:

- Road design and key elements
- Construction activities
- Earthworks
- Staging and early works
- Ancillary facilities.

The study area for this surface and groundwater assessment is defined by the by the area shown in Figure 1-1 and key proposal features described above, with allowance for construction phase activities. It comprises a linear corridor of variable width (about 0.1 to 0.8 kilometres), with a total length of about nine kilometres and a total surface area of around 253 hectares. Key construction phase activities within the study area, and that are relevant to this assessment include:

- Clearing and grubbing
- Stockpiling of materials
- General earthworks
- Temporary works i.e. access roads, compounds, laydown areas and pads
- Construction of bridge piers and abutments, including a bridge over the Hunter River
- Instream drainage works, including possible diversion of a drainage line flowing to the Hunter River
- Placement of fill for embankments.

1.2 Purpose of the report

The purpose of this report is to describe the surface water and groundwater environment relative to the study area and assess the potential impact of the proposal during both the construction phase (Section 4) and operational phase (Section 5).

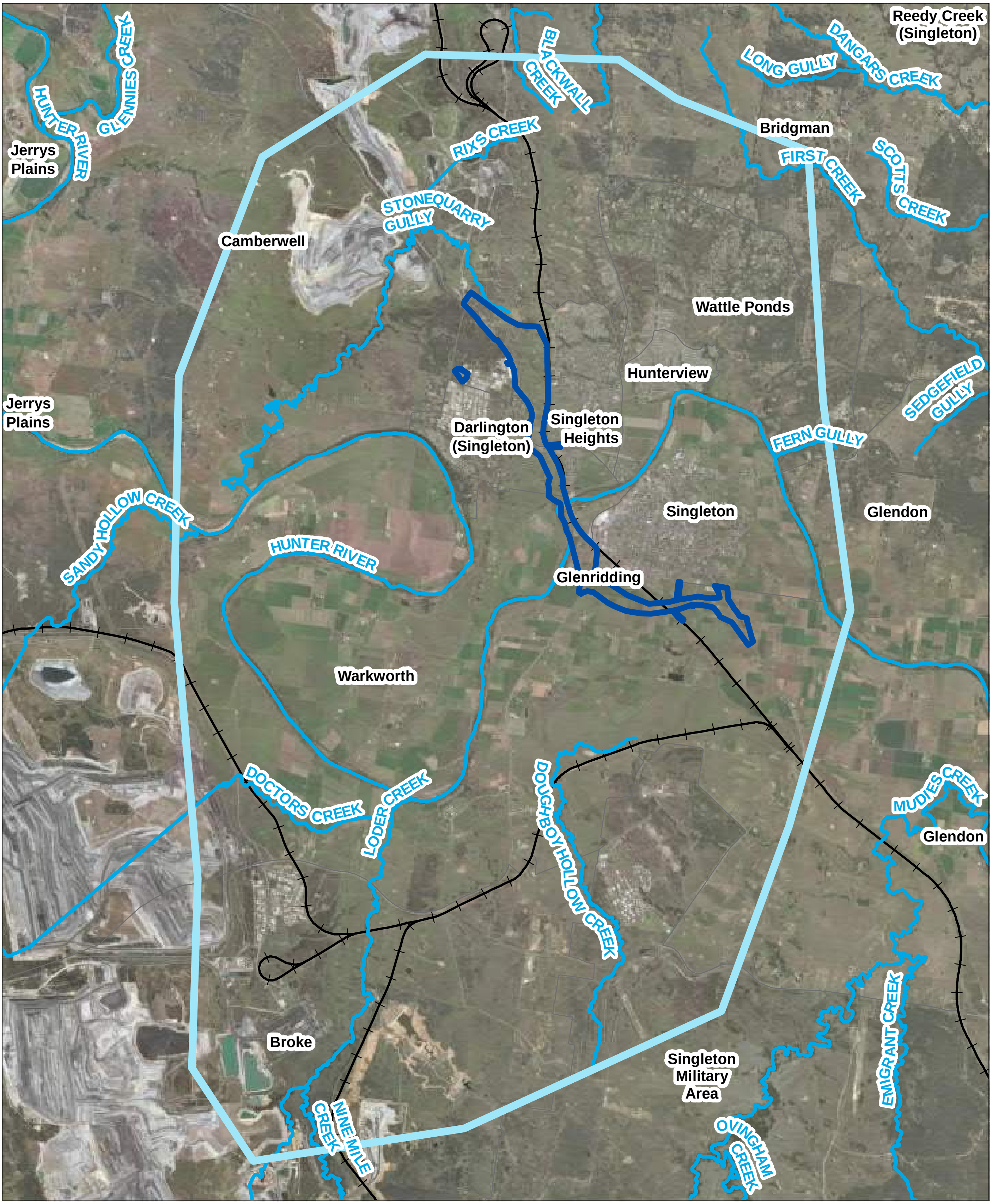

FIG. 1-1 Location of the proposal area

Legend

- Study area
- Watercourse
- Railway line
- Proposal area

Source:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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2. Assessment methodology

2.1 Relevant guidelines and policies

2.1.1 Legislation

The following NSW legislation and statutory requirements apply to the surface and groundwater assessment:

- *Protection of the Environment Operations Act 1997* (POEO Act)
- *Protection of the Environment Administration Act 1991*
- *Local Government Act 1993*
- *NSW Fisheries Management Act 1994*
- Water Management Act 2000 and the Water Management (General) Regulation 2011
- NSW Aquifer Interference Policy 2012
- National Environment Protection (Assessment of Site Contamination) Measure 2013.

'State Environmental Planning Policy (Coastal Management) 2018' (Coastal Management SEPP) has been reviewed and the study area is not subject to the Coastal Management SEPP.

2.1.2 Water sharing plans

The Hunter River is a permanently flowing waterway managed in accordance with the 'Water Sharing Plan for the Hunter Regulated River Water Source' (2016). Surface waters outside of the Hunter Regulated River Water Source are subject to the 'Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources' (2009). Both plans are legal instruments under the *Water Management Act 2000*. Water sharing plans are being developed for rivers and groundwater systems across New South Wales following the introduction of the *Water Management Act 2000*. These plans protect the health of our rivers and groundwater while also providing water users with perpetual access licences, equitable conditions and increased opportunities to trade water through separation of land and water. Section 56 of the *Water Management Act 2000* states Roads and Maritime's obligations as a 'road authority'

Section 56 of the *Water Management Act 2000* establishes access licences for the take of water within a particular water management area. Under section 18(1) of the *Water Management (General) Regulation 2011* and schedule 5 part 1, Roads and Maritime, as a 'roads authority', is exempt from the need to obtain an access licence in relation to water required for road construction and road maintenance.

2.1.3 Water quality guidelines

The relevant water quality guidelines were identified and reviewed to determine the obligations of the construction of the proposal with respect to the water quality objectives for the catchment. In the assessment of the surface water quality and for the protection of aquatic ecosystems in this region, the following guidelines apply:

- Australian and New Zealand Environment Conservation Council (ANZECC)
- Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), 'Guidelines for Fresh and Marine Water Quality' (2000).

ANZECC/ARMCANZ has prepared a guideline for water quality management for use throughout Australia and New Zealand based on the philosophy of ecologically sustainable development.

The NSW Department of Environment and Heritage booklet titled ‘Using the ANZECC Guidelines and Water Quality Objectives in NSW’ (DEC, 2006) is used to assist technical practitioners with applying the ANZECC guideline in NSW (the NSW guideline).

The NSW guideline defines the ‘environmental values’ of receiving waters as those values or uses of water that the community believes are important for healthy ecosystem. The environmental values of the Hunter River receiving waters are:

- Aquatic ecosystem
- Irrigation water supply
- Livestock water supply
- Primary and secondary contact recreation
- Visual amenity.

The ANZECC guideline specifies three levels of protection, from stringent to flexible, corresponding to whether the condition of the particular ecosystem is:

- Of high conservation value
- Slightly to moderately disturbed
- Highly disturbed.

This report assesses the proposal against the environmental values of the water quality guidelines.

2.1.4 Construction phase guidelines

The following design guidelines and management procedures are relevant in identifying the appropriate water quality management and mitigation measures to be implemented during the construction phase of the proposal:

- NSW DECC 2008 ‘Managing Urban Stormwater-Volume 2D Main Road Construction’, NSW Department of Environment, Climate Change and Water (known as the Blue Book Volume 2)
- Landcom, 2004 ‘Managing Urban Stormwater- Soils and Construction, Volume 1’, 4th Edition (known as the Blue Book Volume 1)
- Roads and Traffic Authority 2009, ‘Erosion and Sediment Management Procedure’
- Roads and Traffic Authority 2012, ‘Environmental Direction: Management of Tannins from Vegetation Mulch’
- Roads and Traffic Authority 2005’ Guidelines for the Management of Acid Sulphate Materials: Acid Sulphate Soils, Acid Sulphate Rock and Monosulfidic Black Ooze’
- Roads and Maritime 2011 ‘Technical Guideline: Temporary Stormwater Drainage for Road Construction’
- Roads and Maritime 2011 ‘Technical Guideline – Environmental Management of Construction Site Dewatering’.
- Roads and Maritime 2015 ‘Guideline for Batter Surface Stabilisation using vegetation’.

2.1.5 Operational phase guidelines

The following design guidelines and management procedures are relevant in identifying the appropriate water quality management and mitigation measures to be implemented during the operational phase of the proposal:

- Roads and Traffic Authority 2003 Procedure for selecting treatment strategies to control road runoff
- Austroads, 2001 Road Runoff and Drainage: Environmental Impact and Management Options, Austroads AP-R180
- Austroads, 2003 Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure, Austroads AP-R232
- Austroads, 2013 Guide to Road Design, Part 5: Drainage – General and Hydrology Considerations
- Austroads, 2013 Guide to Road Design, Part 5A: Drainage – Road Surface, Networks, Basins and Subsurface
- Austroads, 2013 Guide to Road Design, Part 5B: Drainage – Open Channels, Culverts and Floodways
- Department of Primary Industries, '2012 NSW Aquifer Interference Policy'.

2.2 Methodology

This surface and groundwater assessment adopted the following methodology:

- Review available water quality, flooding data and existing conditions to obtain background information on catchment history and land use and define the existing environment
- Collation of registered bores from the NSW Department of Industry – Water Division groundwater database
- Collation of groundwater dependent ecosystems (GDE) from the National Atlas of Groundwater Dependant Ecosystems (Australian Bureau of Meteorology (BoM))
- Define the area that influences both the surface and groundwater environments
- Review existing flood conditions and the design flood simulations
- Review hydrogeological data collected during the geotechnical investigation
- Identify potential impact of construction and operational activities and potential cumulative impact on water quality with reference to the ANZECC/ARMCANZ (2000) water quality guidelines for protection of the relevant environmental values
- Develop of water quality treatment measures to mitigate the impact of construction on water quality, following the principles of the Managing Urban Stormwater: Soils and Construction, Volume 1 (Landcom 2004) and Volume 2D (DECC 2008)
- Identify water quality treatment measures to mitigate the impact of the operation of the proposal on water quality following the principle of Procedure for Selecting Treatment Strategies to Control Road Runoff (RTA 2003) and Roads and Maritime Water Policy (RTA 1997)
- Nominate any additional measures to manage potential cumulative impact resulting from the proposal
- Provide a consolidated list of measures to be applied during construction and operational phase to mitigate potential impact to surface water and groundwater.

Components of this report rely on publicly available data being correct and up to date.

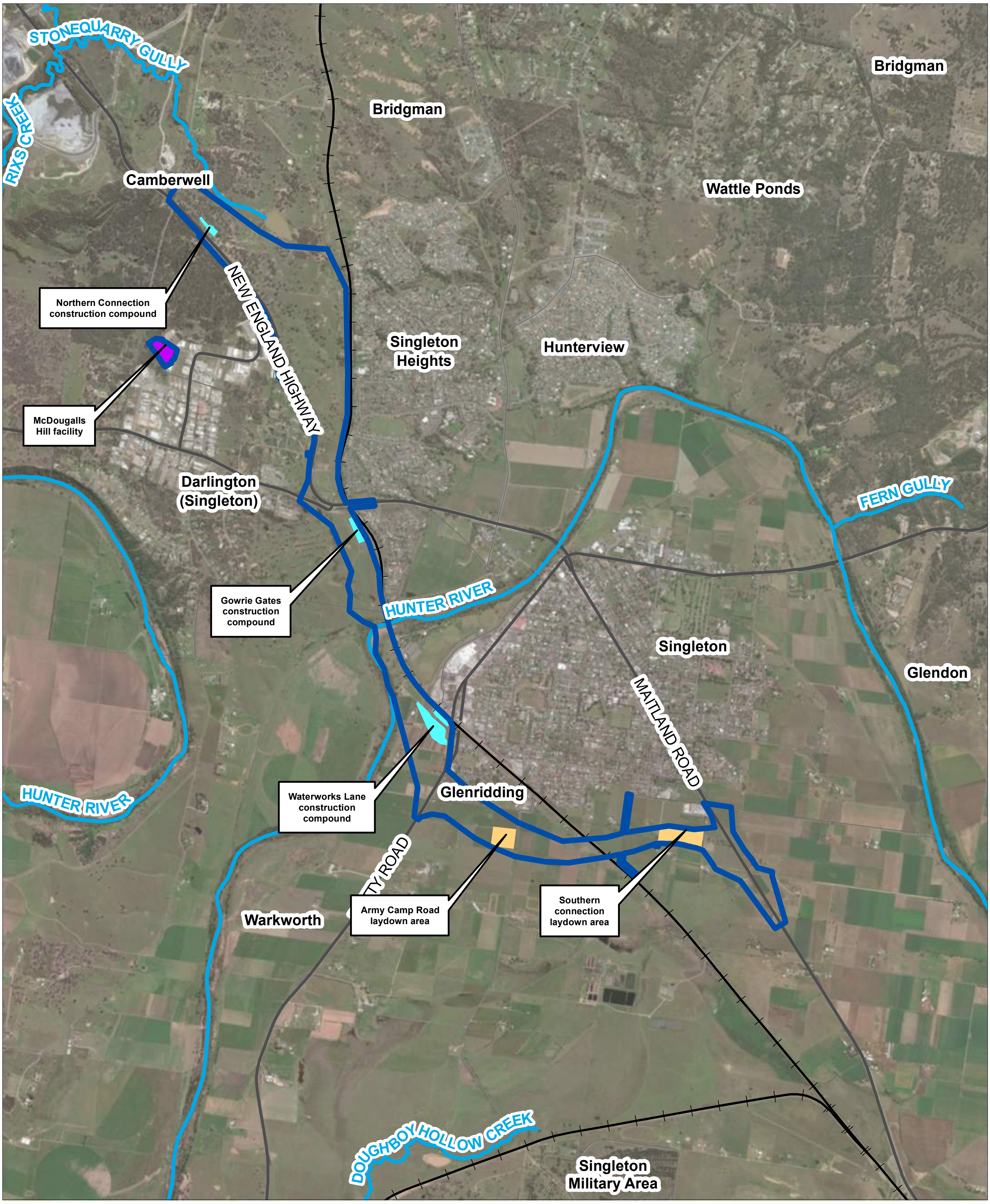

FIG. 2-1 Ancillary facility locations

N

km
0 0.65 1.3

Legend

- Proposal area
- Watercourse
- Main road
- Railway line
- Set-down area/crib sheds/parking
- Compound sites
- McDougalls Hill facility

3. Description of the existing environment

3.1 Climate

Singleton is located in a region with a temperate climate. The closest BoM weather station is the Singleton Sewage Treatment Plant, site number 061397 (Latitude 32.59S Longitude 151.17E) located 1.2 kilometres south-east of the study area. The mean annual rainfall at this station is 655.1 millimetres, based on a data series between 2002 and 2018, with monthly totals being relatively higher in late spring, summer and early autumn months. Table 3-1 illustrates the variation in average monthly rainfall.

The Jerrys Plains Post Office weather station, site number 061086 (Latitude 32.500S Longitude 150.910E) located 35 kilometres north-west of Singleton has recorded a mean annual rainfall of 644.5 millimetres, based on a data series of between 1884 and 2014.

Singleton has a high mean maximum temperature in summer (31.9°C in January) and cool mean minimum temperature in winter (4.3°C in July and August).

Evaporation data is not measured at this meteorological station, however the Climatic Atlas of Australia – Evaporation (BoM 2001) indicates that the annual average potential evaporation is 1300 millimetres.

Table 3-1 Mean monthly rainfall based on records from 2002 to 2018 (current on 15/1/2019), measured at BoM station 061397

	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Mean monthly rainfall (mm) (Current on *15/1/2019*)	64.3	85.6	63.7	58.5	27.9	65.4	24.3	29.4	37.8	45.0	76.7	72.4

3.2 Geology and soil landscapes

The study area is underlain by a series of faulted folded sedimentary deposits of the Permian age, generally assigned to the Maitland Group (Singleton 1:250 000 Geological Sheet SI/56-01 Rasmus P.L *et al.*, 1st edition, 1969).

The Maitland Group consists of the following identified geological units (in descending geological age):

- Qa – (Quaternary) Gravel, sand, silt clay
- Pmm - Mulbring Sandstone – siltstone and sandstone
- Pmms - Muree Sandstone – sandstone and conglomerate
- Pmb - Branxton Formation – mudstone, sandstone and conglomerate.

To the north-west, the Singleton Coal Measures (Ps) overlies the Maitland Group and comprises sandstone, shale, mudstone, conglomerate and coal seams, the latter of which has been historically mined.

The Quaternary rock is associated with the southern section of the study area. The soils in this area are part of the Hunter Soil Landscape and are generally fertile alluvial soils, brown clays, black earths and red podzolic (eSPADE v2, 2017a). The fertile alluvial soils are well suited to cropping and grazing and support the agricultural activities in the area (DPI, 2013). The northern section of the proposal that intercepts

McDougalls Hill lies within the Sedgefield Soil Landscape and is characterised by yellow soloths, black soloths and yellow solodic soils (eSPADE v2, 2017b).

Analysis of soil samples to identify potential acid sulphate soil (PASS), by Douglas Partners (2019), indicate that:

- In-situ surficial soils and groundwater below the water table are not acidic
- Bedrock at the proposed bridge site and deep excavation (BH7, BH12 and BH102) presents a low risk of PASS being present source due to its low sulphur content, net acid generation testing, and excess acid neutralising capacity
- Bedrock beneath the southern end of the proposal (BH2, BH3 and BH4) presents a higher risk of PASS materials being present due to the high total sulphur contents and low pH from the net acid generation testing but that there is some acid neutralising capacity present
- None of the samples exhibited actual acidity, with the titratable acid acidity being less that the laboratory’s reporting limit.

3.2.1 Contamination

A Phase 1 site environmental assessment was completed in the study area and further findings can be found in ‘Technical working paper – Contaminated soil phase 1 assessment’ (AECOM, 2019). The assessment identified potential contamination from various sources within the study area.

Locations identified as potentially containing contamination include market gardens, pastoral lands, the existing New England Highway and associated collector roads, Main North railway line, former railway line north of Gowrie Gates, and existing buildings and historical structures for asbestos containing material (ACM).

Geotechnical investigations observed that the northern portion of the study area may contain ACM within fill material and the in-situ pipeline within former rail abutment in the rail corridor.

The EPA is investigating three sites for potential per- and poly-fluoroalkyl substances (PFAS) contamination: the Singleton Military Area, Singleton NSW Rural Fire Service, and Singleton Heights Mines Rescue Services. The EPA is collecting samples of soils and/or water for analysis for PFAS and reviewing exposure pathways that may increase people’s contact with the chemicals, such as bore and surface water usage.

AECOM were engaged by the Department of Defence to undertake an investigation into the presence of PFAS at Singleton Military Area (publicly available on the EPA website). A number of unregistered bores were sampled and PFOS+Perfluorohexane sulfonic acid (PFHxS) were located in quantities greater than the limit of reporting (LOR) 0.01 – 0.07 µg/L in two of the unregistered bores near the southern connection for the proposal (GW011 and GW004) refer Figure 3-1. The PFAS National Environmental Management Plan, 2018 (NEMP) drinking water guidelines are for PFOS + PFHxS at or below 0.07 µg/L and NEMP recreational use for surface water at or below 0.7 µg/L. PFAS concentrations in the two bores were below the respective NEMP drinking water and recreational use guidelines.

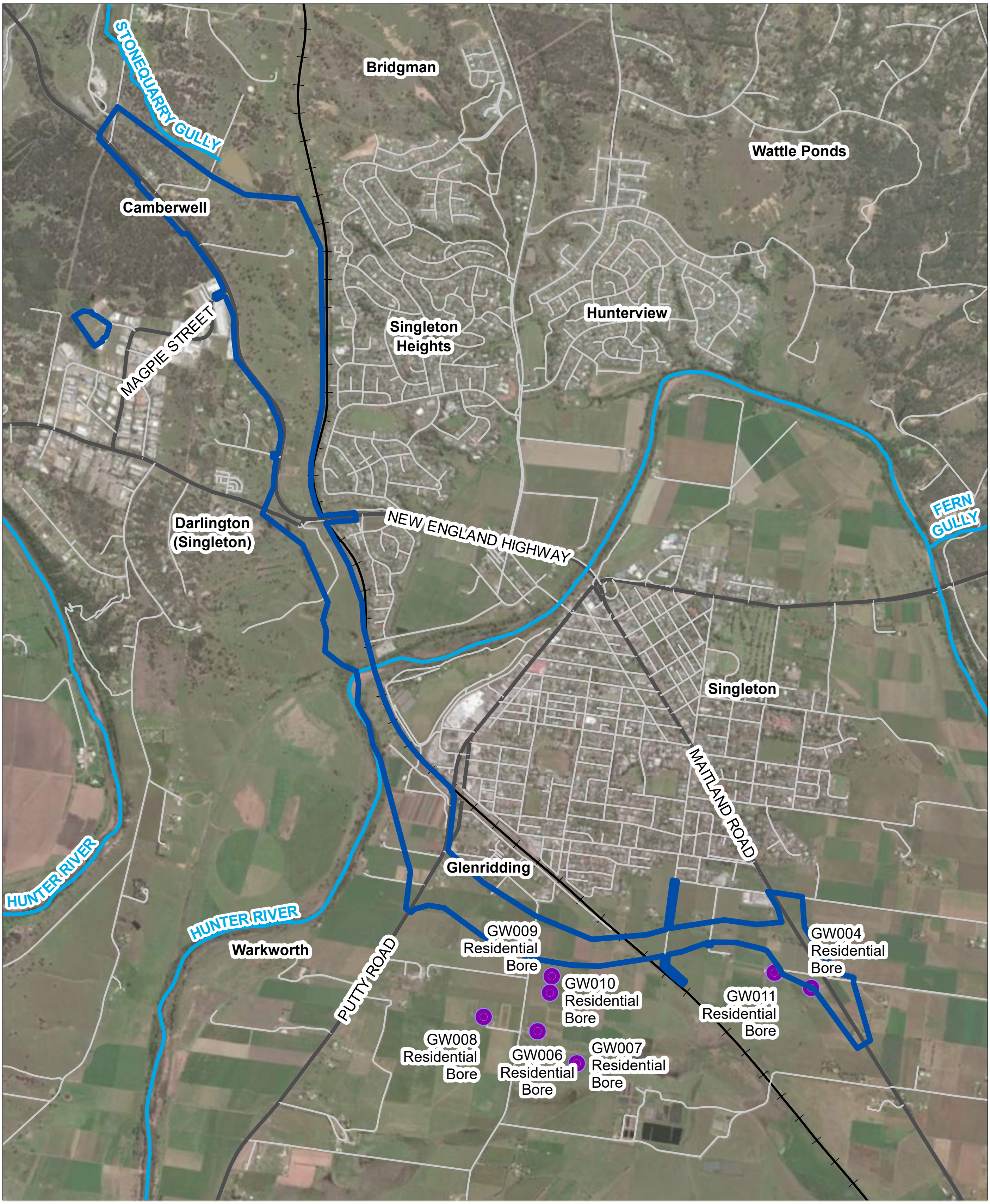

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FIG. 3-1 AECOM PFAS detection

N

0 0.55 1.1 km

Legend

- Proposal area
- Watercourse
- Minor roads
- Main road
- Railway line
- Residential bore

Source:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

3.3 Surface water

3.3.1 Surface water features

The Hunter River begins on the western slopes of the Mount Royal Range, part of the Great Dividing Range, east of Murrurundi, and flows generally south-west and then south-east before flowing into the Pacific Ocean at Newcastle.

The Hunter River has a catchment area to Singleton of roughly 16,000 square kilometres. This catchment can be split into two broad sub catchments: Goulburn River (7800 square kilometres) and Upper Hunter (8600 square kilometres) (BMT WBM 2018). Figure 3-2 shows key features and the topography of the study area.

At Singleton, the Hunter River is incised below the floodplain. The incised channel is some 80 to 90 metres wide at the top of the bank, whilst the Doughboy Hollow / Glenridding floodplain extends to an overall width of three to five kilometres. Doughboy Hollow and Glenridding are flood runners that convey major flood flows. Parts of Singleton are protected from flooding by a 2.7 kilometre long levee system. Included in this levee is a 330 metre long reinforced concrete retaining wall.

A number of unnamed watercourses are traversed by the proposal, and are shown in Figure 3-2:

- North of the Hunter River crossing, flowing south from Maison Dieu Road, capturing flows from McDougalls Hill and the approved Gowrie subdivisions
- Crossings of tributaries to an unnamed watercourse to the north of Gowrie Gates, draining to the east towards Lachlan Avenue in Singleton Heights beneath the proposed alignment.

A number of other creeks are sited near to the study area, but are not traversed by the proposal:

- Muddies Creek, south-east of the southern connection
- Doughboy Hollow Creek, south of Glenridding
- Stone Quarry Gully, north of the northern connection.

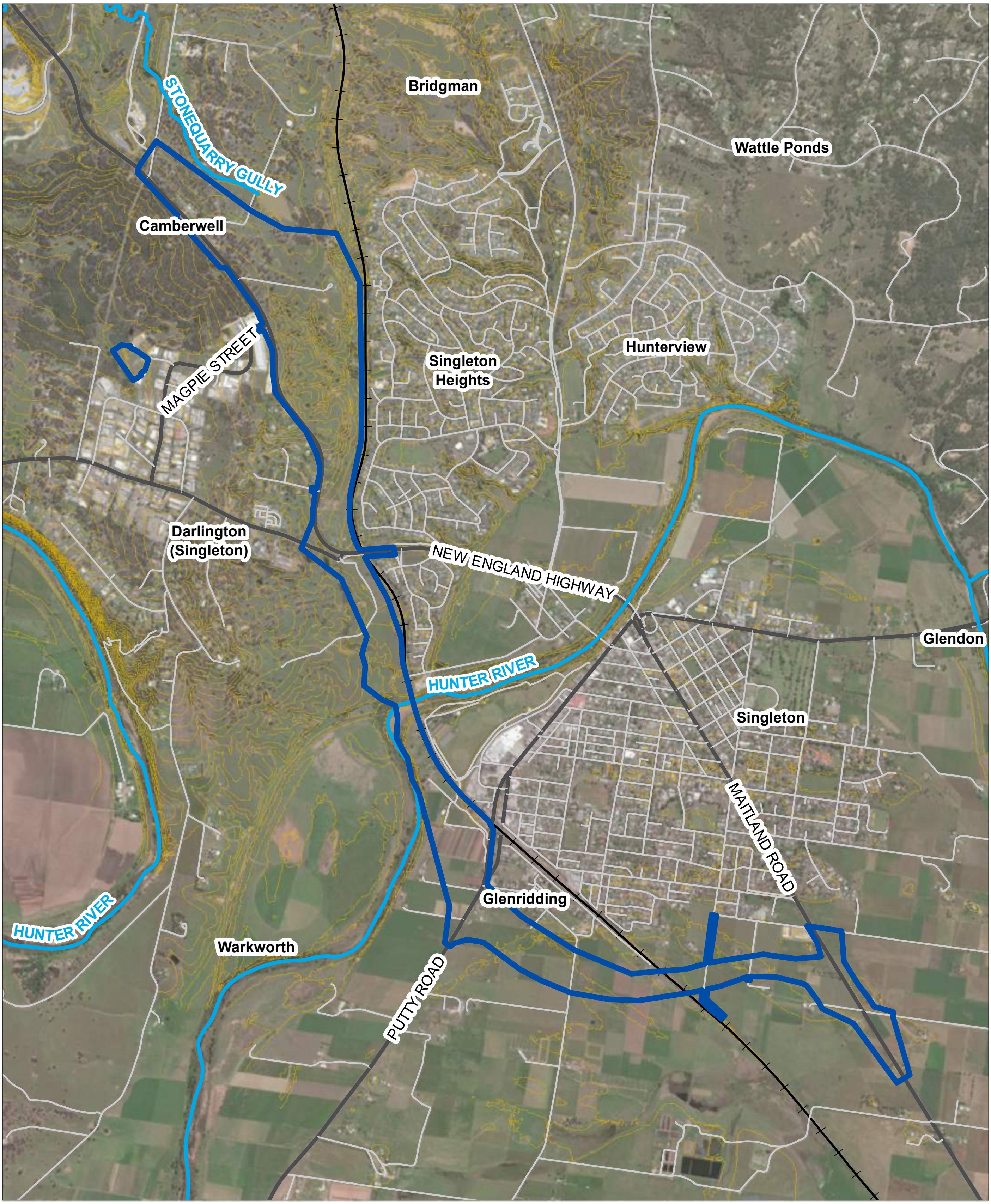

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FIG. 3-2 Topography of the proposal area

N

0 0.55 1.1 km

Legend

- Watercourse
- Proposal area
- Minor roads
- Main road
- Railway line
- Contours (5.0m)

Source:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

3.3.2 Water quality

Upstream of the proposal, mining and agriculture are key influences on the water quality in the Hunter River catchment. Available water quality monitoring data for the Hunter River is limited to electrical conductivity. However, available monitoring data from the nearest upstream waterways is described further below to provide further context regarding local water quality.

Electrical conductivity

Electrical conductivity in the Hunter River has been measured regularly since 1993 by the NSW Department of Primary Industries, DPIE, at gauging station ‘Hunter U/S Singleton’ (Station 210129). This station is located about 700 metres upstream of the Main North railway line bridge over the Hunter River. The installation of the station occurred close to the beginning of the trial Hunter River Salinity Trading Scheme (HRSTS) in 1993. Under the HRSTS, discharges of saline water into the Hunter River catchment is permitted only during periods when the Hunter River is in high flow or flood flow, and only by persons who hold licences that authorise such discharges (discharge licences).

Water quality at the Hunter U/S Singleton gauging station is directly influenced by management of the regulated Hunter River upstream. Irrigation water is normally released into this reach of the Hunter River from Glennies Creek Dam and assists to keep electrical conductivity (a measure of the salinity) low. When Glennies Creek Dam is not releasing water, electrical conductivity trends upwards towards 900 µS/cm because the main influence then becomes the through flow from Glenbawn Dam, which is located in the upper reaches of the Hunter River. By the time water from Glenbawn reaches the station, irrigation abstraction and natural accession of saline ground water has generally increased the salinity to around 800 µS/cm.

Average daily electrical conductivity at the Hunter U/S Singleton gauging station is 660 µS/cm, 91.5 percent of all results are less than 900 µS/cm, and about 17.5 percent are less than 500 µS/cm. Most of the data points fall within the range 300 – 900 µS/cm.

Total suspended solids and pH

Water quality monitoring of total suspended solids (TSS) and pH carried out at Rixs Creek Mine and Bulga Coal Complex are summarised in Table 3-2. Surface water quality monitoring locations are shown in Figure 3-3 and are described as:

- Rixs Creek (one monitoring point around 600 metres north of the Hunter River and four kilometres west, upstream of the study area)
- Stonequarry Gully (two monitoring points around three kilometres north of the Hunter River and 1.4 kilometres north, upstream of the study area)
- Loders Creek (two monitoring points around 1.8 kilometres south of the Hunter River and seven kilometres west, upstream of the study area).

The results in Table 3-2 indicate variable levels of pH and TSS, including elevated levels for both parameters (indicating a more alkaline water quality with higher amounts of solids) which are likely a result of nearby mining and agricultural activities.

Table 3-2 2019 water monitoring data from Rixs Creek Mine and Bulga Coal Complex

Parameter	January	February	March	April	May	June	July	August	September
Rixs Creek – monitoring point W3 (Rixs Creek Mine)									
pH	n/a	n/a	6.4	n/a	n/a	n/a	n/a	n/a	6.7
TSS (mg/L)	n/a	n/a	361	n/a	n/a	n/a	n/a	n/a	305
Stonequarry Gully – monitoring point CWD1 (Rixs Creek Mine)									
pH	8.3	8.1	8.3	6.6	7.2	7.1	7.0	8.0	8.4
TSS (mg/L)	473	328	297	188	154	235	197	172	173
Stonequarry Gully – monitoring point CWD2 (Rixs Creek Mine)									
pH	9.8	9.5	8.8	7.2	7.1	7.0	9.2	8.6	9.0
TSS (mg/L)	300	293	390	322	248	287	296	246	267
Loders Creek – monitoring point W9 (Bulga Coal Operations)									
pH	8.1	7.8	n/a	7.8	n/a	n/a	Monitoring data not published at time of writing		
TSS (mg/L)	186	14	n/a	514	n/a	n/a	Monitoring data not published at time of writing		
Loders Creek – monitoring point W10 (Bulga Coal Operations)									
pH	n/a	7.2	6.9	7.0	n/a	n/a	Monitoring data not published at time of writing		
TSS (mg/L)	n/a	99	102	159	n/a	n/a	Monitoring data not published at time of writing		

Water quality guidelines

The report card for the Singleton water source (NSW Department of Water and Energy, August 2009) states that there is:

- Low economic dependence of the local community on water extracted from the Hunter River for irrigation
- Low risk to instream value (from extraction)
- Medium relative instream value (within catchment): two threatened bird species, three threatened amphibian species; one endangered ecological community, moderate fish community integrity
- The ecology value for invertebrates is deemed to be moderate.

Therefore, default trigger values for physical and chemical stressors for ‘South-East Australian slightly to moderately disturbed lowland rivers’ have been adopted. These default values have been adopted as the baseline or trigger limit against which to assess the water quality of discharge of waters from site. The individual trigger values for each indicator may be used to assess the risk to an environmental value within receiving waterbodies.

The water quality guidelines and objectives applicable to the protection of the nominated environmental values (as listed in Section 2.1.3) that will be applied in the assessment of surface water quality are presented in Table 3-3. Recommended limits for metals are in accordance with ANZECC/ARMCANZ (2000) trigger values for toxicants for the protection of 95 per cent of freshwater aquatic species.

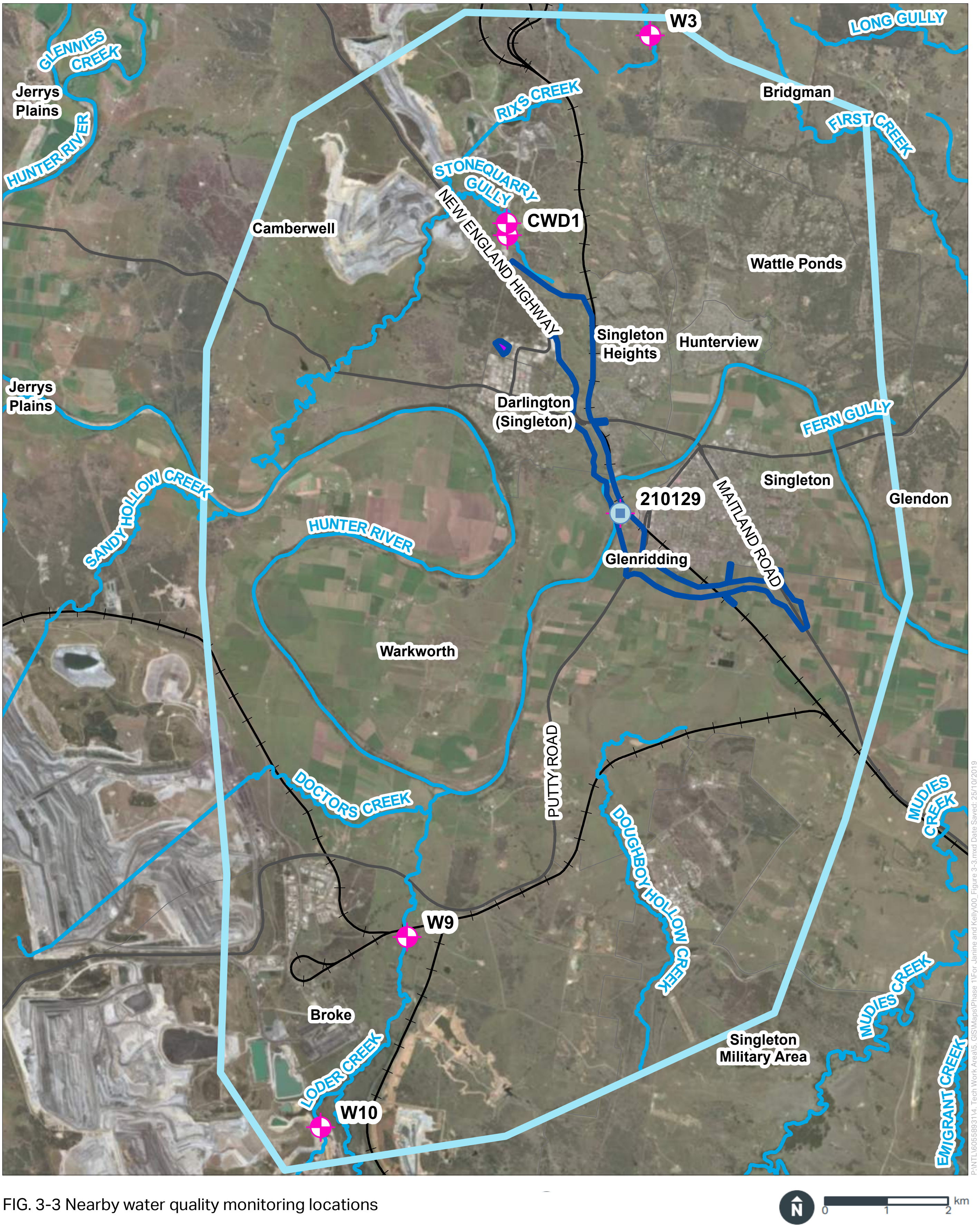


FIG. 3-3 Nearby water quality monitoring locations

Legend

- Study Area
- Watercourse
- Main road
- Proposal area
- Railway line
- McDougalls Hill facility
- 210129 - Gauging station Hunter U/S Singleton
- Surface water monitoring point

Source:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Table 3-3 Trigger values – Southeast Australian slightly to moderately disturbed lowland rivers

Trigger	Units	Trigger Values for Lowland River Ecosystem
Chlorophyll a (Chl a)	µg/L	3[1]
Total phosphorus (TP)	µg/L	25[1]
Filterable reactive phosphorous	µg/L1	20
Total nitrogen (TN)	µg/L	350[1]
Nitrogen oxides (NOx)	µg/L	25[4]
Ammonium (NH4)	µg/L	20[4]
Dissolved oxygen (DO)	per cent saturation	Aquatic ecosystems (Lowland rivers): 85 % Drinking water: >80%
pH		6.5-8
Salinity (EC)	µS/cm	125-2200[3]
Turbidity	NTU	6-50[4]
Temperature	degrees Celsius	Aquatic ecosystems >80%ile <20%ile Primary contact recreation: 15° - 35°C Aquatic foods (cooked): <2°C change over one Hour
Chemical contaminants	µgm/L	Livestock water supply: See Table 4.3.2 ANZECC 2000 Irrigation water supply: See Table 4.2.10 ANZECC 2000 Secondary contact recreation and primary contact recreation: no chemicals that are either toxic or irritating to the skin or mucous membranes Homestead water supply: See Guidelines for Inorganic Chemicals in the Australian Drinking Water Guidelines Drinking water: see ANZECC 2000 guidelines. Aquatic foods (cooked): Copper <5 µgm/L, mercury <1 µgm/L, zinc <5 µgm/L, chlordane <0.004 µgm/L, PCBs <2 µgm/L.
Faecal coliforms	Colony Forming Units (cfu)	Primary contact recreation: < 150 cfu/ 100mL Irrigation water supply: <100 cfu/ 100mL (raw human food crops, no direct

Trigger	Units	Trigger Values for Lowland River Ecosystem
		contact)<1000 cfu/ 100mL (pasture and fodder for grazing animals) Secondary contact recreation: <1000 cfu/ 100mL, with 4 out of 5 samples < 4000 cfu /100 mL Homestead water supply and drinking water: 0 cfu/ 100mL Aquatic foods (cooked): 14 MPN/ 100mL (shellfish), 2.3 MPN/ g (fish).
Algae and blue green algae	cells/mL	Visual amenity: not present in unsightly amounts Livestock water supply: < 11,500 microcystins <2.3 µg/L cells/ mL Irrigation water supply: not visible Secondary contact recreation and primary contact recreation: <15,000 cells/mL Homestead water supply: <1000 algal cells/mL Drinking water: <2000 algal cells/mL
Visual clarity and colour	Munsell colour Scale	Visual amenity and secondary contact recreation and primary contact recreation: Natural visual clarity not reduced more than 20%. Natural hue not be changed more than 10 points on the Munsell Scale. The natural reflectance not be changed more than 50%.
Enterococci	cfu	Secondary contact recreation: < 230 enterococci per 100 mL Primary contact recreation: 35 cfu/100mL
Protozoans	Presence / absence	Primary contact recreation: Absent

[1] Values for east flowing coastal rivers.

[2] Dissolved oxygen values were derived from daytime measurements. Dissolved oxygen concentrations may vary diurnally and with depth. Monitoring programs assess this potential variability.

[3] Lowland rivers may be higher conductivity during low flow periods and if the system receives saline groundwater inputs. NSW coastal rivers are typically in the range of 200-300 µS/cm.

[4] Turbidity in lowland rivers can be extremely variable. Values at the low end of the range would be found in rivers flowing through well vegetated catchments and at low flows. Values at the high end of the range would be found in rivers drainage slightly disturbed catchments and in many rivers at high flows.

3.3.3 Flooding

The original European settlement of Singleton is on the floodplain of the Hunter River, with more recent development located on flood free land north of the Hunter River floodplain. Singleton has a history of flooding, with the highest flood levels to date recorded in 1955.

BMT WBM completed the Singleton Flood Study on behalf of Singleton Council in 2003. The flood study and subsequent flood risk assessments show that the Singleton township has a relatively high exposure to flood risk. The existing levee system has a finite level of protection with substantial parts of the township expected to be inundated in major floods such as the one per cent Annual Exceedance Probability (AEP) event. The 1955 Hunter River flood saw extensive flooding in Singleton and serves as an important reference event for potential flooding impact.

Since completion of the flood study, numerous flood risk assessments for proposed developments in the study area, including rail infrastructure through Doughboy Hollow have been completed. Those additional studies assessed the flood risk of various development proposals and their potential impacts on flooding in the Singleton township and surrounding area.

Both the Main North railway line and New England Highway cross the natural path of major flood flows conveyed through Glenridding and the Doughboy Hollow floodplains. The Singleton flood levee is located along the riverbank to the north-west of the Singleton central business district (CBD), and was constructed in 1963, extended between 1982 and 1983 and again in 1987. The levee has been designed to withhold floods up to and including the one per cent annual exceedance probability (AEP) event, similar to the one experienced in 1955.

The floodplain is defined by steep terrain to the north and the Golden Highway to the south. Figure 3-2 shows the topography of the study area.

Notable ground controls in and around the study area include the New England Highway and the Main North railway line, which traverse the floodplain between Whittingham and Singleton. The existing levee system on the north-western side of Singleton, which joins with the Main North rail line embankment at Glenridding also affects flood behaviour in the area. Natural ground controls include Doughboy Hollow which becomes active during floods such as the 10 per cent AEP event and greater.

Several flow constrictions are also present which include major bridge crossings provided along the Main North railway line, the New England Highway, Dunolly Road and Queen Street. Numerous other drainage and flow control structures are provided beneath the Main North railway line and New England Highway to convey flood flows across the floodplain during major flood events.

The flood modelling of existing conditions and constraints indicate that the Singleton flood levee along the riverbank, is not overtopped by floods up to and including the one per cent AEP event. This is expected, as the levee was built to withhold flooding similar to that experienced in 1955.

However, the model results indicate that flooding by the one per cent AEP event would overtop the Main North railway line in the vicinity of John Street and the railway station, resulting in extensive inundation of residential properties. Also, there is a significant damming effect by the railway embankment and a small ridge adjacent to the wastewater treatment works that results in deep flooding in the Doughboy Hollow floodplain. This increases the likelihood of overtopping of the Main North railway line and subsequent flooding of the township.

Across the broader floodplain area, the New England Highway currently experiences a level of flood immunity somewhere between the 10 per cent AEP and five per cent AEP.

An overview of the baseline flood behaviour indicates two main flow path alignments:

- The Hunter River channel and adjacent floodplain flowing around the northern side of Singleton
- Doughboy Hollow floodplain, which breaks away from the Hunter River at Glenridding and flows around the southern side of Singleton, before combining with the Hunter River floodplain again at Whittingham.

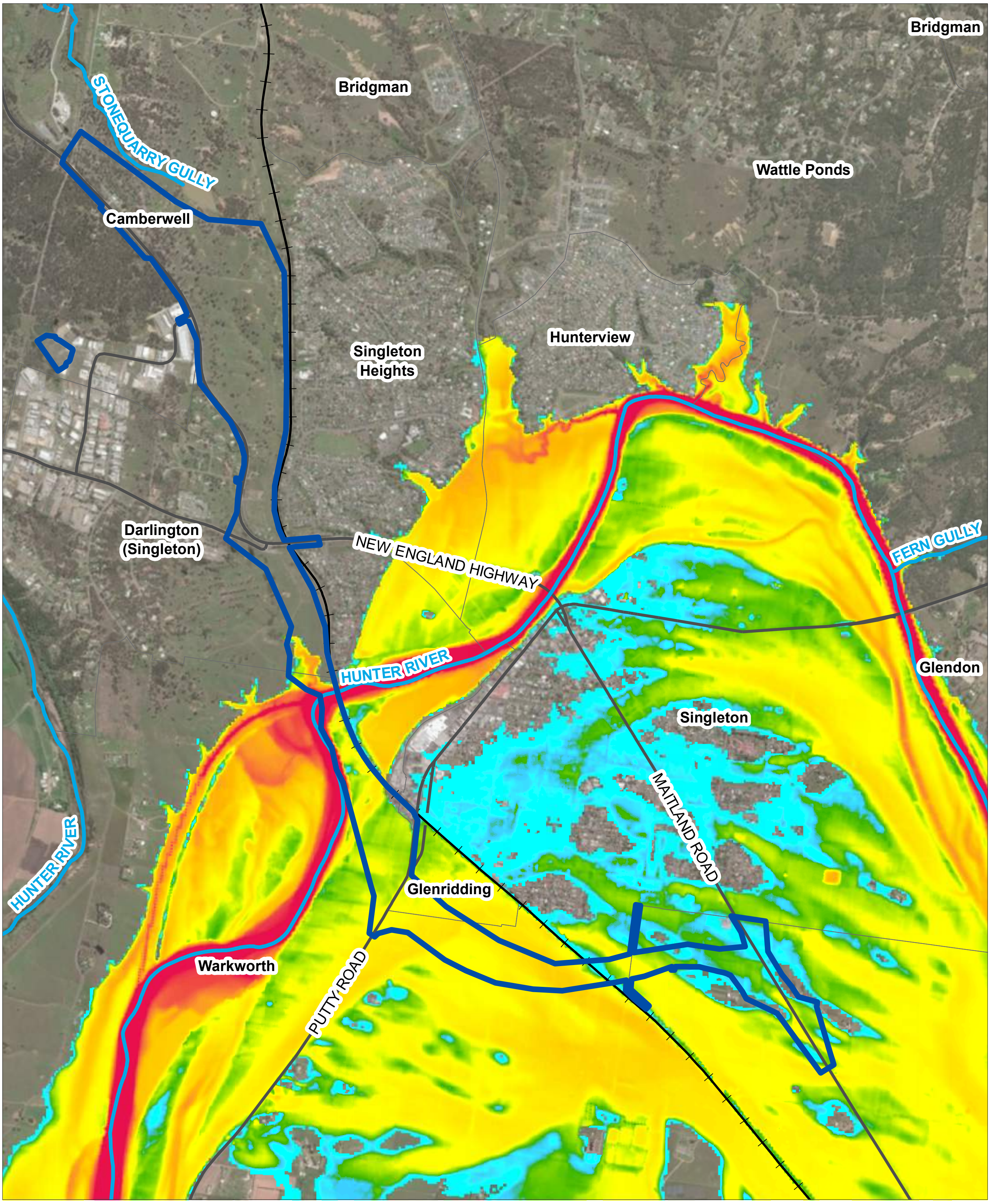


FIG. 3-4 Singleton flood feature during a modelled 1 per cent AEP flood event (source BMT 2018)

N
0 0.55 1.1 km

Legend

- Watercourse
- Proposal area
- Main road
- Railway line

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

3.4 Groundwater

3.4.1 Regional hydrogeology

The hydrogeology of the Upper Hunter Valley is dominated by two aquifers: a superficial aquifer hosted by alluvial deposits of Quaternary age and a bedrock aquifer hosted by consolidated sedimentary rocks and coal measures of Permian age.

Geological logs sourced from WaterNSW for shallow private bores and wells in the region indicate the superficial aquifer includes unconsolidated and permeable sand and gravel beds with overlying sand, silt and clay deposits. Groundwater drawn from this aquifer is typically used for agricultural, stock and domestic purposes. This aquifer directly overlies the bedrock aquifer and is not perched. It is unconfined and is recharged when rainwater percolates through unsaturated soils above the water table. Groundwater in this aquifer discharges to the Hunter River as baseflow. Perched aquifers may occur when recharge accumulates on localised clayey layers during winter. This groundwater drains slowly laterally and/or downward to the water table associated with the sand and gravel beds.

In the bedrock aquifer, groundwater occurs in two places: in the weathered zone, and deep fractures and pore spaces in coal seams and coarse-grained sandstone deposits. In the weathered zone, groundwater fills fractures and residual clayey and silty deposits. As an unconfined aquifer, it is recharged directly by infiltration of rainfall through fractures and outcropping weathered materials. Groundwater discharges from the weathered zone to minor drainages higher in the catchment during and shortly after winter.

Groundwater below the weathered zone is recharged by the slow infiltration of rainwater from the weathered zone where it is in hydraulic connection with coal seams and sandstone, or from flowing creeks where they are above the water table. The deep bedrock aquifer is mostly confined by overlying shale and mudstone beds, or the clayey material in the weathered zone. This groundwater discharges from regional-scale bedrock flow paths as dry season baseflow to major drainages such as the Hunter River.

The rate of recharge is smaller in elevated areas than in low-lying areas occupied by the superficial aquifer because rainfall runs off faster, thus reducing the opportunity for infiltration. As a result, the salinity of this groundwater is higher than in the superficial aquifer. The deeper, confined sections of the bedrock aquifer are higher in salinity than at the water table because of the lower rate of recharge and longer residence time before it is eventually discharged.

Compared to elevated bedrock outcrop areas, the water table in the superficial aquifer dips at a shallow gradient towards the Hunter River. The hydraulic gradient, or slope of the water table is the result of the rate of recharge, the permeability of the sand and gravel beds and the level at the discharge zone along the Hunter River. The elevation of the water table fluctuates in response to the rate of recharge and abstraction from bores and wells.

In the bedrock aquifer, the water table in the weathered zone will rise during and after winter and fall in drier months in summer. The water table in this setting is more variable than in the alluvium because it reflects more local recharge and discharge processes. It is generally at a shallower depth in valleys than in the hills because groundwater accumulates in low-lying areas as it drains from the hilly areas. Groundwater confined deeper in the bedrock forms a piezometric surface that broadly reflects the regional-scaled topography. This surface is less variable than in the weathered zone because it is responding to regional-scaled flow paths controlled by the geological layering and faults or shears.

3.4.2 Local hydrogeology

Local hydrogeological data for the study area were obtained from the WaterNSW online database (realtimedata.waternsw.com.au) and geotechnical boreholes drilled along the alignment of the proposal (Douglas Partners, 2019) shown on Figure 3-5. Relevant groundwater information from these bores is summarised in Table 3-4 and Table 3-5.The key hydrogeological characteristics of the site within the study area are:

- The superficial alluvial aquifer:
  - Is present mainly on the site south of the Hunter River beneath low-lying areas
  - Is present at depths ranging from 5.3 metres to 12.8 metres below the surface
  - Comprises sandy gravel and gravel deposits ranging between 3.2 metres and 9.0 metres in thickness
  - Hosts a flat-lying water table between 9.0 metres and 12.7 metres depth
  - Is not fully saturated in all areas indicating unconfined conditions
  - Is very permeable with well yields ranging from 3.1 litres per second to 26.5 litres per second
  - Contains groundwater which is fresh to brackish with salinities between 300 and 3000 milligrams per litre
  - Is near-neutral to moderately alkaline with the groundwater pH ranging from 7.4 to 10.6.
- The weathered and/or fractured bedrock aquifer:
  - Is present beneath the site north of the Hunter River
  - Comprises fractured, slightly to moderately weathered siltstone and claystone
  - Does not appear to contain much, if any, groundwater as all three geotechnical holes were dry
  - May host an ephemeral water table at the fresh bedrock interface in unconfined conditions
  - Is also present south of the Hunter River beneath low-lying areas but only in discrete slightly weathered fractures in fresh bedrock
  - Contains overburden with low concentrations of stored salt and is of near-neutral to weakly alkaline.

3.4.3 Groundwater users

There are nine registered bores/wells located within the study area as identified by a search of the WaterNSW online database. Three additional bores are not licensed as they were abandoned and backfilled after being drilled. Three bores are licensed for town water use by the local government. The remaining bores are licensed for irrigation, stock and domestic uses.

Details of registered bores within the study area are shown in Table 3-4. Bores within the study area and out to a one kilometre radius are shown on Figure 3-5. Copies of the NSW Government database records are provided in Appendix B.

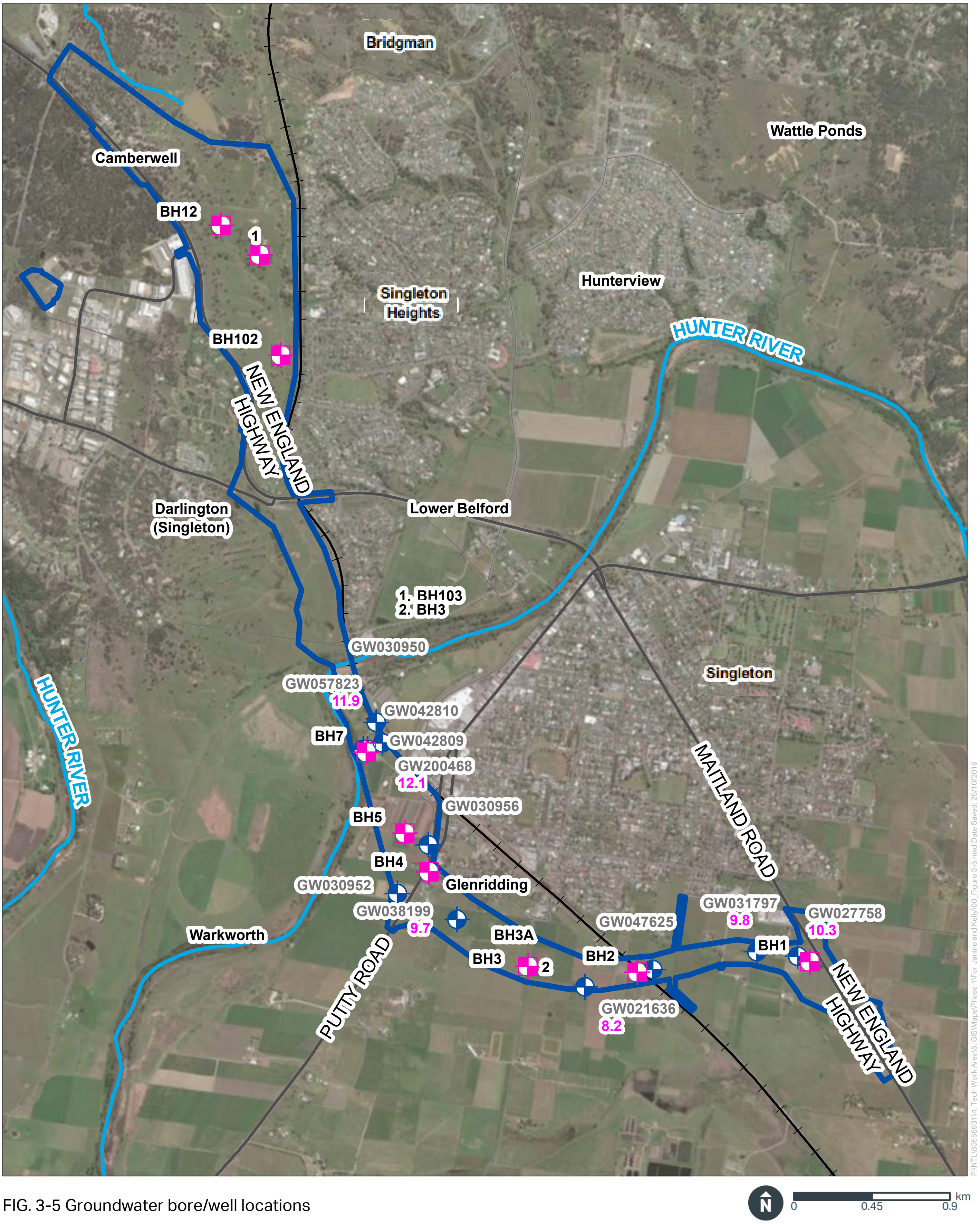


FIG. 3-5 Groundwater bore/well locations

Source:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Watercourse
- Proposal area
- Main road
- Railway line
- Geotechnical bore holes
- Groundwater well location
- Depth to groundwater (mbgl)
- Groundwater elevation (mAHD)

Table 3-4 Details of Private Bores in the Study Area

Site Reference*	Owner Type	Licence	Purpose	Bore Type	Construction Details	Date Installed	Drilled Depth (mbgl**)	Aquifer Description	Aquifer Interval (mbgl)	Depth to Water (mbgl)	Yield (L/s)	Quality Comments
GW021636	Private	20BL014032	Irrigation	Well	Concrete well-liner 1.2m diameter	Feb 1964	12.8	Coarse gravel	8.5 to 12.8	8.2	26.5	"soft"
GW027758	Private	20BL019824	Irrigation, Stock	Well	Concrete well-liner 1.4m diameter	Mar 1967	11.5	Gravel	7.5 to 11.4	10.3	4.6	Salinity 501 to 1000ppm
GW030950	Local Government	N/A	Test bore	Abandoned, Backfilled	203mm diameter (removed)	Sep 1981	16.5	Sand, Gravel	13.8 to 15.3	N.D.	N.D.	N.D.
GW030952	Local Government	N/A	Test bore	Abandoned, Backfilled	203mm diameter (removed)	Sep 1981	11.5	Gravel	6.1 to 11.2	N.D.	N.D.	N.D.
GW030956	Local Government	N/A	Test bore	Abandoned, Backfilled	203mm diameter (removed)	Sep 1981	13.0	Gravel	8.0 to 12.8	N.D.	N.D.	N.D.
GW031797	Private	20BL023368	Irrigation	Well	Concrete well-liner 1.2m diameter	Sep 1969	12.5	Gravel	9.8 to 12.2	9.8	8.7	Salinity 1001 to 3000ppm
GW038199	Private	20BL102288	Irrigation	Well	Concrete well-liner 1.2m diameter	Aug 1975	11.9	Gravel	8.5 to 11.8	9.7	N.D.	N.D.
GW042809	Local Government	20BL101616	Town water supply	Well	Brick-lined 6.4m diameter	Jan 1910	16.7	N.D.	N.D.	N.D.	N.D.	N.D.
GW042810	Local Government	20BL105651	Town water supply	Well	Timber-lined 1.8m diameter	Jan 1940	17.4	N.D.	N.D.	N.D.	N.D.	N.D.
GW047625	Private	20BL111213	Irrigation, Stock, Domestic	Well	N.D.	Oct 1980	13.1	Gravel	6.1 to 13.1	N.D.	N.D.	N.D.
GW057823	Local Government	20BL124313	Town water supply	Well	Concrete well-liner 1.5m diameter	Jan 1975	14.0	Shingle, River sand	11.9 to 13.9	11.9	16.0	Salinity 501 to 1000ppm
GW200468	Private	20BL167976	Stock, Domestic	Bore	168mm diameter steel casing	Feb 2001	20.4	Sand, Gravel	12.1 to 19.5	12.1	3.1	N.D.

Notes: * - site reference and data from the NSW Office of Water database, ** mbgl - metres below ground level, N/A - not applicable, N.D. not determined, ppm - parts per million

Table 3-5 Details of Boreholes in the Study Area

Hole Number*	Easting (MGA z56)	Northing (MGA z56)	Site Elevation (m AHD)	Depth Drilled (mbgl**)	Overburden Description	Superficial Aquifer Depth (mbgl)	Aquifer Elevation (m AHD)	Screened Interval Description	pH	Electrical Conductivity (µS/cm#)	Slotted Interval (mbgl)	Depth to Groundwater (mbgl)	Groundwater Elevation (m AHD)
BH1	329737.8	6393873.4	38.86	24.0	Fill, Clay, Sand	5.3 to 14.3	33.7 to 24.7	Sandy gravel, Gravel	7.4	1200	5.3 to 14.3	9.8	29.4
BH2	328745.7	6393812.3	41.62	30.5	Sand, Clay and Sandy gravel	10.5 to 15.5	31.2 to 26.2	Siltstone	8.0	*1300*	*21.45 to 30.45*	12.7	29.0
BH3	328117.1	6393844.9	40.10	21.0	Silt and Sand	5.7 to 12.0	34.4 to 28.1	Gravelly sand Sandy gravel	10.6	480	9.0 to 12.0	10.3#	29.9
BH3A	Adjacent to BH3			11.8	Silt and Sand	5.7 to 12.0	34.4 to 28.1	Gravelly sand Sandy gravel	N.D.	N.D.	8.8 to 11.8.	10.2	30.0
BH4	327546.1	6394388.9	41.39	27.6	Clay, Silt and Sand	9.0 to 12.2	32.5 to 29.3	Sandy gravel	8.9	600	9.2 to 12.2	11.5	30.0
BH5	327407.4	6394611.3	42.18	23.0	Gravelly sand and Gravel	7.1 to 13.7	35.2 to 28.6	Siltstone	8.3	*930*	*17.0 to 23.0*	12.3	30.0
BH7	327187.3	6395075.3	42.16	34.8	Clay, Silt and Sand	12.8 to 19.4	29.4 to 22.8	Sandy gravel	8.1	1100	13.6 to 19.6	12.9	29.3
BH12	326351.4	6398103.2	106.8	20.1	Clay	2.9 to 10.5	96.3 to 86.7	Weathered siltstone and claystone	N.D.	N.D.	Not Cased	Dry	<86.7
BH102	326694.8	6397355.4	89.54	8.5	Clay	2.7 to 8.5+	86.9 to 81.1	Weathered siltstone	N.D.	N.D.	*5.47 to 8.47*	Dry	<81.1
BH103	326573.9	6397932.2	105.42	11.9	Clay	2.7 to 11.9	102.8 to 93.6	Weathered sandstone	N.D.	N.D.	*8.9 to 11.9*	Dry	<93.6

Notes: * hole number from the geotechnical report (Douglas Partners, 2019), ** mbgl - metres below ground level, # µS/cm - micro siemens per centimetre. N.D. not determined.
Underlined and italicised screened intervals screened in the bedrock aquifer. This information sourced from Douglas Partners, 2019.

3.4.4 Groundwater dependant ecosystems

The proximity of GDEs to the proposal has been assessed by reviewing the Groundwater Dependent Ecosystem Atlas (bom.gov.au). This information indicates several terrestrial GDEs may be present in the study area as shown on Figure 3-6.

The identified GDEs include:

- Hunter-Macleay dry sclerophyll forests
- Coastal swamp forests
- Eastern riverine forests.

No aquatic or subterranean GDEs have been identified in the study area.

3.5 Dryland salinity

Dryland salinity has been observed in the Upper Hunter area. However, no salinity hazard maps have been prepared in the Singleton LEP. Parts of the township of Singleton have a high hazard risk of salinity in areas along the New England Highway identified as being of a very high salinity hazard in the salinity hazard report for Catchment Action Plan upgrade – Hunter-Central Rivers CMA (Nicholson et al., 2012).

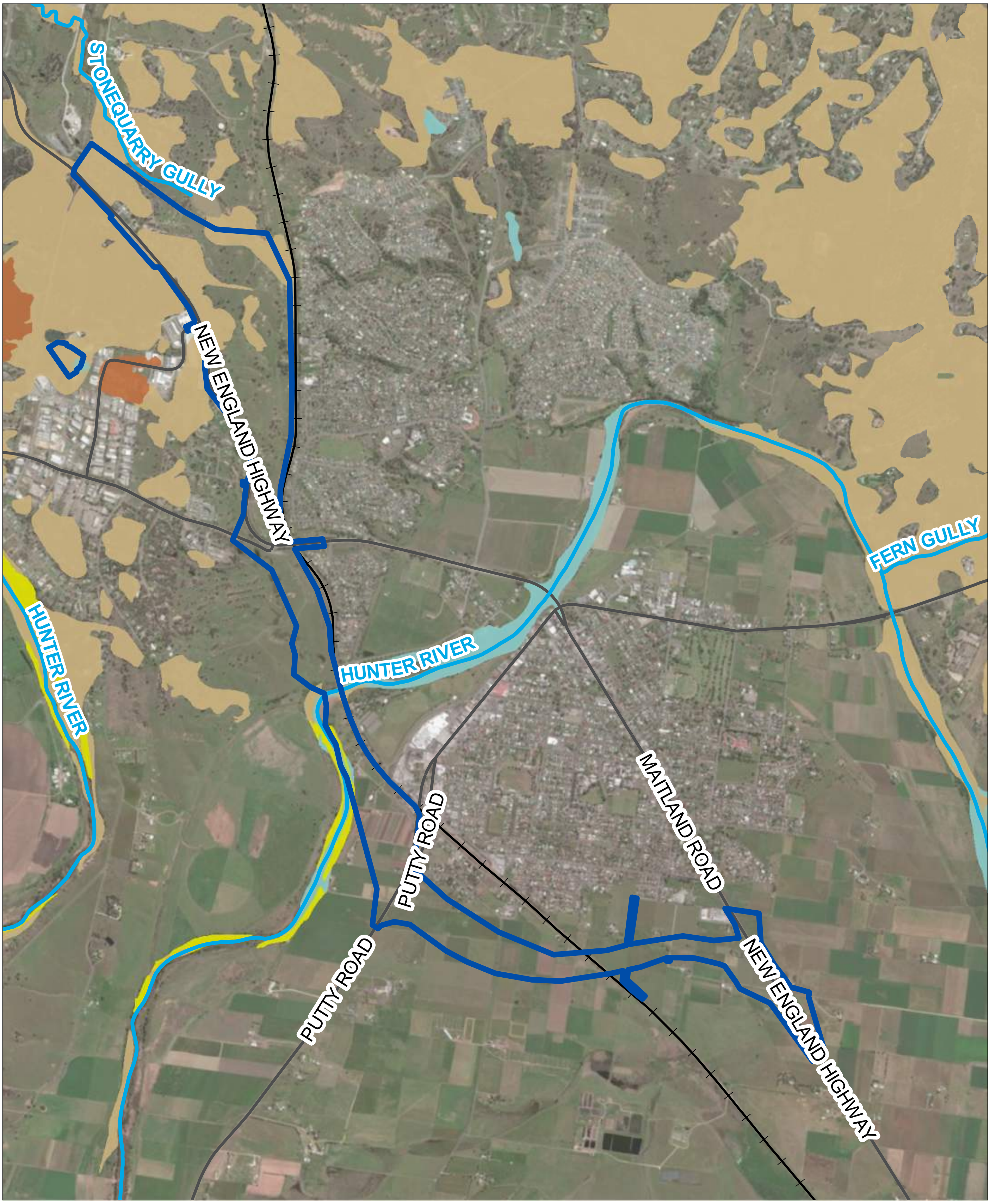


FIG. 3-6 Groundwater dependent ecosystem

Legend

- Watercourse
- Proposal area
- Main road
- Railway line
- Coastal Swamp Forests
- Coastal Valley Grassy Woodlands
- Eastern Riverine Forests
- Hunter-Macleay Dry Sclerophyll Forests

Source:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

4. Assessment of construction impact

This chapter discusses the potential impact of the construction phase activities on surface water and groundwater. The corresponding nominated management or mitigation measures are provided in Section 7.

Construction activities for the proposal are detailed in Section 3.3 of the Singleton bypass Review of Environmental Factors (AECOM, 2019).

4.1 Surface water quality

Construction activities represent a risk to surface water quality within local receiving waters, including the (Hunter River, Glenridding and Doughboy Hollow floodplains). During runoff events or flood conditions, sediment laden waters, chemicals stored on site, and construction waste have the potential to mobilise and enter waterways.

Generation of sediment laden waters and offsite discharge can occur during construction activities such as:

- Clearing and grubbing
- Stockpiling of materials
- General earthworks
- Temporary works i.e. access roads, compounds, laydown areas and pads
- Construction of bridge piers and abutments in and adjacent to the Hunter River
- Instream drainage works
- Placement of fill for embankments.

Sediment laden waters pose a potential risk to downstream surface water quality. Water quality impact includes (but not limited to) increased turbidity, elevated concentration of nutrients and other pollutants, such as heavy metals and organic chemicals.

Other potential sources that may impact surface water quality during construction include:

- Fuel or oils used by construction plant and equipment
- Concrete batching plant
- Waste and litter from building activities and personnel
- Release of nutrients from fertilisers, herbicides and pesticides (eg used in site landscaping)
- Paint and paint wastes
- Acids from acid-based washes
- Disturbance of contaminated soils and/or acid sulfate soils, which may adversely affect water chemistry including pH and dissolved solids.

The assessment of surface water quality applied the applicable water quality guidelines (refer to Section 2.1.3) and objectives (as listed in Section 3.3.2). A description of the potential impact associated with the proposed construction phase activities and expected likelihood of the impact is provided in Table 4-1.

Table 4-1 Assessment of the impact of Singleton bypass on environmental values and associated indicators of the NSW WQOs.

Key indicator	Trigger value	Discussion	Likelihood of impact
Chlorophyll-a	Aquatic ecosystems (upland rivers): 3 ug/L	Increased Chlorophyll-a in the water indicates that plants, algae or cyanobacteria are actually growing. This is usually measured in a waterbody so is not a typical stormwater pollutant.	Chlorophyll-a is not expected to be present in site runoff as a result of the construction activities, and therefore the proposal is expected to have negligible impact on Chlorophyll-a in receiving waters.
Total Phosphorus (TP)	Aquatic ecosystems (lowland rivers): 25 µg/L	Excessive phosphorus could lead to stimulation and growth of nuisance plants which could dominate and change the dynamics of the aquatic ecosystem (e.g. eutrophication, algae and macrophytes). Agricultural and mining activities in the surrounding areas, would also contribute TP to the Hunter River, with these activities disturbing the ground.	The majority of TP is expected to be available in topsoil. Mobilisation of topsoil in runoff during construction of the proposal therefore has a potential to cause an increase in TP in receiving waters if not appropriately managed during construction. Environmental safeguards are discussed in Section 7. Road construction programming typically involves the clearing of vegetation and stripping of topsoil as one of the first activities. Local erosion and sedimentation controls would be provided prior to commencement of disturbance, for topsoil stockpiles (eg cover crops and bunds) and where required, excess run-off from disturbed topsoil areas would be captured by construction sediment basins that reduce TP by retention, settlement and removal of deposited sediment. TP can be further reduced by flocculation of sediment basins prior to discharge. Therefore, whilst elevated TP in receiving waters has the potential to cause harm, with the implementation of management measures and safeguards contained herein, the risk associated is considered low.
Total Nitrogen (TN)	Aquatic ecosystems (lowland rivers): 350 µg/L	Excessive nitrogen could lead to stimulation of the growth of nuisance plants which could dominate and change the dynamics of the aquatic ecosystem. (eg algae and macrophytes). Agriculture and mining activities in the area surrounding the proposal would contribute TN to the Hunter River, with these activities disturbing the ground.	The majority of TN is expected to be available in topsoil. Mobilisation of topsoil in runoff during construction of the proposal therefore has a potential to cause an increase in TP in receiving waters if not appropriately managed during construction. Environmental safeguards are discussed in Section 7. Road construction programming typically involves the clearing of vegetation and stripping of topsoil as one of the first activities. Local erosion and sedimentation controls would be provided for topsoil stockpiles (eg cover crops and bunds) and where required,

Key indicator	Trigger value	Discussion	Likelihood of impact
			excess run-off from disturbed topsoil areas would be captured by construction sediment basins that reduce TN by retention, settlement and removal of deposited sediment. TP can be further reduced by flocculation of sediment basins prior to discharge. Therefore, whilst elevated TN in receiving waters has the potential to cause harm, with the implementation of management measures and safeguards contained herein, the risk associated is considered low.
Dissolved Oxygen	Aquatic ecosystems (Lowland rivers): 85% Drinking water: >80%	The dissolved oxygen concentration in a waterbody is highly dependent on temperature, salinity, biological activity (microbial, primary production) and rate of transfer from the atmosphere.	No substantial change is expected in DO concentrations from proposed site runoff or sediment basin discharges compared to receiving waters and therefore likelihood of direct impacts is considered low. Indirectly, a reduction in DO concentrations downstream could occur if site runoff and sediment basin discharges presented elevated levels of nutrients (TN, TP) or suspended sediments (TSS). Therefore, with the implementation of management measures (Section 7) and safeguards contained herein, the risk associated is considered low.
pH	Aquatic ecosystems (lowland rivers): 6.5 – 8.0	pH is a measure of the acidity or alkalinity of water and has a scale from 0 (extremely acidic) to 7 (neutral), through to 14 (extremely alkaline).	Based on the geological properties and soil landscape of the study area, preliminary sampling and available monitoring data which indicates generally more alkaline pH levels in water, the site has a low probability of encountering PASS materials which can release acid if disturbed (refer to Section 3.2). Therefore, the construction activities have a low likelihood of impacting pH of receiving waters.
Electrical Conductivity	Lowland rivers may have higher conductivity during low flow periods with saline surface water and groundwater inputs. 125-2200 mS/cm	Conductivity is one way to measure the inorganic materials including calcium, bicarbonate, nitrogen, phosphorus, iron, sulphur and other ions dissolved in a water body. Salinity is the component of conductivity that is critical to the survival of some aquatic plants and animals.	The electrical conductivity of site runoff and sediment basin discharges is likely to be consistent with the range of salinity historically observed in the Hunter River. Therefore, the construction activities have a low likelihood of impacting electrical conductivity of receiving waters.

Key indicator	Trigger value	Discussion	Likelihood of impact
Turbidity	Aquatic ecosystems (lowland rivers): 6-50 NTU Primary contact recreation: 6 NTU Homestead water supply: 5 NTU Drinking water: Site-specific determinant.	Turbidity is the presence of suspended particulate and colloidal matter consisting of suspended clay, silt, phytoplankton and detritus measured by a technique called nephelometry. This, which measures the fraction of light scattered at right angles to the light path of water. Increased turbidity can reduce light penetration through the water column and reduce the level of photosynthetic activity. Turbidity increases with sediment load. Agriculture and mining activities in the area surrounding the proposal would contribute to the turbidity of the Hunter River.	Turbidity and TSS are the principle pollutant of concern associated with road construction projects and occur as a result of mobilisation (through erosion) and transport of sediments in surface water runoff. As described in Section 3.3.2, TSS levels are generally elevated in nearby waterways. Notwithstanding, construction activities have the potential to increase turbidity and TSS in local waterways through the through the exposure of topsoils and subsoils (eg as a result of the removal of vegetation, general earthworks, temporary works, instream works, placement of fill, and stockpiling of materials). Environmental safeguards are discussed in Section 7. A number of mitigation measures typically implemented for road construction projects would be implemented to manage site runoff and minimise the risk of mobilisation of turbid site water. Therefore, whilst elevated turbidity and TSS in surface waters has the potential to cause harm, with the implementation of management measures and safeguards contained herein, the risk associated is considered low.
Temperature	Aquatic ecosystems >80%ile <20%ile Primary contact recreation: 15°-35°C	Aquatic ecosystem functioning is very closely regulated by temperature. Temperature changes can occur naturally as part of normal daily and seasonal cycles, or because of human activities (anthropogenic).	Temperature of stormwater runoff or discharge from sediment basins would be similar to that in nearby waterways. Hence, potential impact of temperature changes from site runoff or releases of sediment basin discharges is considered to be negligible.
Chemical contaminants	Livestock water supply: See Table 4.3.2 ANZECC guidelines 2000 Irrigation water supply: See Table 4.2.10 ANZECC 2000	Chemical contaminants are likely to be sourced either from spills that may occur during construction or from naturally occurring contaminants or toxicants made soluble when run-off occurs over disturbed soils.	Potential sources of chemical contamination from spills is likely to be restricted to fuel and oils used by construction plant and equipment, concrete batching plant, waste, fertilisers, herbicides and pesticides (used in site landscaping), paint and paint wastes, acid from acid-based washes and the disturbance of contaminated soils and/or PASS.

Key indicator	Trigger value	Discussion	Likelihood of impact
	Secondary contact recreation and primary contact recreation: no chemicals that are either toxic or irritating to the skin or mucous membranes Homestead water supply: See Guidelines for Inorganic Chemicals in the Australian Drinking Water Guidelines Drinking water: see ANZECC 2000 guidelines. Aquatic foods (cooked): Copper <5 µgm/L, mercury <1 µgm/L, zinc <5 µgm/L, chlordane <0.004 µgm/L, PCBs <2 µgm/L.	The Hunter River is subject to runoff from Singleton township, that has the potential to be contaminated from households/businesses that use fertilisers and other potential chemical contaminants. Agriculture, industries and mining activities in the area surrounding the proposal would potentially contribute to the mobilisation of naturally occurring contaminants in soils as well as from the use of fertilisers, herbicides and pesticides.	Spill occurrences would be readily cleaned up as part of routine construction activities and addressed by the proposed sediment basin discharge limits (pH criteria and visible oils and grease). While there is potential for some mobilisation of naturally occurring contaminants or toxicants chemical contaminants from run-off over naturally occurring soils, these contaminants would be largely removed from discharges following treatment to remove sediment within the supernatant. Therefore, whilst contamination in surface waters from spills or other sources has the potential to cause harm, with the implementation of management measures and safeguards contained herein, the risk associated is considered low.
Faecal coliforms	Primary contact recreation: < 150 cfu/ 100mL Irrigation water supply: <100 cfu/ 100mL (raw human food crops, no direct contact) <1000 cfu/ 100mL (pasture and fodder for grazing animals) Secondary contact recreation: <1000 cfu/	Coliforms are bacteria present in the digestive tracts of animals including humans and are found in their wastes and are used as an indicator of faecal contamination.	There is a low likelihood of environmental impact due to faecal coliforms in surface water from construction activities.

Key indicator	Trigger value	Discussion	Likelihood of impact
	100mL, with 4 out of 5 samples < 4000 cfu /100 mL Homestead water supply and drinking water: 0 cfu/ 100mL Aquatic foods (cooked): 14 MPN/ 100mL (shellfish), 2.3 MPN/ g (fish).		
Algae and blue green algae	Visual amenity: not present in unsightly amounts Livestock water supply: < 11,500 microcystins <2.3 µg/L cells/ mL Irrigation water supply: not visible Secondary contact recreation and primary contact recreation: <15,000 cells/mL Homestead water supply: <1000 algal cells/mL Drinking water: <2000 algal cells/mL	Blue-green algae are a type of bacteria known as Cyanobacteria. They photosynthesise using sunlight to produce oxygen. Low levels of blue-green algae are present in freshwater all the time. However, a series of favourable environmental factors including warm water temperatures, sunny days and nutrients can lead to a blue-green algae bloom. Blooms lead to environmental and visual impact.	Elevated temperature, and nutrients (TN and TP) in discharge from construction activities has the potential to contribute algal blooms in receiving waters downstream. However, this increased likelihood is very small when comparing the relatively small catchment associated with the study area, with the size of the Hunter River catchment and other contributing land uses (i.e. agriculture, urban development). However, given the proposed management measures and safeguards proposed herein, the risk of this potential impact is considered low.
Visual clarity and colour	Visual amenity and secondary contact recreation and primary contact recreation: Natural visual clarity not	Clarity is a measure of how clear or transparent water is. It indicates how much light is available for photosynthesis at different depths.	In relation to the potential impact of the construction activities - this indicator is largely assessed above in relation to turbidity and TSS. There is limited baseline information on the natural visual clarity, hue and reflectance of the receiving environments to determine whether there is likely to be a predicted change in the

Key indicator	Trigger value	Discussion	Likelihood of impact
	reduced more than 20%. Natural hue not be changed more than 10 points on the Munsell Scale. The natural reflectance not be changed more than 50%.		nominated indicator. However, given the proposed mitigation of surface water quality risks to reduce erosion and sediment loads in construction site discharges, it is unlikely that site discharge would adversely impact on this environmental value.
Enterococci	Secondary contact recreation: < 230 enterococci per 100 mL Primary contact recreation: 35 cfu/100mL	Intestinal enterococci are a functional group of organisms from the Enterococcus and Streptococcus genera that are excreted in human and animal waste and are used as an indicator of faecal contamination.	There is a very low likelihood of environmental impact due to enterococci in surface water from construction activities.
Protozoans	Primary contact recreation: Absent	Protozoans are waterborne pathogens that indicate water contaminated with human or animal waste.	There is a very low likelihood of environmental impact due to protozoans in surface water from construction activities.

The mitigation measures in Section 7 have been developed to minimise the potential for construction activities to impact on downstream surface water quality.

4.2 Flooding and drainage

The construction of a road embankment across a floodplain and watercourses can potentially increase flood levels, redistribute flows, increase inundation times and increase velocities (BMT, July 2019). Potential impacts could occur where temporary access tracks and raised working platforms are placed in flood affected zones. However, flood behaviour of the study area is well understood, with adequate advance flood warning likely to be available to remove staff and equipment and protect the work prior to inundation.

Ancillary facilities such as construction compounds, laydown areas and stockpiles have been located outside of areas where they have the potential to impact on major natural flow paths, or exacerbate flood conditions.

4.3 Groundwater

Based on the groundwater information presented in Section 3.4, interaction is expected when constructing bridge piles and piers at the following locations:

- Southern connection
- Bridge over the floodplain
- Putty Road northbound entry ramp
- Bridge over the Rose Point floodway
- Hunter River.

The pile holes for the bridge over the Hunter River will intersect the superficial alluvial aquifer on the southern side and weathered and fractured bedrock on the northern side of the Hunter River.

Interaction with the groundwater is expected when constructing bridge piles. To minimise the potential of encountering groundwater, the pile holes would be installed by advancing steel casing into the ground as they are drilled. The steel casing will pass through one to two metres of gravel below the existing water table. Once the casing has been advanced to the bedrock, groundwater is not expected to be encountered because, based on drilling evidence, it is not permeable below the zone of weathering.

The geotechnical data (Douglas Partners, 2019) indicates the alluvial gravel aquifer is a coarse-grained granular material that is densely packed. Because of this, the additional loading from the earthworks is not expected to substantially change the intergranular pore spaces that give rise to the high permeability of this aquifer material.

Groundwater was not observed to the north of the Hunter River as the ground elevation rises, however the deep excavations near McDougalls Hill may intersect minor groundwater flows from the base of the weathered and fractured bedrock interval at 10 to 15 metres depth once it is exposed. The amount of groundwater entering the construction area will depend on which season the works take place. It may, range from virtually zero in the summer months to minor seepages from exposed fractures during and shortly after wet weather.

Recommended mitigation measures to manage these potential impacts to groundwater are outlined in Section 7.

4.3.1 Groundwater users

As shown on Figure 3-5, there are no registered groundwater users near the deep excavation in the northern corridor of the proposed development. Therefore, minor dewatering, if required, is not expected to result in an impact to groundwater users.

The hydrogeological data from the nine registered water sources in the study area (Section 3.4.3) indicate the water table south of the Hunter River is between 8.1 and 12.1 metres below the ground surface. None of the earthworks south of the proposed bridge over the floodplain across the Hunter River are planned to extend to the water table, thus avoiding dewatering and drawdown-related impact.

The only planned disturbances that will intersect the water table near existing groundwater sources are the pile holes for the proposed bridge over the floodplain. Just outside the study area, close to the southern side of the bridge over the floodplain, are two timber and concrete-lined town water supply wells (GW042810 and GW057823) that intersect gravel and sand deposits. While they are close, the groundwater supplies drawn from these wells are not expected to be disturbed during construction as the pile holes and concrete backfill will be fully contained in steel casing that will be advanced through the alluvium and into the bedrock.

As detailed in Table 4-2, three registered active groundwater sources for private users will be directly impacted as they are within the proposal. Other users within the study area shown on Figure 3-5 may be indirectly impacted if physical access to groundwater bores becomes temporarily restricted by the presence of construction infrastructure. There may be other unregistered groundwater sources in the study area that could be affected.

Table 4-2 Details of private bores and potential impact

Site Reference*	Owner Type	Licence	Purpose	Bore Type	Disturbance Type
GW021636	Private	20BL014032	Irrigation	Well	None or Indirect
GW027758	Private	20BL019824	Irrigation, Stock	Well	None or Indirect
GW031797	Private	20BL023368	Irrigation	Well	Direct impact
GW038199	Private	20BL102288	Irrigation	Well	Direct impact
GW042809	Local Government	20BL101616	Town water supply	Well	None or Indirect
GW042810	Local Government	20BL105651	Town water supply	Well	None or Indirect
GW047625	Private	20BL111213	Irrigation, Stock, Domestic	Well	Direct impact
GW057823	Local Government	20BL124313	Town water supply	Well	None or Indirect
GW200468	Private	20BL167976	Stock, Domestic	Bore	None or Indirect
Notes: * - site reference and data from the NSW Office of Water database, ** mbgl - metres below ground level N/A - not applicable, N.D. not determined, ppm - parts per million					

4.3.2 Groundwater quality

There is also a risk that groundwater could be contaminated during the construction program from activities including:

- Leaks or spills of fuels, oils and lubricating fluids used by construction machinery
- Seepage from spoil areas containing soils derived from below the water table (from excavated pile holes and deep excavations that expose fresh bedrock) that may contain unstable sulphide minerals.

Leaks and spills from machinery are possible following a malfunction of the equipment and during refuelling and in-field maintenance. Small-scaled leaks and spills in the order of a few litres will likely remain in the topsoil until the affected soil is recovered and removed. Larger-scaled leaks, especially those that are not immediately observed and contained, may penetrate the ground further. However, these leaks are unlikely to reach the water table unless they are introduced directly via a pile hole or are at a site that remains uncontrolled for a period of weeks or months. Regular inspections and maintenance of equipment and spill-control structures such hardstand areas and containment will further reduce the risk to groundwater.

Seepage carrying the oxidation by-products of unstable sulphide minerals that could be present in spoil areas may percolate into the ground if not adequately covered or drained. The geochemical analyses of the bedrock materials from BH7 indicate the likelihood of these materials being present is low. If isolated intersections are encountered, groundwater in the immediate vicinity of the spoil areas could be affected if seepage through these materials reaches the water table. This seepage will take a considerable amount of time (weeks to months) to reach the water table assuming a sufficiently large volume of affected water accumulates and passes through the dry soil before it reaches the water table. In-field water and soil testing will easily identify whether these reactions are occurring. Potential impacts associated with seepage are therefore considered to be low.

The proposals risk to groundwater from acid sulphate soils is considered low since the water table appears to be below the planned depth of excavation over most of the site. The only activities that may disturb materials potentially containing unstable sulphide minerals are the pile holes for the bridge over the floodplain and bridge across and south of the Hunter River, and possibly the fresh bedrock at the base of the deep excavation in McDougalls Hill.

The results from geochemical testing (Douglas Partners, 2019) indicate none of the fresh bedrock samples contained any “actual acidity”. The results further indicate there is a low risk of PASS impacts on groundwater near the bridge across and south of the Hunter River, and the deep excavation in McDougalls Hill. Although the results indicate there is a higher likelihood for ASS materials to be present at the southern end of the development, none of the proposed earthworks are planned to intersect or otherwise disturb these materials.

4.3.3 Groundwater dependant ecosystems

The Hunter River GDE is not expected to be disturbed by installation of the bridge’s pile foundations. In this case, each pile hole will be cased-off with steel piping to avoid the need to dewater the superficial alluvial aquifer that will be supporting this GDE. Due to the very high permeability of this aquifer, any minor inflows to these holes from the weathered and/or fractured bedrock are unlikely to result in a measurable change at the water table.

The deep excavation in McDougalls Hill is not expected to influence the two GDE areas to the west because:

- The GDEs are up gradient and will not affect the amount of groundwater recharging the local water table aquifer where the GDEs are located
- Draining small amounts of groundwater expected from an excavation into this low permeability aquifer will not be able to create a drawdown cone that could reach this far up-gradient.

5. Assessment of operational impact

5.1 Surface water quality

A potential impact to surface water quality during the operation of the proposed bypass would include pollutants and contaminants from the surface of the road being conveyed during runoff events to receiving waters. Contaminants could include litter, sediment and suspended solids, nutrients, heavy metals, toxic organics, oils and surfactants. Potential sources are:

- Exhaust particles from vehicle engines
- Wear products from brakes, tyres and other mechanical parts
- Minor discharges from vehicle engines, including fluids, lubricants and other similar materials
- Minor discharges from leaking or damaged loads
- Litter or other waste
- Loss of goods and other materials due to vehicle incidents.

5.1.1 Risk assessment for spill containment

The objective of this assessment is to identify potential spills and assess if an incident could be managed appropriately with standard emergency response procedures, or if additional control measures are required.

The terms "hazard" and "risk" are often used interchangeably. However, in terms of risk assessment, they are two very distinct terms:

- A hazard is any agent that can cause harm or damage to humans, property, or the environment
- Risk is defined as the probability that exposure to a hazard will lead to a negative consequence.

Or more simply, a hazard poses no risk if there is no exposure to that hazard.

Assessment approach

The potential hazard (chemical spill) exists for both construction and operation phase of the proposal. The management of liquids during construction will be managed by the CEMP. Therefore, this assessment relates to the transport of liquids during operation of the bypass.

This assessment does not address the risk posed to road users' safety following a spill. It is a qualitative assessment of the risk and the potential impact on the environment.

Mode of transport

For roadways, a spill generally travels from the point of release to the surrounding environment via the stormwater drainage system. Stormwater or liquids flow from the road surface into small drains which lead to larger stormwater drains and eventually to receiving water bodies. The speed of travel depends on the slope of the site, and the viscosity of the liquid. This assessment adopts the worst case and it is assumed that the spill has a low viscosity, eg it flows like water.

Hazard identification

The principal source of chemical spills during operation would be from the transport of chemical liquids during operation of the bypass and could occur due to a crash.

Environment at risk

The proposal is located close to several environmentally sensitive areas including the Hunter River.

Risk assessment

The probability of a spill is considered low because:

- The bypass provides a higher standard of road design when compared to the existing route. The bypass alignment could be considered to reduce the potential risk of traffic incidents occurring and associated spill incidents
- Legislative controls on the transport of dangerous goods require that safeguards are installed on vehicles transporting hazardous liquids to avoid spillage and isolate dangerous goods in the event of an incident.

The proposal passes through areas that are environmentally sensitive. Whilst the likelihood of a chemical spill is low, if an incident occurred there would be potential for environmental harm.

Hunter River

The Hunter River is a sensitive receiving environment, and the bypass either side of the river drains toward it. Therefore if an incident were to occur, there is potential for environmental harm.

Spill containment, in the form of containment basins near the outlet of the drainage system, would reduce or mitigate this risk to the river. Stormwater from Hunter River Bridge deck drainage system will be captured and piped to provide capture of surface runoff for a 10 % AEP storm. Two spill containment basins north and south of the river, with a minimum volume of 25,000 Litres, would be provided to contain flows prior to discharge to the Hunter River. The basins should be capable of capturing any spills and retaining the liquid so that it can be pumped out and treated appropriately.

Hunter River and Doughboy Hollow floodplains

Should a spill occur further from the river such as over the Hunter River or Doughboy Hollow floodplains, the gently sloping land should provide enough time and storage for the spill to be contained and treated through normal emergency response procedures. It would not therefore be able to reach the Hunter River.

Likewise if a spill were to occur north of Gowrie Gates, there is sufficient storage in the drainage system to delay flow of spill and it could be treated through standard emergency response procedures. Therefore, there is a low probability of flows reaching the Hunter River.

Drainage impact

The operation of the proposed bypass would cause minor impact to natural drainage flow paths.

In the immediate area of the proposed bypass, it is anticipated that there would be minor increases in surface flows along existing flow paths because of the impervious nature of the road. The drainage of the road would also concentrate flows at discharge points along the road length, changing the existing flow paths.

Transverse culverts will convey runoff from the upslope catchments beneath the proposed embankments. The embankments will cause minor disruption to the natural hydrological regime through the diversion of flow to the culverts. The transverse culverts may locally increase the velocity of water discharging from the culvert when compared to the natural watercourse.

5.2 Flooding impact

A flood study was carried out as part of this proposal and the full report can be found in Appendix A. The report's findings are summarised below.

The flood impact assessment considered mainstream flooding of the Hunter River and local catchment runoff from Doughboy Hollow Creek.

The potential impacts that can be quantified through modelling include:

- Changes in peak flood level within the Study area
- Increases in velocity and scour potential
- Increase in flood hazard
- Identification of adjacent property that may be adversely impacted by changed flooding behaviour.

Changes in peak flood level

Flood impact assessment was carried out for a range of flood magnitudes (20 per cent AEP, 10 per cent AEP, five per cent AEP, two per cent AEP, one per cent AEP, 0.5 per cent AEP and 0.2 per cent AEP). The assessment compared the change in peak flood level from existing conditions to the proposed design. Figure 5-1 and Figure 5-2 show the peak flood level impact of the proposal for the five per cent and one per cent AEP.

In a 20 per cent AEP event, there would be no impact on the modelled peak flood levels.

At the 10 per cent AEP event some impacts on the modelled peak flood levels have been identified at the proposed Putty Road connection. However, the impact is minor (increased flood depth of around 0.02 metres so therefore minor), localised, and unlikely to impact on existing property.

In a five per cent AEP event, the proposed Putty Road connection may result in a minor redistribution of flood flows. This includes localised increases in modelled peak flood levels. However, no dwellings appear to be impacted by more than a 0.02 metre increase in flood depths. There is also a broader reduction of modelled peak flood levels in Glenridding of around a 0.07 metre decrease.

In the two per cent AEP event, flood impact near the Putty Road connection area increased in extent and magnitude from those of the five per cent AEP. Existing dwellings are impacted by up to 0.04 metre increase, with a broader reduction of modelled peak flood levels in Glenridding representing around a 0.06 metre decrease. The floodplain near the southern connection is now active and the proposed design results in some localised flood impact. However, the impacts are localised and limited to rural property, with no impact to any existing dwellings.

In the one per cent AEP, 0.5 per cent AEP and 0.2 per cent AEP events, the flood impact near the Putty Road connection and the southern connection generally increase in extent and magnitude with increased flood event rarity.

The modelled peak flood level impacts at the most impacted dwelling locations that wont be acquired by the proposal are up to a 0.05 metre increase at the one per cent AEP event, 0.07 metre at the 0.5 per cent AEP and 0.08 metre at the 0.2 per cent AEP. At the 1 per cent AEP and 0.5 per cent AEP events there are reduced peak flood levels through much of Singleton and Glenridding, up to around a 0.1 metre decrease. At the 0.2 per cent AEP event, peak flood levels are reduced in Glenridding but largely balanced through Singleton, with some minor local changes of up to 0.05 metre. Peak flood level impacts upstream of the southern connection are locally over a 0.5 metre increase. However, the impacts are localised and limited to rural property.

Changes in peak flood velocity and scour potential

For the modelled design events, changes in peak flood velocity distribution associated with the concept design was also undertaken. In general, the changes in floodplain velocity distribution is relatively localised for all design events considered.

At the 20 per cent AEP event there are no substantial impacts on the modelled peak flood velocities due to the minimal extent of out-of-bank flooding and the bridging of the Hunter River. At the 10 per cent AEP event some minor impacts on the modelled peak flood velocities have been identified at the proposed Putty Road connection. The impacts are typically reduced velocities due to the presence of the bypass embankments. However, peak velocities are locally increased where flood waters along the Rose Point floodway overtop the entry ramp and exit ramp at the Putty Road connection.

At the five per cent AEP event the proposed Putty Road connection has resulted in a minor local redistribution of flood flows. This results in localised changes to the modelled peak flood velocities, particularly along the Rose Point floodway alignment and around the northern abutment of the bridge over floodplain. Within the Rose Point floodway upstream of the railway, peak velocities are increased from around 0.7 to 1.0 metres per second. There is a reduction in peak velocity through the floodway rail culverts from around 1.6 to 1.2 metres per second and in the floodway downstream of the railway from around 0.9 to 0.7 metres per second. Peak flood velocities around the northern abutment of the bridge over floodplain are increased from around 0.6 to 0.8 metres per second.

At the two per cent AEP event the peak velocity impacts are generally consistent with those of the five per cent AEP event, albeit to a larger magnitude. Within the Rose Point floodway upstream of the railway, peak velocities are increased from around 0.8 to 1.3 metres per second. There is a reduction in peak velocity through the floodway rail culverts from around 2.2 to 1.5 metres per second and in the floodway downstream of the railway from around 1.5 to 1.0 metres per second. Peak flood velocities around the northern abutment of the bridge over floodplain are increased from around 1.0 to 1.4 metres per second. There are also reduced peak velocities in areas that become partially sheltered by the bypass embankment.

At the one per cent AEP event the peak velocity impacts are generally consistent with those of the two per cent AEP event, albeit to a larger magnitude. Within the Rose Point floodway upstream of the railway, peak velocities are increased from around 0.8 to 1.6 metres per second. There is a reduction in peak velocity through the floodway rail culverts from around 2.6 to 2.0 metres per second and in the floodway downstream of the railway from around 1.1 to 0.8 metres per second. Peak flood velocities around the northern abutment of the bridge over floodplain are increased from around 1.1 to 1.7 metres per second. There is also a minor increase in peak velocities along the right bank of the Hunter River along the area of contraction through the existing rail bridge crossing, of around 0.2 metres per second. Modelled velocities here are in excess of two metres per second in both the existing and post-construction scenarios. There are also reduced peak velocities in areas that become partially sheltered by the bypass embankment.

At the one per cent AEP event the influence of the southern connection and the southern abutment of the bridge over floodplain on local flow redistribution also becomes apparent through changes to the modelled peak flood velocity. Peak velocities within the flow path to the south of the bypass embankment are increased from around 0.6 to 1.1 metres per second through a local constriction and more broadly increased from around 0.4 to 0.6 metres per second. Peak flood velocities around the southern abutment of the bridge over floodplain are increased from around 0.5 to 1.0 metres per second. There are also reduced peak velocities in areas that become partially sheltered by the bypass embankment.

At the 0.5 per cent AEP event the peak velocity impacts are generally consistent with those of the one per cent AEP event, albeit to a larger magnitude. Within the Rose Point floodway upstream of the railway, peak velocities are increased from around 0.9 to 1.7 metres per second. There is a reduction in peak velocity through the floodway rail culverts from around 3.0 to 2.5 metres per second and in the floodway downstream of the railway from around 1.8 to 1.2 metres per second. Peak flood velocities around the northern abutment of the bridge over floodplain are increased from around 1.3 to 2.1 metres per second. The minor increase in peak velocities along the right bank of the Hunter River along the area of contraction through the existing rail bridge crossing is consistent with the one per cent AEP at around 0.2 metres per second. Peak velocities within the flow path to the south of the bypass embankment are increased from around 0.9 to 1.2 metres per second through a local constriction and more broadly increased from around 0.7 to 0.9 metres per second. Peak flood velocities around the southern abutment of the bridge over floodplain are increased from around 0.7 to 1.2 metres per second.

At the 0.2 per cent AEP event the peak velocity impacts are generally consistent with those of the 0.5 per cent AEP event, albeit to a larger magnitude. Within the Rose Point floodway upstream of the railway, peak velocities are increased from around 1.1 to 1.9 metres per second. There is a reduction in peak velocity through the floodway ail culverts from around 3.6 to 3.0 metres per second and in the floodway downstream of the railway from around 2.1 to 1.4 metres per second. Peak flood velocities around the northern abutment of the bridge over floodplain are increased from around 1.4 to 2.3 metres per second. The minor increase in peak velocities along the right bank of the Hunter River along the area of contraction through the existing rail bridge crossing is around 0.3 metres per second. Peak velocities within the flow path to the south of the bypass embankment are increased from around 1.2 to 1.4 metres per second through a local constriction and more broadly increased from around 1.1 to 1.3 metres per second. Peak flood velocities around the southern abutment of the bridge over floodplain are increased from around 1.1 to 1.6 metres per second.

The design would need to consider scour protection as a minimum. To ensure that peak flow velocities can be accommodated to ensure that the flood velocities do not impact road infrastructure or road users.

Other Impact

The duration of flooding varies from event to event. Given the extensive catchment of the Hunter River at Singleton, inundation of the floodplain from major flood events typically last for many days or weeks. Evacuation of the Singleton CBD area under major flood conditions may include closure of the centre until peak floodwaters subside. Presently access routes are expected to be closed for a few days in major flood events. The proposal design does not impact the overall duration of flood inundation, but potentially changes localised drainage following the recession of a flood. The proposal could benefit the region and community by providing improved flood immunity of the affected section of the New England Highway and local accessibility during a flood event.

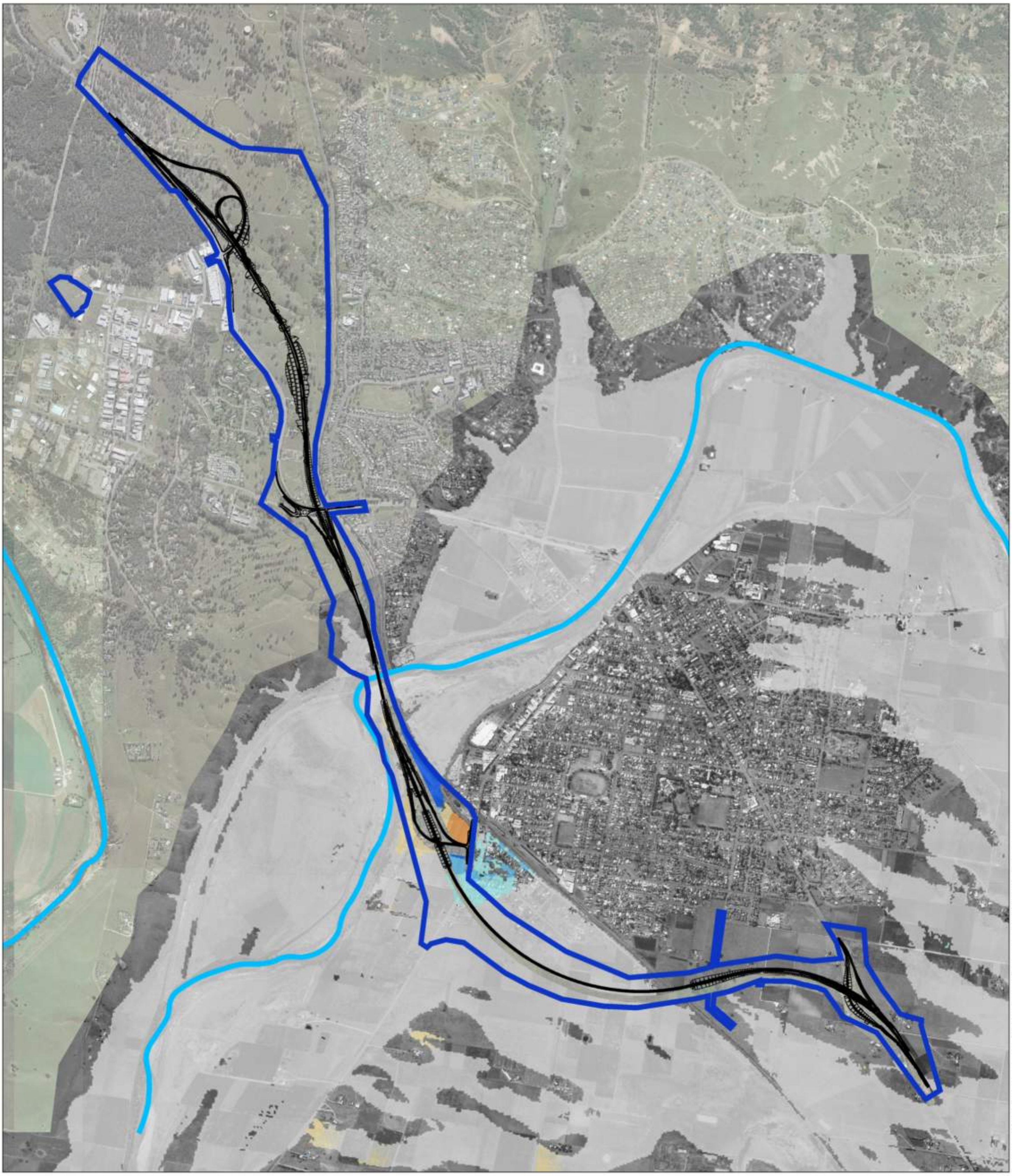
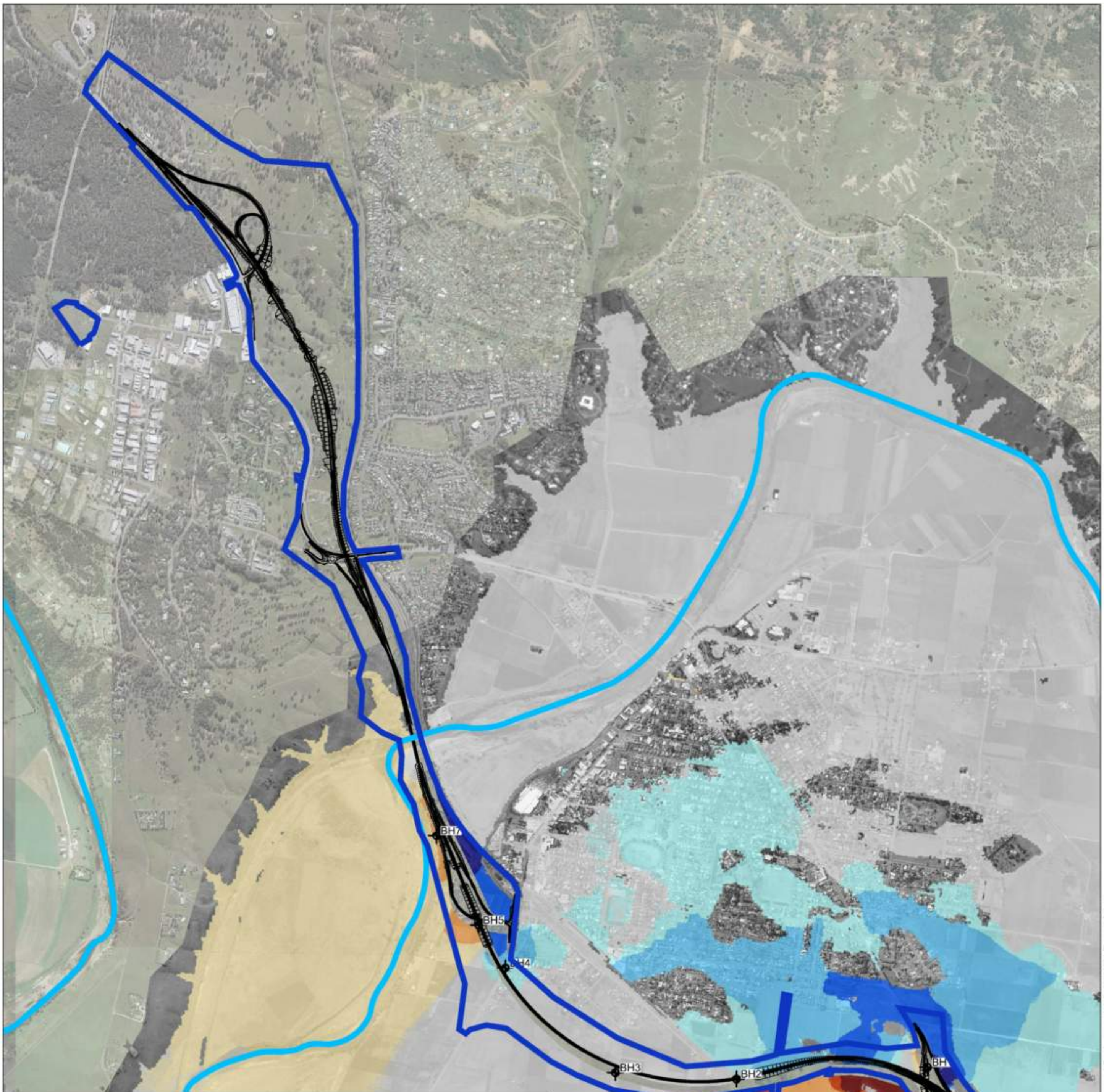


Fig. 5-1 Flood extents for the 5 per cent AEP



Water Aggressiveness Test esults

Location	Type of Test	Date of Sample Taken From Piezometer	Depth To Groundwater At the Time of Sampling (m)	Site Section	pH	EC (µS/cm)	Cl (mg/L)
1	Bore	15/08/2018	9.8	1	7.4	1200	130
2	Bore		12.0	1	8	1300	290
3	Bore		10.1	1	10.6	480	91
4	Bore		11.5	1	8.9	600	92
5	Bore		12.2	1	8.3	930	100
7	Bore		12.8	1	8.1	1100	140

FiIG.5-2 Modelled flood extents for the 1 per cent AEP

N 0 10 20 km

LEGEND

- Bypass Alignment
- Bridge Structure
- Proposal area
- Watercourse

Peak Flood Level Impact (m)

- < -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.02
- -0.02 to +0.02
- +0.02 to +0.05
- +0.05 to +0.10
- +0.10 to +0.20
- > +0.20

5.3 Groundwater

Potential impact on groundwater due to the operation of the proposal is discussed in this section. Mitigation measures to eliminate or manage impact are outlined in Section 7.

5.3.1 Groundwater users

Recognising the existing groundwater users near the proposal are south of the Hunter River, no ongoing impact to existing users to the north is expected while the development is operating.

South of the Hunter River, existing groundwater users in the superficial alluvial aquifer are not expected to be impacted by the proposal as there will be no abstraction or significant changes to the way groundwater is recharged. While there may be small local changes to surface water resulting from a new drainage system, no changes to groundwater are expected due to the high permeability of this aquifer. Effectively, minor changes in the recharge rates and locations will quickly equilibrate across the aquifer.

During the operational phase, there are not expected to be any substantial changes to the level or availability of groundwater in the superficial aquifer due to the proposal.

5.3.2 Groundwater quality

Under normal operating conditions, there are not expected to be any changes to the quality of groundwater resulting from the operation of the proposal due to the low level of impact to the way it is recharged and discharges to the Hunter River.

There is potential for groundwater to be contaminated by accidental spills of substances being conveyed along the proposal if they are not managed. Spills south of the Hunter River have the potential to affect the quality of groundwater being used by existing users downgradient (west) of the proposal. Spills on the proposal alignment to the north of the Hunter River are less likely to affect groundwater due to the lower rate of recharge and higher rate of runoff that occurs over weathered bedrock. Should a major spill occur that does reach the water table, it would slowly migrate towards the local creek lines downslope, east of the proposal. With the recommended safeguards such as routine monitoring in place, the potential for adverse impact to occur to groundwater would be low.

5.3.3 Groundwater dependant ecosystems

Once constructed, the area of the pile foundations will be very small relative to the extent of the superficial aquifers and Hunter River GDE. Because of this, groundwater discharging from the superficial alluvial or weathered bedrock aquifers that support this GDE should not change substantially.

Should groundwater be intersected by the deep cutting in the north between Darlington and Singleton Heights, the GDEs located in this area are not expected to be affected by ongoing interception of seasonal or perennial groundwater flows. This is because of the low permeability of this aquifer.

6. Assessment of cumulative impact

6.1 Other Roads and Maritime projects

A review of Roads and Maritime projects was completed and the following proposals are identified in the area of the proposal.

New England Highway upgrade between Belford and the Golden Highway

Roads and Maritime is planning to upgrade the New England Highway between Belford and the Golden Highway to provide two travel lanes in each direction and a flyover for vehicles turning right from the Golden Highway towards Maitland and Newcastle. The environmental assessment was approved in July 2018.

This project is not in the floodplain and is not a new road but an upgrade to an existing, therefore the cumulative impact with regards to the surface and groundwater aspects are considered to be minor.

6.2 Other projects

The Bloomfield Group – Rix's Creek Coal Mine Continuation of Mining Project

The Bloomfield Group has obtained approval in October 2019 to extend the life of the existing open cut coal mining operations at Rix's Creek until 2037. The continuation of mining operations will extend in a north-westerly direction and require a modification to Mine Lease 1432 for an out of pit overburden emplacement area. The continuation of operations will utilise existing mine infrastructure, including access, coal handling and preparation plant, coal stockpiling and rail facilities.

The project may have a potential impact on regional and local surface water quality, however the 'Surface Water Study for Rix's Creek Continuation of Mining' (JP Environmental 2014) states that no observable impact on water quality are due to the activity of the mine and, provided existing management systems are maintained and mitigation measures adopted, there is a low risk of impact on water quality.

The environmental assessment for the project reports that drawdown effects within the uppermost water table may be felt further northwards of the Mine when compared to the Project only impact (RPS 2014). However, the area identified under the cumulative impact scenario does not detrimentally affect the groundwater resource, have a significant impact on other groundwater users, or impact on GDEs.

Potential cumulative impact associated of the proposed New England Highway bypass with the Rix's Creek Continuation of Mining Project are considered to be negligible.

Yancoal – Ashton Coal Operations Pty Limited Modification to Ashton Mine South East Open Cut Project

Ashton Coal Operations Pty Limited has development consent to commence open cut mining within the South East Open Cut. The timing for the beginning of the open cut mining operations is not fixed.

The Ashton Coal South East Open Cut Project Surface Water Assessment (Worley Parsons 2009) notes potential cumulative surface water impact of the project to be:

- The overall demand for water in the Hunter River and Glennies Creek systems
- The potential for land use practices to result in greater sediment generation and deposition in the Hunter River and Glennies Creek
- The potential for increased salt loads in the Hunter River and Glennies Creek.

The licensing framework and water sharing plans regulate the overall water demands in both the Hunter River and Glennies Creek and as such address the cumulative impact of the various water demands. Accordingly, compliance with the license conditions would ensure that the cumulative impact of water extraction and harvesting are adequately managed.

With consideration of the baseline monitoring results, and the proposed surface water management controls, it is likely that the South East Open Cut project would not exacerbate the cumulative impact of land use practises on the water quality in Glennies Creek or its receiving water, the Hunter River.

Potential cumulative impact associated this project is considered to be negligible.

Singleton urban development

It is anticipated that 60 per cent of additional dwellings provided to 2021 will be in the Singleton Heights/North Singleton urban area, five per cent in Singleton town area, and 35 per cent in rural areas (Singleton Land Use Strategy 2008).

The proposal is upstream of Singleton Heights. Part of the northern section of the proposal will drain through Singleton Heights. There is potential to impact flows through Singleton Heights with the increase in the impervious nature of the road and with the construction of culverts beneath the road embankment. The urban development in the Singleton Heights area has the potential to increase the impervious nature of the area, impacting local flows.

No known Australian Rail Track Corporation (ARTC) or Singleton Council projects are proposed that would contribute to a cumulative impact.

7. Environmental management

7.1 Summary of safeguards and management measures

The safeguards and management measures for the management of potential surface water, groundwater and flooding impacts are summarised in Table 7-1.

Table 7-1: Summary of safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
General	A Soil and Water Management Plan will be prepared in accordance with QA Specification G38 and implemented as part of the CEMP. The Plan will identify all reasonably foreseeable risks relating to soil erosion and water pollution associated with undertaking the activity, and describe how these risks will be managed and minimised during construction. That will include arrangements for managing pollution risks associated with spillage or contamination on the site and adjoining areas, and monitoring during and post-construction.	Construction Contractor	Pre-construction/construction	Core standard safeguard GEN1
Erosion and sediment control mitigation				
Erosion and sediment control mitigation	A site specific Erosion and Sediment Control Plan(s) will be prepared and implemented and included in the Soil and Water Management Plan. The Plan(s) will identify detailed measures and controls to be applied to minimise erosion and sediment control risks including, but not necessarily limited to: runoff, diversion and drainage points; sediment basins and sumps; scour protection; stabilising disturbed areas as soon as possible, check dams, fencing and swales; and staged implementation arrangements. The Plan will also include arrangements for managing wet weather events, including monitoring of potential high risk events (such as storms) and specific controls and follow-up measures to be applied in the event of wet weather.	Construction Contractor	Construction	Core standard safeguard E1
Erosion and sediment control mitigation	Stockpiles will be designed, established, operated and decommissioned in accordance with the RTA Stockpile Site Management Guideline 2011.	Construction Contractor	Construction	Core standard safeguard E6
Erosion and sediment control mitigation	The rehabilitation of disturbed areas will be undertaken progressively as construction stages are completed, and in accordance with: • Landcom's Managing Urban Stormwater: Soils and Construction series • RTA Landscape Guideline • RMS Guideline for Batter Stabilisation using Vegetation (2015)	Construction Contractor	Construction	Core standard safeguard E7
Erosion and sediment control	Consistent with any specific requirements of the approved Soil and Water Management, control measures will be implemented to minimise risks associated with erosion and sedimentation and entry of materials to drainage lines and	Construction Contractor	Construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
mitigation	waterways. That will include, but not necessarily be limited to: • Sediment management devices, such as fencing, hay bales or sand bags • Measures to divert or capture and filter water prior to discharge, such as drainage channels and first flush and sediment • Basins • Scour protection and energy dissipaters at locations of high erosion risk • Installation of measures at work entry and exit points to minimise movement of material onto adjoining roads, such as • Rumble grids or wheel wash bays • Appropriate location and storage of construction materials, fuels and chemicals, including bunding where appropriate.			
Erosion and sediment control mitigation	Batters will be designed and constructed to minimise risk of exposure, instability and erosion, and to support long-term, on-going best practice management, in accordance with Roads and Maritime 'Guideline for Batter Surface Stabilisation using vegetation' (2015).	Roads and Maritime project manager / Construction Contractor	Detailed design / construction	Additional safeguard
Water quality				
Surface water mitigation	Two spill containment basins with a minimum volume of 25,000 Litres are to be provided on the north and south side of the Hunter River.	Construction Contractor	Pre-construction / construction	Additional safeguard
Surface water mitigation	A Spill Management Plan will be prepared and implemented as part of the CEMP to minimise the risk of pollution arising from spillage or contamination on the site and adjoining areas. The Spill Management Plan will address, but not necessarily be limited to: • Management of chemicals and potentially polluting materials • Any bunding requirements • Maintenance of plant and equipment Emergency management, including notification, response and clean-up procedures	Construction Contractor	Pre-construction / construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
Surface water mitigation	A water quality monitoring program would be developed and implemented as part of the Soil and Water Management Plan in accordance with Roads and Maritime Guideline for Construction Water Quality Monitoring (Roads and Maritime, 2003). The monitoring program is to include • Visual monitoring of local water quality • Up and down stream water quality monitoring of the Hunter River prior to the start of construction • Monthly up and down stream water quality monitoring for the duration of working within and over the Hunter River.	Construction Contractor	Construction	Core standard safeguard W2
Groundwater				
Surface water impact mitigation	Any dewatering activities will be undertaken in accordance with the RTA Technical Guideline: Environmental management of construction site dewatering in a manner that prevents pollution of waters.	Construction Contractor	Detailed design / Construction	Additional safeguard
Flooding				
Flood mitigation	A flood response management plan will be prepared as part of the CEMP. The Flood Risk Management Plan will address, but not necessarily be limited to: • Processes for monitoring and mitigation flood risk • Steps to be taken in the event of a flood warning including removal or securing of loose material, equipment, fuels and chemicals.	Construction Contractor	Construction	Additional safeguard

8. Conclusion

This report has assessed and identified surface water and groundwater impacts that may occur as a result of the construction and operation of Singleton bypass.

Surface water and flooding

The proposal would be constructed across the Hunter River, its alluvial floodplain and a series of tributary creeks. The Hunter River is incised below the floodplain, causing the area to be subject to a history flooding.

During construction, potential impacts to surface water quality include increased turbidity, elevated concentration of nutrients and other pollutants, such as heavy metals and organic chemicals. The greatest risk to arise from sediment laden waters and offsite discharge during construction. The potential impacts on receiving surface water and water quality would be mitigated through erosion and sediment controls including sediment management devices such as an Erosion and Sediment Control Plan, the installation of batters, a Spill Management Plan and consistent water quality monitoring. Additionally, the rehabilitation of disturbed areas would be undertaken progressively through construction. The implementation of these measures will ensure there is no further degradation is surface water quality or surrounding environmental values during construction.

Once operational, potential impacts to surface water would include pollutants and contaminants from the surface of the road (i.e. litter, sediment or oils from vehicles) being conveyed during runoff events to receiving waters. However, given the proposed road design and legislative controls when transporting dangerous goods, the probability of impact is considered low.

While construction activities have the potential to impact on the flood regime and redistribute flows across the floodplain, flood behaviour of the study area is well understood. Adequate advance flood warning is likely to be available to remove staff and equipment and protect the work prior to inundation. Once operational, the proposal would change peak flood levels, and peak flood level velocity and scour potential, however these changes are localised for all design events considered and the proposal is unlikely to result in an increased flooding risk to Singleton.

Groundwater

The groundwater systems in proximity to the proposal include two regional aquifers, a superficial alluvial aquifer and a weathered and/or fractured bedrock aquifer.

Interaction with the groundwater is expected when constructing bridge piles. To minimise the potential of encountering groundwater, the pile holes would be installed by advancing steel casing into the ground as they are drilled. The steel casing will pass through one to two metres of gravel below the existing water table. Once the casing has been advanced to the bedrock, groundwater is not expected to be encountered because, based on drilling evidence, it is not permeable below the zone of weathering.

Two groundwater bore/wells are within the impact area, however the groundwater supplies drawn from these wells are not expected to be disturbed during construction.

No groundwater dependent ecosystems are expected to be disturbed by installation of piles for bridge construction or by excavations required by the proposal.

Further concerns to groundwater include contamination from activities including leaks or spills of fuels and seepage from spoil areas containing soils derived from below the water table that may contain unstable sulphide minerals. Mitigation measures include the use of appropriate emergency response protocols outlined in the Spill Management Plan.

Under normal operating conditions, the proposal is not expected to result in any changes to the quality of groundwater in the local or regional aquifers. Similarly impacts to groundwater availability would be negligible as the proposal does not require any significant groundwater extraction or inhibit recharge from the Hunter River.

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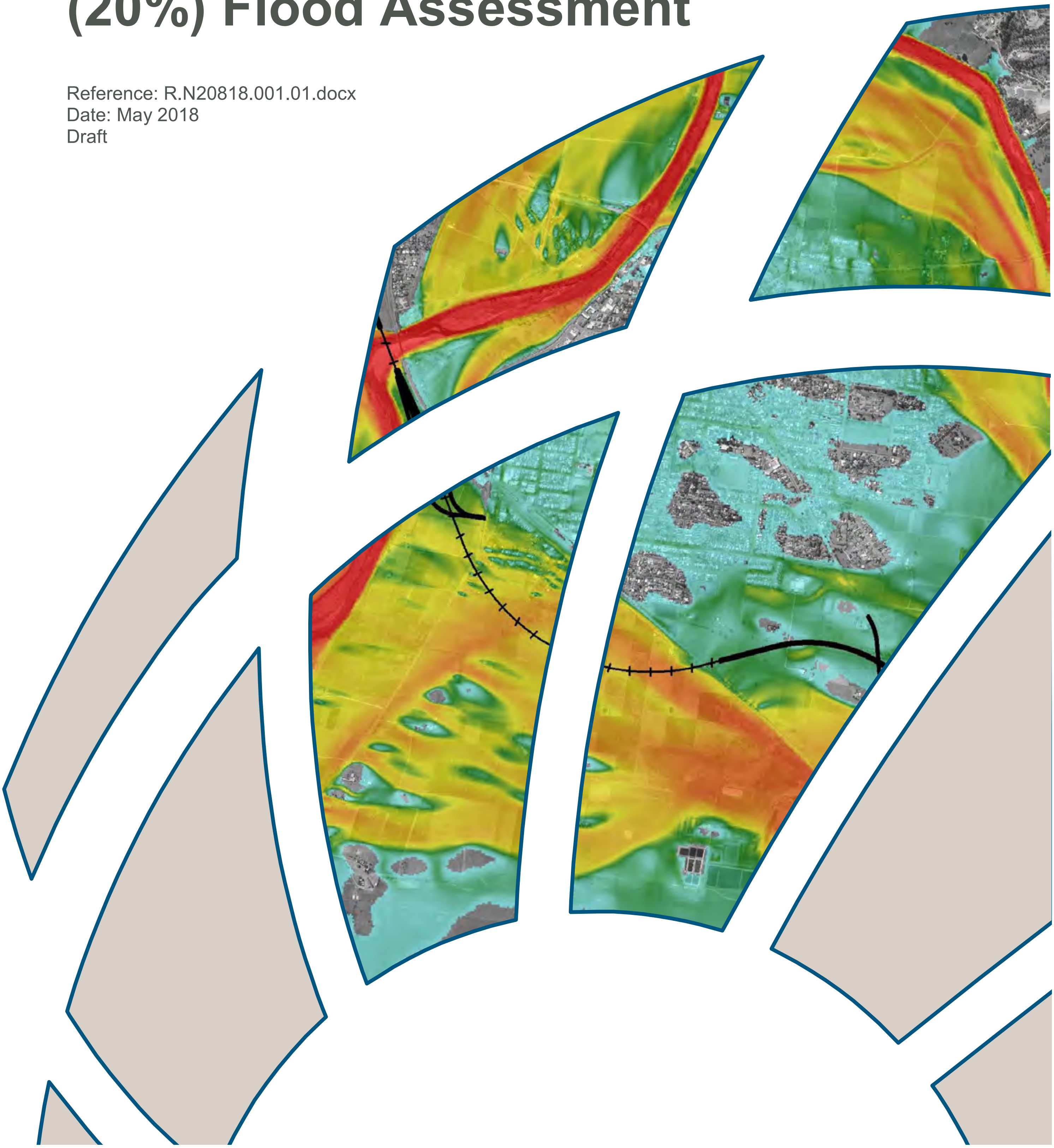
Appendix A

Flood Assessment

Singleton Bypass Concept Design (20%) Flood Assessment

Reference: R.N20818.001.01.docx
Date: May 2018
Draft



Document Control Sheet

BMT WBM Pty Ltd 126 Belford Street Broadmeadow NSW 2292 Australia PO Box 266 Broadmeadow NSW 2292 Tel: +61 2 4940 8882 Fax: +61 2 4940 8887 ABN 54 010 830 421 www.bmt.org	**Document:**	R.N20818.001.01.docx
	Title:	Singleton Bypass Concept Design (20%) Flood Assessment
	Project Manager:	Daniel Williams
	Author:	Daniel Williams
	Client:	AECOM for RMS
	Client Contact:	Ian Leach
	Client Reference:	
Synopsis: This document outlines a flood risk and impact assessment in relation to the concept design of the proposed Singleton Bypass.		

REVISION/CHECKING HISTORY

Revision Number	Date	Checked by		Issued by	
1	23/05/2018	DXW		DXW	

DISTRIBUTION

Destination	Revision										
	0	1	2	3	4	5	6	7	8	9	10
AECOM for RMS		e									
BMT File		e									
BMT Library											

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1 Introduction

1.1 Background

BMT WBM completed the Singleton Flood Study on behalf of Singleton Council in 2003. The flood study and subsequent flood risk assessments show that the Singleton township has a relatively high exposure to flood risk. The existing levee system has a finite level of protection with significant parts of the township expected to be inundated in major floods such as the 1% Annual Exceedance Probability (AEP) event. The 1955 Hunter River flood saw extensive flooding in Singleton and serves as an important reference event for potential flooding impact.

Since completion of the flood study, numerous flood risk assessments for development proposals in the study area, including rail infrastructure through Doughboy Hollow have been completed. Those additional studies assessed the flood risk of various development proposals and their potential impacts on flooding in the Singleton township and surrounding area.

Following the Singleton Bypass Strategic Design (80%) Flood Assessment Report R.N20330.003.01.docx by BMT WBM in April 2016, the Roads and Maritime Service (RMS) are undertaking a Concept Design for the preferred Option identified within the Strategic Design Stage. This report documents the flood assessment of this Concept Design (20%), which has been developed from the original Option B Strategic Design.

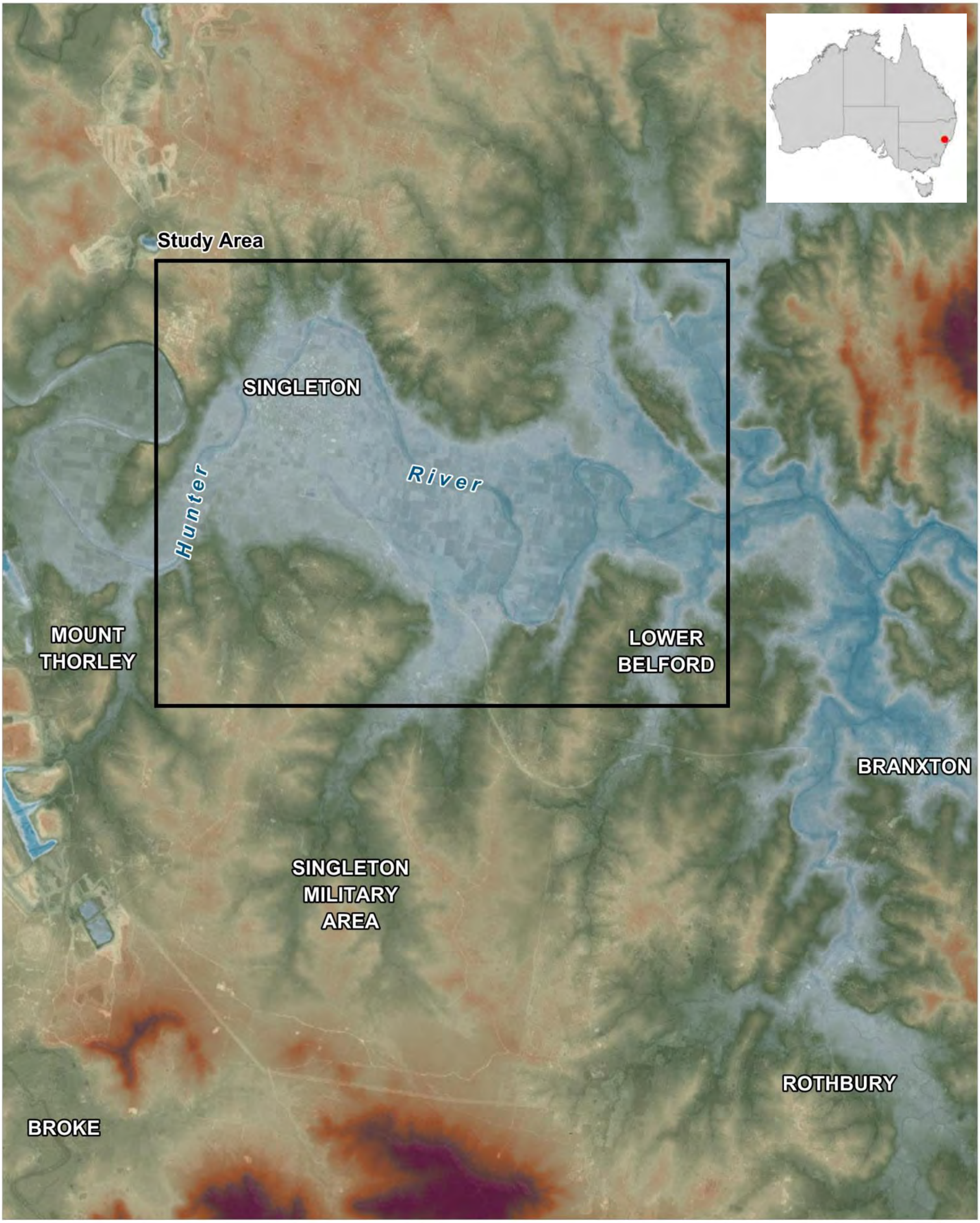
1.2 Study Area

The main study area includes the township of Singleton and the floodplain of the Hunter River between Hambledon Hill to the west and Lower Belford and Glendon to the east. The floodplain is defined by steep terrain to the north and the Golden Highway to the south. A Digital Elevation Model (DEM) of the study region based on SRTM ‘bare earth’ models (Gallant *et al*., 2011) and key localities is shown in Figure 1-1. The study area considered by the flood risk assessment of the proposed Singleton Bypass is shown in Figure 1-2.

Landuse in the study area includes the urban centre of Singleton which comprises residential, commercial and some industrial development. The dominant landuse surrounding the Singleton township is agricultural land and pasture which primarily occupies the Hunter River and Doughboy Hollow floodplains. Numerous rural properties are also located throughout the study area.

Notable ground controls in the study area include the New England Highway and the Main Northern Railway Line, which traverse the floodplain between Whittingham and Singleton. The existing levee system on the north-western side of Singleton township, which joins with the Main Northern Rail Line embankment at Glenridding also affects flood behaviour in the area. Natural ground controls include Doughboy Hollow which becomes active during floods such as the 10% AEP event and greater.

Several flow constrictions are also present which include major bridge crossings provided along the Main Northern Railway Line, the New England Highway, Dunolly Road and Queen Street. Numerous other drainage / flow control structures are provided beneath the Main Northern Railway and New England Highway to convey flood flows across the floodplain during major flood events.



Title:

Study Locality

Figure: **1-1**

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Title:

Singleton Bypass Study Area

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1.3 Report Purpose

This report documents the flood impact assessment in relation to the concept design (20%) for the proposed Singleton Bypass. The flooding assessment incudes consideration of the following:

- existing design flood conditions (to be used as the baseline for impact assessment);
- the proposed bypass route alignments and its service/performance requirements;
- design flood simulations for a range of return period events;
- estimation of pre- and post- 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 Development of the Singleton Flood Model

2.1 Model Background

The Singleton flood model was originally developed using TUFLOW and calibrated as part of the Singleton Flood Study (WBM, 2003). However, since completion of the Flood Study, more detailed LiDAR topographic data has become available for the region and an additional major flood event has occurred (in June 2007).

To ensure that the flood assessment was undertaken using the best available information it was deemed appropriate to develop a new flood model using the LiDAR elevation data and to re-calibrate with the June 2007 flood event.

2.2 Topographic Improvements

A LiDAR survey of the region was flown for NSW LPI between October 2011 and February 2012. This provided an extensive and detailed topographic coverage of the Hunter River floodplain from upstream of Singleton to downstream of Maitland. The existing Singleton flood model had utilised photogrammetric survey data of the Hunter River and the adjacent floodplain. However, this dataset only covered the reach through Singleton. The topography of the Doughboy Hollow floodplain to the south of Singleton had been represented using details of an historic ground survey dataset.

The 2011 LiDAR dataset provides a much more detailed representation of the Doughboy Hollow topography and also revealed some significant hydraulic controls within the Hunter River banks downstream of Singleton. The LiDAR data was incorporated into the TUFLOW model in the form of a 2 m grid resolution DEM and now forms the basis of the channel and floodplain topography. The channel topography upstream of Singleton had not been adequately captured by the LiDAR data as the survey date coincided with a flood event in the Hunter River. An appropriate channel definition was therefore derived from the available cross-section survey data at the water level gauging stations.

2.3 June 2007 Flood Event Calibration

The Hunter River experienced its largest flood in almost two decades in June 2007, resulting from the East Coast Low that saw major flooding in Newcastle – the so-called “Pasha Bulker” storm. The resultant flood event represented somewhere in the order of a 5% AEP magnitude at Singleton. As the Singleton Flood Study had been completed prior to the June 2007 event, the event provided additional data with which to assess the performance of the flood model. This was particularly important, having updated the model topography using the recent LiDAR survey data.

The June 2007 event flood hydrograph was recorded at some four water level gauges near Singleton and a further two between Singleton and Maitland. Given the inherent uncertainties associated with rating curve extensions at the gauges, the flow hydrographs can be inconsistent when converting from the recorded water levels, as presented in Table 2-1. Despite being the gauge location with the greatest potential for bypass flows, the Singleton gauge at Dunolly Bridge “recorded” (when using the site rating curve) the largest flow rate (5300 m^3/s) and is significantly different to the other gauges, which “recorded” flows typically in the order of 3000 m^3/s.

Table 2-1 Gauged Peaks for the June 2007 Event

Gauge Location	Recorded Peak Level (m AHD)	Derived Peak Flow (m^3/s)
Maison Dieu	56.91	3,100
Long Point	50.64	3,500
Upstream of Singleton	42.98	3,100
Singleton (Dunolly Bridge)	41.77	5,300
Greta	23.67	3,000

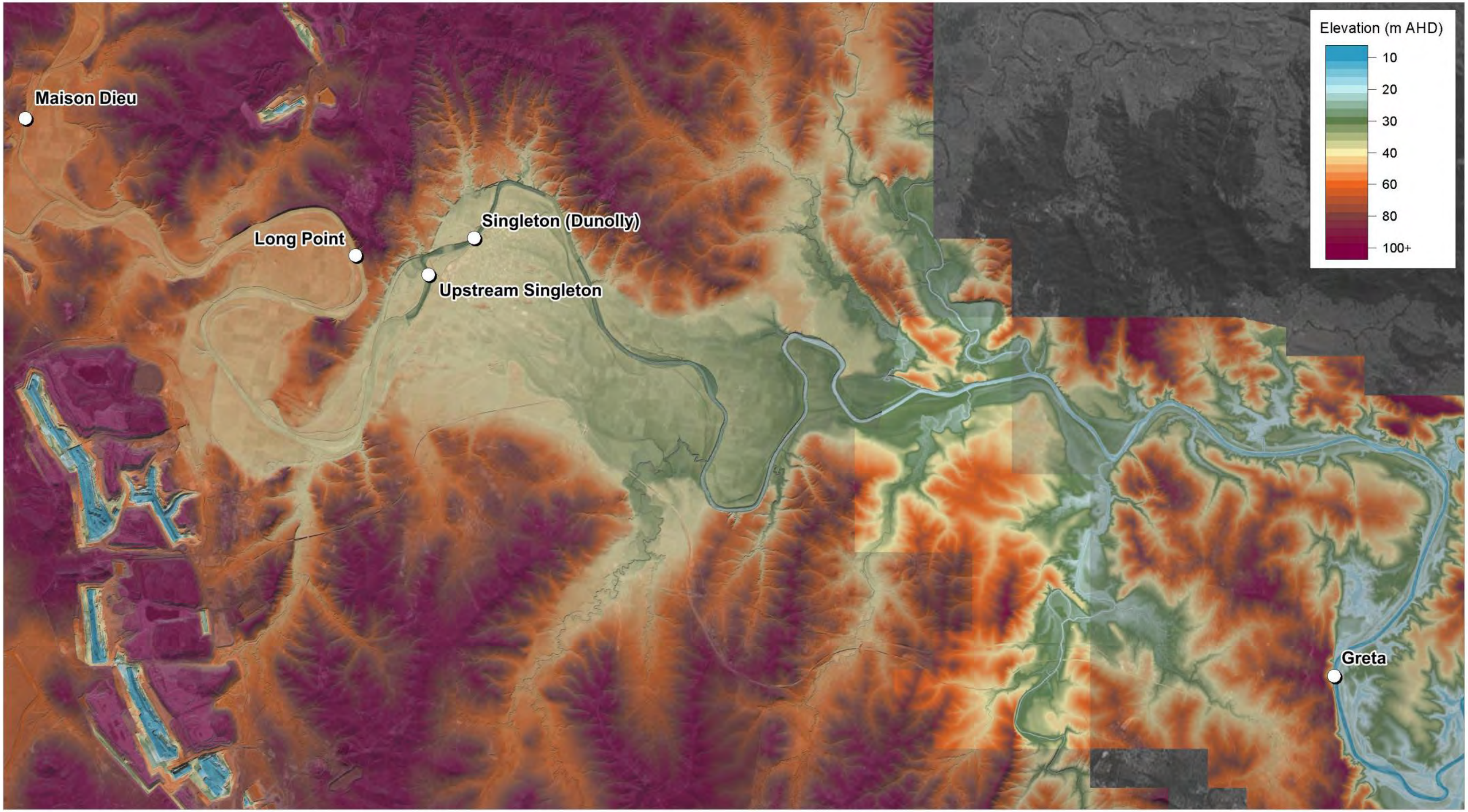
Figure 2-1 shows the location of the gauging stations and the LiDAR topography of the region. It shows the four gauges close to Singleton and that further downstream at Greta. The water levels at Maison Dieu are influenced by the tailwater conditions at the confluence with the Wollombi Brook, which complicates flow estimations at this site. The gauge at Long Point and the two at Singleton are all bypassed to varying degrees at high flows. The Greta gauge is the most reliable of the five sites, being located at a relatively narrow floodplain constriction.

The Greta and Singleton (Dunolly) gauges are the two well-established gauges, with records commencing in 1968 and 1913 respectively. The other gauges have been established more recently – in 1993 at Maison Dieu and 2007 at both Long Point and Upstream of Singleton.

Discussions with the hydrographers at Water NSW have identified that there have been significant changes to the gauging site rating curves for the Hunter River and Wollombi Brook based on recent gauged flow data collected during flood events in 2011 and 2012. There has been significant recovery of riparian vegetation over the last 20 years or so, following changes in catchment management practices and an extended period without a major flood event. As such, flows of a given magnitude now result in much higher water levels than they would have done previously, due to the increased flow resistance of the vegetation. This is evident in the data presented in Figure 2-2. The spot gaugings from the last decade have been highlighted and clearly follow a different rating curve to the older gaugings.

Model simulations were undertaken representing recent and historic vegetation conditions in order to derive modelled rating curves at the Singleton (Dunolly Bridge) site for comparison with the gauged data and have also been presented on Figure 2-2. This provides for a similar shift in rating curves as has been recorded. The large hysteresis effect evident in the modelled rating curve and the capping of levels above 41 m AHD both make this site far from ideal for gauging high flows. This is unfortunate as it is the only gauge in the Singleton area with a long enough period of record to undertake a reliable flood frequency analysis (FFA).

The adopted model roughness values are presented in Table 2-2. For the historic conditions the model was largely defined as river channel or pasture. For the recent conditions the riparian vegetation was digitised from aerial photography.



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Gauge Location

Title:

Gauge Locations and Floodplain Topography

Figure: 2-1

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Table 2-2 Adopted Model Roughness Values

Land Use Type	Adopted Manning's 'n'
River Channel	0.025
Roadways	0.03
Pasture and in-channel brush	0.04
Forest and heavy riparian vegetation	0.12
Buildings	1.0

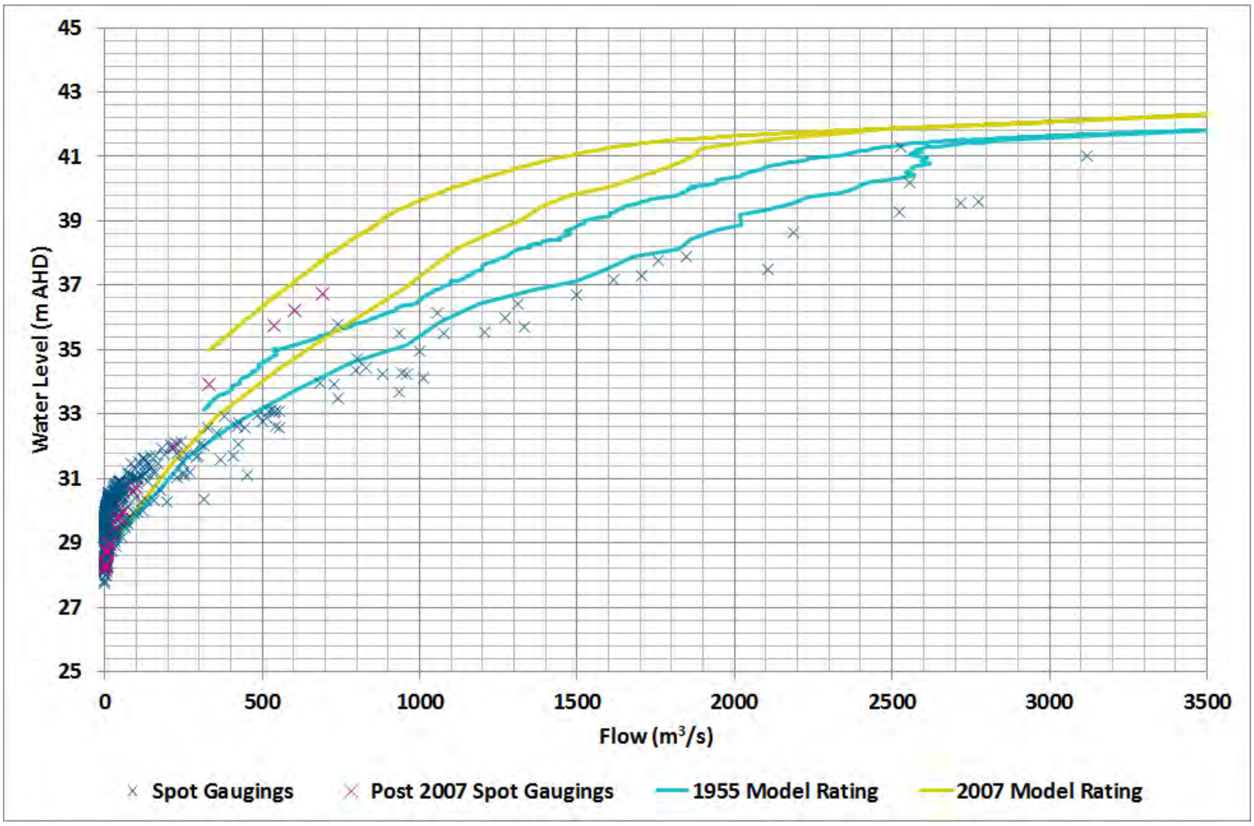


Figure 2-2 Gauged Flows and Modelled Rating Curves at Singleton

The TUFLOW model with the recent riparian vegetation conditions was simulated for the June 2007 flood event, scaling the model inflow hydrograph to provide a range of peak flow conditions. The hydrograph that provided the best match to the recorded peak flood levels at the Singleton gauges had a peak flow of 3500 m^3/s. This produced modelled peak flood levels around 0.2 m higher than recorded at Dunolly Bridge and around 0.2 m below than recorded upstream of Singleton, as presented in Table 2-3.

Table 2-3 June 2007 Model Calibration Results

Gauge Location	Recorded Peak Level (m AHD)	Modelled Peak Level (m AHD)
Upstream of Singleton	42.98	42.83
Singleton (Dunolly Bridge)	41.77	41.99

Model simulations that have been undertaken for the June 2007 event across the broader Hunter River catchment have indicated that a peak flow rate of around 3500 m^3/s at Singleton attenuates to a peak flow rate of around 3000 m^3/s at Greta. This is consistent with the rating curve adopted by Water NSW for Greta (refer to Table 2-1) and suggests that the gauges at Long Point and Greta provide the best estimates of the June 2007 flood flows. Modelled rating curves at these two sites produce a much less significant hysteresis effect than occurs at the other three sites.

2.4 February 1955 Flood Event Calibration

For the February 1955 event the TUFLOW model was simulated using the historic model configuration, without riparian vegetation or the levee scheme. The recorded 1955 flood hydrograph was input to the model and scaled for a range of peak flow conditions. The resultant modelled peak water level surfaces were compared to an extensive collection of estimated flood levels from observed flood marks. Overall a peak flow rate of around 10 000 m^3/s was found to give the best fit to the observed data – both along the alignment of the Hunter River and the floodplain flow paths around and through Singleton. A long section presenting the observed peak flood levels with a range of modelled peak water level profiles is presented in Figure 2-3.

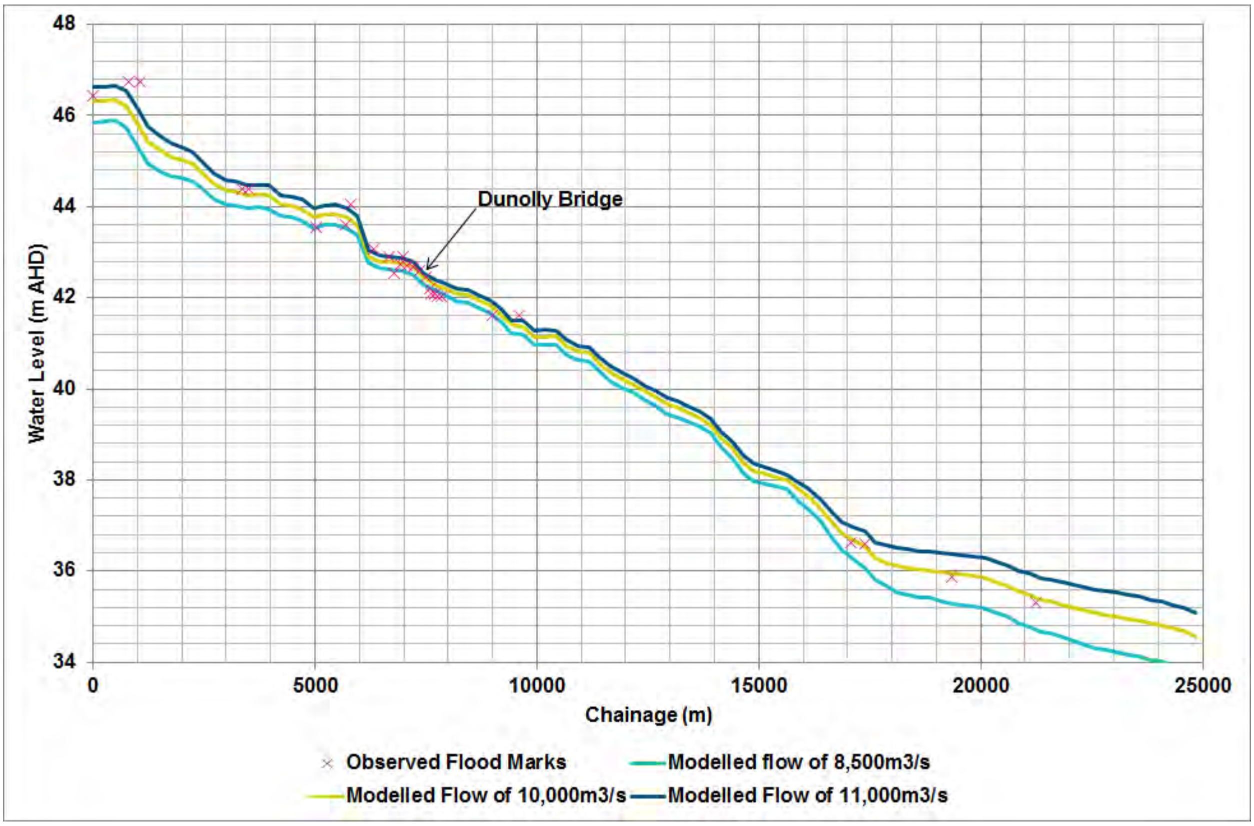


Figure 2-3 February 1955 Model Calibration Results

The peak flow rate of 10 000 m^3/s gives the overall best fit to the observed data when compared to the other flow rates considered, especially around 12 km downstream of Dunolly Bridge where the range of modelled peak flood levels is greatest.

2.5 Model Improvements for Concept Design

For the Strategic Design Assessment modelling the TUFLOW model had utilised a grid cell resolution of 20 m and was simulated using the TUFLOW Classic solver. For the Concept Design Assessment, the TUFLOW model grid cell resolution was improved to 10 m. This effectively increases model simulation times eight-fold. To enable faster, more efficient model simulation, model execution was switched to the TUFLOW HPC (Heavily Parallelised Computing) solver, which harnesses the power of parallelised processing hardware.

TUFLOW HPC uses a second-order solution scheme that provides high numerical accuracy, like the standard TUFLOW Classic solver. It is of far greater accuracy and has significantly greater functionality than the TUFLOW GPU model and includes full integration with the 1d ESTRY solver. The major advantage of the TUFLOW HPC software is that it allows a finer grid resolution to be modelled while still maintaining model run times within manageable durations. It does this by utilising the parallelised processing capabilities of Graphical Processing Units (GPUs) within computer hardware. GPUs offer greater numerical speed than CPUs.

The run time for TUFLOW HPC can be in the order of eight to 100 times faster than TUFLOW Classic, through the application of adaptive time-stepping (TUFLOW Classic uses a fixed timestep). The major advantage of adaptive timesteps lies in the greatly improved stability of the model.

Following the improvement in model grid cell resolution and switching of the model solver it was necessary to re-calibrate the TUFLOW model to provide consistency with that developed for the Strategic Design Assessment. This process required a slight adjustment to the adopted Manning's 'n' values, as presented in Table 2-4. The adjusted roughness values provide a similar modelled rating curve at the Singleton gauge site to that of the Strategic Design model and as such maintains a consistent model calibration and Flood Frequency Analysis.

Table 2-4 Adjusted Model Roughness Values

Land Use Type	Adopted Manning's 'n'
River Channel	0.03
Forest and heavy riparian vegetation	0.135

2.6 Design Flood Estimation

2.6.1 Flood Frequency Analysis

Having established a reasonable set of model roughness values, and determined reasonable estimates of peak flow rates for the June 2007 and February 1955 events, the historic peak flood level record at Singleton (Dunolly) was assessed to derive an FFA.

Despite the considerable limitations of the Dunolly Bridge gauging site for the estimation of peak flood flows, this site was selected as it has the longest period of record of any gauge in the area (over 100 years, compared to just under 50 years for the next longest record at Greta) and is the only one to have recorded the 1955 event.

A series of annual maxima water level records was extracted from the gauge records. A set of three rating curves were then derived to convert these records to a best estimate of peak flows. The rating curves were based on the Office of Water actual ratings for flood levels under 41 m AHD, transitioning to the modelled rating curves for flood levels above 41 m AHD. Two rating curves were based on the historic rating curves with limited riparian vegetation – one pre-levee and one post-levee construction, i.e. pre-1963 and post-1963. The third rating curve was based on the recent rating curve with extensive riparian vegetation, and was considered for events from 1998 onwards.

An annual maxima flow series consisting of 102 records from 1913 to 2014 was analysed using the FLIKE FFA software. A Bayesian inference method was adopted with a Log Pearson III probability model. Major floods were also known to occur in 1820 and 1893 and were incorporated into the analysis as censored threshold exceedance values. The ten largest flood events recorded at Singleton and their corresponding peak flow estimates are presented in Table 2-5. The resultant fitted distribution is presented in Figure 2-4 together with the plotting positions of the annual maxima, determined using the Cunnane formula.

Table 2-5 Ten Largest Flood Events Recorded at Singleton

Event Year	Estimated Peak Flow Rate (m^3/s)
1955	10,000
1893	*8,000*
1820	*5,500*
1913	4,700
2007	3,500
1971	3,200
1952	2,900
1930	2,800
1949	2,600
1977	2,500

There is a fairly even spread of flood events between a 1000 m^3/s and 4000 m^3/s magnitude. The two largest events in 1955 and 1893 are substantially larger than the other floods (at around 10 000 m^3/s and 8000 m^3/s respectively). Inspection of the respective rainfall distributions for the historic floods shows that the two largest events have significant rainfall across the entire Hunter River catchment. The Hunter River catchment upstream of Singleton can be split into two broad sub-catchments: Goulburn River (7800 km^2) and Upper Hunter (8600 km^2). The largest flows would be expected to be generated by heavy rainfall across both.

Table 1 shows the 3-day rainfall distribution across the two sub-catchments for four of the largest ten events. The two largest events (1893 and 1955) show significant rainfall across both sub-catchments. The other two events show significant rainfall in the Upper Hunter sub-catchment and only moderate rainfall across the Goulburn River catchment.

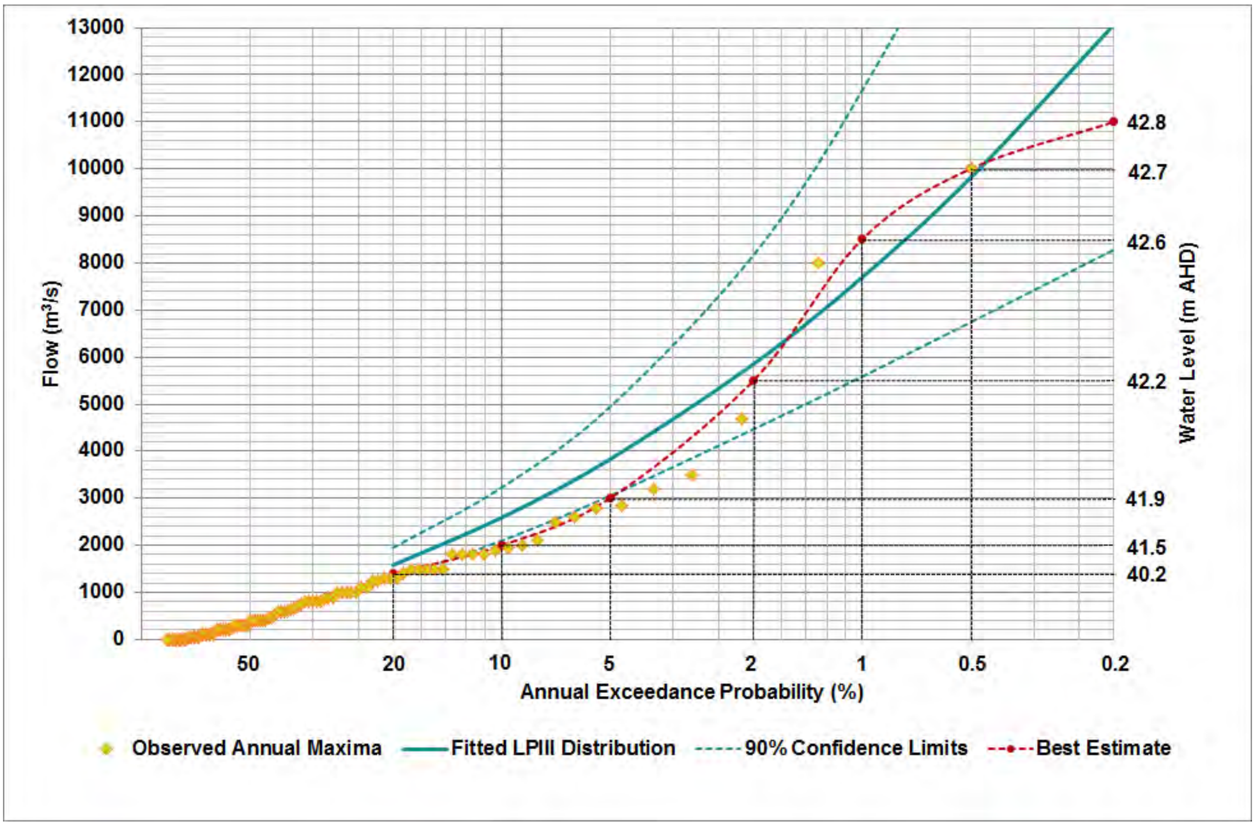


Figure 2-4 Singleton Flood Frequency Analysis

Table 2-6 Historic Event 3-day Rainfall Distribution across Sub-catchments

Gauge Location	Goulburn River (mm)	Upper Hunter (mm)
1893	200	270
1913	120	250
1930	110	210
1955	310	320

The flood flows from the FFA have been converted to water levels using the current rating curve and were included within Figure 2-4. The update of the Singleton FFA from the 2003 Flood Study has considered:

- There is an extra 12 years of annual maxima data from which to derive the revised FFA;
- Assessment of high flow rating extensions; and
- The current rating curve has been revised significantly using site gaugings of the 2011 and 2012 events and been applied to the 2007 event.

The revised FFA is significantly influenced by the step change in historic flood event magnitudes between those events around or below 4000 m^3/s and the two largest events at over 8000 m^3/s. It is difficult to fit a distribution well to both, with the potential to overestimate some more frequent event magnitudes and underestimate some less frequent event magnitudes.

Improved design flood estimation would incorporate a fitted distribution to the lower magnitude historic events, another fitted to the more extreme historic events and a transition between the two. Although there is a reasonable amount of certainty in fitting to the more frequent flood events, there are only a few historic events (and therefore more uncertainty) from which to derive a representative transition and large magnitude design flood estimate. A “best estimate” has been determined using the statistical FFA and engineering judgement, and has also been presented in Figure 2-4.

There remain significant uncertainties with the design flood flow estimation, including:

- The substantial hysteresis effect at the gauge site;
- The relatively small change in peak water level for major out-of-bank floods;
- The impact that the re-vegetation of the channel might have on long-term annual maxima flow statistics; and
- Whether the re-vegetated channel will be stripped clean during the next major flood event.

2.6.2 Design Flood Conditions

Having established appropriate estimates of design flood flows, the TUFLOW model was simulated to derive the baseline design flood conditions for the study area. The model configuration adopted the recent riparian vegetation extents used to calibrate the June 2007 event. The design inflow hydrographs were based on the June 2007 flood hydrograph shape and scaled to match the peak flows from the FFA. A similar approach using the recorded February 1955 event hydrograph produced an almost identical hydrograph shape.

The resultant peak flood levels modelled at Singleton (Dunolly Bridge) from the design simulations are presented in Table 2-7. These are compared to the three significant historic flood event levels. The data shows that despite using reduced estimates of design flood flows the revised flood modelling typically produces flood levels around 0.4m higher for the major flood events. This is due to the significant changes in model topography and the model roughness values associated with the regrowth of riparian vegetation.

The revised design flood levels appear to be inconsistent with those recorded for the 1913 and 1955 events. However, the Singleton levee scheme has been constructed since these events and the flood levels for a given flow at Dunolly Bridge have increased as a result. The design 0.5% AEP flood flow estimate of 10 000 m^3/s is consistent with that estimated for the 1955 event (which is the generally accepted magnitude of that flood for the Hunter River). The revised flood modelling suggests that a similar flood occurring now would result in a peak flood level of around 42.7 m AHD at Dunolly Bridge – some 0.5 m higher than the 1955 recorded level of around 42.2 m AHD. This is due to the presence of the levee and the re-vegetation of the channel.

The revised design flood conditions for the study area are presented in Appendix A and formed the baseline for the subsequent flood impact assessment of the Singleton Bypass Concept Design.

Table 2-7 Comparison of Design and Historic Flood Levels

Flood Event	2015 Study (m AHD)
20% AEP	40.1
10% AEP	41.4
2007	*41.8*
1913	*41.8*
5% AEP	41.9
2% AEP	42.2
1955	*42.2*
1% AEP	42.6
0.5% AEP	42.7
0.2% AEP	42.9
Extreme	44.0

2.6.3 Very Rare to Extreme Flood Events

The estimation of very rare and extreme flood events requires extrapolation beyond those typically derived from an FFA. Appropriate peak design flows for the 0.05% AEP and Extreme events were therefore assessed using the information presented in Figure 2-5.

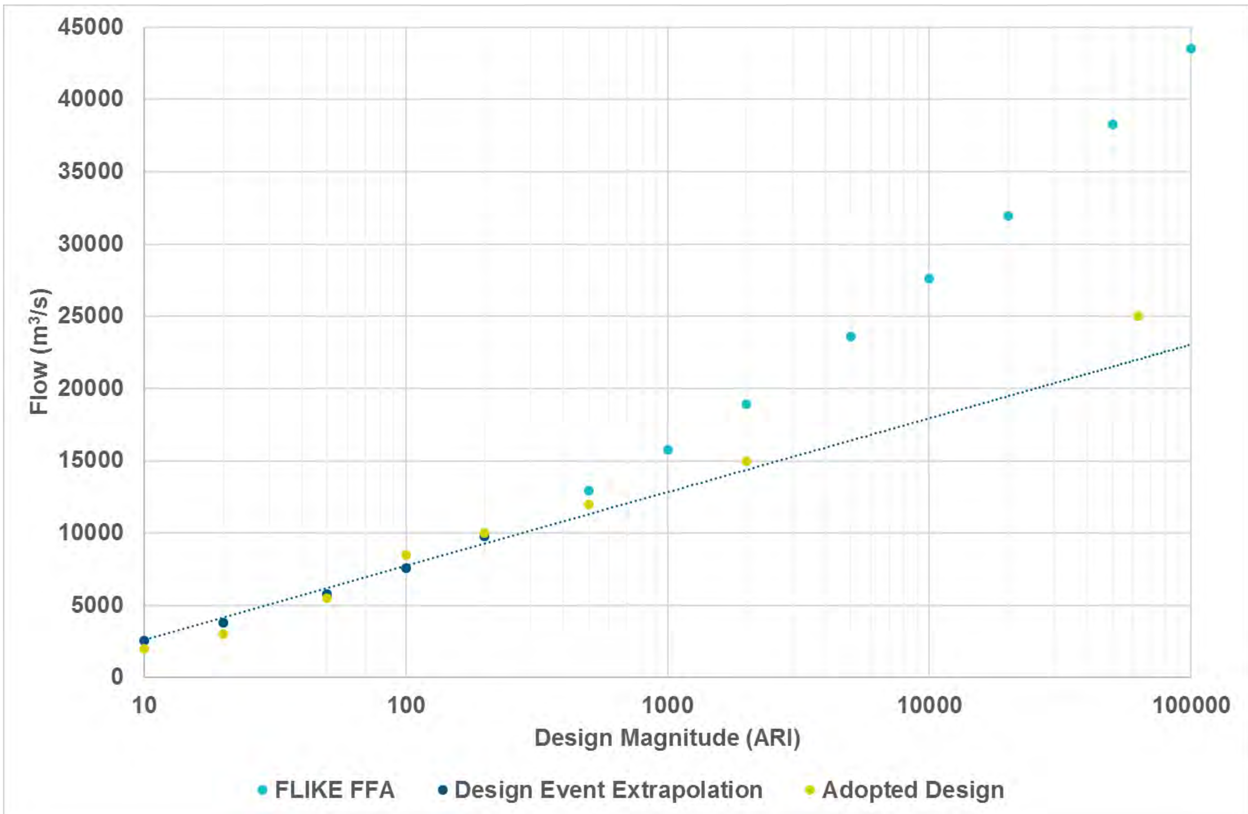


Figure 2-5 Estimation of Very Rare to Extreme Events

From guidance provided in ARR 2016, the expected AEP of the Probable Maximum Flood (PMF) event for a catchment area similar to that of the Hunter River at Singleton is approximately 0.0016% (or a 62 500-year ARI). The estimated peak flow for an event of this rarity from the FLIKE FFA is around 40 000 m^3/s. The estimation of the PMF event for large catchments is highly uncertain. However, Extreme event magnitudes for large river catchments are often represented through the adoption of a peak flow of three times the 1% AEP event, which is around 25 000 m^3/s.

For the Singleton Bypass Concept Design Assessment an Extreme flood event condition with a peak flow of 25 000 m^3/s has been adopted, with a peak flow of 15 000 m^3/s being adopted for the 0.05% AEP condition.

3 Existing Conditions and Constraints

3.1 Existing Conditions

The establishment of existing design flood conditions provides for description of the:

- General flood behaviour throughout the study area;
- Existing flooding conditions based on design flood events; and
- Constraints and limitations along potential routes with respect to flooding regimes.

Design flood modelling results are shown for the 20% AEP, 10% AEP, 5%, AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP, 0.05% AEP and Extreme flood events in Appendix A, and are used as a baseline for the assessment of the Concept Design in Section 4. Table 3-1 summarises the peak flood levels for those events (the reporting locations are noted on Figure 3-1).

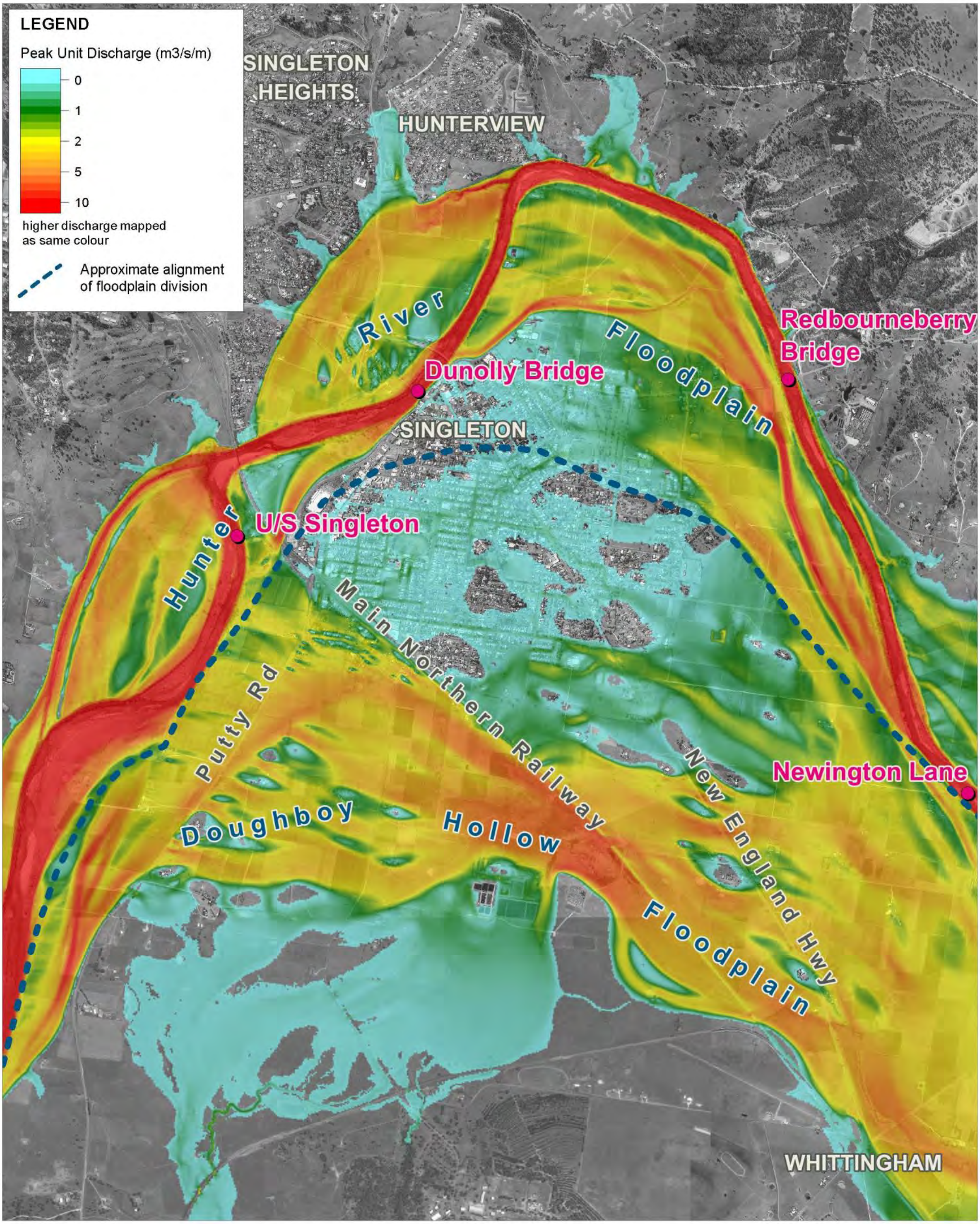
Table 3-1 Peak Design Flood Levels at Selected Locations

Design Flood Event	Peak Flood Level (m AHD)			
	U/S Singleton Gauge	Dunolly Bridge	Redbourneberry Bridge	Newington Lane
20% AEP	40.7	40.1	38.3	36.9
10% AEP	42.1	41.4	39.1	37.7
5% AEP	42.7	41.9	39.7	37.9
2% AEP	43.2	42.2	40.1	38.3
1%AEP	43.8	42.6	40.5	38.7
0.5% AEP	44.1	42.7	40.7	39.0
0.2% AEP	44.4	42.9	41.0	39.3
0.05% AEP	44.8	43.1	41.4	39.8
Extreme	46.1	44.0	43.1	42.3

Peak flood velocities of between 2 m/s and 4 m/s are typical in the Hunter River while floodplain flows (e.g. through Doughboy Hollow) of between 0.5 m/s and 1.5 m/s are typical.

While design flood behaviour for the study area is similar to that previously reported by WBM (2003), the following differences in flood level and extent should be noted:

- Revised model predicts flood levels of up to 0.5 metres greater than the 2003 Singleton flood model at some locations;
- The controlling influence of floodplain topography and levee banks on flood levels is modelled more accurately with the revised 2018 flood model than the earlier 2003 flood model;
- The representation of channel roughness in the 2018 model is more representative of the current state of riparian vegetation; and
- The FFA has been updated accounting for the recent changes in gauging site rating curves.



Title:

Singleton 1% AEP Flood Flow Distribution

Figure: 3-1

Rev: A

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3.2 Flooding Constraints

The Singleton Flood Study (WBM, 2003) describes the flooding mechanisms for the study area. Both the Main Northern Railway Line and New England Highway bisect the natural path of major flood flows conveyed through Glenridding and Doughboy Hollow floodplains. The Singleton flood levee along the riverbank, which was constructed initially in 1963 and extended in 1982-1983 and again in 1987, is not overtopped by floods up to and including the 1% AEP event. This is not surprising, as the levee was built to withhold flooding similar to that experienced in 1955.

However, the 2003 flood study and updated 2018 results indicate that flooding by the 1% AEP event would overtop the Main Northern Railway Line in the vicinity of John Street South and the railway station, resulting in extensive inundation of residential properties. Also, there is a significant damming effect by the railway embankment and a small ridge adjacent to the Wastewater Treatment Works that results in deep flooding in the Doughboy Hollow floodplain, and increases the likelihood of overtopping of the Main Northern Railway line and subsequent flooding of the township.

Across the broader floodplain area, the New England Highway currently experiences a level of flood immunity somewhere between the 10% AEP and 5% AEP. To reduce the potential adverse flood impacts on the Singleton township and surrounding properties resulting from the construction of potential bypass routes, mitigation measures aimed at maintaining the current level of flood immunity have been investigated. An assessment of the Singleton Bypass Concept Design (including the potential impacts, performance of the design and identified flood mitigation requirements) are outlined in Section 4.

An overview of the baseline flood behaviour is presented in Figure 3-1, which provides mapping of the spatial concentration of flood flows. It indicates the two main flow path alignments:

- the Hunter River channel and adjacent floodplain flowing around the northern side of Singleton; and
- the Doughboy Hollow floodplain, which breaks away from the Hunter River at Glenridding and flows around the southern side of Singleton, before combining with the Hunter River floodplain again at Whittingham.

4 Assessment of the Singleton Bypass Concept Design

The construction of a road embankment across a floodplain can potentially increase flood levels, re-distribute flows, increase inundation times and increase velocities. These impacts need to be minimised, especially in populated areas and in areas of agricultural or environmental significance. It is also important that an economically viable solution is achieved.

Flood mitigation and/or design modifications that may be required to achieve the selected design criteria are summarised Section 4.1. The flood impacts and performance of the potential bypass route options is presented in Section 4.2.

4.1 Flood Mitigation and Design Modification

A reasonable understanding of bridge structure extents was gained through the Singleton Bypass Strategic Design Flood Assessment. The initial 20% Concept Design therefore required no significant modifications to mitigate flood impacts.

The Strategic Design options (including preferred Option B) were developed with consideration of a number of constraints, including:

- Required flood immunity of 1% AEP for the bridge structures and 5% AEP for the approach roads;
- The objective to target a minimal impact on flooding;
- The need for the road to tie-in with the existing network at either end of the bypass and additional potential intersection locations; and
- The need to minimise the cost associated with the road construction to maximise the associated benefit cost ratio.

However, several modifications were made to the Option B Strategic Design by the design team during the development of the 20% Concept Design, which required the assessment of flood impacts. The modifications to the previously assessed Strategic Design include:

- Separation of the Hunter River bridge section from the broader Doughboy Hollow floodplain viaduct, with the bypass to be on embankment for a 350 m length between the Hunter River and Putty Road;
- The relocation of the Putty Road interchange in relation to the above, with the on/off ramps being close to current grade, rather than on bridge structures;
- A minor relocation of the southern abutment of the Doughboy Hollow floodplain viaduct; and
- A minor reconfiguration of the southern interchange.

4.2 Potential Impacts

4.2.1 Overview

The Concept Design model was simulated for the 20% AEP to 0.2% AEP design flood event range (the results of which are presented in Appendix B) and compared to simulations of existing conditions, providing for a relative assessment of the potential impacts and performance of the bypass design.

Potential impacts that can be quantified through the modelling include:

- Changes in peak flood level within the study area;
- Increases in velocity and scour potential;
- Increase in flood hazard; and
- Identification of adjacent property that may be adversely impacted by changed flooding behaviour.

The performance of the Concept Design can also be considered in terms of:

- Flood immunity level;
- Relative timing of overtopping; and
- Duration of inundation.

4.2.2 Changes in Peak Flood Level

Appendix C contains flood impact mapping in terms of change in peak flood level from existing conditions to the modelled Concept Design. Seven design flood magnitudes – the 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP and 0.2% AEP design events are presented, which include the events to satisfy OEH requirements for the Review of Environmental Factors.

At the 20% AEP event there are no significant impacts on the modelled peak flood levels due to the minimal extent of out-of-bank flooding and the bridging of the Hunter River. At the 10% AEP event some impacts on the modelled peak flood levels have been identified at the proposed Putty Road intersection. However, the impacts are minor and localised and would be unlikely to impact on existing property.

At the 5% AEP event the proposed Putty Road interchange has resulted in a minor redistribution of flood flows between the Hunter River and Doughboy Hollow floodplain alignments. This results in localised increases in modelled peak flood levels. However, no dwellings appear to be impacted by more than a 0.02 m increase.

At the 2% AEP event the flood impacts near the Putty Road interchange are reduced in extent and magnitude from those of the 5% AEP. The floodplain near the southern interchange is now active and the proposed design results in some localised flood impacts. However, the impacts are localised and limited to rural property, with no impacts to any existing dwellings.

At the 1% AEP, 0.5% AEP and 0.2% AEP events the flood impacts near the southern interchange increase in extent and magnitude with increased flood event rarity. Much of the area local to the interchange would be acquired by RMS for the construction and operation of the Singleton By-pass and therefore, adverse effects to property in this area would be limited. However, at the 0.5% AEP and 0.2% AEP events the impacted area extends across parts of the city of Singleton and steps should be taken to reduce these impacts through mitigation works.

There is the potential to reduce the modelled flood impacts through a combination of the following design modifications:

- Relocation of the southern abutment of the Doughboy Hollow floodplain viaduct eastwards towards the southern interchange;
- Angling of the southern abutment to modify the flood flow distribution through deflecting flood waters around the southern side of the bypass embankment, rather than to the north;
- Provision of cross-drainage culverts through the southern interchange offramp embankment and/or the bypass embankment between the viaduct and southern interchange.

4.2.3 Changes in Peak Flood Velocity and Scour Potential

Appendix D presents simulated changes in peak flood velocity distribution associated with the Concept Design for the range of modelled design events. In general, the mapping shows that changes in floodplain velocity distribution is relatively localised for all design events considered. The main exception to this is around the southern interchange during rare to very rare flood event magnitudes. These impacts would be reduced through mitigation works considered to reduce the modelled peak flood level impacts, as discussed in Section 4.2.2.

Whilst there is no general change across broader floodplain areas, there are localised increases/decreases in peak flow velocity associated with the redistribution of flow driven by the proposed embankments and location of the provided cross drainage.

Localised increases in peak flow velocity of around 0.5 – 1m/s are simulated in some locations. These generally coincide with locations of the waterway openings, which tend to concentrate the flow and accordingly accommodate higher flow velocities. In the design of all structures, it would be expected that scour potential and requirement for scour protection works would be addressed later in the concept and detailed design phases.

Localised velocity increases are also noted across the road embankments at overtopping locations. Whilst a 5% AEP flood immunity level has been assumed for the road alignments, at higher flood events such as the 1% AEP some extensive overtopping of some sections may occur. Associated with this overtopping are higher velocities generated across the embankments.

4.2.4 Other Impacts

This flood impact assessment has considered mainstream flooding of the Hunter River. At other locations where the proposed bypass alignment traverse creeks and gully lines, local cross-drainage will need to be sized and constructed accordingly by the AECOM road design team.

Currently the duration of flooding varies from event to event. Given the extensive contributing catchment to the Hunter River at Singleton, major flood events typically last for a few days. Whilst potentially not directly impacted by on-site floodwater, evacuation of the Singleton CBD area under major flood conditions may require closure of the centre for a few days until peak floodwaters subside. Presently access routes are expected to be closed for a few days in major flood events. The bypass design does not impact the overall duration of flood inundation, but potentially changes localised drainage following the recession of a flood. The bypass can benefit the community by providing additional flood evacuation routes and local accessibility during a flood event.

5 Conclusion

The Singleton Bypass Concept Design (20%) Flood Assessment Report documents the existing flooding conditions in the study area and the likely flood impacts of the proposed bypass. The assessment represents a Concept Design level assessment of the proposed Singleton Bypass in terms of potential impact on existing Hunter River flood conditions and bridge structure requirements to minimise adverse flood impact.

The existing design flood conditions for a range of flood event magnitudes are presented in Appendix A through a flood mapping series, incorporating peak flood extents, levels, depth and velocity distribution. The impact of the proposed bypass alignment and adopted bridge structure configuration was presented in terms of relative change from the existing peak flood level and velocity distribution, as presented in Appendix C and Appendix D respectively.

There is the potential to reduce the modelled flood impacts through a combination of the following design modifications:

- Relocation of the southern abutment of the Doughboy Hollow floodplain viaduct eastwards towards the southern interchange;
- Angling of the southern abutment to modify the flood flow distribution through deflecting flood waters around the southern side of the bypass embankment, rather than to the north;
- Provision of cross-drainage culverts through the southern interchange offramp embankment and/or the bypass embankment between the viaduct and southern interchange.

Further refinement of Concept Design (20%), incorporating minor alterations and provision of additional local cross-drainage can be readily assessed with the existing models to further assist the subsequent design phases.

6 References

Gallant, J.C., Dowling, T.I., Read, A.M., Wilson, N., Tickle, P., Inskeep, C. (2011) 1 second SRTM Derived Digital Elevation Models User Guide. Geoscience Australia www.ga.gov.au/topographic-mapping/digital-elevation-data.html.

WBM, 2003. Singleton Flood Study, Final Draft Report prepared for Singleton Shire Council, May 2003.

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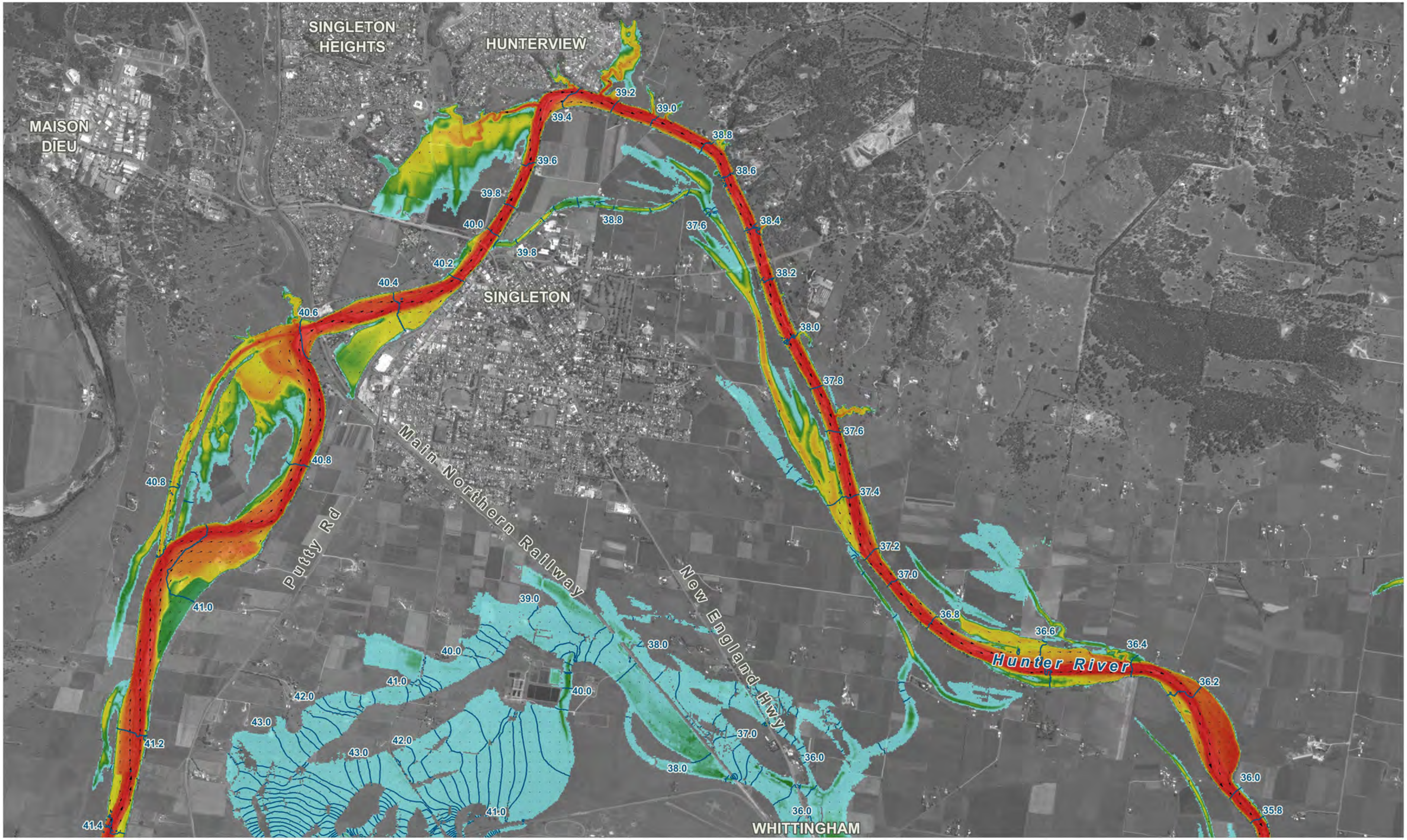
Appendix A Existing Design Flood Mapping



LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Title:

Singleton Bypass Concept Design Flood Assessment
Existing - 20% AEP Modelled Peak Flood Conditions

Figure: A-1

Rev: A

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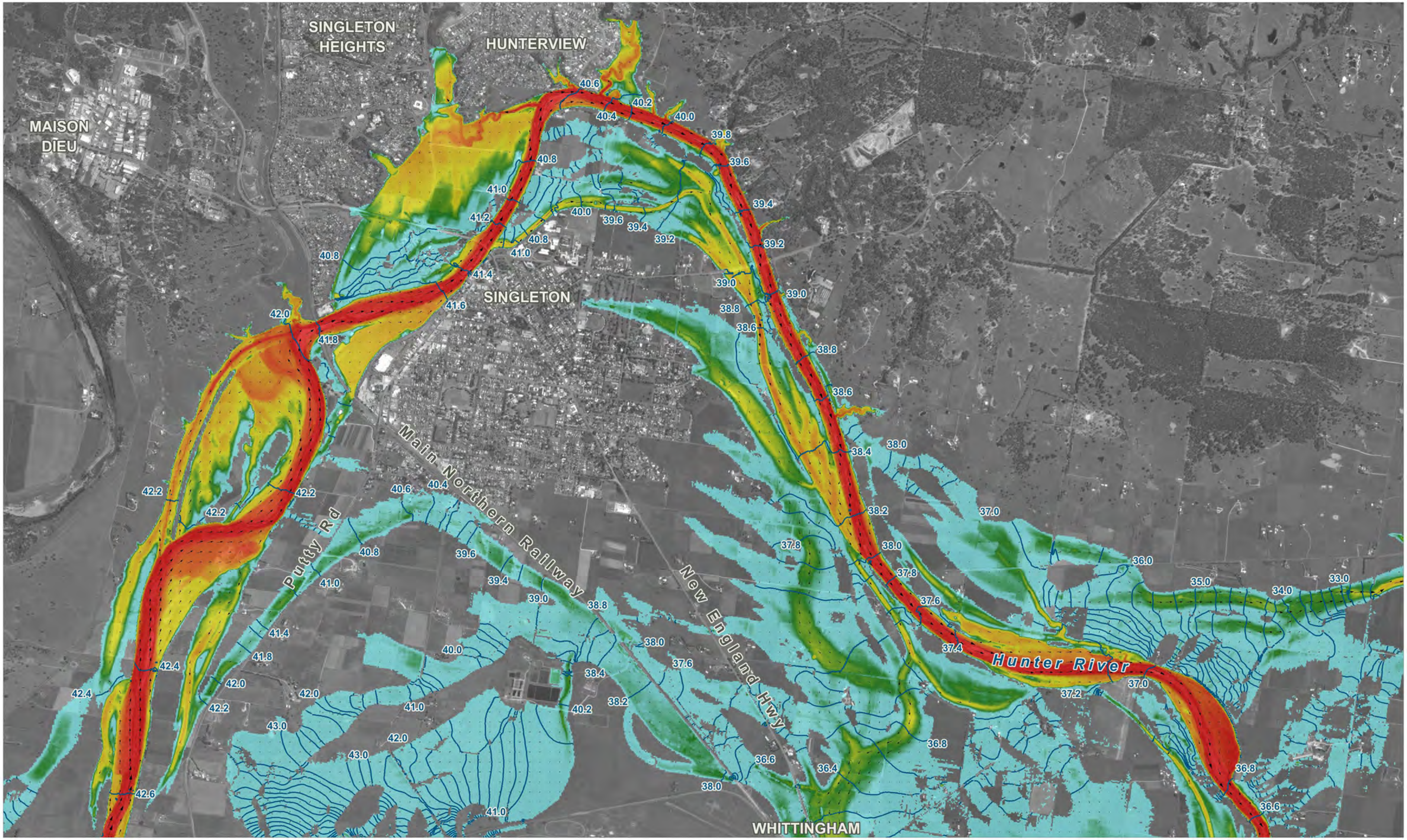

LEGEND

Peak Flood Depth (m)
- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)
Scale: 1mm = 0.5m/s @A3
- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Title:
Singleton Bypass Concept Design Flood Assessment
Existing - 10% AEP Modelled Peak Flood Conditions

Figure: **A-2**

Rev: **A**

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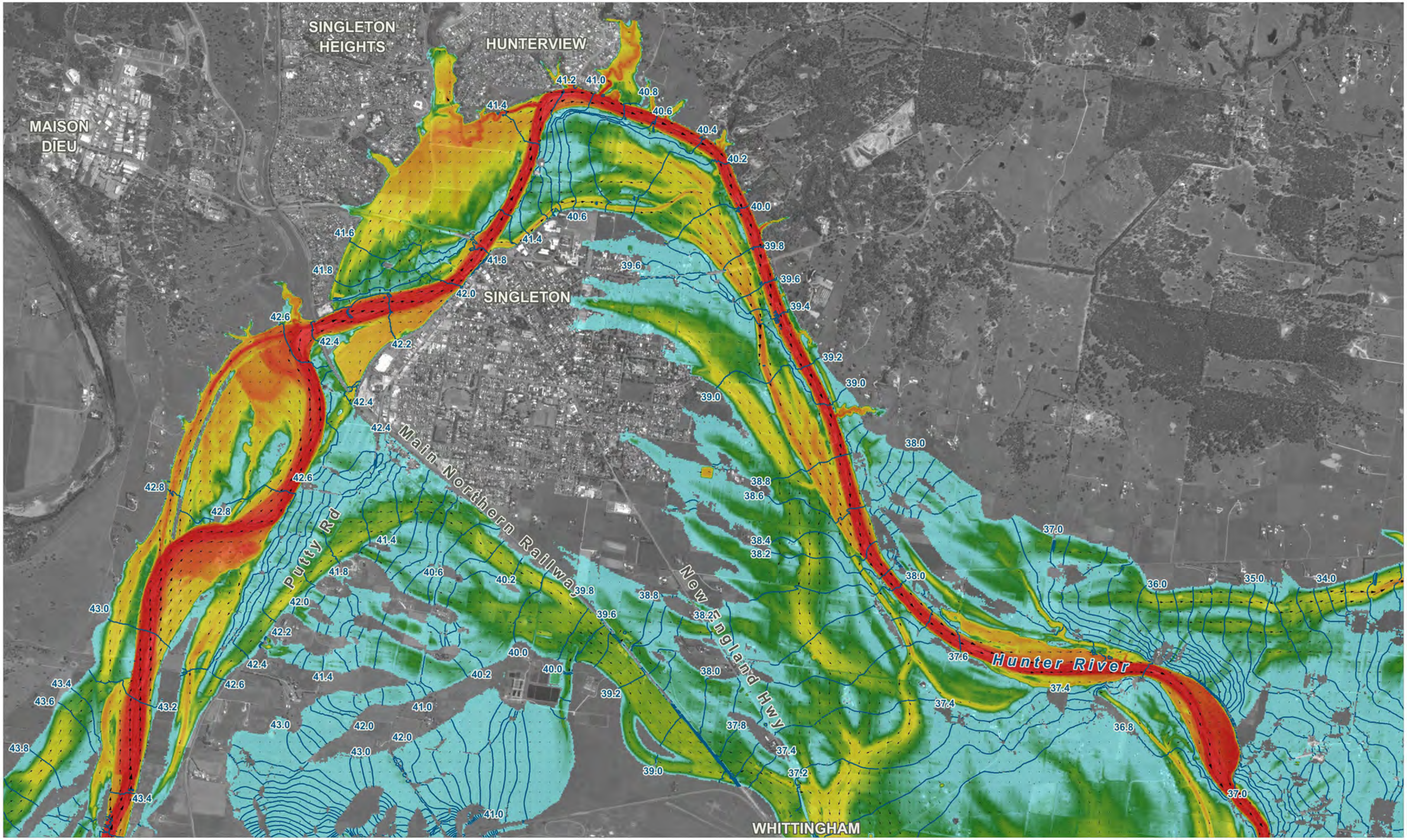

LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Title:

Singleton Bypass Concept Design Flood Assessment
Existing - 5% AEP Modelled Peak Flood Conditions

Figure: **A-3**

Rev: **A**

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Approx. Scale

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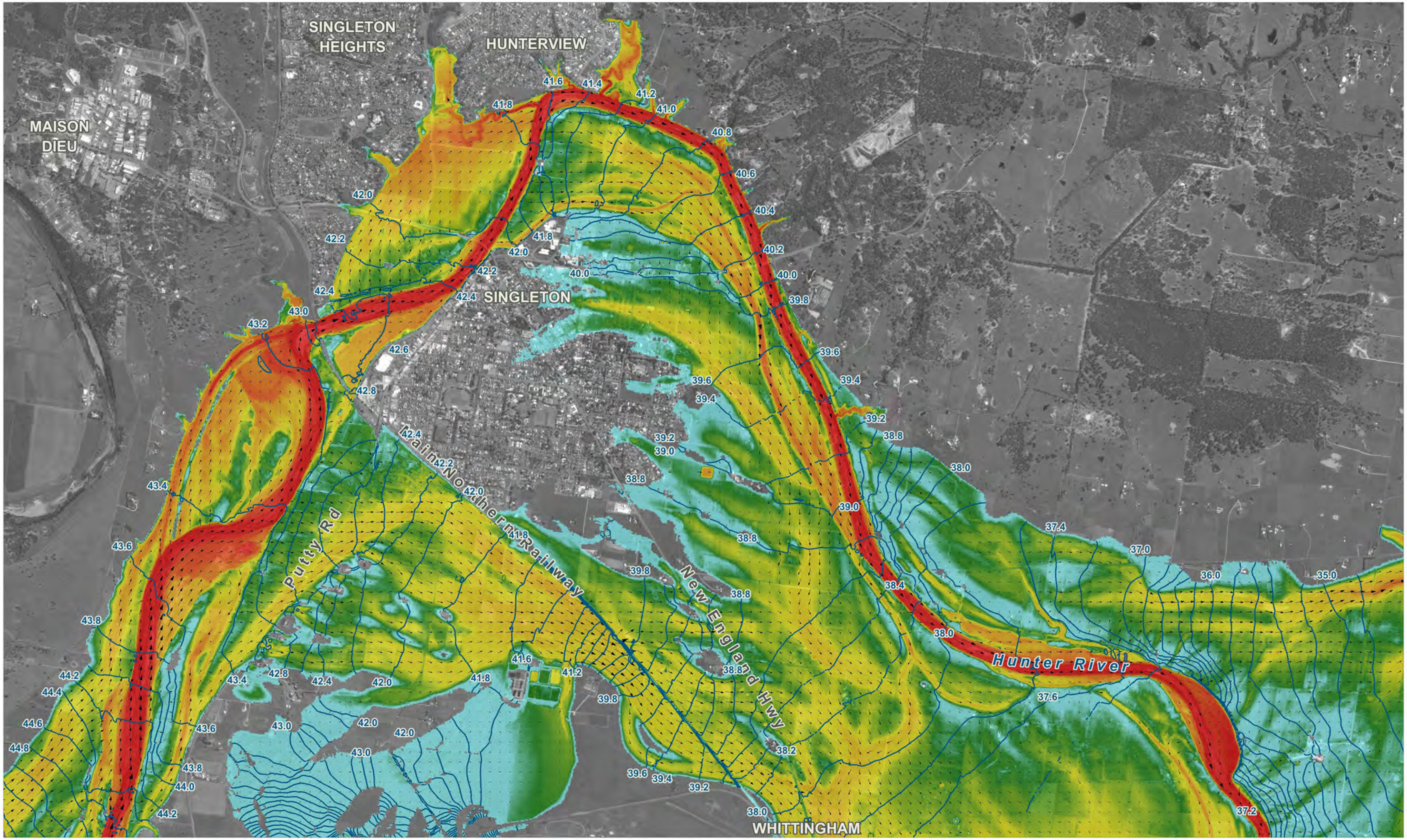

LEGEND

Peak Flood Depth (m)
- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)
Scale: 1mm = 0.5m/s @A3
- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Title:
Singleton Bypass Concept Design Flood Assessment
Existing - 2% AEP Modelled Peak Flood Conditions

Figure: **A-4**

Rev: **A**

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N

0 0.5 1km
Approx. Scale

BMT
www.bmt.org

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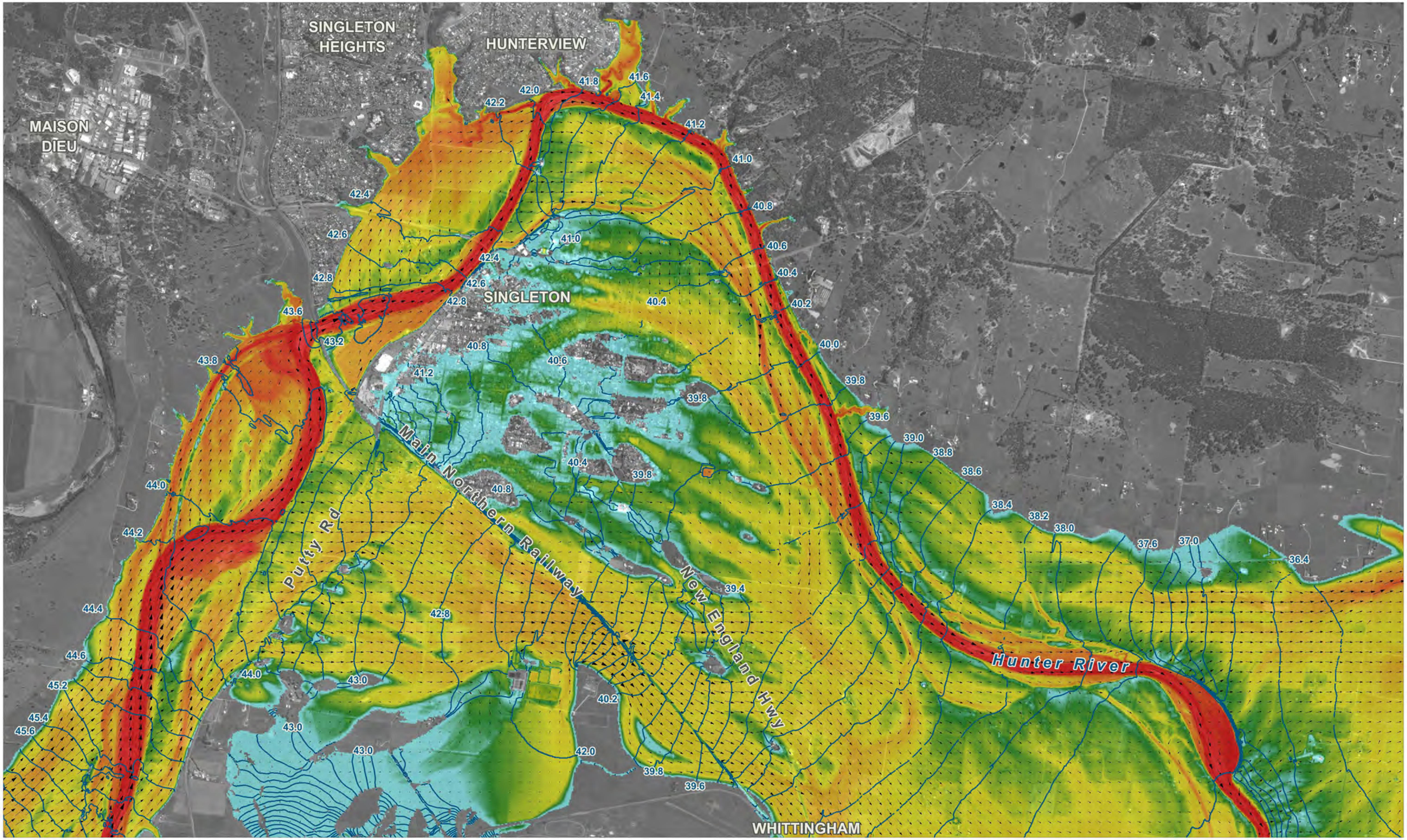

LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Title:

Singleton Bypass Concept Design Flood Assessment
Existing - 1% AEP Modelled Peak Flood Conditions

Figure: A-5

Rev: A

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

N

0 0.5 1km

Approx. Scale

BMT
www.bmt.org

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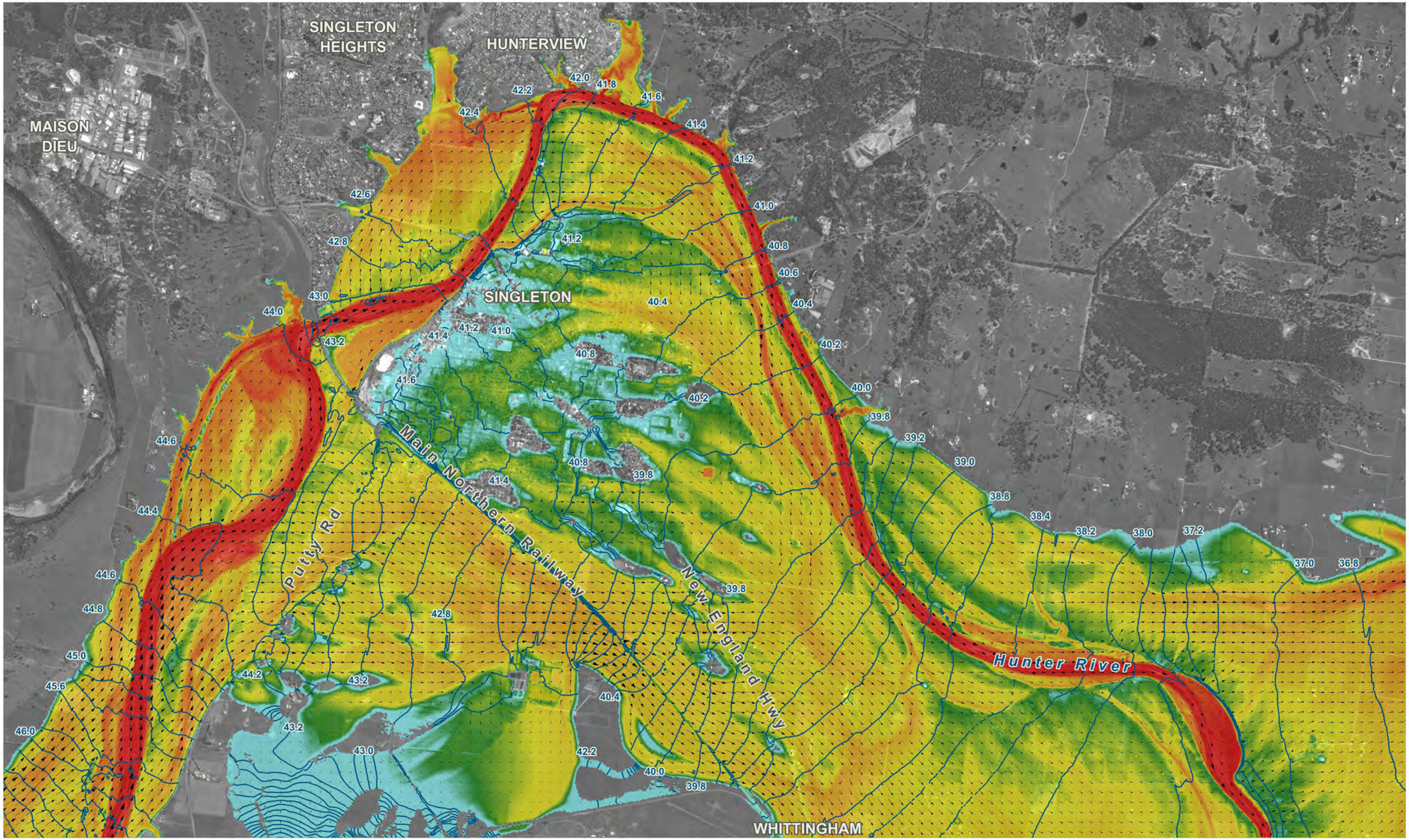

LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Title:

Singleton Bypass Concept Design Flood Assessment
Existing - 0.5% AEP Modelled Peak Flood Conditions

Figure: **A-6**

Rev: **A**

N

0 0.5 1km
Approx. Scale

BMT
www.bmt.org

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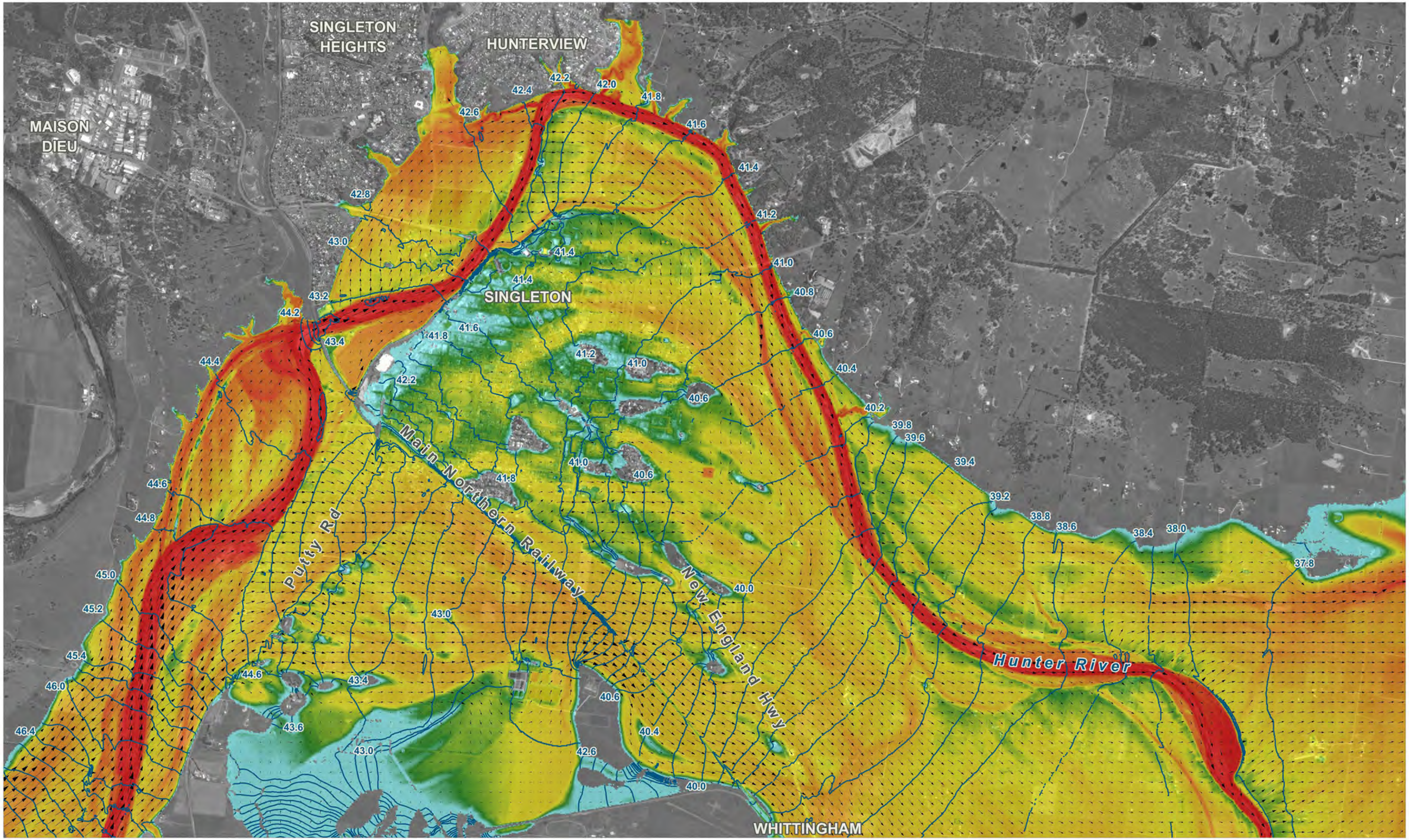


LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Title:

Singleton Bypass Concept Design Flood Assessment
Existing - 0.2% AEP Modelled Peak Flood Conditions

Figure: **A-7**

Rev: **A**

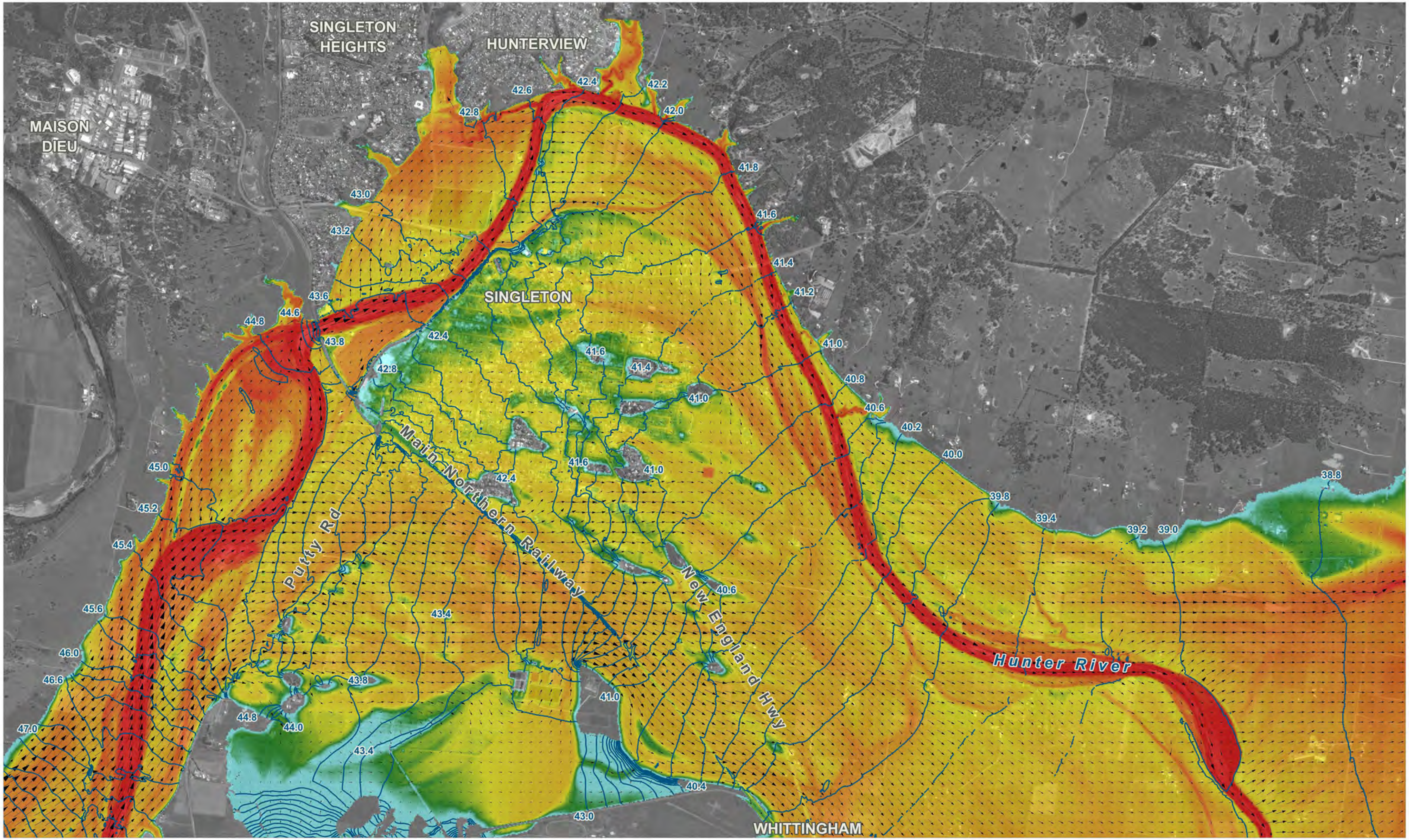
N

0 0.5 1km

Approx. Scale

www.bmt.org

Filepath: K:\N20818_Singleton_Bypass_Concept_Design_FIA\MapInfo\Workspaces\DRG_107_180510_0.2%AEP_EXG.wor



LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Title:

Singleton Bypass Concept Design Flood Assessment
Existing - 0.05% AEP Modelled Peak Flood Conditions

Figure: **A-8**

Rev: **A**

N

0 0.5 1km

Approx. Scale

BMT

www.bmt.org

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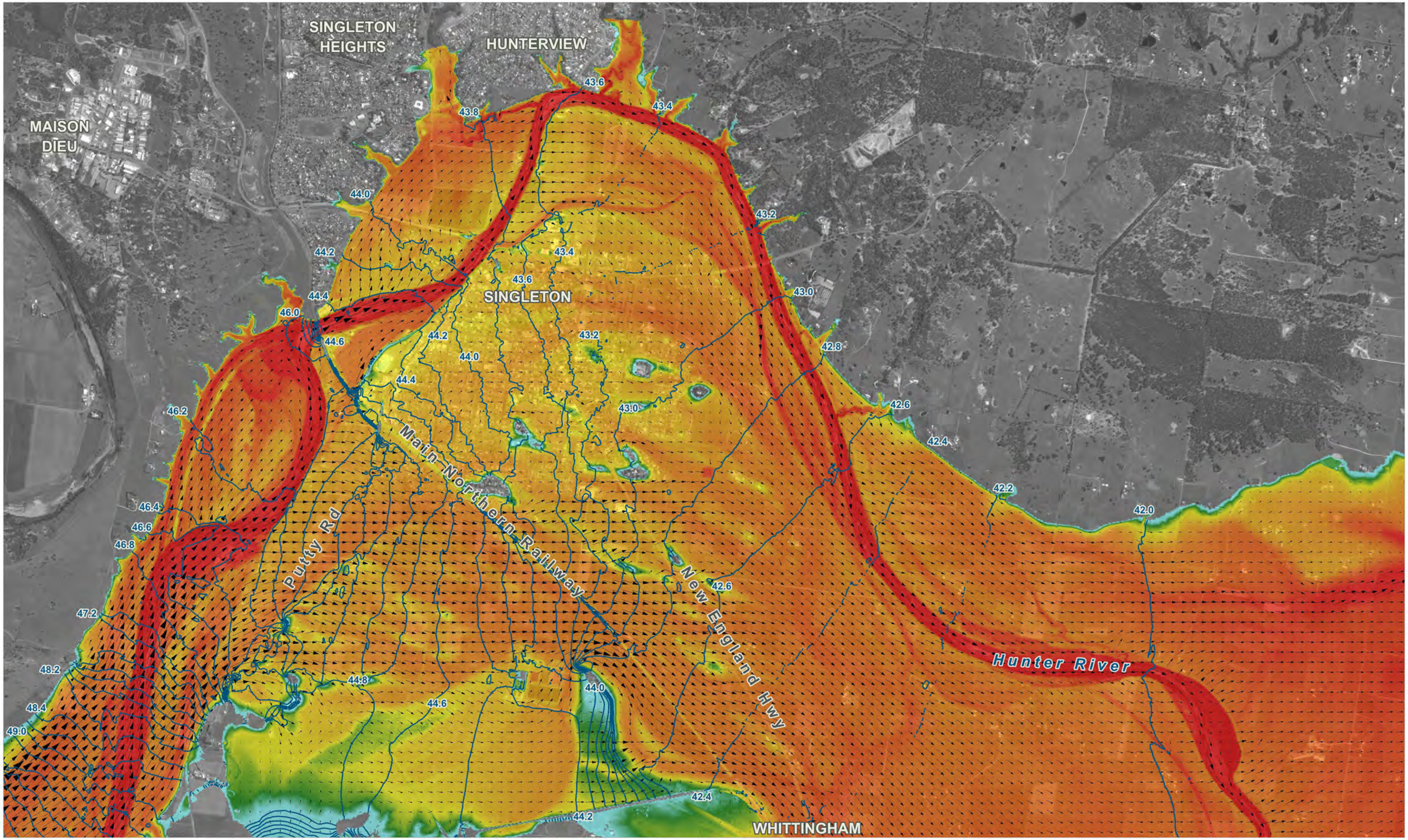

LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Title:

Singleton Bypass Concept Design Flood Assessment
Existing - Extreme Event Modelled Peak Flood Conditions

Figure: **A-9**

Rev: **A**

N

0 0.5 1km

Approx. Scale

BMT

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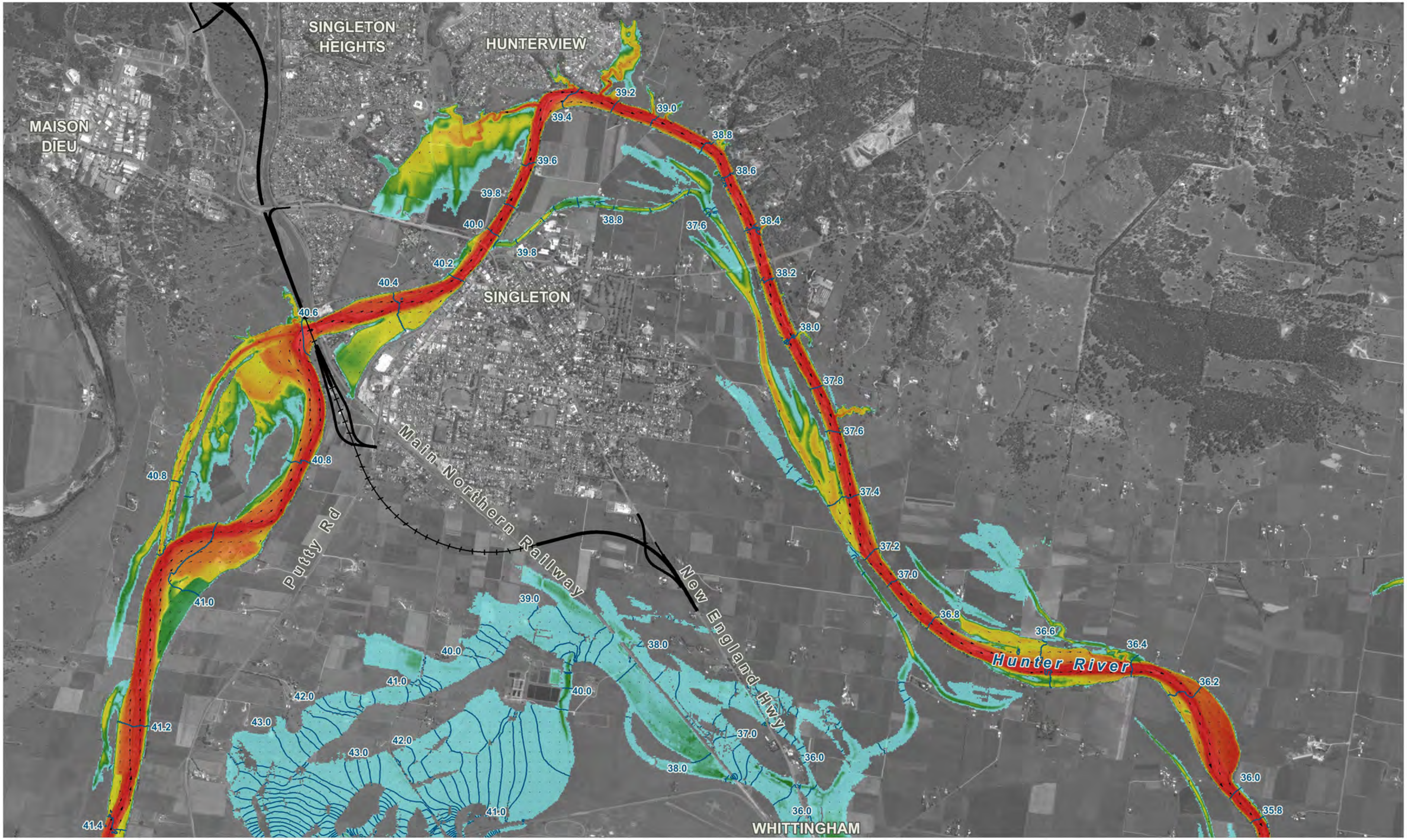
Filepath: K:\N20818_Singleton_Bypass_Concept_Design_FIA\MapInfo\Workspaces\DRG_109_180510_Extreme_EXG.wor

Appendix B Concept Design Flood Mapping



LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Bypass Alignment

Bridge Structure

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 20% AEP Modelled Peak Flood Conditions

Figure: **B-1**

Rev: **A**

N

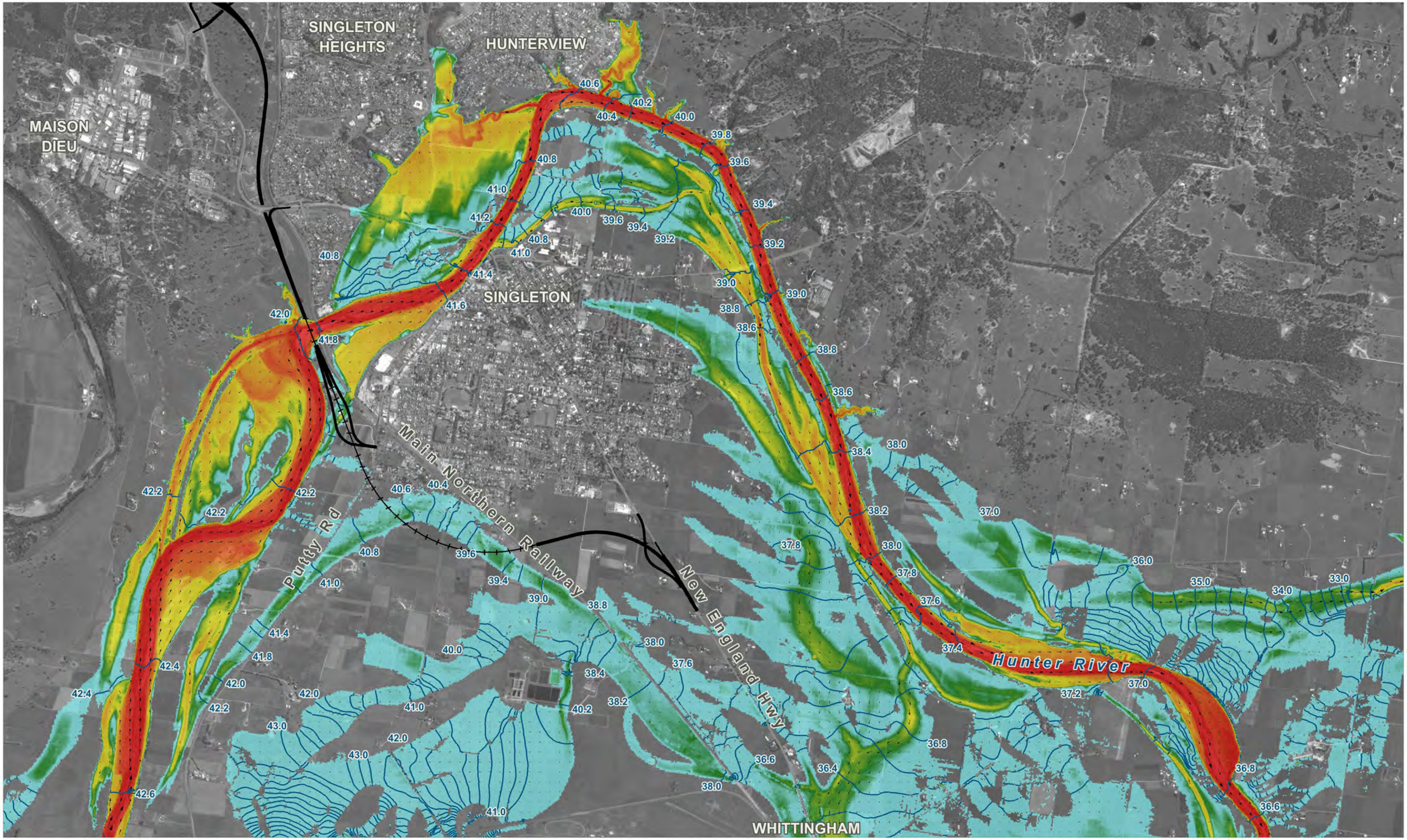
0 0.5 1km

Approx. Scale

BMT

www.bmt.org

Filepath: K:\N20818_Singleton_Bypass_Concept_Design_FIA\MapInfo\Workspaces\DRG_201_180510_20%AEP_DSN.wor



LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Bypass Alignment

Bridge Structure

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 10% AEP Modelled Peak Flood Conditions

Figure: **B-2**

Rev: **A**

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

N

0 0.5 1km
Approx. Scale

BMT
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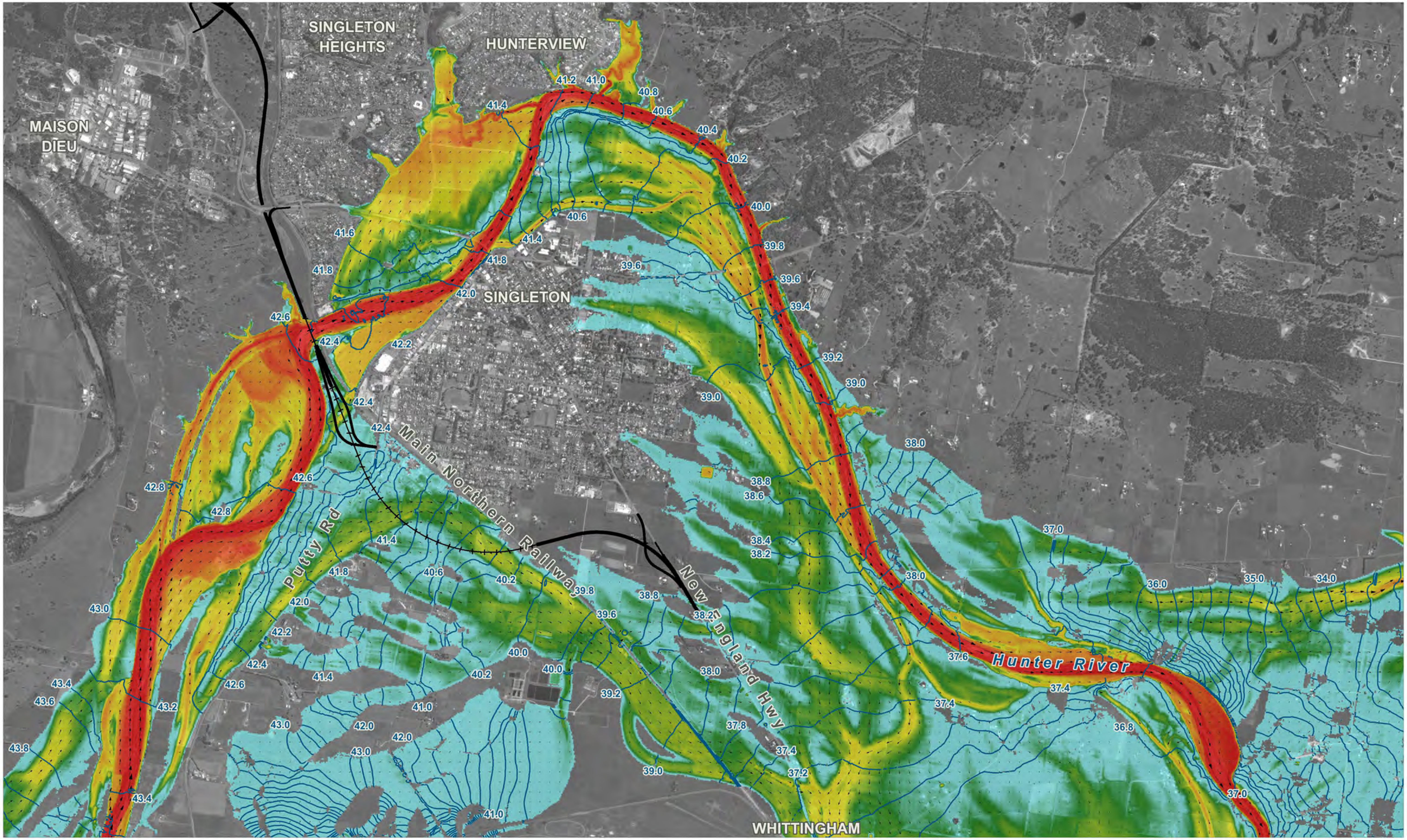

LEGEND

Peak Flood Depth (m)
- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)
Scale: 1mm = 0.5m/s @A3
- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Bypass Alignment

Bridge Structure

Title:
Singleton Bypass Concept Design Flood Assessment
20% Design - 5% AEP Modelled Peak Flood Conditions

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N

0 0.5 1km
Approx. Scale

Figure: B-3

Rev: A

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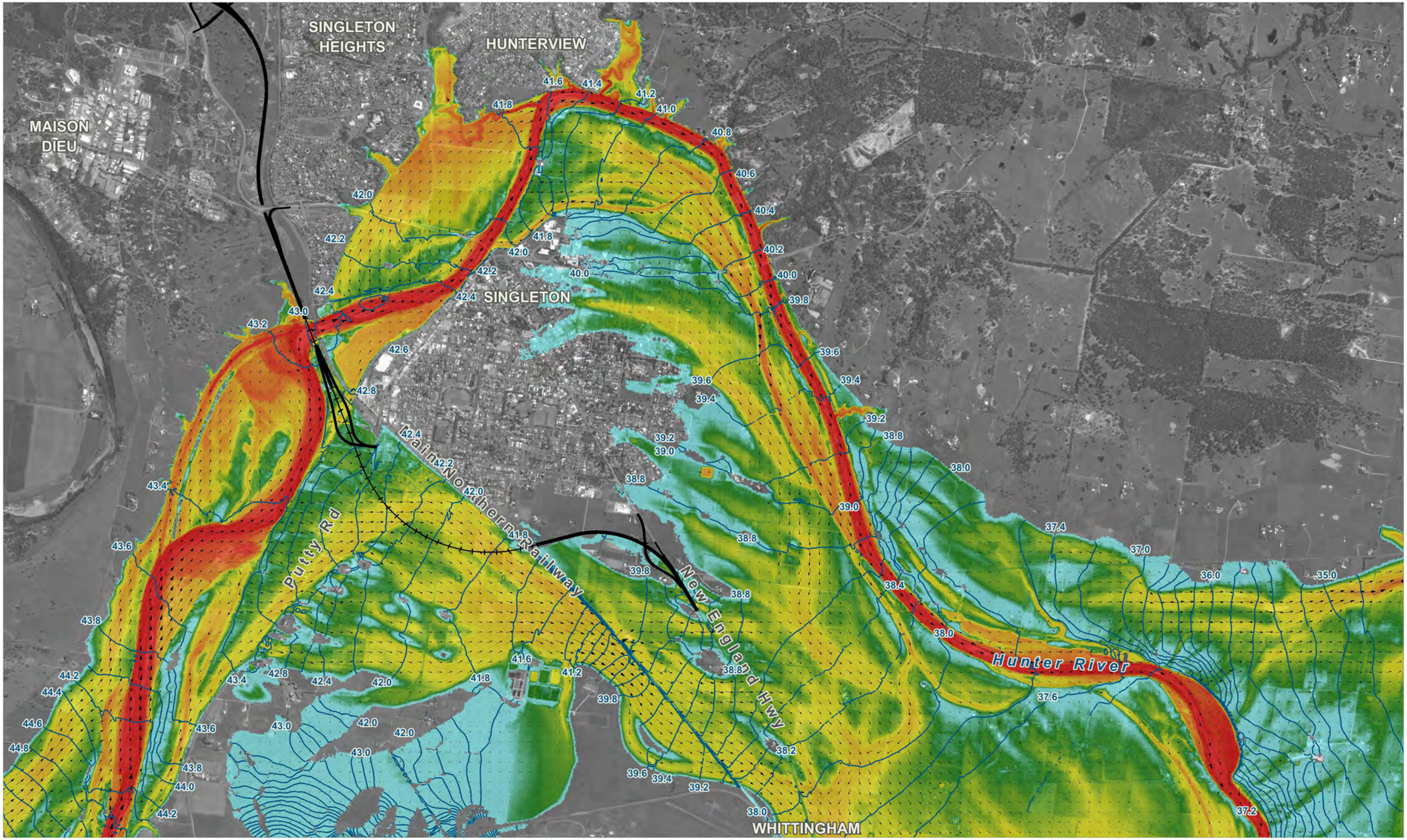

LEGEND

Peak Flood Depth (m)
- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)
Scale: 1mm = 0.5m/s @A3
- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Bypass Alignment

Bridge Structure

Title:
Singleton Bypass Concept Design Flood Assessment
20% Design - 2% AEP Modelled Peak Flood Conditions

N

0 0.5 1km
Approx. Scale

Figure: B-4

Rev: A

BMT
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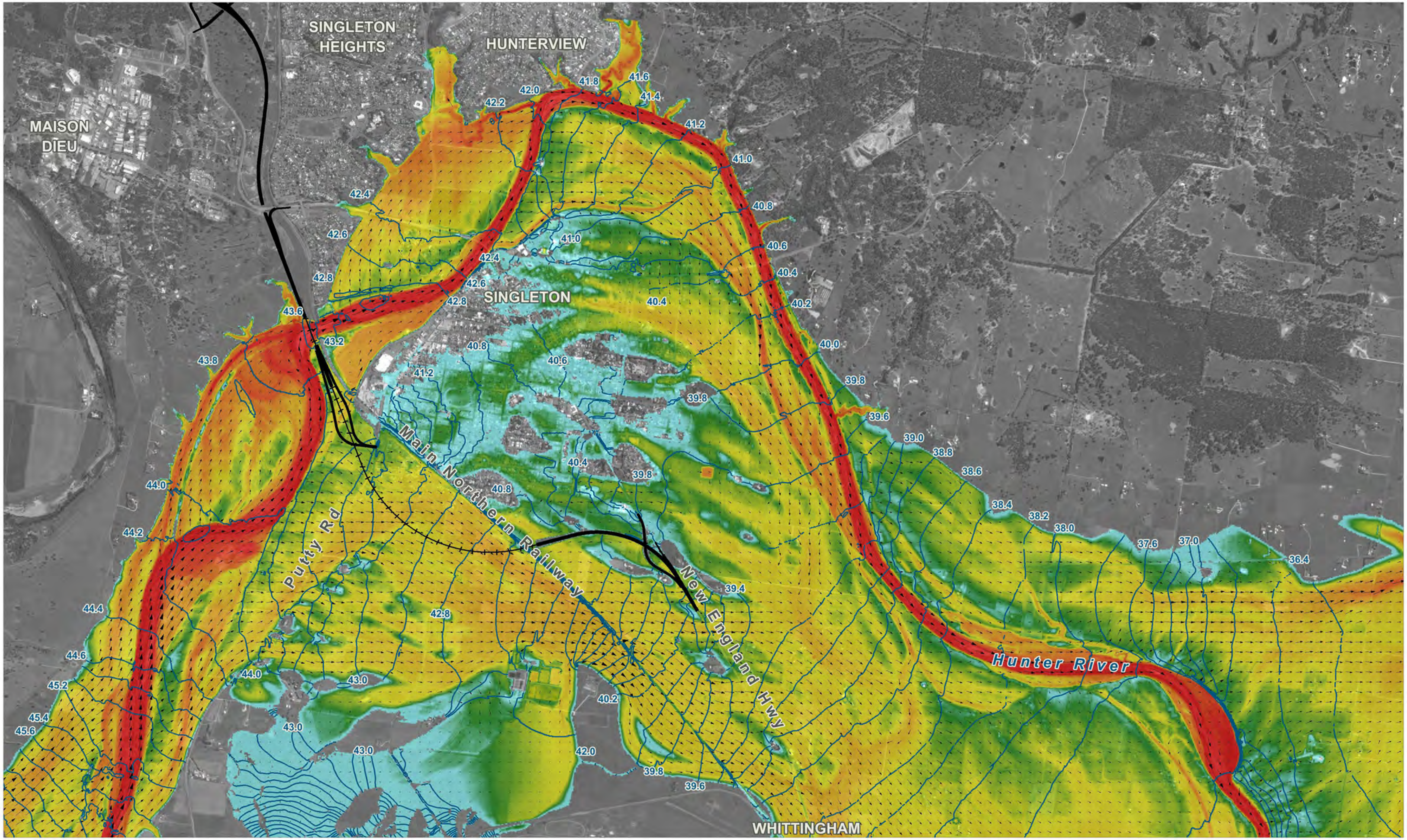

LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Bypass Alignment

Bridge Structure

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 1% AEP Modelled Peak Flood Conditions

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

N

0 0.5 1km

Approx. Scale

Figure: B-5

Rev: A

BMT

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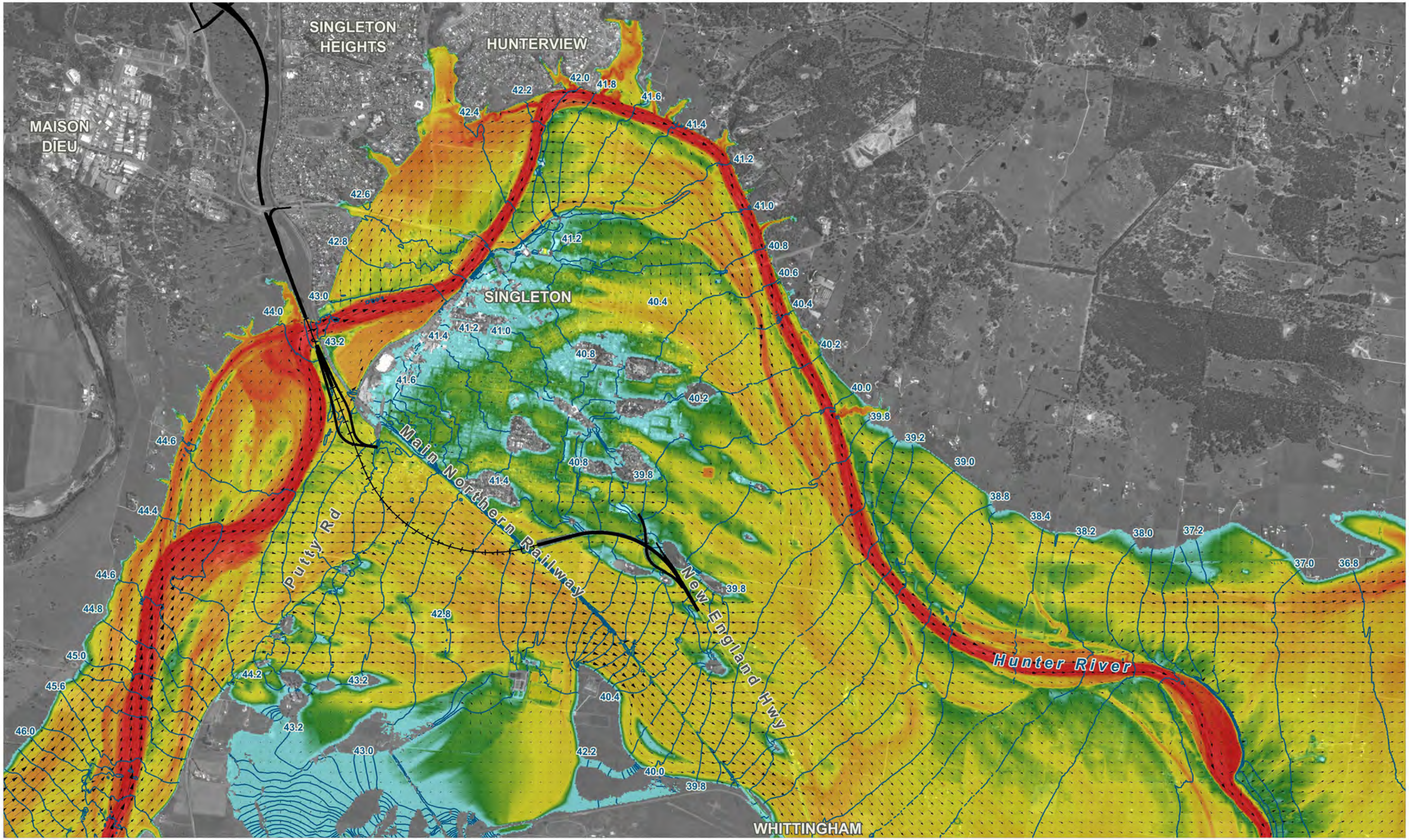

LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Bypass Alignment

Bridge Structure

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 0.5% AEP Modelled Peak Flood Conditions

Figure: **B-6**

Rev: **A**

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N

0 0.5 1km

Approx. Scale

BMT

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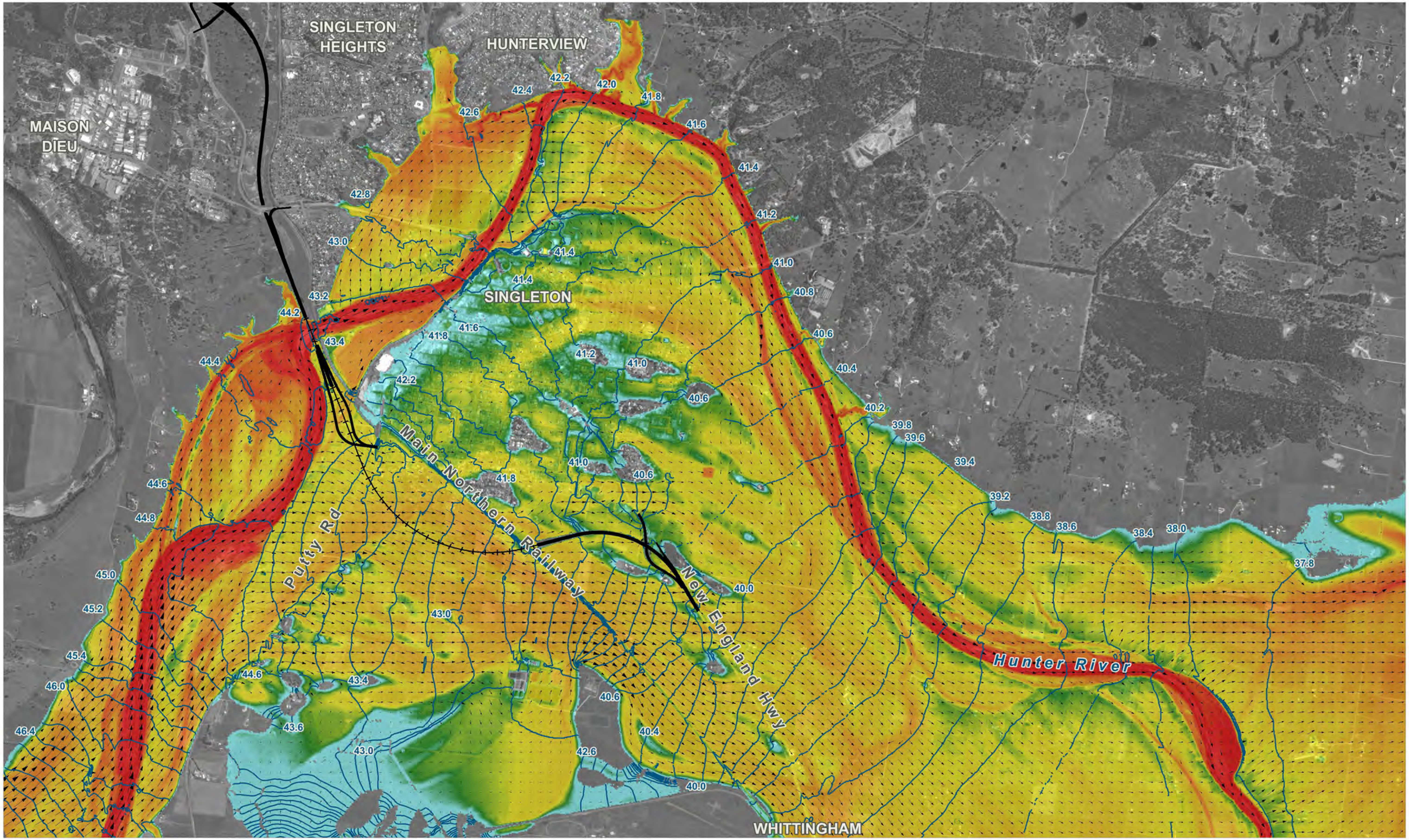

LEGEND

Peak Flood Depth (m)

- 0.5 lower depths mapped as same colour
- 1.0
- 2.0
- 5.0
- 10 higher depths mapped as same colour

Peak Flood Velocity (m/s)

Scale: 1mm = 0.5m/s @A3

- 0.5
- 1.0
- 2.0
- 3.0

20 Peak Flood Level Contours (m AHD)

Bypass Alignment

Bridge Structure

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 0.2% AEP Modelled Peak Flood Conditions

Figure: B-7

Rev: A

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N

0 0.5 1km
Approx. Scale

BMT
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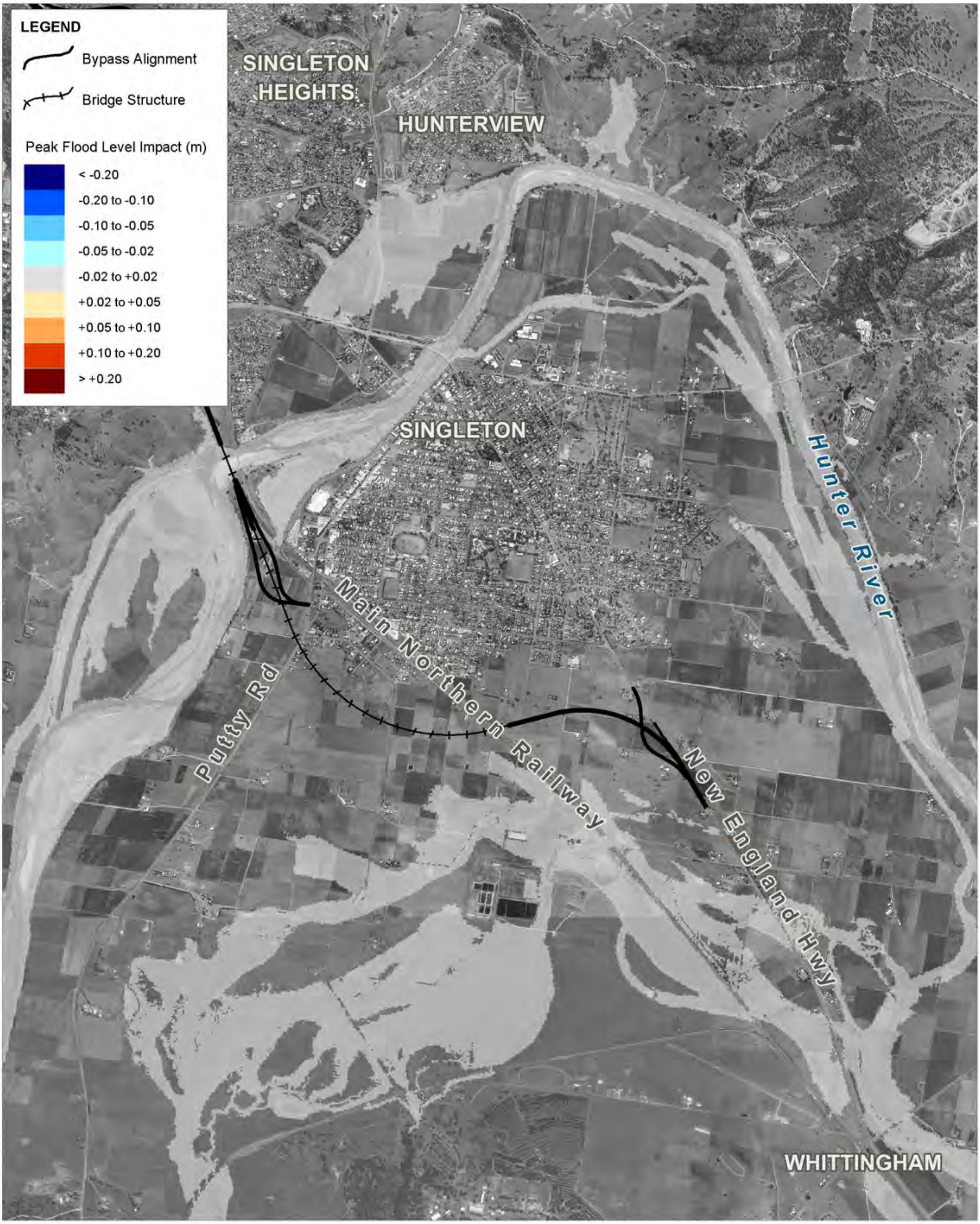
Filepath: K:\N20818_Singleton_Bypass_Concept_Design_FIA\MapInfo\Workspaces\DRG_207_180510_0.2%AEP_DSN.wor

Appendix C Concept Design Flood Level Impact Mapping



Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 20% AEP Peak Flood Level Impact

Figure: C-1

Rev: A

N

0 0.75 1.5km

Approx. Scale

BMT

www.bmt.org

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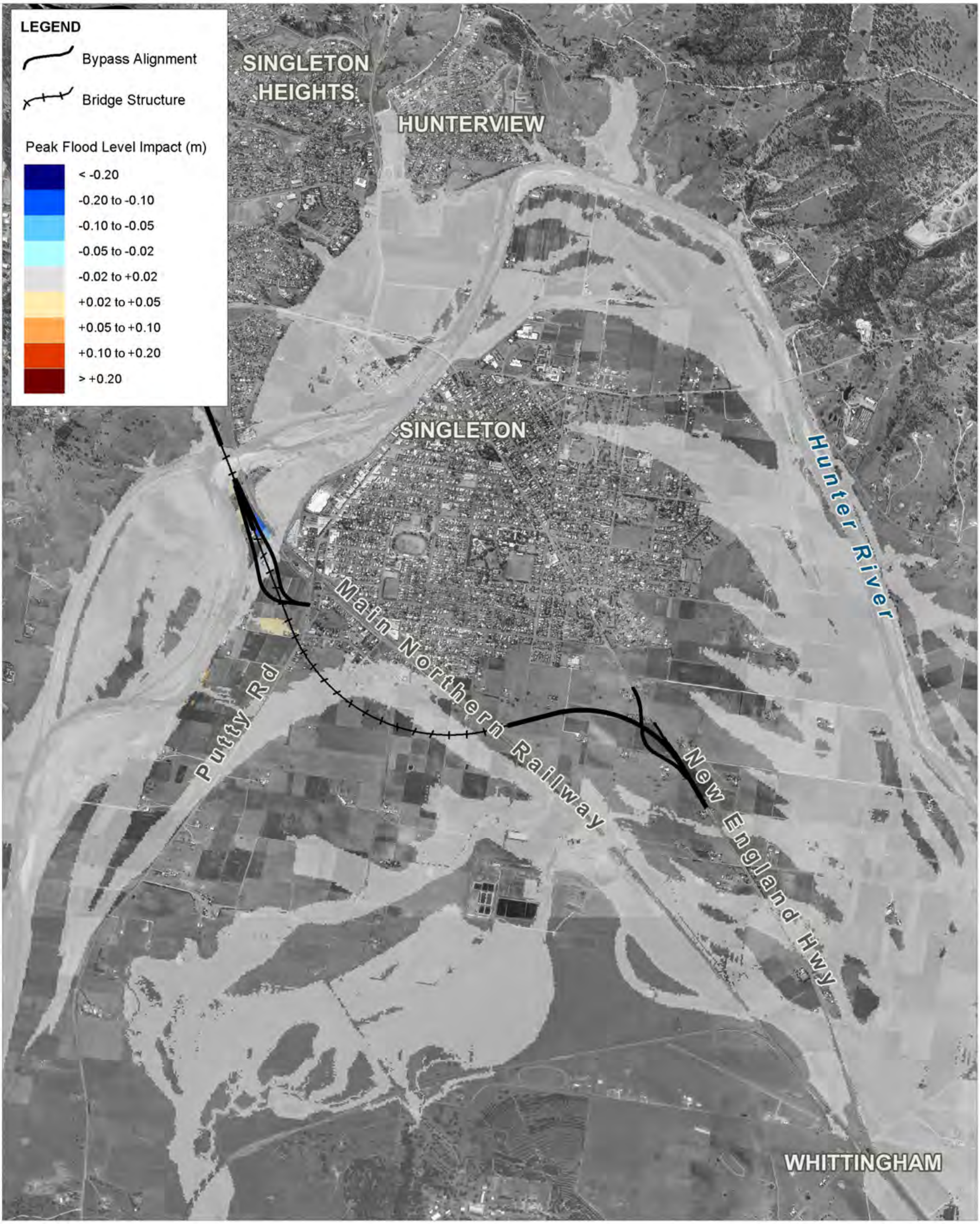

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 10% AEP Peak Flood Level Impact

Figure: C-2

Rev: A

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

N

0 0.75 1.5km

Approx. Scale

BMT

www.bmt.org

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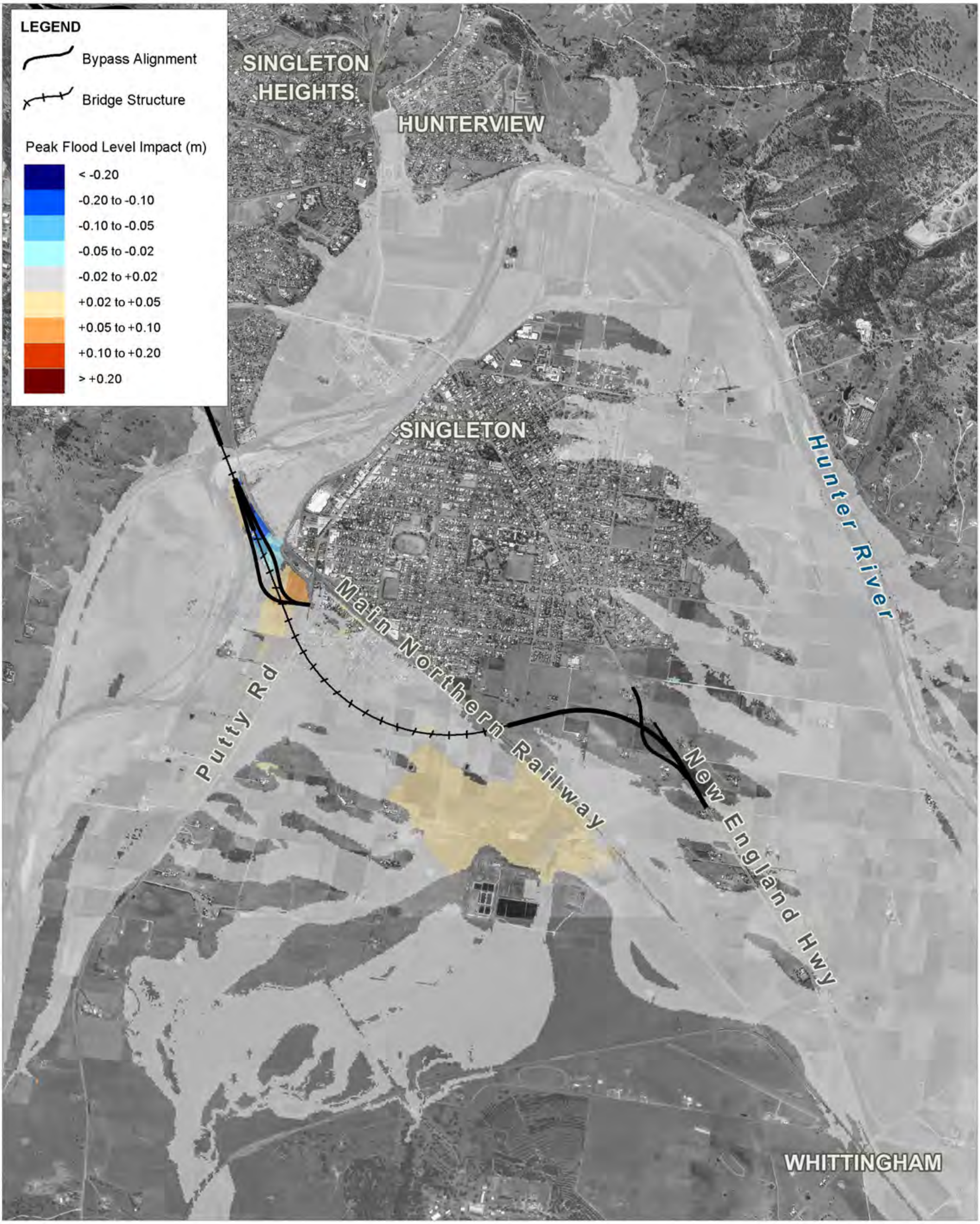


Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 5% AEP Peak Flood Level Impact

Figure: C-3

Rev: A

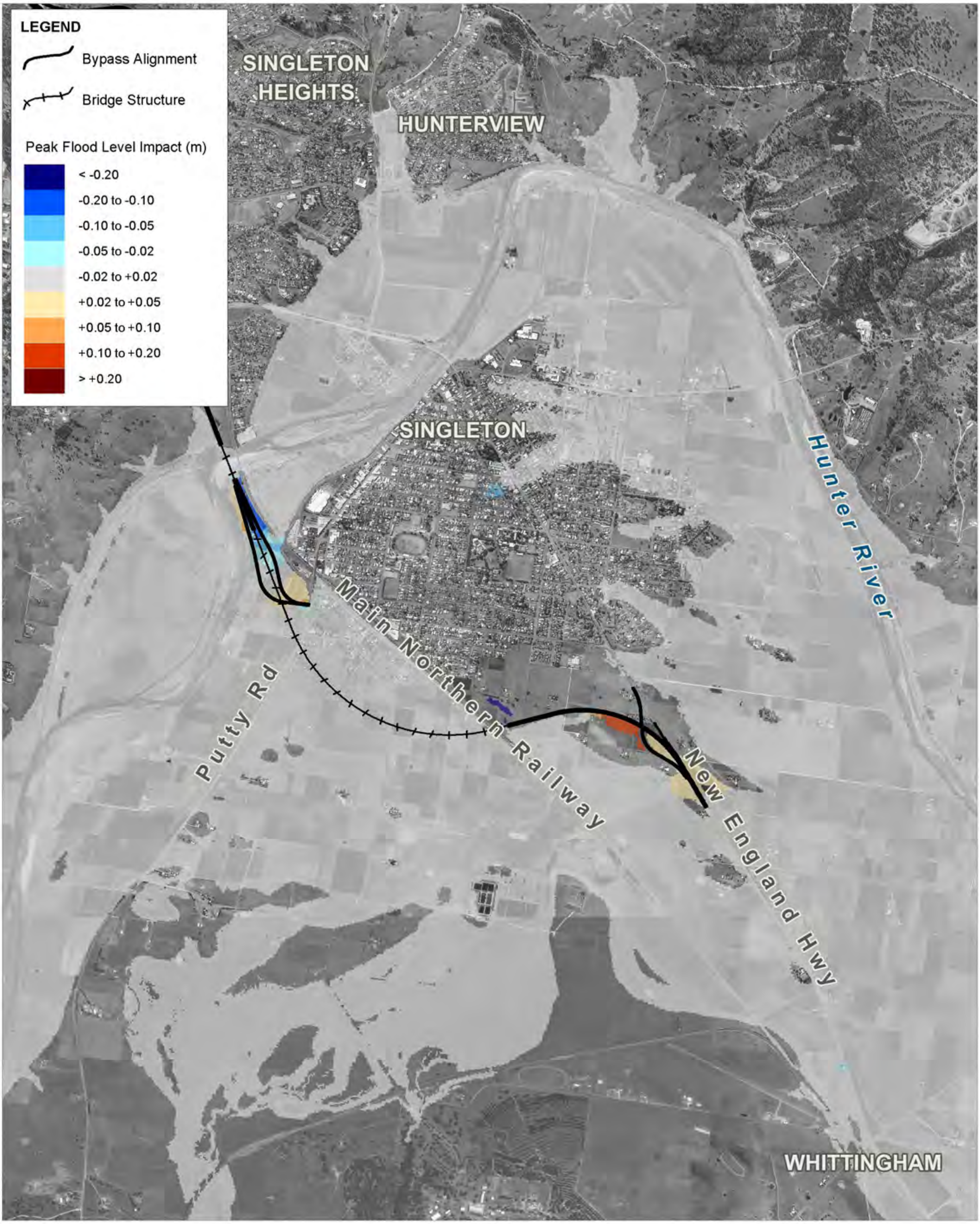
N

0 0.75 1.5km

Approx. Scale

BMT
www.bmt.org

Filepath: K:\N20818_Singleton_Bypass_Concept_Design_FIA\MapInfo\Workspaces\DRG_303_180510_5%AEP_h_impact.wor



Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 2% AEP Peak Flood Level Impact

Figure: C-4

Rev: A

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

N

0 0.75 1.5km

Approx. Scale

BMT

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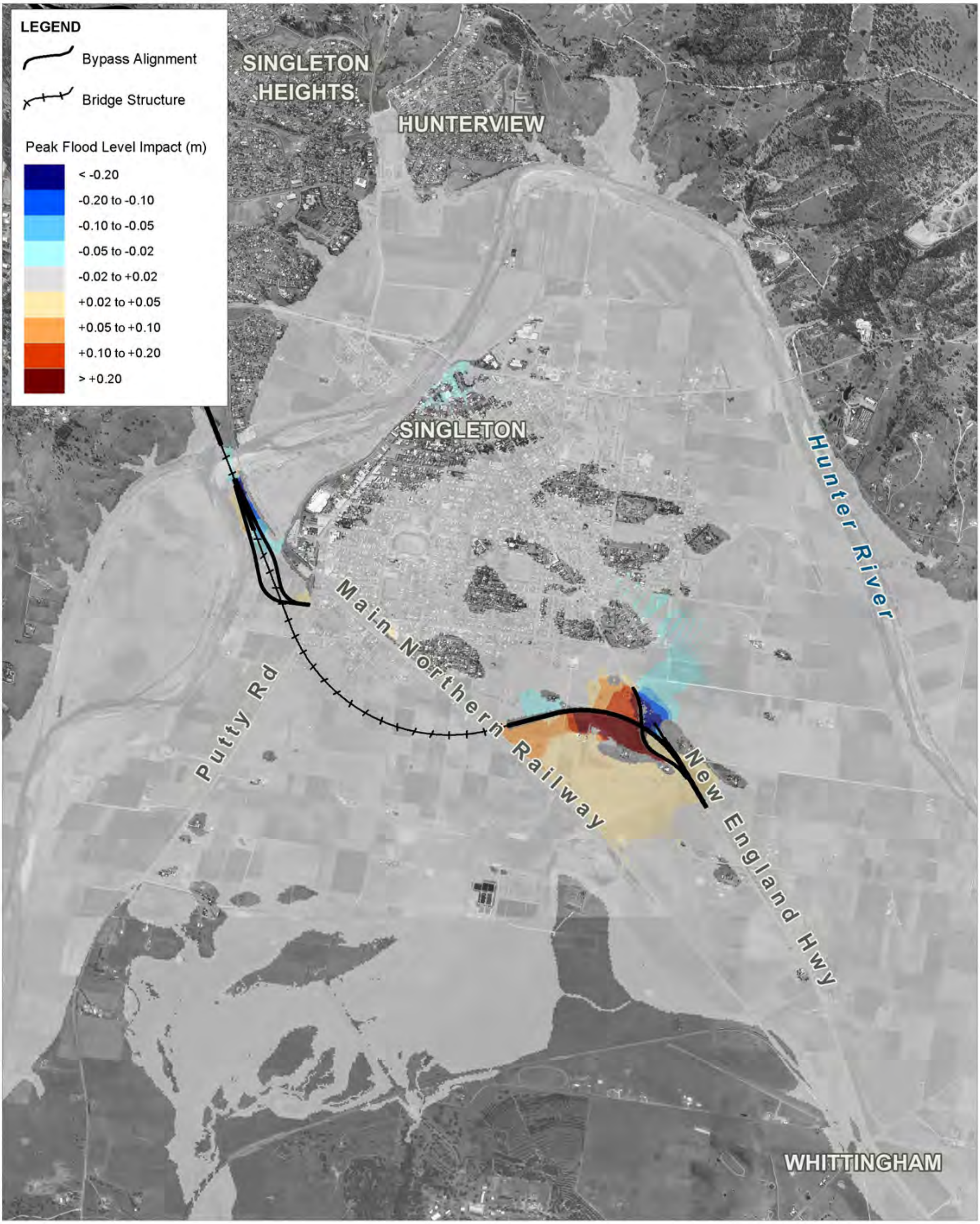

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 1% AEP Peak Flood Level Impact

Figure: C-5

Rev: A

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

N

0 0.75 1.5km

Approx. Scale

BMT

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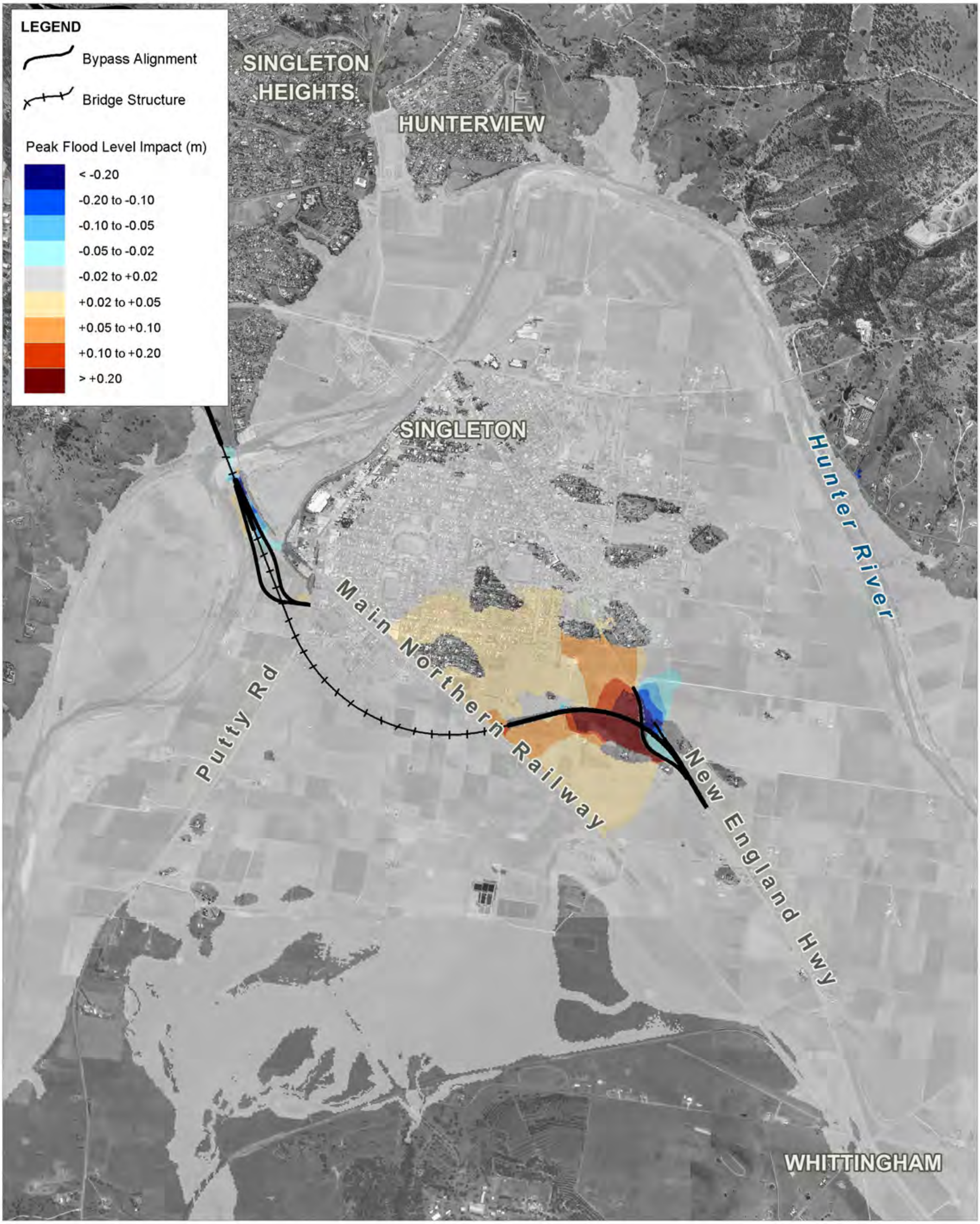
Filepath: K:\N20818_Singleton_Bypass_Concept_Design_FIA\MapInfo\Workspaces\DRG_305_180510_1%AEP_h_impact.wor



Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 0.5% AEP Peak Flood Level Impact

Figure: C-6

Rev: A

N

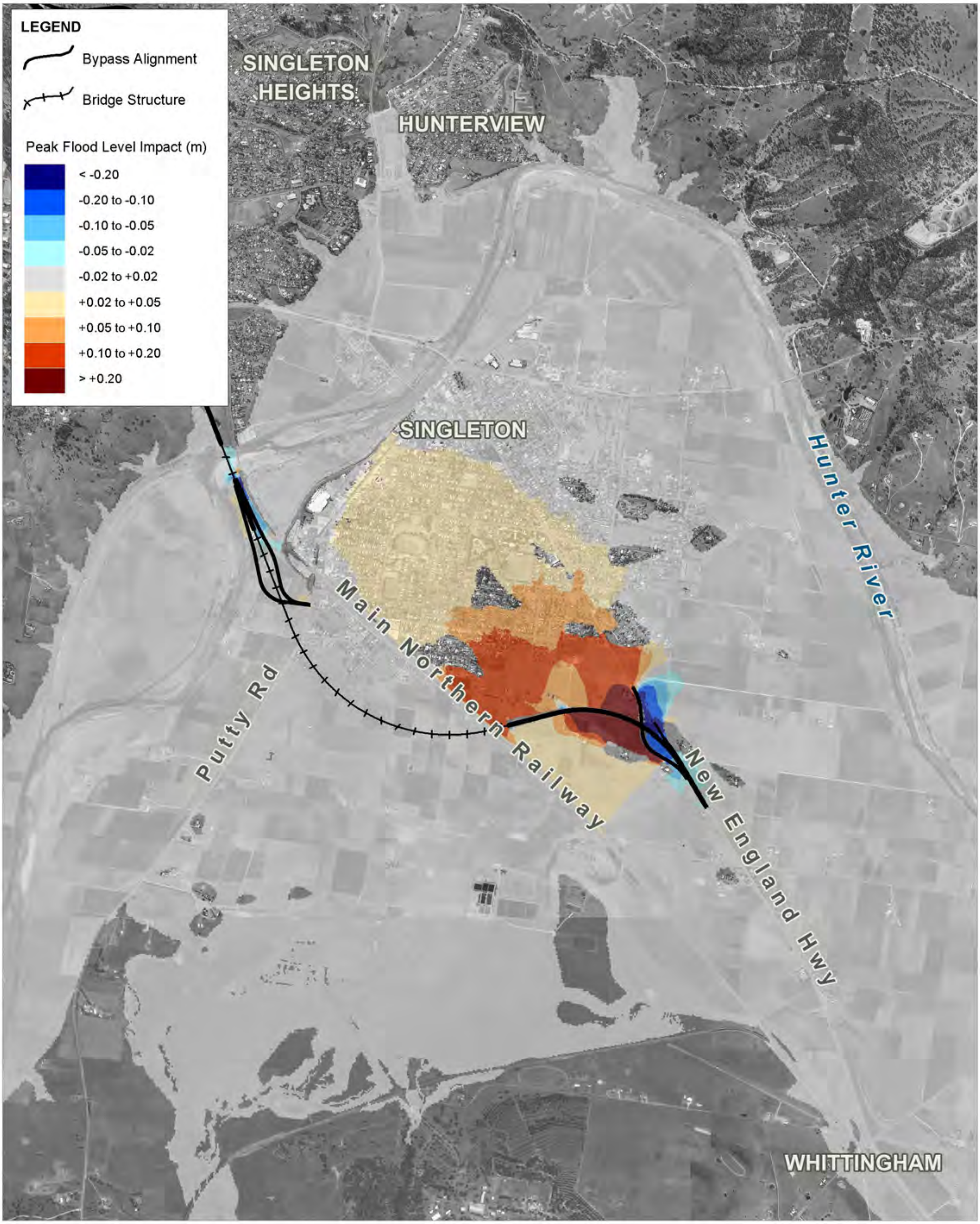
0 0.75 1.5km

Approx. Scale

BMT

www.bmt.org

Filepath: K:\N20818_Singleton_Bypass_Concept_Design_FIA\MapInfo\Workspaces\DRG_306_180510_0.5%AEP_h_impact.wor



Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 0.2% AEP Peak Flood Level Impact

Figure: C-7

Rev: A

N

0 0.75 1.5km

Approx. Scale

BMT
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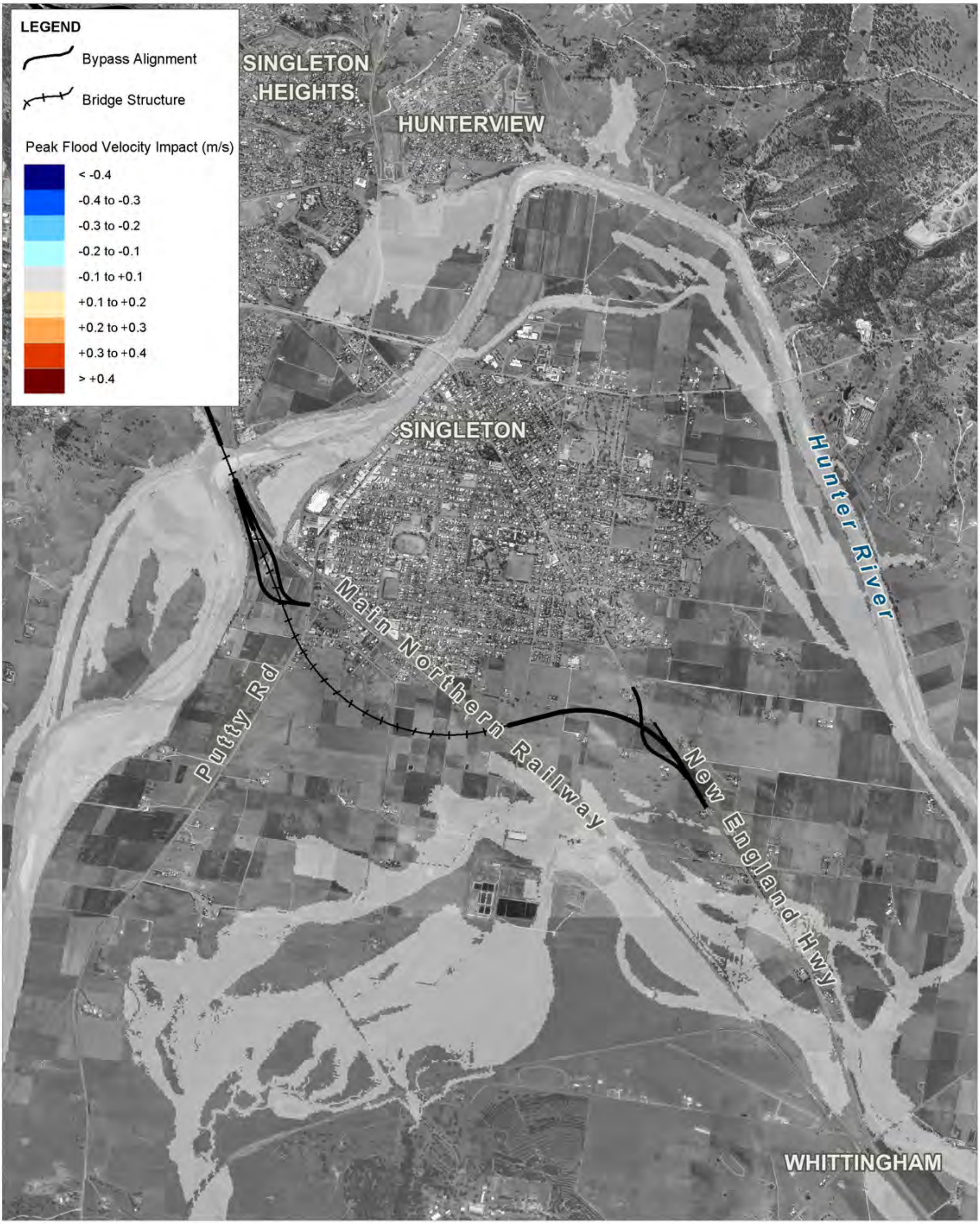
Filepath: K:\N20818_Singleton_Bypass_Concept_Design_FIA\MapInfo\Workspaces\DRG_307_180510_0.2%AEP_h_impact.wor

Appendix D Concept Design Flood Velocity Impact Mapping



Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 20% AEP Peak Flood Velocity Impact

Figure: **D-1**

Rev: **A**

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

N

0 0.75 1.5km

Approx. Scale

BMT
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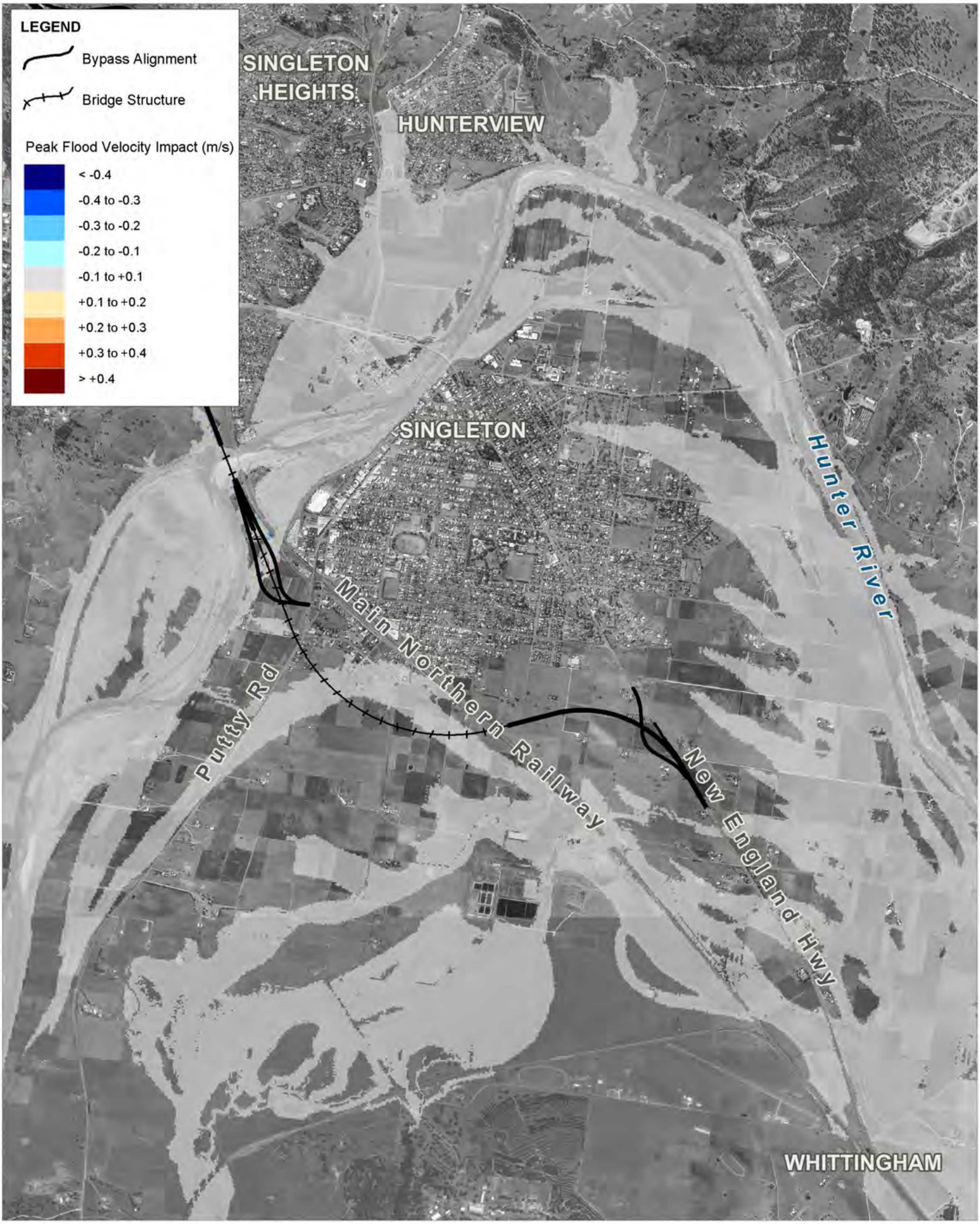

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 10% AEP Peak Flood Velocity Impact

Figure: D-2

Rev: A

N

0 0.75 1.5km

Approx. Scale

BMT
www.bmt.org

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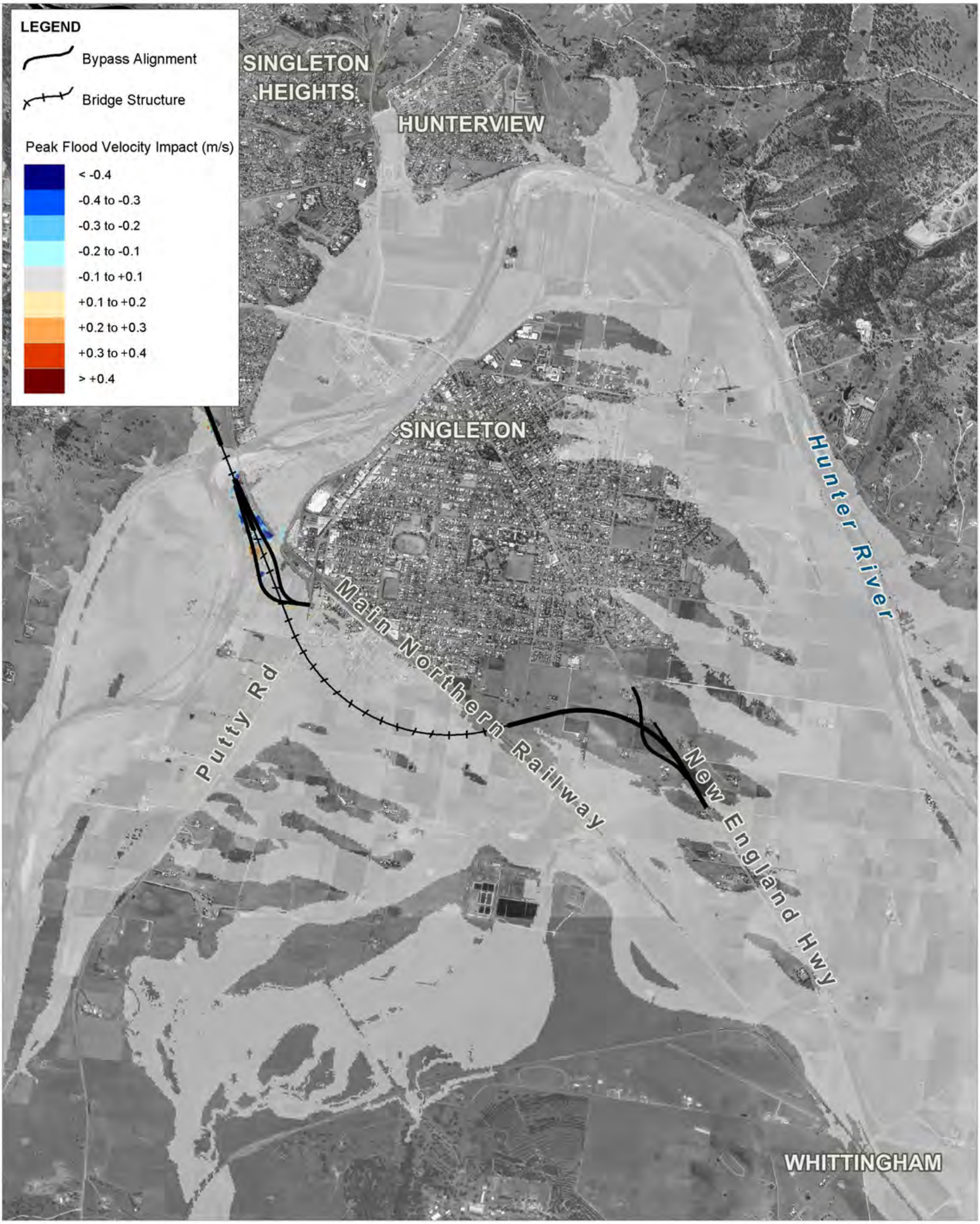

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 5% AEP Peak Flood Velocity Impact

Figure: D-3

Rev: A

N

0 0.75 1.5km

Approx. Scale

BMT
www.bmt.org

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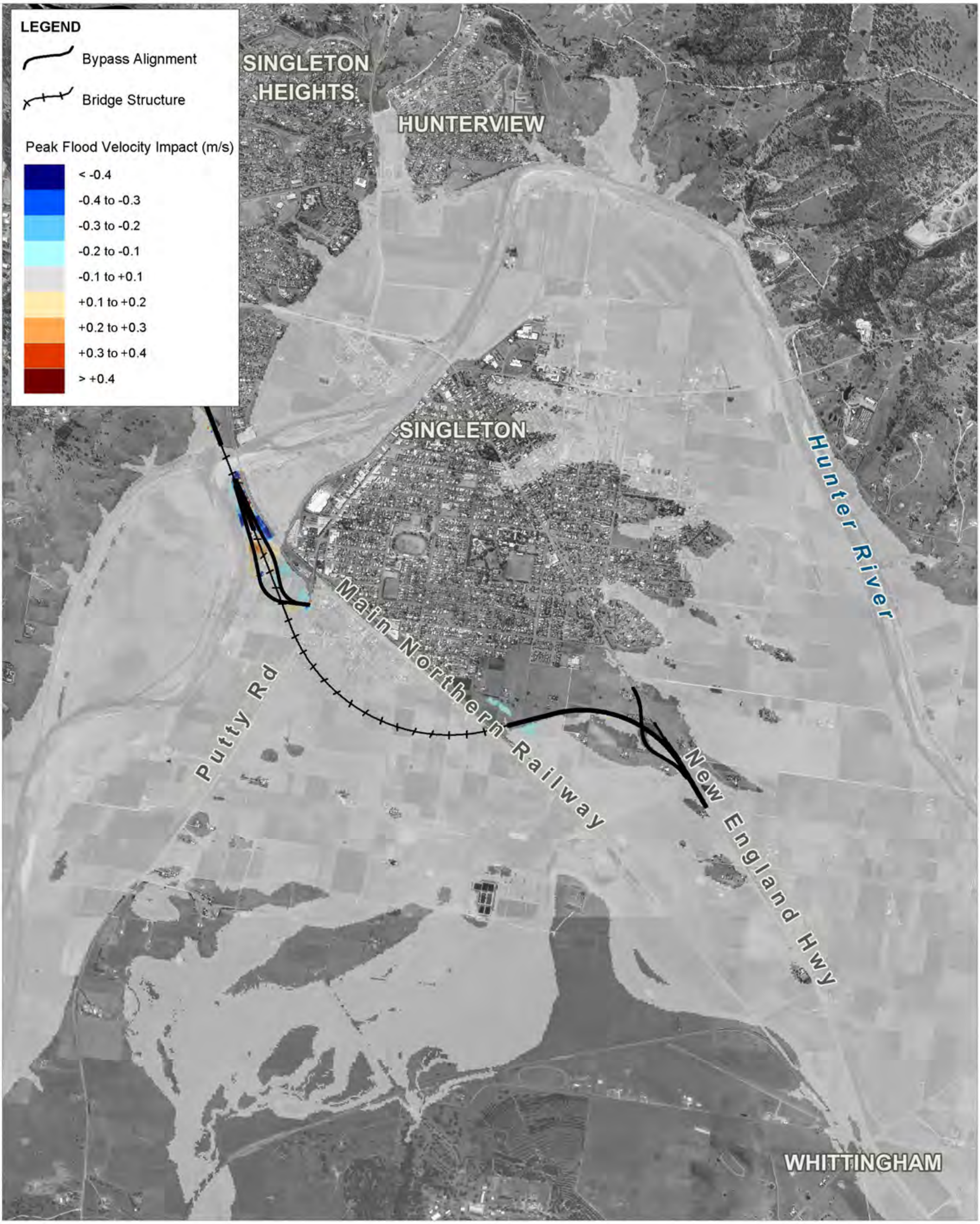

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 2% AEP Peak Flood Velocity Impact

Figure: D-4

Rev: A

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

N

0 0.75 1.5km

Approx. Scale

BMT
www.bmt.org

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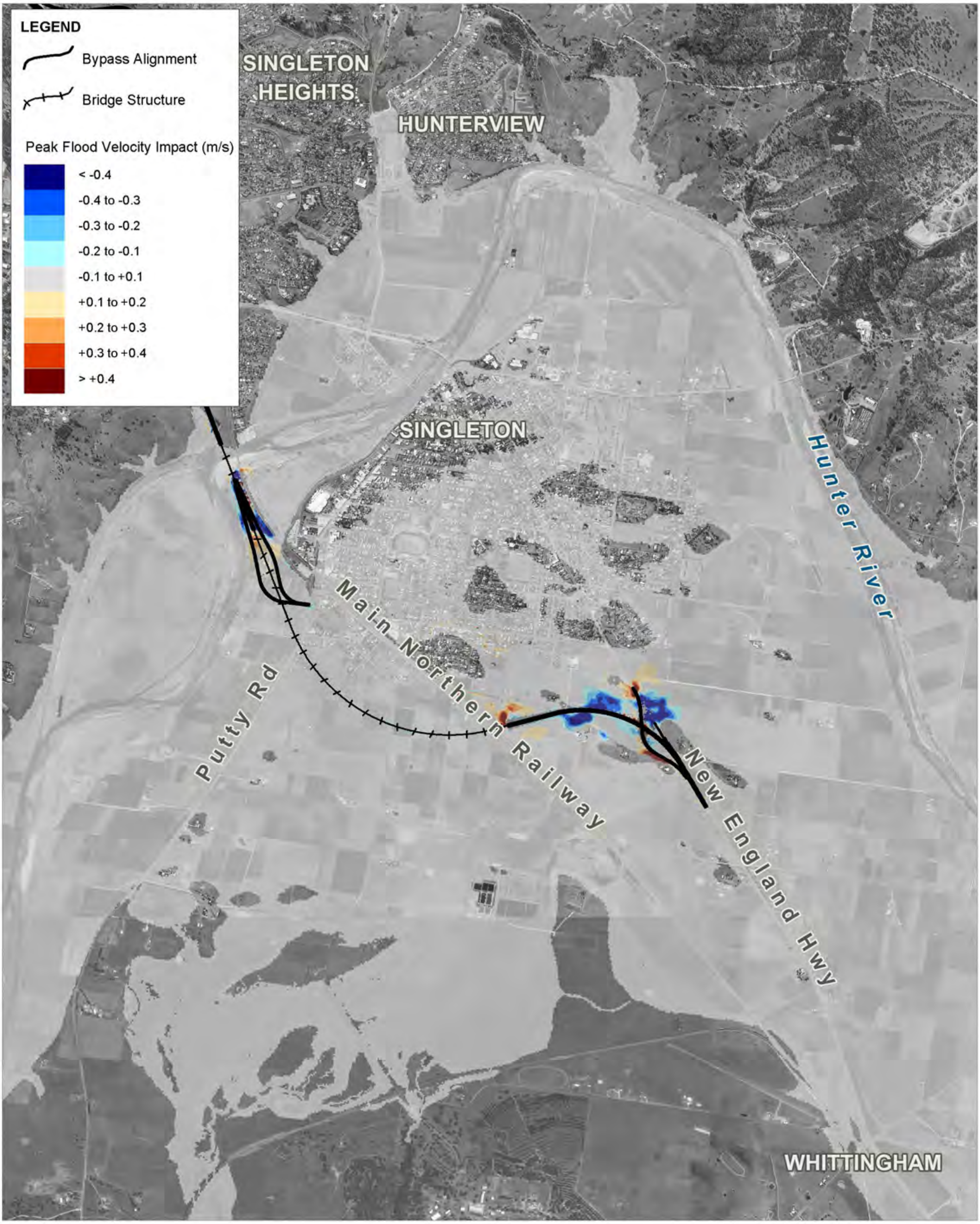

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 1% AEP Peak Flood Velocity Impact

Figure: **D-5**

Rev: **A**

N

0 0.75 1.5km

Approx. Scale

www.bmt.org

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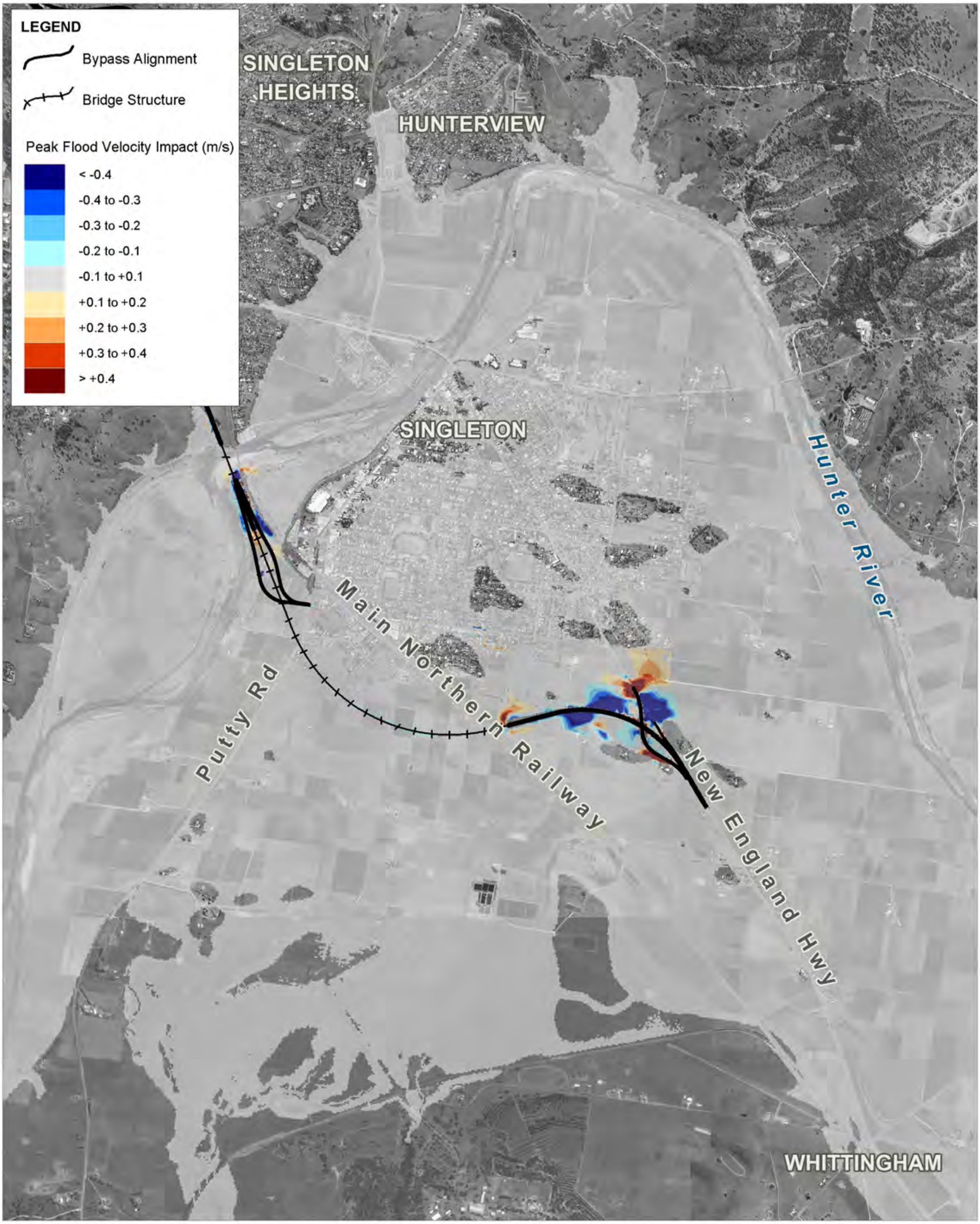

Title:

Singleton Bypass Concept Design Flood Assessment
20% Design - 0.5% AEP Peak Flood Velocity Impact

Figure: **D-6**

Rev: **A**

N 0 0.75 1.5km
Approx. Scale

BMT
www.bmt.org

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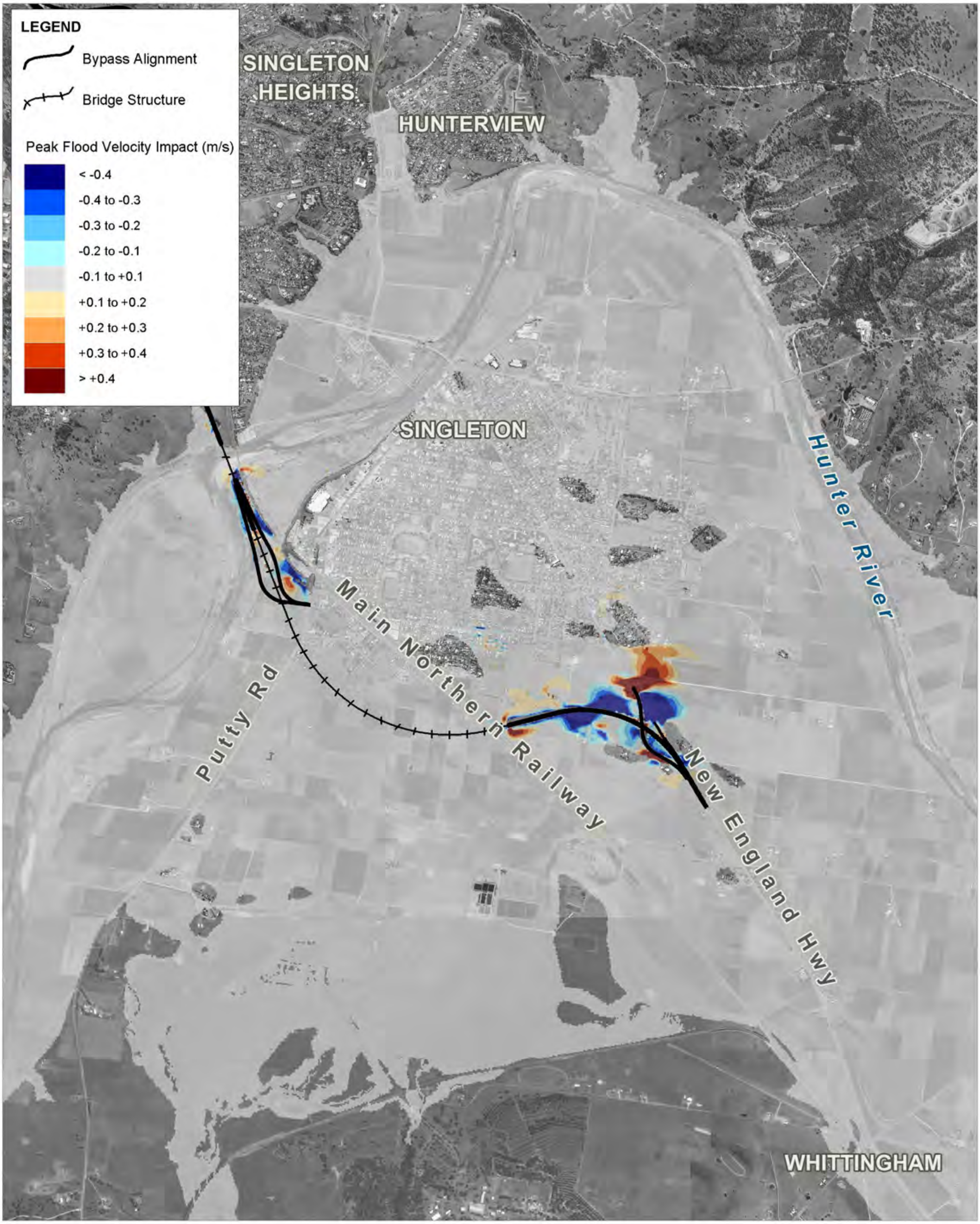

Title:
Singleton Bypass Concept Design Flood Assessment 20% Design - 0.2% AEP Peak Flood Velocity Impact

Figure: D-7

Rev: A

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

N

0 0.75 1.5km

Approx. Scale

BMT

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Filepath: K:\N20818_Singleton_Bypass_Concept_Design_FIA\MapInfo\Workspaces\DRG_407_180510_0.2%AEP_v_impact.wor

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Appendix B

Registered bore logs

NSW Office of Water
Work Summary

GW021636

Licence: 20BL014032

Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): NOT KNOWN

Work Type: Well
Work Status:
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 01/02/1964

Final Depth: 12.80 m
Drilled Depth: 12.80 m

Contractor Name:
Driller:
Assistant Driller:

Property: N/A 36B VICTORIA STREET GLENRIDDING SINGLETON 2330 NSW
GWMA: 017 - HUNTER
GW Zone: -

Standing Water Level (m):
Salinity Description: Soft
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.066	35
Licensed:	NORTHUMBERLAND	WHITTINGHAM	Whole Lot 4//1089420

Region: 20 - Hunter
River Basin: 210 - HUNTER RIVER
Area/District:

CMA Map: 9132-4N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6393728.0
Easting: 328444.0

Latitude: 32°34'50.3"S
Longitude: 151°10'20.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Concrete Cylnder	-0.70	-0.70	1219			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
8.50	12.80	4.30	Unconsolidated	8.20		26.52			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	8.53	8.53	Loam Red	Loam	
8.53	12.80	4.27	Gravel Coarse Water Supply	Gravel	

Remarks

***** End of GW021636 *****

NSW Office of Water
Work Summary

GW027758

Licence: 20BL019824

Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION,STOCK
Intended Purpose(s): IRRIGATION

Work Type: Well
Work Status:
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 01/03/1967

Final Depth: 11.40 m
Drilled Depth: 11.50 m

Contractor Name:
Driller:
Assistant Driller:

Property: N/A 4367 NEW ENGLAND HIGHWAY WHITTINGHAM 2330 NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description: 501-1000 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.066	11
Licensed:	NORTHUMBERLAND	WHITTINGHAM	Whole Lot 28//1104815

Region: 20 - Hunter
CMA Map: 9132-4N

River Basin: 210 - HUNTER RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6393903.0
Easting: 329667.0
Latitude: 32°34'45.3"S
Longitude: 151°11'07.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Concrete Cylnder	-0.80	-0.80	1372			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
10.30	11.40	1.10	Unconsolidated	10.30		4.55			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.91	0.91	Soil Black	Soil	
0.91	7.47	6.56	Loam Sandy	Loam	
7.47	11.43	3.96	Gravel Water Supply	Gravel	
11.43	11.45	0.02	Shale Water Supply	Shale	

Remarks

***** End of GW027758 *****

NSW Office of Water
Work Summary

GW030950

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): TEST BORE, TOWN WATER SUPPLY

Work Type: Bore
Work Status: Abandoned,Backfilled
Construct.Method: Cable Tool
Owner Type: Local Govt

Commenced Date:
Completion Date: 01/09/1981

Final Depth:
Drilled Depth: 16.50 m

Contractor Name:
Driller:
Assistant Driller:

Property:

GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.66	2//883810
Licensed:			

Region: 20 - Hunter
CMA Map: 9132-4N

River Basin: 210 - HUNTER RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 42.10 m (A.H.D.)
Elevation Source: R.L. at Surface
Northing: 6395459.0
Easting: 327006.0
Latitude: 32°33'53.3"S
Longitude: 151°09'26.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	0.00	16.50				
1	1	Casing	Withdrawn	0.00	16.30	203			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
13.80	15.30	1.50	Unconsolidated						

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	13.00	13.00	Clay	Clay	
13.00	16.50	3.50	Sand Gravel Water Supply	Sand	
16.50	16.51	0.01	Siltstone	Siltstone	

Remarks

30/06/1982: SINGLETON TWS TEST HOLE.
04/11/2008: Nat Carling, 4-Nov-2008: Updated RL's (no date found), cadastre (was entered as '21') & casing protector details (based on RL's), based in info provided in State Water Survey database, provided by Jim Salmon.

***** End of GW030950 *****

NSW Office of Water
Work Summary

GW030952

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): PUBLIC/MUNICIPL

Work Type: Bore
Work Status: Test Hole
Construct.Method: Cable Tool
Owner Type: Local Govt

Commenced Date:
Completion Date: 01/09/1981
Final Depth:
Drilled Depth: 11.50 m

Contractor Name:
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.066	35
Licensed:			

Region: 20 - Hunter
CMA Map: 9132-4N
River Basin: 210 - HUNTER RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6394264.0
Easting: 327365.0
Latitude: 32°34'32.3"S
Longitude: 151°09'39.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	0.00	11.50				
1	1	Casing	Withdrawn	-1.50	11.50	203			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Topsoil	Topsoil	
2.00	6.10	4.10	Clay	Clay	
6.10	11.20	5.10	Gravel	Gravel	
11.20	11.50	0.30	Shale	Shale	

Remarks

***** End of GW030952 *****

NSW Office of Water
Work Summary

GW030956

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): PUBLIC/MUNICIPL

Work Type: Bore
Work Status: Test Hole
Construct.Method: Cable Tool
Owner Type: Local Govt

Commenced Date:
Completion Date: 01/09/1981

Final Depth:
Drilled Depth: 13.00 m

Contractor Name:
Driller:
Assistant Driller:

Property:

GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.066	35
Licensed:			

Region: 20 - Hunter
CMA Map: 9132-4N

River Basin: 210 - HUNTER RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6394544.0
Easting: 327543.0

Latitude: 32°34'23.3"S
Longitude: 151°09'46.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	0.00	13.00				
1	1	Casing	Withdrawn	0.00	13.70	203			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Topsoil	Topsoil	
2.00	6.50	4.50	Clay	Clay	
6.50	8.00	1.50	Sand Clayey	Sand	
8.00	12.80	4.80	Gravel	Gravel	
12.80	13.00	0.20	Shale	Shale	

Remarks

***** End of GW030956 *****

NSW Office of Water
Work Summary

GW031797

Licence: 20BL023368

Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Well
Work Status:
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 01/09/1969

Final Depth: 12.50 m
Drilled Depth: 12.50 m

Contractor Name:
Driller:
Assistant Driller:

Property: BEBEAH 4403 NEW ENGLAND HIGHWAY WHITTINGHAM SINGLETON 2330
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description: 1001-3000 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.066	11
Licensed:	NORTHUMBERLAND	WHITTINGHAM	Whole Lot 101//1048703

Region: 20 - Hunter
CMA Map: 9132-4N

River Basin: 210 - HUNTER RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6393930.0
Easting: 329432.0

Latitude: 32°34'44.3"S
Longitude: 151°10'58.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Concrete Cylnder	-0.50	12.00	1219			
1	1	Opening	Perforations	11.30	11.30	1219		1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
9.80	12.20	2.40	Unconsolidated	9.80		8.68			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	5.49	5.49	Loam Clay	Loam	
5.49	12.19	6.70	Gravel Water Supply	Gravel	
12.19	12.50	0.31	Clay	Clay	

12.50	12.51	0.01	Rock	Rock	

Remarks

***** End of GW031797 *****

NSW Office of Water
Work Summary

GW038199

Licence: 20BL102288

Licence Status: CANCELLED

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Well
Work Status: Supply Obtained
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 01/08/1975

Final Depth: 11.80 m
Drilled Depth: 11.90 m

Contractor Name:
Driller:
Assistant Driller:

Property: N/A NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.066	35
Licensed:	NORTHUMBERLAND	WHITTINGHAM	Whole Lot //

Region: 20 - Hunter
River Basin: 210 - HUNTER RIVER
Area/District:

CMA Map: 9132-4N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6394116.0
Easting: 327707.0

Latitude: 32°34'37.3"S
Longitude: 151°09'52.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Concrete Cylnder	-0.90	-0.90	1219			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
8.50	11.80	3.30	Unconsolidated	9.70					

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	8.53	8.53	Loam Sandy	Loam	
8.53	11.89	3.36	Gravel Water Supply	Gravel	

Remarks

***** End of GW038199 *****

NSW Office of Water
Work Summary

GW042809

Licence: 20BL101616

Licence Status: LAPSED

Authorised Purpose(s): TOWN WATER SUPPLY
Intended Purpose(s): PUBLIC/MUNICIPL

Work Type: Well
Work Status:
Construct.Method: Hand Dug
Owner Type: Local Govt

Commenced Date:
Completion Date: 01/01/1910

Final Depth: 16.70 m
Drilled Depth:

Contractor Name:
Driller:
Assistant Driller:

Property: N/A NSW

GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.066	35
Licensed:	NORTHUMBERLAND	WHITTINGHAM	Whole Lot //

Region: 20 - Hunter

CMA Map: 9132-4N

River Basin: 210 - HUNTER RIVER
Area/District:

Grid Zone:

Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6395092.0
Easting: 327169.0

Latitude: 32°34'05.3"S
Longitude: 151°09'32.1"E

GS Map: -

MGA Zone: 0

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Brick	0.00	0.00	6400			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

10/03/1981: SINGLETON TOWN WATER SUPPLY

***** End of GW042809 *****

NSW Office of Water
Work Summary

GW042810

Licence: 20BL105651

Licence Status: LAPSED

Authorised Purpose(s): TOWN WATER SUPPLY
Intended Purpose(s): PUBLIC/MUNICIPL

Work Type: Well
Work Status:
Construct.Method: Hand Dug
Owner Type: Local Govt

Commenced Date:
Completion Date: 01/01/1940

Final Depth: 17.40 m
Drilled Depth:

Contractor Name:
Driller:
Assistant Driller:

Property: N/A NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.066	35
Licensed:	NORTHUMBERLAND	WHITTINGHAM	Whole Lot //

Region: 20 - Hunter
CMA Map: 9132-4N

River Basin: 210 - HUNTER RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6395093.0
Easting: 327195.0
Latitude: 32°34'05.3"S
Longitude: 151°09'33.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Timber	0.00	0.00	1800			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

20/07/1984: SINGLETON TOWN WATER SUPPLY

***** End of GW042810 *****

NSW Office of Water
Work Summary

GW047625

Licence: 20BL111213

Licence Status: CONVERTED

Authorised Purpose(s): STOCK,IRRIGATION,DOMESTIC
Intended Purpose(s): IRRIGATION

Work Type: Well
Work Status: Supply Obtained
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 01/10/1980

Final Depth:
Drilled Depth:

Contractor Name:
Driller: Daryl George Wilson
Assistant Driller:

Property: N/A 15 ADA STREET SINGLETON 2330 NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.066	35
Licensed:	NORTHUMBERLAND	WHITTINGHAM	Whole Lot PT35//755269

Region: 20 - Hunter
CMA Map: 9132-4N

River Basin: 210 - HUNTER RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6393827.0
Easting: 328834.0
Latitude: 32°34'47.3"S
Longitude: 151°10'35.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	6.10	6.10	Loam	Loam	
6.10	13.11	7.01	Gravel	Gravel	

Remarks

***** End of GW047625 *****

NSW Office of Water
Work Summary

GW057823

Licence: 20BL124313

Licence Status: LAPSED

Authorised Purpose(s): TOWN WATER SUPPLY
Intended Purpose(s): PUBLIC/MUNICIPL

Work Type:

Work Status:

Construct.Method: Auger

Owner Type: Local Govt

Commenced Date:
Completion Date: 01/01/1975

Final Depth: 13.60 m
Drilled Depth: 14.00 m

Contractor Name:

Driller:

Assistant Driller:

Property: N/A NSW

GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description: 501-1000 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.066	35
Licensed:	NORTHUMBERLAND	WHITTINGHAM	Whole Lot //

Region: 20 - Hunter

CMA Map: 9132-4N

River Basin: 210 - HUNTER RIVER
Area/District:

Grid Zone:

Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6395247.0
Easting: 327244.0

Latitude: 32°34'00.3"S
Longitude: 151°09'35.1"E

GS Map: -

MGA Zone: 0

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	13.60	13.90				
1	1	Casing	Concrete Cylnder	-2.70	13.70	1520			
1	1	Opening	Screen	0.00	0.00			1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
11.90	13.90	2.00	Unconsolidated	11.90		16.00			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	11.89	11.89	Clay Silty	Clay	
11.89	13.94	2.05	Shingle River Sand Water Supply	Sand	
13.94	13.95	0.01	Shale Sandstone	Shale	

Remarks

17/01/1985: SINGLETON TOWN WATER SUPPLYSPEARS IN BASE OF WELL

***** End of GW057823 *****

NSW Office of Water
Work Summary

GW200468

Licence: 20BL167976

Licence Status: CONVERTED

Authorised Purpose(s): DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 07/02/2001

Final Depth: 20.40 m
Drilled Depth: 20.40 m

Contractor Name: Drillwell Construction
Driller: Alec Linton
Assistant Driller:

Property: N/A
GWMA: -
GW Zone: -

Standing Water Level: 12.100
Salinity:
Yield: 3.100

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NORTH	NORTH.66	1//360940
Licensed:	NORTHUMBERLAND	WHITTINGHAM	Whole Lot 1//360940

Region: 20 - Hunter
CMA Map:

River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6395129.0
Easting: 327279.0
Latitude: 32°34'04.2"S
Longitude: 151°09'36.4"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	20.40	170			Rotary Air
1	1	Casing	Steel	0.60	20.40	168	159		Seated on Bottom, Welded
1	1	Opening	Slots - Vertical	9.00	19.00	168		1	Oxy-Acetylene Slotted, Steel, SL: 10.0mm, A: 4.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
12.10	19.50	7.40	Unknown	12.10		3.10	20.40		

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.20	1.20	loam (sandy)	Loam	
1.20	7.90	6.70	clay	Clay	
7.90	14.90	7.00	sand	Sand	
14.90	19.50	4.60	gravel	Gravel	

19.50	20.40	0.90	shale (grey)	Shale	

Remarks

***** End of GW200468 *****

rms.nsw.gov.au

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Customer feedback
Roads and Maritime
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