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Hexham Relief Roads and NSW Long-term Train Support Facility Joint Flood Impact Assessment

Revised Draft Report

R.N2335.003.01

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Hexham Relief Roads and NSW Long-term Train Support Facility Joint Flood Impact Assessment Revised Draft Report

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Title :	Hexham Relief Roads and NSW Long-term Train Support Facility Joint Flood Impact Assessment
Author :	Daniel Williams
Synopsis :	Report for the Hexham Relief Roads and NSW Long-term Train Support Facility detailing the existing flood conditions and impacts of the proposed developments, including the provision of mitigation measures to reduce the flood impacts.

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1 INTRODUCTION

1.1 Purpose of this Report

This report has been commissioned by Engenicom on behalf of Aurizon (formerly QR National) for the purposes of identifying potential impacts of the proposed NSW Long-term Train Support Facility, in conjunction with other planned developments in the vicinity of the site. The flood impact assessment of this report considers the cumulative impacts of the Aurizon Train Support Facility, the ARTC Hexham Relief Roads and the joint access road from the Tarro interchange (referred to as the 'proposed works'). The cumulative impacts of the proposed works and the RMS Pacific Highway upgrade from the F3 to Heatherbrae are also assessed.

The assessment includes a regional flood impact investigation using an existing TUFLOW flood model to define existing flood conditions and quantify flooding impacts related to the proposed works. The existing flood model was initially developed for the Williams River Flood Study, completed by BMT WBM in 2009 on behalf of Port Stephens Council (Council) and was further developed as part of the Williamtown / Salt Ash Flood Study Review (BMT WBM, 2011). Council has kindly given permission to use the existing model in the current flood impact assessment.

This report also contains a detailed local flood impact assessment for the Hexham area. Preliminary investigations of potential mitigation options for the localised flood impacts identified area complex local flood flow paths and hydraulic controls in the Hexham area that required further detailed flood modelling. Following comments from the original EIS submission, a detailed local flood model was used to better understand the nature of existing flood behaviour and flood impacts in Hexham, and further refine the requirements for flood mitigation in respect of the proposed works. This detailed assessment is presented in Section 4.

The flood impact assessment presented in this document details the nature of the proposed works and the analysis undertaken to quantify and mitigate flood impacts.

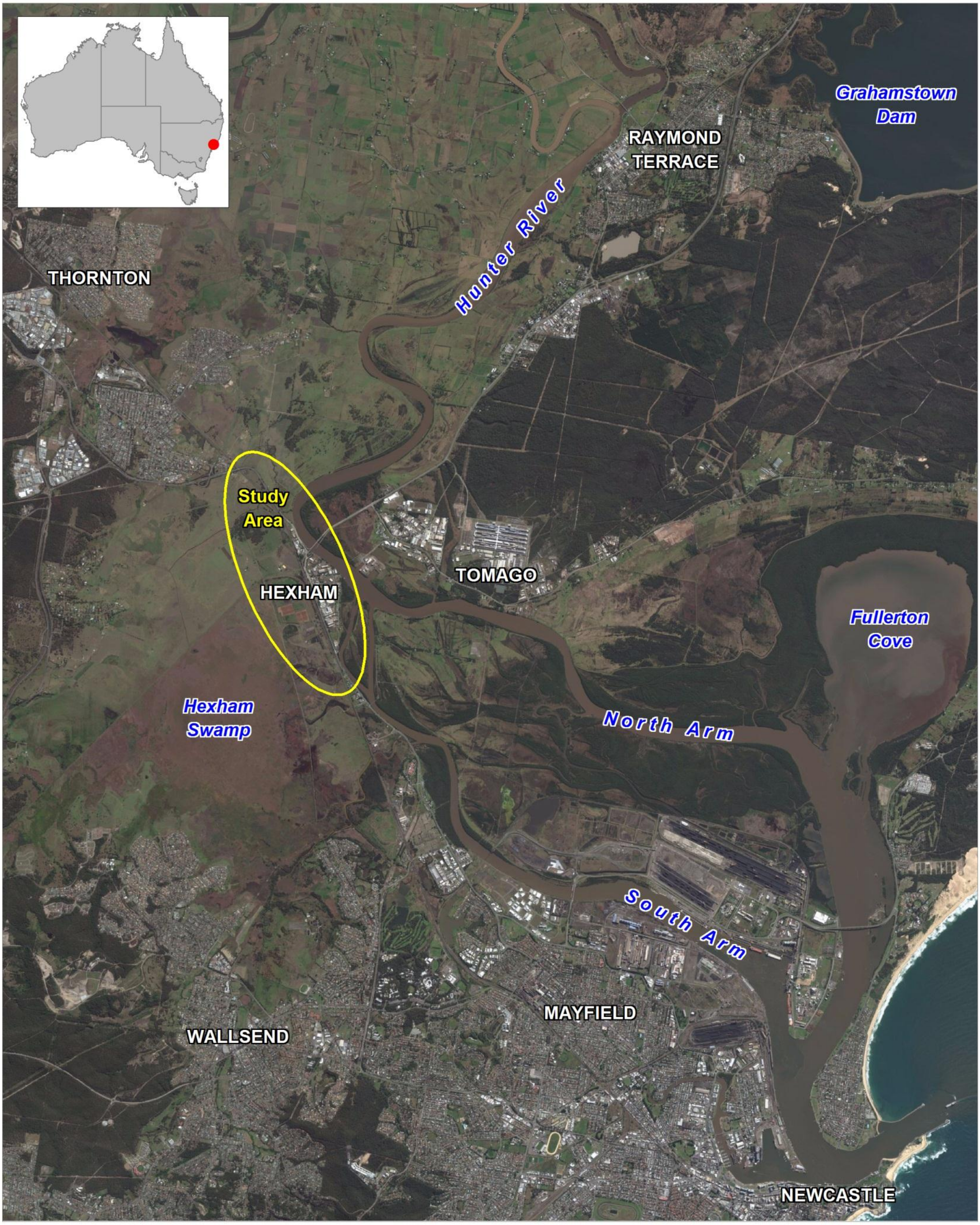
1.2 Site Location

The proposed site of the Relief Roads and NSW Long-term Train Support Facility is located within the Lower Hunter Valley, near Hexham and is presented in Figure 1-1.

1.3 Computer Modelling Tool

A two dimensional computer model of the Lower Hunter floodplain was developed by BMT WBM as part of the Williams River Flood Study (BMT WBM, 2009), on behalf of Port Stephens Council and Dungog Shire Council. The model used a regular 40 by 40 m grid, covering an area of some 120 square kilometres.

There is considerable interaction between flooding in the lower parts of the Williams River and the Hunter River, requiring a model linking the two floodplains. The Hunter River model was developed as part of a project for the Roads and Traffic Authority (RTA) investigating a new Pacific Highway crossing of the Hunter River.



Title:

Study Locality

Figure: **1-1**

Rev: **A**

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The hydraulic model was calibrated to the February 1990, March 1978 and May 2001 flood events. In terms of the Lower Hunter reach relevant to the subject proposed development site, the February 1990 flood event was the principal event used to calibrate the lower section of the Williams River model and the lower Hunter River model, being the largest Hunter River flows (coincident with a Williams River flood).

The hydraulic model was further developed for the Williamtown / Salt Ash Flood Study Review (BMT WBM, 2011) which extended the modelled floodplain from Fullerton Cove through to Port Stephens. The interaction of the Hunter River with the Williamtown / Salt Ash floodplain is important for assessing large magnitude flood events in the Lower Hunter, particularly when considering potential climate change impacts. The combined design flood flows from the Hunter River and Williams River match the flood frequency analysis at Raymond Terrace from the Lower Hunter River Flood Study (PWD, 1994)

The same computer model that was developed for these studies has been used for the regional flood investigations described in this report.

2 EXISTING FLOOD BEHAVIOUR

2.1 Flooding Mechanisms

The Hunter River catchment covers an area of the order of 22,000km^2 which flows into the Tasman Sea through the Port of Newcastle. The lower reaches of the Hunter system are tidal and forms the Hunter River estuary. Three major rivers discharge into the estuary, namely the Hunter River, the Paterson River and the Williams River. The confluence of the Williams River and Hunter River is at Raymond Terrace approximately 30 km upstream of the estuary mouth (i.e. Newcastle Harbour). The Paterson River joins the Hunter River between Morpeth and Hinton some 15 km upstream of Raymond Terrace. The estuary extends a further 20 km along the Hunter River to the tidal limit at Oakhampton, near Maitland.

The proposed development site is located on the reach of the Hunter River that lies in the vicinity of Hexham Bridge (approximately 20km upstream of the mouth). Immediately upstream of Hexham Bridge, the Hunter River changes from a general south-westerly flow direction to a south-easterly flow direction. Downstream of Hexham Bridge the Hunter River main channel splits into two arms, the North Arm and the South Arm, separated by Kooragang Island. To the south-west of this location is Hexham Swamp, a large wetland area that would have been frequently inundated by the Hunter River prior to modern infrastructure development. The topography of the Hunter River floodplain in the region of the proposed works is shown in Figure 2-1.

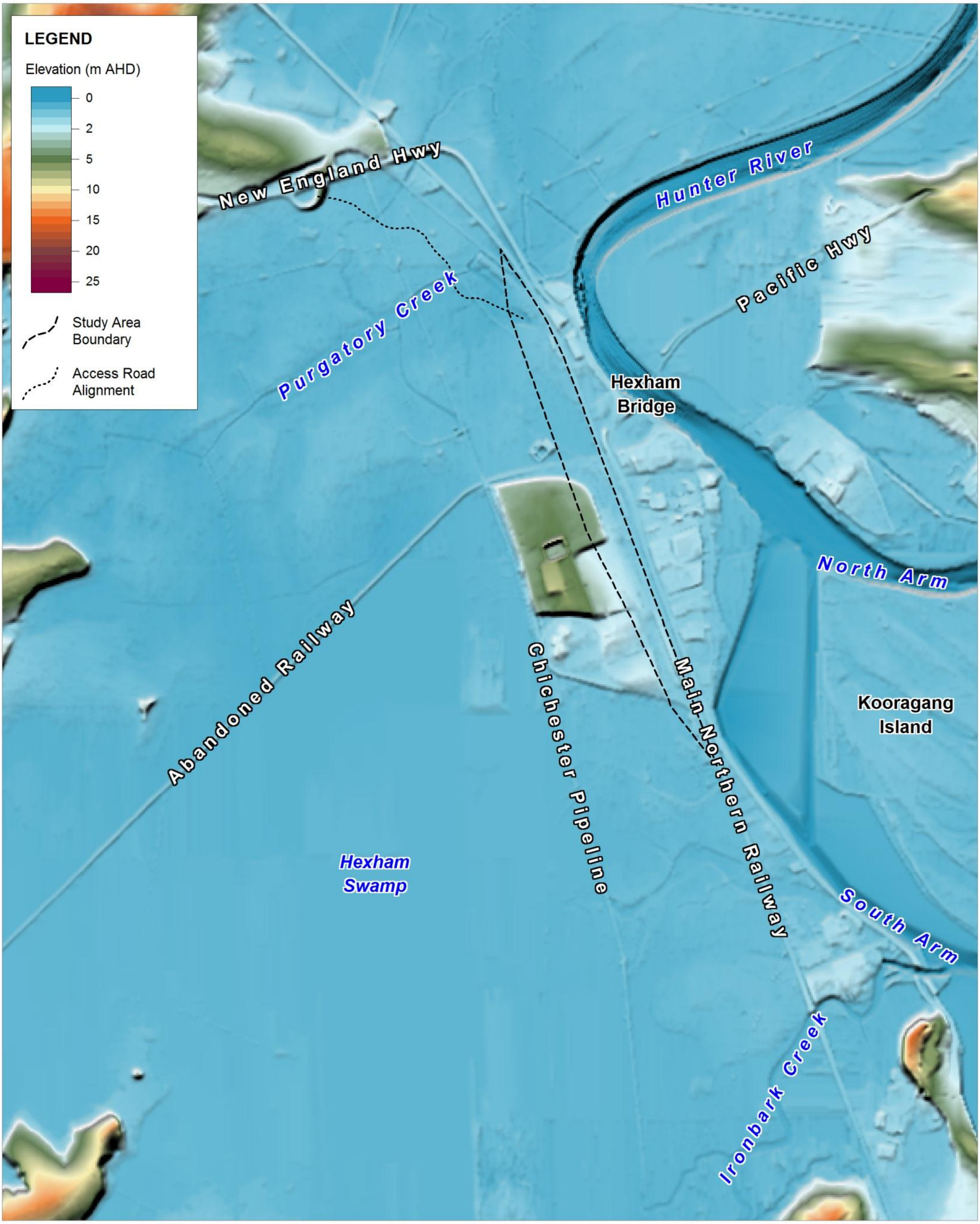
The Hunter River has experienced many floods during its recorded history. The largest flood on record was in 1955. After this event, which claimed 14 lives, the Hunter Valley Flood Mitigation Scheme was established, which has subsequently instigated some 160km of levees, 3.8km of spillways, 40km of control banks, 245 floodgates and 120km of drainage canals.

Within the Lower Hunter Estuary, the 1955 flood caused extensive overbank inundation, with flood depths of up to three metres across the Kooragang Island wetlands. This flood has been estimated at approximately a 1 in 100yr event (PWD, 1994).

When the floodwaters reach Hexham Bridge overtopping of the New England Highway will occur, filling the available flood storage of Hexham Swamp. Flood flows will then return to the Hunter River South Arm in the vicinity of Ironbark Creek, the principal natural drainage channel of the swamp. The progression of flood flows through Hexham Swamp is controlled by a number of topographical features, including an abandoned railway and the Chichester Pipeline.

There is a set of eight flood gates located on Ironbark Creek, near the confluence with the Hunter River South Arm. These gates control flows in and out of Hexham Swamp through Ironbark Creek for lower order flood events, but are overtopped for events above the 5% AEP. The model configuration is representative of the current proposed operation, where the gates have been raised open to enable flow into the swamp.

Ocean water levels, influenced by storm surge and the tide, have an effect on flood levels within the lower estuary, up to Green Rocks (approx. 8km upstream of the Williams River / Hunter River confluence).



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Local Floodplain Topography

Figure: **2-1**

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In higher frequency low discharge floods, the flow is contained within the rivers banks and levees. As flood magnitude increases, floodwaters overtop the natural and man-made levees and flow across the floodplain.

The proposed development site itself is situated within the broader floodplain area of Hexham Swamp. This floodplain receives flow spilling over the New England Highway and in major flood events will be subject to significant inundation. Major catchment flooding of the Hunter River system is accordingly the dominant flooding mechanism.

2.2 Hunter River Flood Hydrology

The hydrological inputs to the TUFLOW model are based on those that were adopted for the Williams River Flood Study. A critical storm duration of 48 hours was used to derive design inflows for the Williams River. For the PMF event a 36-hour Generalised Tropical Storm Method (GTSM) storm was used. The design inflow to the Hunter River was based on the recorded hydrograph from the 1955 historical flood event, which is the most significant Hunter River flood of modern times and was of the order of a 1% AEP design event. The inflow hydrographs were derived by scaling the 1955 flood hydrograph shape to match the estimated peak design flows for each event, based on a flood frequency analysis of peak water levels at Raymond Terrace. This approach is consistent with the Lower Hunter River Flood Study (PWD, 1994). The Hunter River inflow hydrograph for the PMF event is approximately four times the peak flow of the 1% AEP event and almost seven times the volume.

Being a large catchment of some 22,000km^2, the Hunter River at Hexham will typically have a significant warning time of any floods that are moving down the catchment. Depending on the specific rainfall distributions in a given event, it is likely that significant flooding of Hexham Swamp will typically not occur until a couple of days after a major rainfall event. Flood warnings issued by the Bureau of Meteorology (BoM) and the State Emergency Service (SES) are given 24 hours in advance for Singleton and Maitland. This provides sufficient warning a day in advance of when Hexham Swamp is likely to be inundated by Hunter River flood waters. However, once the flood level in the Hunter River rises above the New England Highway at Hexham, the Swamp can fill to a level of over 2m AHD within a few hours, inundating the study site.

The periods of inundation are dependent on the design hydrographs adopted. As discussed, the design hydrographs for the Hunter River are based on a scaling of the recorded 1955 flood hydrograph shape to estimated design peak flow magnitudes. Event hydrograph shapes would vary considerably dependent on the spatial and temporal distribution of rainfall across the extensive catchment area. However, the 1955 hydrograph shape as a representative condition for a major flood event in the catchment provides a useful indication of potential inundation periods for the study site.

During flood events in the order of a 5% AEP or greater, extensive spilling of flood waters over the New England Highway and the existing railway will occur through Hexham Swamp. For flood events of a larger magnitude the existing rail infrastructure in the swamp may also become inundated through elevated tailwater conditions in Hexham Swamp. At a 1% AEP magnitude event, the site may be inundated for a period of three to four days. At a PMF event magnitude the site is likely to be inundated for a full week.

2.3 Design Flood Conditions

The existing Williams River/Hunter River flood model has been used to simulate design flood conditions for the development assessment. Model simulations for a range of design event magnitudes have been undertaken to establish existing flooding conditions across the site and to provide baseline conditions for assessing the impact of the proposed works on flooding.

Table 2-1 summarises the simulated peak flood levels in Hexham Swamp for a range of design event magnitudes. There is a general flood water level gradient from north to south across the swamp, such that the peak water levels presented in Table 2-1 represent the maximums at the northern (ch.176800) and southern (ch.174300) site locations.

Table 2-1 Design Flood Levels for Hexham Swamp (m AHD)

Design Flood Magnitude	Northern End of Site	Southern End of Site
10% AEP	1.0	0.8
5% AEP	1.2	1.0
2% AEP	2.2	2.1
1% AEP	3.7	3.5
PMF	8.3	7.7

The nature of flooding across the proposed development site is similar for a range of design event magnitudes. This principally originates from floodwaters spilling over the New England Highway from the Hunter River into Hexham Swamp. At the 20% AEP (Annual Exceedance Probability) event the Hunter River remains principally in-bank and has therefore not been modelled. For events greater than around a 10% AEP magnitude flood waters spill over the New England Highway and existing railway into Hexham Swamp. Hexham Swamp is also filled from the southern end by flow from the Hunter River South Arm through Ironbark Creek.

The general flood extent and behaviour is similar for each event, albeit with the severity of flood depths and velocities increasing with event magnitude. For major events with substantial flood volumes, such as a 1% AEP event, the Hexham Swamp floodplain becomes fully connected, with flood waters entering over the New England Highway and flowing back to the Hunter River between Hexham Bridge and Ironbark Creek.

The modelled 5% AEP event is only just over the required level for overtopping the New England Highway, with less than 4% of the Hunter River flows spilling into Hexham Swamp at the peak of the flood. Small increases in peak flow and corresponding flood levels upstream of Hexham Bridge result in a significant increase in peak flood levels within Hexham Swamp. This is evidenced by the large increases in flood levels for the modelled 2% AEP and 1% AEP events in Table 2-1, where around 13% and 34% of the peak flood flow is spilling into Hexham Swamp respectively. For events at and above the 1% AEP, the floodplain is fully connected and the sensitivity of flood waters spilling over the New England Highway and into Hexham Swamp is reduced.

The 1% AEP design flood event is typically used as the flood planning event for development control. The design flood conditions for the 1% AEP event representing peak flood level and depth, peak flood velocity and peak flow-rate per unit area, or unit flow (q), are presented in Figure 2-2 to Figure 2-4. Additional design flood mapping for the 10% AEP, 5% AEP, 2% AEP and PMF events is included in Appendix A. A rail chainage reference for the proposed works is included in the results presentation and is referred to in the discussion of the results.

Typical inundation depths across the proposed rail development site for the 1% AEP event are of the order of 1.5 – 3.0m and 3 – 4m along the access road alignment. Peak flood velocities are typically less than 0.5 m/s, but are locally much higher near to the New England Highway, where the initial spilling from the Hunter River occurs. The floodplain flow distribution shows that the major area of conveyance is through the area to the north of Hexham Swamp. The northern end of the proposed works site (ch.176800 to ch.177300) is located in this flowpath, whereas the majority of the site downstream of Hexham Bridge is sheltered to some degree by the surrounding areas of higher land and is not a principal flood flow path (ch.174500 to ch.176000).

As detailed in the Newcastle City-wide Floodplain Risk Management Study and Plan (BMT WBM, 2012), the site is located within the broad floodway area of Hexham Swamp, presenting a high flood hazard for the site. This has implications for personal safety, evacuation logistics and the structural integrity of buildings. However, the provisional hazard classification for the site can be reduced through the reduction of flood depths associated with the regrading of the site. Sections of the proposed works will be much closer to the 1% AEP flood level than the existing ground levels and will be largely flood free at the 2% AEP event. The access road from Tarro interchange is also located in an area of high hazard floodway, corresponding to the high flow areas as shown in Figure 2-4.

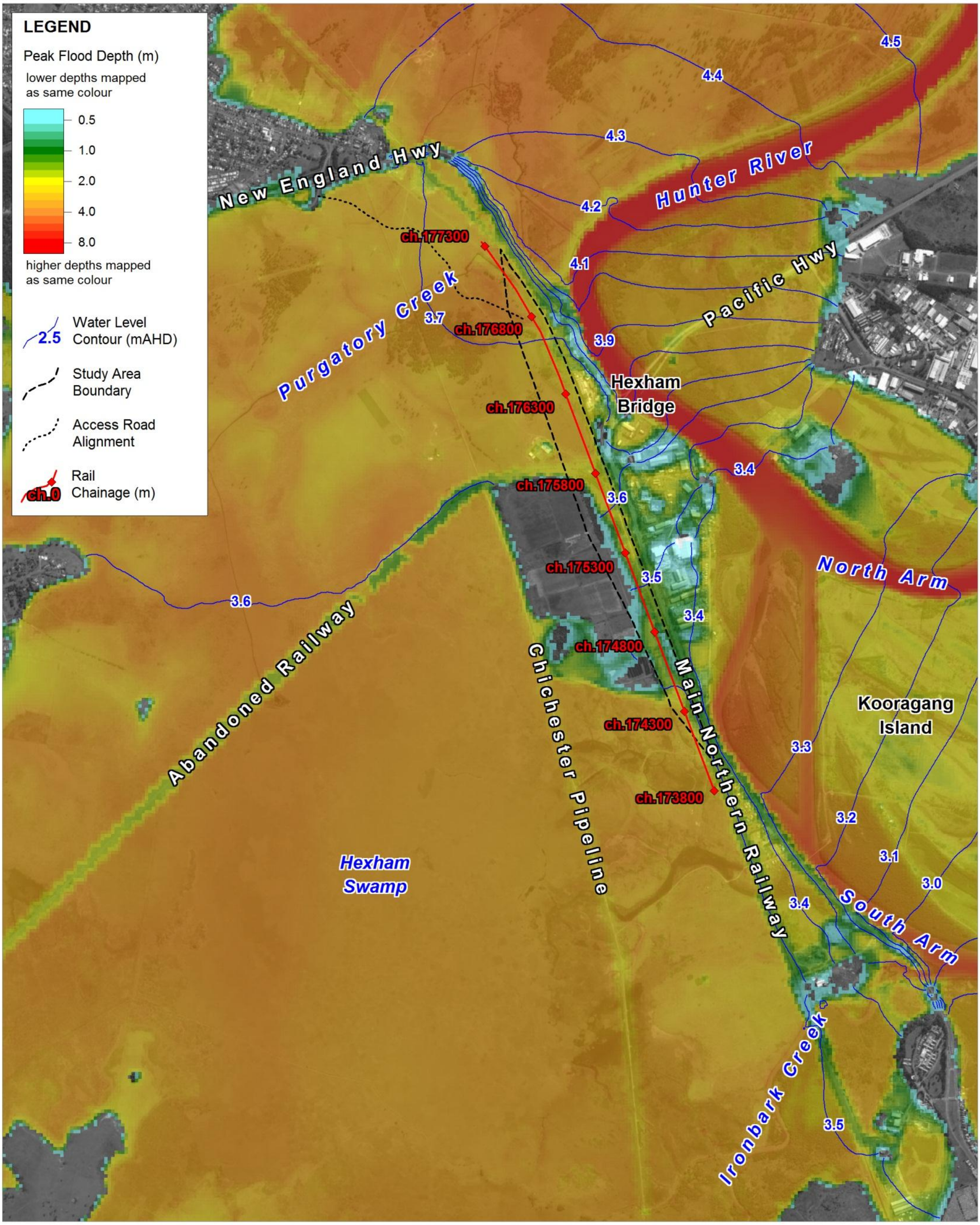
2.4 Comparison with Previous Studies

In addition to the studies discussed in Section 1.3, from which the TUFLOW model of the Williams River and Lower Hunter has been developed, there have been a number of other flood investigations within the region. The principal of these is the Lower Hunter River Flood Study (PWD, 1994), which included the construction of a one-dimensional MIKE11 model and has been used as the basis for subsequent Floodplain Risk Management applications in the Lower Hunter. This model was further developed by DHI in 2009 to incorporate a two-dimensional representation of the Hexham Swamp floodplain area.

A two-dimensional RMA-2 model was developed by WorleyParsons in 2011 as part of the original Flood Impact Assessment for the Hexham Train Support Facility. It also covers the entire of the Lower Hunter River floodplain, from upstream of the Williams River confluence to Newcastle Harbour.

Table 2-2 shows modelled flood levels from the previous studies compared to the modelled flood levels from this study. The models generally show a good level of consistency, with peak flood levels being typically within 0.3m of each other for most locations. The most significant difference between the models occurs downstream of Hexham Bridge, where the water levels of the TUFLOW model deviate from those of the other two models, as evidenced by the levels at Kooragang Island.

The difference in modelled flood level at this location is most likely due to an improved representation of the floodplain between Kooragang Island and Fullerton Cove. This section of the DHI model is represented within the 1-D domain, whereas the TUFLOW model provides a fully 2D representation.



Title:

1% AEP Peak Flood Depths and Levels - Existing Conditions

Figure: 2-2

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Approx. Scale

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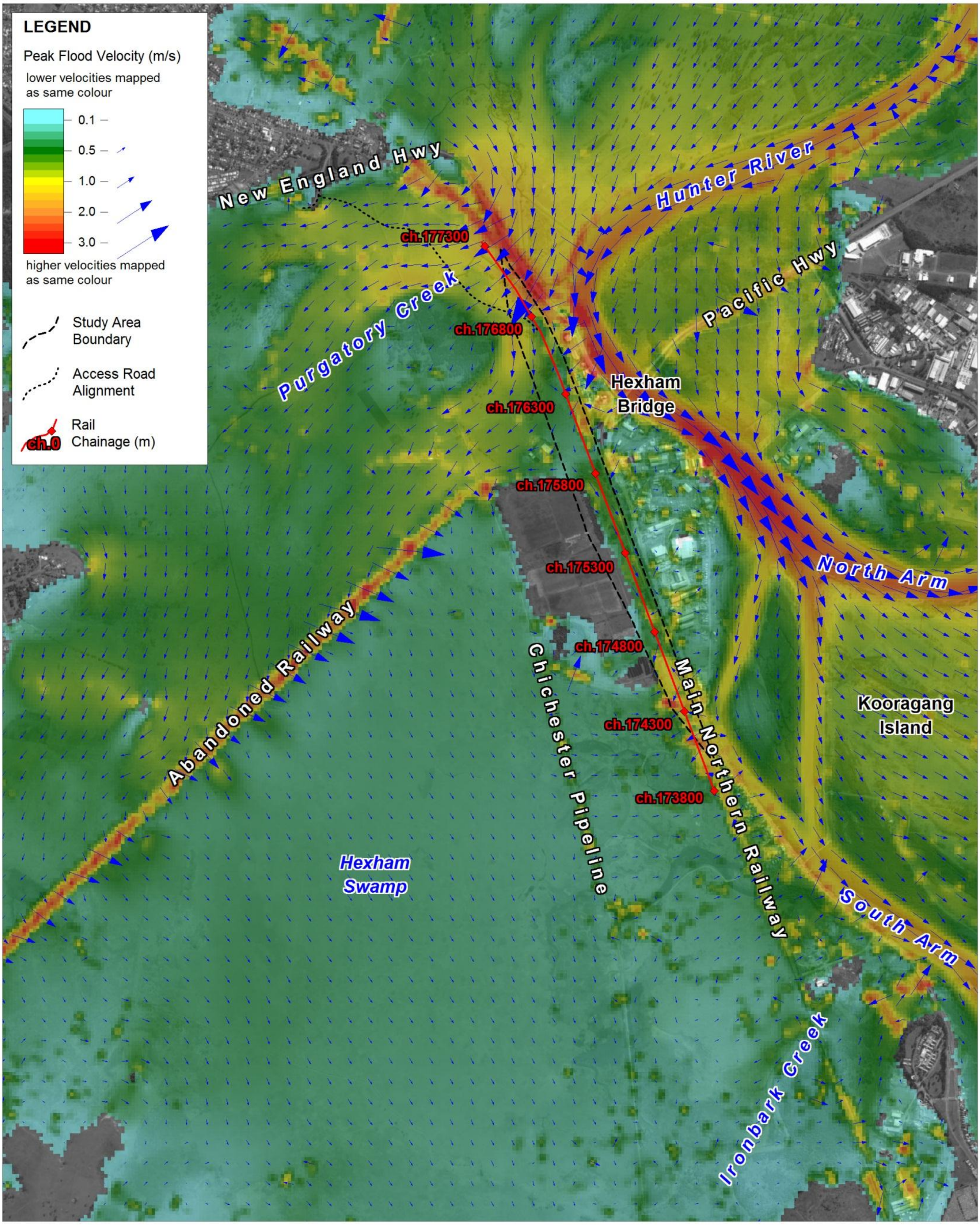

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1% AEP Peak Flood Velocities - Existing Conditions

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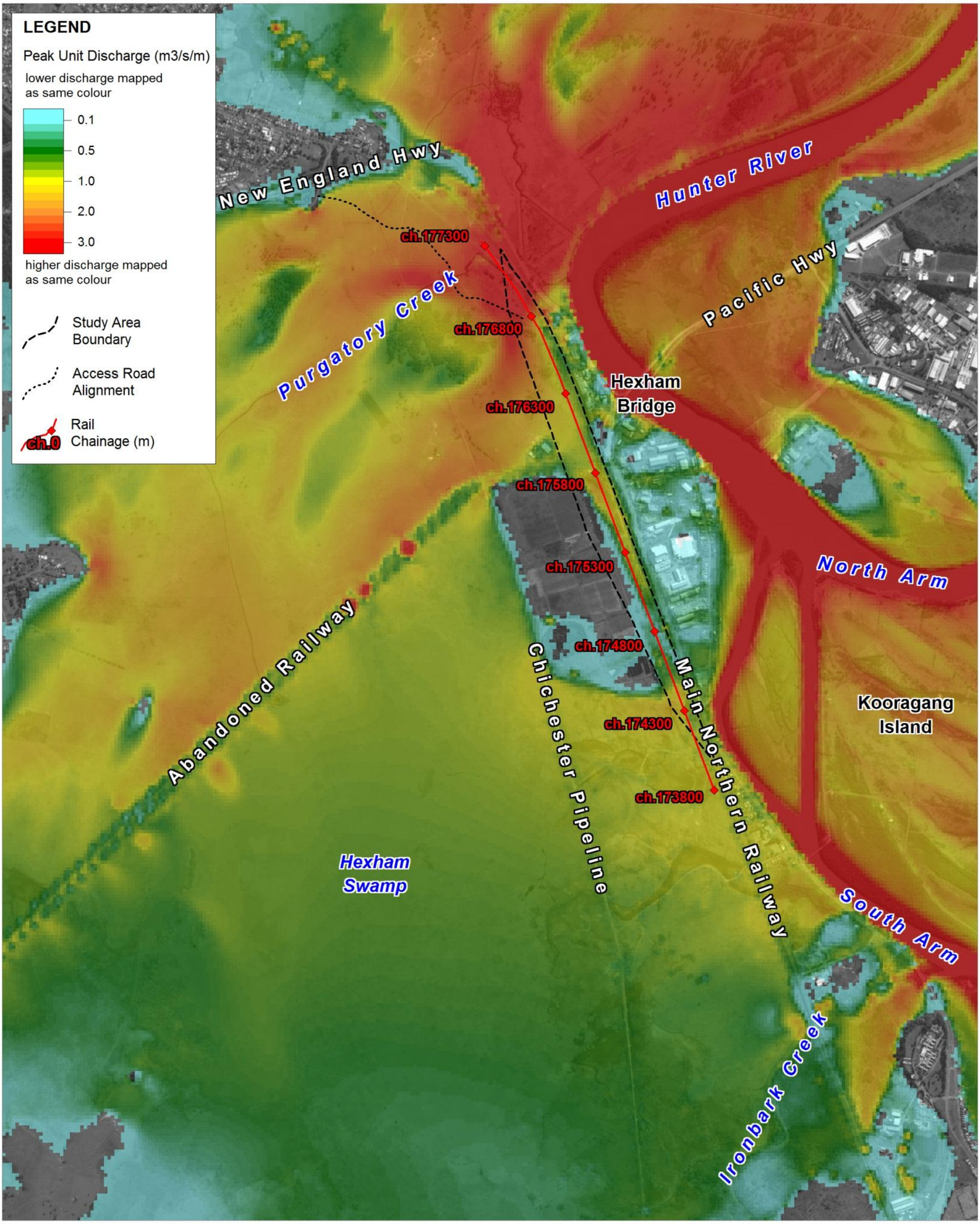

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1% AEP Peak Unit Discharge - Existing Conditions

Figure: 2-4

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It is also noted that several adjustments were made to the RMA-2 model to better fit with the existing model results (WorleyParsons, 2011), which may explain the consistency between the DHI and WorleyParsons models at Kooragang Island.

The flood levels in the study area are driven primarily by the Hunter River upstream of Hexham Bridge, where the models provide reasonably consistent results. The flow of flood waters through Hexham Swamp is highly sensitive to the modelled geometry of the New England Highway and this is likely to explain the small differences in modelled flood levels at the development site.

Table 2-2 Comparison of the 1% AEP Peak Flood Levels (m AHD) Predicted by Previous Studies

Location	LHFS (1994) DHI (2009)	Worley Parsons (2011)	BMT WBM (2012)
Williams River confluence	5.0	4.9	4.9
d/s Raymond Terrace	4.5	4.7	4.7
Beresfield	4.1	4.5	4.5
Hexham Bridge	4.0	4.0	3.8
Development Site	**3.8**	**3.9**	**3.6**
Hexham Swamp	3.8	3.8	3.5
Kooragang Island	3.5	3.5	2.8

3 PROPOSED WORKS

3.1 Description

The NSW Long-term Train Support Facility covers an area of approximately 250ha in the vicinity of Hexham Bridge. The development of the site will involve the construction of a fill platform for a new Train Support Facility. The Hexham Relief Roads upgrade is around 2.5km in length and is situated, between the Train Support Facility and the existing railway. It involves regrading of the site and the installation of rail tracks parallel to the existing alignment of the Main Northern Railway (from approximately ch.174100 to ch.176600). The proposed works also include a joint access road off the New England Highway at Tarro. The access road will provide site access for the construction stages of both projects and permanent access for the servicing of the Train Support Facility.

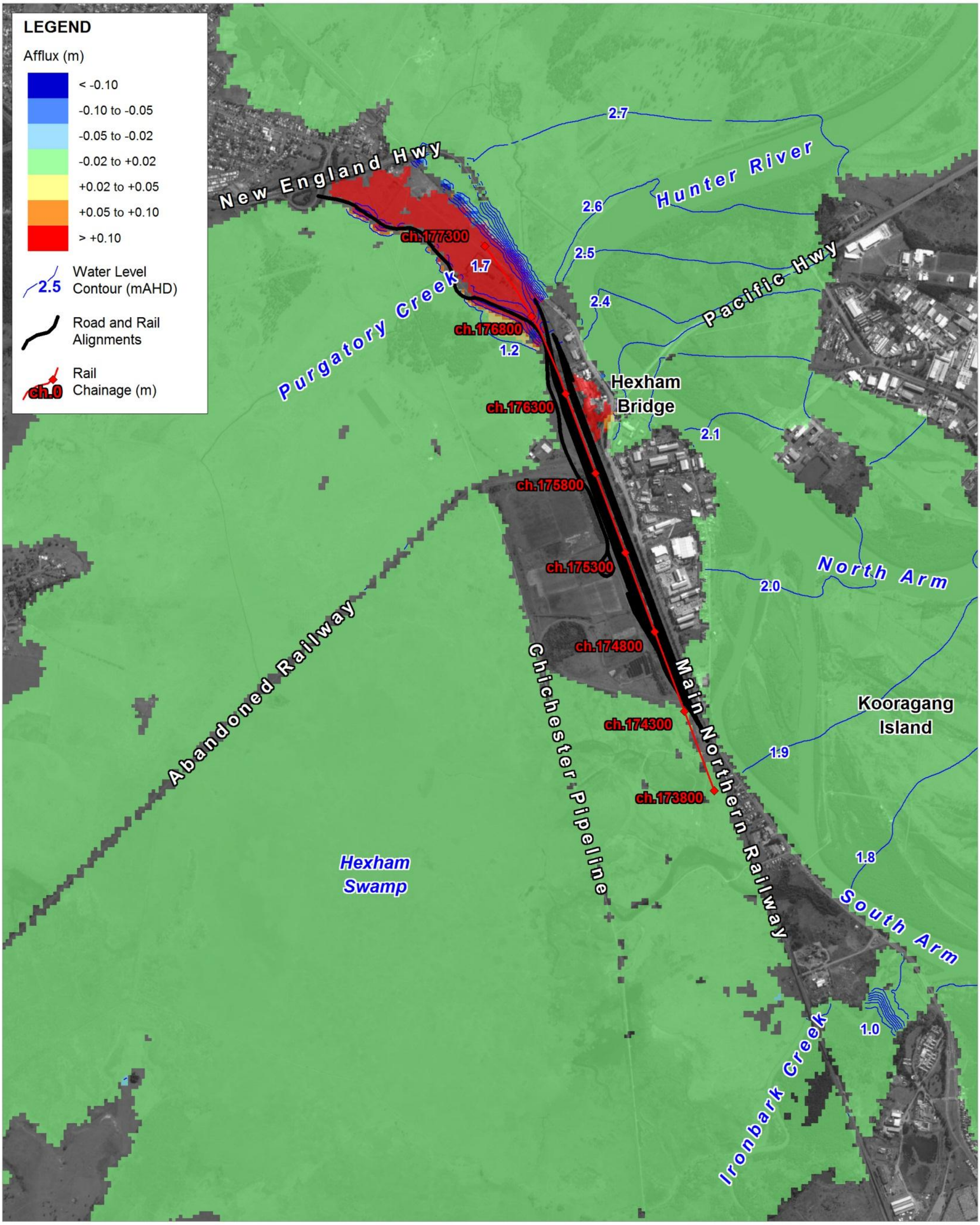
Details of the Hexham Relief Roads design were provided by Parsons Brinckerhoff as a Digital Terrain Model (DTM). Details of the Train Support Facility design were also provided by the client. The topographic details of the proposed works have been incorporated into the TUFLOW model to assess the impacts on regional Hunter River flooding.

The details of the proposed access road from the Tarro interchange have also been supplied as a DTM. The access road is some 1.5km in length, with typical crest levels varying between 1.5m AHD and 2.5m AHD. The road alignment includes a bridge crossing of Mid-site Creek and the provision of cross-drainage structures at Purgatory Creek and other drainage locations.

3.2 Flood Impacts

The model results indicated that the proposed works had limited impact on regional flood behaviour. For the modelled 1% AEP event a minor redistribution of flood flow occurs. Increased flood flows through Hexham Swamp raised modelled peak flood levels by a few centimetres, with a corresponding reduction in peak flood levels in Hexham. For events less than the order of a 5% AEP condition the flood impacts are minor as the Hunter River remains largely in-bank (i.e. confined by the New England Highway). However, for events greater than the order of a 5% AEP event some significant localised flood impacts were identified upstream of the access road and in Hexham, as shown in Figure 3-1. Modelled flood level increases were in the order of 0.2m to 0.4m.

Further details of local flood impacts are provided in Section 4. The flood mitigation is discussed in Section 5.



Title:

Impact of Proposed Works on Peak Flood Levels for an Event in the Order of a 5% AEP

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4 DETAILED HEXHAM FLOOD IMPACT ASSESSMENT

The flood modelling undertaken using the Hunter River flood model had demonstrated that there were no significant impacts on regional flood behaviour. However, there are some localised flood impacts in the Hexham locality for events in the order of a 5% AEP and 2% AEP. Further investigation into requirements to mitigate these impacts identified complex local flood flow paths. The flood behaviour of these local flow paths is driven by topographic controls that are at a scale beyond the representation of the regional modelling.

4.1 Detailed Flood Model Development

In order to fully understand the complex nature of flood behaviour in the Hexham area a detailed local TUFLOW model was developed. For events up to a 10% AEP magnitude the flow paths through the Hexham area are not active, with flooding being confined to the Hunter River and Hexham Swamp. For events of a 1% AEP magnitude or greater the Hunter River and Hexham Swamp system becomes fully connected and the regional flood model provides an appropriate representation of local peak flood conditions.

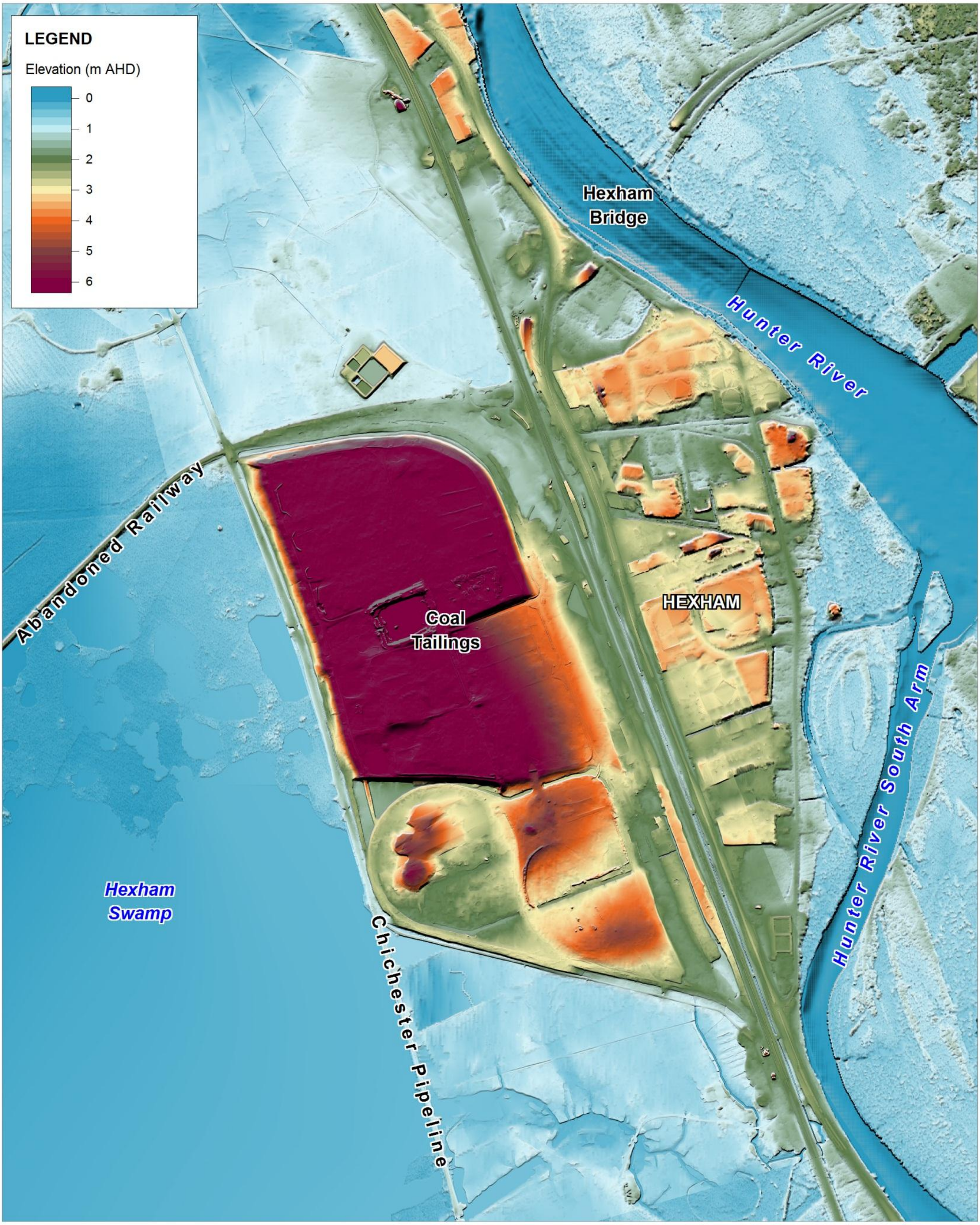
Much of the Hexham area is elevated above the 2% AEP flood level. However, for events in the order of a 5% AEP and 2% AEP magnitude, flood waters spill from the Hunter River through localised low spots in the vicinity of Hexham Bridge. These flood waters progress through the developed area, principally through overtopping of the existing rail line, and into Hexham Swamp. A detailed flood model was developed to fully understand the nature of the flood behaviour of these flow paths and the implications of the proposed developments for local flood risk.

The local topography is presented in Figure 4-1. The model topography was constructed from LiDAR survey data and a detailed photogrammetric survey, which was undertaken to assist with the detailed design of the proposed works. A TUFLOW model with a 4m grid resolution was developed. The regional flood behaviour in the Hunter River and Hexham Swamp is largely independent of the local flood behaviour for the 5% AEP and 2% AEP flood events. Appropriate model boundaries were therefore established using results from the regional Hunter River model.

4.2 Hexham Flood Behaviour

The Hexham area is predominantly flood-free for the 10% AEP flood event. Only one industrial site, located immediately to the south of Hexham Bridge is inundated during an event of this magnitude. The peak flood level of around 1.8m AHD is not sufficient to overtop the Pacific Highway, which has an elevation of around 2m AHD at this location.

Figure 4-2 shows the flood behaviour in Hexham as output from the detailed local modelling for an event in the order of a 2% AEP. It presents peak flood depths and is annotated to indicate the major flood flow paths. There are two main flood flow paths in the area which connect the Hunter River and Hexham Swamp (marked A and B on Figure 4-2), with a number of smaller local flow paths through the Hexham industrial area. Once the flood level in the Hunter River at Hexham Bridge exceeds 2.0m AHD, flood waters begin to spill over the highway, inundating the industrial and commercial properties located to the east of the railway. The flood waters must overtop the existing railway (which is elevated above the natural ground surface) before discharging to Hexham Swamp.



Title:

Floodplain Topography in Hexham

Figure: 4-1

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Approx. Scale

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This local flood flow path through Hexham is minor in terms of regional flood behaviour and typically represents only around 1% of the total Hunter River flood flows, in terms of peak flow rates and volumes. However, given the nature of the local topography, which consists of developed depressions situated behind a raised embankment, this relatively minor flood flow path presents a significant existing flood risk. Historic development and topographic modifications within Hexham constrain the flood flow paths to areas of lower elevation. This presents both a complex and significant flood risk to the existing properties located within these lower-lying areas.

4.3 Hexham Flood Impacts

The detailed Hexham model was used to better understand the local flood impacts of the proposed works. The proposed works were incorporated into the model to determine the impacts on flood events in the order of a 5% AEP and 2% AEP.

Figure 4-3 shows the flood impacts of the proposed works on the 2% AEP event peak water levels. It can be seen that impacts are largely restricted to the area bounded by the Pacific and New England Highways to the east and by the rail alignment to the west. The new rail alignments are set at a higher elevation than the existing tracks, which restricts the capacity for flood waters to spill over the existing rail alignment and into Hexham Swamp. Additional flood flows are pushed north around where the proposed works tie in with the existing rail and south along the road and rail corridor. This increases the typical peak flood conditions by around 0.2m.

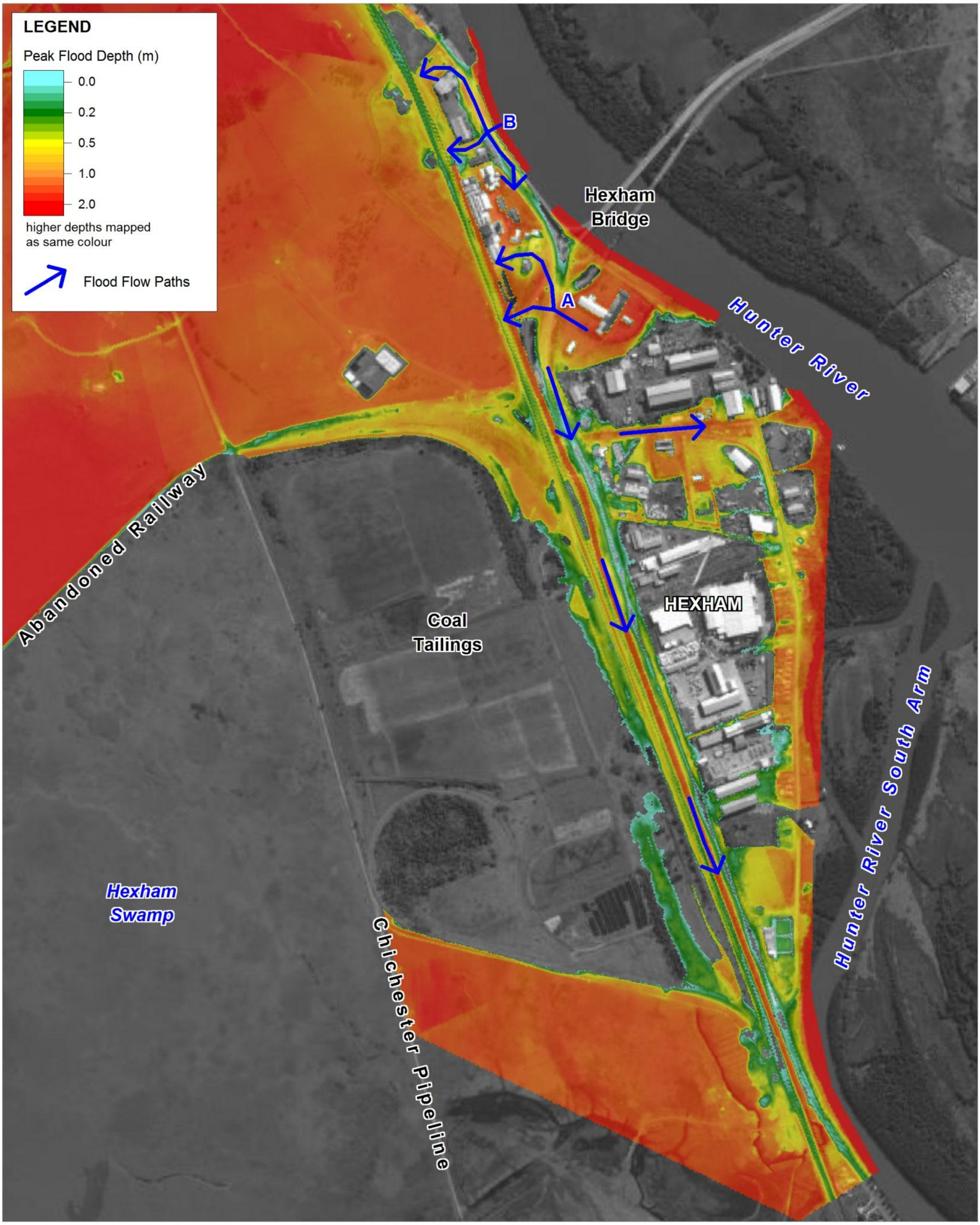
4.4 Access Road Flood Impacts

The detailed model extents also incorporate the northern section of Hexham Swamp in order to better represent the flood impacts associated with the access road. The aerial survey data for the site that was undertaken to assist with the design process captured a number of topographic controls for which data was not previously available. These features have a significant influence on the existing flood behaviour and associated flood impacts of the access road.

During a major flood event in the Hunter River, overtopping of the New England Highway occurs between Hexham and Tarro. The flood waters then flow over the existing railway and a number of other topographic controls, such as Woodlands Close, the Mid-site Creek banks and the Chichester Pipeline track, before filling the available storage to the north of the abandoned railway. As there is only limited cross-drainage capacity through these topographic features, the crest levels of the raised embankments typically control upstream water levels, with floodwater filling the storage behind the embankment prior to overtopping. The construction of the site access road introduces an additional topographic control, impacting on upstream flood levels by up to 0.4m for an event of around a 5% AEP magnitude, as show in Figure 4-4.

For events in the order of a 2% AEP magnitude or greater, the northern section of Hexham Swamp fills to a substantial depth and overtops the abandoned railway. The level of flooding effectively drowns out the upstream topographic controls, including the proposed access road. The flood impacts associated with the access road for events of this magnitude are therefore negligible.

Accordingly, the proposed access road has the most significant impacts on local flood conditions for a relatively narrow window of flood event magnitude, the highest impacts at around the 5% AEP level.



Title:

Flood Behaviour in Hexham for a Flood Event in the Order of a 2% AEP

Figure: 4-2

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