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# Hexham Relief Roads Flood Impact Assessment

Final Report

R.N2197.001.02

May 2012

# Hexham Relief Roads
# Flood Impact Assessment
# Final Report

| | |
|---|---|
| Prepared For: | Parsons Brinckerhoff |
| Prepared By: | BMT WBM Pty Ltd (Member of the BMT group of companies) |

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| | |
|---|---|
| ***Title*** : | Hexham Relief Roads Flood Impact Assessment |
| ***Author :*** | Daniel Williams |
| ***Synopsis :*** | Report for the Hexham Relief Roads upgrade detailing the existing flood conditions of the proposed development, flood impacts of the proposed upgrade and the assessment of potential cumulative flood impacts with other planned developments in the vicinity of the site. |

## REVISION/CHECKING HISTORY

| REVISION NUMBER | DATE OF ISSUE | CHECKED BY | | ISSUED BY | |
|---|---|---|---|---|---|
| 0 | 05/03/12 | DJL | | DXW | |
| 1 | 21/03/12 | DJL | | DXW | |
| 2 | 02/05/12 | DJL | | DXW | |

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# 1 INTRODUCTION

## 1.1 Purpose of this Report

This report has been commissioned by Parsons Brinckerhoff for the purposes of identifying potential impacts of the proposed Hexham Relief Roads rail upgrade. The assessment includes a detailed flood investigation using the existing TUFLOW flood model to define existing flood conditions and quantify flooding impacts related to the proposed upgrade 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 risk assessment.

The flood impact assessment presented in this document details the nature of the proposed development and the analysis undertaken to quantify potential flood impact. The combined impacts of other proposed developments within the vicinity of the Hexham Relief Roads upgrade have also been assessed, these being the neighbouring Train Support Facility for QR National and the proposed Pacific Highway upgrade from the F3 to Heatherbrae.

## 1.2 Site Location

The proposed site of the rail upgrade is located within the Lower Hunter Valley, near Hexham and is presented in Figure 1-1.


Title:

**Study Locality**

Figure: **1-1**

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## 1.3 Computer Modelling Tool

A detailed 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. Hence, the 2D/1D TUFLOW model of the Williams River was linked to a 2D/1D TUFLOW model of the Hunter River. This 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.

The hydraulic model was calibrated to the February 1990, March 1978 and May 2001 flood events. In terms of the Lower Hunter 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 climate change. 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 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 development is shown in Figure 2-1.

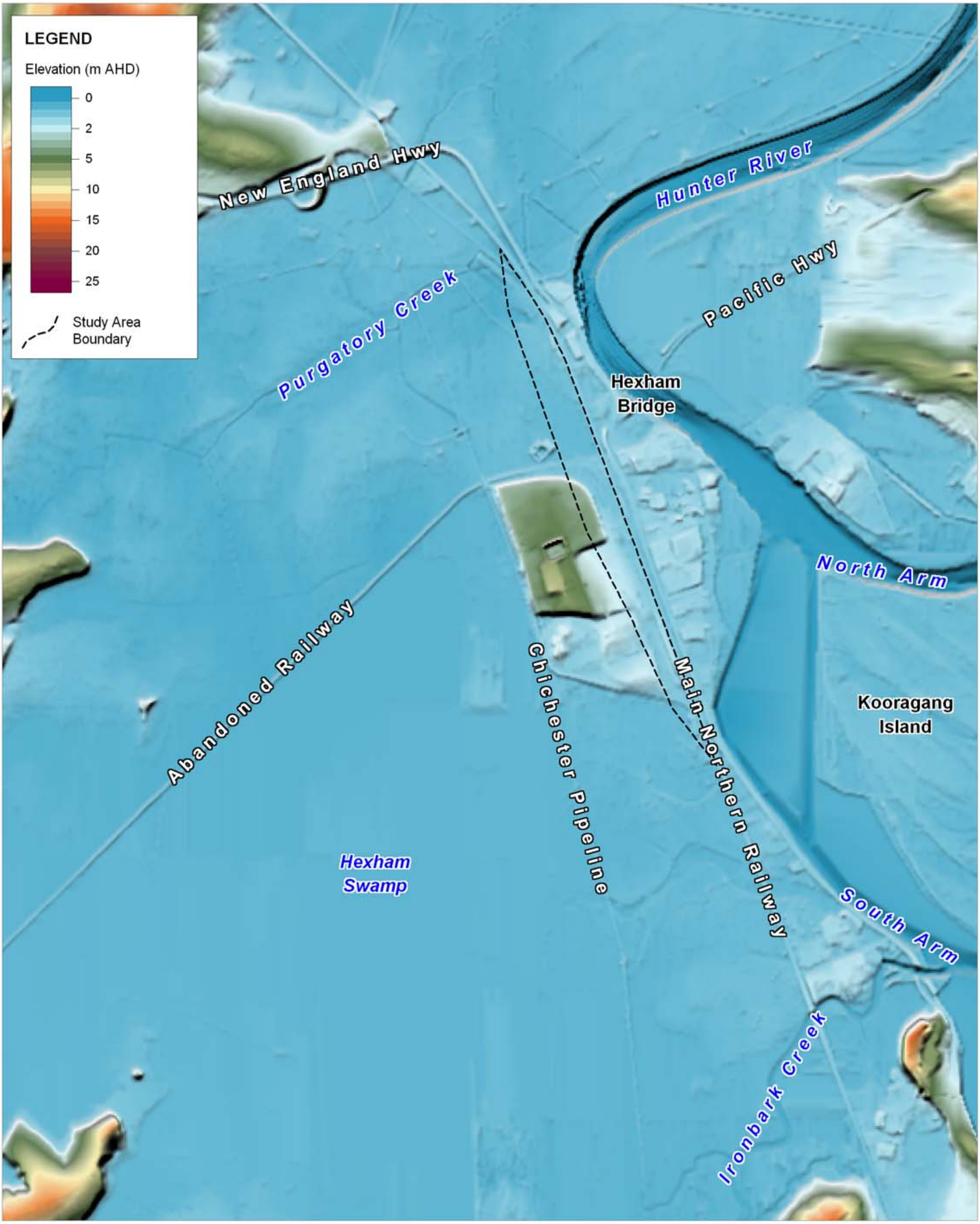
The Hunter River has experienced many floods during its recorded history. The largest flood on record was in 1955. After this event, which claimed 14 lives, the Hunter Valley Flood mitigation Scheme was established, which has subsequently instigated 160km of levees, 3.8km of spillways, 40km of control 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 for the Hexham flood gates is for three gates to allow flow into the swamp and all eight gates to allow flow out of the swamp. This is representative of the current operation, where three of the gates have been raised open to enable flow into the swamp, while all eight gates are flapped to enable flow out of 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. In higher frequency low discharge floods, the flow is contained

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**Local Floodplain Topography**

Figure: 2-1

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Filepath : K:\N2197_Hexham_Rail_Development\MapInfo\Workspaces\DRG_002_120227_Topography.WOR within the rivers banks and levees. As flood severity 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. Hunter River flooding, being from catchment derived, ocean derived or combinations 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 BoM and the SES are required to be 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 then 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.

For events up to the 2% AEP, inundation of the existing rail lines will not occur, or at worst be very localised. However, for flood events of a larger magnitude the existing rail infrastructure at the study site will become inundated. 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 upgrade works on flooding.

Table 2-1 summarises the simulated peak flood levels at the proposed development site for a range of design event magnitudes. There is general flood water level gradient from north to south across the site, such that the peak water levels represent the maximums at the northern (ch.3000) and southern (ch.2000) site locations.

**Table 2-1 Design Flood Levels for Proposed Development Site**

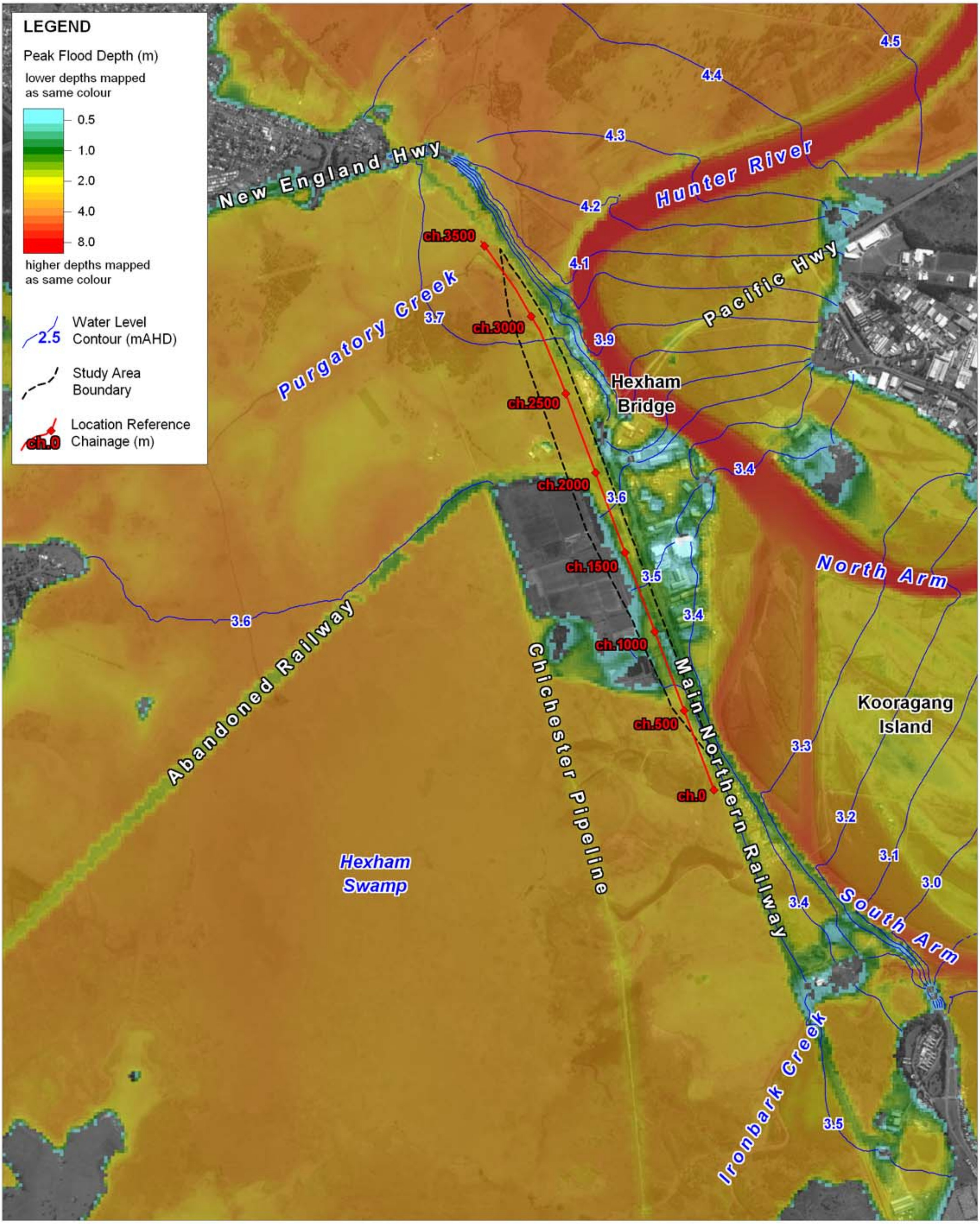
| Design Flood Magnitude | Northern End of Site | Southern End of Site |
|---|---|---|
| 10% AEP | 1.0 | 0.9 |
| 5% AEP | 1.2 | 1.1 |
| 2% AEP | 2.2 | 2.1 |
| 1% AEP | 3.7 | 3.5 |
| PMF | 8.3 | 7.7 |

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. At the 10% AEP, 5% AEP and 2% AEP events flood waters spill into Hexham Swamp over the New England Highway. 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. At the 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 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 chainage for location referencing is included in the results presentation and is referred to in the discussion of the results.

Typical inundation depths across the proposed development site for the 1% AEP event are of the order of 1.5 – 3.0m. 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 site (ch.3000 to ch.3500) 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.700 to ch.2300).

As detailed in the Train Support Facility Flood Impact Assesment (Worley Parsons, 2011), the site is located within a high hazard flood storage area. This has implications for personal safety, evacuation logistics and the structural integrity of buildings. However, the provisional hazard classification for the

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# 1% AEP Peak Flood Depths and Levels - Existing Conditions

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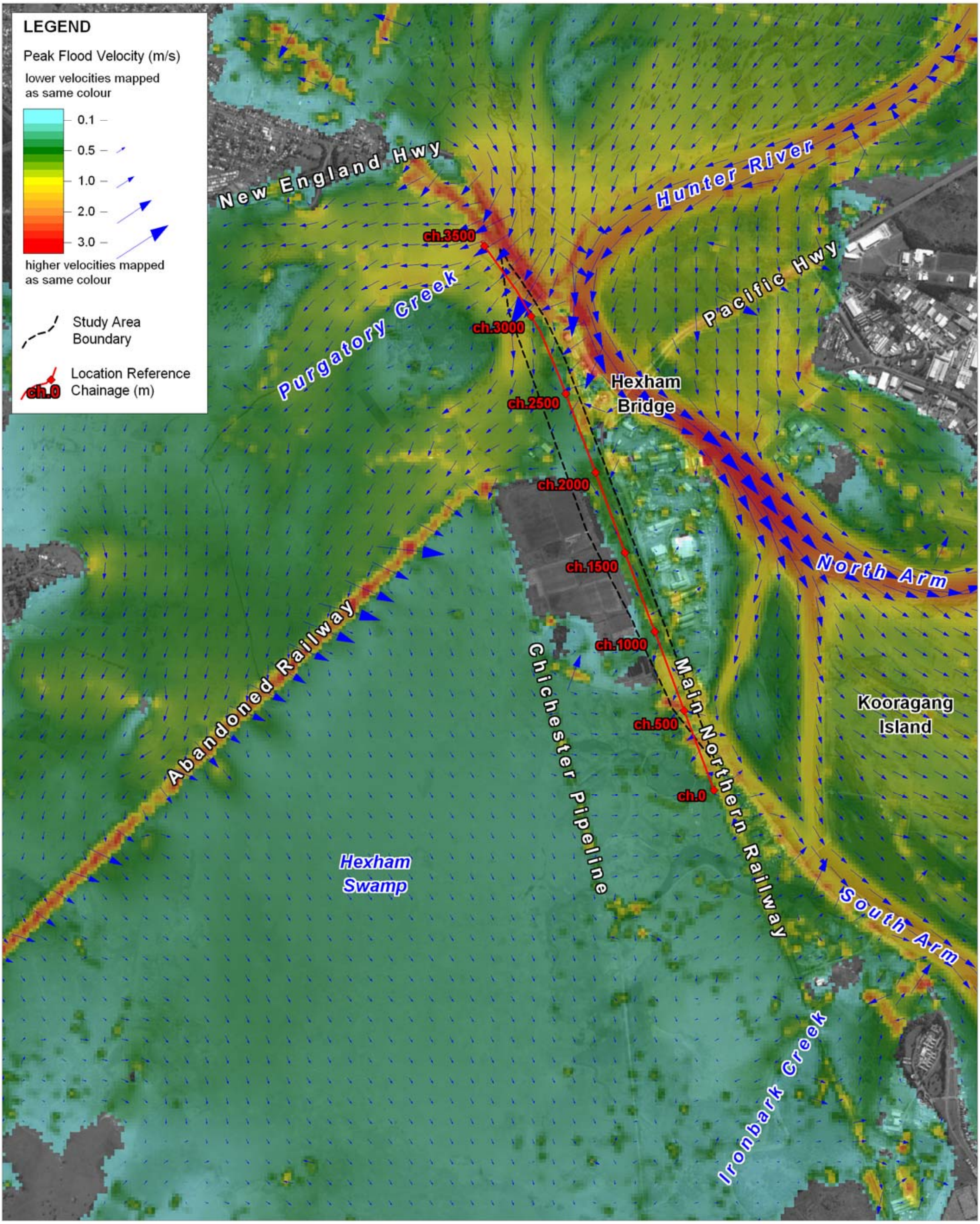


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**1% AEP Peak Flood Velocities - Existing Conditions**

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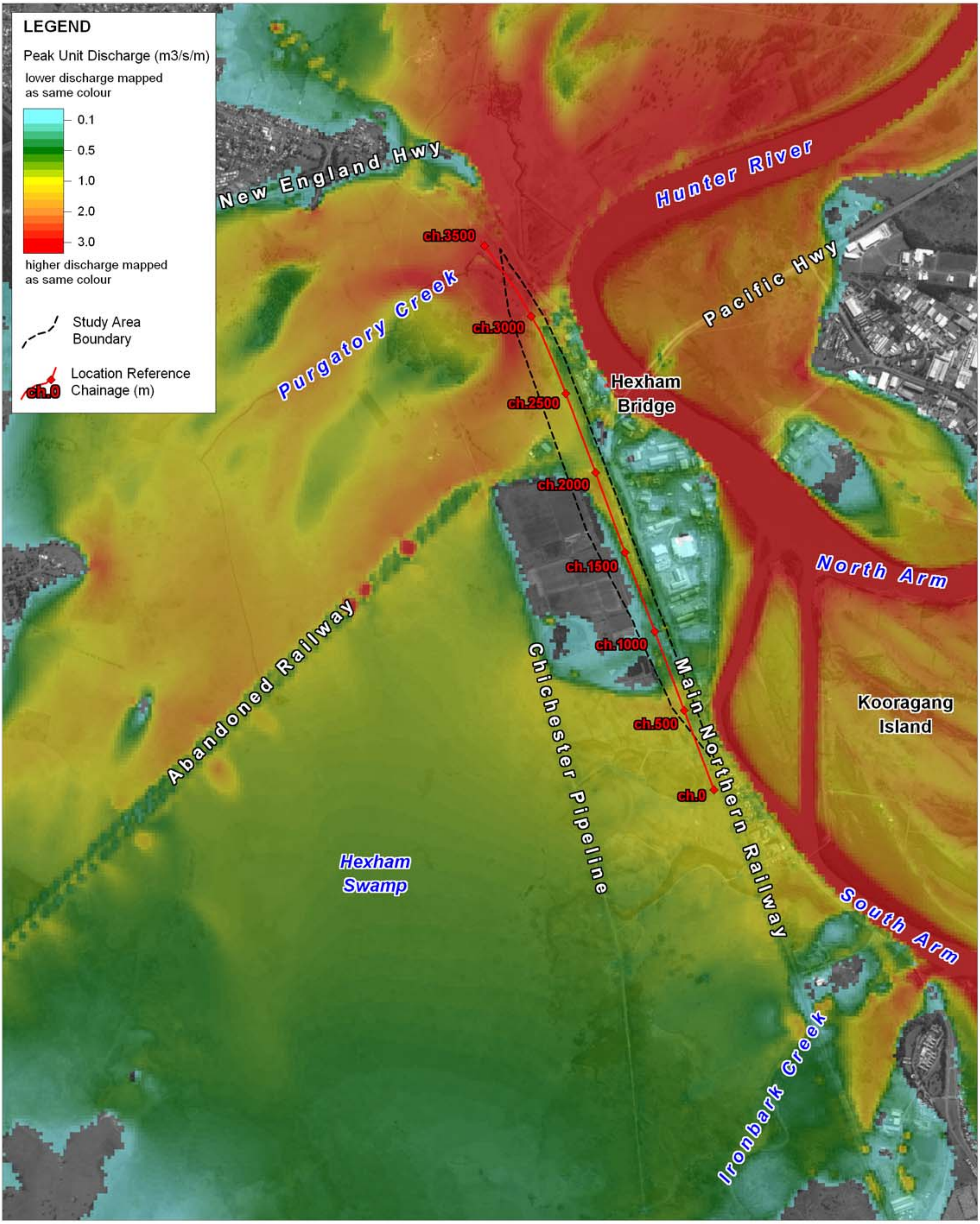


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**1% AEP Peak Unit Discharge - Existing Conditions**

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## 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 Flood Impact Assessment for the QR National 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.

**Table 2-2 Comparison of the 1% AEP Peak Flood Levels 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 |

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. 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.

# 3 PROPOSED DEVELOPMENT

## 3.1 Description

The proposed development of the Hexham Relief Roads upgrade is around 2km in length and is situated in the vicinity of Hexham Bridge. The upgrade involves regrading of the site and the installation of rail tracks parallel to the existing alignment of the Main Northern Railway (from approximately ch.400 to ch.2500). It also involves road works off the New England Highway at Tarro, for site access purposes. A Digital Terrain Model (DTM) of the proposed site regrading and the Tarro access road intersection was provided by Parsons Brinckerhoff and has been incorporated into the TUFLOW model to assess the impacts on regional Hunter River flooding.

The final design option was still to be determined when the flood impact assessment was undertaken and so the details provided by Parsons Brinckerhoff represent the 'worst case' (i.e. highest level of regrading) of the options being developed. The modelled flood impacts therefore represent a slightly conservative scenario. The regraded area is typically elevated at between 3 to 4m AHD and ties into the existing rail elevation of around 2m AHD at either end. The proposed levels of the new works are above the 2% AEP flood level, but largely still below the 1% AEP flood level.

## 3.2 Impacts

The relative impact of the proposed upgrade works in terms of changes in peak flood water level and peak flood velocity for the range of design events considered is shown in Figure 3-1 to Figure 3-8. Flood impacts for the PMF event are included in Appendix B. The impacts of the proposed works are restricted locally to the site and Hexham Swamp. The impact to the Hunter River floodplain beyond Hexham Swamp is negligible.

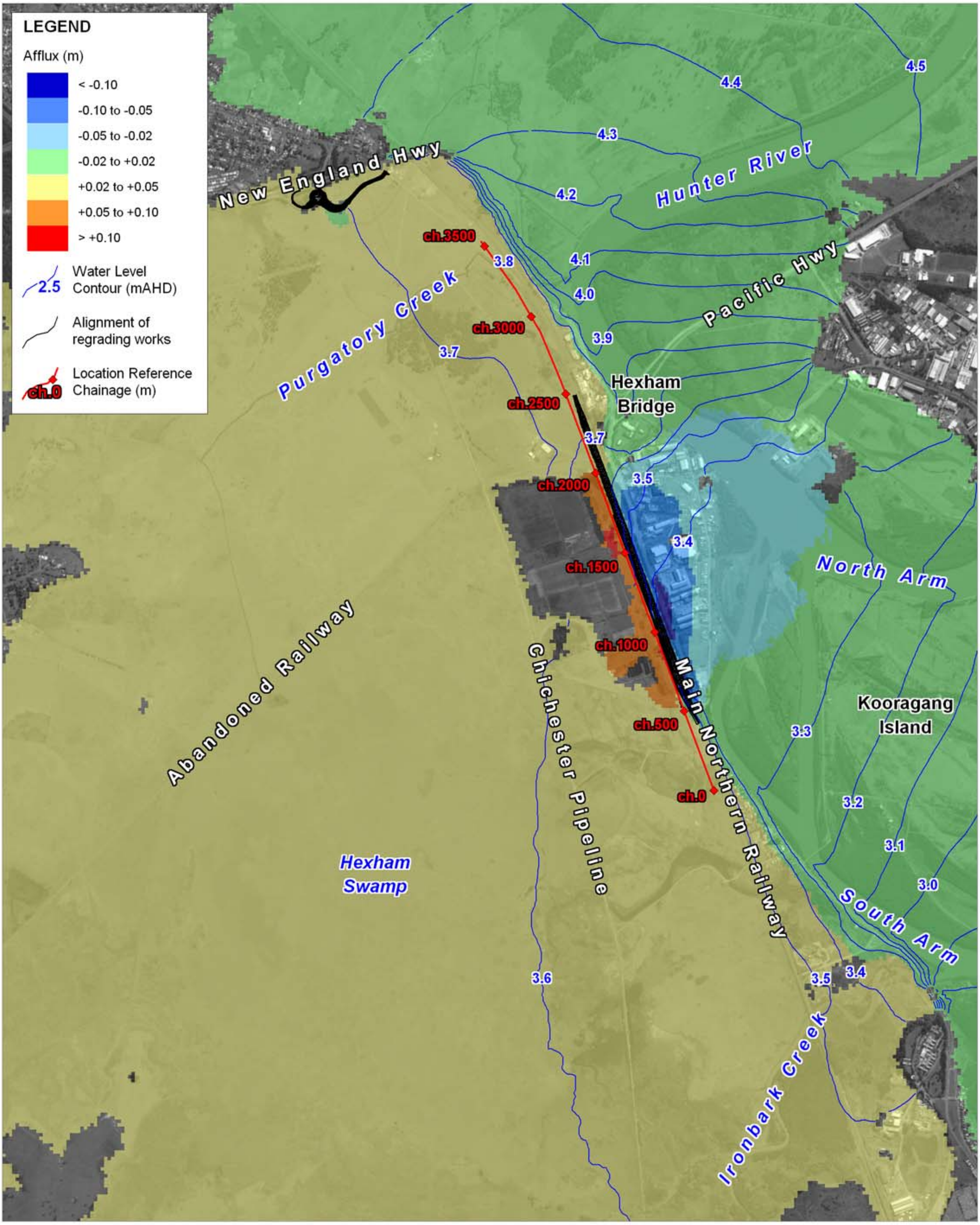
The greatest impact on modelled flood behaviour is for the 1% AEP event. The regrading of the rail upgrade reduces the capacity of the rail corridor to convey flood flows between the two areas of surrounding higher land. This results in a small redistribution of floodplain flows, pushing more water round to the west and through Hexham Swamp. However, the impact on flood levels in Hexham Swamp is relatively minor, at around 0.03m. There are locally higher increases in peak flood level of up to 0.1m, but these are restricted to the rail corridor immediately to the west (ch.500 to ch.2000). There is also a corresponding reduction in peak flood levels to the east of the site.

For the 2% AEP and 5% AEP events the impacts on peak flood levels are locally restricted to the east of the upgrade. Here water is spilling from the Hunter River to fill the available flood storage. With the regrading of the site, this water is becoming 'trapped' behind the rail tracks, raising the peak flood level, typically to the order of 0.2m. This occurs at three locations at about ch.600, ch.1200 and ch.2400. However, no cross drainage infrastructure has been accounted for in the modelling. The provision of sufficient cross drainage structures in the affected locations would assist in mitigating the flood level increases. For the 10% AEP event there is no impact on peak flood levels as the site is not inundated.

The changes in peak velocities for the 1% AEP event as a result of the proposed development are typically less than 0.2m/s. There are two locations for which there is a greater modelled increase in peak flood velocity. Adjacent to the proposed roundabout construction (just off the New England Highway) there is an area of increased peak velocity of around 0.3m/s, from an existing peak of around 0.8m/s. At the northern end of the rail upgrade (ch.2500) there is a localised increase in peak velocities of around 1m/s, where existing peak velocities are also in the order of 1m/s. This occurs at the onset of spilling from the Hunter River on to the floodplain. As the flood waters spill over the railway they are pushed around the northern end of the regrading works, locally increasing velocities. However, the scale of the regional modelling is not at a resolution to define precise local velocity distributions. Further investigation of this increase may be required to determine the need for any local protection works, if the increased velocities are of concern.

At the 2% AEP event there is only a localised increase in peak velocity, again at the northern end of the rail upgrade (ch.2500). This increase is around 1m/s over the existing peak velocities of around 0.5m/s. The impact on peak velocity is minimal for both the 5% AEP and 10% AEP events.

The flood impacts for the PMF event show some localised redistribution of peak flood velocities and localised peak flood depth increases of over 0.05m. However, this impact occurs in an area already that is flooded to a depth of over 4m and can be regarded as an insignificant impact. These impacts are related to the roundabout works off the New England Highway rather than the rail upgrade.




Title:

**Impact on Peak 1% AEP Flood Level - Hexham Relief Roads**

Figure: 3-1

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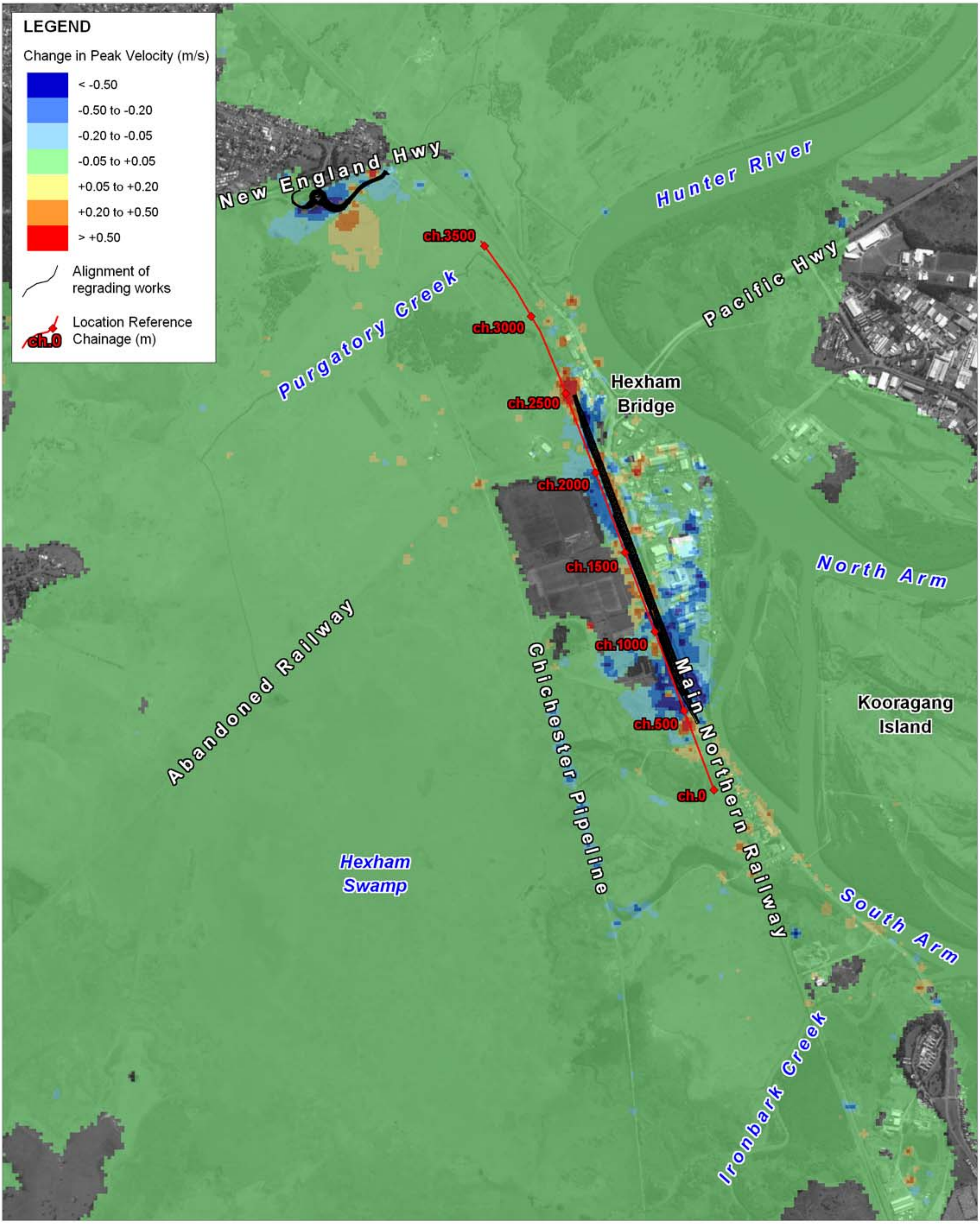


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**Impact on Peak 1% AEP Flood Velocity - Hexham Relief Roads**

Figure: 3-2

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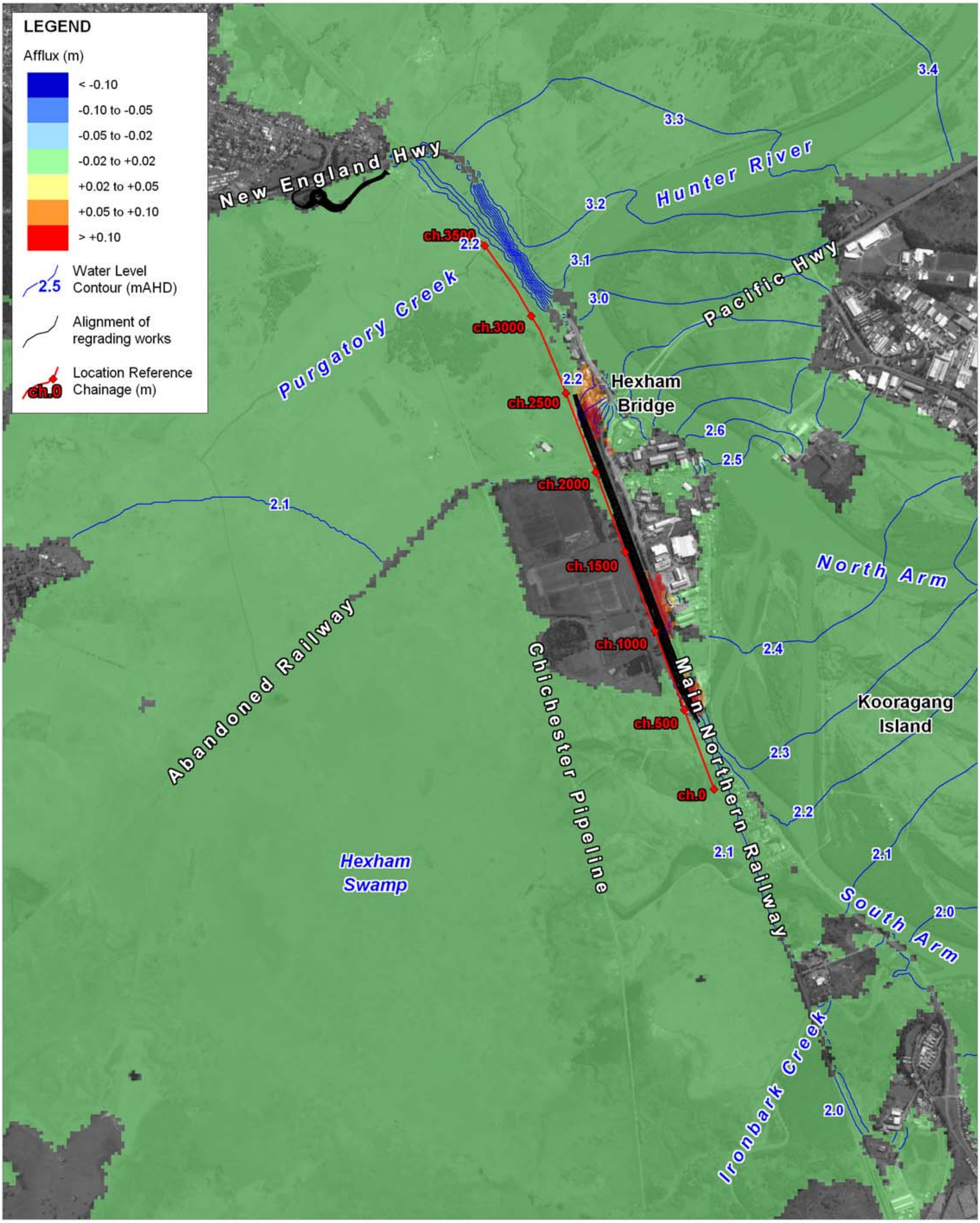


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**Impact on Peak 2% AEP Flood Level - Hexham Relief Roads**

Figure: 3-3

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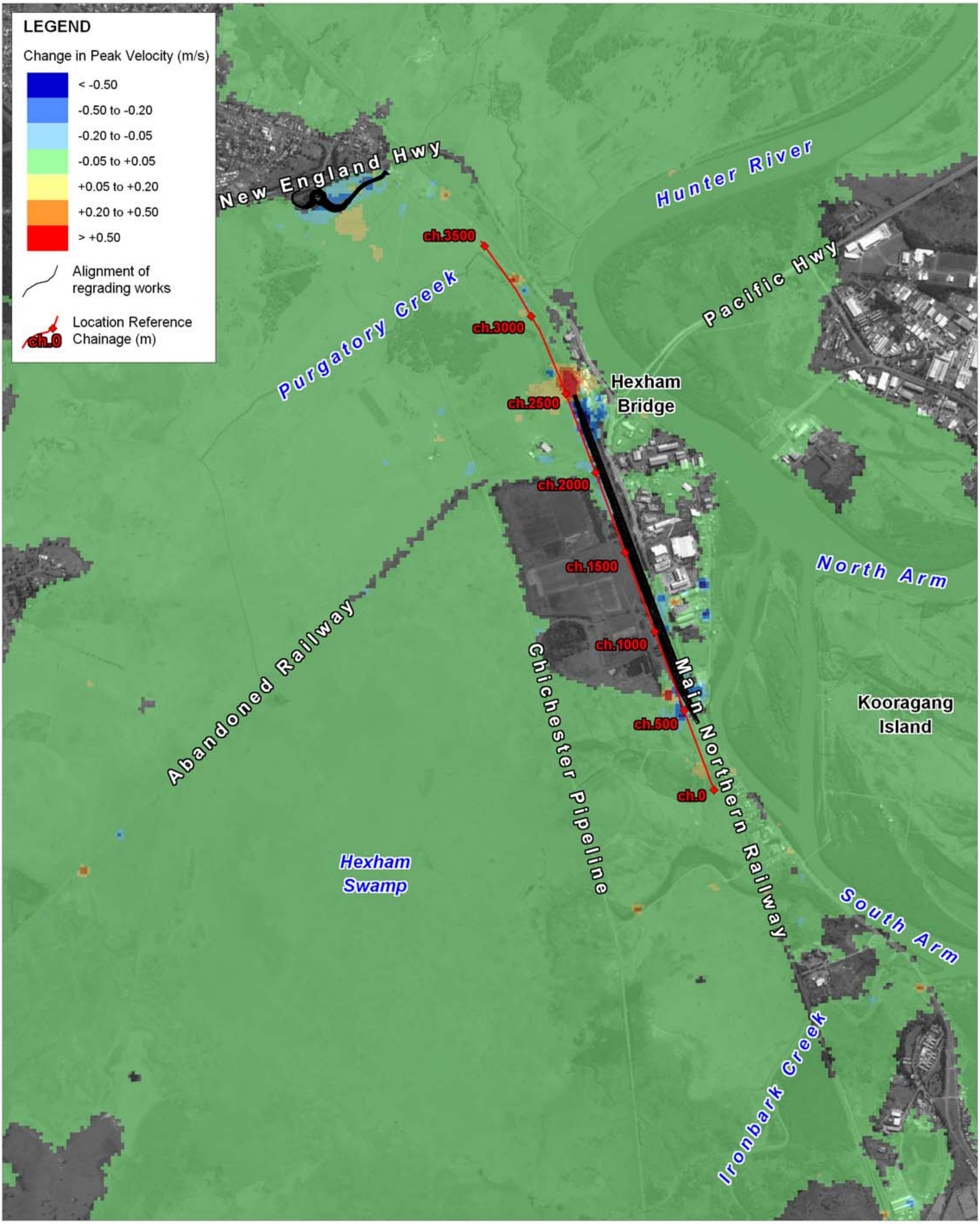


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**Impact on Peak 2% AEP Flood Velocity - Hexham Relief Roads**

Figure: **3-4**

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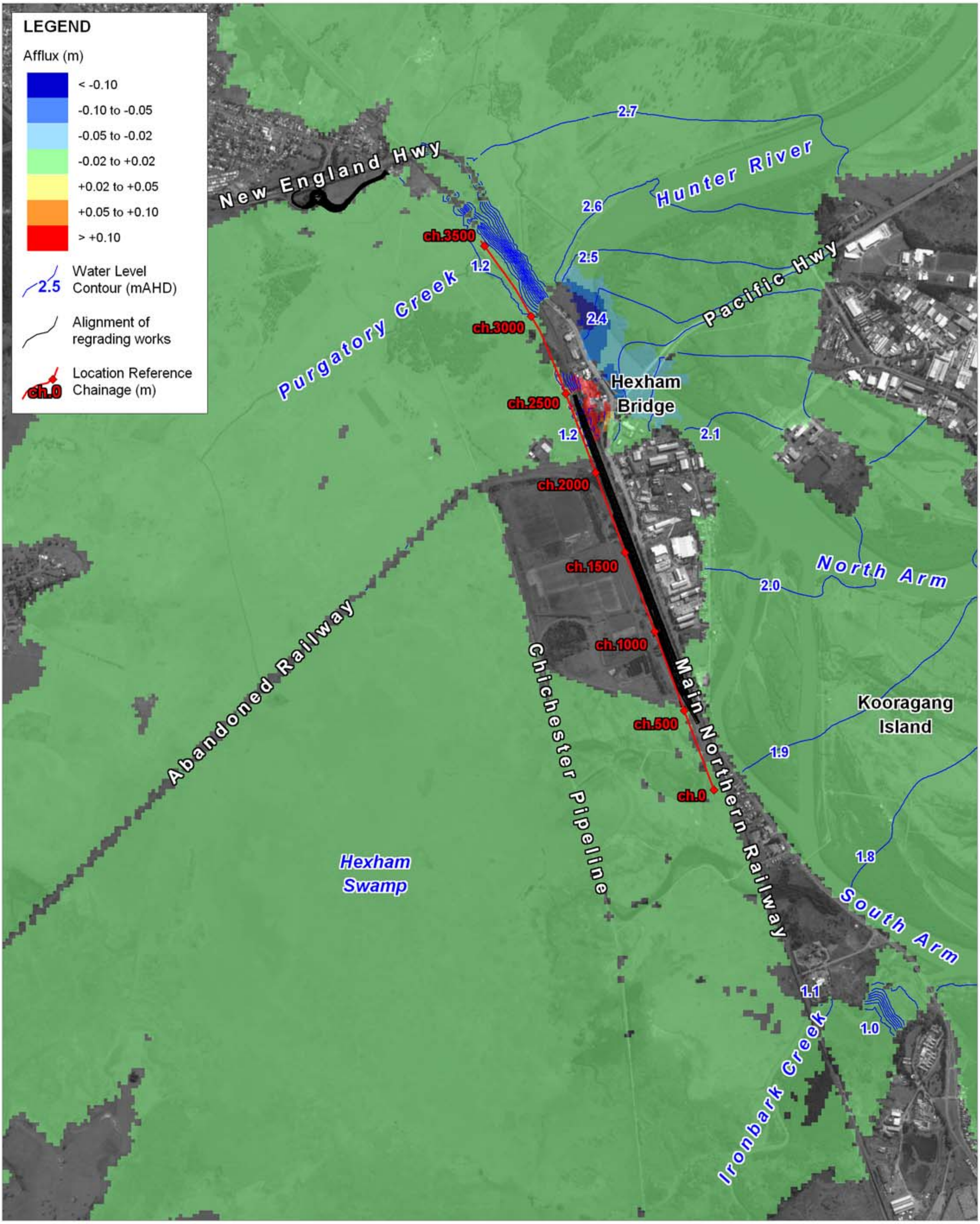


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**Impact on Peak 5% AEP Flood Level - Hexham Relief Roads**

Figure: 3-5

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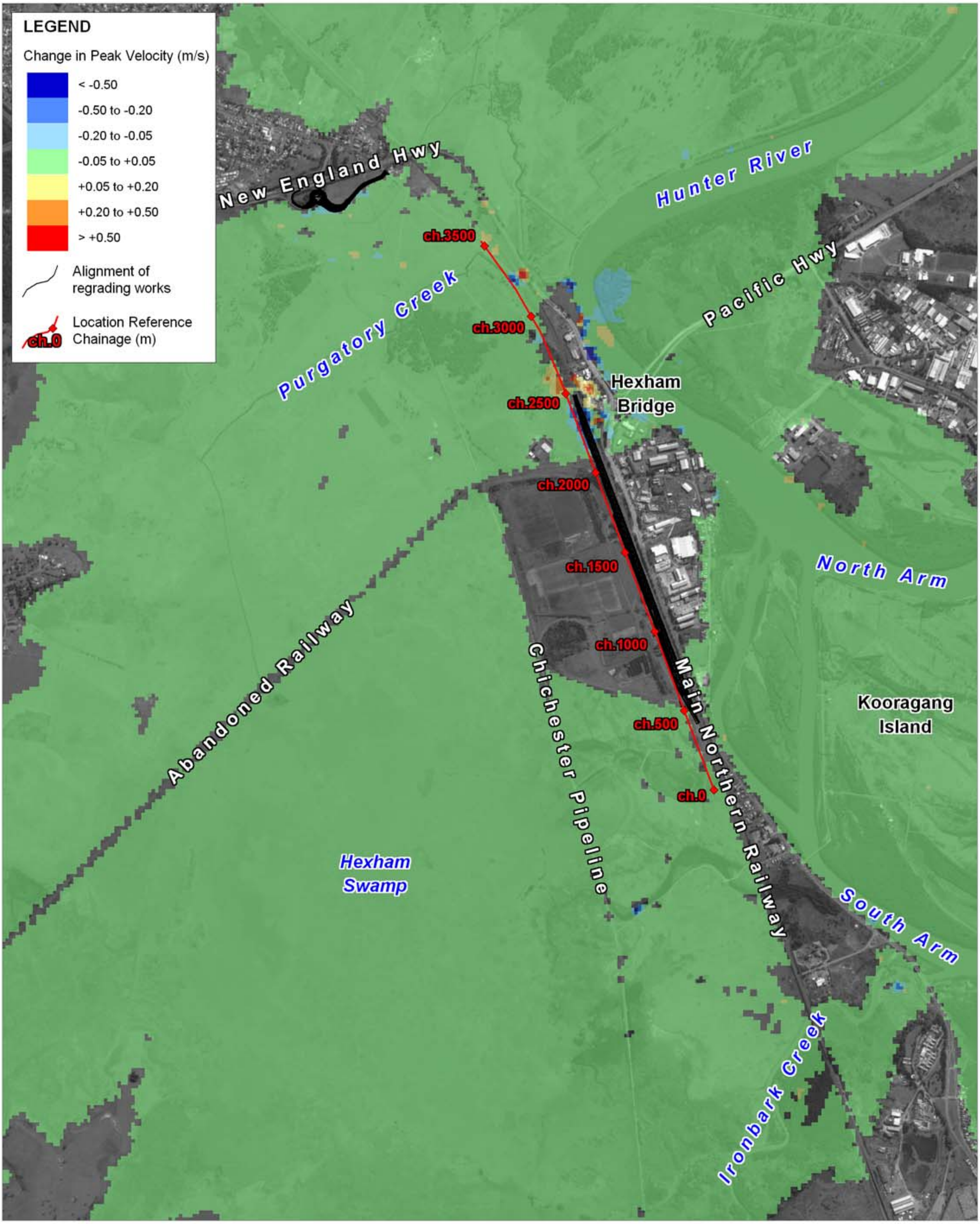


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**Impact on Peak 5% AEP Flood Velocity - Hexham Relief Roads**

Figure: 3-6

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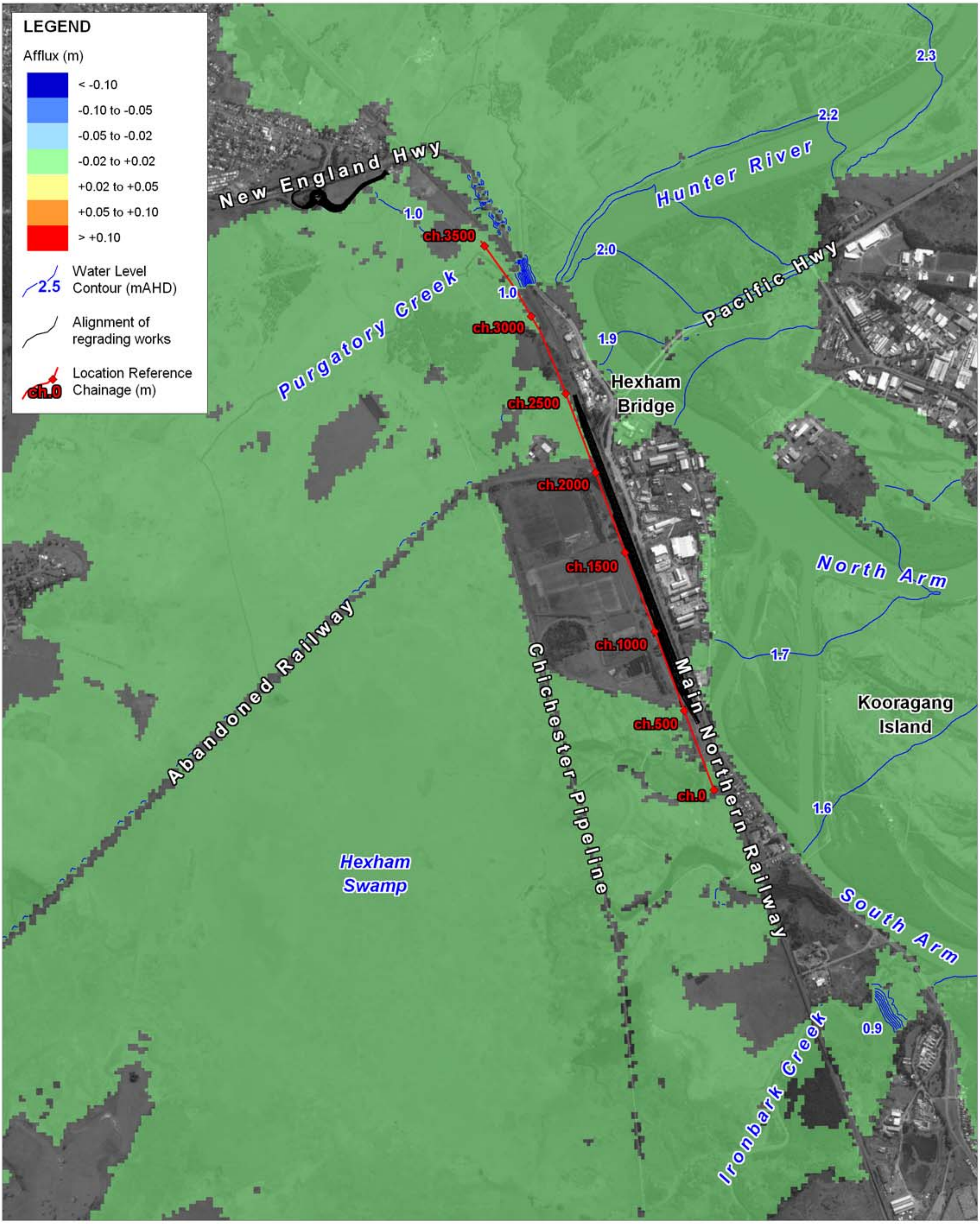


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**Impact on Peak 10% AEP Flood Level - Hexham Relief Roads**

Figure: 3-7

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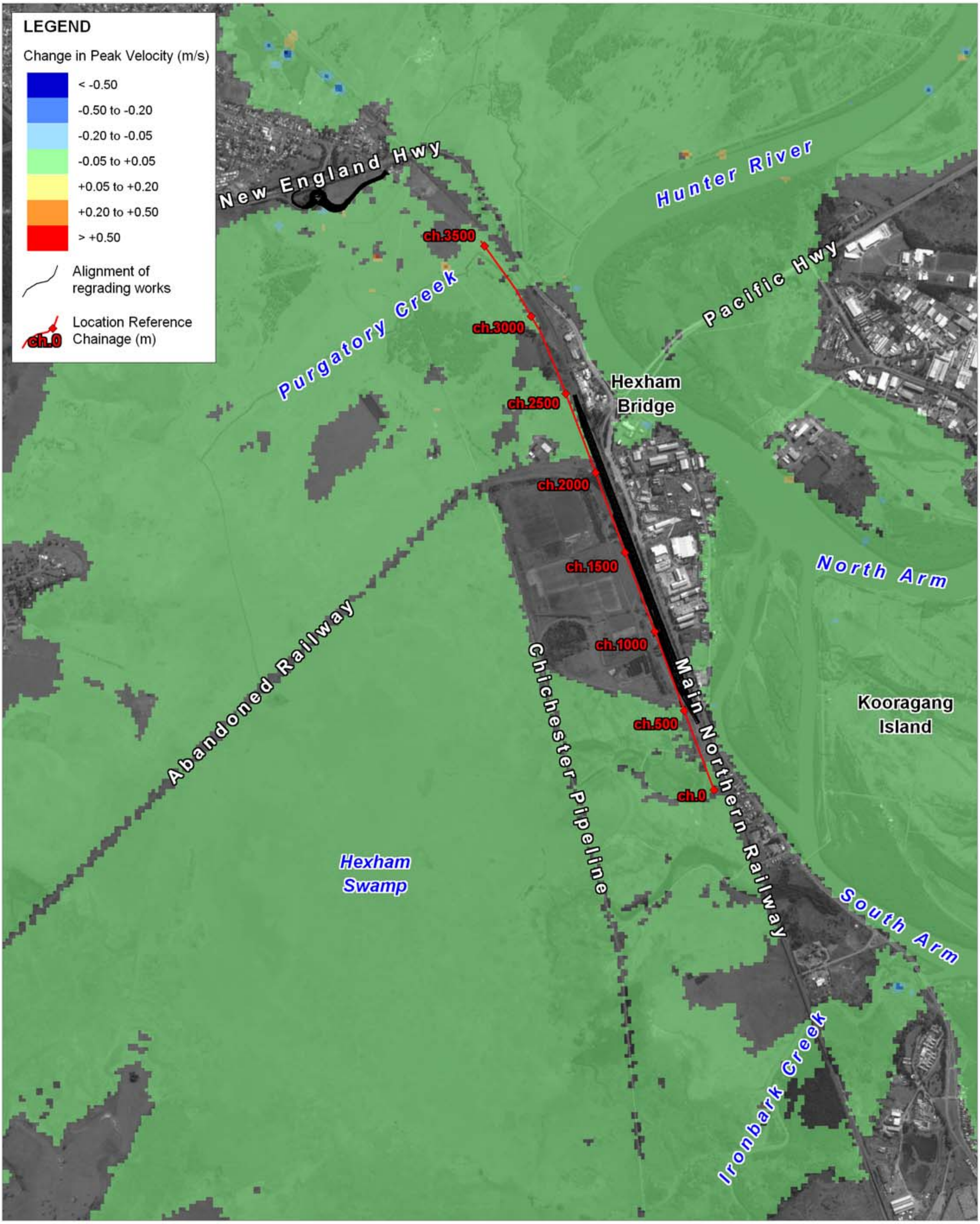


Title:

**Impact on Peak 10% AEP Flood Velocity - Hexham Relief Roads**

Figure: 3-8

Rev: A

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# 4 TRAIN SUPPORT FACILITY

## 4.1 Description

The proposed development of the QR National Train Support Facility upgrade is around 3.5km in length and is also situated in the vicinity of the Hexham Relief Roads upgrade. The works involve the redevelopment of around 120ha of land immediately to the west of the Hexham Relief Roads (approximately ch.0 to ch.3400). The proposed works include the construction of a fill platform for a new Train Support Facility and a new industrial subdivision. The buildings that form part of the industrial subdivision will be elevated above Newcastle City Council's adopted flood planning level. A separate flood impact assessment has been undertaken by WorleyParsons to determine the potential flood impacts associated with the proposed development. The focus of the current investigation is to assess the cumulative flood impacts of the Hexham Relief Roads and the Train Support Facility.

The design options for the Train Support Facility have not yet been finalised and were also impacted by the Hexham Relief Roads upgrade. The Train Support Facility has effectively been pushed to the west by the relief roads and the final design will need to be further developed in response to this. However, for the purposes of this assessment the details of the preliminary Train Support Facility design have been accordingly modified by Parsons Brinckerhoff and supplied as a DTM. The final design may differ to that which has been modelled, but it is likely that the flood impacts would be similar in nature. This can be confirmed once the Train Support Facility designs have been finalised. The topographic details of the preliminary design have been incorporated into the TUFLOW model to assess the cumulative impacts on regional Hunter River flooding. The northern end of the works include a crossing of Purgatory Creek (approximately ch.3300) and it has been assumed that the capacity of the culvert in this location will be maintained.

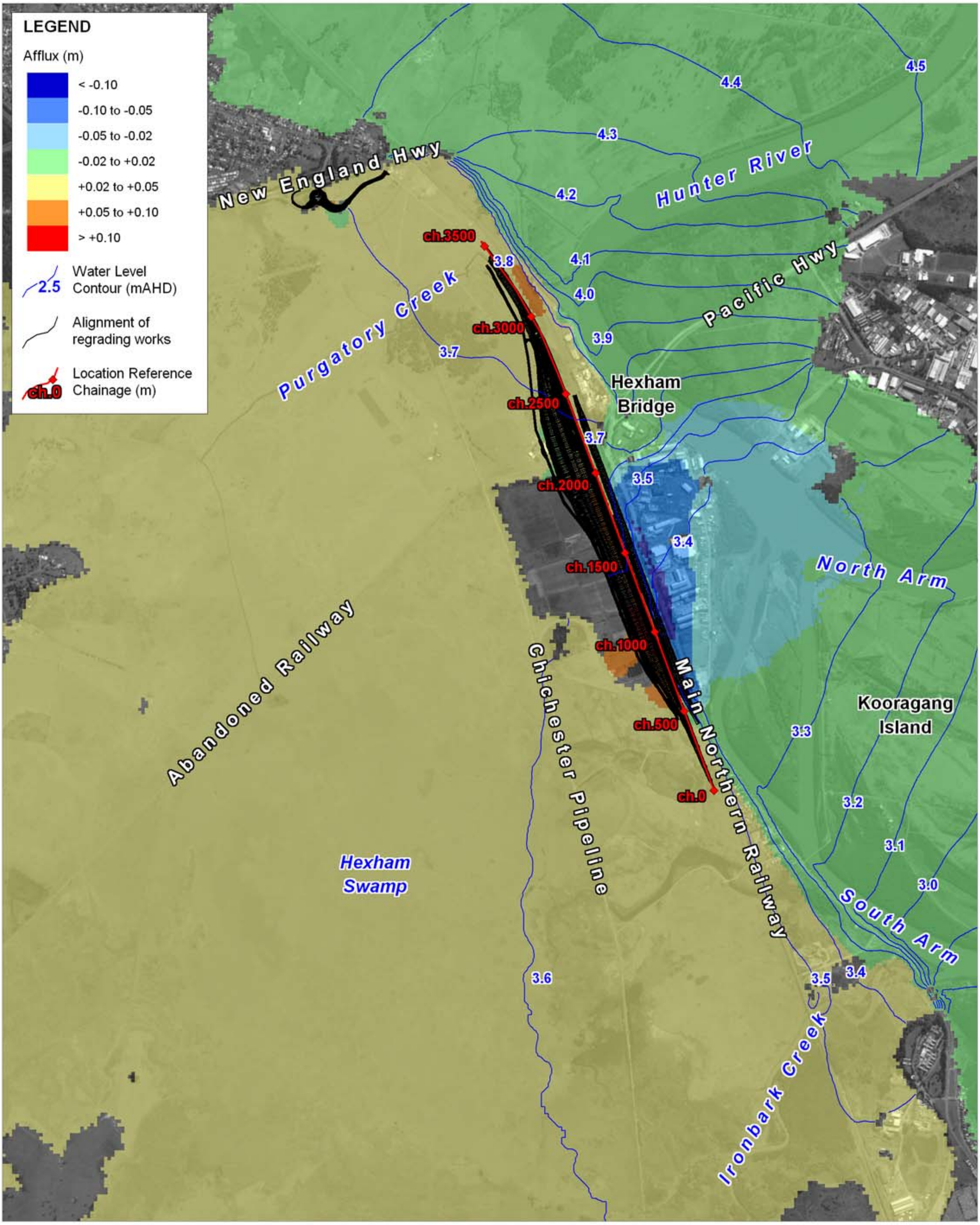
## 4.2 Cumulative Impacts

The cumulative impacts of the proposed relief roads upgrade and train support facility in terms of changes in peak flood water level and peak flood velocity for the range of design events considered is shown in Figure 4-1 to Figure 4-8.

The model results show that the cumulative flood impacts of the two proposed developments are similar to those discussed for the Hexham Relief Roads in Section 3.2. These include:

- A 0.03m peak flood level increase in Hexham Swamp for the 1% AEP event;
- Localised peak flood level increases of around 0.2m to 0.4m for the 2% AEP and 5% AEP events (at locations ch.600, ch.1200 and ch.2300 to ch.3300), for which potential mitigation may be provided through the adequate provision of cross drainage structures;
- No impact on flooding at the 10% AEP event; and
- Localised increases in peak flood velocities (largely at ch.2500 to ch.3500), which may have the potential to result in damage to the rail infrastructure when flood waters spill from the Hunter River.

There is no noticeable increased flood impact resulting from the cumulative consideration of the two proposed developments when compared to consideration of the developments in isolation.




Title:

**Impact on Peak 1% AEP Flood Level - Hexham Relief Roads and Train Support Facility**

Figure: 4-1

Rev: A



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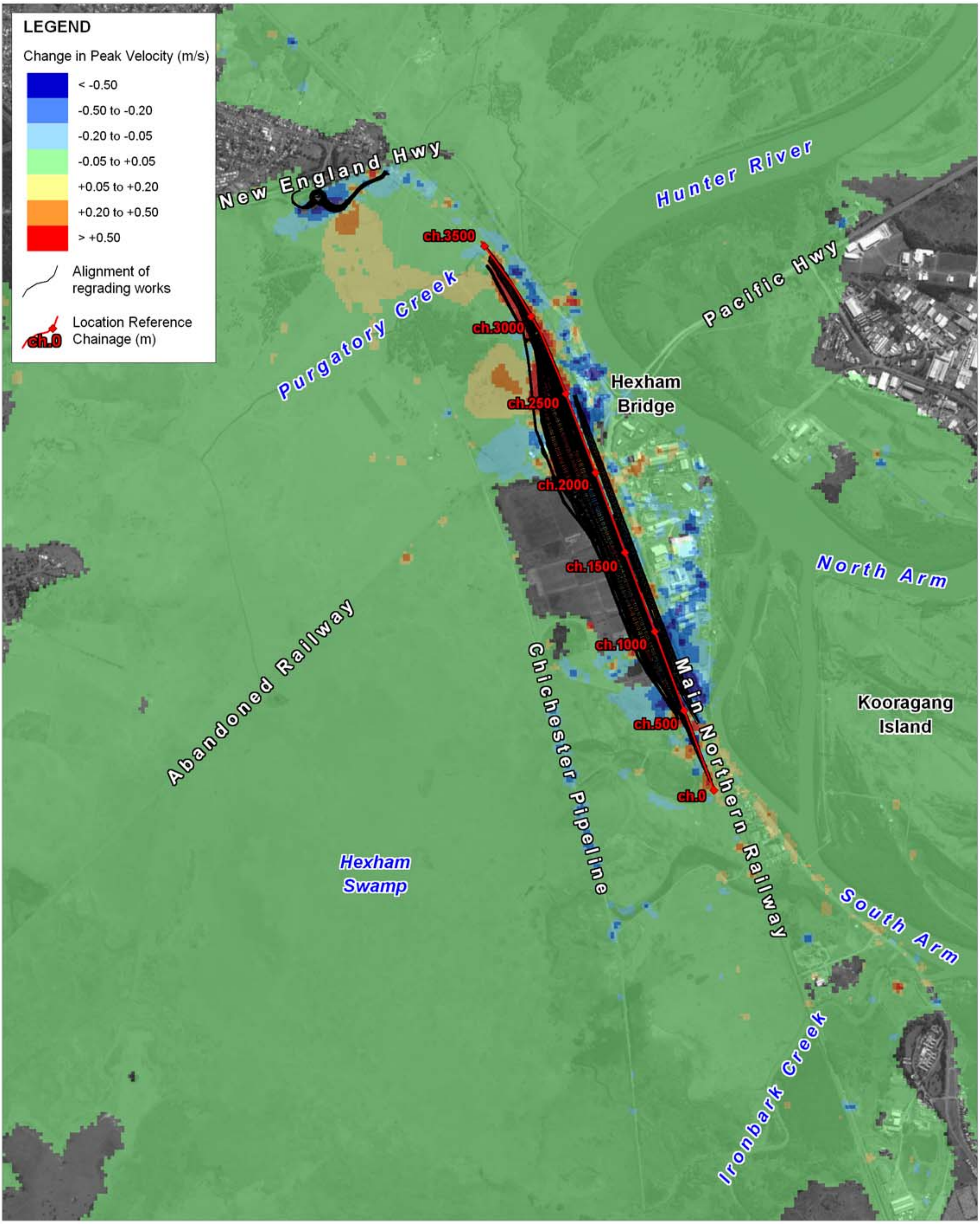


Title:

**Impact on Peak 1% AEP Flood Velocity - Hexham Relief Roads and Train Support Facility**

Figure: 4-2

Rev: A



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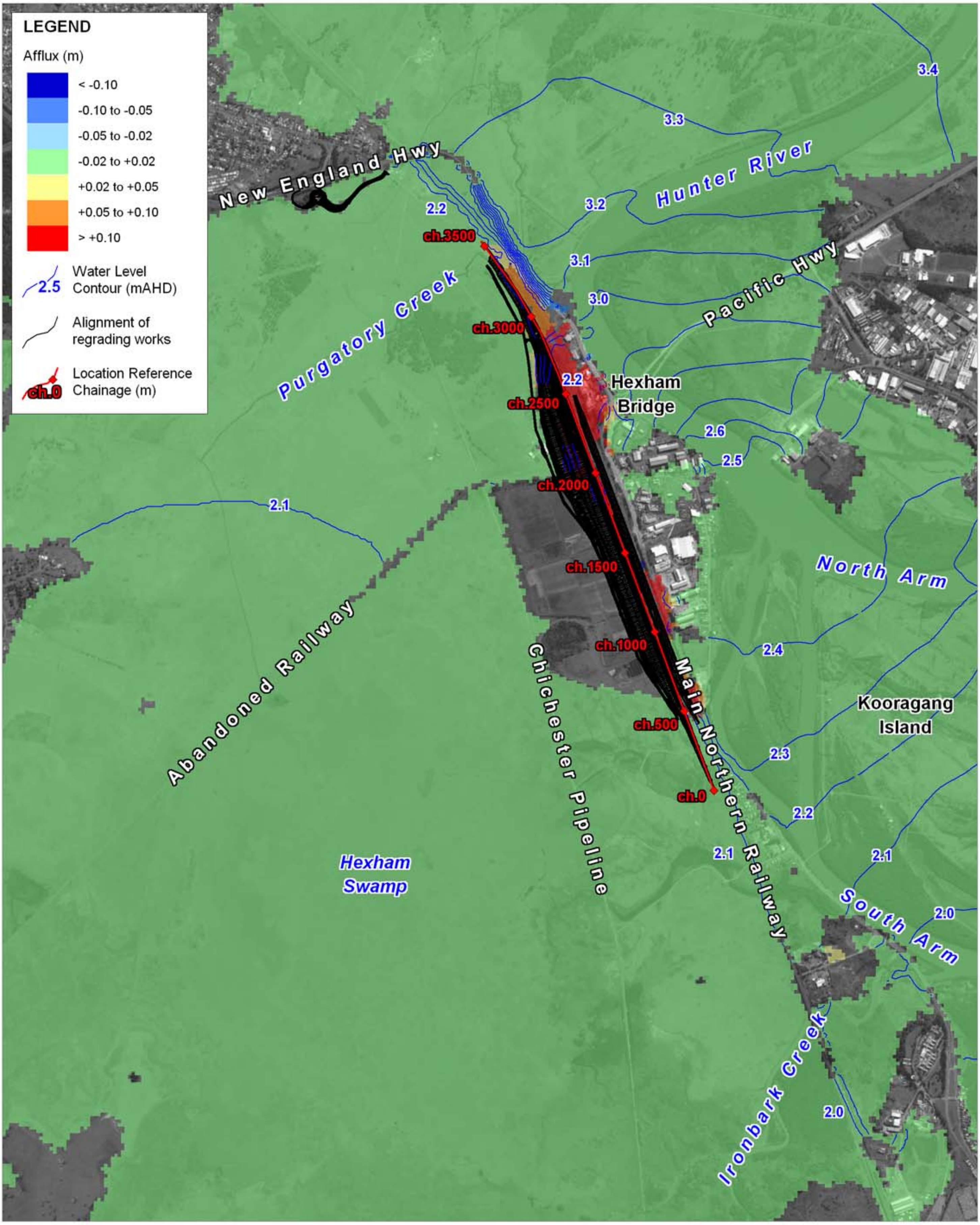


Title:
**Impact on Peak 2% AEP Flood Level - Hexham Relief Roads and Train Support Facility**

Figure: 4-3

Rev: A



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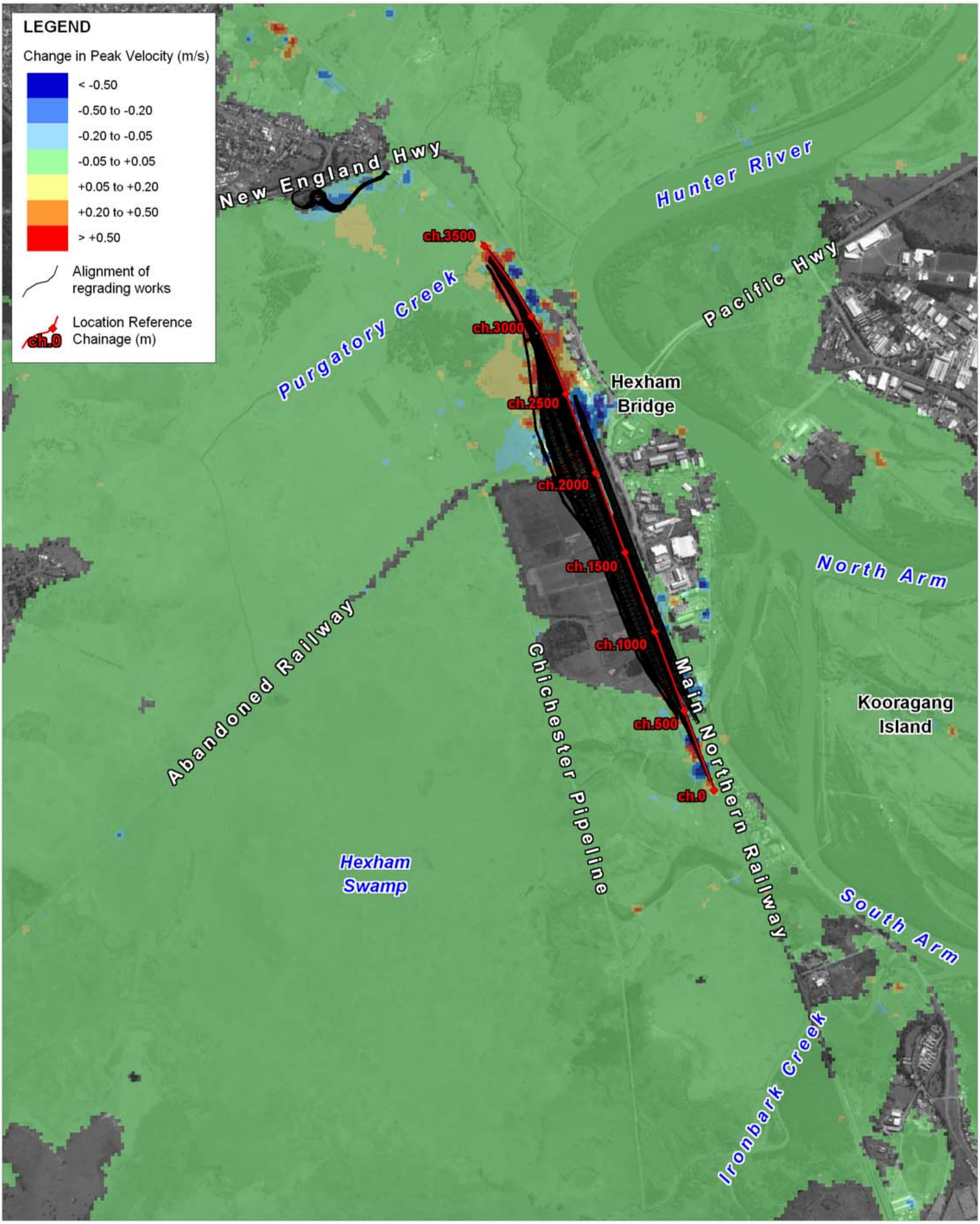


Title:

**Impact on Peak 2% AEP Flood Velocity - Hexham Relief Roads and Train Support Facility**

Figure: **4-4**

Rev: **A**

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Approx. Scale

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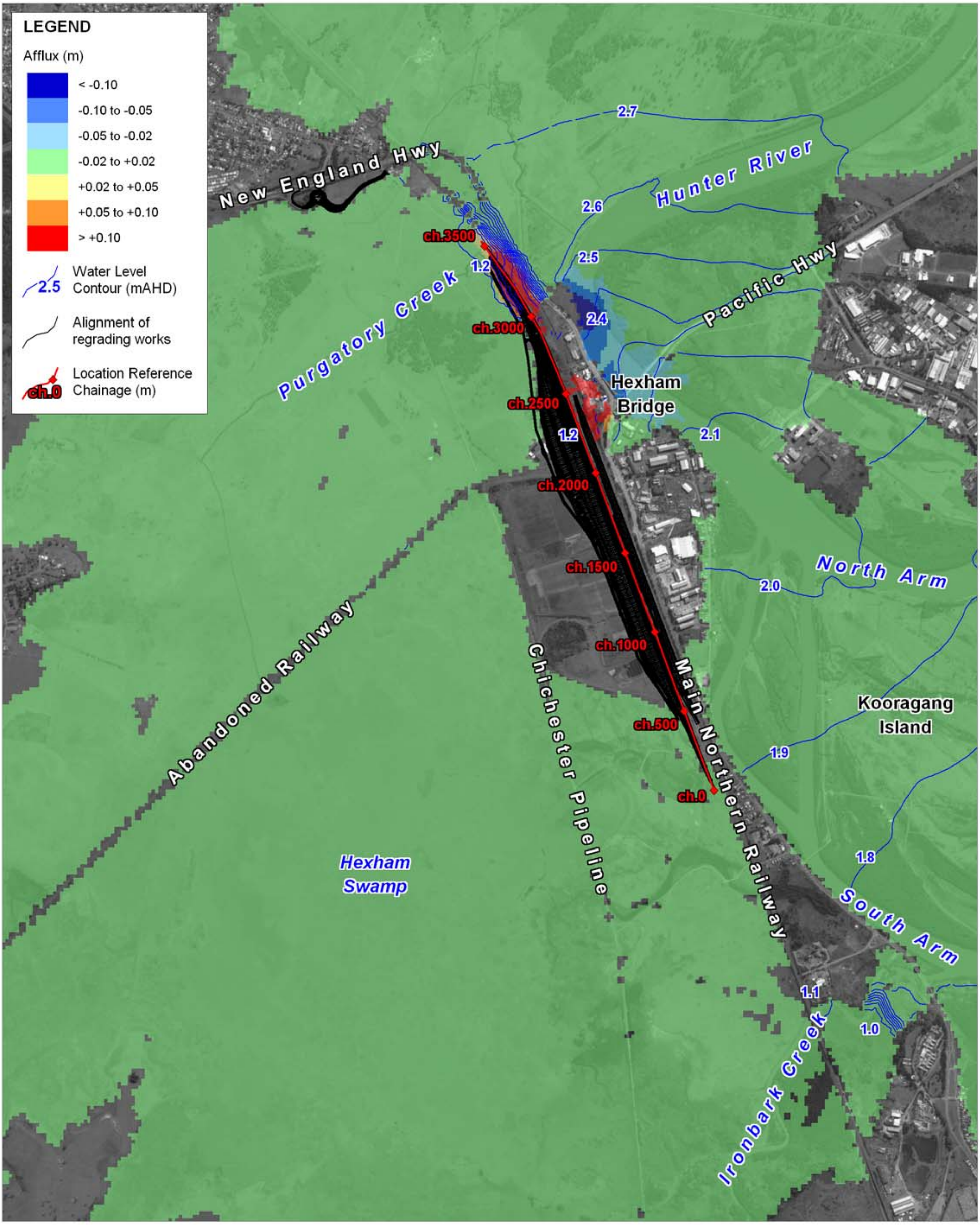


Title:

**Impact on Peak 5% AEP Flood Level - Hexham Relief Roads and Train Support Facility**

Figure: 4-5

Rev: A

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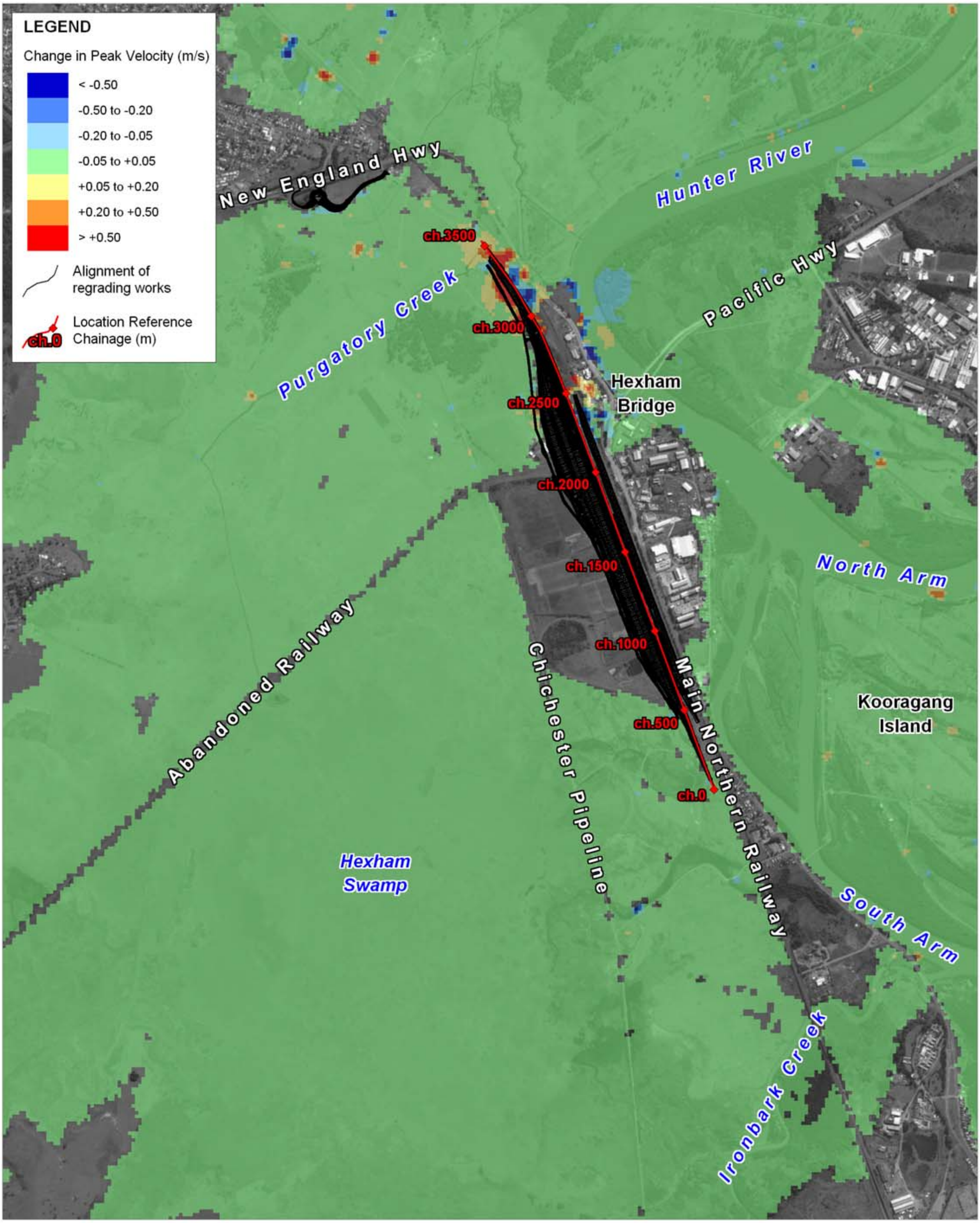


Title:

**Impact on Peak 5% AEP Flood Velocity - Hexham Relief Roads and Train Support Facility**

Figure: 4-6

Rev: A



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Approx. Scale

BMT WBM

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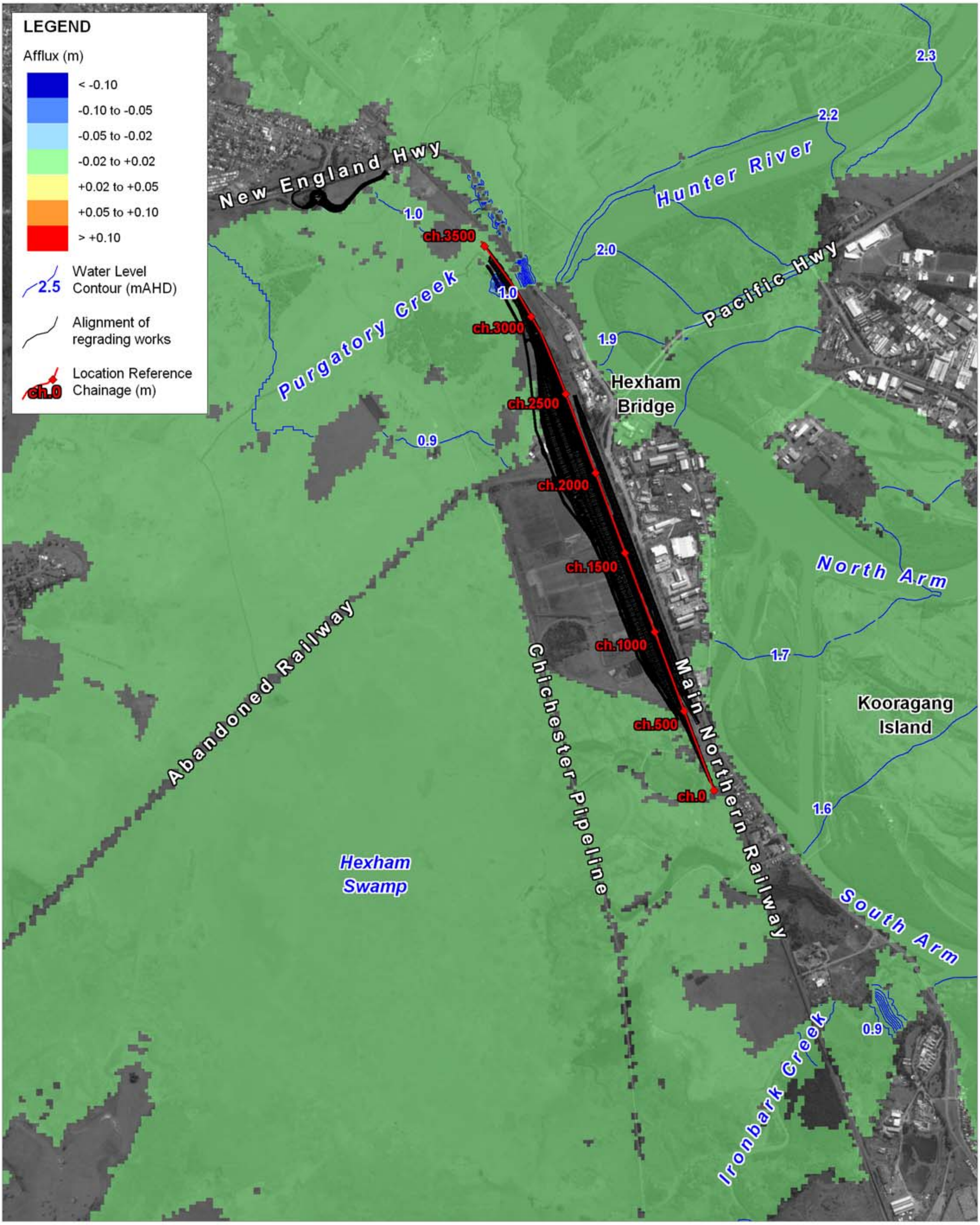


Title:

**Impact on Peak 10% AEP Flood Level - Hexham Relief Roads and Train Support Facility**

Figure: 4-7

Rev: A



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Approx. Scale

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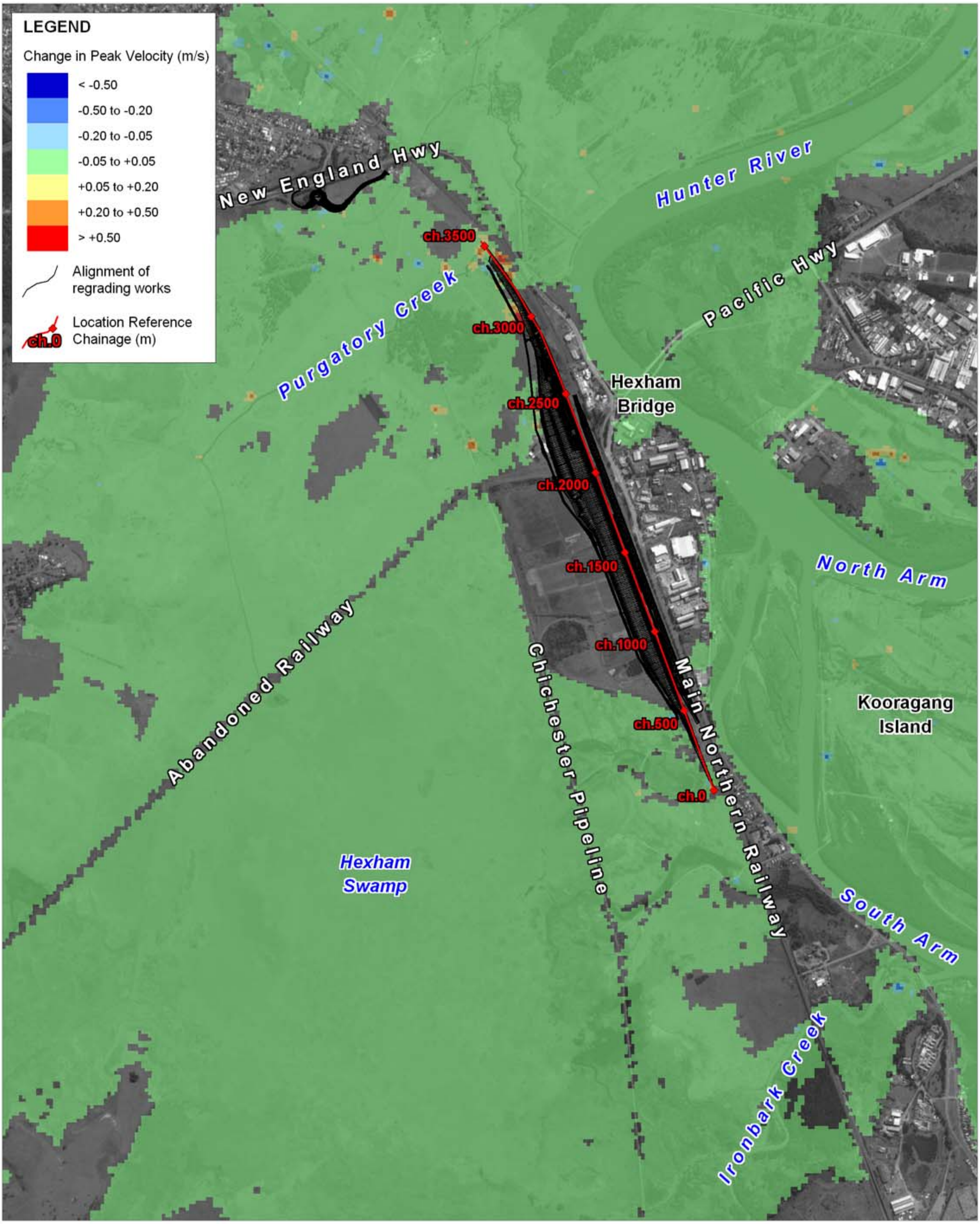


Title:

**Impact on Peak 10% AEP Flood Velocity - Hexham Relief Roads and Train Support Facility**

Figure: 4-8

Rev: A

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# 5 F3 UPGRADE

## 5.1 Description

The Roads and Maritime Service (RMS) is proposing to upgrade the Pacific Highway from the F3 Freeway, south of John Renshaw Drive to the Raymond Terrace bypass, north of Heatherbrae. The freeway extension would be approximately 13 km long and follow a route that crosses the Hunter River and associated floodplain. A separate flood impact assessment has been undertaken by BMT WBM to determine the potential flood impacts associated with the proposed development. The focus of the current investigation is to assess the cumulative flood impacts of the Hexham Relief Roads, Train Support Facility and F3 Upgrade.

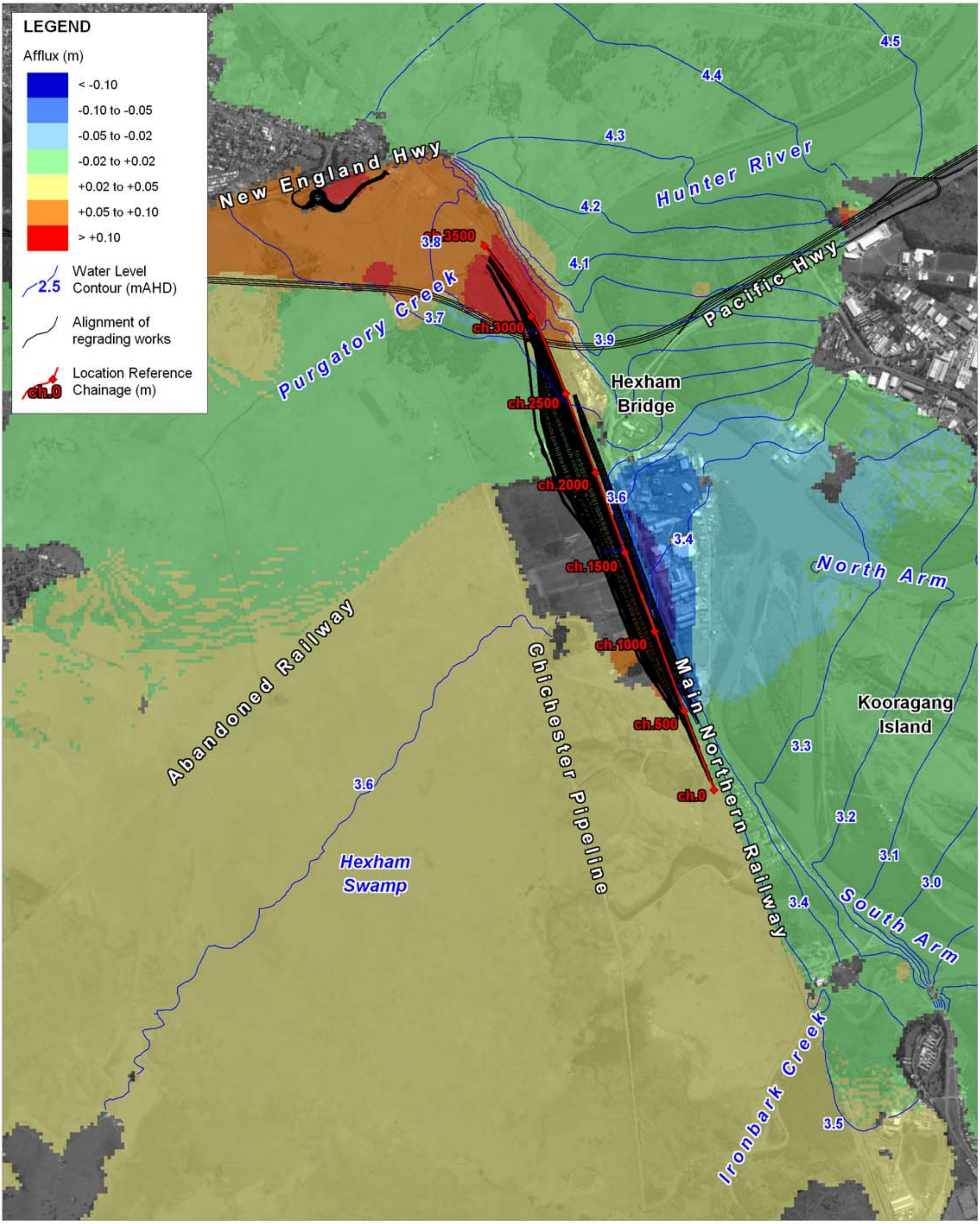
The design details for the preferred route option of the road upgrade were incorporated into the TUFLOW model of the Lower Hunter as part of the study for the Roads and Traffic Authority in 2011. The road levels have been designed to be flood free in the 5% AEP event, with flood impacts at the 1% AEP event reduced to acceptable standards through the provision of adequate flood flow cross drainage. The details of the design that were incorporated into the TUFLOW model for the 2011 study have also been included in this study to assess the cumulative impacts on regional Hunter River flooding. This includes road crest elevations, bridge and culvert details.

## 5.2 Cumulative Impacts

The cumulative flood impacts of the two proposed rail developments and the F3 upgrade have been modelled for the 1% AEP event. The cumulative impacts on peak flood level are presented in Figure 5-1, with the impact on peak flood velocity presented in Figure 5-2.

The pattern of flood level impacts is similar to that presented in Figure 3-1 and Figure 4-1, with around a 0.02m increase to peak flood levels in Hexham Swamp. The most significant area of impact attributable to the inclusion of the proposed F3 upgrade is the area bounded by the upgrade to the south and the New England Highway to the north. In this area, peak flood level increases of just over 0.1m have been modelled. However, this is a similar order of magnitude to the impacts presented in the Pacific Highway Upgrade F3 to Heatherbrae: Flooding, Drainage and Water Quality Impact Assessment (BMT WBM, 2011). There is no significant increased flood impact resulting from the cumulative consideration of the three proposed developments when compared to consideration of the developments in isolation.

The inclusion of the F3 upgrade results in changes to the peak velocities, corresponding to the redistribution of flood flows across the floodplain in relating to the location of flood relief cross drainage structures and bridge openings. This may be an important consideration for the location at which the F3 upgrade would cross over the Train Support Facility works (approximately ch.2800). In this location the peak flood velocities are showing an increase of up to around 2m/s, which would raise local peak velocities to around 3m/s. However, the scale of the regional modelling is not at a resolution to define precise local velocity distributions. Further investigation of this increase may be required to determine the need for any local protection works, if the increased velocities are of concern.




Title:

**Impact on Peak 1% AEP Flood Level - Hexham Relief Roads, Train Support Facility and F3 Upgrade**

Figure: 5-1

Rev: A



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0 0.5 1km

Approx. Scale

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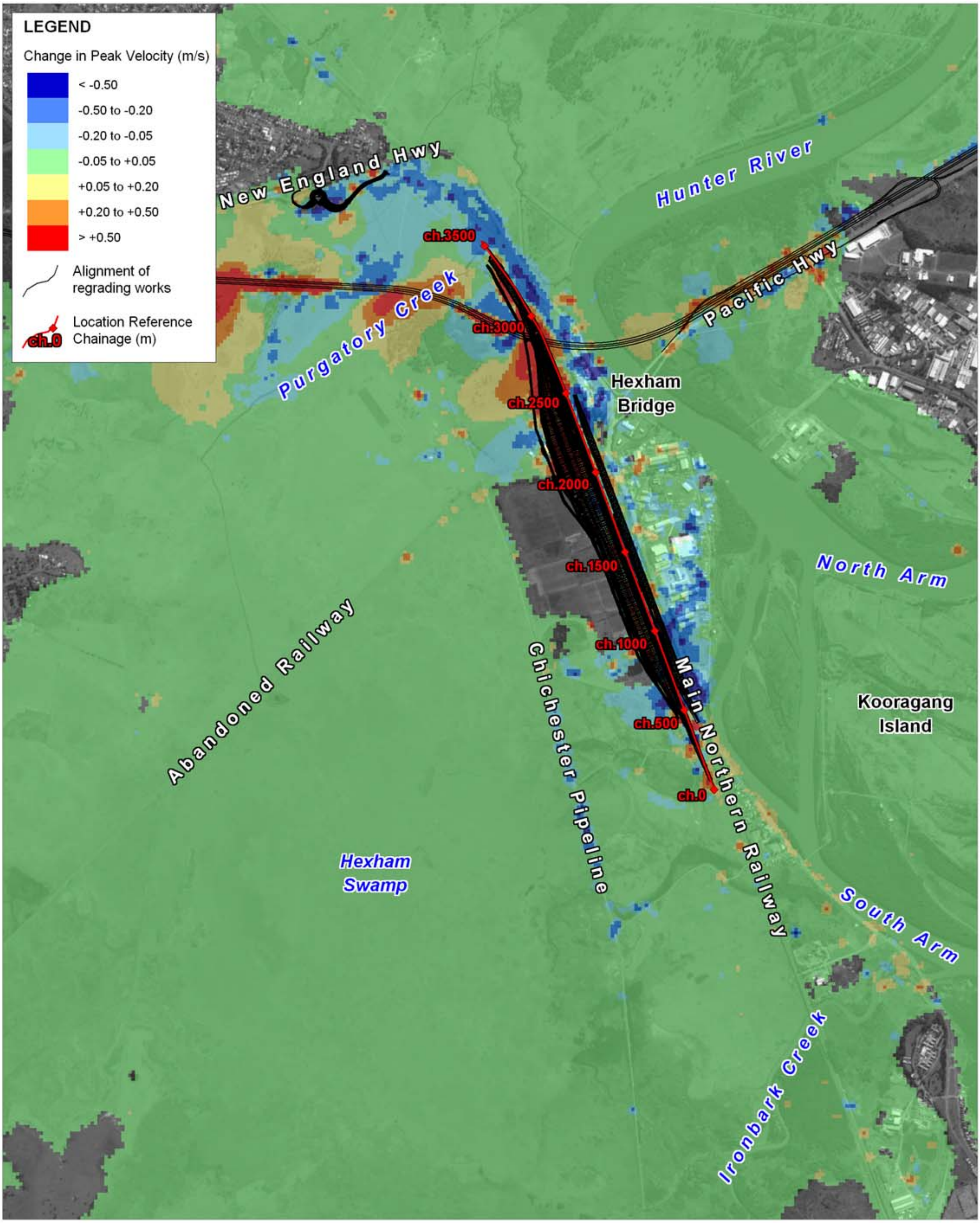


Title:

**Impact on Peak 1% AEP Flood Velocity - Hexham Relief Roads, Train Support Facility and F3 Upgrade**

Figure: 5-2

Rev: A



N

0 0.5 1km

Approx. Scale

BMT WBM

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# 6 CLIMATE CHANGE CONSIDERATIONS

The NSW Government recently adopted sea level rise planning benchmarks to ensure consistent consideration of sea level rise in coastal areas of NSW. These planning benchmarks are an increase above 1990 mean sea levels of 40cm by 2050 and 90cm by 2100.

To assess the impact these sea level rise scenarios have on the proposed development, sensitivity tests on the 1% AEP design event have been undertaken incorporating the above potential increases in water level conditions at Newcastle Harbour (model boundary). Separate simulations were undertaken for the 2050 and 2100 planning horizons.

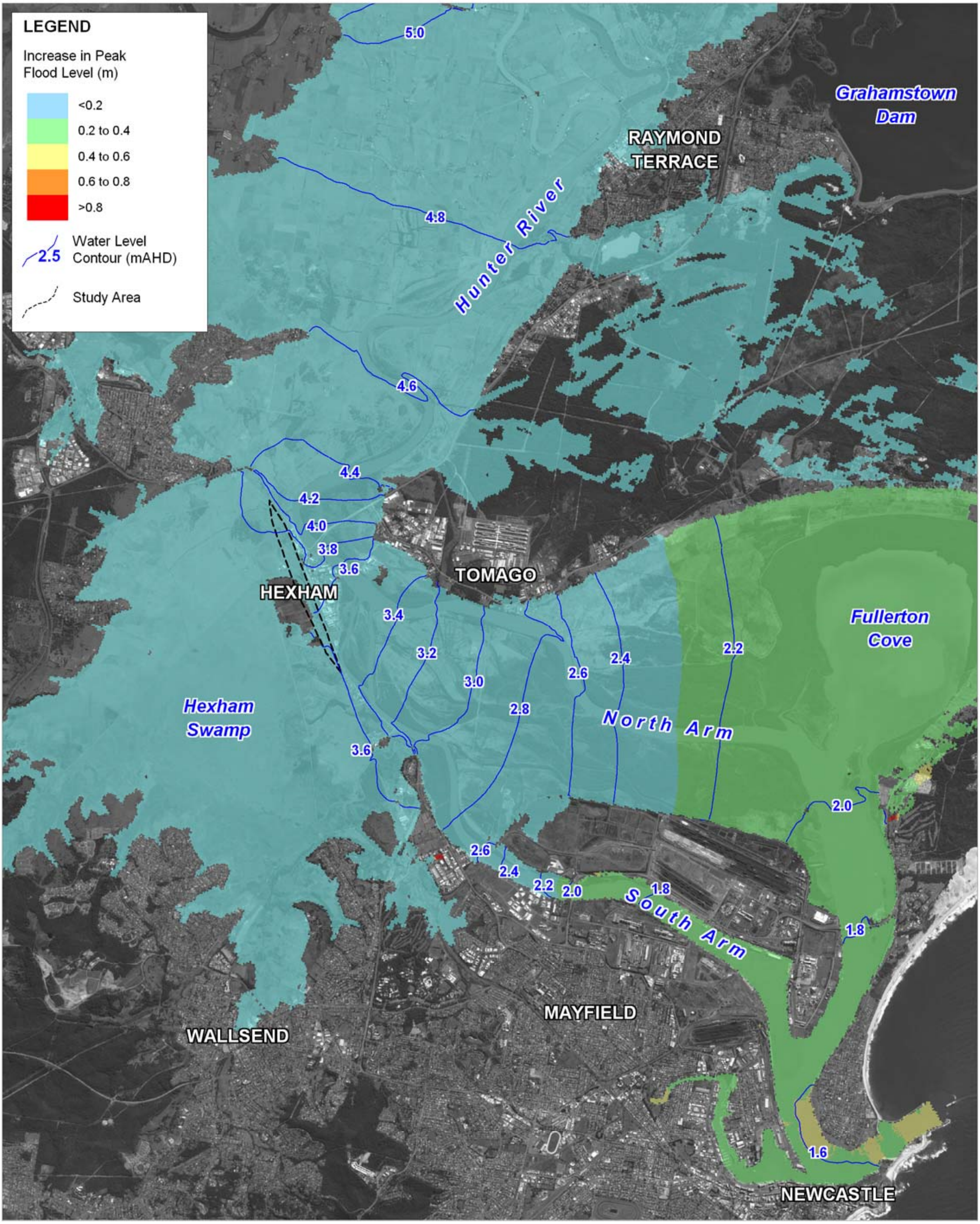
Typically climate change sensitivity tests also consider increases in design rainfall intensity of 10%, 20% or 30% in accordance with DECCW Practical Consideration of Climate Change Guideline for Floodplain Risk Management (2007). Increased rainfall intensities of 10% and 30% have been considered for this study, represented as direct increases to the inflow hydrographs, to assess the potential impacts on flood conditions at the development site.

The changes in peak 1% AEP flood level from existing conditions to the 2050 and 2100 planning horizons are shown in Figure 6-1 and Figure 6-2 respectively. Typically the increase in peak flood level local to the development site is around 0.1m for the 2050 scenario and around 0.2m for the 2100 scenario, increasing peak flood levels to around 3.7m AHD and 3.8m AHD respectively.

The potential increase in rainfall has a much greater impact on existing peak flood levels. A 10% increase in rainfall corresponds to around a 0.3m increase in peak flood level at the development site, with a 30% increased rainfall resulting in around a 0.8m peak flood level increase. Table 2-2 presents a summary of peak flood levels at the development site for the 1% AEP event under existing and potential future climate change conditions. Maps showing the changes in peak 1% AEP flood levels under increased rainfall conditions are presented in Appendix C.

**Table 6-1 Summary of Climate Change 1% AEP Flood Levels (m AHD)**

| Rainfall Scenario | Existing Sea Level | +0.4m Sea Level Rise | +0.9m Sea Level Rise |
|---|---|---|---|
| Existing | 3.6 | 3.7 | 3.8 |
| Existing +10% | 3.9 | 4.0 | 4.0 |
| Existing +30% | 4.4 | 4.4 | 4.5 |




Title:

**Impact on Peak 1% AEP Flood Level - 0.4m Sea Level Rise to 2050**

Figure: 6-1

Rev: A

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0 2 4km

Approx. Scale

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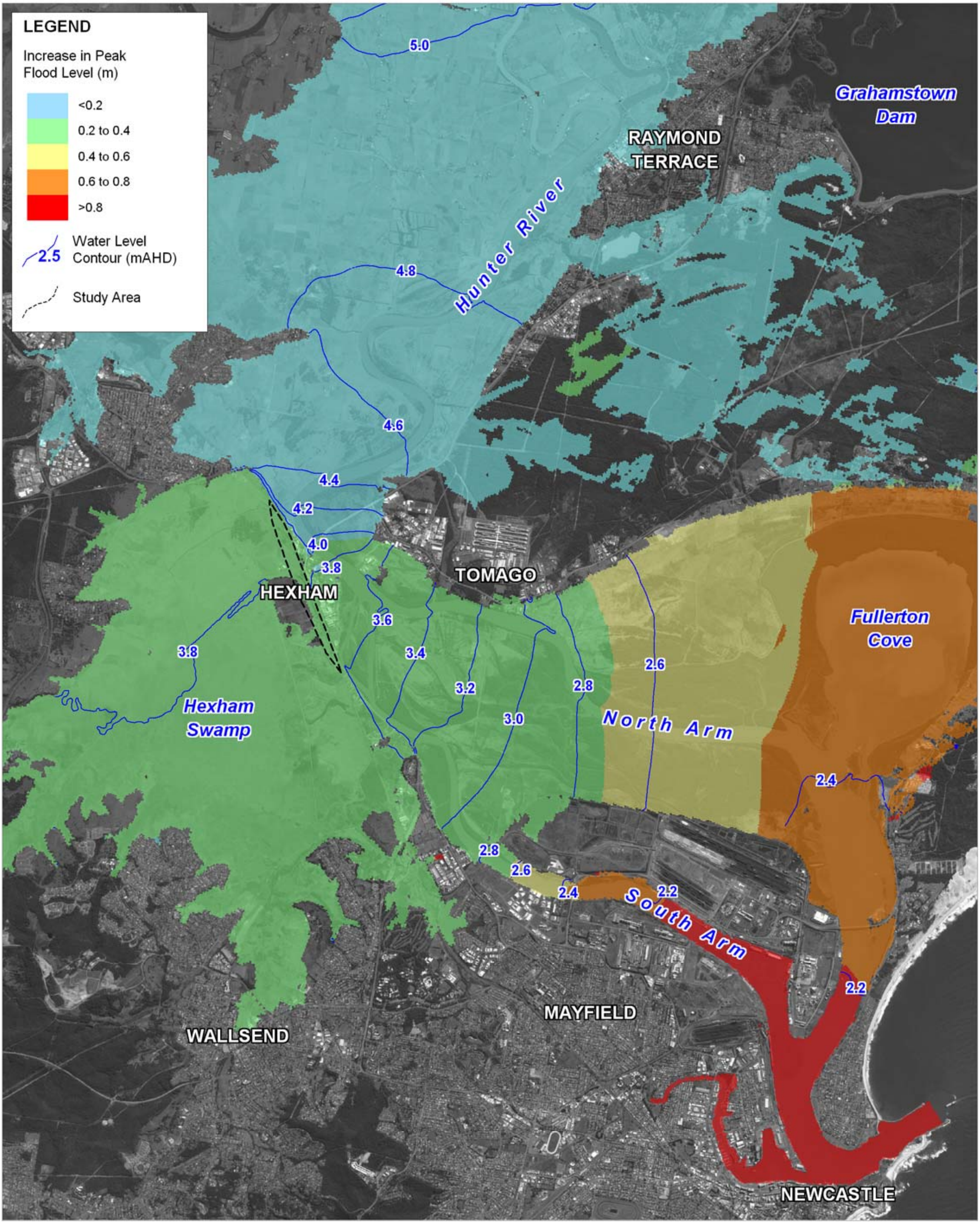


Title:

**Impact on Peak 1% AEP Flood Level - 0.9m Sea Level Rise to 2100**

Figure: 6-2

Rev: A

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# 7 CONCLUSIONS

The objective of the study was to undertake a detailed flood impact assessment of the proposed development on Hunter River flood conditions. Central to this was the application of a two-dimensional hydraulic model of the Hunter River floodplain developed as part of the Williams River Flood Study (BMT WBM, 2009) and updated for the Williamtown / Salt Ash Flood Study Review (BMT WBM, 2011) for Port Stephens Council.

Specifically the modelling undertaken for the proposed development aimed to:

- Confirm existing flooding conditions across the site including flood levels, flows and velocities to establish baseline conditions for impact assessment;
- Identify the potential flood impacts of the proposed development over a range of design flood magnitudes; and
- Consider the potential cumulative flood impacts of development with the QR National Train Support Facility and the RMS Pacific Highway upgrade from the F3 to Heatherbrae.

The results of the modelling and flood impact assessment have confirmed:

- Peak 1% AEP flood levels for existing conditions are estimated to vary from 3.7m AHD at the northern end of the site to 3.5m AHD at the southern end;
- The majority of the proposed development would be subject to significant inundation in major flood events where typical 1% AEP flood depths across the site are of the order of 1.5 – 3.0m;
- Corresponding peak flow velocities for the 1% AEP event under existing conditions are typically of the order 0.5m/s, but locally higher;
- The site is located within an area of high hazard flood storage, which has implications for safety considerations;
- The site is to be raised to a level above that of the 2% AEP flood level but largely below the 1% AEP flood level. The potential for further raising is constrained by the existing rail infrastructure;
- Local increases in peak flood level of up to 0.1m immediately adjacent to the proposed fill area are simulated for the 1% AEP event, with a broader 0.03m increase to peak flood levels in Hexham Swamp.
- Localised increases in peak flood velocity at the northern end of the relief roads upgrade may require consideration in terms of protecting the rail infrastructure from potential flood damage;
- Impacts for flood events below the 1% AEP event were less significant. Some localised increases in peak flood level can be addressed through adequately designed cross drainage infrastructure; and
- The cumulative impacts of the relief roads upgrade with the Train Support Facility and F3 upgrade show no significant additional flood impacts to those when considering the developments in isolation.

# 8 REFERENCES

BMT WBM (2009) *Williams River Flood Study*

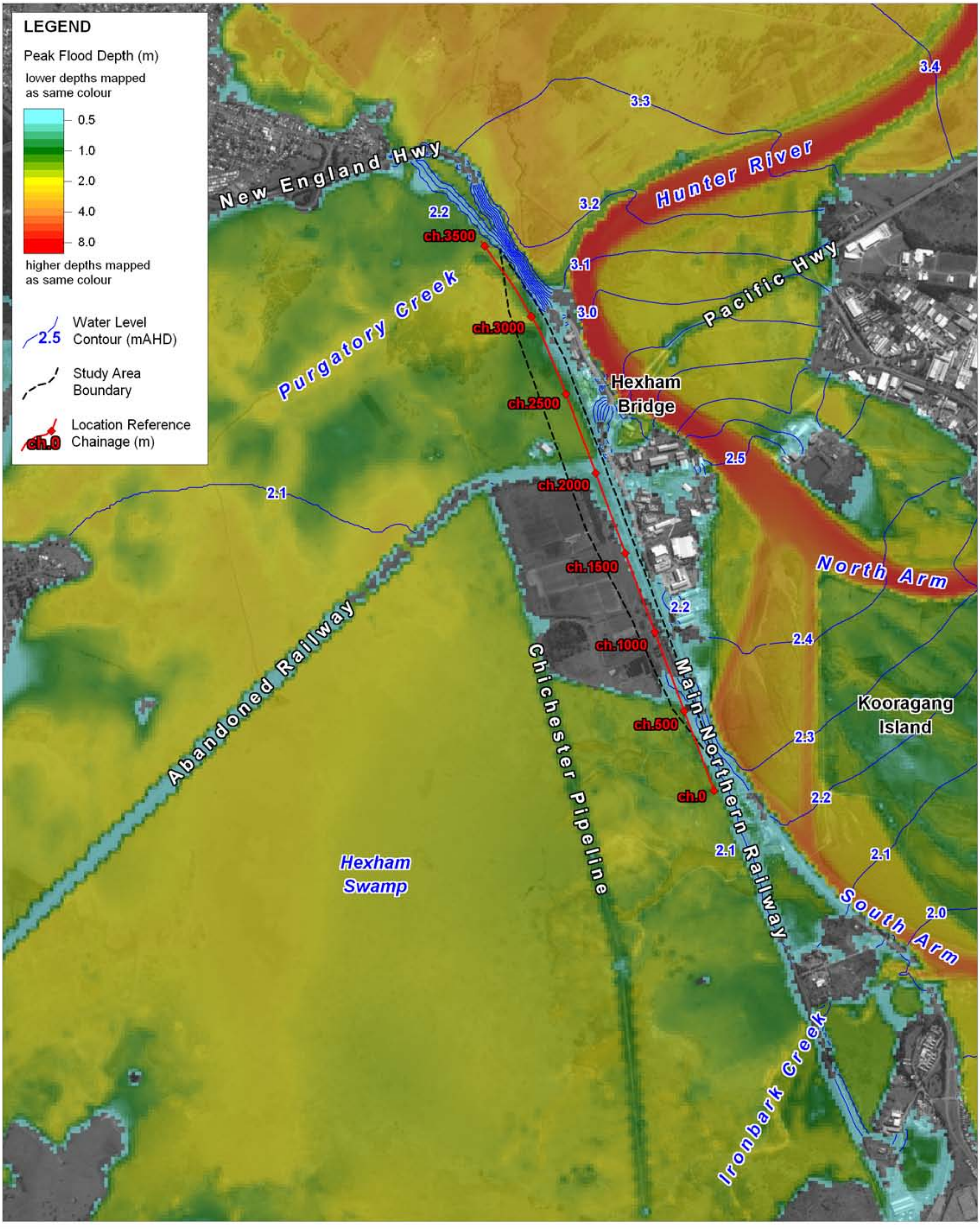
BMT WBM (2011) *Williamtown / Salt Ash Flood Study Review*

Department of Environment and Climate Change (DECC) (2007) *Floodplain Risk Management Guideline – Practical Consideration of Climate Change.*

PWD (1994) *Lower Hunter River Flood Study – Green Rocks to Newcastle*

WorleyParsons (2011) *Hexham Redevelopment Project Incorporating a Train Support Facility, Industrial Subdivision and Intermodal Facility – Flood Impact Assessment*

# APPENDIX A: FLOOD MAPS FOR EXISTING CONDITIONS




Title:

**2% AEP Peak Flood Depths and Levels - Existing Conditions**

Figure: A-1

Rev: A

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Approx. Scale

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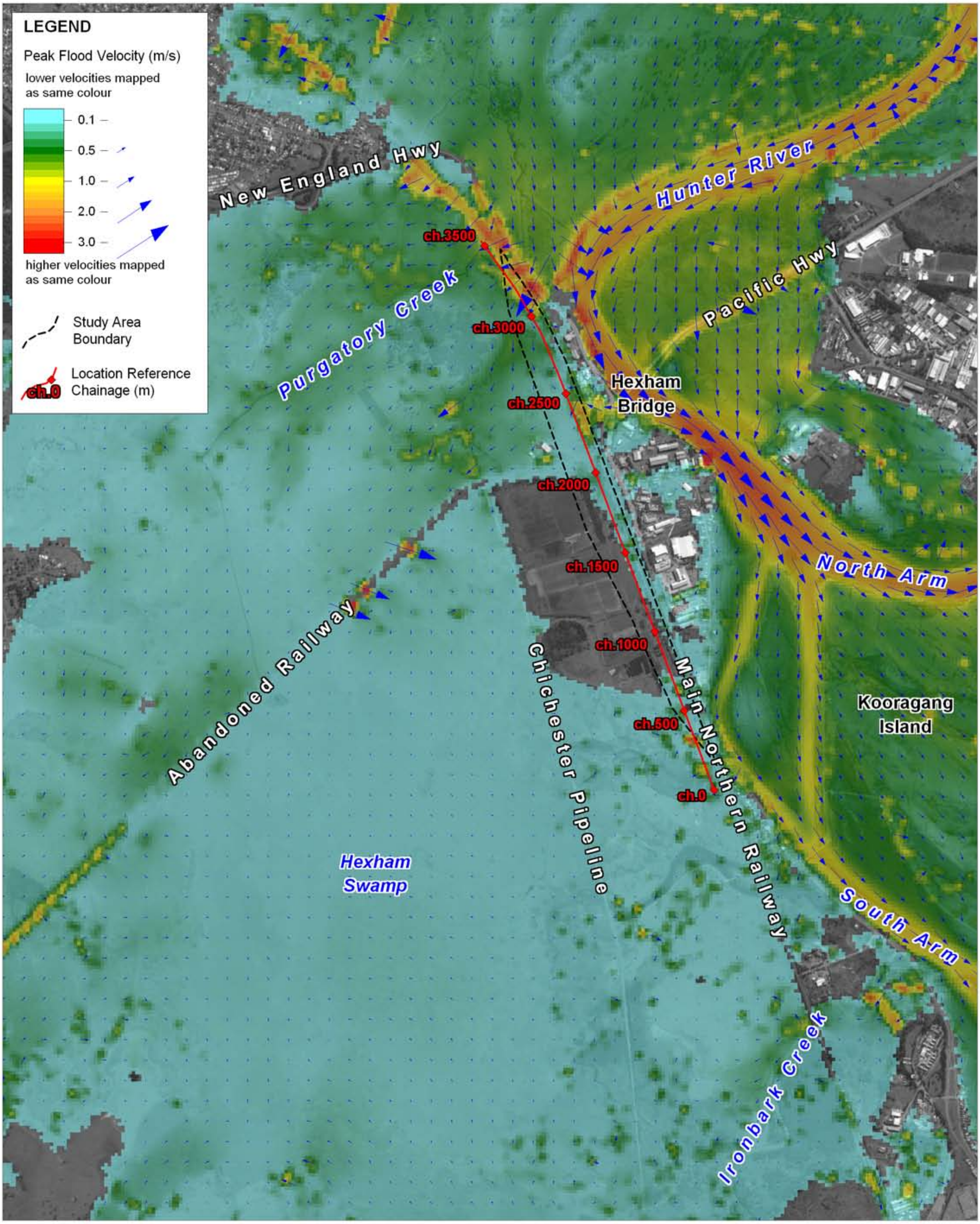


Title:

**2% AEP Peak Flood Velocities - Existing Conditions**

Figure: **A-2**

Rev: **A**



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Approx. Scale

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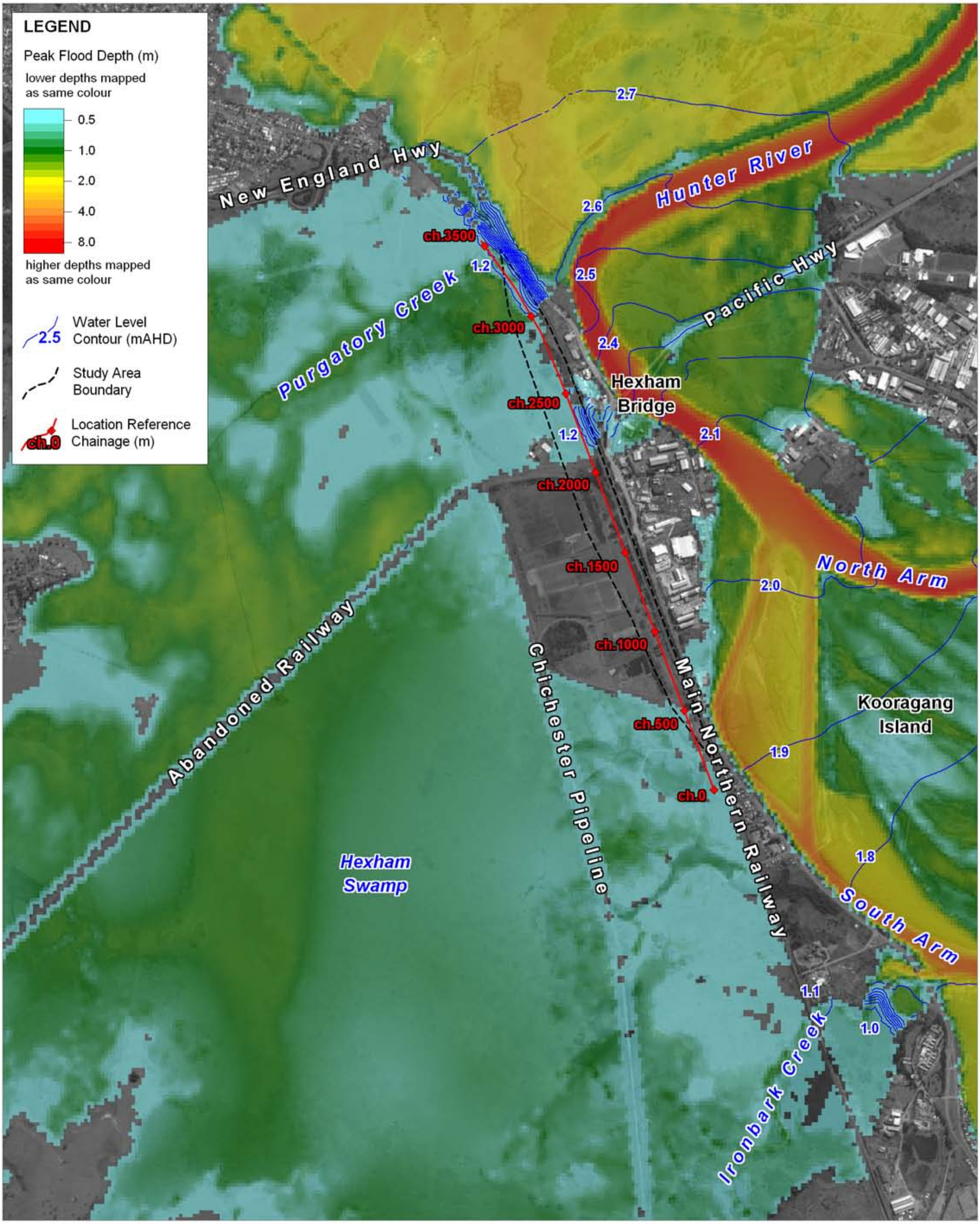


Title:

**5% AEP Peak Flood Depths and Levels - Existing Conditions**

Figure: A-3

Rev: A



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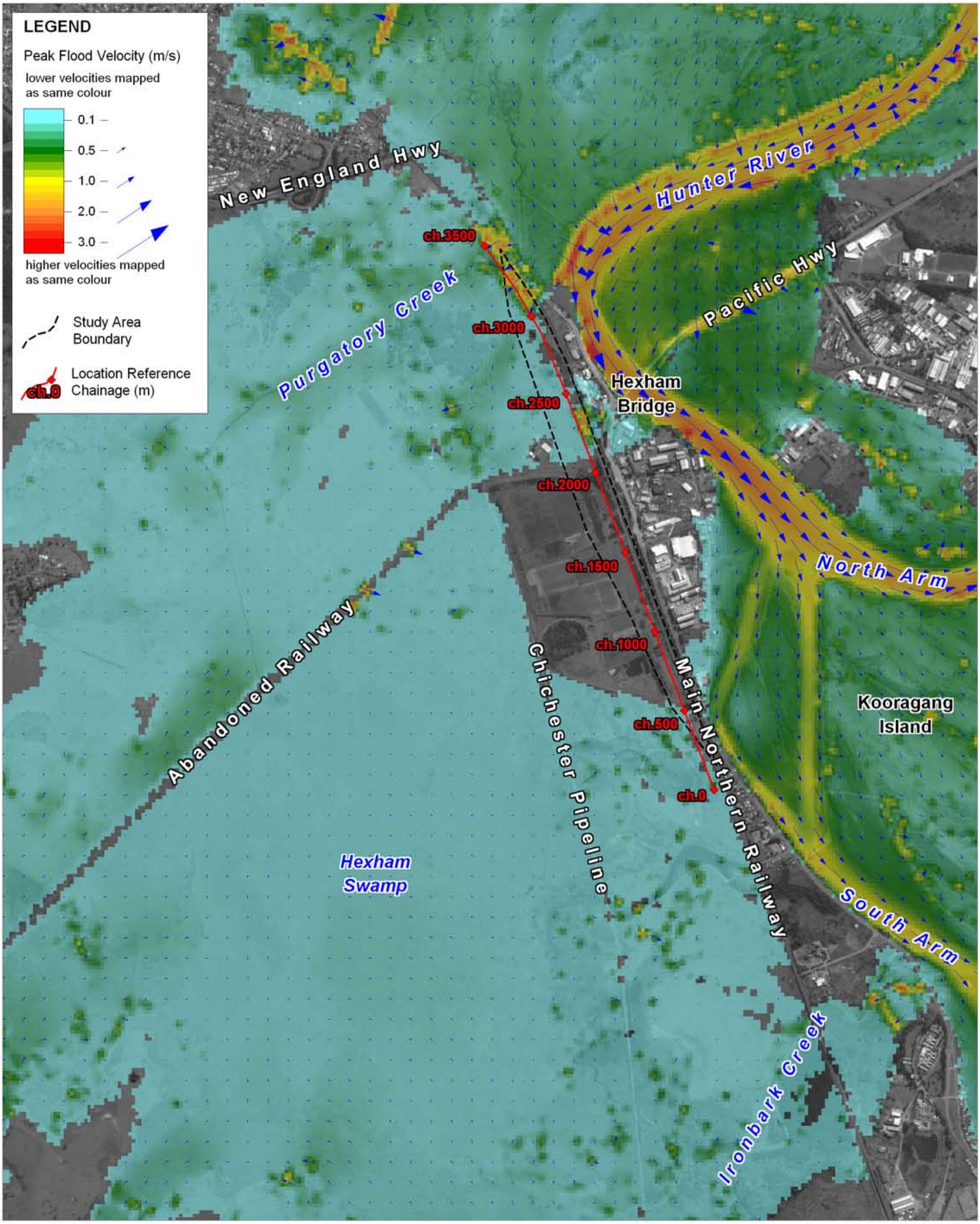


Title:

## 5% AEP Peak Flood Velocities - Existing Conditions

Figure: **A-4**

Rev: **A**

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Approx. Scale

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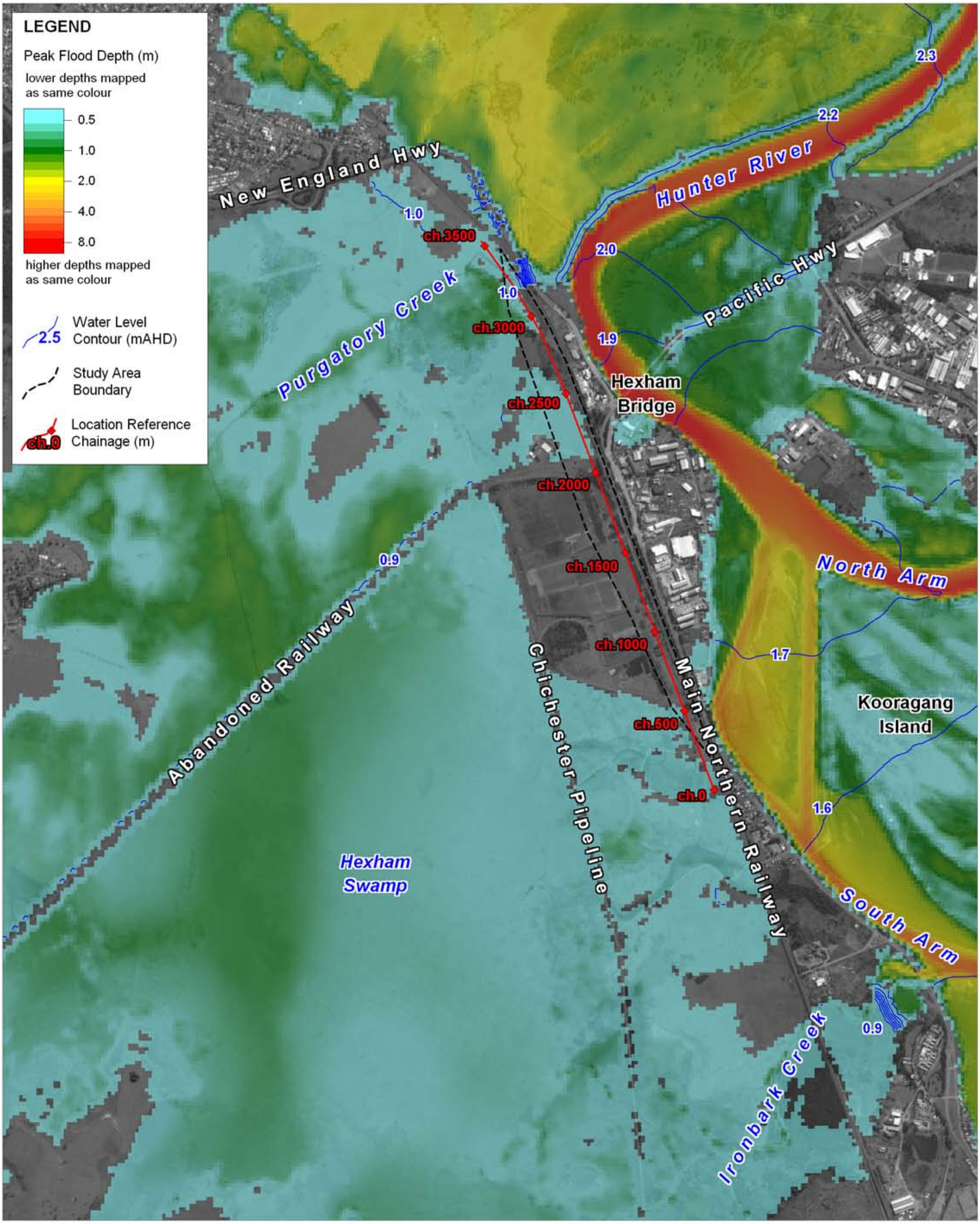


Title:

**10% AEP Peak Flood Depths and Levels - Existing Conditions**

Figure: **A-5**

Rev: **A**

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Approx. Scale

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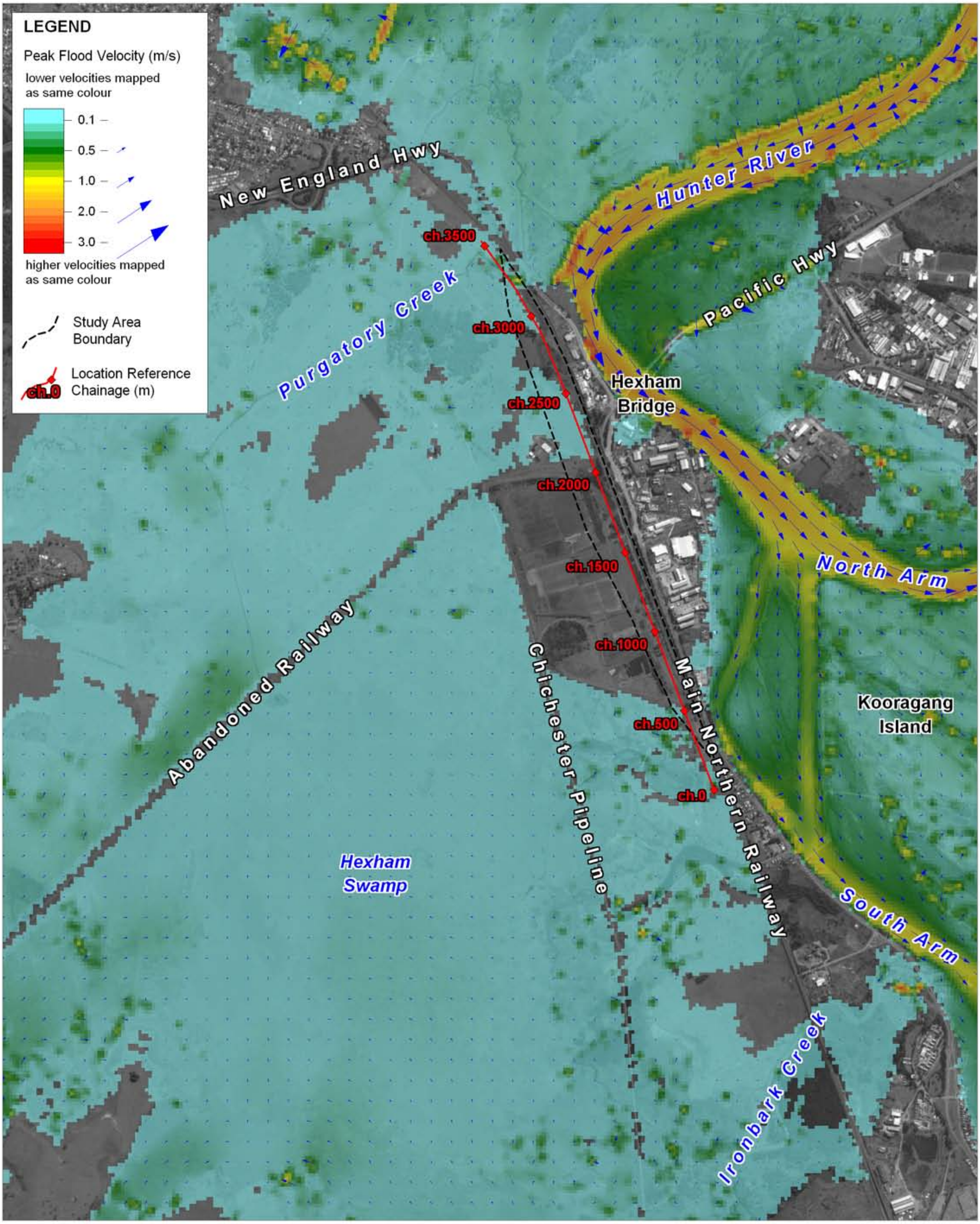


Title:

# 10% AEP Peak Flood Velocities - Existing Conditions

Figure: A-6

Rev: A



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Approx. Scale

BMT WBM
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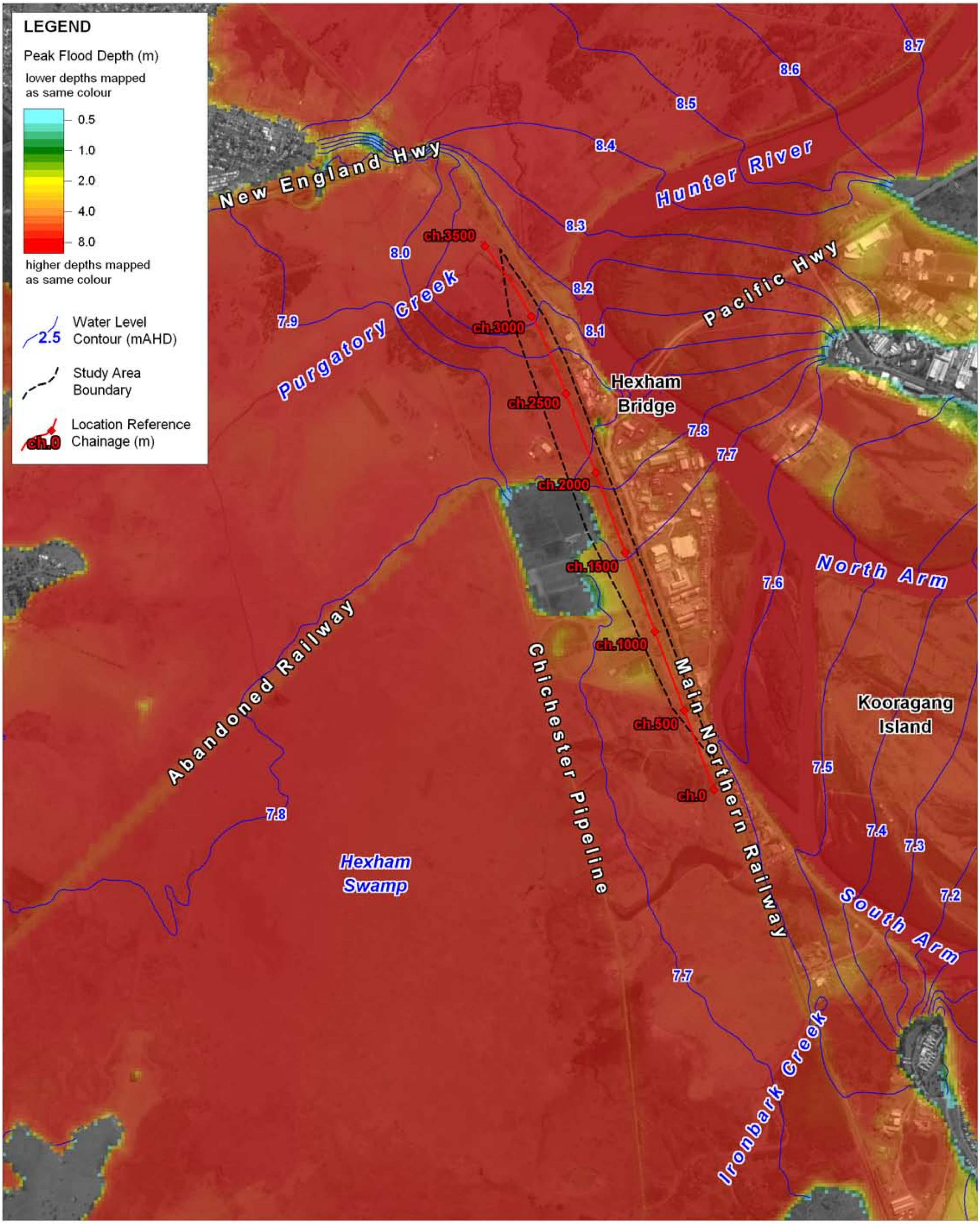


Title:

**PMF Peak Flood Depths and Levels - Existing Conditions**

Figure: A-7

Rev: A



N

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Approx. Scale

BMT WBM
www.bmtwbm.com.au

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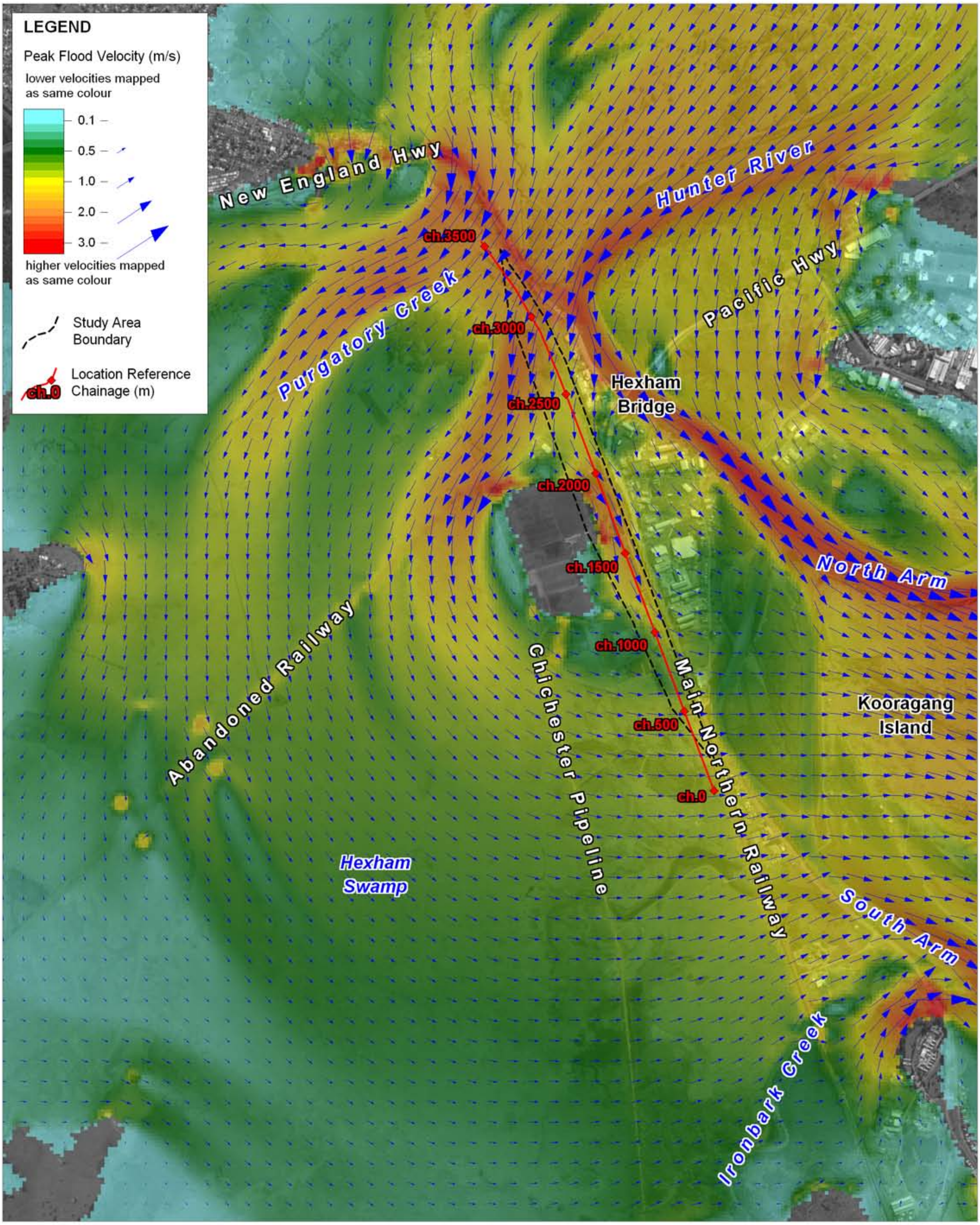


Title:

**PMF Peak Flood Velocities - Existing Conditions**

Figure: **A-8**

Rev: **A**



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Approx. Scale

BMT WBM
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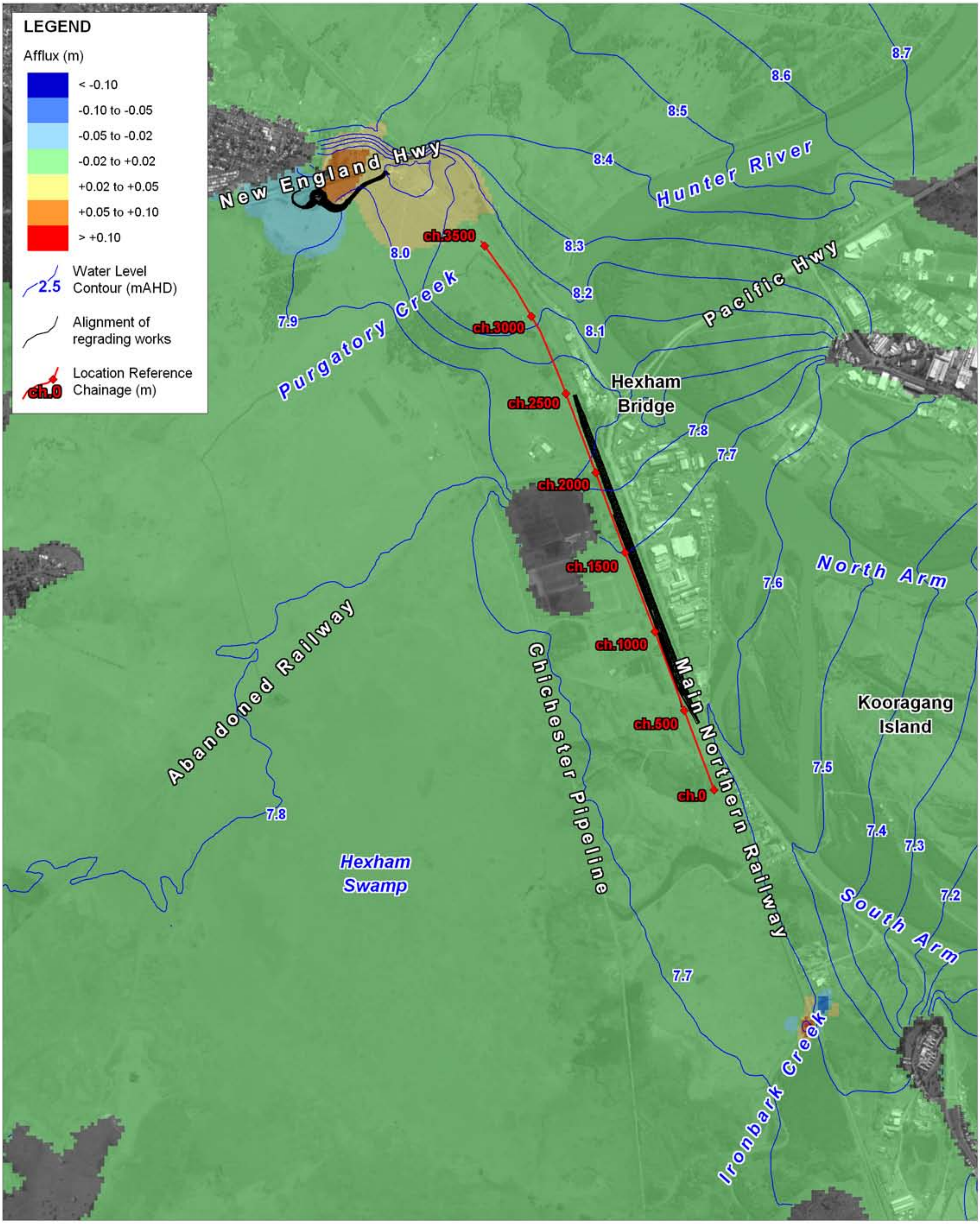
Filepath : K:\N2197_Hexham_Rail_Development\MapInfo\Workspaces\DRG_041_120320_PMF_Velocities.WOR

# APPENDIX B: FLOOD IMPACTS FOR THE PMF EVENT




Title:

**Impact on Peak PMF Flood Level - Hexham Relief Roads**

Figure: **B-1**

Rev: **A**

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Approx. Scale

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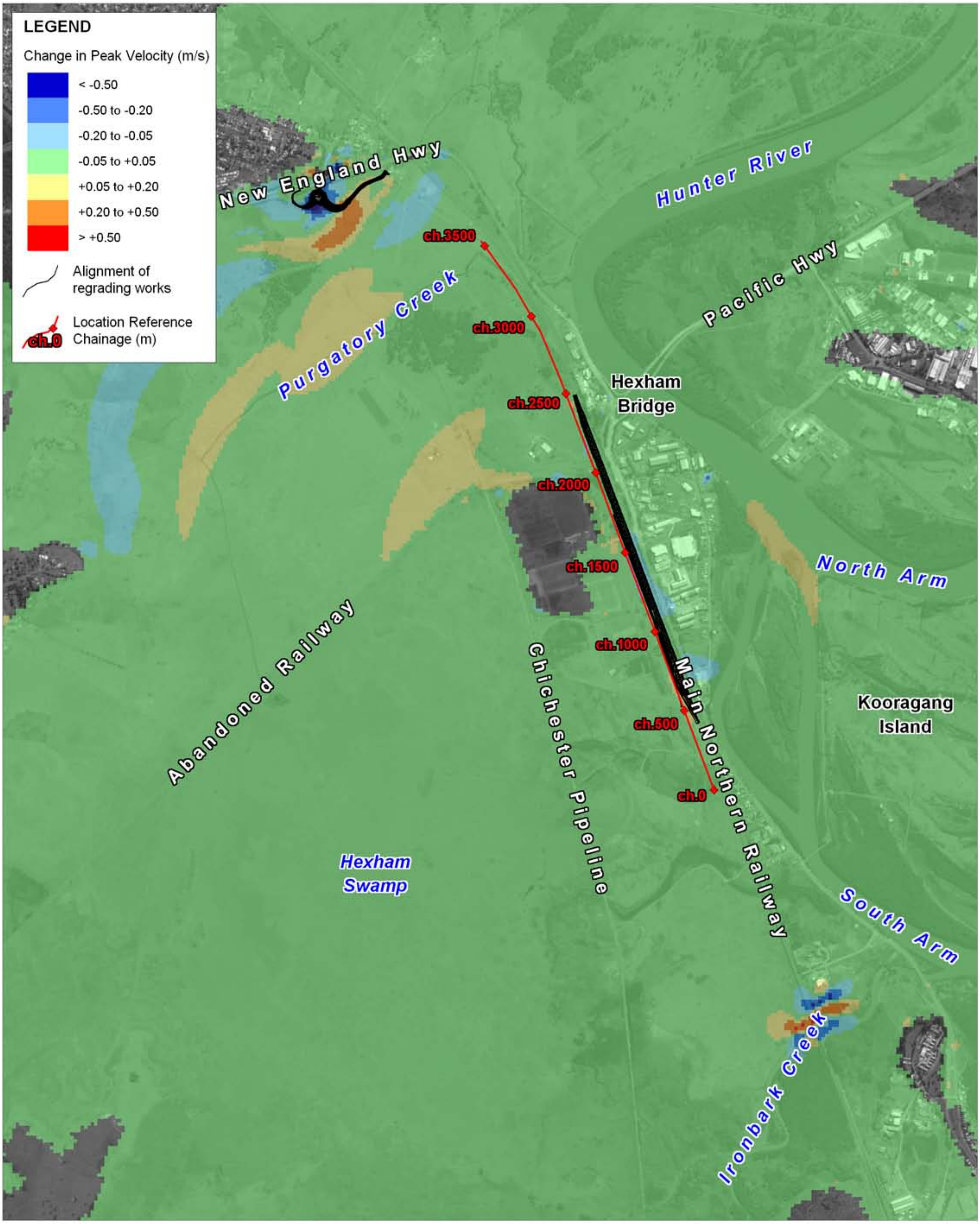


Title:

**Impact on Peak PMF Flood Velocity - Hexham Relief Roads**

Figure: **B-2**

Rev: **A**



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Approx. Scale

BMT WBM

www.bmtwbm.com.au

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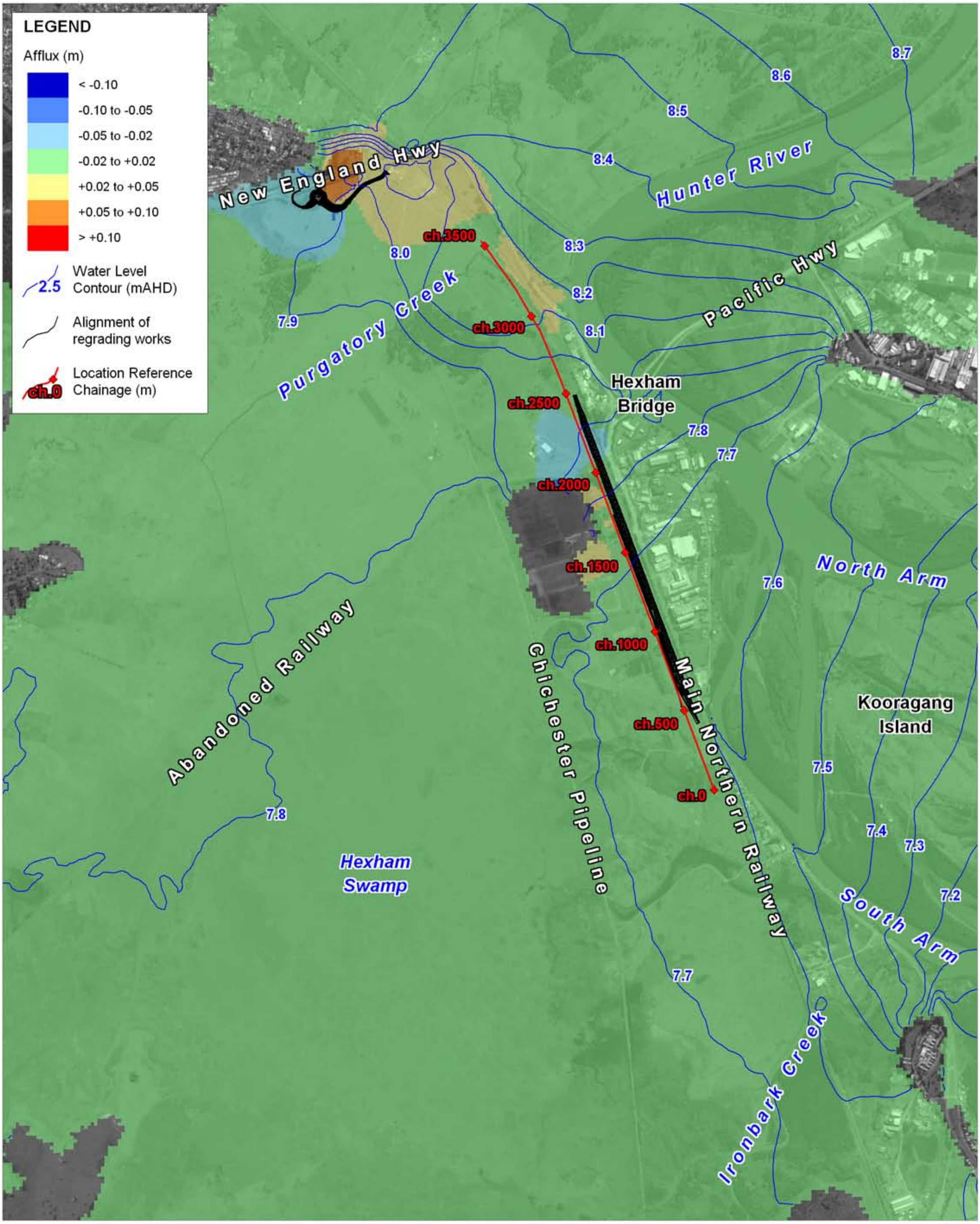



Title:

**Impact on Peak PMF Flood Level - Hexham Relief Roads and Train Support Facility**

Figure: **B-3**

Rev: **A**



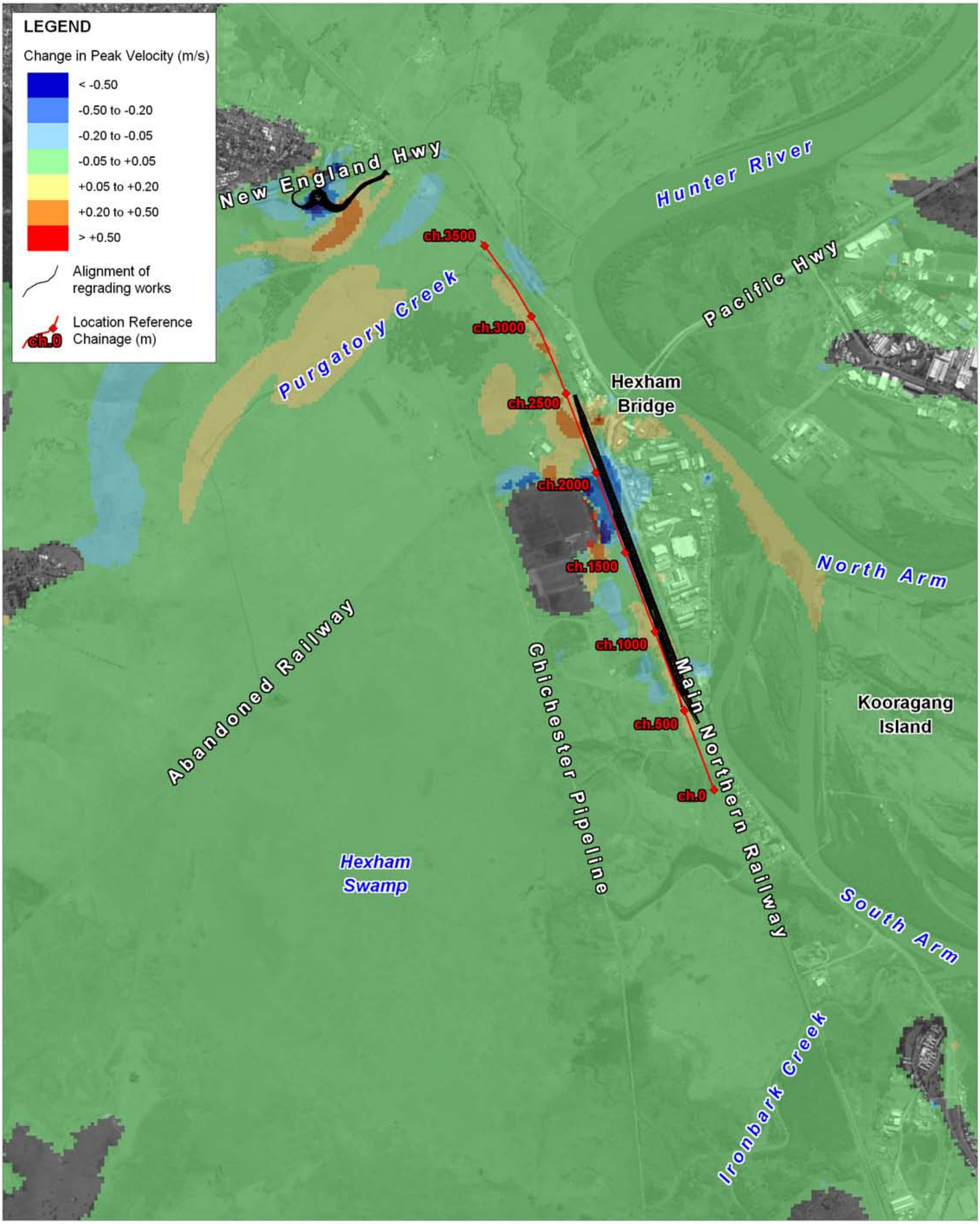
N

0 0.5 1km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N2197_Hexham_Rail_Development\MapInfo\Workspaces\DRG_042_120320_PMF_RR_Impact_h.WOR




Title:

**Impact on Peak PMF Flood Velocity - Hexham Relief Roads and Train Support Facility**

Figure: **B-4**

Rev: **A**



N

0 0.5 1km

Approx. Scale

BMT WBM

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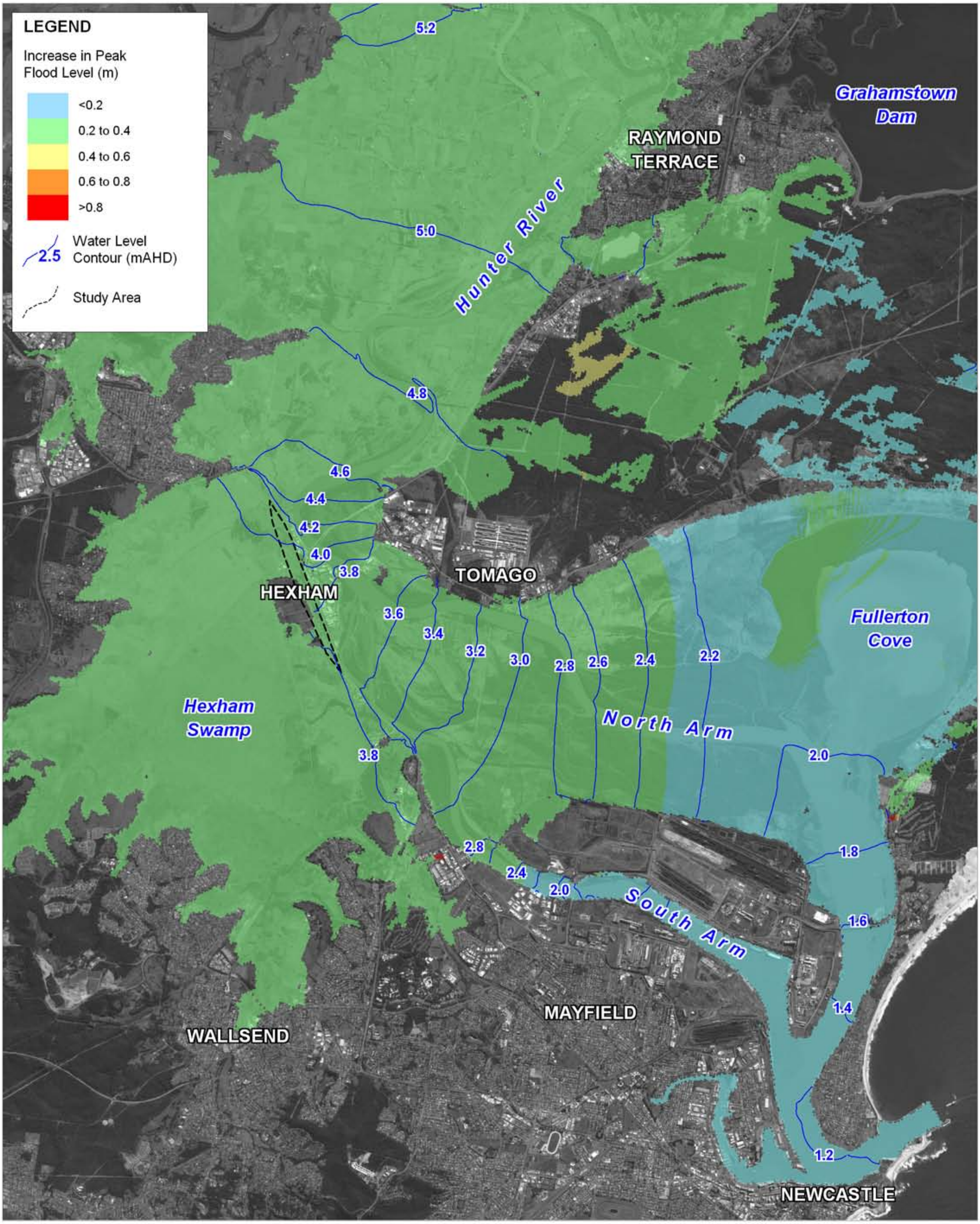
Filepath : K:\N2197_Hexham_Rail_Development\MapInfo\Workspaces\DRG_045_120320_PMF_RRQR_Impact_v.WOR

# APPENDIX C: CLIMATE CHANGE MAPS




Title:

**Impact on Peak 1% AEP Flood Level - 10% Increase in Design Rainfall**

Figure: C-1

Rev: A



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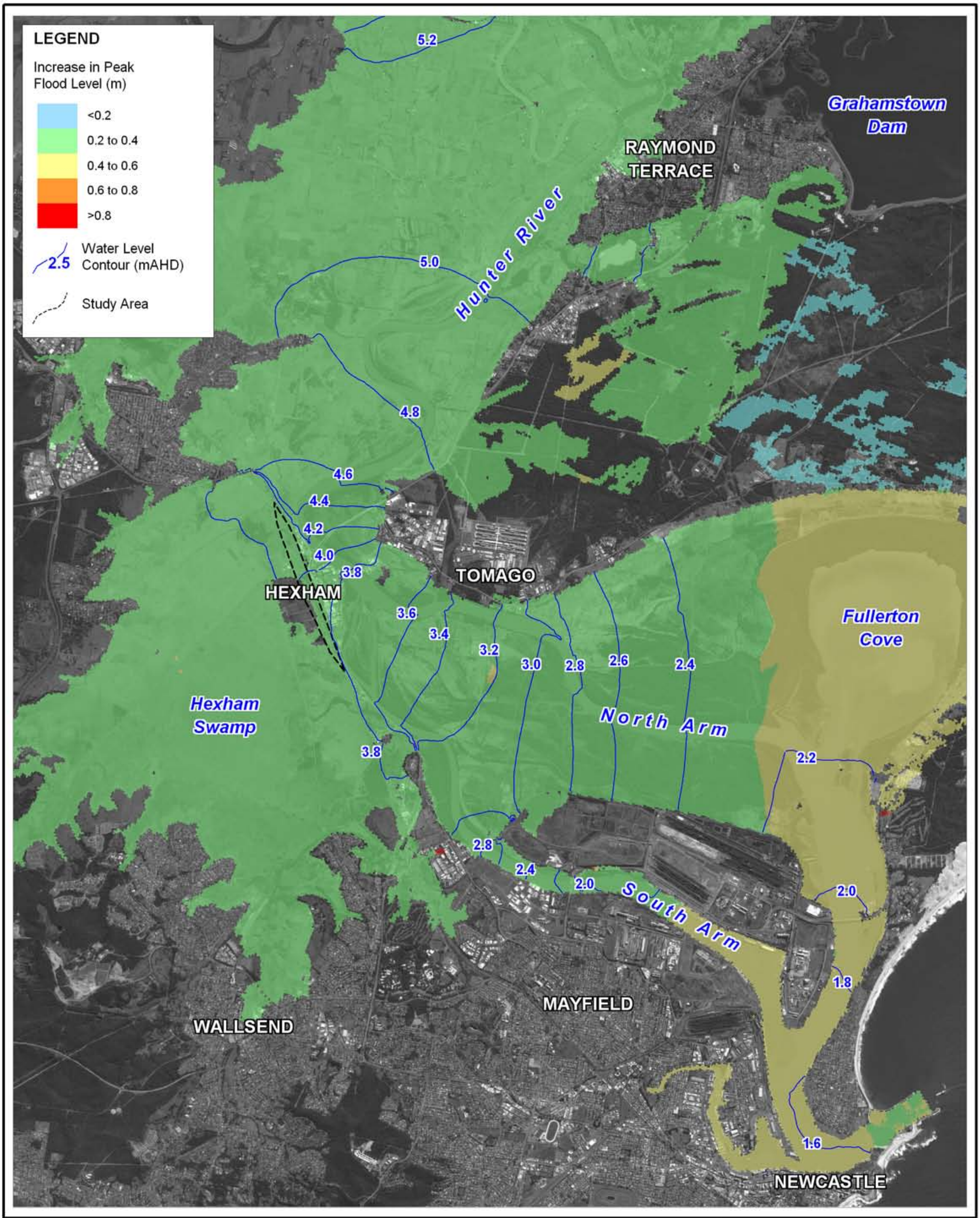
Filepath : K:\N2197_Hexham_Rail_Development\MapInfo\Workspaces\DRG_035_120320_1%AEP_inc10pc_Impact_h.WOR




Title:

**Impact on Peak 1% AEP Flood Level - 0.4m Sea Level Rise to 2050 and 10% Increase in Design Rainfall**

Figure: C-2

Rev: A



BMT WBM
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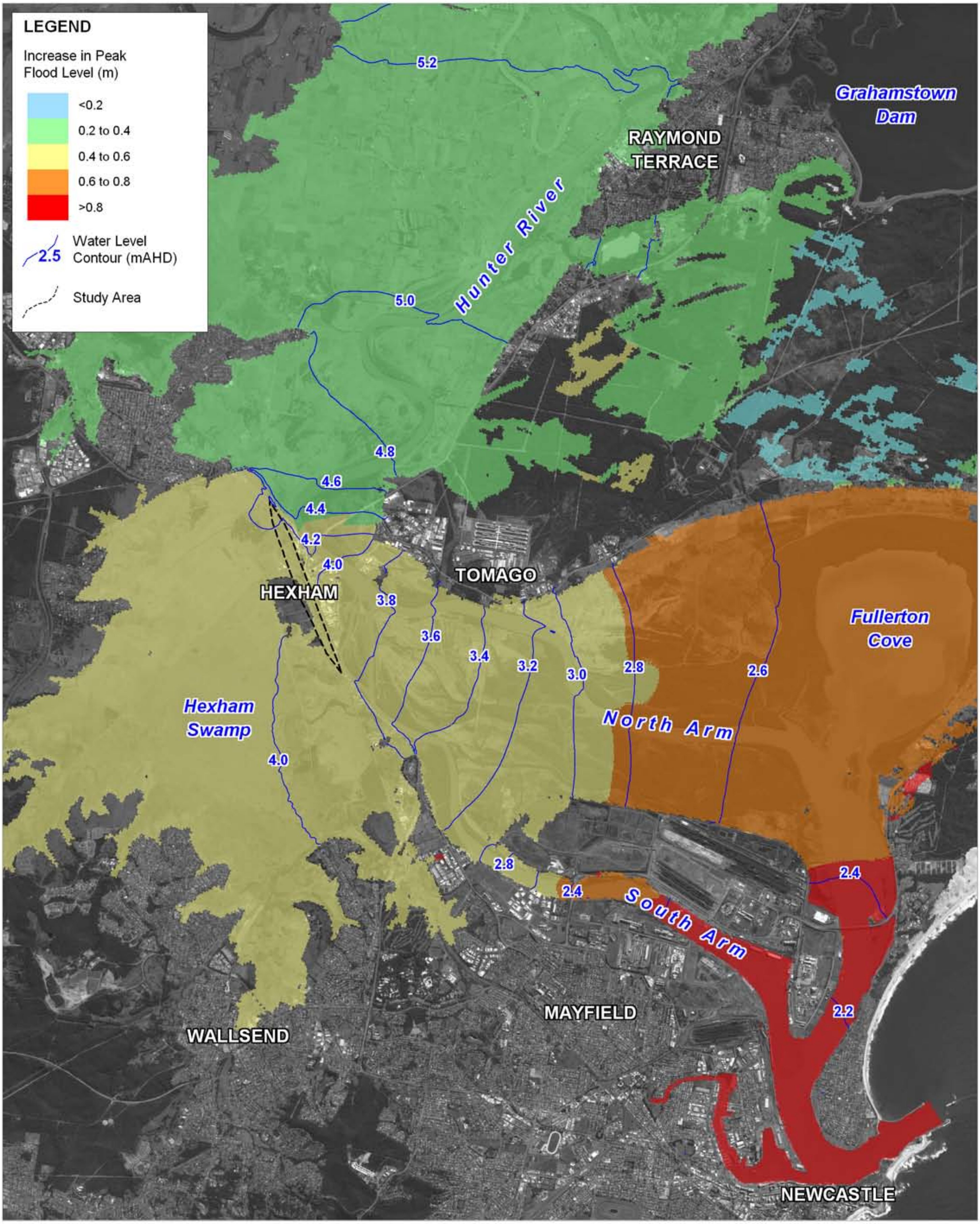
Filepath : K:\N2197_Hexham_Rail_Development\MapInfo\Workspaces\DRG_036_120320_1%AEP_2050inc10pc_Impact_h.WOR




Title:

**Impact on Peak 1% AEP Flood Level - 0.9m Sea Level Rise to 2100 and 10% Increase in Design Rainfall**

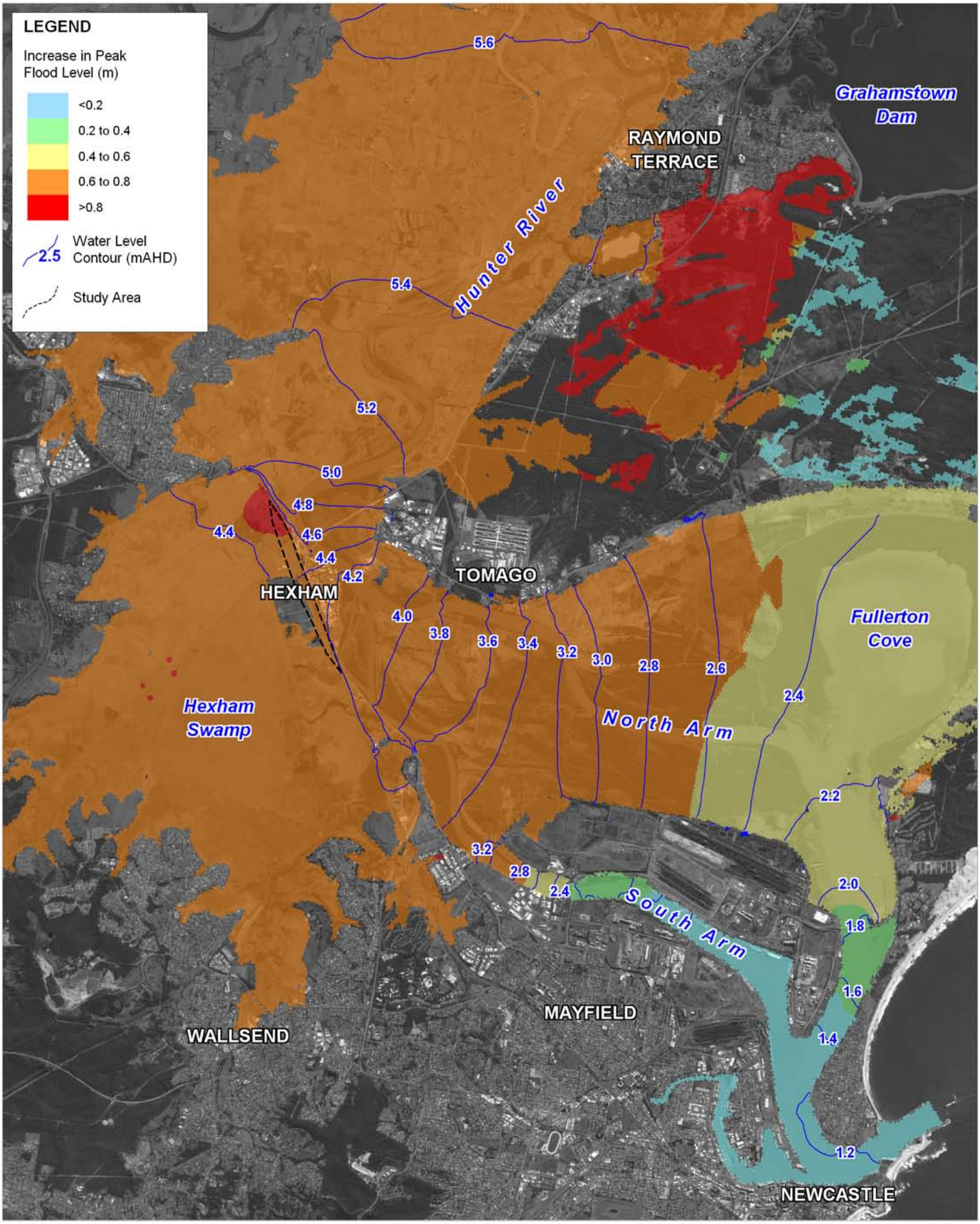
Figure: C-3

Rev: A



BMT WBM
www.bmtwbm.com.au

Filepath : K:\N2197_Hexham_Rail_Development\MapInfo\Workspaces\DRG_037_120320_1%AEP_2100inc10pc_Impact_h.WOR




Title:

**Impact on Peak 1% AEP Flood Level - 30% Increase in Design Rainfall**

Figure: C-4

Rev: A



N

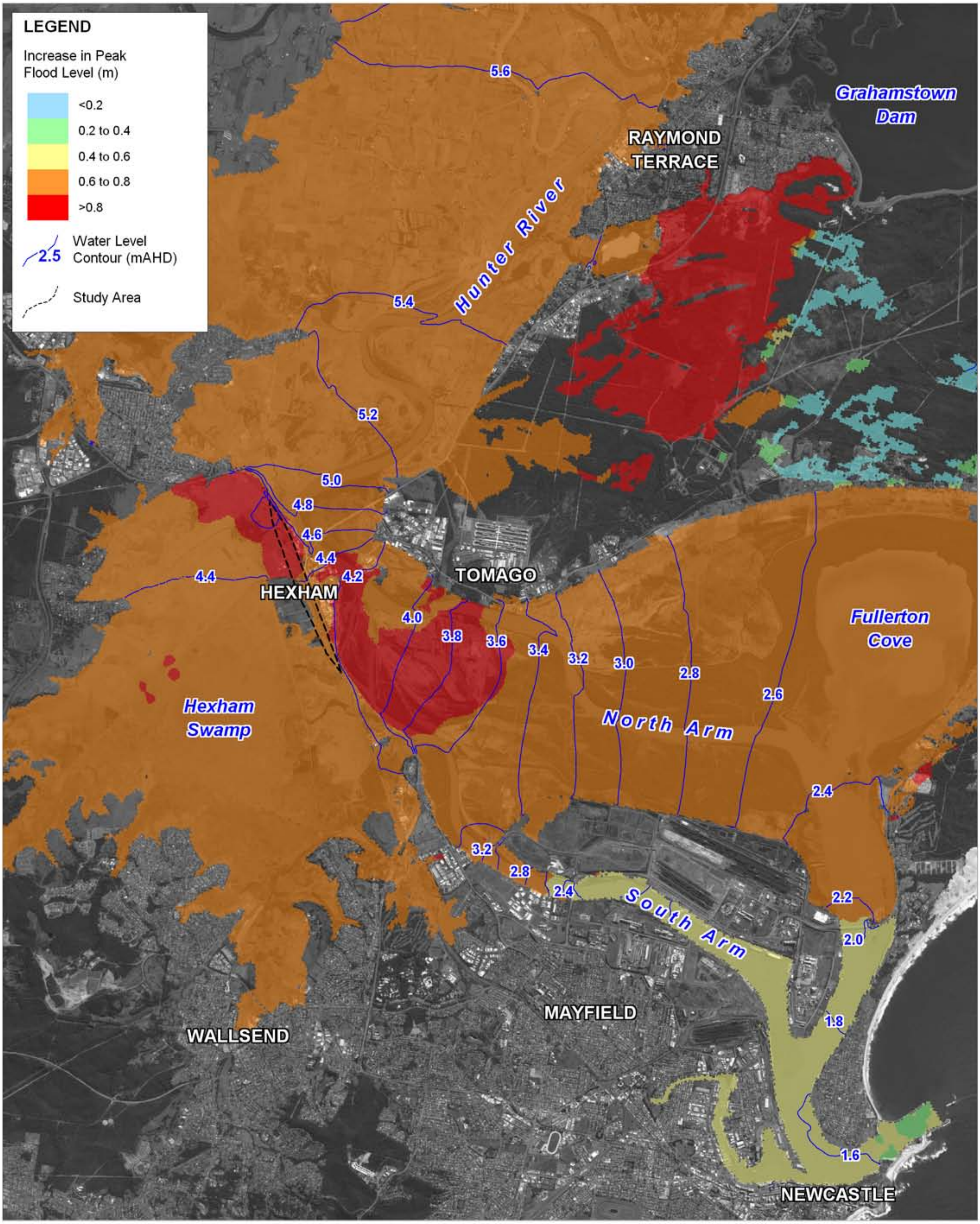
0 2 4km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N2197_Hexham_Rail_Development\MapInfo\Workspaces\DRG_038_120320_1%AEP_inc30pc_Impact_h.WOR




Title:

**Impact on Peak 1% AEP Flood Level - 0.4m Sea Level Rise to 2050 and 30% Increase in Design Rainfall**

Figure: C-5

Rev: A

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

N

0 2 4km
Approx. Scale

BMT WBM
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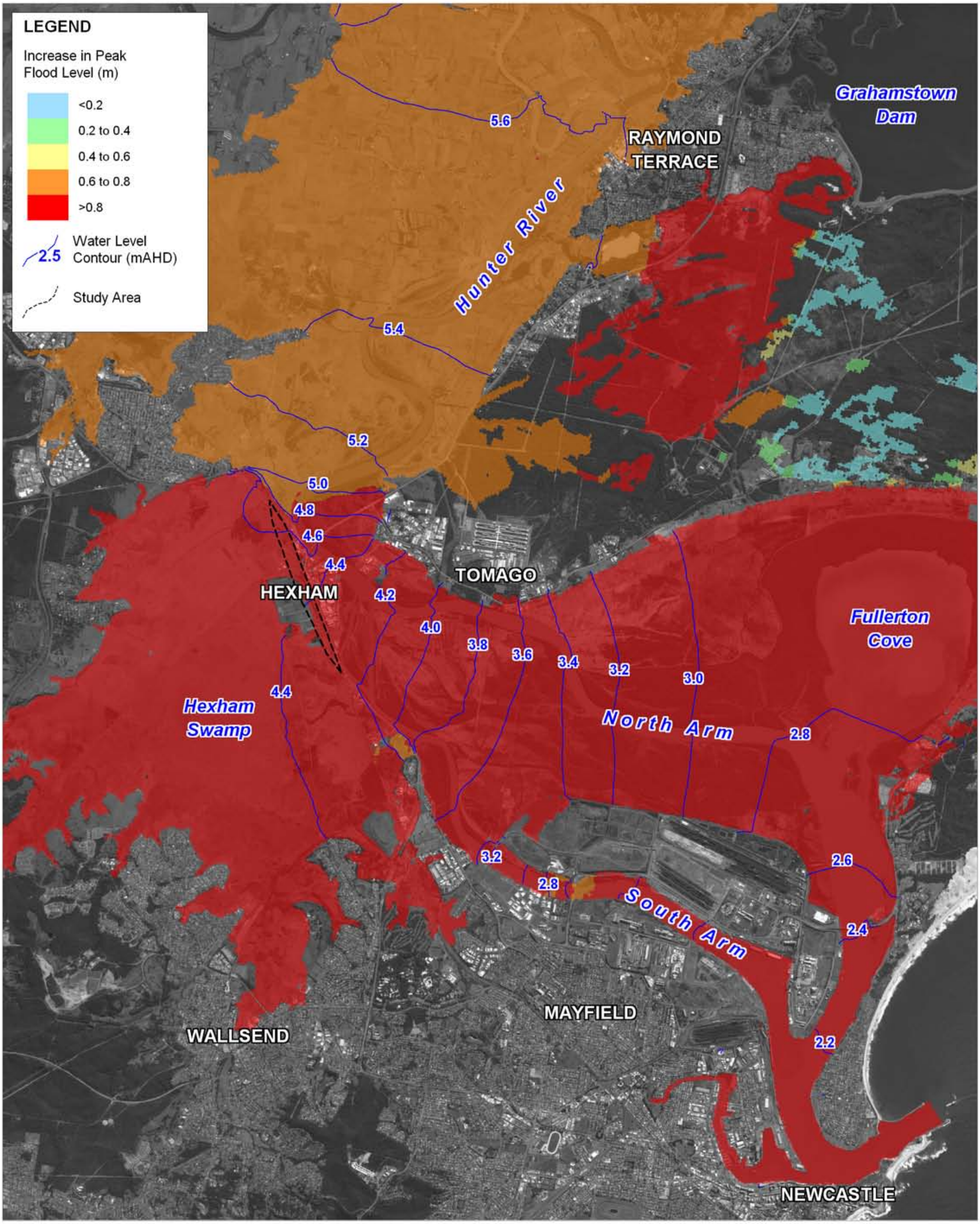
Filepath : K:\N2197_Hexham_Rail_Development\MapInfo\Workspaces\DRG_039_120320_1%AEP_2050inc30pc_Impact_h.WOR




Title:

**Impact on Peak 1% AEP Flood Level - 0.9m Sea Level Rise to 2100 and 30% Increase in Design Rainfall**

Figure: C-6

Rev: A

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N

0 2 4km

Approx. Scale

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Filepath : K:\N2197_Hexham_Rail_Development\MapInfo\Workspaces\DRG_040_120320_1%AEP_2100inc30pc_Impact_h.WOR

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