A63 Castle Street Improvements, Hull
Environmental Statement

Volume 3 Appendix 11.2

Flood Risk Assessment

HE514508-MMSJV-EWE-S0-RP-LE-000004

A63 Castle Street Improvements, Hull

Environmental Statement

Appendix 11.2 Flood risk assessment

Revision Record

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1. Executive summary

1.1.1 Sweco, in joint venture with Mott MacDonald, has been commissioned by the Highways Agency to undertake Stage 3 of the preliminary design phase of the A63 Castle Street Improvements in Hull (which is referred to in this study as “the Scheme”). A detailed Flood Risk Assessment is required to be carried out at this stage of the Scheme in accordance with National Planning Policy Framework.

1.1.2 The Scheme area is located south of the city centre, some 500m to the north of the River Humber and 350m to the west of the River Hull. Potential sources of flooding include tidal (including wave overtopping) and fluvial from both the River Hull and Humber, surface water flooding from pluvial (rainfall) events, sewerage flooding and groundwater flooding.

1.1.3 The study involved the development of a combined one-dimensional and two-dimensional (1D/2D) hydraulic flood risk model using Infoworks ICM software based on an existing Yorkshire Water one-dimensional drainage model for Hull. The 2D flood risk model represents an area of 3.99 km^2 bordering the River Hull to the east and the Humber Estuary to the south and extending 1km to the north and west of the Scheme. The model can predict overland flow and its interaction with the rivers and the existing drainage system.

1.1.4 Consultation with the Environment Agency and Hull City Council occurred throughout the flood risk assessment process to agree the approach, the scenarios to be considered, as well discussing the results of the FRA and mitigation measures including the proposed flood emergency procedures. Yorkshire Water was also consulted regarding the drainage arrangements.

1.1.5 Currently, the greatest risk of flooding to the Scheme area is from wave overtopping of the tidal defences during an extreme storm surge on the north bank of the Humber Estuary. The impacts of wave overtopping flooding on the Scheme and wider Hull city centre from a 1 in 200-year return period or greater tidal event is extensive.

1.1.6 Tidal flooding from the River Hull occurs only in the event of the Hull Tidal Surge Barrier failing to close. This is unlikely as the barrier incorporates a system to automatically close in the event of a power failure. However, in the unlikely event of the barrier remaining open during a 1 in 200-year return period tidal event, the proposed Scheme underpass structure is predicted to be completely flooded. The area to the north and west of Mytongate Junction floods under existing conditions but the presence of the Scheme underpass prevents flood flows reaching this area, particularly around the junction of A1079 Ferensway and Anlaby Road. For this scenario, there is a predicted minor increase in flood risk in the area between the Docks and the River Hull north and south of the Scheme, caused by the slight change in the elevation of the road to facilitate construction of the Scheme. This results in the diversion of flood flows into Princes Quay and increases in flood depths at Kingston Retail Park, Waverley Street and surrounding streets.

1.1.7 Widespread and significant flooding is predicted from the Humber Estuary during a 1 in 1000-year wave overtopping event and during all return period events in the undefended Humber Estuary tidal flooding scenarios. The impact of a flood of this magnitude would be significant, not just for the Scheme but for the whole of Hull city centre. During such an event, the A63 would be completely closed west of Mytongate Junction regardless of whether or not the Scheme goes ahead.

1.1.8 The extent of flooding from combined sources (e.g. high sea levels in the River Hull and Humber during high fluvial baseflow conditions in the River Hull) was also considered in the study. However, the analysis indicates that the risk from these combined sources of flooding is low. Such events would only occur in the unlikely scenario of the Hull Tidal Surge Barrier failing to close.

1.1.9 The underpass drainage system has been designed for a 1 in 100-year critical duration rainfall event including a 30% allowance for climate change. The risk posed to and from the scheme from pluvial (heavy rainfall) flooding is minimal.

1.1.10 The risk of groundwater flooding to the Scheme, and from the Scheme, is considered to be slight. The walls of the underpass structure are estimated to discharge an average of 1.4 m^3 per day into the underpass equivalent to < 1 litre per second. This would be well within the design capacity of the drainage system.

1.1.11 Analysis of predicted flood routes and flow velocities during the extreme tidal events shows the greatest impact of the Scheme results from the proposed underpass structure. Predicted maximum velocities of water (combined with the depth) flowing into the underpass are classified as ‘danger for all’ under Defra’s Hazard to People Classification during a 1 in 200-year River Hull tidal flooding event or greater and from a 1 in 1000-year Humber wave overtopping event or greater.

1.1.12 The resilience of the Scheme to climate change was considered for tidal, fluvial, pluvial and groundwater flooding sources. The underpass drainage system is designed to accommodate flows generated from a 1 in 100-year event with a 30% increase in rainfall intensity for climate change impacts.

1.1.13 Predicted climate change impacts on tidal flooding scenarios from the Humber Estuary are more significant, flooding not only the Scheme area but significant parts of Hull city centre. This is a result of predicted tidal water levels exceeding the level of the existing Humber defences.

1.1.14 The proposed underpass will be drained, under normal conditions, by a surface water pumping station located to the south of Mytongate Junction. The underpass will be designed and constructed to ensure that is resistant and / or resilient to the effects of flooding for events up to and including a 1 in 1000-year return period event for wave overtopping from the Humber Estuary.

1.1.15 In 2015, the Environment Agency and other stakeholders completed upgrade works to the existing flood defences at Albert Dock, with defence levels raised to approximately 6.05 mAOD and a raised standard level of protection of 1 in 200 years along the length of Albert Dock on the north bank of the Humber. Furthermore, an Environment Agency scheme is currently under construction to install and upgrade the Humber north bank defences to a 1 in 200-year standard of protection including an allowance for climate change to 2040. Climate change effects beyond 2040 will be accommodated through a 'managed adaptive' approach. This scheme, known as the Humber Hull Frontages, will increase the standard of protection offered by the defences to the A63 Castle Street Scheme.

1.1.16 According to the NPPF, development of essential infrastructure, such as the Scheme, should only be permitted if it passes the requirements of the Exception Test. Besides the requirement to provide wider sustainability benefits, a Flood Risk Assessment must demonstrate that the development is safe and does not increase flood risk elsewhere. This FRA demonstrates that the Scheme does cause some increase in flood risk to surrounding areas but there are also some reductions in flood risk to other areas. The presence of the underpass structure generally reduces flooding to the north and north-west of the A63 through attenuation of flood volumes. However, there are increases in flooding elsewhere (for example to areas south of the A63 and east of the underpass) due to diversions of flood water. The areas at increased flood risk would already be subject to flooding under existing conditions, particularly during a Humber Estuary wave overtopping event, which is the most likely source of flood risk to the Scheme.

1.1.17 The greatest impact is on the Scheme would be during extreme Humber wave overtopping events during which the proposed Scheme underpass would be completely flooded. However, the Scheme will provide significant local benefits in line with the Local Transport Plan and Hull Local Plan 2016 to 2032.

1.1.18 For extreme tidal flooding events such as those witnessed on 5 December 2013, there is an existing procedure in place whereby flood alerts from the Environment Agency are issued to the Highways Agency Emergency Planning team who consider an appropriate response; for example, the closure of the underpass.

1.1.19 A Flood Emergency and Evacuation Plan (FEEP) was developed as part of this assessment and in agreement with relevant stakeholders including Hull City Council, the Environment Agency and the emergency services. This plan is appended to the report for reference. The plan includes procedures to monitor and ensure the safe closure of the underpass during an extreme flood event, including those events with minimal or no flood warning; for example, a flood resulting from a flood defence breach.

2. Introduction

2.1 Scope of the study

2.1.1 Sweco, in a joint venture with Mott MacDonald, has been commissioned by Highways England to undertake a detailed flood risk assessment (FRA) as part the Stage 3 Preliminary Design phase of the Scheme.

2.1.2 The Environment Agency and Hull City Council have a duty to evaluate proposed developments in respect to flood risk in accordance with the requirements of the National Planning Policy Framework (NPPF)[1] and the supporting Planning Practice Guidance (PPG)[2]. In accordance with this guidance and following consultation with the Environment Agency, a detailed site-specific FRA is required for the Scheme.

2.1.3 The FRA was developed in close consultation with the Environment Agency and Hull City Council. The scope and methodology were agreed following extensive consultation. An Environmental Statement Scoping Report was issued by Mott Macdonald Grontmij (MMG), now Mott Macdonald Sweco (MMSJV), in March 2013[3]. The Scoping Opinion from the Planning Inspectorate presented flooding and drainage issues raised by the consultees. This assessment addresses the concerns related to flooding and drainage outlined in the Scoping Opinion. The principal aim of the study was to evaluate the risk of flooding to the Scheme and the risk of flooding to the surrounding areas posed by the Scheme.

2.1.4 It must be noted that the study focuses on the operational impact of flooding around the Scheme. The impact during the construction stage of the Scheme is discussed in Chapter 11 Road Drainage and Water Environment of the A63 Castle Street Improvement, Hull – Environmental Statement, to which this FRA forms an Appendix.

1 Department for Communities and Local Government (2012). National Planning Policy Framework. March 2012.

2 Department for Communities and Local Government (2016) Planning Practice Guidance. The National Planning Policy Framework and relevant planning practice guidance. November 2016

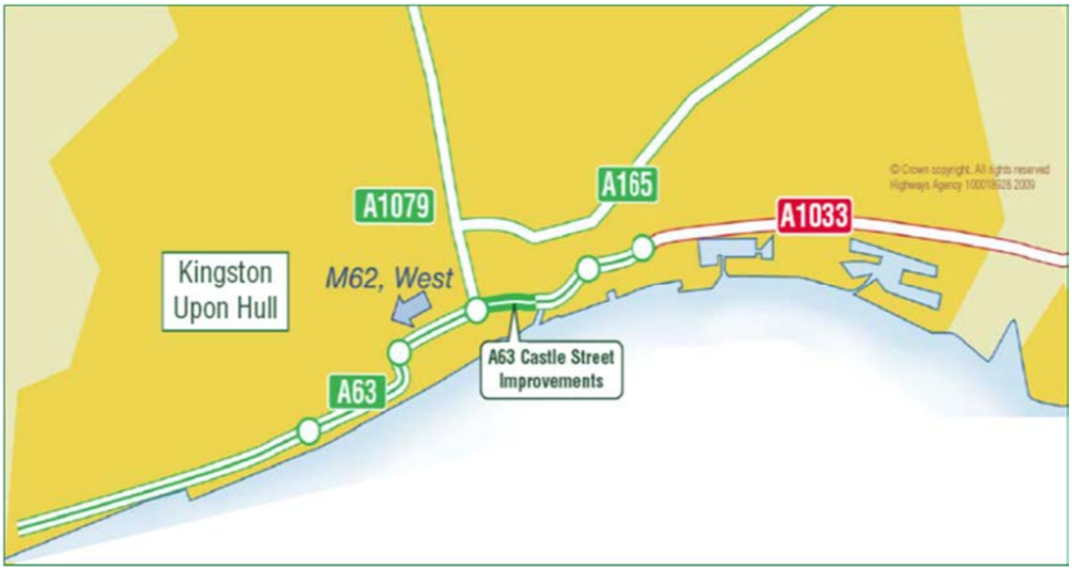
3 Mott MacDonald Grontmij (2013). A63 Castle Street Improvements, Hull – Environmental Statement Scoping Report - 1168-10-221-RE-001-PD1.

3. Description of the scheme

3.1 Existing site description

3.1.1 Kingston upon Hull is located on the banks of the River Hull, at the confluence with the River Humber. The A63, Castle Street, is located south of the city centre, some 500m to the north of the River Humber and about 350m to the west of the River Hull. It is a vital link between the M62 motorway, as well as the Humber Bridge and A15, to the west of the city and the Port of Hull to the east of the city. A general location plan is shown in Figure 3.1 with a detailed map of the existing layout provided in Volume 2 Figure 1.1 of the A63 Castle Street Improvement, Hull – Environmental Statement. The A63 is a key route of both local and strategic importance and is part of the E20 Trans European Route. Traffic congestion occurs at two major junctions, at Commercial Road / Ferensway (Mytongate Junction) and Market Place/Queen Street. Other traffic problems arise on this section of main road from numerous bus stops, direct access to side streets and a number of pedestrian crossings.

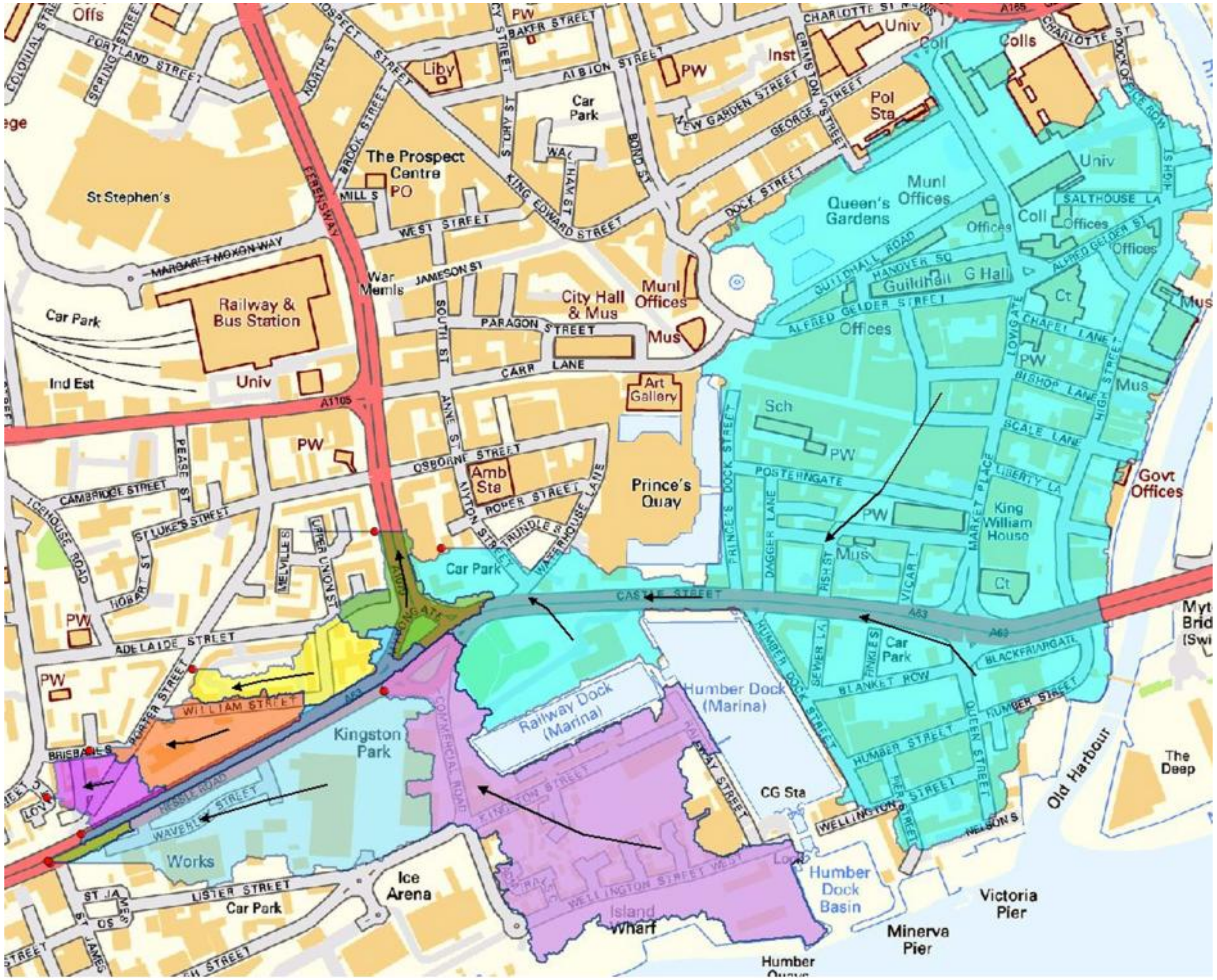
Figure 3-1 - General location of the A63 Castle Street Improvement Scheme



3.1.2 Existing ground levels with the Scheme area are relatively flat and low-lying varying between 2.8m and 4.1m AOD. The study area lies within a heavily urbanised catchment with minor and isolated permeable areas mostly consisting of small urban parks and the existing permeable roundabout at the Mytongate Junction roundabout. The drainage within the Scheme area is dominated by the existing Yorkshire Water combined sewer network. Overland surface water flows generated from intense rainfall events will drain to the existing highway drainage and sewer system. Local topography shows there is a tendency for flows to drain westwards away from the River Humber and the River Hull.

3.1.3 Currently, there is no central barrier or vehicle restraint system along the A63 carriageway. However, much of the length of the existing A63 has steel pedestrian guardrail between the eastbound and westbound carriageways.

Figure 3-2 - Surface topography sub catchments extending over the Scheme area. Flow arrows denote general overland flow direction



3.1.4 Figure 3.2 illustrates the overland flow sub-catchments under the existing conditions[4]. All flows from the Scheme area ultimately drain to the Humber via Yorkshire Water's Saltend Wastewater Treatment Works to the east of Hull and remote from the Scheme and study areas.

3.2 Description of the scheme

3.2.1 On 22 March 2010, the Secretary of State for Transport announced the Underground Option was the Preferred Route for improving the A63 Castle Street, Hull.

3.2.2 The Scheme lowers the level of the existing A63 in the vicinity of Mytongate Junction (Ferensway/Commercial Road) by approximately 7m (the underpass) with Ferensway and Commercial Road being raised by approximately 0.5m and passing over the A63 underpass on a new bridge (Mytongate Bridge) to create a new fully grade separated junction with associated entry and exit slip roads. The Scheme general layout drawings are shown in Volume 2 Figure 2.5.1 to Figure 2.5.6 of the A63 Castle Street Improvement, Hull – Environmental Statement indicating the outline of the area where ground levels are altered by the Scheme. This outline is used in subsequent figures to denote the area of the Scheme. Changes to ground elevations are shown (as long-section profiles) in TR010016 2.6 Engineering Drawings and Sections. An overview of the Scheme is provided in Figure 3-3.

3.2.3 Between Mytongate Junction and Market Place, the eastbound carriageway would be widened to three lanes, with the nearside lane being marked for local traffic only and which, for safety reasons, would be physically segregated from the main eastbound carriageway from Mytongate Junction as far as Princes Dock Street. Vehicles wishing to access Myton Street and Princes Dock Street from the A63 would do so via the eastbound exit and entry slip-roads. The westbound carriageway would have two lanes, as at present.

3.2.4 Westbound traffic leaving the A63 at the new Mytongate Junction would use a two-lane slip road. The slip road would widen to three lanes at the top of the slip road for the signalised junction with Commercial Road. The wall between the slip road and the A63 mainline would be a piled retaining wall of variable height increasing from east to west along the side of the westbound diverge slip road. A 1.4m high parapet fence would be provided on top of the string course beam on top of the piled wall. The string course beam would be approximately 75-100 mm above the height of the eastern verge of the westbound diverge slip road. The lowest point on the vertical alignment of the westbound diverge slip road would be lowered by approximately 2.9m below the current level.

[4] The catchments were derived based on the Digital Terrain Mapping (DTM) data raster utilising the spatial analyst hydrology tool in ArcGIS and using the existing ground model derived from LiDAR information obtained in 2013.

Figure 3-3 – Overview of the A63 Castle Street Improvement Scheme

3.2.5 The realigned A63 and the westbound exit slip road to Commercial Road would pass through the northern part of the Trinity Burial Ground, affecting around one third of the Burial Ground. The wall between the slip road and the Trinity Burial Ground would be a piled retaining wall, with the existing boundary wall mounted on top. The piled retaining wall would remain visible, and would be faced in new red brick to be in keeping with the existing boundary wall.

3.2.6 The existing A63 junction roundabout which is largely permeable and vegetated would be completely replaced with new hardstanding areas of carriageway.

3.2.7 East of Mytongate Junction, the level of the A63 would gradually rise from being in cutting to be at existing ground level in the vicinity of the Earl de Grey Pub. However, within the vicinity of the proposed Princes Quay Bridge (footbridge), carriageway levels would be lowered on both the eastbound and westbound sides in order to maintain adequate headroom for vehicles passing under the bridge.

3.2.8 The Scheme will require the demolition of a number of buildings to the north of the existing A63 carriageway:

- The former Earl de Grey Public House
- The Myton Centre
- The Hull Marina Hotel electricity sub-station

3.2.9 In addition to the above works to the carriageway, two footbridges will be constructed to allow continued pedestrian access across the A63. Porter Street pedestrian, cycle and disabled user bridge will be constructed at the west of the Scheme close to the junction of the A63 and Porter Street. Princes Quay footbridge will be constructed to the east of the proposed underpass over the A63 between Princes Quay to the north and the Humber Dock Marina to the south. A small length of the new A63 carriageway will be lowered beneath Princes Quay Bridge to maintain headroom for high vehicles passing under the bridge. Two existing pelican crossings will be removed close to the proposed locations of the Porter Street and Princes Quay footbridges.

3.2.10 Along the centre of the A63 main carriageway, a 0.90m high continuous vertical concrete barrier (VCB) will be installed through the full length of the Scheme area. The VCB will be constructed in reinforced concrete and will tie in the central pier of the new Mytongate Bridge over the underpass.

Proposed drainage

3.2.11 The overall drainage strategy is detailed in a separate report[5]. The proposed drainage systems can be split into two distinct networks. Namely, the at-grade network which will drain the modified A63 carriageway and new slip roads and the underpass network which will drain the length of the carriageway lowered into the new underpass.

3.2.12 The design of the Scheme has taken into consideration the existing flow routes and has aimed to minimise the changes in the flow paths within the limitation of the construction site and design requirements. While the proposed road design will inevitably alter the impermeable surfaces and levels in the area of development, the most significant change will be the ground depression created by the underpass.

3.2.13 The increase in impermeable area which results from the replacement of the permeable vegetated areas of the roundabout at Mytongate Junction with a hard surface road was taken into account in the highway drainage design. The overall increase in impermeable area as outlined in Volume 3, Appendix 11.8 Drainage impact assessment is approximately 0.81a (approximately 18%).

3.2.14 The drainage system of the proposed underpass is designed based on criteria agreed with the Environment Agency and guidance within the Design Manual for Roads and Bridges (DMRB)[6]. The underpass drainage would be designed to protect against flooding in a 1 in 100-year return period rainfall event, with a 30% allowance for climate change. This is in excess of current DMRB standard of a 20% allowance for climate change. This departure from the DMRB standard has been agreed in principle with the Highways Agency, at the request of the Environment Agency to meet a site-specific situation and in consideration of historic flooding in Hull. It must be noted that this agreement was reached prior to the issuing of the latest climate change allowances for flood risk assessments[7] and prior to the release of the latest UKCP18 climate change allowance information[8].

3.2.15 External overland flows generated from outside the underpass catchment area and flows from the westbound diverging slip road are also incorporated into the underpass drainage design. Details of the proposed drainage arrangement are available in the A63 Castle Street Improvements Drainage Impact Assessment Report[9].

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[5] Arup (2017). A63 Castle Street Improvements Drainage Impact Assessment HE514508-ARP-HDF-S0-RP-CD-000505. November 2017.

[6] Highways Agency (2018). Design Manual for Roads and Bridges. http://www.dft.gov.uk/ha/standards/dmrb/. Accessed April 2018.

[7] Environment Agency (2019). Flood risk assessment: climate change allowances. Guidance to support the NPPF. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances. Accessed April 2017

8 Met Office (2019). UK Climate Projections (UKCP18). https://www.metoffice.gov.uk/research/collaboration/ukcp

[9] Arup (2017). A63 Castle Street Improvements Drainage Impact Assessment HE514508-ARP-HDF-S0-RP-CD-000505. November 2017.

3.2.16 According to the A63 Castle Street Improvements Drainage Impact Assessment Report[9], surface water flows from the underpass would be diverted underground via the proposed combined kerb drainage system. Flows would be conveyed in the underground channel beneath the kerb until they reach the lowest point of the underpass. Sumps would be situated at least every 100m to minimise blockages. Flows would be discharged from the channel to an oil separator before being conveyed through online cylindrical attenuation units to the pump station, which would pump flows through a rising main. Currently, there are two proposed options for the outfall from the rising main: one to the Humber Estuary at Albert Dock via a new rising main and one to the existing Yorkshire Water sewer network via a shorter new rising main.

3.2.17 The route of the proposed rising main option and outfall is shown in Volume 2, Figure 11.1 Surface water features. The location of the proposed Humber outfall is part of an existing flood defence structure (see Section 7) and as such would be subject to consent from the Environment Agency to undertake the works.

3.2.18 The proposed Humber outfall would discharge above Mean High Water Springs (MHWS) and would be fitted with a flap valve or similar non-return valve to prevent the proposed drainage being flooded when tide levels are higher than the outfall. To prevent tide locking, i.e. the prevention of discharge when the outfall is submerged by tides greater than outfall level, the proposed rising main and outfall would operate under pumped, pressurised conditions. The length of this rising main to the Humber outfall would be approximately 800m.The pumping station would be designed to operate under various rainfall conditions with a provisional pumping rate of 100 litres per second for the Humber Estuary outfall option or 200 litres per second for the Yorkshire Water sewer outfall option. The required attenuation volume for the design event is 635 m^3 for the Humber Estuary outfall option and 300m^3 for the Yorkshire Water sewer outfall option [9].

3.2.19 The Yorkshire Water system outfall option reduces the required length of rising main. The drainage strategy confirmed an increased discharge rate of 200 l/s to the combined system would reduce the attenuation volume requirements to 300 m^3 and would not cause additional flooding during a 1 in 100-year event.

3.2.20 Drainage from all other slip roads and the proposed bridge connecting Commercial Road and Ferensway (Mytongate Bridge) would be diverted into Yorkshire Water's existing combined sewerage system subject to the condition that proposed flow rates are equal to, or less than, the existing flow rates. In addition, the drainage would be subject to the design requirements quoted in the DMRB including no flooding for a range of storms during a 1 in 5-year return period rainfall event including a 30% allowance for climate change. Further details are provided in the At Grade Drainage System Strategy Report[10].

[10] Mott MacDonald Grontmij (2014b). A63 Castle Street Improvements; At Grade Drainage System Strategy. Report for Highways Agency. Doc Ref: 1168-08-005-RE-001 A2. March 2014.

3.2.21 The Scheme would require the diversion of some of the existing Yorkshire Water sewer network to facilitate construction of the underpass. Currently a number of options for necessary sewer diversions are subject to discussion and consultation with Yorkshire Water and appropriate adjacent landowners, in particular, the Holiday Inn through which the diverted sewers will pass.

3.2.22 Proposed Scheme lifetimeThe traffic and economic assessments demonstrate that the proposed Scheme would operate adequately for the first 60 years of opening to the Design Year of 2085. Typically, highway schemes are designed to have a material life-span of between 20 and 40 years before major maintenance and upgrading is required dependant on material properties, maintenance and usage. Elements including structural concrete and steelwork have extended design lives of up to 120 years with drainage elements having a design life of 60 years. As a consequence, for the purposes of the assessments within this flood risk assessment and the A63 Castle Street Improvement, Hull Environmental Statement, the design life of the Scheme is 60 years.

4. Legislative and policy framework and climate change

4.1 Policy framework

4.1.1 The NPPF[1] and the accompanying online PPG[2] are the relevant guidance documents that local authorities use in reviewing proposals for development with respect to flood risk. If a site was to be developed the NPPF sets out policies for planning authorities to:

- Ensure flood risk is properly taken into account at all stages of the planning process
- Prevent inappropriate development in areas at high risk of flooding
- Direct development away from areas at highest risk
- Ensure that new developments take climate change into account and do not increase flood risk elsewhere

4.1.2 The NPPF provides guidance on the assessment of flood risk and how it may be addressed or mitigated. The guidance advises, inter alia, planning authorities in their planning decisions to use a risk-based approach to avoid flood risk wherever possible and manage flood risk elsewhere.

4.1.3 The National Policy Statement for National Networks (NPSNN)[11] sets out the needs and government policies related to national significant infrastructure rail and road projects in England. Sections 5.92 to 5.97 of the NPSNN give guidance on the requirements for flood risk assessments for relevant applications. Sections 5.107 to 5.109 outline the requirements of the Sequential and Exception Tests which are broadly consistent with those outlined in the NPPF.

4.1.4 In addition, the Flood and Water Management Act (FWMA) 2010 provides for better and more comprehensive management of flood risk for people, homes and business estates. The Act states that the Lead Local Flood Authorities (LLFAs) (either unitary authorities or county councils) are responsible for developing, maintaining and applying a strategy for local flood risk management in their areas and for maintaining a register of flood risk assets. They also have lead responsibility for managing the risk of flooding from surface water, groundwater and ordinary watercourses. Hull City Council is the LLFA in the area of the Scheme.

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11 Department for Transport (2014). National Policy Statement for National Networks. December 2014. Available online at https://www.gov.uk/government/publications/national-policy-statement-for-national-networks

4.1.5 In 2012 various amendments were introduced to the FWMA 2010. Amongst other changes the amendments specified some new duties and responsibilities of the LLFAs, namely LLFAS must:

- prepare and maintain a strategy for local flood risk management in their areas, coordinating views and activity with other local bodies and communities through public consultation and scrutiny, and delivery planning
- investigate significant local flooding incidents and publish the results of such investigations
- play a lead role in emergency planning and recovery after a flood event

4.1.6 An essential part of managing local flood risk will be taking account of new development in any plans or strategies.

4.1.7 The Act also states that if a flood happens, all local authorities are 'category one responders' under the Civil Contingencies Act. This means they must have plans in place to respond to emergencies, and control or reduce the impact of an emergency. LLFAs also have a duty to determine which risk management authorities have relevant powers to investigate flood incidents to help understand how they happened, and whether those authorities have or intend to exercise their powers.

Local

4.1.8 The Hull City Council Strategic Flood Risk Assessment (SFRA)[12] confirms the majority of Hull is protected from flooding by existing defences although the consequences of a defence breach or overtopping event would be significant. The SFRA also provides a more nuanced representation of Flood Zone 3a (split into Flood Zone 3ai (Low) to Flood Zone 3aiv (High)) depending on predicted flood depths. The SFRA includes detailed maps of the effects of potential breaches in existing flood defences along the north bank of the Humber Estuary.

4.1.9 The Hull City Council Local Flood Risk Management Strategy (LFRMS)[13] brings together information on flooding in Hull and identifies ways of managing risk in partnership with the relevant Risk Management Authorities. The LFRMS outlines a number of actions in the following areas:

- Prevention of risk

[12] Hull City Council (2016). Hull City Council Strategic Flood Risk Assessment REP/232639/001. December 2016.

[13] Hull City Council (2015) Hull City Council Local Flood Risk Management Strategy. Available online at http://www.hullcc.gov.uk/pls/portal/docs/PAGE/HOME/PLANNING/FLOOD%20RISK/LOCAL%20FLOOD%20RISK%20MANAGEMENT/LFRMS%20FINAL%20VERSION.PDF, last accessed June 2018

- Protection from risk
- Preparing for risk
- Recovery and review of risk

4.1.10 In addition, the Hull City Council LFRMS provides a summary of ongoing and future projects aimed in the Hull area with a total value of approximately £234M.

4.1.11 The Hull City Council Surface Water Management Plan (SWMP)[20] provides a long-term strategy for surface water management in the City of Hull and includes identification, assessment and selection of preferred options for implementation.

4.1.12 Hull City Council's Local Plan 2016 to 2032[14] was adopted on 23 November 2017, and is used to guide new development in the city for the next 15 years, up to 2032. The Local Plan contains the following policies relevant to the water environment:

- Policy 37 Flood Defences:
    - Development adjacent to flood defences must not reduce their effectiveness, or prevent or hinder their future maintenance or improvement
    - Improvement of the standard of flood defences will be supported
    - Development may be required to improve the standard of flood defence infrastructure if required to make the development acceptable
- Policy 38 Surface Water Storage and Drainage
    - Development of strategic facilities for the storage of water will be supported where they can be shown to improve the flood resilience of the city
    - Development which will reduce the effectiveness of any surface water storage operation or facility will be refused
    - Localised surface water storage and drainage facilities will be supported
- Policy 39 Sustainable Drainage
    - All development should incorporate sustainable drainage systems unless it has been demonstrated this is not technically or economically feasible

[14] Hull City Council (2017). Hull Local Plan 2016 to 2032, November 2017

- Drainage Impact Assessments should include a 30% allowance for climate change to ensure the development is safe for its lifetime
- Applications should demonstrate how the long-term maintenance of the sustainable drainage system will be assured

- Policy 40 Addressing Flood Risk in Planning Applications
  - Development of sites or uses not allocated on the Policies Map must be supported by a Sequential Test and Exception Test
  - Development which requires a Flood Risk Assessment and/or the Exception Test must demonstrate that appropriate flood mitigation, flood resilience and, where appropriate, sustainable drainage measures have been incorporated in its design and layout
- Policy 41 Groundwater Protection
  - Within Source Protection Zone 1, all development will be required to be supported by a detailed hydro-geological risk assessment
  - Applications for development which has the potential to have a negative impact on Source Protection Zones, which has not demonstrated consideration of their presence and how the risk of pollution has been mitigated, will be refused

4.2 Climate change

4.2.1 For site specific flood risk assessments, the NPPF Section 14 (Meeting the challenge of climate change, flooding and coastal change) states:

> "*When determining any planning applications, local planning authorities should ensure that flood risk is not increased elsewhere. Where appropriate, applications should be supported by a site-specific flood-risk assessment. Development should only be allowed in areas at risk of flooding where, in the light of this assessment (and the sequential and exception tests, as applicable) it can be demonstrated that:*
>
> > *a) within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;*
> >
> > *b) the development is appropriately flood resistant and resilient;*
> >
> > *c) it incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;*
> >
> > *d) any residual risk can be safely managed; and*

e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan."

4.2.2 In addition to this, it also states:

"*Plans should take a proactive approach to mitigating and adapting to climate change, taking into account the long-term implications for flood risk, coastal change, water supply, biodiversity and landscapes, and the risk of overheating from rising temperatures..*"

4.2.3 The NPPF states that:

"*Policies should support appropriate measures to ensure the future resilience of communities and infrastructure to climate change impacts, such as providing space for physical protection measures, or making provision for the possible future relocation of vulnerable development and infrastructure.*"

4.2.4 Current climate change allowance guidance[7] states the revised peak rainfall intensity (to assess surface water flood risk) climate change allowance is 40 % (upper end estimate in 2080s). However, the current design incorporates a 30 % allowance within the drainage design, which is an enhancement to the Design Manual for Roads and Bridges (DMRB) guidance of 20%. This allowance was agreed in consultation with the Environment Agency in 2014 and prior to Hull City Council taking on the role for statutory consultee on surface water flood issues. Climate change guidance in place in 2014 recommended an allowance of 20%. A sensitivity analysis incorporating the 40% upper end climate change allowance was also carried out.

4.2.5 In December 2018, the Met Office released the latest set of climate projections known as UKCP18[8]. These projections include assessments of the impact of climate change on sea level rise, rainfall volume and rainfall intensity. The Environment Agency guidance does not currently incorporate the outputs from UKCP18[7].

4.2.6 The FRA also considered the impact of climate change from all sources of flooding including the impact on tidal levels in the Humber and River Hull. This was incorporated by applying a uniform increase in peak sea level of 1.125m to allow for the effects of climate change throughout the life of the Scheme (2010 to 2115) (as per data supplied and derived from The River Humber, North Bank Tidal Modelling Study. Water Level, Tide, Surge and Wave Analysis report)[25]. Furthermore, an increase of 10% was applied to peak wave heights[7].

4.2.7 Outcomes from the preceding River Hull and Holderness Drain Flood Mapping Study[15] were used to assess the impact of flooding from the River Hull as part of this FRA. However, the required 1 in 200-year plus climate change event was not modelled in the previous River Hull study. Following consultation and agreement with the EA, the 1 in 1000-year event was used as a surrogate for the appropriate climate change event in this study.

[15] Halcrow (2013). River Hull and Holderness Drain Flood Mapping Study, Modelling Report for Environment Agency. September 2013.

5. Approach to the flood risk assessment

5.1 Introduction

5.1.1 This section describes the approach taken in the FRA including:

- An overview of previous consultation
- The FRA methodology
- Application of the Exception Test to the Scheme

5.2 Summary of the DMRB stage 2 FRA and previous consultation

5.2.1 During the DMRB Stage 2 Preferred Option Assessment a FRA[16] was prepared in accordance with the requirements of PPS25, 'Development and Flood Risk', to provide an overall strategic review of the proposed works. The NPPF and PPG guidance has effectively replaced the Planning Policy statement (PPS) series, however, the various sections dealing with flood risk and climate change have retained much of the technical guidance which appeared in PPS25.

5.2.2 The Pell Frischmann FRA Report[16] concluded that the site is protected from flooding from the River Hull and River Humber by flood defences serving the City of Hull, and therefore it can be considered that the site would be protected for its lifetime. It was recommended in the report that the Scheme's highway drainage system is designed to current standards. It also states that emergency traffic diversion and evacuation procedures will be developed as the part of the detailed design of the Scheme.

Environment Agency response to the stage 2 FRA

5.2.3 In their letter from 12 May 2009, the Environment Agency states that they would object to the option to lower the existing level of A63 at Mytongate Junction by approximately 7m due to the perceived increase in flood risk. Subsequently, after the final issue of the FRA[16], in their letter of 6 November 2009[17], the Environment Agency states that they consider that the FRA is inadequate mainly in respect to the emergency procedures detailed in the report. The Environment Agency requires a detailed Emergency Plan incorporated into the FRA[17]. In addition, during a meeting between the Environment Agency, Pell Frischmann and the

[16] Pell Frischmann (2009a). Highways Agency - Project Support Framework- A63 Castle Street Improvements, Hull. Flood Risk Assessment Report. Doc Ref: W11189/T13/03. October 2009.

[17] Environment Agency (2009). Letter to Pell Frischmann in response to the update to the flood risk assessment in 2009 dated 6th November 2009. Ref: RA/2009/11042/03-L01.

Highways Agency (now Highways England) on 18 September 2009, it was agreed that[18]:

> "*once a preferred option is chosen an evaluation of the impact of potential changes to overland flow routes would be undertaken and appropriate mitigation measures proposed where required*".

It was also agreed that:

> "*the risk of flooding from breach of the permanent Humber defences will be considered as part of the assessment*".

5.3 Planning Inspectorate scoping opinion

5.3.1 In March 2013, the Scoping Report was issued by MMG as part of the preliminary design phase of the Scheme. The Scoping Report presents how the Scheme is to be assessed and set out the scope and content of the Environmental Statement (ES). In response to the Scoping Report, the Planning Inspectorate published the Scoping Opinion in April 2013. The Scoping Opinion outlines the recommendations and considerations to be addressed in the ES. Those recommendations specifically related to the FRA are paraphrased as follows:

- The provision of an updated FRA in consultation with Environment Agency and Hull City Council including the consideration of tidal and fluvial flooding and wave overtopping of the existing flood defences. The impacts of climate change should be considered.
- The impact on existing flood defences should be considered.
- Provision of details of the proposed drainage including the proposed outfall and the potential impacts on the existing public sewer network should be considered.

5.3.2 A detailed response to all the recommendations from the Planning Inspectorate response to the Scoping Report is provided in Volume 1, Chapter 4 Consultation.

5.4 Flood risk assessment methodology

5.4.1 The methodology adopted for the FRA follows the guidance provided in NPPF and the PPG [1] [2] . It also addresses the recommendations from the Planning Inspectorate Scoping Opinion. The FRA consists of four main components:

- A review of data sources

[18] Pell Frischmann (2009b) Record of Meeting Held on 18th September 2009 between Pell Frischmann and Environment Agency. Ref: W11190/01.

- Consultation with stakeholders
- Surface water flood risk assessment
- Groundwater flood risk assessment

5.5 Data sources

5.5.1 As part of this assessment the following information was considered:

- NPPF and the supporting PPG [1] [2]
- Hull City Council's Strategic Flood Risk Assessment including data and assessments relevant to a flood defence breach [12,19]
- Hull City Council's Surface Water Management Plan[20]
- Hull City Council's Preliminary Flood Risk Assessment[21]
- Environment Agency's Humber Flood Risk Management Strategy[22]
- Hull and Coastal Streams Catchment Flood Management Plan[23]
- Environment Agency's River Hull and Holderness Drain Flood Mapping Study[15]
- Environment Agency's River Humber North Bank Tidal Modelling Study (Mott Macdonald, [24], [25], [26])
- Environment Agency's 2014 Interim Water Level Profile[27] (Environment Agency, 2014)
- Digital Terrain Mapping (DTM) data from Bluesky Aerial Survey
- Hull Hydrology and Data Investigation Study Report, Technical Note[28]

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19 Halcrow (2007). Strategic Flood Risk Assessment. Report for Hull City Council. November 2007.

20 Halcrow (2009). Surface Water Management Plan. Report for Hull City Council. November 2009.

21 Halcrow (2011a). Preliminary Flood Risk Assessment. Draft Report for Hull City Council. July 2011.

22 Environment Agency (2008). The Humber Flood Risk Management Strategy. March 2008.

23 Environment Agency (2010). Hull and Coastal Streams Catchment Flood Management Plan. December 2010.

24 Mott MacDonald (2011a). The River Humber, North Bank Tidal Modelling Study. Main Report for the Environment Agency. December 2011.

25 Mott MacDonald (2011b). The River Humber, North Bank Tidal Modelling Study. Water Level, Tide, Surge and Wave Analysis. December 2011.

26 Mott MacDonald (2011c). The River Humber, North Bank Tidal Modelling Study. Flood Defence Conceptualisation Report. December 2011.

27 Environment Agency (2014). Humber Estuary 2014 Interim Water Level Profile

28 Halcrow (2011b). Hull Hydrology and Data Investigation Study Report, Technical Note. March 2011.

- Defra R&D Technical Report FD2308/TR1 Joint probability: Dependence mapping and best practice: Technical report on dependence mapping (Defra, 2006)[29]
- The River Hull Advisory Board's 2016 River Hull Integrated Catchment Strategy (River Hull Advisory Board, 2016)[30]
- Environment Agency's High++ (H++) climate change allowance guidance[31]
- Met Office's UKCP18 climate projections[8]
- Environment Agency's Humber Hull Frontages Hydraulic Modelling Report[32]

5.6 Summary of relevant consultation

5.6.1 Ongoing consultation regarding the FRA has been undertaken with the Environment Agency and Hull City Council throughout this assessment to agree the approach, discuss the results of the assessment and consider mitigation measures. The record of consultation with the Environment Agency is documented in the Statement of Common Ground[33]. Meetings were held with Hull City Council on 30th January 2013, 13th January 2014, 30th January 2014, 15th October 2014, 27th February 2018 and 18th April 2018.

5.6.2 Meetings with Yorkshire Water to discuss the connection of the proposed highway drainage to the Yorkshire Water's public sewer network were held on 1st March 2013, 18th April 2013 and 16th January 2014. Further details of the consultation process can be found in Volume 1, Chapter 4 Consultation of the A63 Castle Street Improvement, Hull – Environment Statement.

5.6.3 A meeting was held with the Environment Agency on 3rd August 2018 to discuss the findings of a draft version of this FRA. At this meeting an agreement was made to provide a number of items of additional information in terms of detailed flood risk impacts; these additional requirements are outlined in Volume 3, Appendix 11.9 Additional flood risk information requirements.

5.6.4 Consultation with the Environment Agency and Hull City Council continued from December 2018 and throughout the DCO Examination process in 2019. The focus of the consultation with the Environment Agency was around supplying the additional information outlined in Volume 3, Appendix 11.9 Additional flood risk information requirements and focussed on the transfer of flood risk and additional

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[29] Defra (2006). R&D Technical Report FD2308/TR1 Joint probability: Dependence mapping and best practice: Technical report on dependence mapping. March 2006.

[30] River Hull Advisory Board (2016) River Hull Integrated Catchment Strategy. May 2016.

31 Environment Agency (2016). Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities

32 Arup (2016). Humber Hull Frontages Improvements Programme: Hydraulic Modelling Report (Draft). July 2016.

assessments of flood defence breaches, H++ climate change, the Flood Emergency and Evacuation Plan and the resilience of the underpass surface water pumping station.

5.6.5 A detailed record of the ongoing consultation with the Environment Agency in relation to flood risk (including references to additional information) is provided in the Statement of Common Ground.[33]

5.7 Surface water flood risk modelling methodology

5.7.1 A flood risk model is required to investigate the surface water flood risk to the Scheme and caused by the Scheme to the surrounding areas, including the potential changes in flood flow paths, depths, velocities and flood hazard around the Scheme.

5.7.2 A review of the available flood risk models developed for the area of Hull was undertaken and the Infoworks one-dimensional (1D) CS Hull Combined Drainage Area Zone (DAZ) model of the combined sewer network serving Hull was chosen. The model was selected on the basis that it explicitly considers flooding in sewers including their role in overland flow generation. In consultation with the Environment Agency, it was agreed that this model was suitable for use as a starting point in creating an integrated model for the study area to examine flood risk from all sources. The model was provided by Clear Environmental Ltd working on behalf of East Riding of Yorkshire Council (ERYC). Approval was also sought and obtained from Yorkshire Water, Hull City Council and the Environment Agency for the use and update / revision of this model.

5.7.3 The model was converted to Infoworks ICM (v8.0.2) and a two-dimensional (2D) overland flow element was added to assess the impact of the Scheme on the behaviour of the surface water flood flow paths. Further details of the model development and data input can be found in Volume 3, Appendix 11.13 Flood risk technical modelling report.

5.7.4 Several scenarios considering the impact of various flooding sources were agreed with the Environment Agency (see Section 9.3) under existing and proposed conditions. Specifically, tidal and fluvial scenarios for the River Hull and River Humber were based on output from studies commissioned by the Environment Agency:

- River Hull and Holderness Drain Flood Mapping Study provided fluvial, tidal and combined fluvial/tidal outputs for the River Hull[15]
- River Humber North Bank Tidal Modelling Study[24,25,26]. This includes the 2014 update to the study following the 2013 storm surge flood event[27].

33 Highways England's A63 Castle Street Improvement, Hull, TR010016, Statement of Common Ground (SoCG) with the Environment Agency

These studies provided tidal and wave overtopping outputs for the north bank of the Humber

- The Hull City Council SFRA[12] provided breach flow inputs from breaches of the existing Humber north bank defences at four locations within the study area.

5.7.5 Flooding from a combination of sources is also considered within this assessment.

5.7.6 The results were compared in order to determine the extent of flooding under different conditions including flood hazard and the significance of the potential impacts. In addition, detailed analyses were undertaken to assess the potential changes to overland flow routes, flood depths, velocities and flood hazard during operation of the Scheme.

5.8 Groundwater flood risk assessment methodology

5.8.1 Consideration of groundwater flooding was undertaken as a separate study to understand the hydrogeology in the vicinity of the Scheme. A summary of the findings within the context of the FRA are reported here. The groundwater investigation included an extensive site investigation programme, development of a baseline hydrogeological conceptual model and construction of a numerical groundwater model to investigate potential impacts on groundwater receptors during the Construction and Operational Phases of the Scheme. The assessment of potential impacts on groundwater levels has focussed on the underpass as its dimensions and orientation means that it is likely to have a far greater impact on groundwater levels and flow than any other excavation or below-ground structure currently included in the Scheme.

5.8.2 Preliminary design details for the underpass are provided in Volume 3, Appendix 11.4 Groundwater report. A groundwater model was developed to investigate the impacts of the underpass on groundwater flow, using MODFLOW (GW Vistas). A full description of the model and results are presented in the Volume 3, Appendix 11.6 Groundwater modelling report.

5.9 The exception test

5.9.1 The Environment Agency Flood Map for Planning[34] indicates the Scheme is located within Flood Zone 3a with a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

5.9.2 The Scheme is also identified as being within an 'area benefitting from flood defences'[34].

[34] Environment Agency (2017a). Flood Map for Planning https://flood-map-for-planning.service.gov.uk/summary/509353/428386. Accessed December 2017.

5.9.3 The Scheme is classified as essential infrastructure under the flood risk vulnerability classification (Table 2 of the PPG[2]). According to *Table 3: flood risk vulnerability and flood zone 'compatibility'* in the PPG[2], development of essential infrastructure is only permitted in Flood Zone 3a if it passes the Exception Test. The PPG also notes that, in Flood Zone 3a, essential infrastructure should be designed and constructed to remain operational and safe in times of flood. For the Exception Test to be passed, the following criteria must be met (paragraph 102 of the NPPF):

- it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared
- a site-specific flood risk assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

5.9.4 The Local Transport Plan (2011-2026)[35] and the Hull Local Plan 2016 to 2032[14] highlights the significant social and economic benefits of the Scheme, and thereby provides a basis for demonstrating compliance with the first criterion of the Exception Test. The second criterion is addressed in detail in this report.

[35] Hull City Council (2011). Local Transport Plan (2011-2026). January 2011. http://www.hullcc.gov.uk/portal/page?_pageid=221,161326&_dad=portal&_schema=PORTAL Accessed 7th March 2014.

6. Sources of potential flooding

6.1 Sources of potential flooding

6.1.1 Flooding in the area of the Scheme arises from a number of sources namely:

- Tidal including breaches of the existing Humber north bank flood defences
- Fluvial
- Pluvial
- Sewerage and drainage network
- Groundwater

6.1.2 The site is not at risk from flooding as a result of reservoir failure[36].

6.1.3 The sections below describe the potential sources of flooding to the Scheme in more detail.

6.2 Tidal flooding from the River Humber and River Hull

6.2.1 A significant part of the city is located within an area identified by the Environment Agency as being liable to tidal flooding. According to the SFRA[12] and the Environment Agency's Flood Map for Planning[34], the Scheme is located within Flood Zone 3a (ignoring the presence of defences) and is assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year. The Environment Agency's Flood Map for Planning identifies the whole of the Scheme area as benefitting from flood defences.

6.2.2 The Humber Estuary and River Hull are heavily tidal in the reaches bordering the Scheme and as such pose a risk of tidal flooding during high tides or as a result of wave overtopping of the existing defences during a storm surge. Flooding may arise from river bank or flood defence overtopping. Inundation due to high water levels in either waterbody associated with a river bank or flood defence overtopping or breach could result in the Scheme area flooding due to the relatively flat and low ground levels that exist in the area.

6.2.3 The city of Hull is situated along the north bank of the Humber Estuary. Coastal and large estuary defences are subject to wave action which can result in overtopping even when the still water level is lower than the crest of the defences.

[36] Environment Agency 2017b. Long term flood risk assessment for locations in England. https://flood-warning-information.service.gov.uk/long-term-flood-risk/. Accessed December 2017.

6.3 Fluvial flooding

6.3.1 Fluvial flooding arises from high water levels in water courses overtopping or exceeding the capacity of the banks of the channel. The River Hull runs from north to south to the east of the Scheme and potentially poses a risk of fluvial flooding. However, as stated in the Hull City Council Strategic Flood Risk Assessment[12], water levels in the River Hull, particularly in its lower reaches, are dominated by the tidal levels in the Humber Estuary and presently are not significantly affected by fluvial flooding, which is dominant in the headwaters and middle reaches of the River Hull, remote from the Scheme area. This statement is supported by the findings of the River Hull and Holderness Drain Flood Mapping Study[15] which indicates that the lower reaches of River Hull are not at risk of fluvial flooding.

6.4 Pluvial flooding

6.4.1 Surface water flooding occurs when intense rainfall is unable to infiltrate into the ground or enter the drainage system quickly enough to prevent water ponding and then flowing on the surface. In the context of the Scheme area, which is dominated by the extensive highway and combined sewer drainage network, pluvial flood risk relates to sewer network excess (see Section 6.5). The SWMP[20] did not identify the Scheme area as being at high risk of surface water flooding.

6.4.2 The Environment Agency's Long term flood risk assessment for locations in England[36] indicates that the Scheme area is at generally low risk of surface water flooding with small areas of the Scheme around Mytongate Junction and the docks at medium to low risk of surface water flooding

6.5 Sewerage and drainage network flooding

6.5.1 As mentioned previously, drainage in the Scheme area is managed by an existing Yorkshire Water combined sewerage system, which receives domestic and commercial sewerage as well as storm water runoff. Apart from sewer flooding as a result of intense rainfall events as discussed in Section 6.4, flooding can also result when a sewer becomes blocked or when it is of inadequate capacity for the area it drains. An extreme storm event incident on another area of the drainage catchment, hydraulically upstream of the Scheme area, may also result in sewer flooding within the Scheme area.

6.5.2 The Hull City Council Preliminary Flood Risk Assessment[21] states that flooding from the sewerage and drainage network during extreme rainfall events is a major concern in Hull.

6.6 Groundwater flooding

6.6.1 Groundwater flooding is identified in the Hull and Coastal Streams Catchment Flood Management Plan[23] as a potential source of flooding. However, the SFRA[12] states that there are no formal records of existing groundwater flooding in the SFRA study area.

6.6.2 Groundwater flooding may occur if the Scheme causes groundwater levels to raise to such an extent that groundwater emerges at the surface in the form of springs or seepages, or causes below-ground structures, such as basements, or infrastructure, such as the surface water drainage, to flood. As there is no intention to inject water into the ground, the most likely reason for this to occur is if structures act as a barrier to flow, i.e. effectively as a groundwater dam.

7. Flood defence structures

7.1 Introduction

7.1.1 This section of the report provides a brief description of the flood defence structures in the vicinity of the Scheme.

7.2 River Hull flood defences

7.2.1 The SFRA[12] states that the flood defence infrastructure on the River Hull is in variable condition with some parts being in poor condition. Defences in poor condition may not necessarily have a low standard of protection (based on probability of over topping) and vice versa. Figure 1 of the SFRA[12] indicates that the flood defences along the banks of River Hull have a standard of protection, excluding freeboard, of greater than 1 in 200 (0.5% annual probability) assuming the Hull Tidal Surge Barrier operates as intended. Defences are maintained at a level as defined within the Kingston upon Hull Act 1984.

7.2.2 The SFRA[12] reports that there are isolated low points in the flood defences where the standard of protection is between 1 in 75 and 1 in 100 (1.33% and 1% annual probability), located in the area between Ferry Lane bridge and the railway line bridge.

7.2.3 Meteorological conditions in the northern North Sea can result in a sustained north westerly or northerly wind along the coast. This can result in a wave developing that travels down the North Sea coast. Waves or storm surges such as this can reach heights of up to 2m by the time they reach the Humber. If the crest of this surge were to coincide with a high tide, significant flooding would be likely.

7.2.4 The Hull Tidal Surge Barrier protects the City of Hull along the lower reaches of the River Hull by providing a 1 in 200-year standard of protection from tidal flooding. According to Table B1 of the Flood Defence Conceptualisation Report[26], the defence elevation of the Hull Tidal Surge Barrier is 6.3mAOD. The maximum still water level at this location for tidal events with a return period of 1 in 200 years, 1 in 1000 years and 1 in 200 years with allowance for climate change is 5.28mAOD, 5.44mAOD and 6.41mAOD respectively. This indicates that, while the barrier will provide protection from a tidal flooding event with a return period of up to 1 in 1000 years, it is not designed to protect the area from a 1 in 200-year event with consideration of the effects of climate change on sea level rise.

7.2.5 It is understood from consultation with Environment Agency staff that the Hull Tidal Surge Barrier is lowered between 1 to 3 hours in advance of high water when the tide level is predicted to exceed 4.4mAOD. If there is a power failure the barrier will automatically close to ensure flood protection is provided.

7.3 River Humber flood defences

7.3.1 As stated in the SFRA[12], the current standard of protection, excluding freeboard allowance, of the Humber defences adjacent to the City of Hull varies from 1 in 200 or greater in the west to less than 1 in 5 adjacent to Victoria Pier and the western part of Victoria Dock village (which is outside of the boundary of the study area). No inspection location plans have been provided, but records show that defects in the defences are typically of a relatively minor nature. Further details of the Humber defences and their schematisation can be found in the Volume 3, Appendix 11.3 Flood risk modelling technical report.

7.3.2 New flood defences were constructed in 2015 at Albert Dock after the December 2013 tidal surge. These defences provide a standard level of protection 1 in 100 to 1 in 200 years[37] with an approximate top of defence level at 6.05mAOD.

7.3.3 An Environment Agency scheme to install, improve and upgrade 7km of tidal defences on the north bank of the Humber is currently under construction. This scheme is known as the Humber Hull Frontages and is scheduled for completion in 2021 and will therefore be completed prior to completion of the A63 Scheme. The standard of protection of the scheme would be for a return period of 1 in 200 years with an allowance for climate change to the 2040s[7]. The remaining climate change allowance beyond 2040 would be accounted for with a ‘managed adaptive approach’ which would allow for easier upgrading of the defences in the future.

7.3.4 The Humber Hull Frontages will limit overtopping to 1 l/m/s for the above design event. Defence levels are given below:

- St Andrew’s Quay: 7.10mAOD (constructed to 2115 climate change level)
- St Andrew’s Dock: 6.20mAOD
- William Wrights Dock to Albert Dock: 6.30mAOD
- Island Wharf & Humber Basin Dock: 6.40mAOD
- Victoria Pier: 6.50mAOD
- Victoria Dock Village West/East: 6.40mAOD.

8. Historic and predicted flooding

8.1 Historic flooding

8.1.1 There is a long history of flooding within the city of Hull. Much of the city centre was affected during the tidal flood in 1969. Figure 8.1 shows the extent of flooding that occurred during this flood event.

Figure 8-1 - Extent of flooding (pink shading) in the vicinity of the Scheme during the tidal flood of 1969.

8.1.2 In 1980, the Hull Tidal Surge Barrier was constructed at the mouth of the River Hull. The Environment Agency reports that, since the Barrier became operational, there are no records of any flooding occurring on the lower reaches of the River Hull until 2007.

8.1.3 Significant flooding was experienced in Hull and the River Hull catchment during June 2007 following prolonged summer rainfalls. These events are well documented and the 2009 SWMP [20] provides a map of flood extents for the event. Figure 8.2 shows the extent of the 2007 flooding based on information provided by the Environment Agency. The 2007 event was simulated as part of the 2007 Hull City Council SFRA and the results indicated that it had a return period of greater than 1 in 200 years.

8.1.4 City wide flash flooding occurred in August 2012 and resulted in the flooding of 21 properties as well as widespread highway flooding. The main cause of the flooding was extreme rainfall which was isolated to a narrow east-to-west band across the city centre[38]. The extreme rainfall overloaded the Yorkshire Water sewer network and caused localised surface flooding.

8.1.5 A further heavy rainfall event in August 2014 also caused widespread highway flooding as well as flooding 2 properties. The flooding was a result of extreme heavy rainfall from remnants of Hurricane Bertha overloading the Yorkshire Water sewer network[39].

Figure 8-2 - Extent of flooding (blue shading) near the Scheme during the floods of 2007.

8.1.6 On 5th December 2013, the area between Albert Dock and A63 south west of Mytongate Junction was flooded following a tidal surge which coincided with high spring tides and which subsequently overtopped the lower tidal defences along the Albert Dock frontage. The tidal surge peak arrived approximately 30 minutes ahead of the expected peak of astronomical tide. The surge level was approximately 1.9m above the astronomical tide. A height of 5.80m was recorded at the Hull Tidal Surge Barrage[40] which was the highest ever recorded tide at this location. The extent of the flooding has been mapped by the Environment Agency and is shown in Figure 8.3. Over 400 properties across the East Riding (north bank of the Humber) were flooded during this event. Significant flooding also occurred on the south bank of the Humber. The flood investigation report[40] recorded 264 properties within Hull as flooded. The majority of the flood waters entered Albert Dock via a low-spot in the defences. The dock was rapidly filled,

[38] Hull City Council (2013). Flood Investigation Report: City Wide Flash Flooding. August 2012.

[39] Hull City Council (2014a) Flood Investigation Report: Section 19 Heavy Rain August 2014.

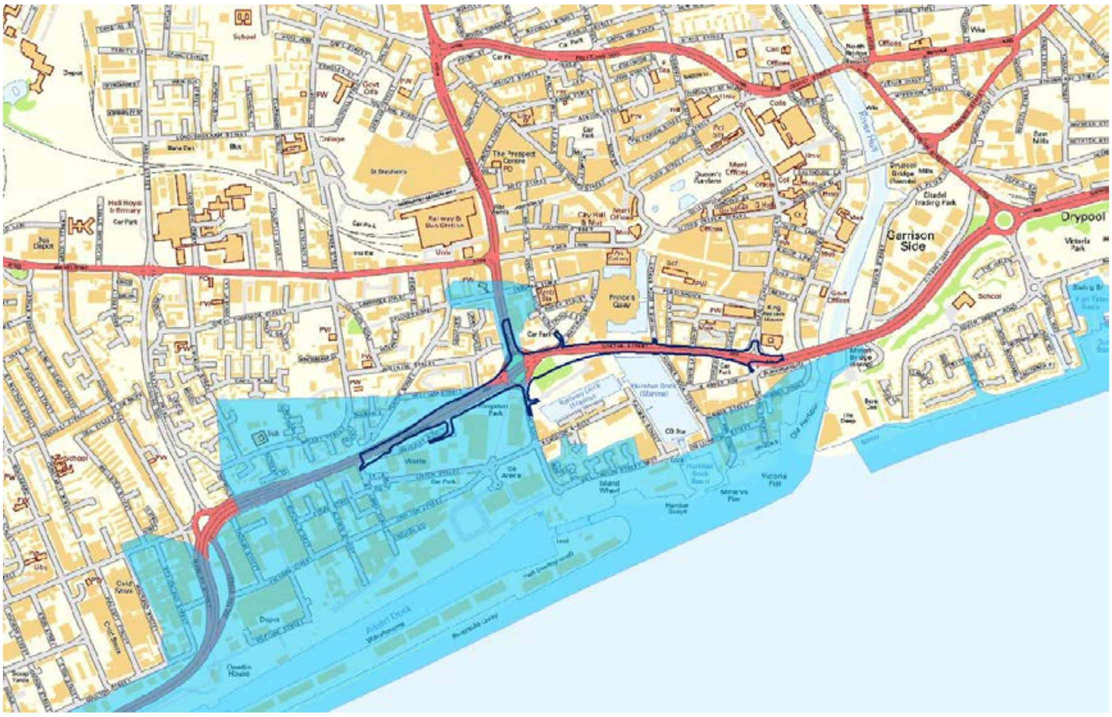
[40] Hull City Council (2014b). Flood Investigation Report: December 2013 City Centre Tidal Surge Flood Event. February 2014.

and flood waters propagated north around English Street at the Castle Street junction via Commercial Road.

8.1.7 The SFRA[12] indicates that a large section of Hull and its surrounding area, including the area of the Scheme, is at risk of flooding in the event of defence failure (i.e. a breach). This is especially evident when combined with the impacts of climate change. In addition to this, the SFRA states that the presence of the defences means that the probability of flood risk is low in much of the city but the consequences of a breach or overtop are high. It is unclear what the intention is with regard to maintaining the standard of protection of existing defences in the area due to future climate change. However, the Humber Hull Frontages scheme will provide a 1 in 200-year standard of protection including an allowance for climate change to 2040[37].

8.1.8 The eastern half of the Scheme lies within the boundary of the area flooded during the 1969 event, while the western area of the Scheme from Mytongate Junction was flooded during the December 2013 tidal surge flood event.

Figure 8-3 - Extent of flooding (blue shading) near the Scheme during the tidal surge of December 2013.



8.2 Predicted flooding

8.2.1 The indicative floodplain map[34], in the absence of existing flood defences, shows the whole site area to be located in Flood Zone 3a and as such liable to flooding from the sea during a 1 in 200-year return period event.

8.2.2 Following the December 2013 storm surge flood event, the Environment Agency commissioned an update to the River Humber North Bank Tidal Modelling Study[24].

This update is referred to as the Humber Estuary 2014 Interim Water Level Profile[27]. These updated levels are outlined below in Table 8.1. According to this information the 1 in 200-year extreme water level at this location is predicted to be between 5.72mAOD.

Table 8-1 – Relevant tide levels and ground levels in the locality

Description	Level (m AOD)
Mean Sea Level (MSL)[1]	+0.30
Mean High Water Neaps (MHWN)[1]	+2.10
Mean High Water Spring (MHWS)[1]	+3.70
Highest Astronomical Tide (HAT)[1]	+4.50
River Humber Extreme Water Level (1 in 50 yr)[2]	+5.46
River Humber Extreme Water Level (1 in 100 yr)[2]	+5.59
River Humber Extreme Water Level (1 in 200 yr)[2]	+5.72
River Humber Extreme Water Level (1 in 500 yr)[2]	+5.90
River Humber Extreme Water Level (1 in 1000 yr)[2]	+6.04
River Humber Extreme Water Level (1 in 200+CC yr)[2]	+6.85
2013 storm surge level at Hull Tidal Surge Barrier[40]	+5.80
Statutory Flood Defence Level[3]	+4.88
Existing Road Level Range[4]	+2.8 to +8.3
Proposed Scheme Road Level Range	-2.6 to +8.2

Information sources:

1. Normal tide levels from Admiralty Tide Tables
2. Level at Hull Barrier (H180) from Humber Estuary 2014 Interim Water Level Profile (Environment Agency, 2014)
3. From Kingston Upon Hull Act 1984, at River Hull tidal barrier
4. From Bluesky Aerial Survey Data

8.3 Potential impact of climate change

8.3.1 The Flood risk assessment: climate change allowances guidance[7] offers guidance on the predicted variable rates of sea level rise that should be applied during the period 1990 to 2115. These are presented in Table 8.2 below. Hull is located south of Flamborough Head, falling in the East of England Administrative Region and therefore predicted to be subject to the most severe impact from sea level rise. Applying these defined rates for the period from 2014 (which is the year of the reported tidal levels in 2014 Interim Water Level Profile in Table 8.1) to 2115 results in a predicted rise of sea level of 1.125m. Thus, when including climate change impacts, the 1 in 200-year sea water level of 5.72m AOD at the Hull Tidal Surge Barrier will increase to 6.85m AOD. This is consistent with the extreme water levels presented in Table 8.1.

Table 8-2 – Sea level allowance for each epoch in millimetres (mm) per year with cumulative sea level rise for each epoch in brackets (use 1990 baseline). Table 3 Flood risk assessments: climate change allowances guidance[7]

Administrative Region	Net Sea Level Rise (mm/yr) Relative to 1990			
	1990 to 2025	2026 to 2055	2056 to 2085	2086 to 2115
East of England, East Midlands, London, SE England (south of Flamborough Head)	4.0 (140 mm)	8.5 (255 mm)	12.0 (360 mm)	15.0 (450 mm)
South West	3.5 (122.5 mm)	8.0 (240 mm)	11.5 (345 mm)	14.5 (435 mm)
NW England, NE England (north of Flamborough Head)	2.5 (87.5 mm)	7.0 (210 mm)	10.0 (300 mm)	13.0 (390 mm)

8.3.2 Wave heights may change because of increased water depths resulting from climate change. The frequency, duration and severity of storms could also change. Flood risk assessments: climate change allowances guidance[7] advises on the sensitivity range to be considered when making an assessment of the impact of climate change. This range may provide an appropriate precautionary response to the uncertainty about climate change impacts on wave height and wind speed. The sensitivity range is outlined in Table 4 of Flood risk assessments: climate change allowances guidance[7]. These allowances are quoted in Table 8.3.

Table 8-3 – Offshore wind speed and extreme wave height allowance. Table 4 Flood risk assessments: climate change allowances guidance[7]

Parameter	1990 to 2055	2055 to 2115
Offshore wind speed allowance	+5%	+10%
Offshore wind speed sensitivity test	+10%	+10%
Extreme wave height allowance	+5%	+10%
Extreme wave height sensitivity test	+10%	+10%

UKCP18 climate change allowances

8.3.3 The Environment Agency requested a consideration of newly updated climate projection information known as UCKP18[8]. This information was published and made available for use in December 2018. No guidance for use of UKCP18 equivalent to that published by the Environment Agency[7] is currently available. Furthermore, UKCP18 allowances post-date all of the third-party modelling studies which were used to inform this assessment. Therefore, it was not possible to explicitly model the impacts of UKCP18 climate change allowances on flood risk to or from the Scheme. However, Table 8-4 below confirms that for all but the most extreme UKCP18 scenarios (RCP 8.5 95th percentile), the sea levels allowances are less than those given in the UKCP09 projections on which the current Environment Agency guidance is based.

Table 8-4 – Flood risk assessment – climate change allowances

Parameter	Total potential change anticipated for the '2080s' (2070 to 2115)
Peak river flow[1]	20% Central 30% Higher central 50% Upper end[2]
Peak rainfall intensity	20% Central 40% Upper end
Offshore wind speed	10%
Extreme wave height	10%
Sea level allowance based on UKCP09 2019 EA guidance (2010 baseline)[7]	1.129m/1.125m to 2115
Sea level allowance based on UKCP18 guidance RCP 2.6 50th percentile (2010 baseline)	0.492m to 2115
Sea level allowance based on UKCP18 guidance RCP 4.5 50th percentile (2010 baseline)	0.621m to 2115
Sea level allowance based on UKCP18 guidance RCP 8.5 50th percentile (2010 baseline)	0.925m to 2115
Sea level allowance based on UKCP18 guidance RCP 2.6 95th percentile (2010 baseline)	0.806m to 2115
Sea level allowance based on UKCP18 guidance RCP 4.5 95th percentile (2010 baseline)	0.978m to 2115
Sea level allowance based on UKCP18 guidance RCP 8.5 95th percentile (2010 baseline)	1.392m to 2115
H++ sea level allowance[31] (2010 baseline)	2.226m to 2115

1. Values are for Humber river basin district
2. Guidance states for 'essential infrastructure' in Flood Zone 3a to use the upper end allowance
3. 1.129m values for the 'East, east midlands, London, south east' area of England. However, value adopted in previous studies (from which data for this assessment is derived, was 1.125m)

H++ climate change allowances

8.3.4 The Environment Agency also requested a consideration of extreme climate change impacts on sea level rise using the High++ (H++) allowances[31]. The sea level rise allowances for H++ climate change to 2115 are given in Table 8-4. These allowances are significantly greater (up to 1.101m) greater than the UKCP09 allowances upon which current Environment Agency guidance is based. Due to limitations of third-party data, it was not possible to fully consider all flood scenarios using the H++ allowances.

9. Hydraulic modelling of surface water flooding

9.1 Introduction

9.1.1 This section of the report describes briefly the modelling approach adopted for this assessment including the data sources used in the modelling. Further details of the approach can be found in Volume 3, Appendix 11.3 Flood risk modelling technical report.

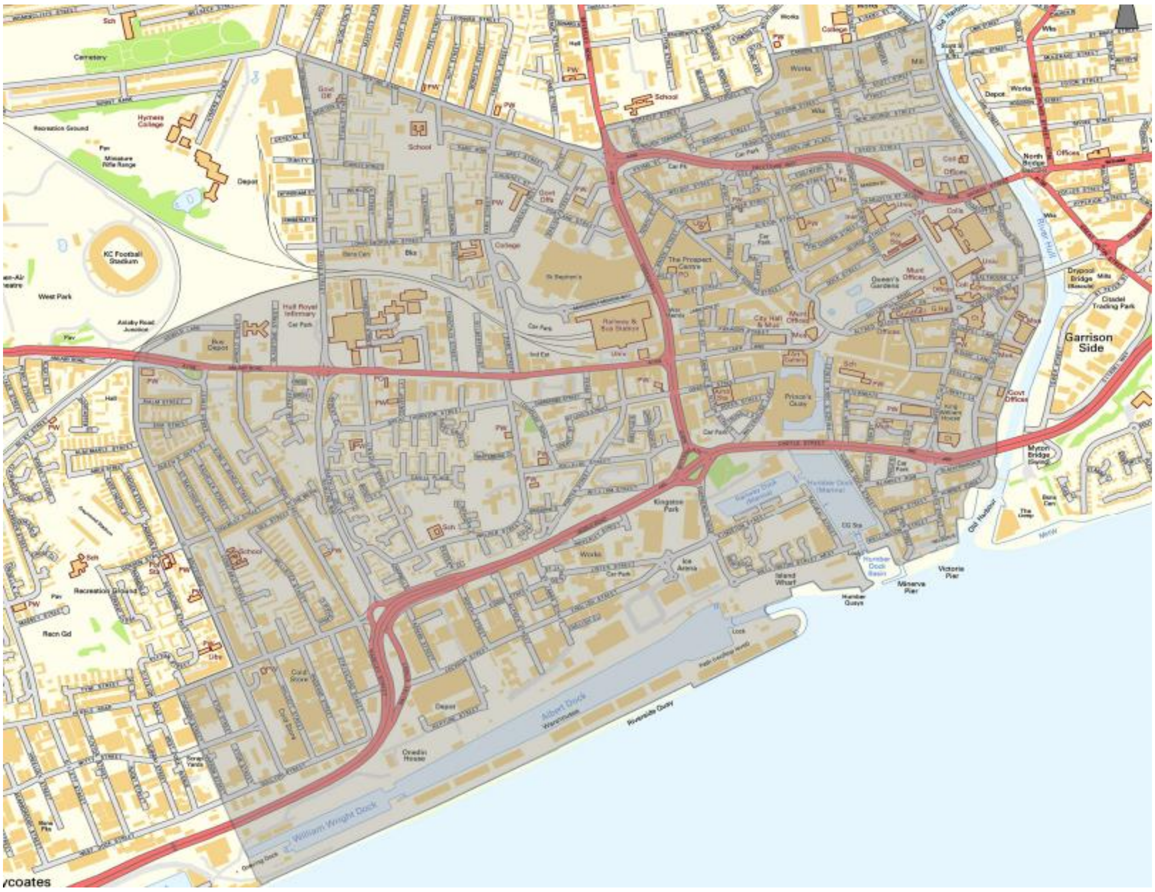
9.1.2 As described earlier in this report (Section 5.3) the hydraulic modelling was undertaken using Infoworks ICM model (v8.0.2) with a two-dimensional (2D) zone created around the area of the Scheme to allow the prediction of surface water flood depths, velocities and flood hazard.

9.2 Model construction

Existing ground elevation model

9.2.1 A ground elevation model for the area of the Scheme and the surrounding areas was required to enable surface water flooding to be modelled in the 2D domain. Bluesky Aerial Survey was commissioned by MMG to undertake an aerial LiDAR survey of the area in the vicinity of the Scheme to produce a digital terrain model (DTM) with a horizontal resolution of 0.5m and a vertical resolution of 0.025m. The DTM data was used to represent the existing ground surface in the 2D hydraulic model. The area of available DTM data, and consequently the area of the 2D zone within the model, is 3.99km^2. It is bounded by the River Hull to the east and by the River Humber to the south. It extends about 1 km north and west of the Scheme. This defines the study area for this FRA and is shown in Figure 9.1.

Figure 9-1 - Extent of the Flood Risk Assessment study area (2D zone in Infoworks ICM model).



9.3 Proposed ground elevation model

9.3.1 A three-dimensional (3D) LandXML model for the proposed road alignment including Princes Quay pedestrian, cycle and disabled user bridge was converted to a surface raster utilising ArcGIS and cut into and merged with the existing layout raster to produce a ground elevation model for the Scheme. Linear features such as the retaining walls of the underpass and new concrete road barriers were explicitly defined in the model to better reflect the level variations in these areas. Amendments were also made to reflect the demolition of a number of buildings in the vicinity of the Scheme. More details regarding the proposed ground model construction are given in the Volume 3, Appendix 11.3 Flood risk modelling technical report.

9.4 Defence conceptualisation

9.4.1 The flood defences along the River Humber and the River Hull were conceptualised into various sections according to their physical location. Twenty-one defence sections were derived to represent the flood defences along the Humber north bank in accordance with the upgraded Albert Dock flood defence levels following completion of the works in 2015 and based on surveyed levels supplied by the Environment Agency. Similarly, nineteen defence sections based on the defence locations in the River Hull and Holderness Drain Flood Mapping study[15] were created to represent the defences along the right (west) bank of the River Hull. The defences were plotted as 2D boundary lines on the edge of the model 2D zone. Further detail on the schematisation of flood defences is given in Volume 3, Appendix 11.3 Flood risk modelling technical report.

9.5 Data sources

Design rainfall

9.5.1 Design rainfall events for different return periods were generated using the Flood Estimation Handbook (FEH) methodology embedded in the Infoworks ICM software for catchment descriptors as provided with the supplied Infoworks CS model. A critical storm duration analysis was undertaken for a 1 in 100-year return period with climate change (30%) rainfall event, using storm durations between 15 and 360 minutes and for both winter and summer profiles. The critical storm duration was assessed by determining the highest flood depth generated across the 2D modelled area for a given return period and was found to be 120 minutes. The results for the events with duration 60, 120 and 240-minute winter profile are presented in Table 9.1. The 120-minute winter profile storm was chosen as the critical storm duration.

Table 9-1 – Critical Storm Duration Analysis Assessment Summary

Pluvial Flooding for 1 in 100 + climate change event					
Flood Depth (m)	**0.05-0.15**	**0.15-0.30**	**0.30-0.60**	**>0.60**	**Total**
Event Duration (min)	**Areas with different Flood Depths (m^2)**				
60	581,596	107,252	15,563	2,876	707,287
120	567,183	125,691	25,520	3,970	722,364
240	532,342	130,873	35,134	5,090	703,439

Model inflows

Pluvial and subcatchment inflows

9.5.2 Current hydraulic modelling techniques are not readily able to represent the full extent of entry points for drainage into the sewer. The current hydraulic model does not represent the road gullies and secondary network elements that collect runoff from the surface into the drainage network. To simulate inflows at each node/manhole, the subcatchment approach was used which acts to route rainfall into runoff across an area contributing to an individual node or manhole. As such, the interface between the 2D surface model element and the sewer network is limited to defined manhole locations, where all ‘non-sealed’ manholes permit flows either into or out of the sewer. This exchange of flow depends on predicted water levels within the sewer exceeding predicted 2D surface water levels at the manhole location, or vice versa.

9.5.3 Rainfall was applied to the subcatchments to estimate runoff and inflow at each node location. No rainfall was applied directly to the 2D mesh area.

9.5.4 Further detail on subcatchment schematisation is available in Volume 3, Appendix 11.3 Flood risk modelling technical report.

Tidal and fluvial inflows

9.5.5 Modelling outputs for the relevant scenarios from the Humber Estuary 2014 Interim Water Level Profile[27] and River Hull and Holderness Drain Flood Mapping study[15] were provided by the Environment Agency. These were used as input boundary conditions, to predict the impact of tidal and fluvial flooding from the River Humber and River Hull upon the Scheme. The data and its sources are described below and listed in Table 9.2, including the various return periods modelled for each scenario.

9.5.6 Model outputs from the Humber Estuary 2014 Interim Water Level Profile[27] included flow hydrographs for wave overtopping (storm surge) scenarios for each River Humber defence unit between the Hull Tidal Surge Barrier and the western most point of Albert Dock (the extent of the river bordering the 2D zone). These inflow hydrographs also included a scenario including the effects of a 1.125m sea level increase due to climate change (2010 to 2115) and a further climate change allowance for wave height (10%).

9.5.7 Water level time series were also provided for extreme tidal events for the undefended scenarios. This was provided for 11 tidal cycles including one tidal cycle before the surge peak, the peak surge tidal cycle and the nine tidal cycles after the maximum surge. The effect of waves was not considered for the undefended scenarios although they did include the 1.125m mean sea level increase due to climate change.

9.5.8 The information provided was based on predictions from the River Humber Tidal Model simulated with Albert Dock gates closed, water levels in the Dock in agreement with ABP's operating rules, and a wave attack angle of 120 degrees.

9.5.9 In mid-2013, Halcrow completed the River Hull and Holderness Drain Flood Mapping Study for the Environment Agency[15]. The study provided updated flood extents for the "with defences" and "without defences" scenarios in the River Hull catchment area. Flood maps from various scenarios covering both fluvial and pluvial flooding were made available for the purpose of this FRA. Model output was provided in the form of flow hydrographs for locations along the River Hull.

Flood defence breach inflows

9.5.10 The Environment Agency requested a consideration of the potential impacts on the Scheme from a breach of the existing Humber north bank defences. Modelling of defence breaches was carried out as part of the Hull City Council SFRA[12]. This modelling included four breach locations within the study area for the Scheme, the locations of these are given in Figure 9-2Figure 9-2: Flood defence breach locations (from Hull City Council SFRA). Hull City Council provided output from these models in the form of breach flow hydrographs which were directly incorporated into the Infoworks ICM model. These breaches were for a 1 in 200-year event plus an allowance for climate change to 2115.

9.5.11 The modelling outputs described above and summarised in Table 9.2 were applied along the boundary lines representing the flood defences as boundary conditions to the 2D zone. Further details are provided in Volume 3, Appendix 11.3 Flood risk modelling technical report.

9.5.12 The details of the flood risk scenarios to be considered in this assessment, as agreed in consultation with the Environment Agency and Hull City Council, are presented in Section 9.6.

Figure 9-2: Flood defence breach locations (from Hull City Council SFRA)

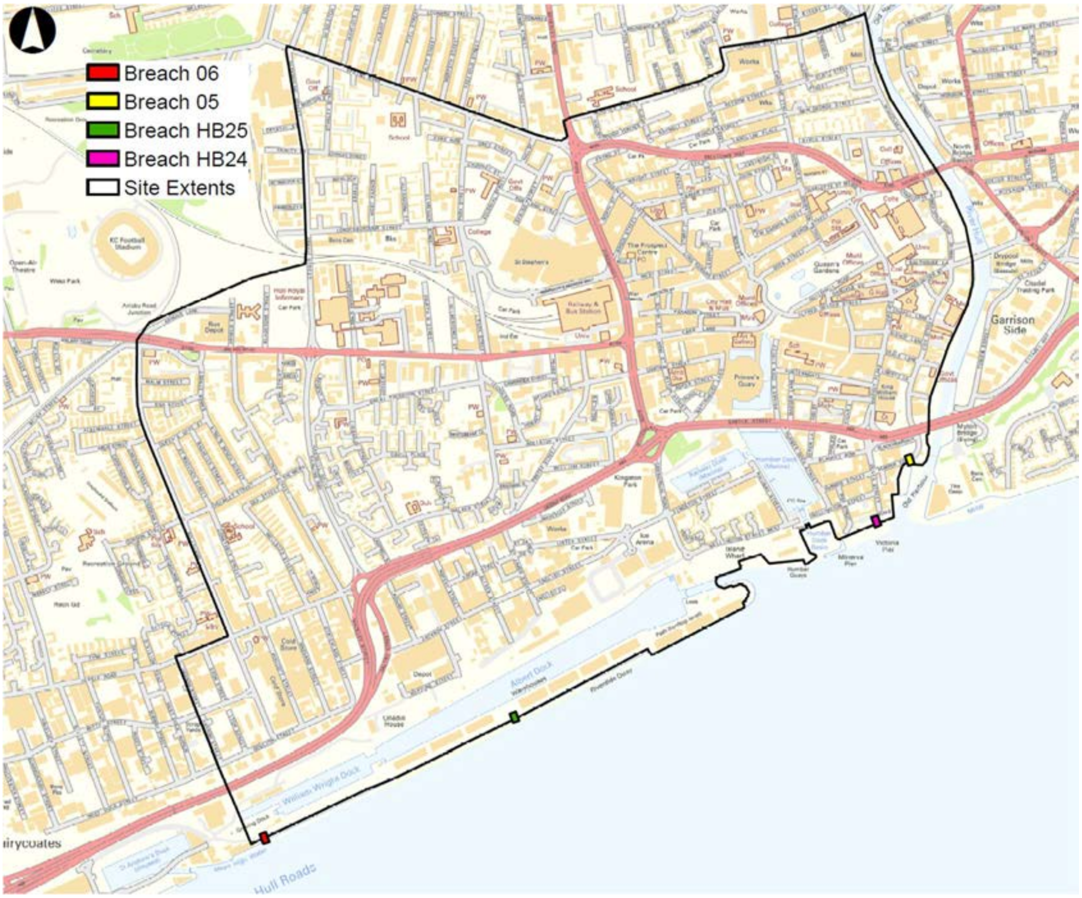


Table 9-2 - Third party modelling outputs provided by the Environment Agency and Hull City Council

No	Model	Owner	Developed by	Modelling outputs	Return Period (Years)
1	River Humber North Bank Tidal Model including Humber Estuary 2014 Interim Water Level Profile	Environment Agency	Mott MacDonald	Wave overtopping flow hydrographs for each Humber defence unit between Hull Tidal Surge Barrier and Albert Dock	1 in 200 1 in 1000 1 in 200 + climate change
				Tide level hydrographs for each Humber defence unit between Hull Tidal Surge Barrier and Albert Dock from the undefended scenarios.	1 in 200 1 in 200 + climate change
2	River Hull Fluvial/Tidal flooding	Environment Agency	Halcrow	Flow hydrographs overtopping each defence unit along River Hull for tidal events assuming Hull Tidal Surge Barrier is open.	1 in 10 1 in 100 1 in 200 1 in 1000
				Flow hydrographs overtopping each defence unit along River Hull for combined fluvial and tidal events assuming Hull Tidal Surge Barrier is open.	1 in 100 1 in 200 1 in 1000
3	Hull City Council SFRA	Hull City Council	Arup	Breach inflow hydrographs at four locations in study area	1 in 200 + climate change

9.6 Flooding scenarios

9.6.1 The scenarios used to assess the flood risk impact of the Scheme are outlined in Table 9.3 and were agreed with the Environment Agency during prior consultation. The flood risk scenarios were simulated for both existing and proposed (Scheme) cases. Further details with respect to the River Hull scenarios, climate change and combined source flooding are discussed below.

Table 9-3 - Summary of agreed flooding scenarios

Source of flooding	Return Period (Years)
Pluvial	1 in 30 1 in 100 1 in 100 plus climate change (30%)
Tidal from River Hull (with Hull barrier open)	1 in 200 1 in 1000 (surrogate for a 1 in 200 plus climate change event)
Combined fluvial and tidal from River Hull (with Hull barrier open)[1]	1 in 200 1 in 1000 (surrogate for a 1 in 200 plus climate change event)
Wave overtopping (defended) from River Humber	1 in 200 1 in 1000 1 in 200 plus climate change (2010 to 2115)
Tidal (undefended) from River Humber	1 in 200 1 in 200 plus climate change (2010 to 2115)
Flood defence breaches (4 locations)	1 in 200 plus climate change (2010 to 2115)
H++ tidal (undefended) from the Humber Estuary	1 in 200 plus climate change (2010 to 2115)

1. The combined events have the following joint probability conditions
    a. Fluvial return period 1 in 5 years, tidal return period 1 in 2 years: Overall return period 1 in 200 years
    b. Fluvial return period 1 in 10 years, tidal return period 1 in 5 years: Overall return period 1 in 1000 years

9.7 Review of River Hull and Holderness Drain flood modelling output

9.7.1 The study states that developing a ‘without defences’ scenario as defined in the flood mapping specification is complicated in the Hull catchment because the River Hull is an artificial channel where bed levels are above the surrounding flood plain elevations for much of the lower reaches[15]. Therefore, removing the channel defences in their entirety would mean the channel network was no longer defined making it difficult to model. Therefore, a number of scenarios were modelled by Halcrow[15] which could be combined in order to derive the ’without defences’ extents.

9.7.2 Upon reviewing the results from the range of scenarios as provided from the Halcrow study[15], it became clear that fluvial flooding from River Hull affects predominantly the upper reaches, the land-drainage network and low-level drainage system, as well as inflows from the eastern side of the catchment. The downstream river reaches, and in particular the reach adjacent to the city of Hull, is not affected by flooding as a result of fluvial events.

9.7.3 The majority of the scenarios with ‘Single asset removal’, such as pumps and outfalls, also affected the drains and the upper reaches of the River Hull. The only scenario which results in flooding in the vicinity of the Scheme is the failure of the

Hull Tidal Surge Barrier to close (with all flood defences operating as per specification).

9.7.4 In consultation with the Environment Agency it was agreed that, for the purpose of the A63 FRA, two main scenarios will be considered for the River Hull (Table 9.3):

- Tidal flooding with Hull Tidal Surge Barrier open for a 1 in 200-year and 1 in 1000-year return period events
- Combined tidal and fluvial base flow flooding scenario with Hull Tidal Surge Barrier open for an overall return period of 1 in 200-year and a 1 in 1000-year (see Table 9-3).

Consideration of climate change impacts

9.7.5 Climate changes impacts are considered for each source of flooding depending on the output provided by the Environment Agency. For the River Hull, where the only relevant scenarios which have an impact on the Scheme are those where the Hull Tidal Surge Barrier is open, explicit climate change scenarios were not available from the Environment Agency. Instead it was agreed with the Environment Agency to use the 1 in 1000-year return period event as an approximation to a 1 in 200-year event with allowance for climate change.

Flooding from combined sources

9.7.6 Flooding can arise not only from individual sources but also from contribution of more than one source, e.g., high sea levels in the River Hull and Humber during high fluvial base-flow conditions in the River Hull.

9.7.7 Chapter 7 of the Hull Data Investigation Report[28] discusses the joint probability of flooding types based on the methods detailed in the Defra FD2308 Report[29] and states that it is reasonable to assume independence between flood sources for River Hull catchment. This assessment is summarised in Table 9.4.

Table 9-4 - Correlation between flood parameters for the River Hull. Adapted from the Hull Data Investigation Report[28]

Variable pair	Justification for assuming independence
Baseflow and sea level	Very low correlation ('near independence') between flow recorded at Hempholme Weir and surge recorded at Immingham. The apparent slight dependence is probably explained by seasonality. This indicates independence for groundwater base flows and sea levels.
Rapid runoff and sea level	Very low correlation between intense rainfall and surge recorded at Immingham. This shows independence between fluvial and sea levels

Baseflow and rapid runoff	Baseflow in the River Hull permeable catchment is a response to seasonal rainfall, whilst rapid runoff is a response to short duration rainfall. It is assumed that rainfall at these different timescales is essentially independent.

9.7.8 For the purpose of the FRA, the dependency between short term (two hourly) intensive rainfall and sea level was also analysed, using the Defra joint probability method[29]. The analysis indicates that the dependency between these two variables in the study area is also very low. Details regarding the analysis are outlined in the Volume 3, Appendix 11.3 Flood risk modelling technical report.

9.7.9 In consultation with the Environment Agency, it was agreed that the joint probability scenarios combining high River Hull fluvial flows and high tidal levels would be considered as part of this FRA. These are combined 1 in 5-year or 1 in 10-year fluvial events and 1 in 2-year or 1 in 5-year tidal events for overall return periods of 1 in 200-years and 1 in 1000-years respectively (see Table 9-3).

9.8 Results

9.8.1 The 2D nature of the hydraulic model allows predictions of flood depth and velocity over the study area enabling the characterisation of flood flow paths. For each scenario, maps were produced indicating the extent and the depth of the flooding as well as the difference in flooding depth between the existing and proposed (Scheme) cases. Differences in flood depths of less than 0.05m are not shown. In addition, Flood Hazard maps were generated for each scenario. Flood Hazard is defined as “the flood conditions that cause people to be swept away”[29]. The model calculates the Flood Hazard Rating (HR) as a function of flood depth and velocity. The Hazard to People Classification using the HR is discussed in more detail in the Volume 3, Appendix 11.3 Flood risk modelling technical report and summarised in Table 9.5.

Table 9-5 – The Hazard to People Classification for Flood Hazard Rating

Flood Hazard Rating (HR)	Hazard to People Classification
Less than 0.75	Very low hazard – caution
0.75 to 1.25	Danger for some – includes children, the elderly and the infirm
1.25 to 2.0	Danger for most – includes the general public
More than 2.0	Danger for all – includes emergency services

9.8.2 All the results of the flood impact scenarios are presented as figures in Appendix A of this report and are discussed in detail in Section 10.

10. Flood risk analysis

10.1 Introduction

10.1.1 This chapter discusses the flood risk from various sources to the Scheme and the flood risk to the surrounding areas arising as a result of the Scheme.

10.2 Pluvial flooding

10.2.1 The surface water flooding resulting from a rainfall event with a return period of 1 in 100 years, together with a 30% increase in rainfall intensity to allow for climate change, is presented in Figure 13.1 and Figure 13.2 in Appendix A for the existing and the Scheme scenarios, respectively.

10.2.2 Model predictions indicate only minor, isolated surface water flooding at depths of less than 0.05m within the Scheme area for either the existing or Scheme scenarios.

10.2.3 There is evidence of surface water flooding to the north west and north-east of the Scheme area with depths generally less than 0.30m.

10.2.4 Figure 13.3 shows negligible differences in pluvial flood depths between the existing and Scheme scenarios during the 1 in 100-year plus 30% climate change pluvial event with differences less than +/- 0.05m in depth.

10.2.5 The underpass drainage was designed for a 1 in 100-year return period pluvial flooding event, with a 30% allowance for climate change. An assessment using the Microdrainage drainage design software confirmed that no flooding is predicted in the underpass for this event (Arup, 2017).

10.2.6 As agreed with the Environment Agency, scenarios representing surface water flooding from rainfall events with a 1 in 30-year and a 1 in 100-year return period were also assessed. The maps illustrating the flood extent and difference in flood depth for these scenarios are presented in Appendix A (Figures 13.4 to 13.9). As expected, the flood extent for these events were less compared to the 1 in 100-year plus 30% climate change event. Furthermore, the flood depth differences between the existing and Scheme scenarios are <0.05m throughout the study area for these events.

10.2.7 The flood hazard maps for the different pluvial events are presented in Figures 13.10 to 13.15 in Appendix A. The maps for the 1 in 100-year plus climate change pluvial event (Figures 13.14 and 13.15) illustrate that the flood hazard rating during this event is predominantly classified as “danger for some” with some small areas as “danger for most”. These areas of greater hazard are localised in a few small areas across the study area to the north west and north-east area of the Scheme area. There is a further isolated area of “danger for most” flood hazard to the east at the underpass near Blackfriargate.

10.2.8 The results indicate no appreciable change in Flood Hazard Rating between the existing and Scheme scenario throughout the Scheme and study areas for either the 1 in 30, 1 in 100 or 1 in 100-year plus climate change events (see Figures 13.10 to 13.15).

10.3 Tidal and fluvial flooding

10.3.1 The Scheme lies within an area that is protected from inundation by the existing flood defences along the banks of the River Hull and the River Humber, as well as the Hull Tidal Surge Barrier which operates when the tidal level exceeds 4.40mAOD.

10.3.2 The long-term climate change contingency allowances, described in Section 8.3 and considered as part of this assessment, indicate that the possibility of the defences being overtopped will increase markedly towards the next century with severe implications for the city of Hull as well as the wider Humber Estuary on both the north and south banks.

10.3.3 An Environment Agency scheme to install, improve and upgrade 7km of tidal defences on the north bank of the Humber is currently under construction. This scheme is known as the Humber Hull Frontages and is scheduled for completion in 2021 and will therefore be completed prior to final completion of the A63 Scheme. The standard of protection of the scheme would be for a return period of 1 in 200 years with an allowance for climate change to the 2040s[7]. The remaining climate change allowance beyond 2040 would be accounted for with a 'managed adaptive approach' which would allow for easier upgrading of the defences in the future.

10.3.4 The Humber Hull Frontages scheme will provide additional protection against the projected effects of climate change on tidal flood levels up to 2040. However, there remains a degree of residual risk beyond 2040 and for the lifetime of the A63 Scheme. The significance of this residual risk will depend on the 'managed adaptive' approach adopted by the Environment Agency post-2040 and any subsequent flood defence upgrades.

10.3.5 Tidal and wave overtopping flooding impacts from the River Humber are considered first, followed by a consideration of both tidal and fluvial flooding from the River Hull.

River Humber

Wave overtopping (defended) events

10.3.6 The wave defence overtopping hydrographs derived from the River Humber North Bank Tidal model[24] and the 2014 Interim Water Level Profile[27], as listed in Table 9.1, were applied to the conceptualised Humber defences at the boundary of the 2D zone within the Infoworks ICM model. These were applied for both the existing and Scheme scenarios. Results from all scenarios and the agreed range of return periods are presented in Figures 13.16 to 13.30 in Appendix A.

10.3.7 The results presented in Figure 13.16 indicate that, under existing conditions, the flooding caused by a 1 in 200-year wave overtopping event reaches the Scheme area in the vicinity of the Mytongate Junction and propagates further north and west along the A1079 Ferensway, Myton Street and the A63. However, Figure 13.17 for the Scheme scenario indicates that the proposed underpass acts as a barrier to flooding and prevents the flood extent propagating further north. Flooding is still experienced on Commercial Road, Kingston Retail Park and other areas to the south of the Scheme and between Princes Dock Street and the High Street to the north of the Scheme.

10.3.8 Figure 13.18 in Appendix A indicates the primary differences in flood depth between existing and Scheme scenarios. The increases in flood depth are confined to the south side of the A63 and the streets south of the eastern extent of the Scheme, with increases in flood depths of up to 0.20 to 0.30m at Sewer Lane and Blanket Row and smaller increases (0.05 to 0.10m) around Blackfriargate and High Street. Figure 13.18 indicates reductions in flood depths of up to 0.30m at Railway Dock, Myton Street, Osborne Street and areas around Mytongate Junction. The underpass is indicated as flooding to a significant depth during such an event. These differences arise as a result of the raised carriageway levels (change in ground elevations) in approach to the new roundabout above the A63 underpass.

10.3.9 The impact of the Scheme on flooding within the study area is more pronounced during a 1 in 1000-year wave overtopping event, with flood waters propagating through the Scheme area and further north beyond the Hull Royal Infirmary grounds. As shown on the flood depth maps in Figures 13.19 and 13.20 (Appendix A), the proposed A63 Scheme underpass acts, in effect, to attenuate and store flood waters during such an event, with the underpass fully submerged by flood waters.

10.3.10 When flood waters reach the western extent of the Scheme, a considerable volume of water enters the underpass, which acts to reduce maximum flood depths north of the Scheme although the alteration in carriageway levels causes some increase in flood depths to the south of the Scheme; this is demonstrated in Figure 13.21. This figure shows decreases in flood depths of between 0.05 and 0.30m in the streets to north of Mytongate Junction and with greater decreases of >0.40m at Mytongate Junction itself and Princes Quay. Figure 13.21 shows areas of increased flood depth of between 0.05 and 0.20m to areas south of the Scheme stretching from Tadman Street in the west to Blackfriargate in the east. Kingston Retail Park and Waverley Street show increases in flood depths of up to 0.30m for this event.Figure 13.

10.3.11 During a 1 in 1000-year wave overtopping flood event, the underpass is predicted to be completely flooded, with flooding depths within the centre of the underpass of up to 6.00m. It must be noted that, while the designed discharge rate of 100 l/s of the surface water pumping station for the highway drainage is reflected in the model, the flood storage[5] of about 635m^3 which is provided in the proposed drainage system is not modelled. However, this volume is small in comparison to the significant flood volume of nearly 26,700m^3 predicted to accumulate in the underpass during such an event. At a discharge rate of 100 l/s, it would take up to 3 days to clear the underpass of flood water without additional pumps.

10.3.12 The impact of a flood of this magnitude would be significant, not just for the Scheme but for the whole of Hull. During such an event, the A63 would be completely closed west of Mytongate Junction regardless of whether or not the Scheme goes ahead (Figures 13.19 and 13.20 in Appendix A). Maps showing the Flood Hazard Rating during these events are presented in Figures 13.25 to 13.28 (Appendix A) and illustrate that much of the flooded area and a large proportion of Hull are classified as 'danger for most' under both the existing and Scheme scenarios.

10.3.13 The magnitude of the wave overtopping event for a 1 in 200-year return period including climate change (to 2115) is much more severe than the flooding from the 1 in 200-year and 1 in 1000-year events (see Figures 13.22 to 13.24). During this event, the vast majority of the 2D zone study area is predicted to be inundated for both the existing and Scheme cases, with flood depths of up to 4.20m on the south of the A63 and 2.90m to the north. The predicted impact of the Scheme on flood depths is relatively minor (Figure 13.24), with a slowing down of flood propagation by approximately 5 minutes and reduction in flooding depths of between 0.05m and 0.10m. Predicted peak flood depths for these scenarios are shown in Figures 13.22 and 13.23, with flood hazard mapping presented in Figures 13.29 and 13.30. There are significant areas of Flood Hazard classified as 'danger for all' or 'danger for some' for both scenarios in the modelled area.

10.3.14 Figure 13.24 shows the flood depth difference map for the 1 in 200-year return period plus climate change wave overtopping event. The results indicate a reduction in flood depths of between 0.05 and 0.30m along the A1079 Ferensway to the north of the Scheme. Furthermore, there are reductions in flood depth along the A63 to both the west and the east of the proposed underpass. Princes Quay has reductions in flood depths of up to 0.30m with a further area to the north around Queen's Gardens showing flood depths reduced by 0.05 to 0.10m. There are smaller areas of increased flood depth of 0.05 to 0.10m at Kingston Retail Park, around the demolished Myton Centre and in Humber Dock and the surrounding streets.

Flood flow routing during wave overtopping events

10.3.15 The predicted behaviour of floodwater propagating northwards from Albert Dock during the wave overtopping events was compared to the observations from 5th December 2013 flood event. It was agreed during consultation with the

Environment Agency and Hull City Council that the predicted flow directions compare well with the observed behaviour of the December 2013 flood.

10.3.16 Figures 10.1 and 10.2 below illustrate the flow propagation under the Scheme scenario for a 1 in 200-year Humber Estuary (defended) wave overtopping event. Flood waters approach the underpass from the east along the A63 and also from the south along Commercial Road and through Kingston Retail Park.

Figure 10-1 – Flow propagation for a 1 in 200-year Humber wave overtopping event at simulation time 12hrs 33mins

Figure 10-2 – Flow propagation for a 1 in 200-year Humber wave overtopping event at simulation time 15hrs 00mins

10.3.17 Upon reaching the underpass, the flood waters spread along the south-west side of the road for a short distance before spilling over the lowest section of the underpass embankment wall near the west entrance.

10.3.18 Note that both the 1 in 200-year and the 1 in 1000-year design input hydrographs have the same duration of 5 hours 50 minutes, starting at 09:30 (simulation time) and finishing at 15:15, with peak flows over the Humber defences occurring at 12:15. During the 1 in 1000-year Humber Estuary wave overtopping event it is predicted to take about 1 hours 30 minutes from the start of wave overtopping for the flood waters to propagate through Albert Dock, Humber Dock Marina and along Commercial Road and Kingston Park before reaching the underpass. During a 1 in 200-year Humber Estuary wave overtopping event, he time from initial defence overtopping to the onset of underpass flooding is predicted to be 1 hour 48 minutes.

10.3.19 Further information on flooding and inundation times is given in Section 10.6.

Undefended Events

10.3.20 In consultation with the Environment Agency, it was agreed that two undefended tidal flooding scenarios with return periods of 1 in 200-years and 1 in 200-years plus climate change should be assessed. The above scenarios represent flooding assuming the absence or total failure of the existing Humber North Bank defences. Inputs to the model boundaries are time series of tide level in the Humber Estuary as opposed to inflow (wave overtopping) hydrographs for the defended scenarios.

10.3.21 Predicted flooding from all undefended scenarios for the 1 in 200-year return period event with and without climate change impacts are presented in Figures 13.32 to 13.40 in Appendix A. The results indicate that the majority of the study area would be flooded to depths up to 1.20m.

10.3.22 Figures 13.33 and 13.36 show flood differences between the existing and Scheme cases for the 1 in 200-year and 1 in 200-year plus climate change (2115) scenarios respectively. The results indicate reductions in flood depths of up to 0.30m north of the proposed underpass and increases of flood depths of up to 0.20m in Kingston Park and up to 0.10m around Blackfriargate and Blanket Row. There are also decreases in flood depths of up to 0.10m in Princes Quay and around Posterngate. However, during such an undefended flood event, the changes in flood depth as a result of the Scheme would be of secondary consideration as much of Hull city centre would be inundated to already significant depths.

10.3.23 Figure 13.37 to 13.40 show maximum flood hazard ratings for the 1 in 200-year event (with and without climate change to 2115) for both the existing and Scheme cases. These figures show that the majority of Hull city centre would be classed as Danger for Most with some isolated areas of Danger for All, including in the Scheme underpass.

River Hull

10.3.24 The following River Hull flooding scenarios were agreed with the Environment Agency:

- Tidal flooding with Hull Tidal Surge Barrier open for 1 in 200-year and 1 in 1000-year return period events, and;
- Combined fluvial base flow and tidal flooding with Hull Tidal Surge Barrier open for 1 in 200-year and 1 in 1000-year return period events.

10.3.25 Inflow hydrographs for the 2D modelling domain were extracted from the outputs of the River Hull and Holderness Drain study[15]. These hydrographs were applied to the boundaries along the west bank of the River Hull in the Infoworks 2D ICM model domain. The extent of predicted flooding for both the existing and Scheme cases, together with Flood Hazard maps, are provided in Figures 13.41 to 13.60 in Appendix A.

River Hull tidal flooding

10.3.26 The scenarios described below represent tidal flooding from the River Hull if the Hull Tidal Surge Barrier remains open. Figures 13.41 to 13.43 in Appendix A represent the flooding from the 1 in 200-year tidal surge event for the existing and proposed cases and the difference in the flood depth between the two cases respectively. The general direction of the flood propagation is westwards along the A63 and, for the Scheme case, into the westbound entrance of the underpass.

This prevents the onward (eastward) propagation of the flood into areas to the north of Mytongate Junction. Predicted flooding in the existing case reaches a maximum depth of 0.60m along Osborne Street and Myton Street, but in the Scheme case no flooding was evident around the junction. However, the underpass floods and fills with water to a maximum predicted depth of approximately 5.80m. Furthermore, the underpass reduces the extent of flooding in Kingston Park to the west of the underpass. The results indicate increases in flood depths, generally in the range of 0.05 to 0.10m, in the areas to the east of Princes Dock and Humber Dock marina with the area around Sewer Street showing depth increases of up to 0.20m. Areas to the north of the A63 show increased depths of up to 0.10m around Fish Street and Dagger Lane with Princes Quay showing increases in flood depths of 0.20 to 0.30m. Areas to the north of Mytongate Junction around Osborne Street and St Luke’s Street show reductions in flood depth of up to 0.40m.

10.3.27 For the Scheme case, the level of the main road in the section between the River Hull and the underpass entrance is slightly elevated in comparison to the existing road. Due to this and the presence of the central vertical concrete barrier, the proposed road is flooded to a lesser extent; however, this causes slightly higher predicted flood depths in the surrounding streets to the north and south of the main road. The predicted flood depth on the A63 carriageway is reduced by 0.05 to 0.40m depth for the Scheme case. Figures 13.47 and 13.48 in Appendix A shows the flood hazard in both cases is rated as “Danger for most” on the A63 carriageway.

10.3.28 Since the area between Princes Dock Street and Market Place is very flat, the small differences in ground levels between the existing and the Scheme cases affect the direction of flow propagation in this location. While in the existing case the water flows mainly towards the A63, under the Scheme case it flows towards Princes Quay where it spills over the dock walls. As a result, the water levels in the Quay for the Scheme case rise by up to 0.30m during this event. For this event, the time from initial defence overtopping to the onset of flooding of the underpass is predicted to be approximately 1 hour 21 minutes.

10.3.29 During a tidal flood event of this magnitude the modelling results indicate that flood waters are spilling over the wall along the road to the north of Humber Dock, entering the Humber Dock and subsequently the Railway Dock. However, the Scheme road levels and central vertical concrete barrier alter these flow paths and as such, the water levels in the docks are expected to decrease by approximately 0.20 to 0.30m as a result of the Scheme.

10.3.30 Similar behaviour is observed during a 1 in 1000-year return period River Hull tidal flooding event. In the Scheme case, flood depths in the areas to the east of Humber Dock and Princes Quay are slightly greater reaching 1.06m, as opposed to a maximum of 1.00m in the existing case. However, the proposed underpass significantly reduces the flooding of the areas around Mytongate Junction and further along A1079 Ferensway to as far north as Prospect Street where flood depths are reduced by 0.20 to 0.30m . Flood depths around St Luke's Street and Osborne Street are reduced by more than 0.40m. Flood depths around Margaret Moxon Way and Brook Street are decreased by up to 0.30m. Flood depths are increased by up to 0.05 to 0.30m around Kingston Retail Park and Waverley Street. Flood depths in Princes Quay and the around Blanket Row and Blackfriargate are increased by 0.05 to 0.10m. The predicted flood depth maps and the flood hazard maps are presented in Figures 13.44 to 13.46 and Figures 13.49 to 13.50 in Appendix A respectively.

10.3.31 A comparison of flood depth maps for the 1 in 200-year and 1 in 1000-year event (included as a surrogate assessment of climate change impacts) (Figures 13.44 and 13.47 in Appendix A) indicate that the underpass and the area around Waverley Street and Kingston Retail Park is flooded to a greater extent during the 1 in 1000-year event. However, the relative changes in flood depths in Princes Quay and the Humber and Railway Docks is less for the 1 in 1,000 when compared to 1 in 200 year event.

10.3.32 The flood hazard maps for a 1 in 200-year tidal event (Figures 13.47 and 13.48) and for a 1 in 1000-year event (Figures 13.49 and 13.50) indicate that the flood hazard is increased around the underpass. However, the Scheme would mitigate any flood hazard to the north of Mytongate Junction.

River Hull combined fluvial and tidal flooding

10.3.33 Scenarios for combined fluvial and tidal flooding from River Hull were simulated for the River Hull and Holderness Drain Flood Mapping Study[15] and the resulting hydrographs for the relevant scenarios were used as input to the flood risk model. The combined return periods arise from a combination of a fluvial River Hull return period (e.g. 1 in 10 years) and a tidal Hull return period (e.g. 1 in 5 years). For details of the combined return periods, see Table 9.3.

10.3.34 The results of the simulations are presented in Figures 13.51 to 13.60 in Appendix A and demonstrate that the predicted flooding during a combined flood event with a 1 in 200-year or a 1 in 1000-year return period does not reach the boundary of the Scheme.

10.3.35 The flood extents during a combined fluvial and tidal flood event is restricted to the area immediately adjacent to the River Hull defences, particularly around Dock Office Road and High Street. This is due to the relatively small volume of flood waters flowing over the defences during such a combined event. Total inflow volumes for a 1 in 1000 year combined fluvial/tidal event for the River Hull (see Table 9-3) are 5,754m^3, compared to 342,826m^3 for a River Hull tidal only flooding event, and 1,367,739m^3 for a Humber Estuary wave overtopping event.

10.3.36 The flood depth difference maps for the combined River Hull fluvial and tidal flooding events confirm the Scheme does not appreciably alter flood depths for either the 1 in 200-year event (Figure 13.53) or the 1 in 1,000-year event (Figure

13.56). The flood hazard maps indicate the hazard from such events is negligible under both existing and Scheme conditions (Figure 13.57 to Figure 13.60).

Defence breach flooding

10.3.37 The Hull City Council SFRA[12] includes maps for maximum flood depths for flood defence breach scenarios. These maps indicate that the Scheme would be flooded to a depth of between 0.15 and 0.60m during a defence breach with velocities ranging between 0.30 and 1.00 m/s.

10.3.38 The Environment Agency requested that additional modelling of the impacts to and from flood defence breaches on the Scheme be carried out. Hull City Council provided defence breach hydrographs from the SFRA breach modelling study. There were four breach locations within the Scheme study area; breaches 05, 06, HB24 and HB25. The locations of the breaches are shown in Figure 9-2.

10.3.39 The results of this flood defence breach modelling are given as composite maximum flood depth maps (Figures 13.63 and 13.64) and composite maximum flood hazard rating maps (Figures 13.65 and 13.66) for both the existing and Scheme conditions. The maps show significant flooding of the Scheme and wider Hull city of a similar extent to the 1 in 1,000 year defended wave overtopping events. Flood hazard within the Scheme area is generally classified as ‘Danger to Some’ with small areas of ‘Danger to Most’. The underpass would be completely flooded during such breach events with a hazard rating classed as ‘Danger to All’.

Scheme flood risk with VCB removed

10.3.40 This section examines the risk of flooding to and from the Scheme excluding the presence of the central vertical concrete barrier (VCB). Flood depth, depth difference and hazard maps are presented for the previously agreed flooding scenarios as outlined below:

- Pluvial flooding (Figures 13.67 to 13.75)
- Humber Estuary wave overtopping (defended) flooding (Figures 13.76 to 13.84)
- Humber Estuary tidal (undefended) flooding (Figure 13.85 to 13.90)
- River Hull tidal flooding (Hull Tidal Surge Barrier open) (Figures 13.91 to 13.96).

10.3.41 The presence or absence of the VCB makes no discernible difference in flood risk or flood depth changes for the pluvial flooding scenarios.

10.3.42 For the Humber defended 1 in 200-year flooding scenario (see Figures 13.18 and 13.77), the presence of the barrier increases the magnitude of flood depth change at Blanket Row, Sewer Lane and Finkle Street to 0.20 to 0.30m (from 0.05 to 0.20m without the VCB). However, the presence of the VCB acts to significantly reduce the extent of increased flood risk around Posterngate, Lowgate and the surrounding streets to the north of the A63.

10.3.43 For the 1 in 1,000-year Humber defended flooding scenario, the presence of the VCB causes increased flood depths (of between 0.05 and 0.30m) to areas south-east and south-west of the Scheme (around Blanket Row, the Humber and Railway Docks and the areas around Lister Street and English Street (Figure 13.21). These areas show changes in flood depth of less than 0.05m without the VCB (Figure 13.79). However, without the VCB, the extent of the reduction in flooding north of the Scheme (e.g., of up to 0.30m around Posterngate and >0.40m in Princes Quay) decreases and flood depths at Queen's Gardens are slightly increased (0.05 to 0.10m).

10.3.44 For the Humber Defended 1 in 200-year plus climate change (2115) flooding scenario, the pattern of flood depth changes is broadly similar between the VCB In scenario (Figure 13.24) and the VCB Out scenario (Figure 13.83) apart from the extent of reduced flood risk increases due to the presence of the VCB to include Dock Office Row and High Street (flood depths reduce by up to 0.1m) at the eastern extent of the study area.

10.3.45 For the Humber tidal undefended 1 in 200-year (Figures 13.33 and 13.86) and 1 in 200-year plus climate change (Figures 13.36 and 13.88) the presence of the VCB results in increased flood depths of 0.05 to 0.10m around Blanket Row, Blackfriargate and Lister Street. There is also an increase in the magnitude of depth change from 0.10 to 0.20m at Kingston Retail Park. However, the presence of the VCB also results in areas of reduced flood depths (by up to 0.10 to 0.20m) around Posterngate, Princes Quay and in isolated areas around Dock Street, Baker Street and Frances Street to the north.

10.3.46 For the River Hull 1 in 200-year tidal flooding scenario, the presence of the VCB (Figure 13.43) causes greater increases in depths at Princes Quay by 0.20 to 0.30m when compared to 0.10 to 0.20m without the VCB (Figure 13.92). Furthermore, flood depths at Sewer Lane, Finkle Street and Blanket Row are increase by 0.10 to 0.20m with the VCB compared to 0.05 to 0.10m without the VCB.

10.3.47 For the River Hull 1 in 1,000-year tidal flooding scenario (Figure 13.46 and 13.94), the pattern of flood risk north and west of the Scheme is broadly similar with or without the VCB. However, the presence of the VCB (Figure 13.46) increases the extent of the area of increased flood depth (by 0.05 to 0.10m) to the south-east of the Scheme to include Wellington Street, Queen Street and Nelson Street. Furthermore, without the VCB (Figure 13.94) flood depths in Humber Dock marina are expected to decrease by 0.10 to 0.30m whereas with the VCB the depths in the marina are unchanged. Without the VCB, flood depths in the Waverley Street area increases by 0.3 to 0.4m but with the VCB, flood depth increases by 0.2 to 0.3m.

Changes in flood extent

10.3.48 The Environment Agency requested an assessment of the changes in maximum flood extent between the existing and proposed Scheme conditions (including the presence of the VCB within the Scheme). This section presents results from this analysis in the form of flood extent change maps (Figures 13.97 to 13.106).

10.3.49 The pluvial flooding extent change maps (Figures 13.97 to 13.99) show the presence of the Scheme does not alter maximum flood extents.

10.3.50 The Humber Estuary wave overtopping (defended) flood extent change maps (Figures 13.100 to 13.102) show marginal areas of reduced flood extent to the north of Mytongate Junction and minor areas of increased extent in Queen's Gardens for the 1 in 200-year event (Figure 13.100). For the 1 in 1,000-year event (Figure 13.101), flood extents are broadly similar except for small areas of reduced extent associated with the landscaping for Princes Quay Bridge. For the 1 in 200-year plus 2115 climate change event (Figure 13.102), the entire study area and wider Hull city centre are inundated regardless of the presence or absence of the Scheme as such, the flood extents are unchanged.

10.3.51 The Humber Estuary tidal (undefended) flood extent change maps (Figure 13.103 and 13.104) show very minor reductions in flood extent at the northern edge of the study area for both the 1 in 200-year and 1 in 200-year plus climate change (2115) events.

10.3.52 For the 1 in 200-year River Hull tidal flooding event (Figure 13.105), the flood extent change maps show reduced flood extent to A1079 Ferensway and surrounding streets and the Humber and Railway Docks. The maps indicate areas of increased flood extent to around William Street, Waverley Street and parts of Wellington Street, Nelson Street.

10.3.53 For the 1 in 1,000-year River Hull tidal flooding event (Figure 13.106), the flood extent change maps show areas of reduced flood extent to the north of Mytongate Junction extending north to Prospect Street and Portland Street. The maps indicate areas of increased flood extent around Waverley Street and Edgar Street and parts of Kingston Retail Park.

Flood risk to Hull City Council allocated development sites

10.3.54 Hull City Council and the Environment Agency requested an assessment of the change in flood risk to sites within Hull city centre which have been allocated for development under the Hull Local Plan 2016 to 2032[14]. The results of this assessment are presented in the form of flood depth difference maps in Figures 13.107 to 13.116.

10.3.55 Figures 13.107 to 13.109 indicate no changes to flood risk at allocated development sites for pluvial flooding events.

10.3.56 Figures 13.110 to 13.112 indicate increased flood depths at allocated development sites 9, 22, 23, 24, 26, and 27 and reduced flood depths at sites 0, 7, 8, 13, 17, 18, 20, 21, 29, 32, 33, 35, and 37 for Humber Estuary wave overtopping flood events. The magnitude of flood depth changes depends on the return period of the flood event.

10.3.57 Figures 13.113 and 13.114 indicate flood depth changes at allocated sites for the Humber Estuary tidal (undefended) flooding events. The maps indicate reduced flood depths at allocated development sites 0, 7, 8, 13, 17, 18, 20, 25, 29, 30 and 35. Flood depths are increased at allocated development sites 9, 23 and 24.

10.3.58 Figures 13.115 and 13.116 indicate flood depth changes at allocated sites for the River Hull tidal flooding events. The maps indicate reduced flood depths at allocated development sites 0, 1, 2 and 36. The maps indicate increased flood depths at allocated development sites 7, 9, 18, 23, 24 and 35.

Flood hazard at strategic diversion routes

10.3.59 As part of the consultation with the Environment and Hull City Council on the FEEP report, an assessment of the change in maximum Flood Hazard Rating along the strategic diversion routes was carried out to ensure that during a flood event, these routes would not be subject to increased flood hazard due to the presence of the Scheme.

10.3.60 The results of this assessment are presented as flood hazard difference maps in Figures 13.117 to 13.126. These maps show areas where hazard is increased by one class (e.g. ‘Hazard to Some’ to ‘Hazard to Most’) or by two classes (e.g. ‘Hazard to Some’ to ‘Hazard to All’) as light and dark red colours respectively. Conversely, reductions in hazard by one or two classes are shown indicated by light and dark green colours respectively.

10.3.61 These maps show that the strategic diversion routes, which are located to the west and north of the Scheme (as indicated by the bold black lines) are in areas where maximum Flood Hazard Rating is either unchanged or decreased because of the Scheme.

10.4 Sewerage and drainage network flooding

10.4.1 As discussed in Section 5.7 and Volume 3, Appendix 11.3 Flood risk modelling technical report, the hydraulic flood risk model incorporates details of the combined sewerage network serving Hull. As such, the pluvial flooding scenarios (Section 10.2) consider the effects of rainfall falling both within and outside the 2D study zone using sub-catchments of the sewer network. This ensures that any potential surcharge or flooding of the sewer system which may occur because of rainfall falling outside the study area is reflected within the pluvial flooding assessments. Similarly, any overland flows generated from fluvial or tidal flooding can also drain to the sewer network. However, the interaction between fluvial and tidal flooding with sewer network flooding outside the study area has not been explicitly considered as part of this assessment.

10.4.2 The flood risk model includes the emergency combined sewer outfalls from Hull East and Hull West pumping stations. Both pumping stations are located outside the study area but are linked via the wider Hull sewer network represented in the model. There are no sewer outfalls within the modelled study area although previous site visits identified the possible presence of surface water outfalls to the east of Albert Dock.

10.4.3 Flooding of the sewer system from high tide events is considered as part of the pluvial flooding scenarios through the application of 1 in 10-year tide event at the outfall locations. However, the model results indicated that high tides had no impact on pluvial flooding.

10.5 Predicted flow velocities

10.5.1 Analysis of model predictions indicate that the magnitude of flow velocities across the study area (but outside the Scheme boundary) do not change significantly because of the Scheme. The greatest flow velocities are observed in the Scheme underpass and the westbound exit slip road due to the high gradient of these sections of the proposed carriageway. Figures 13.61 and 13.62 (Appendix A) illustrate the maximum modelled flow velocities at these locations during a 1 in 200-year River Humber wave overtopping event and a 1 in 200-year River Hull tidal flooding event, respectively. The results show maximum velocities within the underpass of 0.75m/s and >1.50m/s for the Humber wave overtopping and Hull tidal flooding scenarios, respectively.

10.6 Underpass inundation times

10.6.1 The Environment Agency requested clarification of inundation times between the initial defence overtopping or breach and the subsequent initial flooding of the proposed Scheme underpass. This data would be used to inform the detailed requirements of the Flood Emergency and Evacuation Plan (FEEP) (see Appendix B) and to ensure the procedures outlined in that document are sufficient to secure a safe closure of the underpass in the event of a minimal or ‘no warning’ flood event.

10.6.2 The FEEP outlines the use of technologies within the underpass including CCTV and water level sensors coupled with the use of electronic closure and diversion signs which could be used in the case of a no warning or minimal warning flood scenario. Further details of these technological solutions and the associated underpass closure procedures are provided in the FEEP (Appendix B).

10.6.3 Reports from the public and other stakeholders following the December 2013 tidal surge flood event suggest inundations times to flooding of properties of just several (perhaps less than 10) minutes following the onset of flooding and wave overtopping. However, it is not clear where (in relation to the Scheme or the

Humber north bank) that these inundation times were reported from. Given the disparity between modelled inundation times and those reported above, it is likely that the rapidly inundated locations are situated closer to the Humber bank i.e. south of the Scheme.

10.6.4 Furthermore, the flooding in December 2013 took place prior to the upgraded defences at Albert Dock in 2015. The construction of these upgrades caused a shift in the main flooding source to the Scheme to go from the south (at Albert Dock) to include more contribution of flooding from further east towards the River Hull confluence. This additional pathway is located further away from the Scheme and so may, influence current inundation times to the Scheme underpass.

10.6.5 Additionally, during the December 2013 tidal surge flood event, the operators of Albert Dock were unable to safely close the dock gates and the docks would have been inundated earlier during the flood event (due to rising tides and the surge) and as such, a substantial volume of potential ‘flood storage’ was already filled with water prior to defence overtopping. Since the 2013 event, more robust solutions and procedures for closure of the dock gates have been adopted and the modelling has assumed the gates would be closed and that some volume of ‘storage’ would be available during the early stages of a wave overtopping flood event. This mechanism may act to delay the propagation of flood waters north away from Albert Dock and may also, influence current inundation times to the Scheme underpass.

10.6.6 It is reasonable to assume that in the event of a flood defence breach, there would be other warning signs (such as issue of Flood Alert or notable presence of high levels within the Humber Estuary) that would be sufficient to trigger a response under the FEEP. This would be equivalent to the Level 1 (Flood Alert) response outlined in the FEEP. Part of this response would be to place personnel and assets (including temporary pumps) on standby at a location close to the underpass who would then be able to more rapidly respond to a flood resulting from a breach of the defences or where there was a failure to issue a Flood Warning.

10.6.7 Table 10-1 below outlines the underpass inundation times for the various agreed flooding scenarios including a flood defence breach based on information supplied by Hull City Council. The results indicate there would be just less than 1-hour lead-time available for underpass closure during the worst-case ‘no warning’ flood defence breach event.

Table 10-1 – Times from initial flooding to underpass inundation

Flooding scenario	Underpass inundation time
Humber Estuary (defended) wave overtopping flood - 1 in 200-years	1hr 48min
Humber Estuary (defended) wave overtopping flood - 1 in 1,000-years	1hr 30min
Humber Estuary (defended) wave overtopping flood - 1 in 200-years plus climate change (2115)	1hr 15min
Humber Estuary (undefended) tidal flood - 1 in 200-years	1hr 45min
Humber Estuary (undefended) tidal flood - 1 in 200-years plus climate change (2115)	1hr 42min
River Hull tidal flooding (Hull Tidal Surge Barrier open) - 1 in 200-years	1hr 21min
River Hull tidal flooding (Hull Tidal Surge Barrier) - 1 in 1,000-years	1hr 09min
Hull City Council SFRA[12] Humber Estuary north bank flood defence breach - 1 in 200-years plus climate change (2115) - Worst-case breach scenario	0hr 57min

10.7 Groundwater Flooding

10.7.1 At the location of the Scheme, the Yorkshire Chalk Aquifer is typically found between 20 and 30 metres below ground level. It is covered by several lower permeability superficial deposits which also contain groundwater. Groundwater within the chalk strata has been shown to be tidally influenced with some much smaller and delayed tidal impacts within the superficial deposits. Existing groundwater levels in the superficial deposits typically range between -0.5 and 1.5 mAOD based on monitoring from the ground investigation. For comparison, ground level is around 3.0mAOD. This suggests there is negligible risk of groundwater flooding under baseline conditions.

10.7.2 The main predictions of the steady state and transient groundwater models, which incorporate the Scheme underpass, were:

- Negligible impact on the Chalk groundwater level or flow
- Changes in groundwater levels within the superficial deposits immediately outside the walls of the underpass of 0.13m or less, due to diversion of groundwater flows around the underpass
- Changes in groundwater levels result in drawdown or groundwater mounding, depending on the direction of tides
- Groundwater inflow to the underpass through the base of the underpass and diaphragm walls of approximately 1.4 m^3/day (equivalent to <1 litre per second). This would drain to the underpass drainage system

10.7.3 Based on the above analysis, the construction of the Scheme underpass is not expected to increase the risk of groundwater flooding near the Scheme.

10.8 Climate change impacts

10.8.1 Model predictions indicate that climate change has varying impacts on flooding in Hull depending on the source of flooding.

Pluvial flooding

10.8.2 Consideration of climate change was dictated, to a large extent, by the availability of third-party data from both the Environment Agency and Hull City Council. These data sources included allowances for climate change on sea level rise to 2115. This is beyond the 60-year lifetime of the Scheme but provides a longer-term and more conservative assessment of the impacts of climate change on flood risk to the Scheme.

10.8.3 Figures 13.2 and 13.8 (Appendix A) represent flood extents and depths resulting from a 1 in 100-year (no climate change) pluvial flood event and a 1 in 100-year (plus 30% climate change) pluvial flood event, respectively. The Scheme underpass drainage system is designed not to flood during a 1 in 100-year plus 30% climate change rainfall event. As such, any impact of climate change for these events would only be observed outside of the Scheme boundary.

Tidal flooding

10.8.4 The impact of climate change on rising sea levels and wave heights within the Humber has significant effects on the extent and severity of flooding in Hull. During a 1 in 200-year River Humber wave overtopping event, the Scheme underpass represents the approximate northern extent of inundation, with flood waters only extending to along Ferensway to St Luke's Street and Osborne Street (Figure 13.17 Appendix A). However, when climate change effects are included for a 1 in 200-year event, flooding extends much further northwards, well beyond the Scheme area and throughout the study area (Figure 13.23 Appendix A). Indeed, the extent of flooding during a 1 in 200-year plus climate change event is greater than that for the 1 in 1000-year flood event (Figure 13.20 Appendix A). This reflects a predicted increase in sea level of 1.125m (2011 to 2115) plus a 10% increase in wave height due to climate change.

10.8.5 The impact of climate change for the undefended River Humber wave overtopping scenario during a 1 in 200-year event shows similar degree of impact as described above. This is reflected in Figures 13.32 and 13.35 (Appendix A).

10.8.6 No explicit consideration of climate change effects on flooding from the River Hull with the Hull Tidal Surge Barrier open has been given in this assessment. This is due to the absence of climate change scenarios in the River Hull and Holderness Drain Flood Mapping Study[15] from which the relevant model inflow information was derived. In consultation with the Environment Agency, it was agreed that the 1 in 1000-year event from the above study could be used as a surrogate for the in 1 200-year plus climate change event. The impact of this 'climate change' on flooding is significant with greater flood extents predicted particularly to the north and west (Figures 13.42 and 13.45 Appendix A). During the 1 in 1000-year flood event, the Scheme underpass would be flooded completely with flood waters flowing further west along Castle Street. The extent of flooding during a 1 in 1000-year Hull tidal event (Figure 13.45) is greater than a 1 in 200-year tidal event (Figure 13.42 Appendix A) particularly to the north of the A63.The Humber Hull Frontages scheme will substantially improve the standard of protection to the Scheme area. However, there will be residual risk to the Scheme beyond 2040 given the lifetime of the Scheme to 2085. The degree of residual risk will be dependent on the Environment Agency's 'managed adaptive' approach and potential future upgrades to the Humber Hull Frontages defences.

H++ climate change tidal flooding from the Humber Estuary

10.8.7 Given the location, nature and lifetime of the Scheme, the Environment Agency requested additional modelling of sea level rise with an allowance for extreme (H++) climate change scenarios[31]. Due to limitations of third-party data availability, these additional runs were only carried out for the 'undefended' tidal flooding scenarios using amended level-time series boundary conditions. These additional runs were carried out to include climate change allowances for sea level rise to 2115 (to be consistent with previous modelling).

10.8.8 The results of this modelling are presented as flood depth, flood depth difference and flood hazard rating maps for both the existing and Scheme conditions (Figures 13.127 to 13.13).

10.8.9 The flood depth map for the Scheme (Figures 13.127) show significant inundation of the Scheme area and wider Hull city centre, similar in extent to the 1 in 1,000 year defended flood events. The flood depth difference map (Figure 13.129) shows areas of reduced flood depths to the north of the Scheme including A1079 Ferensway extending north to Brook Street, Princes Quay and the area around Posterngate. Flood depths are increased by up to 0.10m around Blanket Row, Blackfriargate, Lister Street and English Street. Flood depths in Kingston Retail Park are increased by 0.20 to 0.30m due to the Scheme.

Groundwater flooding

10.8.10 Climate change is likely to increase groundwater recharge into the superficial deposits and the underlying Yorkshire Chalk aquifer which may, in turn, increase groundwater levels and the risk of groundwater flooding. Increase in groundwater levels would increase the groundwater mounding effect behind the northern underpass wall. An increase in groundwater recharge may result in increased flows through the underpass walls and into the drainage system.

10.9 Summary of Scheme flood risk impacts

10.9.1 Table 10-2 below presents a summary of the differences in flood extent areas for varying depths between the existing and Scheme cases. The differences in areas for each Hazard Rating level is also given. Table 10-3 provides the same information in terms of percentages to aid comparison.

10.9.2 Overall, the results indicate that the Scheme will broadly reduce flood depths and Hazard Ratings in the study area with the exception of the areas described below.

10.9.3 Table 10-2 and Table 10-3 indicate an increase in areas with flood depths >0.30m in the Scheme case; this is due to increased ponding of water within the Trinity Burial ground. As discussed previously in Section 10.1, the permeable nature of this area is not represented within the model and as such, is likely to overestimate the degree of surface water flooding.

10.9.4 Table 10-2 and Table 10-3 indicate an increase in areas flooded to a depth >0.60m and a Hazard Rating of greater than 2 for the Scheme case in the wave overtopping and tidal flooding scenarios. This is due to flooding in the Scheme underpass, although the magnitude of underpass flooding depends on the magnitude of the Humber wave overtopping event.

Table 10-2 – Changes in Hazard Rating and flood depths between existing and Scheme cases

Scenario		Difference in area (m^2) for Hazard Rating			Difference in area (m^2) for flood depth (m)				
Source of Flooding	**Return period (years)**	**HR 0.75-1.25**	**HR 1.25-2.00**	**HR>2.00**	**0.01-0.05**	**0.05-0.15**	**0.15-0.30**	**0.30-0.60**	**>0.60**
Pluvial	30	0	0	0	0	0	0	0	0
	100	-17	0	0	-49	93	-13	0	0
	100 plus 30% climate change	-5	0	0	-170	-31	42	-8	0
River Humber wave overtopping	200	5512	3225	3551	-15067	30629	-49221	6755	8279
	1000	-2046	-36338	19681	353	-4234	-4763	-14865	-5659
	200 plus climate change (2115)	162	8276	-9261	-84	403	113	2901	-3982
River Humber tidal (undefended)	200	-13410	5334	-2783	10	-5316	-14924	-2517	-5010
	200 plus climate change (2115)	-9082	-7800	-1821	-3477	-1882	-13098	-4303	-6056
	200 plus climate change (H++ 2115)	-9552	-13685	-598	-895	-1456	-6460	-11873	-6357
River Hull tidal	200	-13328	8151	5497	-2346	-9838	-48833	-12840	17215
	1000	-12116	-18642	2270	-9816	-16240	-13276	-22543	-6616

Table 10-3 – Percentage changes in Hazard Rating and flood depths between existing and Scheme cases

Scenario		% difference in area for Hazard Rating			% difference in area for flood depth (m)				
Source of Flooding	**Return period (years)**	**HR 0.75-1.25**	**HR 1.25-2.00**	**HR>2.00**	**0.01-0.05**	**0.05-0.15**	**0.15-0.30**	**0.30-0.60**	**>0.60**
Pluvial	30	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100	-0.3%	0.0%	0.0%	-0.2%	0.4%	-0.1%	0.0%	0.0%
	100 plus 30% climate change	0.0%	0.0%	0.0%	-0.4%	-0.1%	0.2%	-0.1%	0.0%
River Humber wave overtopping	200	7.5%	1.6%	40.5%	-15.7%	18.4%	-25.7%	6.8%	5.8%
	1000	-0.7%	-2.7%	8.0%	0.5%	-2.1%	-1.4%	-1.8%	-0.6%
	200 plus climate change (2115)	1.2%	5.1%	-0.3%	-3.1%	2.8%	0.4%	4.1%	-0.1%
River Humber tidal (undefended)	200	-3.3%	0.4%	-2.8%	0.0%	-1.8%	-3.2%	-0.3%	-0.7%
	200 plus climate change (2115)	-2.6%	-0.5%	-1.5%	-3.7%	-0.8%	-3.1%	-0.5%	-0.7%
	200 plus climate change (H++ 2115)	-2.9%	-0.9%	-0.4%	-1.0%	-0.7%	-1.6%	-1.4%	-0.6%
River Hull tidal	200	-21.9%	5.2%	53.6%	-6.9%	-15.7%	-44.0%	-11.8%	18.7%
	1000	-10.3%	-7.3%	5.6%	-11.6%	-11.7%	-11.9%	-12.1%	-3.4%

11. Mitigation measures

11.1 Existing flood defence infrastructure

11.1.1 The Scheme lies entirely within Flood Zone 3a in a heavily urbanised area of Hull. The area is currently protected by flood defences along the north bank of the Humber and the west bank of the River Hull. In addition, the site is protected from flooding from the River Hull by the Hull Tidal Surge Barrier.

11.2 Design Mitigation

11.2.1 The design of the Scheme, and in particular the proposed A63 underpass, has taken into consideration the following criteria which were agreed during previous consultation with the Environment Agency:

- The A63 underpass should not flood during a 1 in 100-year rainfall event plus 30% allowance for climate change (in line with guidance outlined in the NPPF)
- Traffic diversion routes around the A63 underpass should be passable during tidal flooding events or pluvial events in excess of a 1 in 100-year return period plus a 30% allowance for climate change
- Consideration must be given to overland flows external to the Scheme boundary entering the underpass during an extreme event
- Flows from the A63 underpass drainage system may be pumped into the River Humber at an unrestricted rate, provided the following:
    - Alternative power supply sources should be considered to manage the risk of power failure
    - Emergency procedures should be developed to minimise the risk to road users should pump or power failure occur over an extended period
- The surface water pumping station should be sufficiently flood resilient to ensure it can remain safe and operational during significant flood events. During consultation with the Environment Agency, it was agreed that the pumping station should be appropriately resistant and/or resilient to flooding such that it would remain operational during a 1 in 1000-year Humber Estuary wave overtopping flood event. This was agreed during the DCO Examination process and is documented in the Statement of Common Ground between Highways England and the Environment Agency.

11.2.2 The Scheme lies within a heavily urbanised area with no opportunity for alternative drainage options such as soakaways, ponds and other sustainable drainage (SuDS) features.

11.3 Other Mitigation

11.3.1 The Environment Agency outline their strategy for flood protection of Hull and the wider area in the Humber FRMS[22]. The Scheme is protected by existing flood defences in the Hull West (Flood Area 6) area. The Humber FRMS states that the existing flood defences generally provide a good Standard of Protection (SoP), generally to 1 in 200-years although some local areas are just 1 in 20-years. The FRMS highlighted the remaining operational life of the defences was between 5 and 20 years. The FRMS included plans to improve flood defences, where necessary, to maintain protection to the large number of properties, business and industry in Hull. Approximately 79,974 properties are located within the floodplain of Flood Area 6.

11.3.2 Flood defence upgrade and improvement works at Albert Dock were completed in 2015 and increased the SoP along this stretch of the north Humber bank to in excess of 1 in 200-years.

11.3.3 The Environment currently have a scheme under construction to improve the standard of protection to flood defences along the north bank of the Humber. The Humber Hull Frontages will improve install and improve a 7km stretch of tidal defences on the north bank of the Humber and is due for completion in 2021[37]. The standard of protection of the scheme would be for a return period of 1 in 200 years with an allowance for climate change to the 2040s[7]. The remaining climate change allowance would be accounted for with a ‘managed adaptive approach’ which would allow for easier upgrading of the defences in the future.

11.4 Emergency and Evacuation Procedures

11.4.1 Emergency and evacuation procedures are considered below for two types of critical flooding situations, namely:

- Mechanical or power failure of the underpass drainage pumping station
- Extreme tidal flooding events

11.4.2 The Mytongate Pumping Station Approval in Principle[41] highlights the proposed detail and location of of the pumping station.

Pumping station failure

11.4.3 According to the A63 Castle Street Improvements Drainage Impact Assessment report[5], any mechanical and/or electrical failures of the pumping station would be dealt with by the appointed maintenance area contractor (MAC). If one pump is subject to failure, the backup (standby) pump will activate and pump the flow.

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[41] Arup (2018). Mytongate Pumping Station – Approval in principle, Issue 4, HE514508-ARP-SSP-S0-ML-PS-RP-CB-000001, 9 February 2018

11.4.4 In case of grid power supply loss, alternative power sources would be required, such as standby generators, uninterruptable power supplies or a separate grid power supply.

11.4.5 It is proposed to install high water level alarms within the drainage attenuation tanks (upstream of the pumping station) to provide an escalating response to potential flooding issues. CCTV will be in place allowing remote monitoring of the underpass in case of a pump failure.

11.4.6 More details regarding the pump failure procedures are outlined in the A63 Castle Street Improvements Drainage Impact Assessment report[5].

Extreme tidal flooding event

11.4.7 The Scheme and surrounding area lie within either an Environment Agency Flood Warning Area or Flood Alert Area. Within a Flood Warning Area, the Environment Agency issues flood warnings to residents or business when flooding is expected, and recipients of these warnings are urged to take immediate action. Within a Flood Alert Area, the Environment Agency issues flood alerts to residents or business when flooding is possible, and recipients of these alerts are urged to prepare for flooding. Flood alerts cover larger areas than flood warnings and are issued more frequently.

11.4.8 The Scheme area is located partly within the following flood warning areas:

- ‘Hull city centre’ (122FWF112), and;
- ‘North bank of the Humber Estuary in the west of Hull’ (122FWT024).

11.4.9 For extreme tidal flooding events, such as those witnessed during the tidal surge event on 5th December 2013, the Environment Agency have an existing procedure whereby they issue flood alerts to the Highways England Emergency Planning Team who then consider and initiate an appropriate response from the local emergency services. Such an example response might be closure of the Scheme underpass. The Flood Emergency and Evacuation Plan is included in Appendix B for reference and a brief summary is provided below. The plan was written in consultation with relevant stakeholders including the emergency planning team from Highways England North East Regional Control Centre (NERCC), the emergency services, the Humber Local Resilience Forum and Hull City Council.

- Upon receipt of a flood alert, personnel from the Area Maintenance Team (AMT) and key assets (including a temporary, mobile, high-volume pump owned by Highways England) will be put on ‘standby’ for deployment.
- Upon receipt of a flood warning, the NERCC will monitor the underpass via CCTV, variable message signs (VMS) will be activated to direct traffic away from the underpass and personnel from the AMT will be moved closer to the underpass to put in place a physical road closure, if required.

- Upon receipt of a severe flood warning, the high-volume pump will be moved to the underpass and a physical road closure will be put in place by the AMT personnel. VMS will direct traffic away from the underpass and long pre-agreed strategic diversion routes. The underpass will be monitored via CCTV.

- The FEEP also includes procedures to be rapidly put in place and the underpass closed, in the event of a minimal or no warning flood event such as a defence breach.

- All relevant measures outlined above would remain in place until a ‘Warnings no longer in force’ notification is issued by the Environment Agency. During the recovery phase, the temporary, high-volume pumps will be deployed in combination with the underpass surface water pumping station to drain the underpass of flood waters. Following this, the AMT will clear the carriageway and an assessment will be made as to whether the underpass can safely be re-opened to traffic.

- The underpass pumping station would have high volume alarms to alert the NERCC to pump failure, which would trigger the above closure responses, if required. This would only be required in the event of a failure of all other warnings and would provide a last chance warning of flooding of the underpass.

- The plan would be under the ownership of Highways England with a review every 3 years..

12. Conclusions

12.1.1 The Scheme is located within Flood Zone 3a, with a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any one year.

12.1.2 The city of Hull and the entirety of the proposed Scheme and study areas are protected from flooding by the existing Humber Estuary and River Hull flood defences, including the Hull Tidal Surge Barrier. The Humber defences generally provide a standard of protection of 1 in 200 years although for some areas, for example from Albert Dock to St. Andrews Quay, the estimated standard of protection is 1 in 20 years. The River Hull defences generally provide a standard of protection from fluvial flood events of 100 years.

12.1.3 There is currently under construction an Environment Agency scheme to further upgrade the flood defences on the north bank of the Humber. The Humber Hull Frontages will improve install and improve a 19km stretch of tidal defences on the north bank of the Humber and is due for completion in 2021[37]. The standard of protection of the scheme would be for a return period of 1 in 200-years with an allowance for climate change to the 2040s[7]. The remaining climate change allowance would be accounted for with a ‘managed adaptive approach’ which would allow for easier upgrading of the defences in the future.

12.1.4 The Scheme is at risk of potential flooding from tidal, fluvial, pluvial, sewerage and groundwater sources. The Scheme lies within the indicative 1 in 100-year floodplain (in the theoretical absence of the existing defences) and, according to the Environment Agency’s flood zone classification, has a high probability of flooding. The eastern half of the Scheme is within the area that was flooded during the 1969 flood event that occurred before the installation of the Hull Tidal Surge Barrier on the River Hull. Surface water flooding during the 2007 floods has been identified near the Scheme. The Scheme area was also flooded during the 5th December 2013 tidal surge event.

12.1.5 Currently, the greatest risk of flooding to the Scheme is from wave overtopping of the existing Humber north bank defences with the proposed underpass flooded during a 1 in 200-year flood event. The whole of the Scheme area, including the underpass, would be inundated during a 1 in 1000-year and a 1 in 200-year plus climate change flood event.

12.1.6 Tidal flooding from the west bank of the River Hull would occur if the Hull Tidal Surge Barrier failed to close. This is unlikely, as the Barrier incorporates a system to automatically close the barrier in the event of a power failure. However, under the 1 in 200-year event (with Barrier open) the underpass structure is almost entirely flooded to a depth of 5.80m. This flooding and ponding in the underpass prevent flood flows reaching the area north and west of Mytongate Junction, particularly around the junction of Ferensway and Anlaby Road and acting to reduce flood risk in this location. There is a minor increase in flood risk in the area between Humber Dock and the River Hull north and south of the Scheme area due to a slight increase in the elevation of the road. This results in the diversion of flood flows into Princes Quay and increases in flood depths at Kingston Retail Park, Waverley Street and surrounding streets.

12.1.7 Widespread and significant flooding is predicted for the Humber Estuary 1 in 1000-year wave overtopping events and for all the Humber Estuary undefended scenarios. During an event of this magnitude, the impact would be significant, not just for the Scheme, but for the whole of Hull city centre. During such an event, the A63 would be completely closed west of Mytongate Junction under both existing and Scheme cases.

12.1.8 The probability of flooding from combined sources (high tide levels in the River Hull and Humber Estuary during high fluvial baseflow conditions in the River Hull) was also considered as part of this assessment. The analyses indicated that the dependence between the different sources of flooding within the study area is very low. Flooding area from combined tidal and fluvial sources with a 1 in 1000-year return period did not reach the boundaries of the Scheme area.

12.1.9 The underpass drainage system is designed for a 1 in 100-year critical duration rainfall event including a 30% allowance for climate change. The drainage system is designed to convey the 1 in 100-year peak flow and appropriately designed storage is provided to accommodate the runoff from longer duration storms of the same return period. The model predictions confirm that no flooding occurs in the underpass and the adjacent slip roads under this scenario.

12.1.10 The risk of groundwater flooding to and from the Scheme is slight. The walls of the underpass structure are estimated to discharge an average of 1.4m^3 of groundwater flow per day (equivalent to < 1 litre per second) into the underpass drainage system. The drainage system has sufficient capacity to drain this flow.

12.1.11 Analysis of flood routes and flow velocities during the extreme Humber Estuary and River Hull tidal events showed that the greatest impact of the Scheme results from the proposed underpass structure. Predicted maximum velocities of water (combined with the depth) flowing into the underpass are classified as ‘danger for all’ under Defra’s Hazard to People Classification.

12.1.12 The resilience of the Scheme to climate change is considered for tidal, fluvial, pluvial and groundwater flooding sources. The underpass drainage is designed to accommodate flows generated during a 1 in 100-year rainfall event with a 30% increase in rainfall intensity for climate change impacts. As a result, climate change does not impact on flooding within the Scheme boundary and results in only a slight increase to flooding immediately outside the Scheme area.

12.1.13 The underpass will be drained, during normal operational conditions, by a surface water pumping station located to the south of Mytongate Junction. The pumping station will be designed and constructed to ensure that is resistant and/or resilient to the effects of flooding during a 1 in 1,000-year Humber Estuary wave overtopping flood event.

12.1.14 Climate change impacts on tidal flooding scenarios from the Humber are more significant, flooding not only the Scheme area but significant parts of Hull city centre. This is a result of tidal water levels exceeding the level of the existing Humber defences.

12.1.15 According to the NPPF, Essential Infrastructure, such as the Scheme, is only permitted in Flood Zone 3 if it passes the Exception Test. The Exception includes a requirement that any development must provide wider sustainability benefits, in addition to the following:

- The development will be safe for its lifetime taking account of the vulnerability of its users
- The development will not increase flood risk elsewhere, and, where possible will reduce flood risk overall

12.1.16 This FRA demonstrates that there are adverse impacts on flood risk to some surrounding areas but there are also some benefits to other areas because of the Scheme. The greatest impact is on the Scheme itself when during extreme events the underpass is completely flooded and would require closure in accordance with the Flood Emergency and Evacuation Plan (FEEP).

12.1.17 A FEEP was developed as part of this assessment and in agreement with relevant stakeholders including Hull City Council, the Environment Agency and the emergency services. This plan is appended to the report for reference.

13. Appendix A: Flood risk figures

Figure 13.1 1 in 100-year plus climate change pluvial flooding maximum flood depth for existing layout

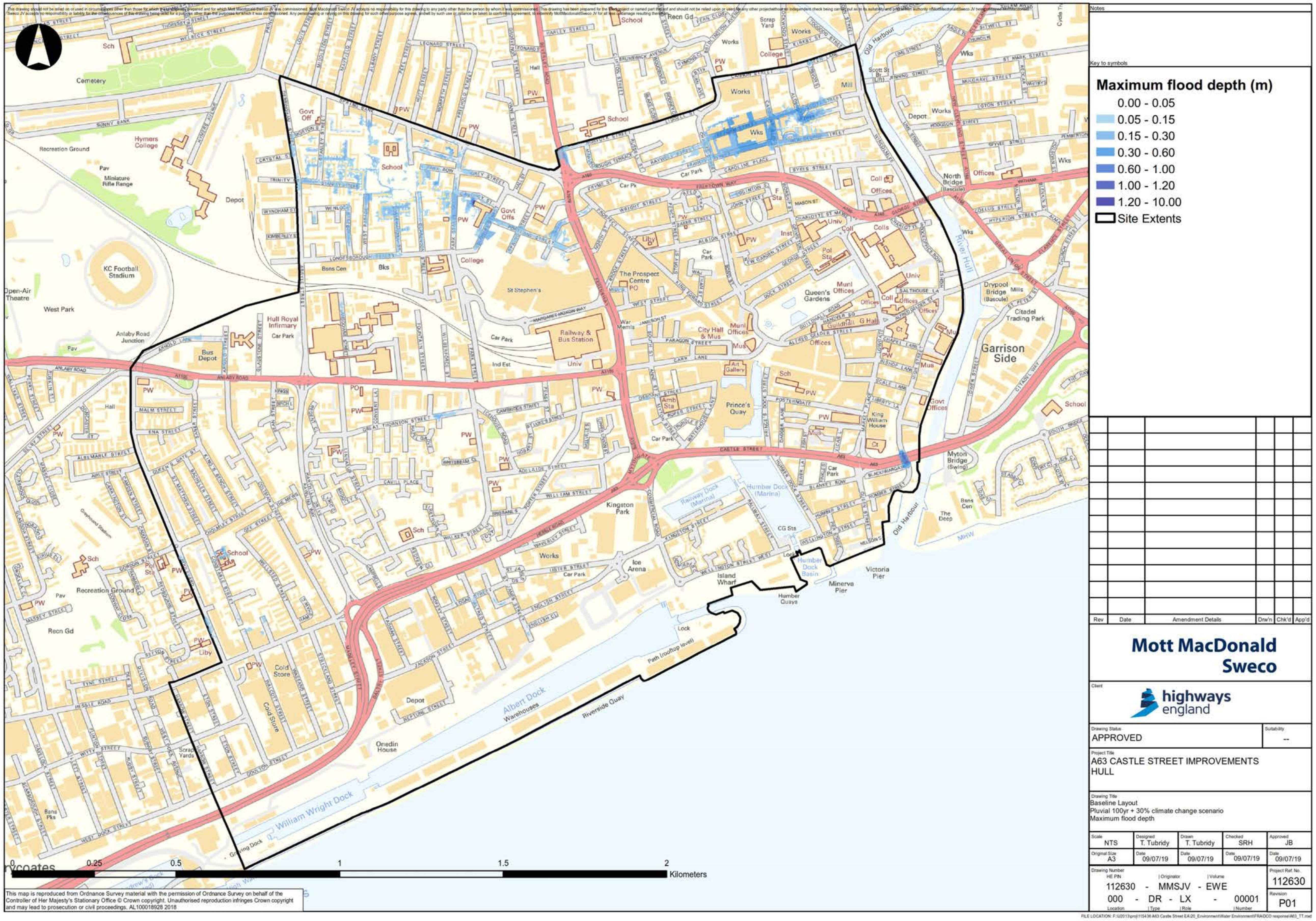


Figure 13.2 1 in 100-year plus climate change pluvial flooding maximum flood depth for Scheme layout

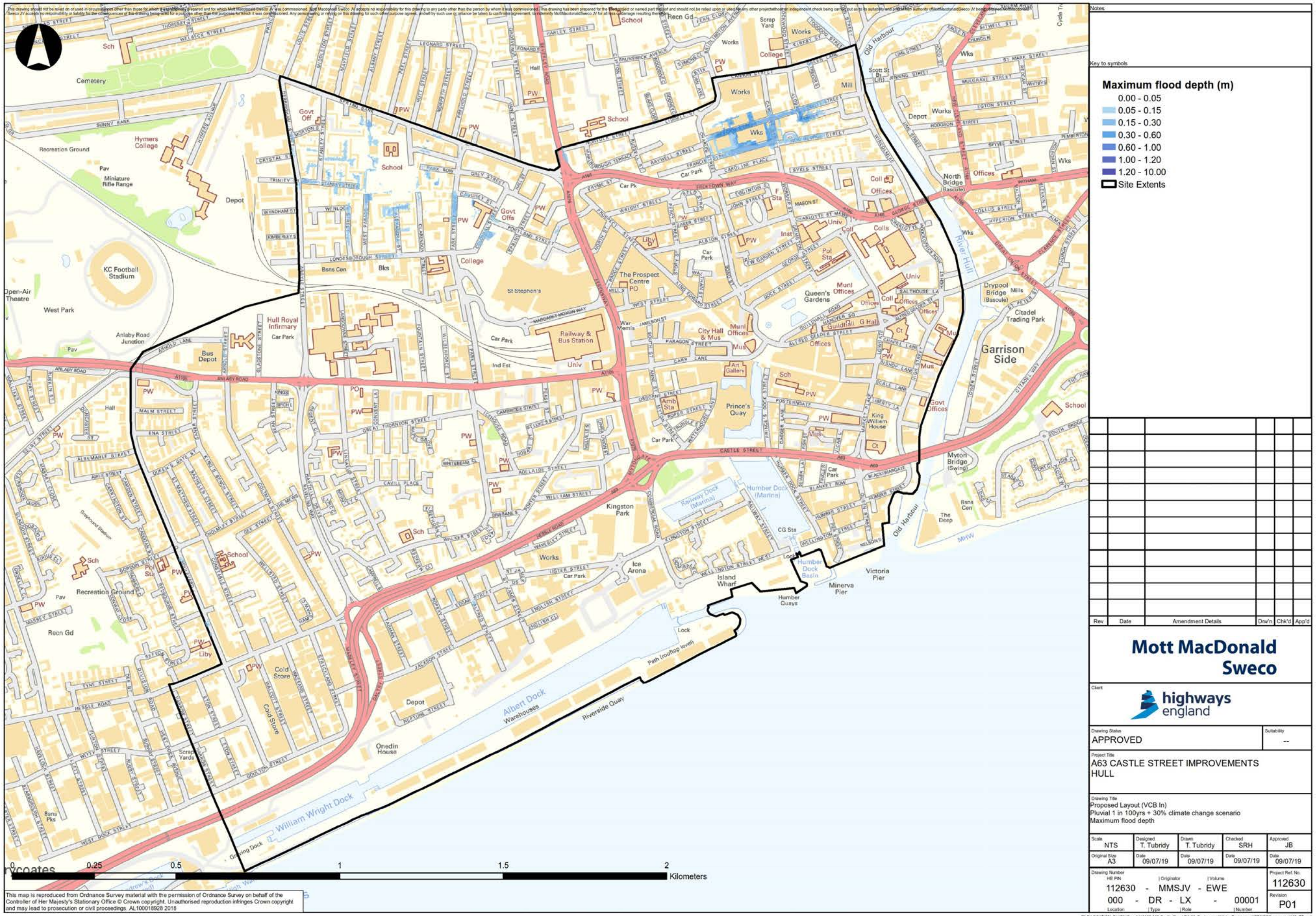


Figure 13.3 1 in 100-year plus climate change pluvial flooding maximum flood depth difference

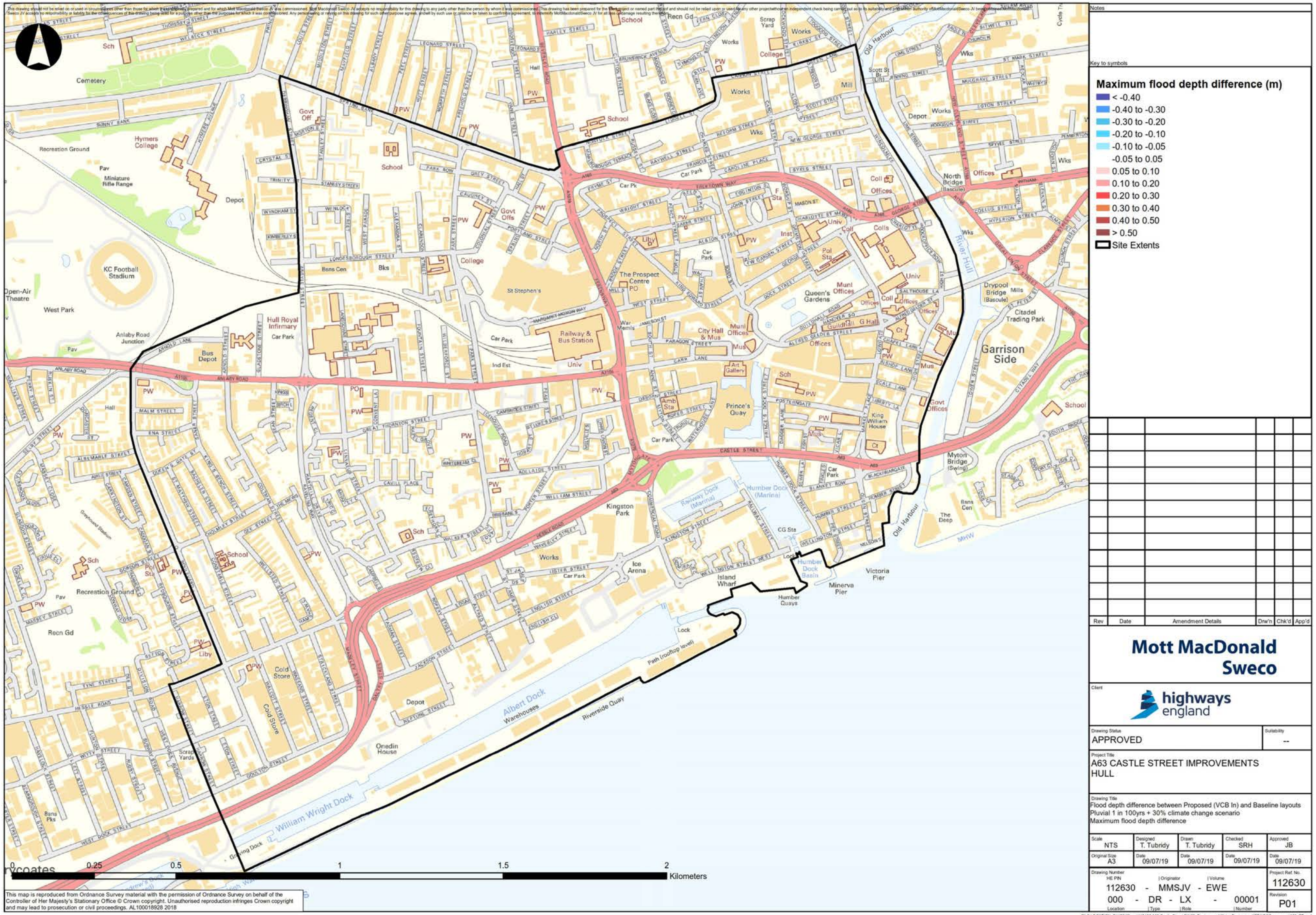


Figure 13.4 1 in 30-year pluvial flooding maximum flood depth for existing layout

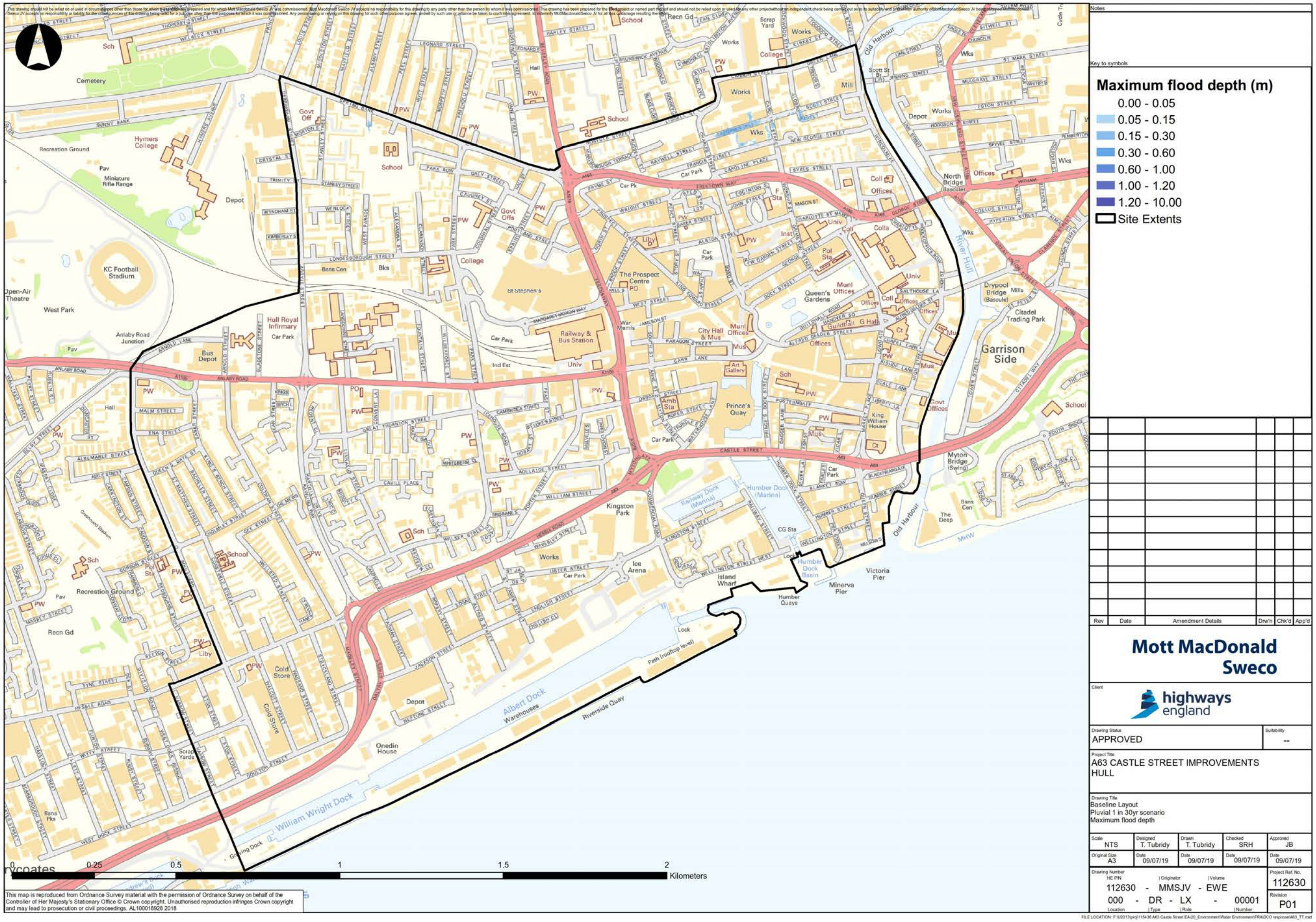


Figure 13.5 1 in 30-year pluvial flooding maximum flood depth for Scheme layout

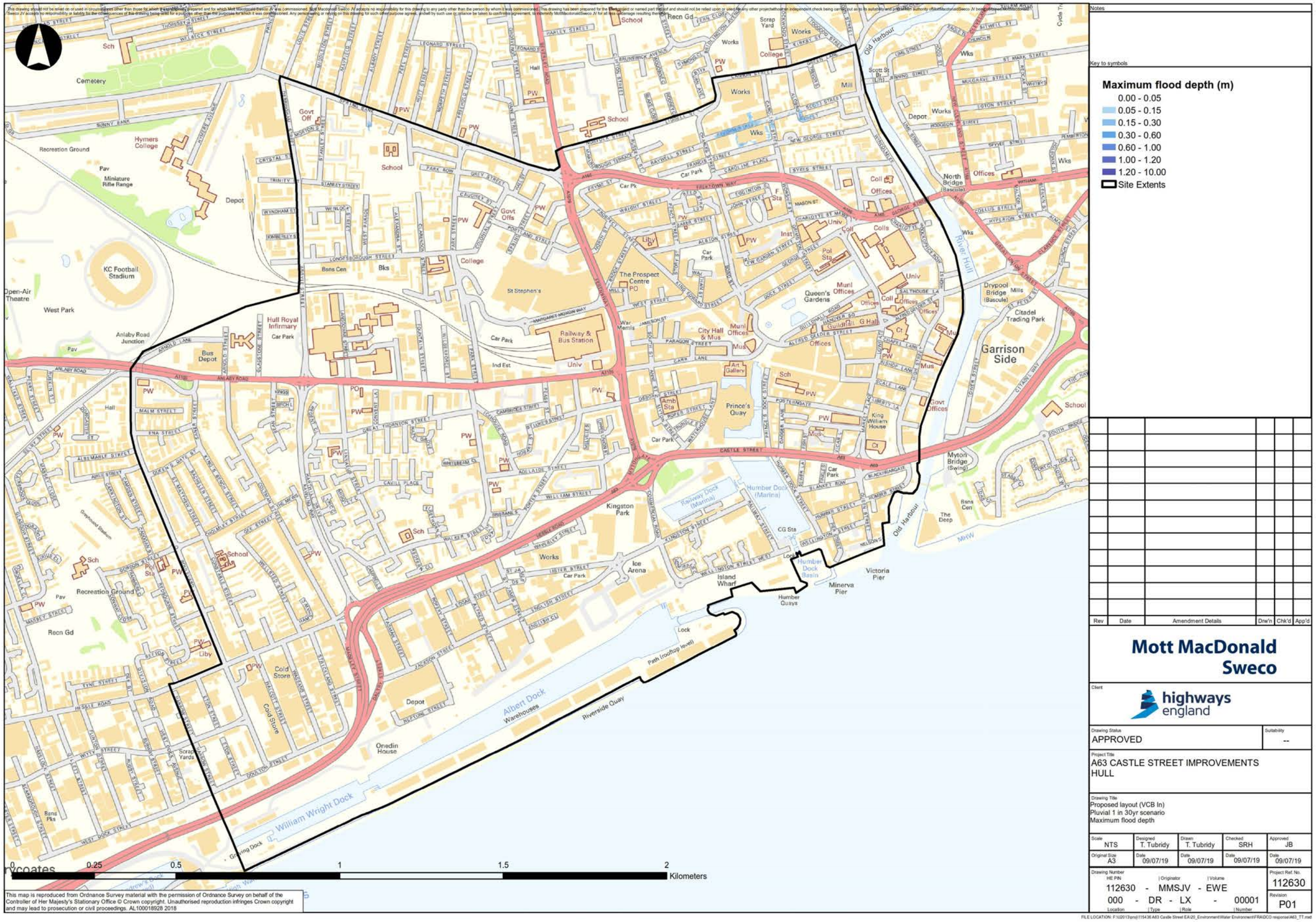


Figure 13.6 1 in 30-year pluvial flooding maximum flood depth difference for existing and Scheme layouts

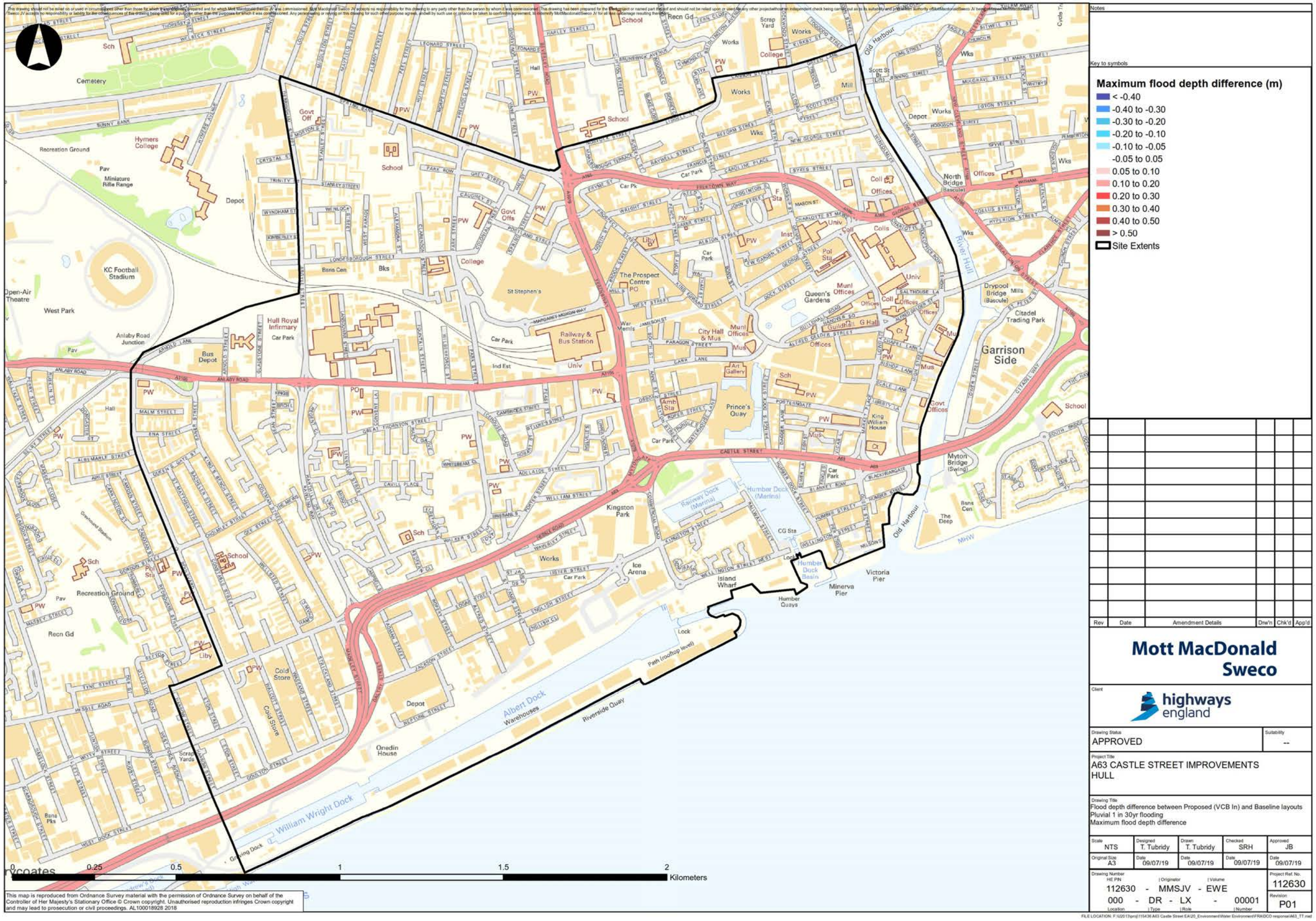


Figure 13.7 1 in 100-year pluvial flooding maximum flood depth for existing layout

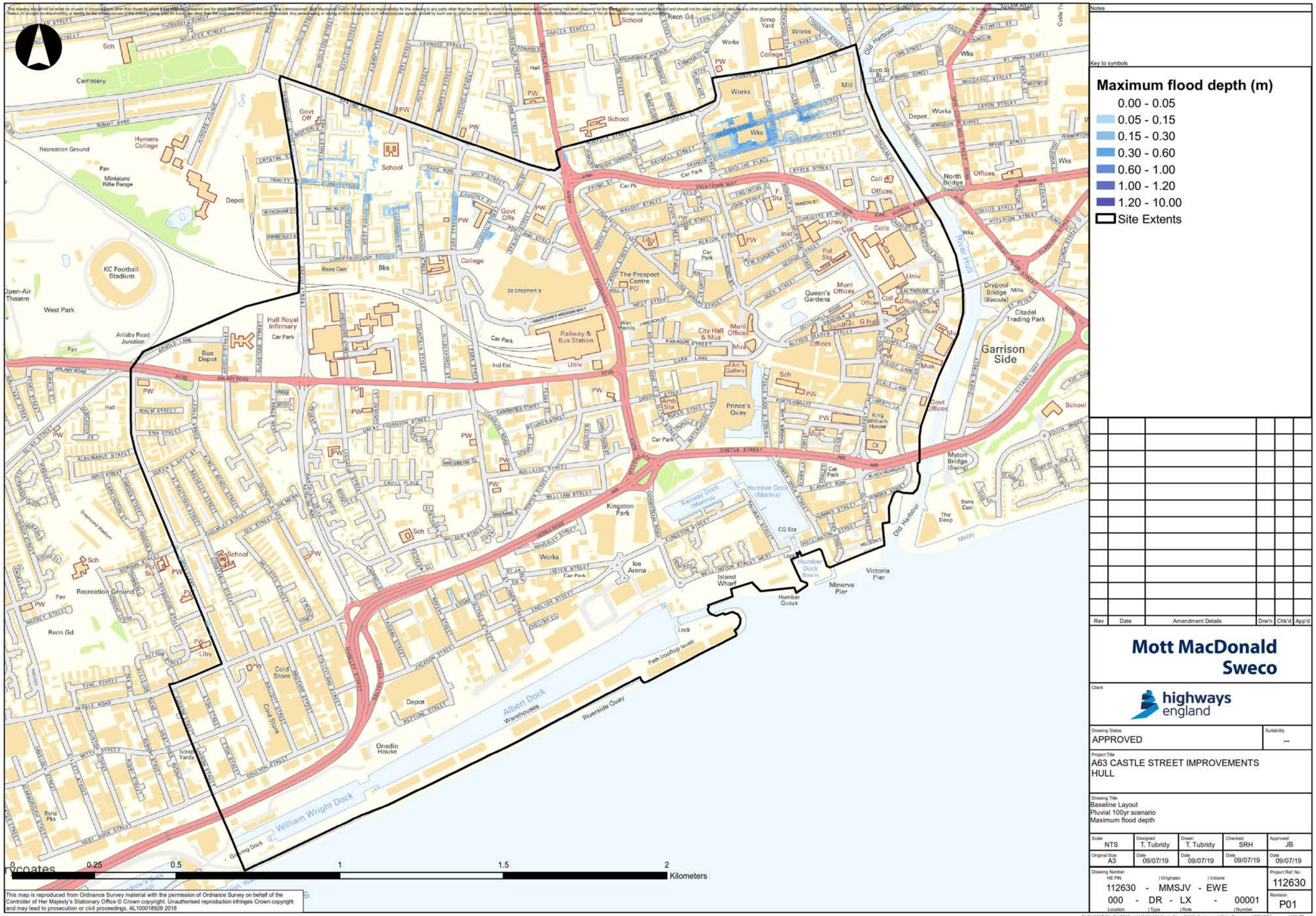


Figure 13.8 1 in 100-year pluvial flooding maximum flood depth for Scheme layout

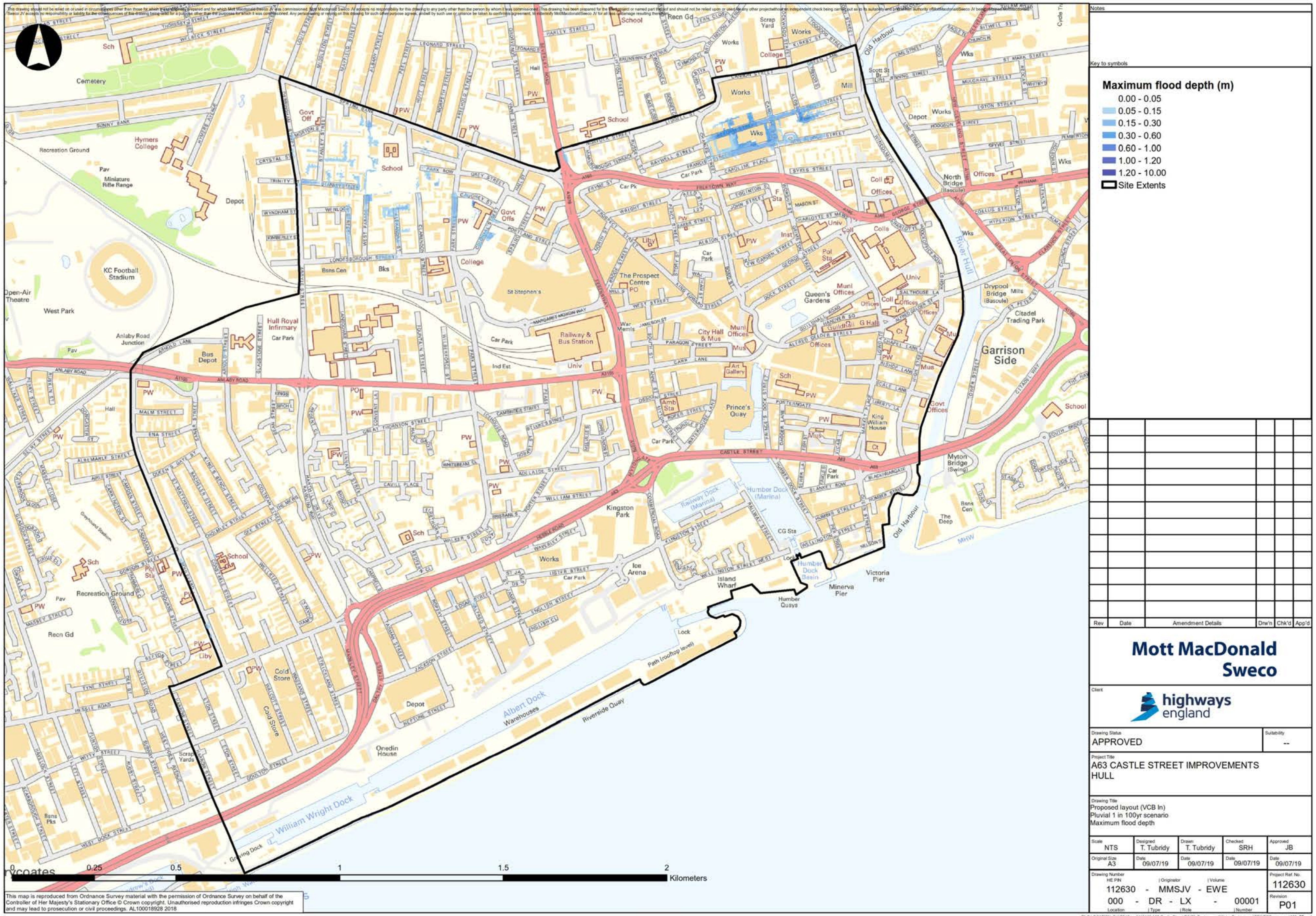


Figure 13.9 1 in 100-year pluvial flooding maximum flood depth difference for existing and Scheme layout

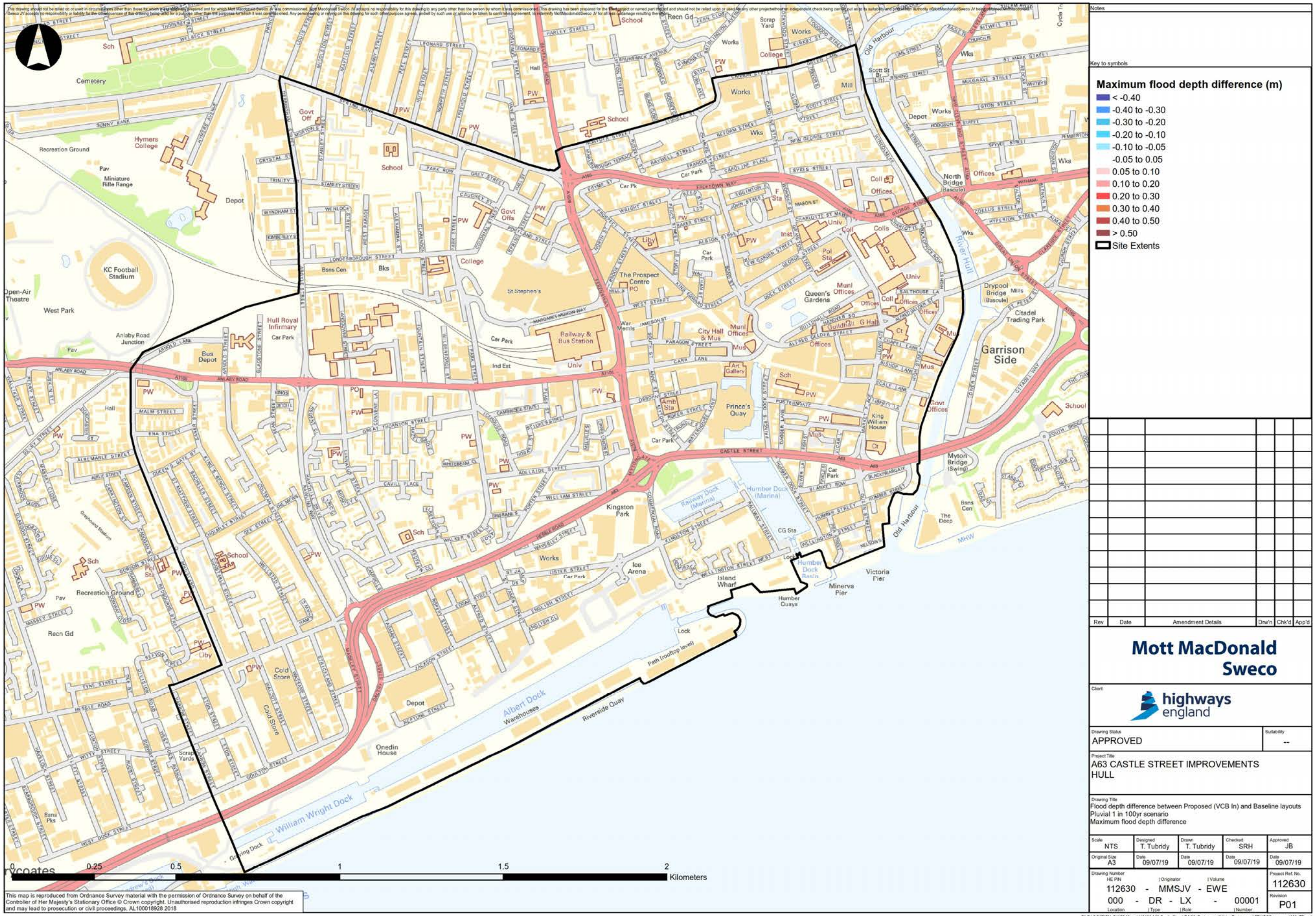


Figure 13.10 1 in 30-year pluvial flooding maximum flood hazard rating for existing layout

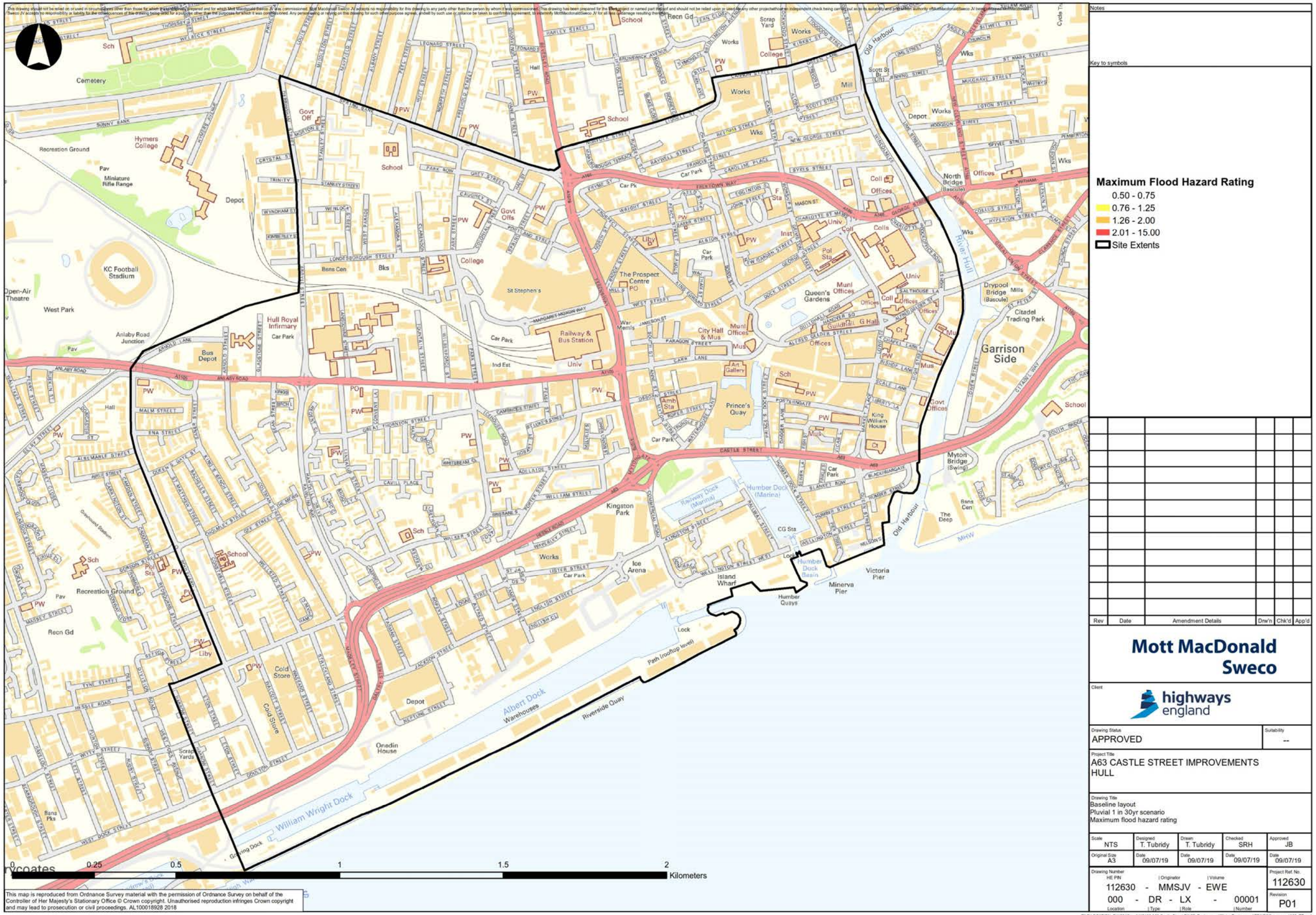


Figure 13.11 1 in 30-year pluvial flooding maximum flood hazard rating for Scheme layout

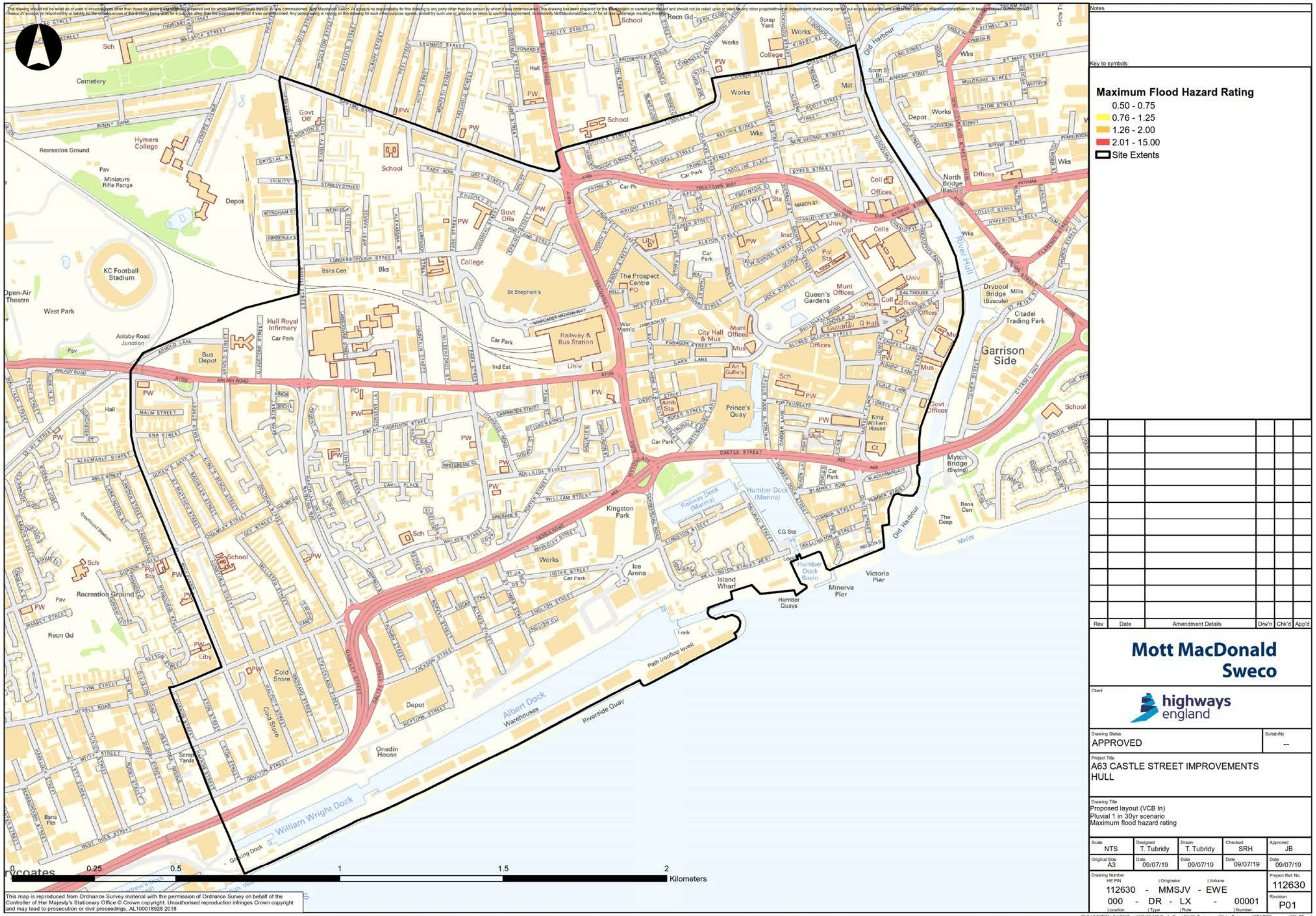


Figure 13.12 1 in 100-year pluvial flooding maximum flood hazard rating for existing layout

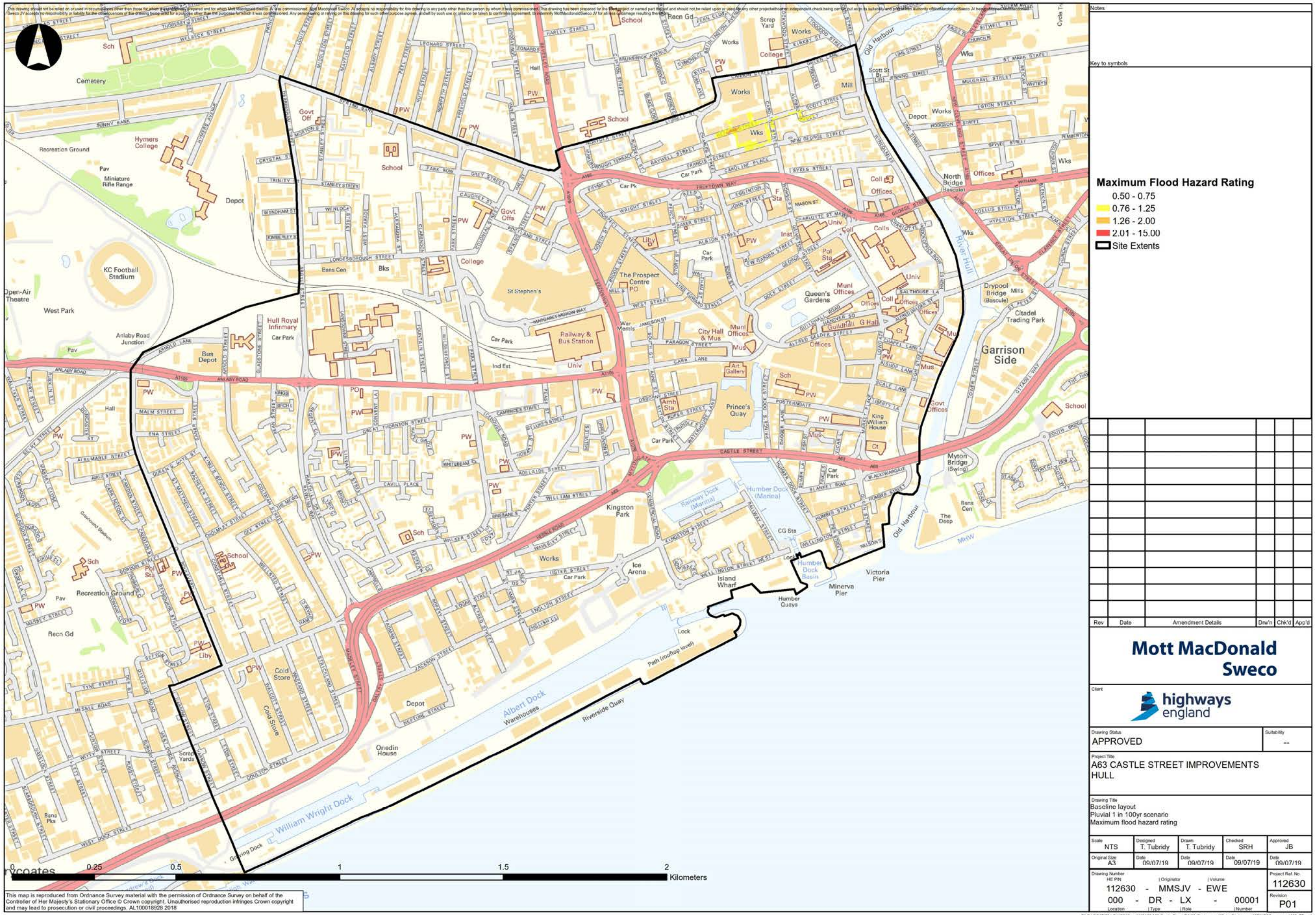


Figure 13.13 1 in 100-year pluvial flooding maximum flood hazard rating for Scheme layout

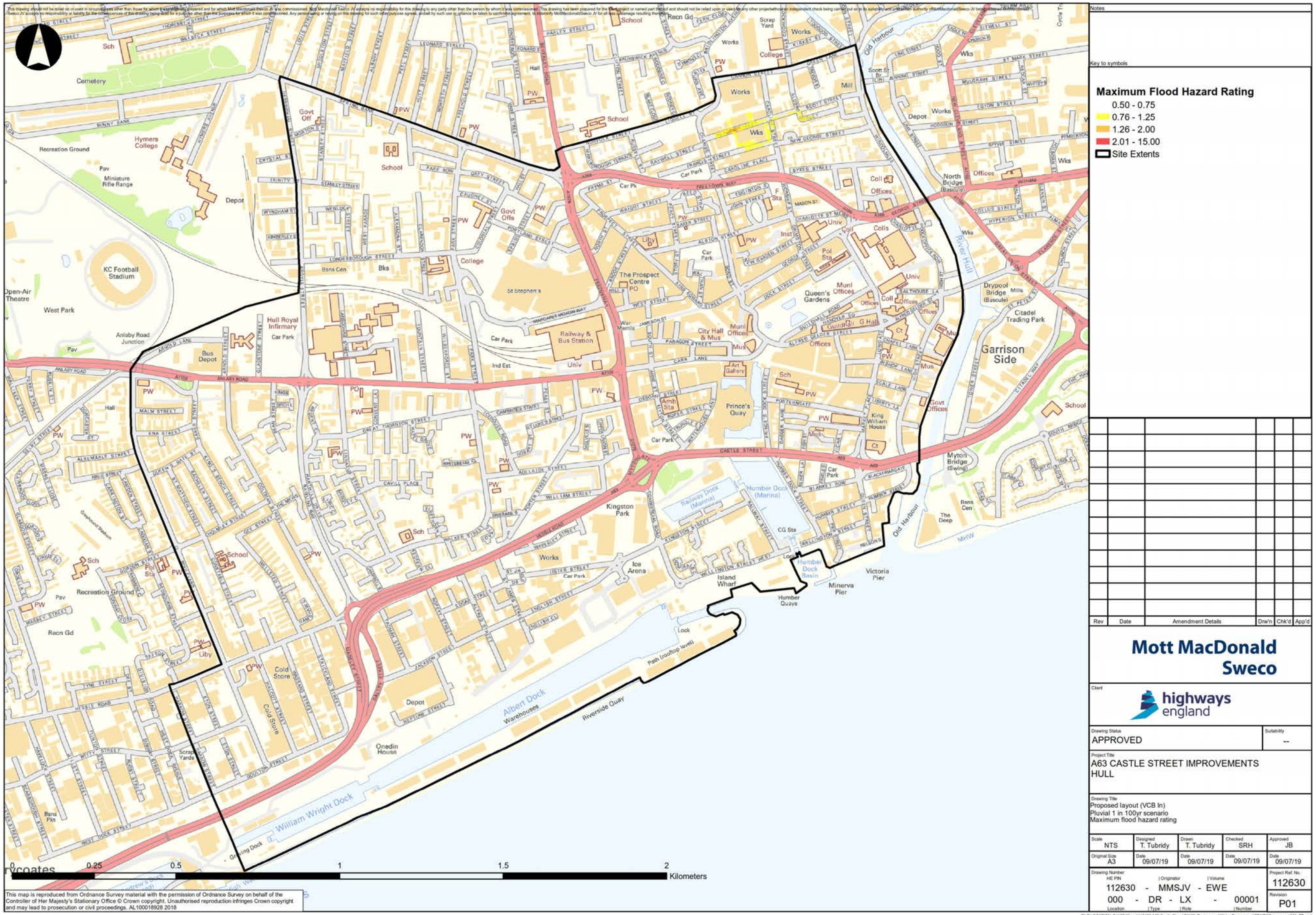


Figure 13.14 1 in 100-year plus climate change pluvial flooding maximum flood hazard rating for existing layout

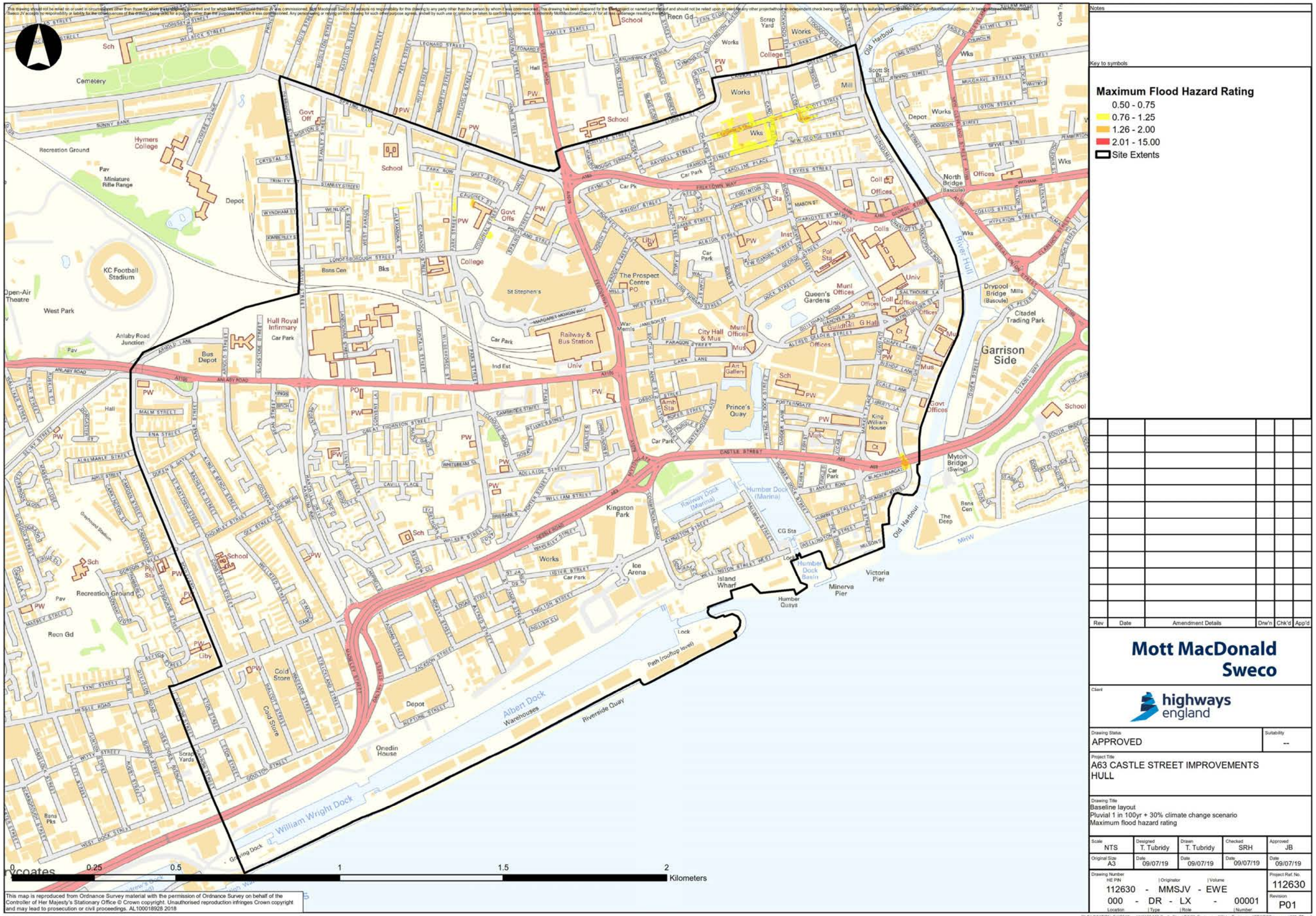


Figure 13.15 1 in 100-year plus climate change pluvial flooding maximum flood hazard rating for Scheme layout

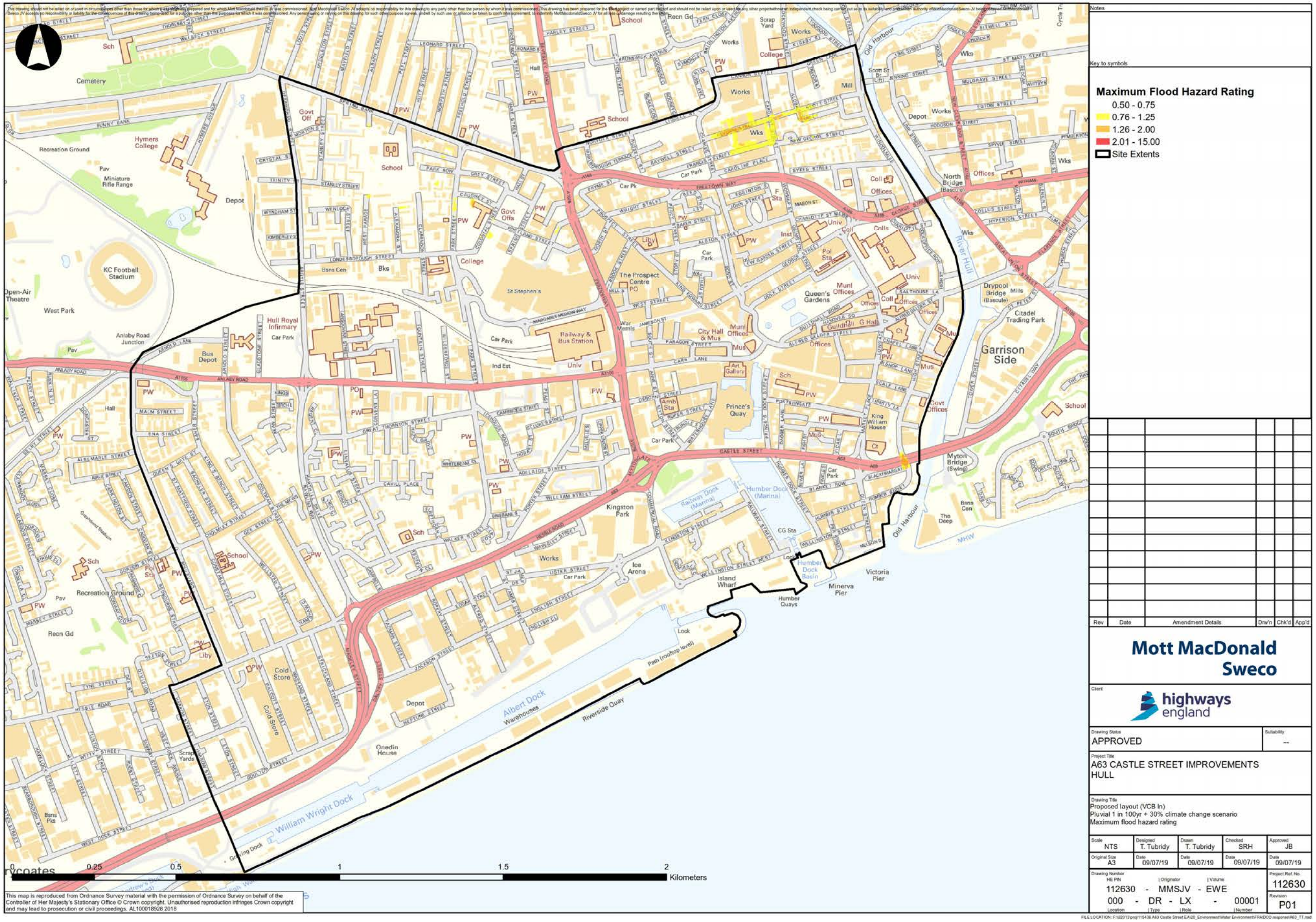


Figure 13.16 1 in 200-year Humber wave overtopping maximum flood depth for existing layout

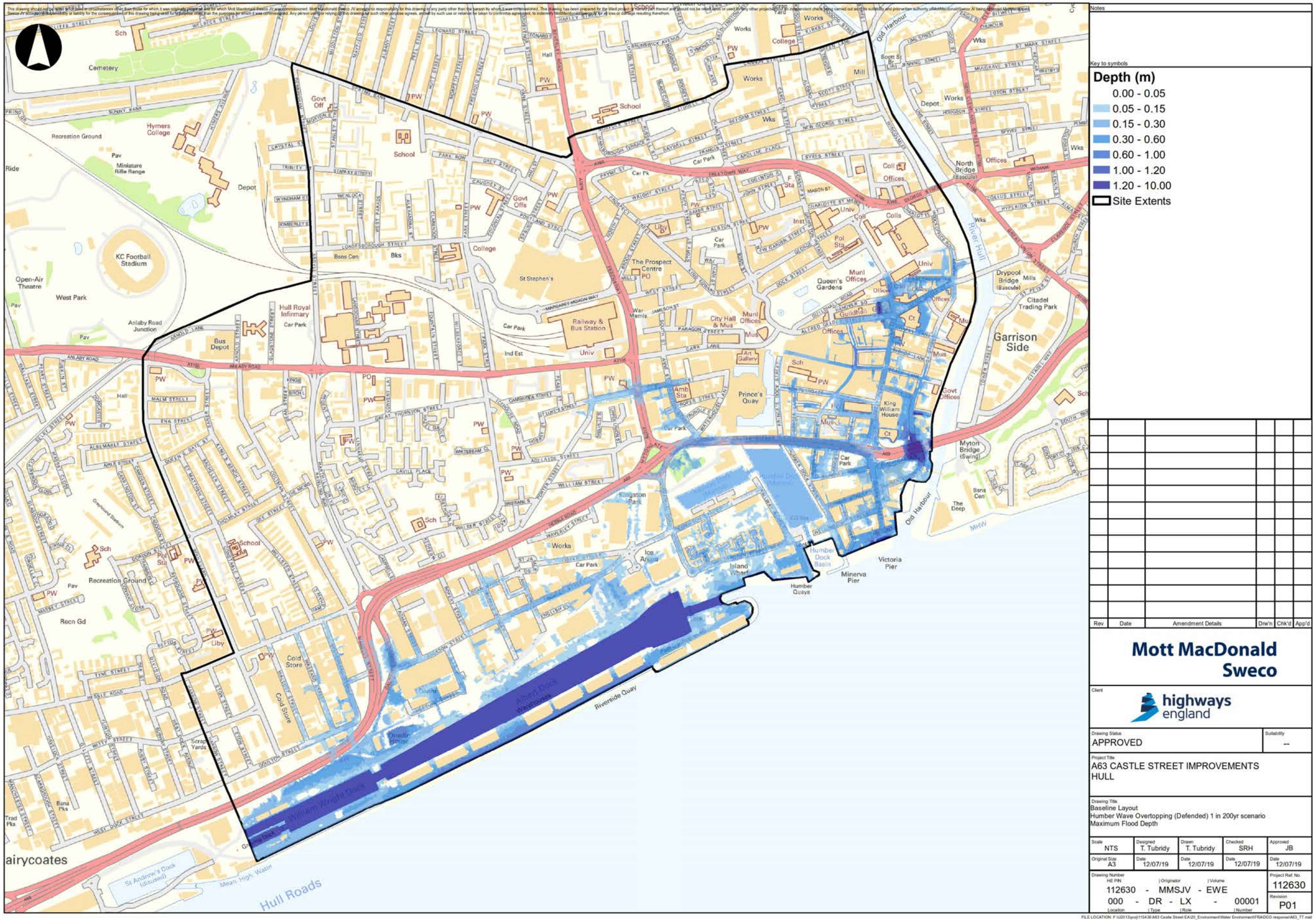


Figure 13.17 1 in 200-year Humber wave overtopping maximum flood depth for Scheme layout

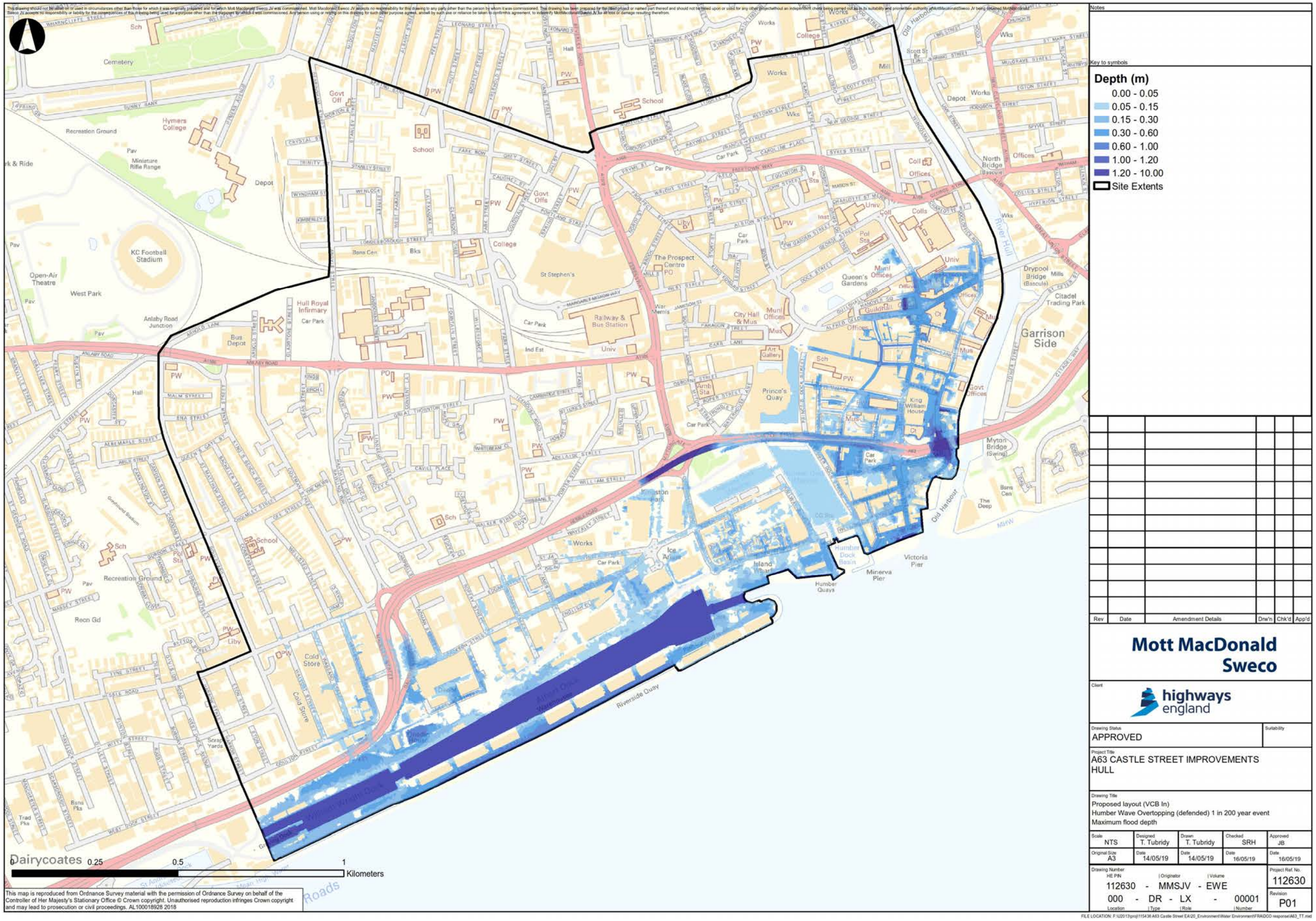


Figure 13.18 1 in 200-year Humber wave overtopping maximum flood depth difference

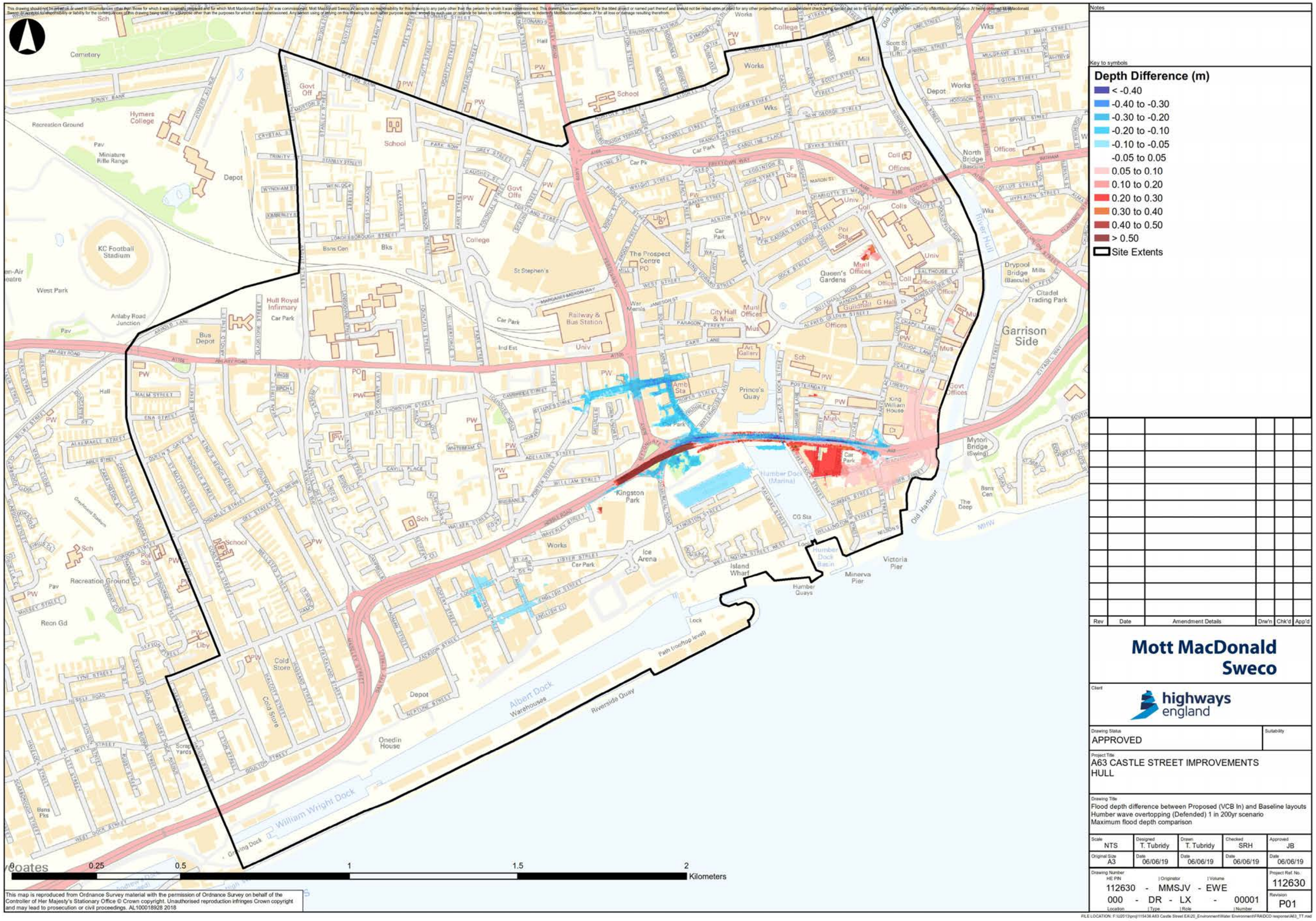


Figure 13.19 1 in 1,000-year Humber wave overtopping maximum flood depth for existing layout

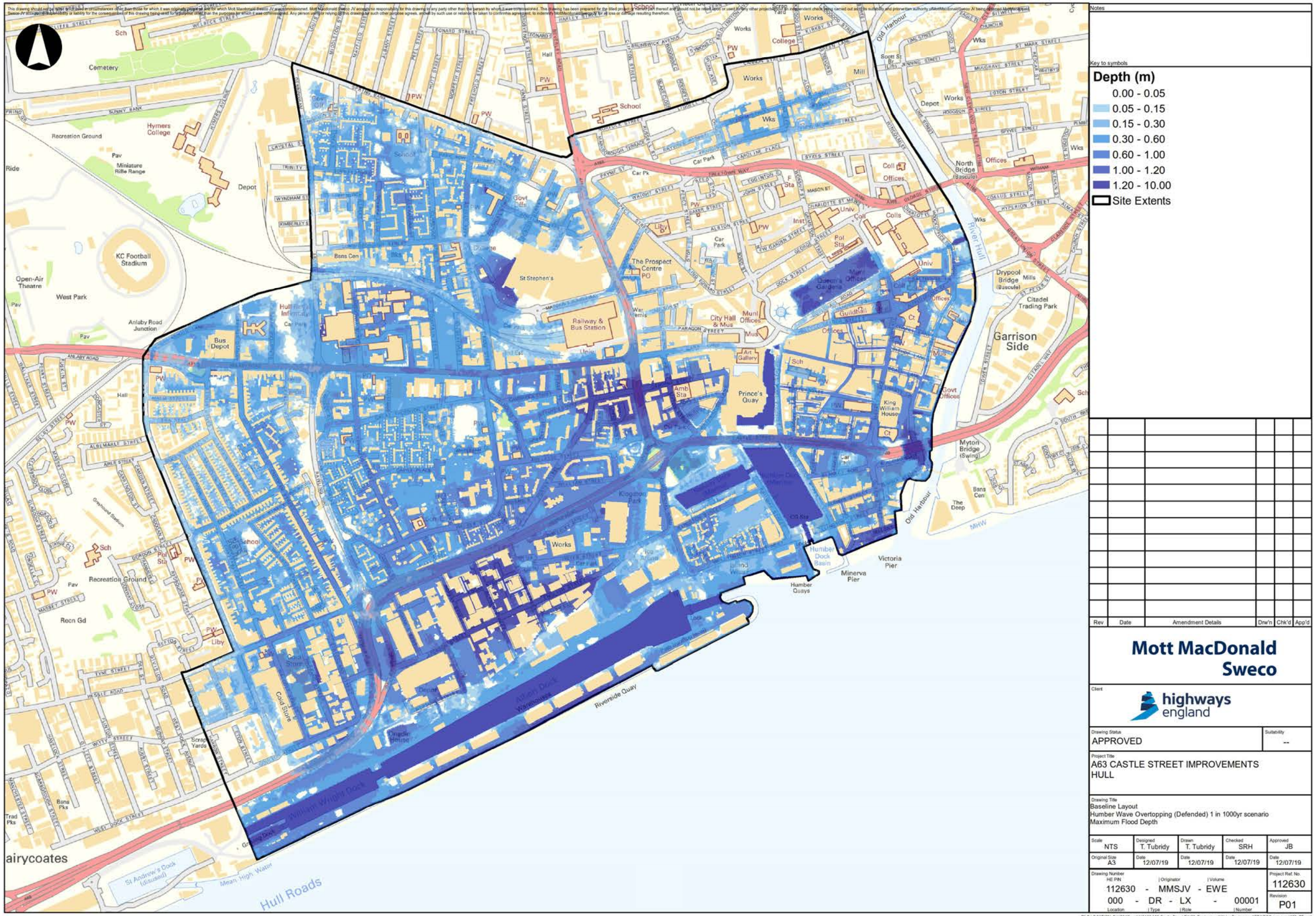


Figure 13.20 1 in 1,000-year Humber wave overtopping maximum flood depth for Scheme layout

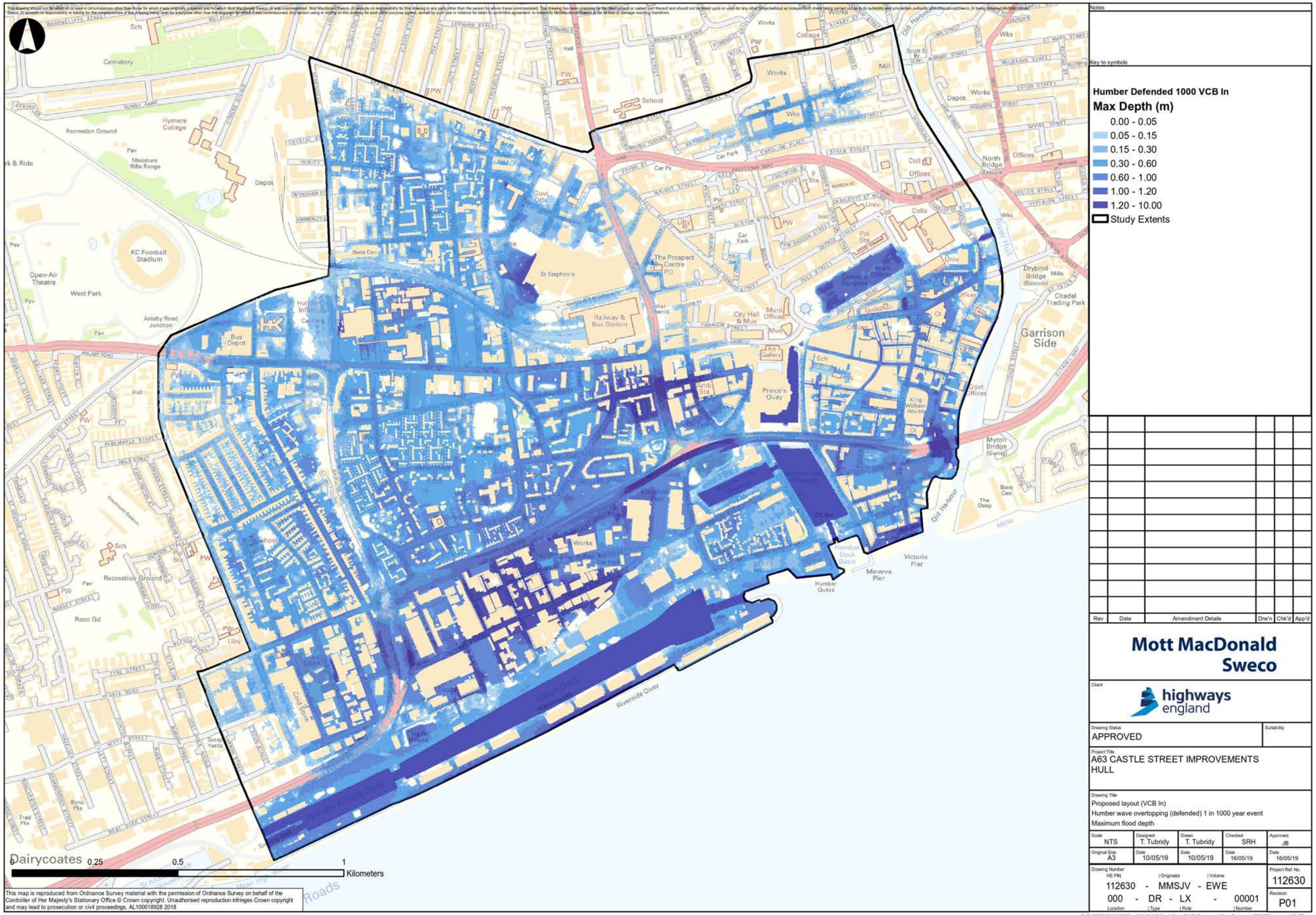


Figure 13.21 1 in 1,000-year Humber wave overtopping maximum flood depth difference

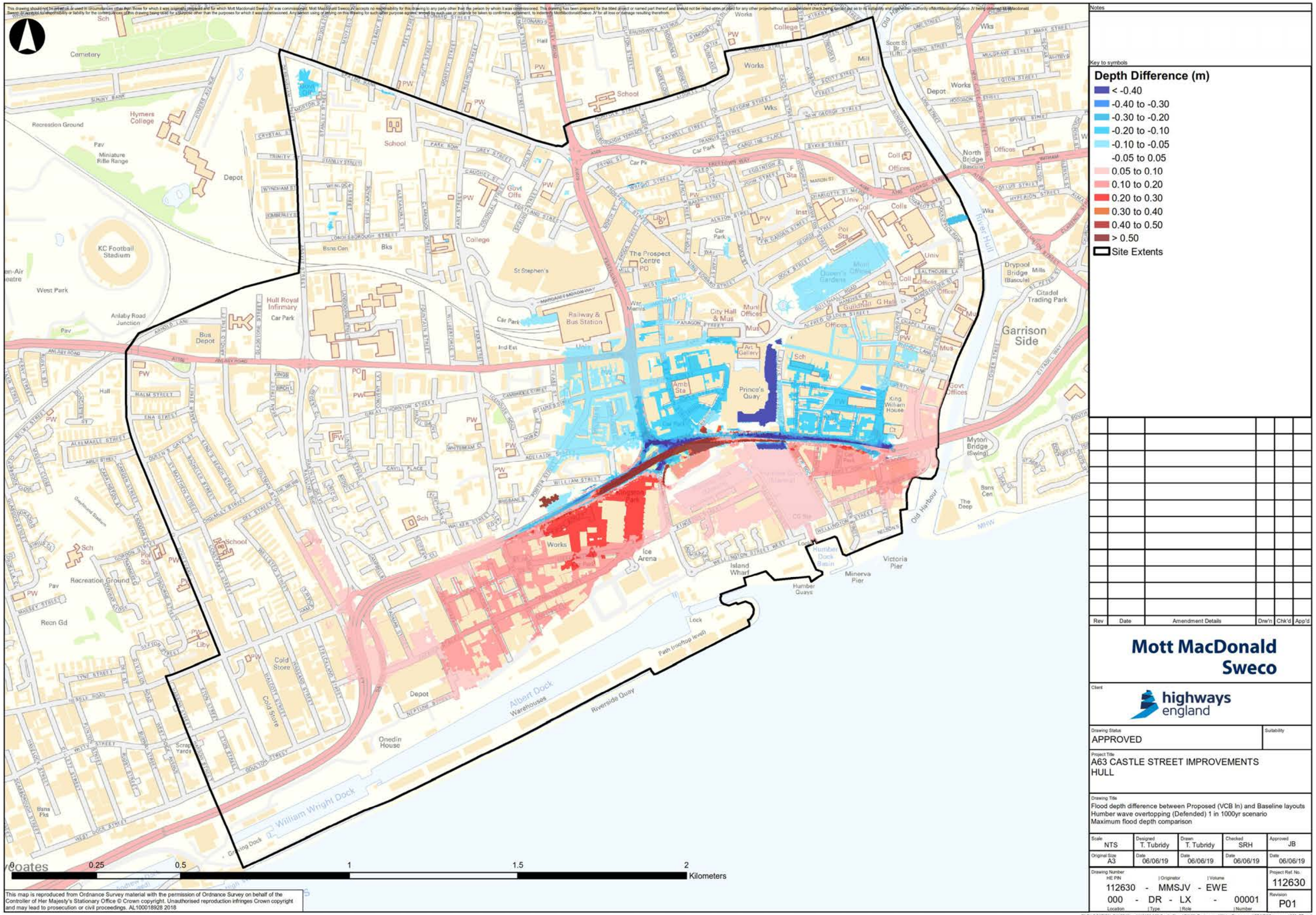


Figure 13.22 1 in 200-year plus Climate Change (2115) Humber wave overtopping maximum depth for existing layout

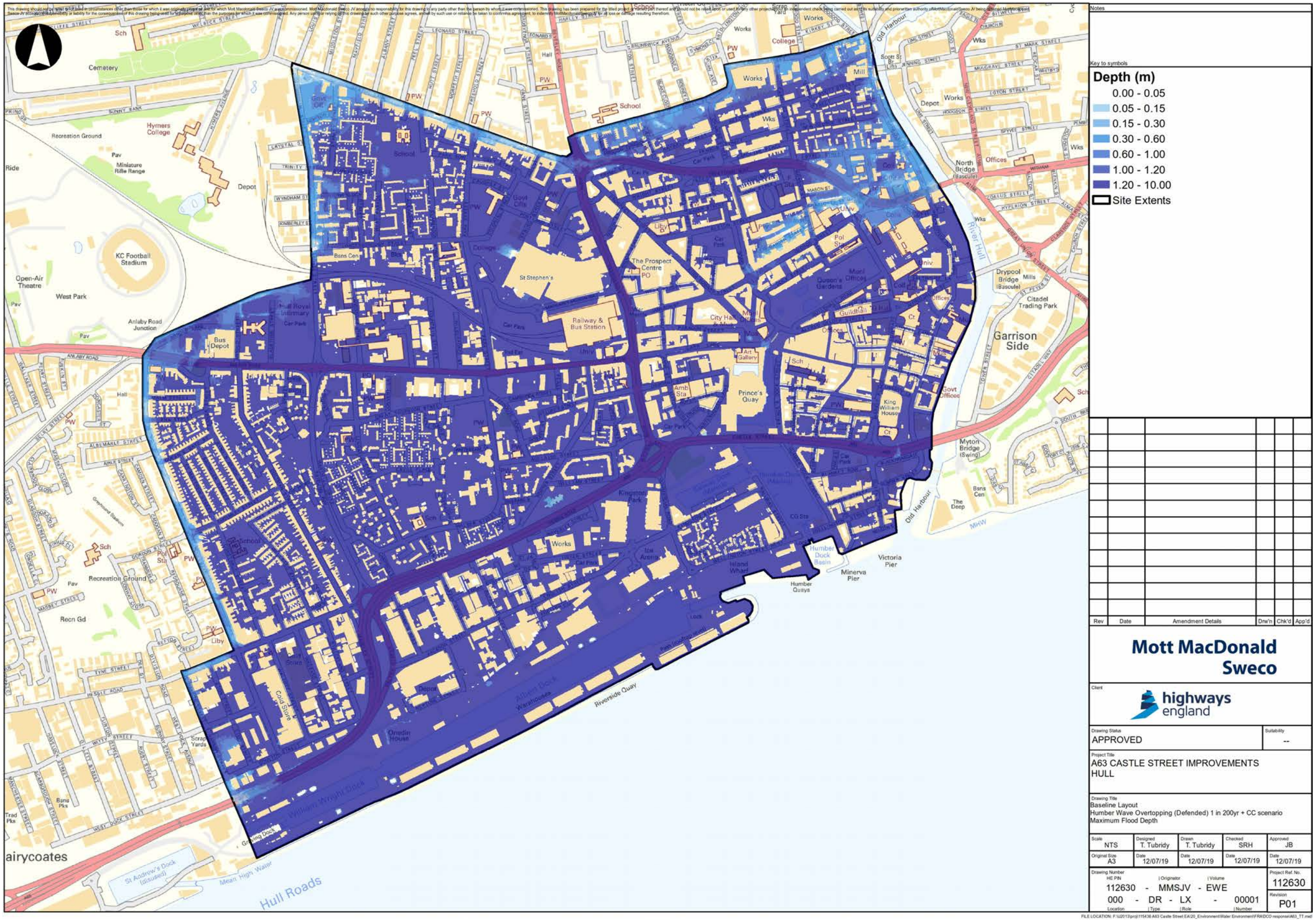


Figure 13.23 1 in 200-year plus climate change (2115) Humber wave overtopping maximum flood depth for Scheme layout

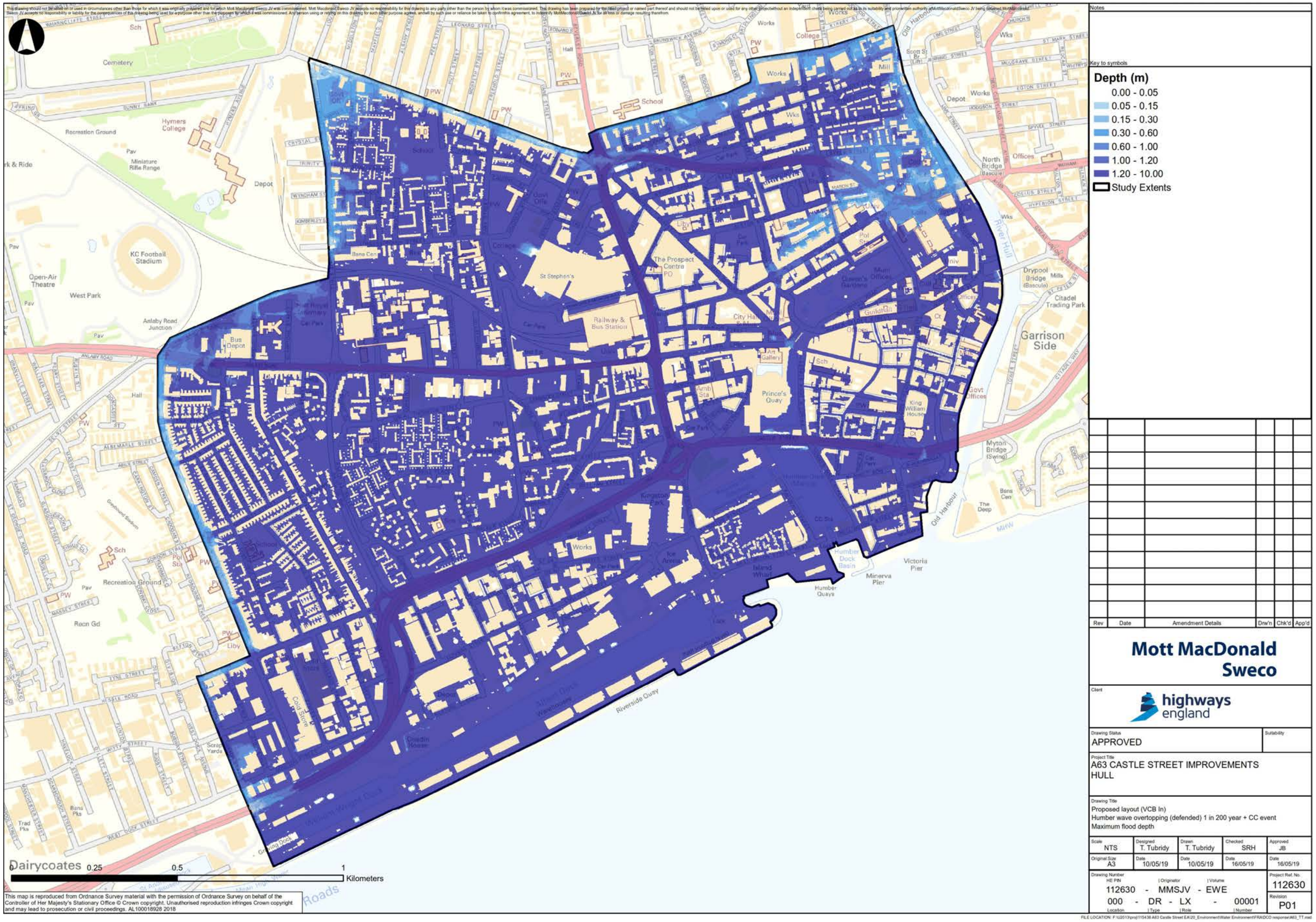


Figure 13.24 1 in 200-year plus climate change (2115) Humber wave overtopping maximum flood depth difference

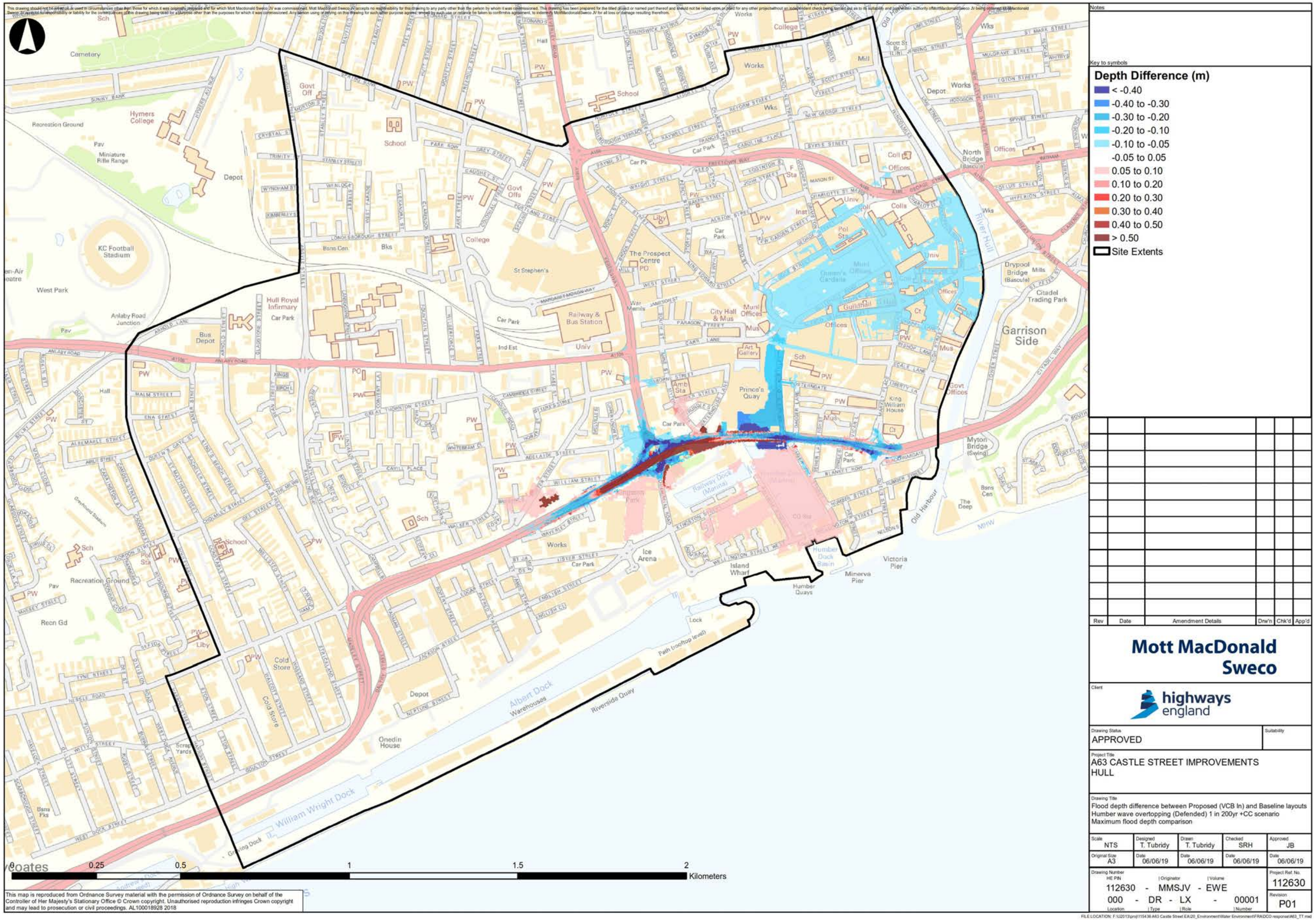


Figure 13.25 1 in 200-year Humber wave overtopping maximum flood hazard rating for existing layout

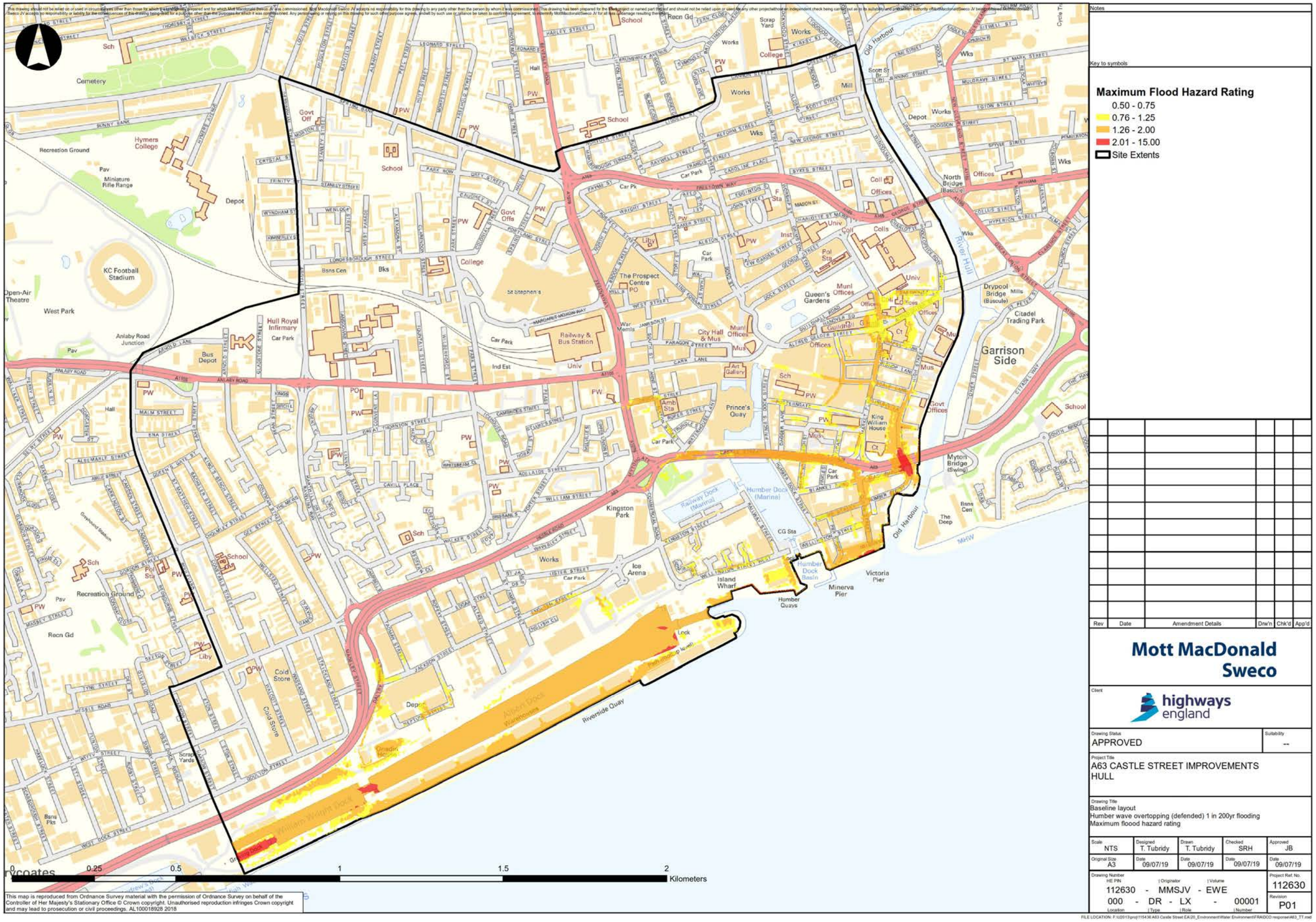


Figure 13.26 1 in 200-year Humber wave overtopping maximum flood hazard rating for Scheme layout

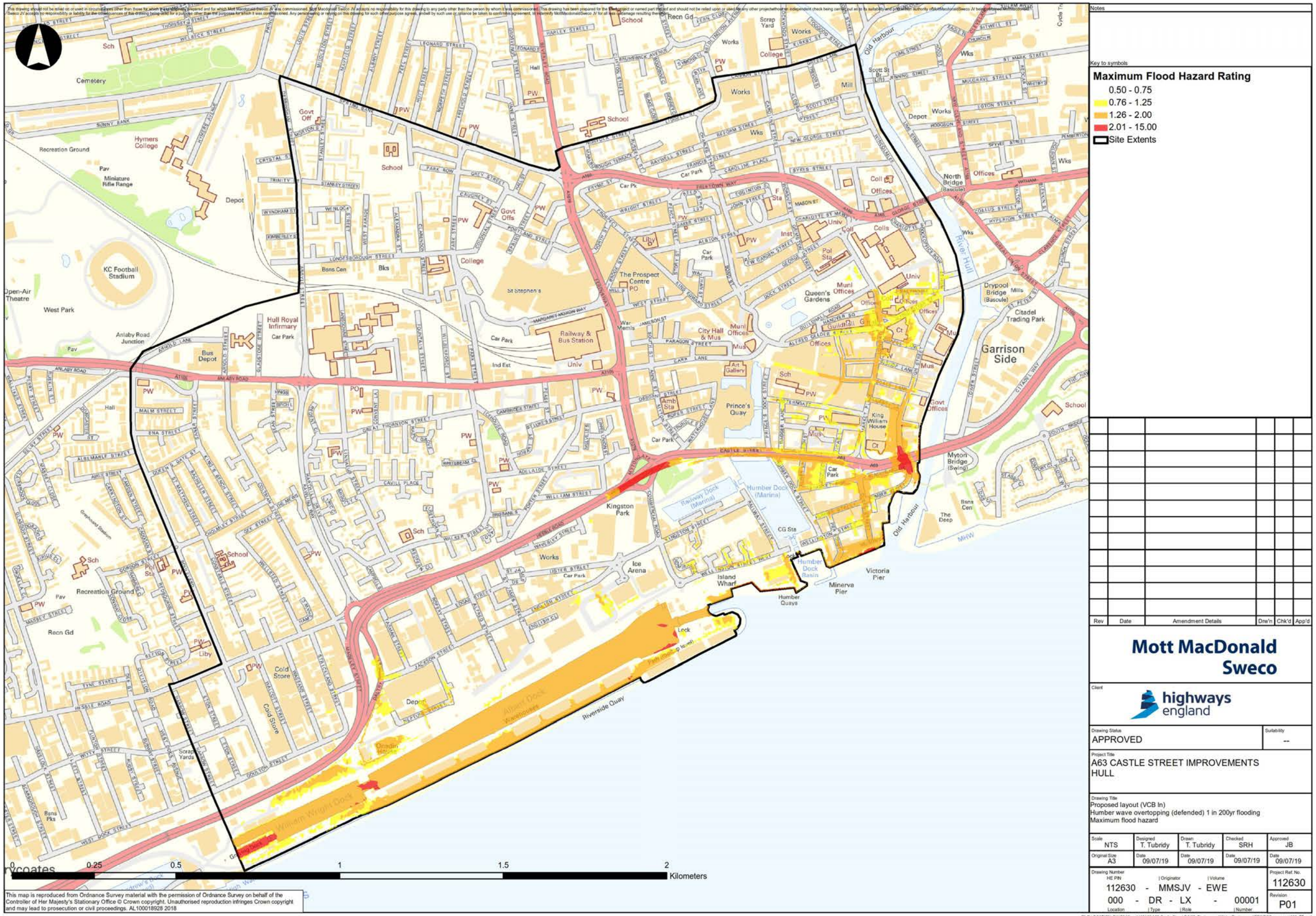


Figure 13.27 1 in 1,000-year Humber wave overtopping maximum flood hazard rating for existing layout

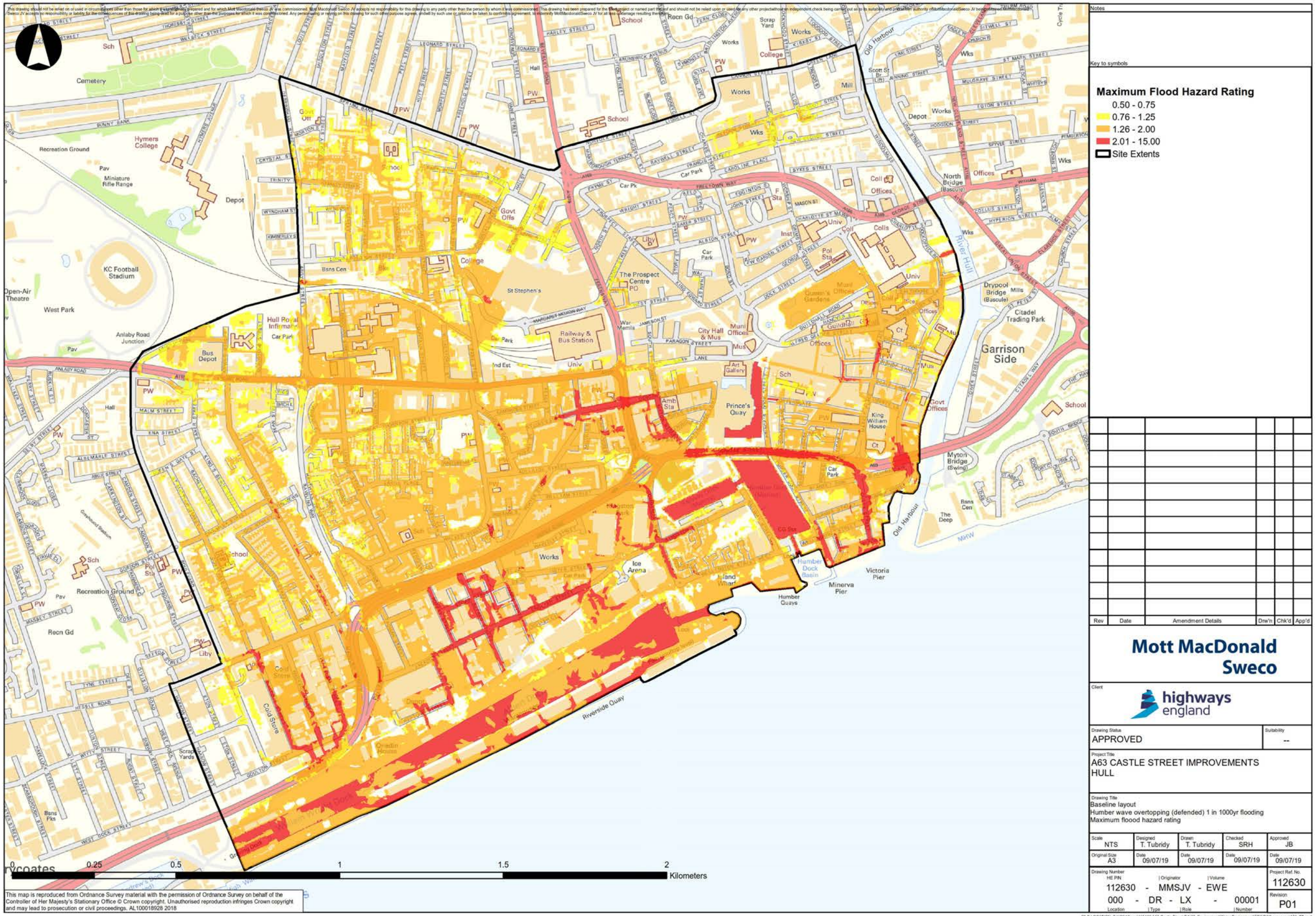


Figure 13.28 1 in 1,000-year Humber wave overtopping maximum flood hazard rating for Scheme layout

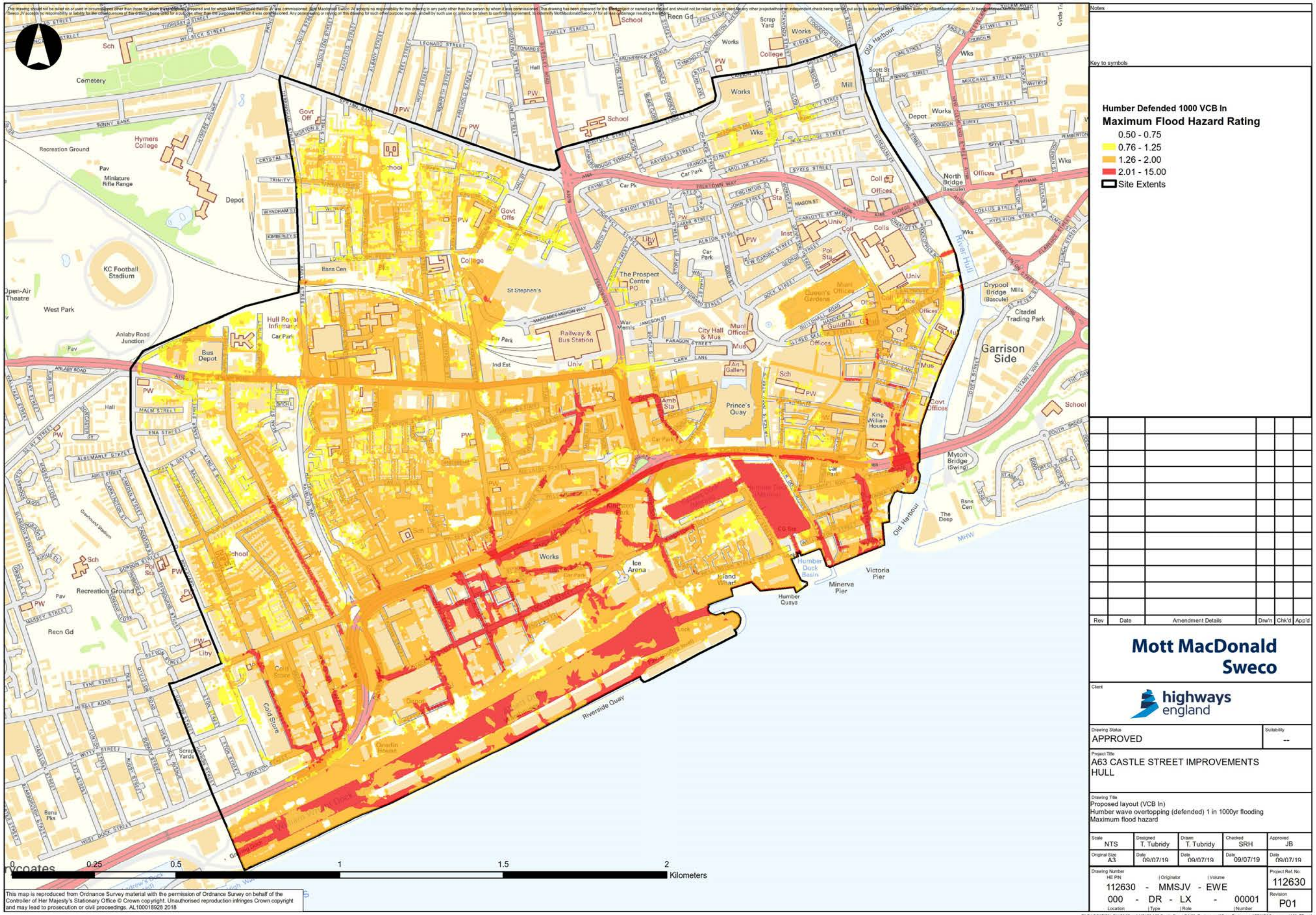


Figure 13.29 1 in 200-year plus climate change (2115) Humber wave overtopping maximum flood hazard rating for existing layout

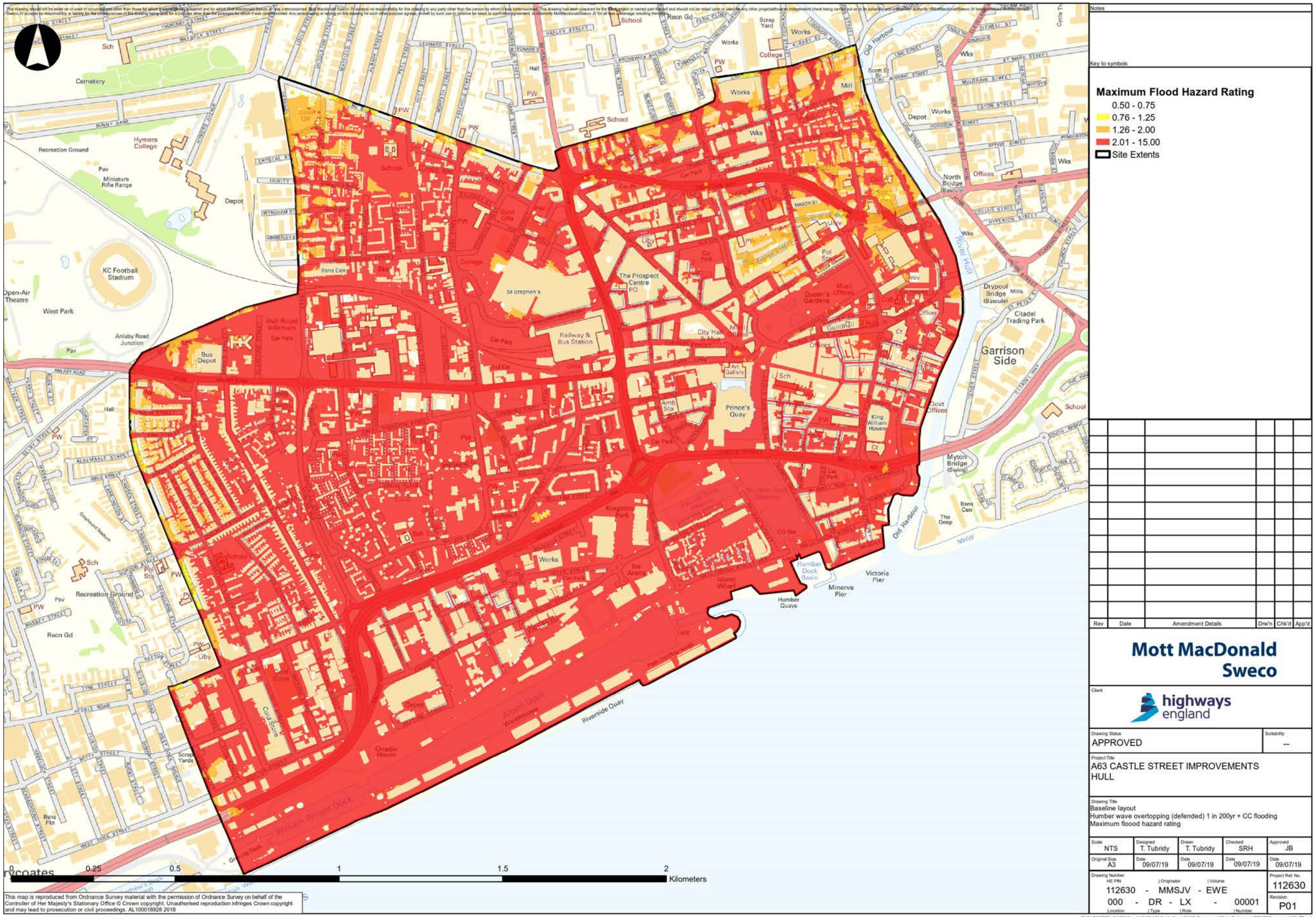


Figure 13.30 1 in 200-year plus climate change (2115) Humber wave overtopping maximum flood hazard rating for Scheme layout

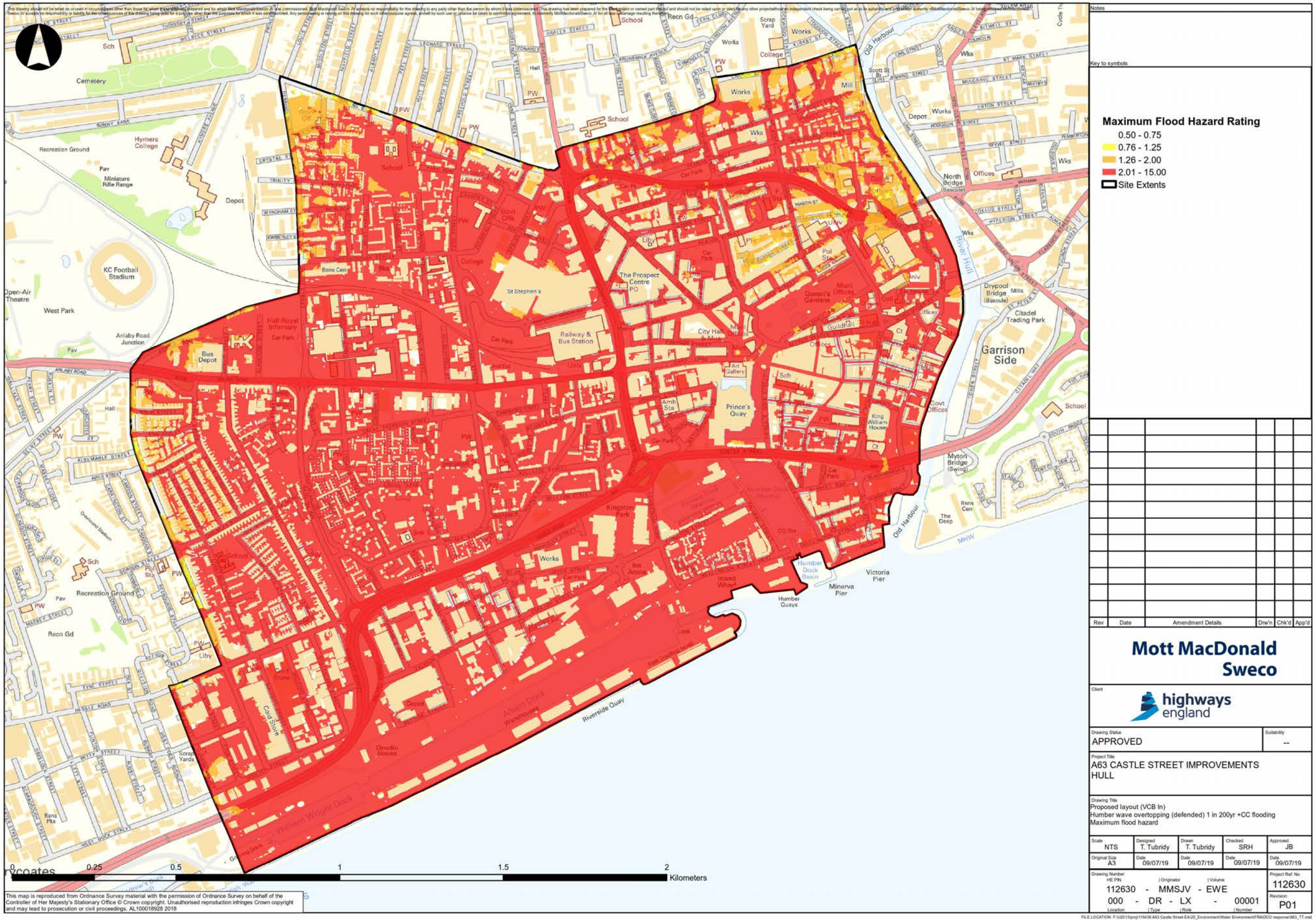


Figure 13.31 1 in 200-year Humber undefended tidal flooding maximum flood depth for existing layout

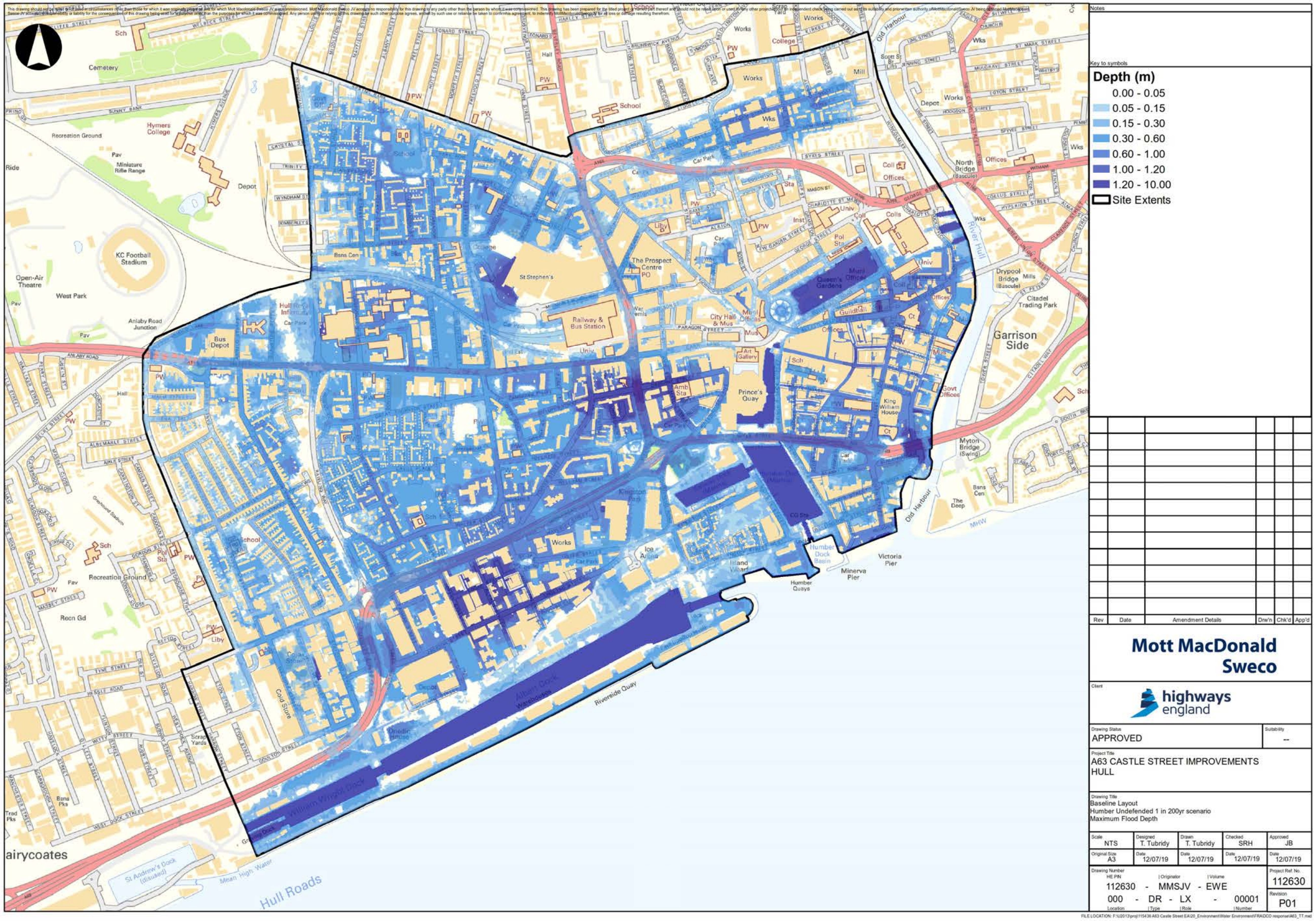


Figure 13.32 1 in 200-year Humber undefended tidal flooding maximum flood depth for Scheme layout

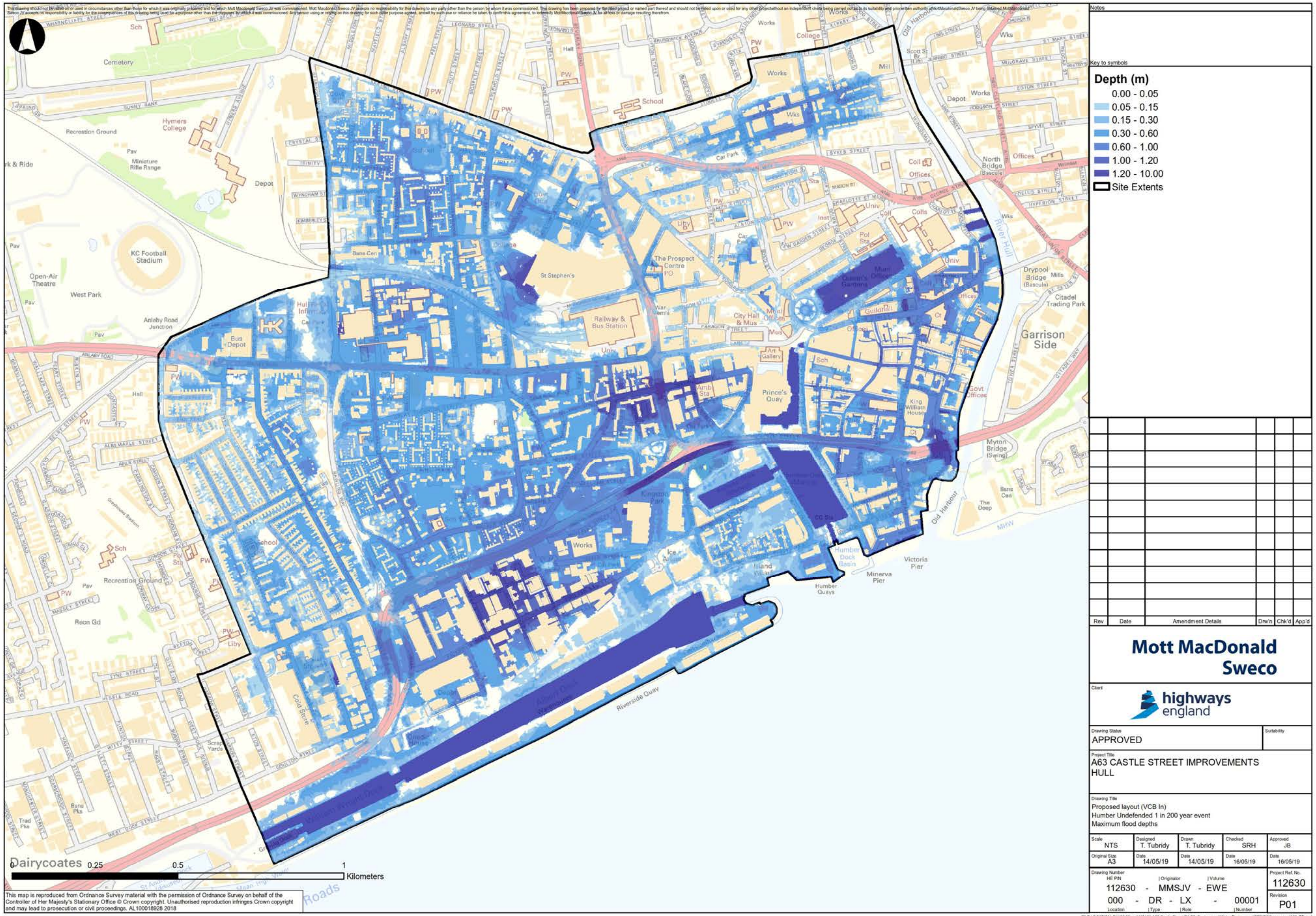


Figure 13.33 1 in 200-year Humber undefended tidal flooding maximum flood depth difference

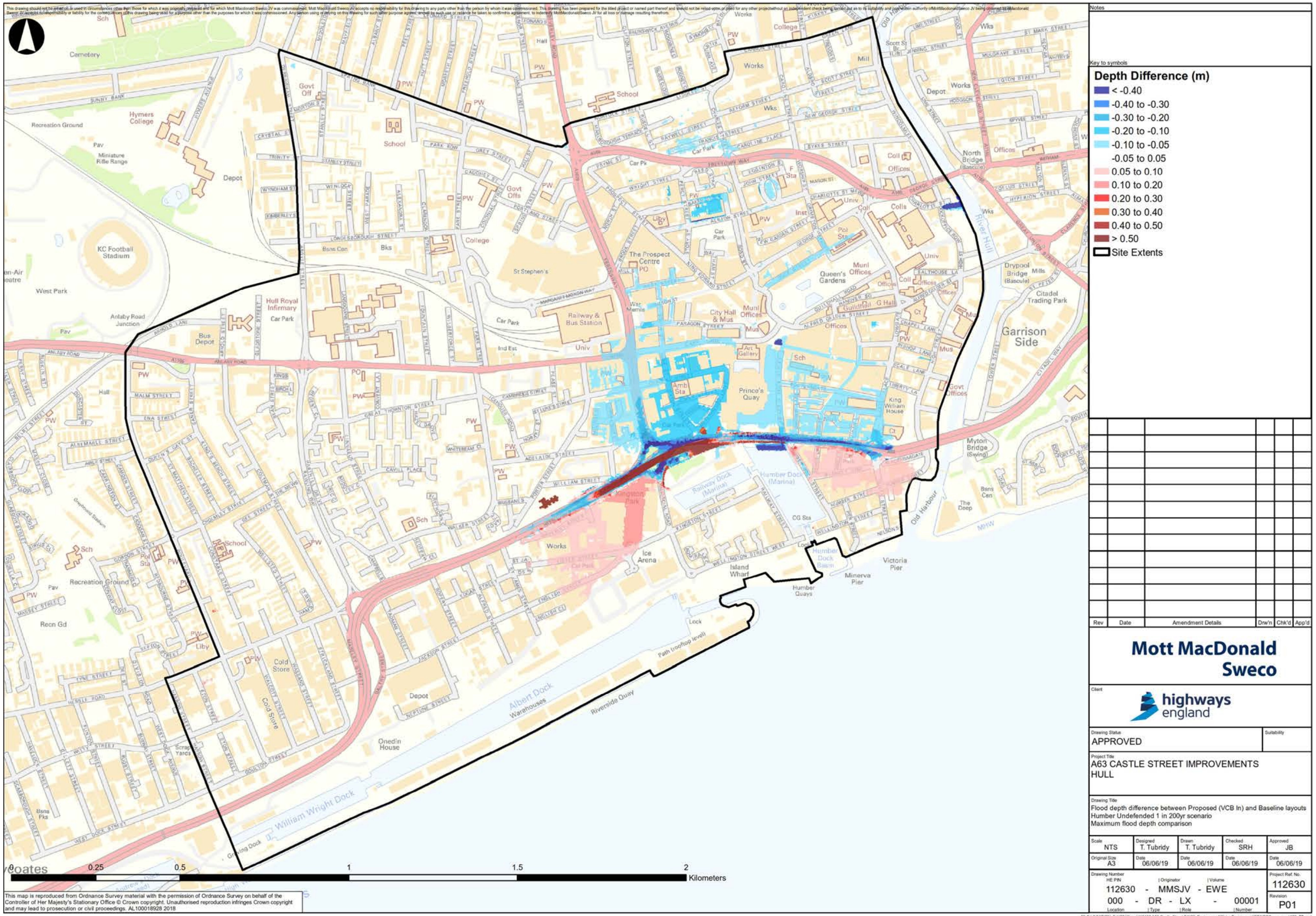


Figure 13.34 1 in 200-year plus climate change (2115) Humber undefended tidal flooding maximum flood depth for existing layout

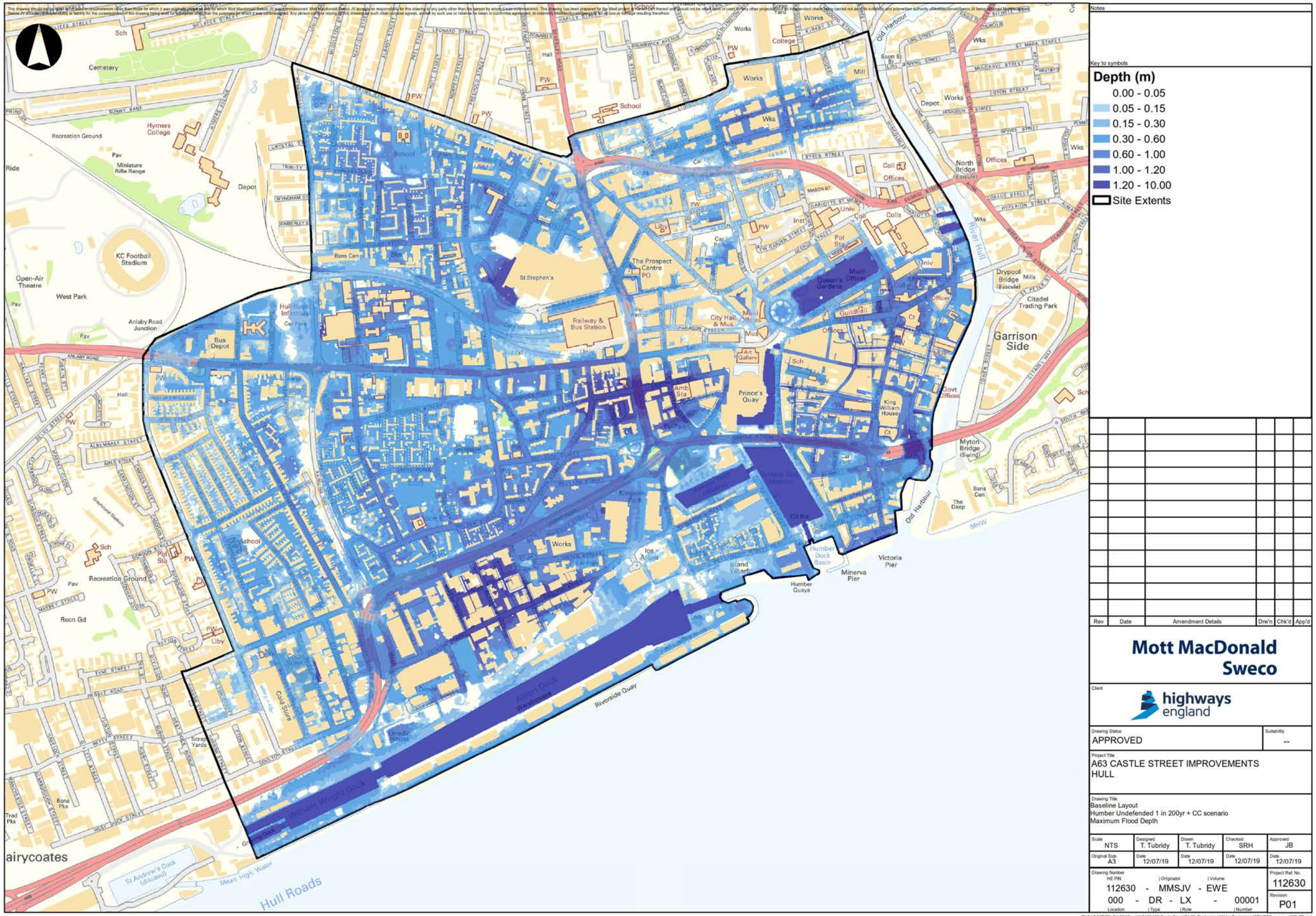


Figure 13.35 1 in 200-year plus climate change (2115) Humber undefended tidal flooding maximum flood depth for Scheme layout

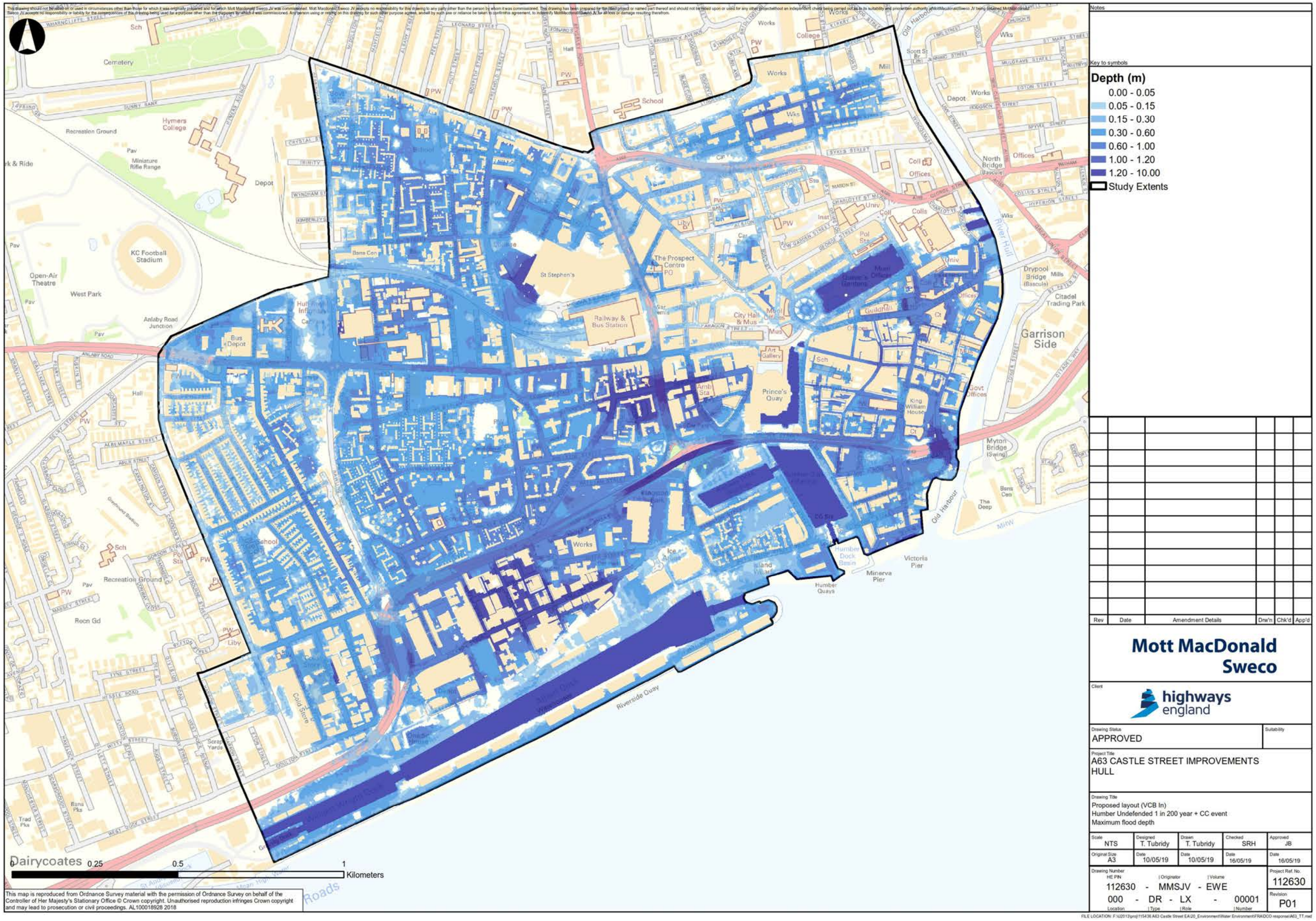


Figure 13.36 1 in 200-year plus climate change (2115) Humber undefended tidal flooding maximum flood depth difference

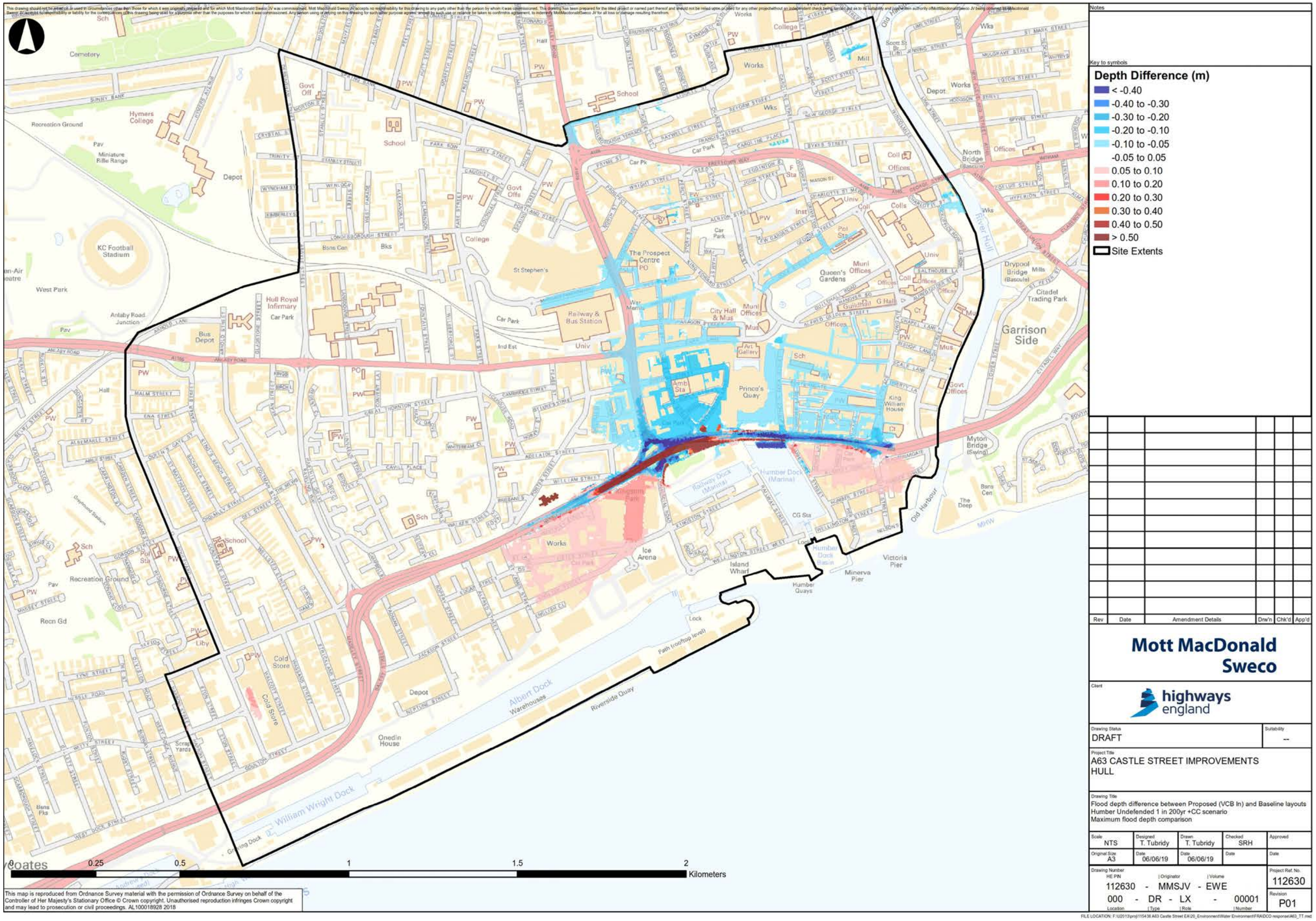


Figure 13.37 1 in 200-year Humber undefended tidal flooding maximum flood hazard rating for existing layout

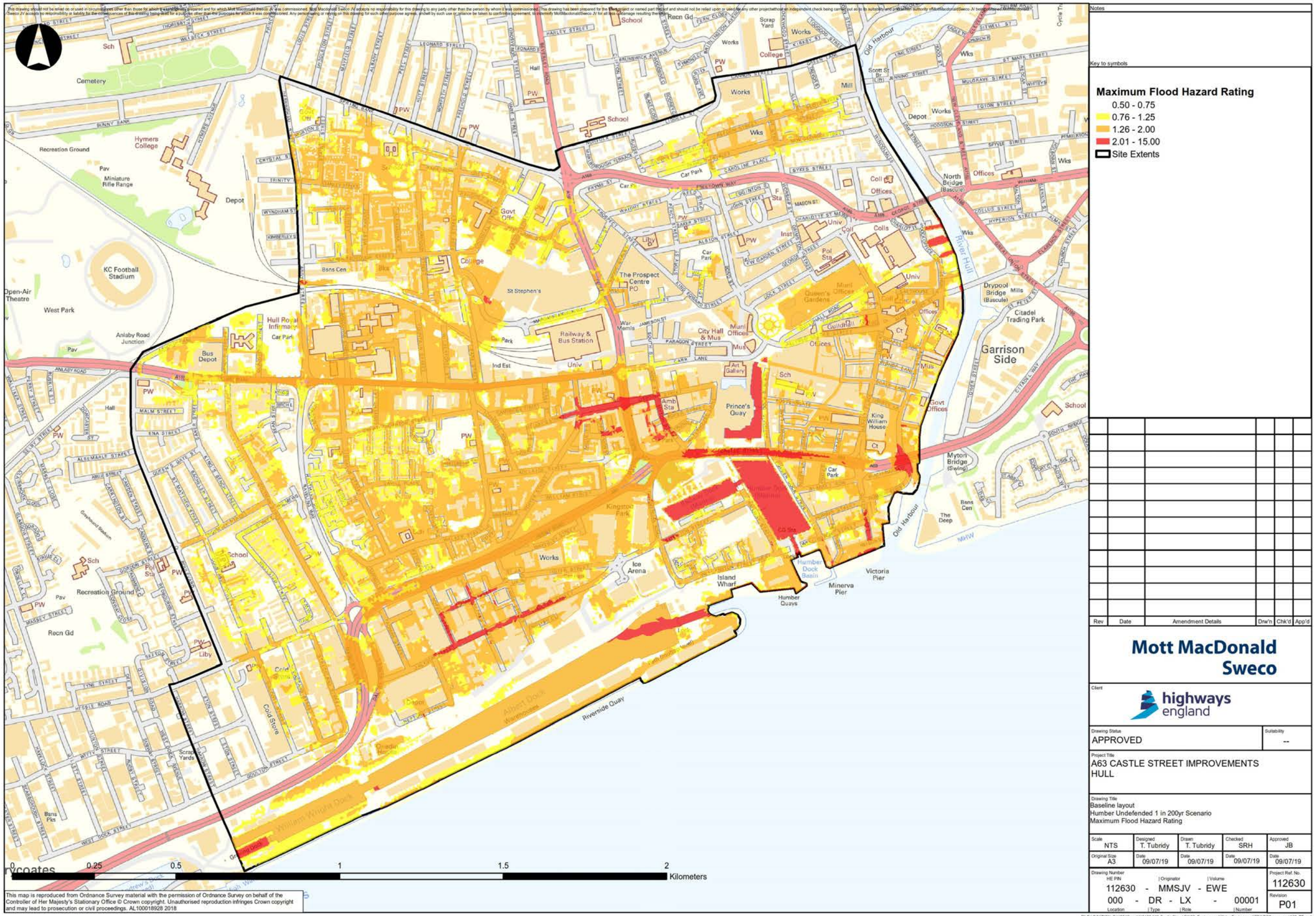


Figure 13.38 1 in 200-year Humber undefended tidal flooding maximum flood hazard rating for Scheme layout

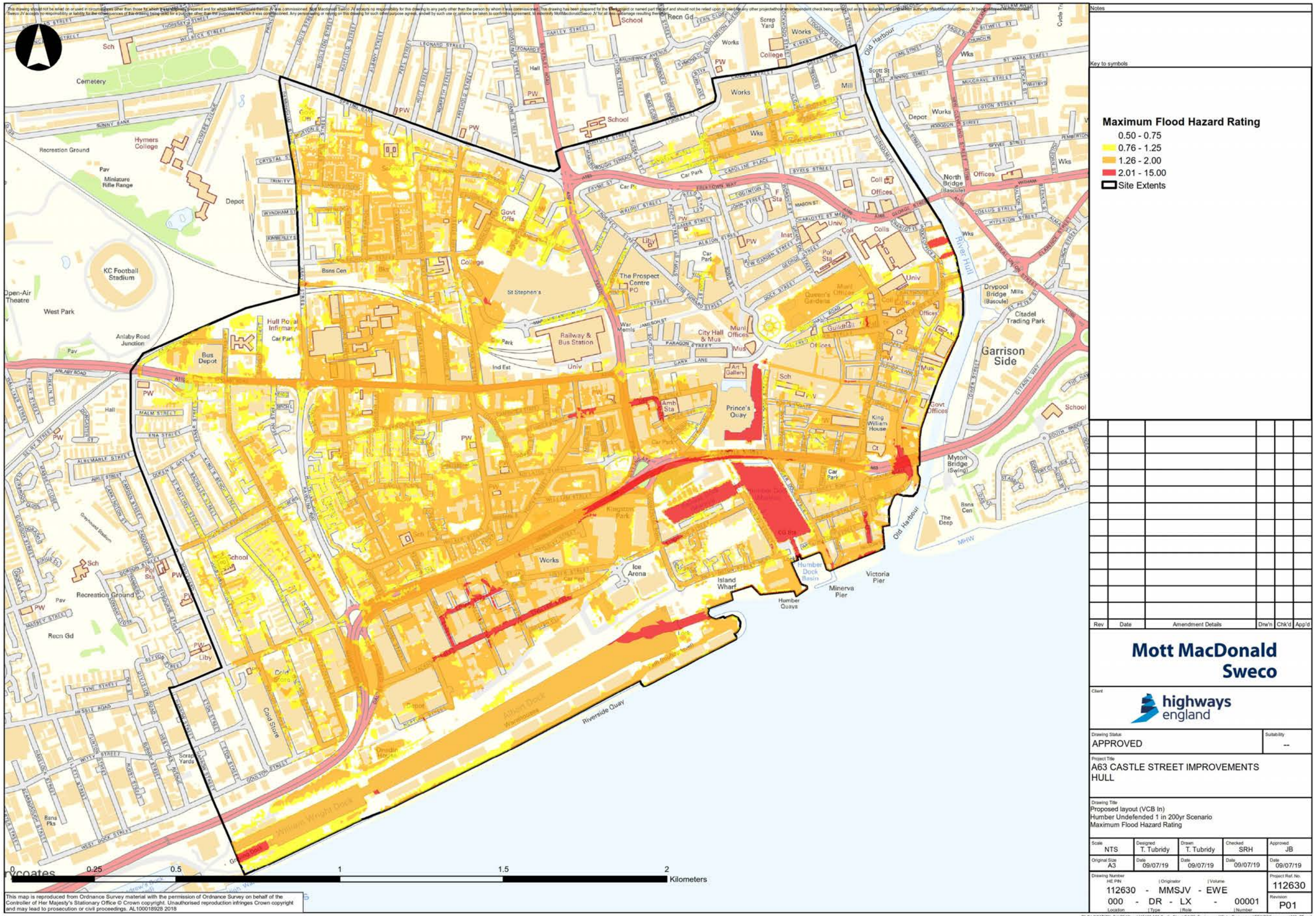


Figure 13.39 1 in 200-year plus climate change (2115) Humber undefended tidal flooding maximum flooding hazard rating for existing layout

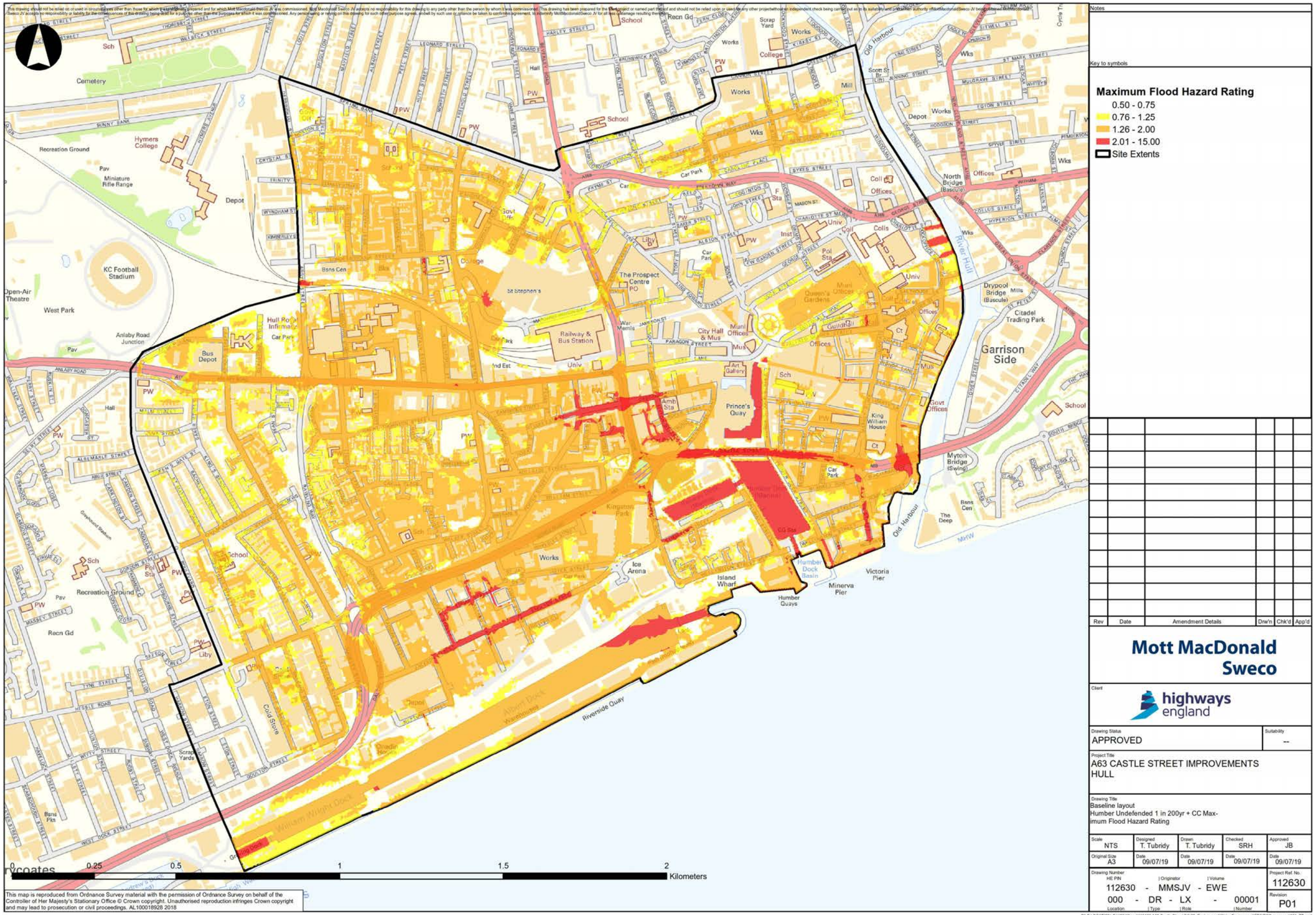


Figure 13.40 1 in 200-year plus climate change (2115) Humber undefended tidal flooding maximum flood hazard rating for Scheme layout

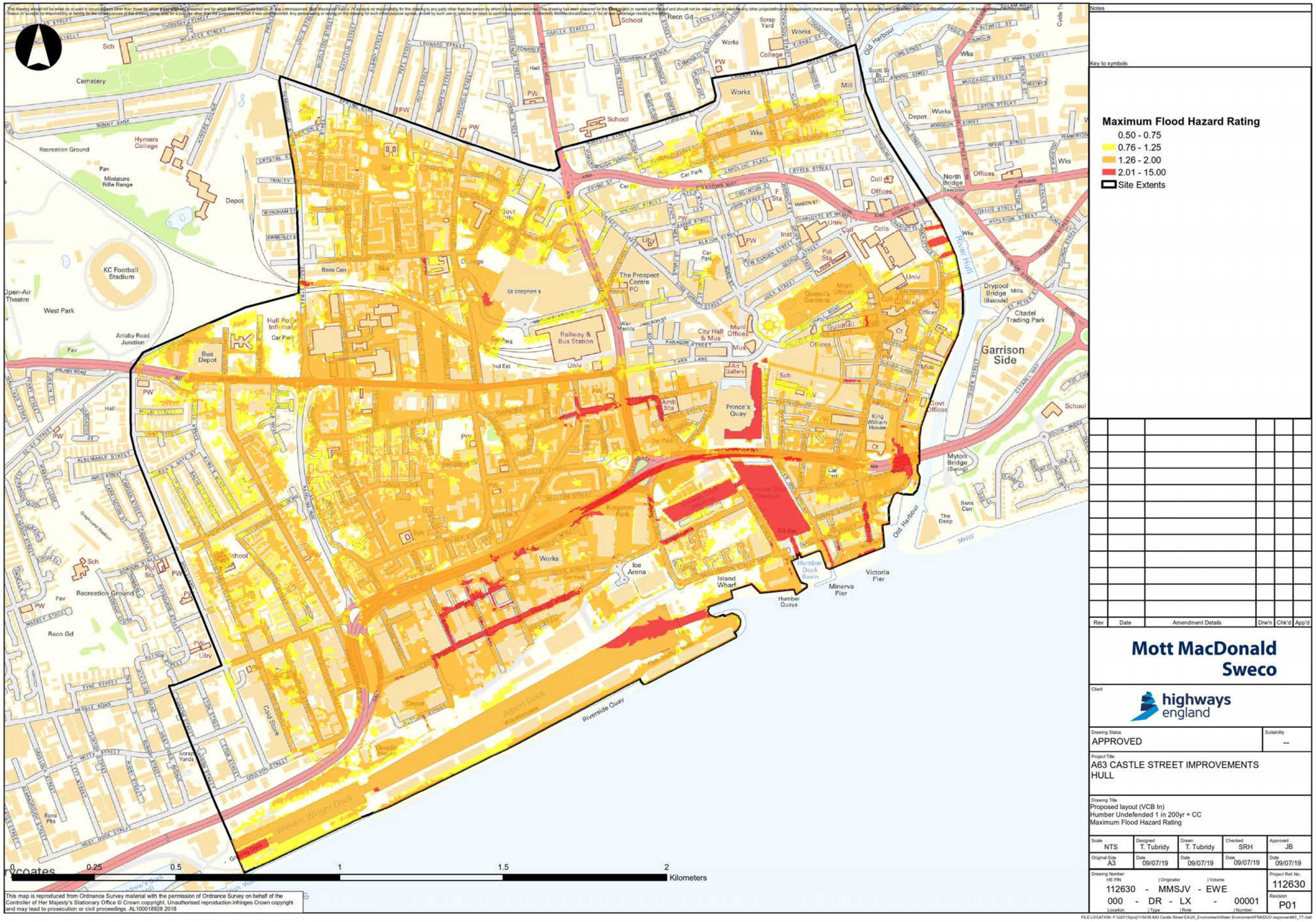


Figure 13.41 1 in 200-year River Hull tidal flooding maximum flood depth for existing layout (Hull Tidal Surge Barrier open)

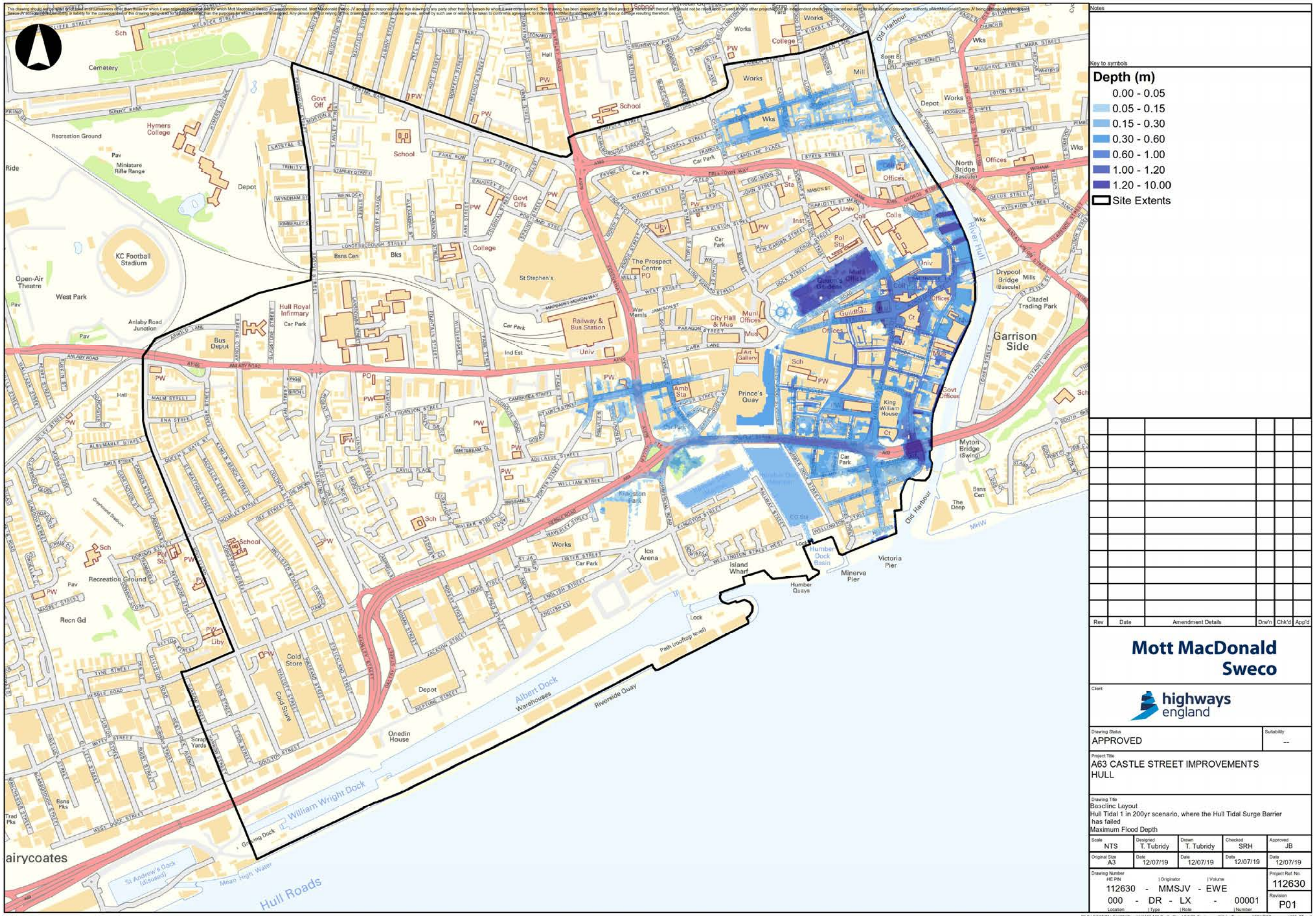


Figure 13.42 1 in 200-year River Hull tidal flooding maximum flood depth for Scheme layout (Hull Tidal Surge Barrier open)

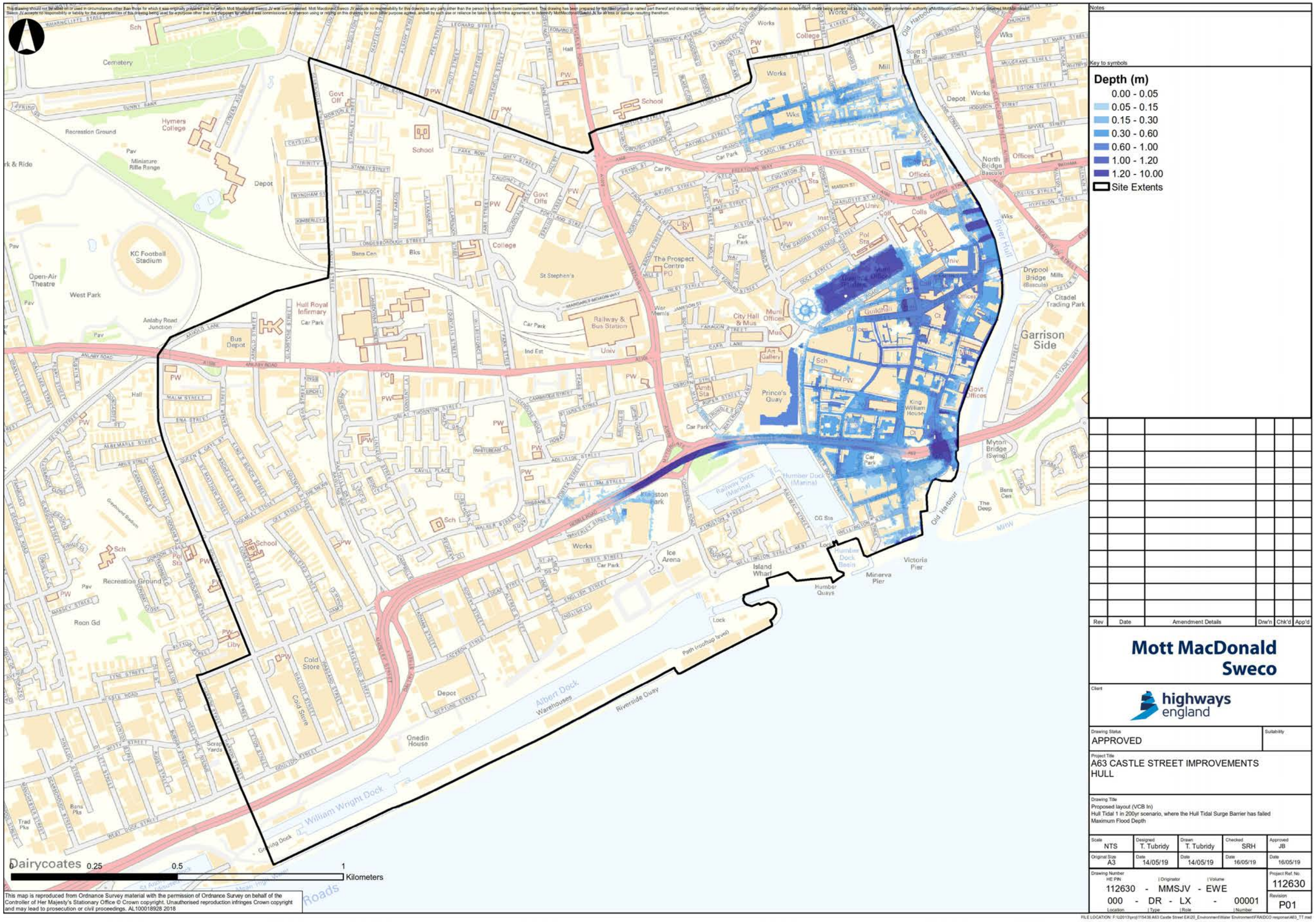


Figure 13.43 1 in 200-year River Hull tidal flooding maximum flood depth difference (Hull Tidal Surge Barrier open)

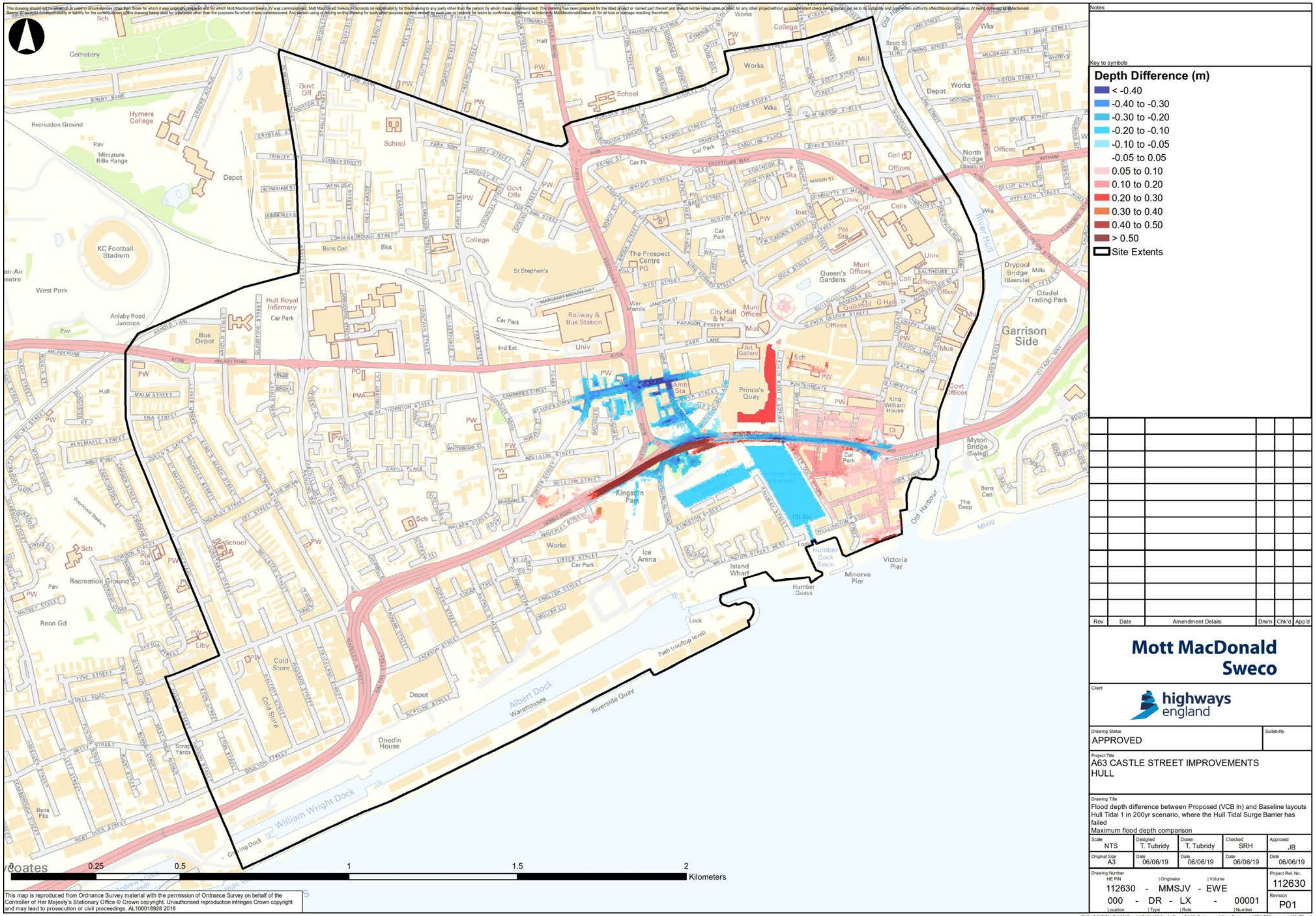


Figure 13.44 1 in 1000-year River Hull tidal flooding maximum flood depth for existing layout (Hull Tidal Surge Barrier open)

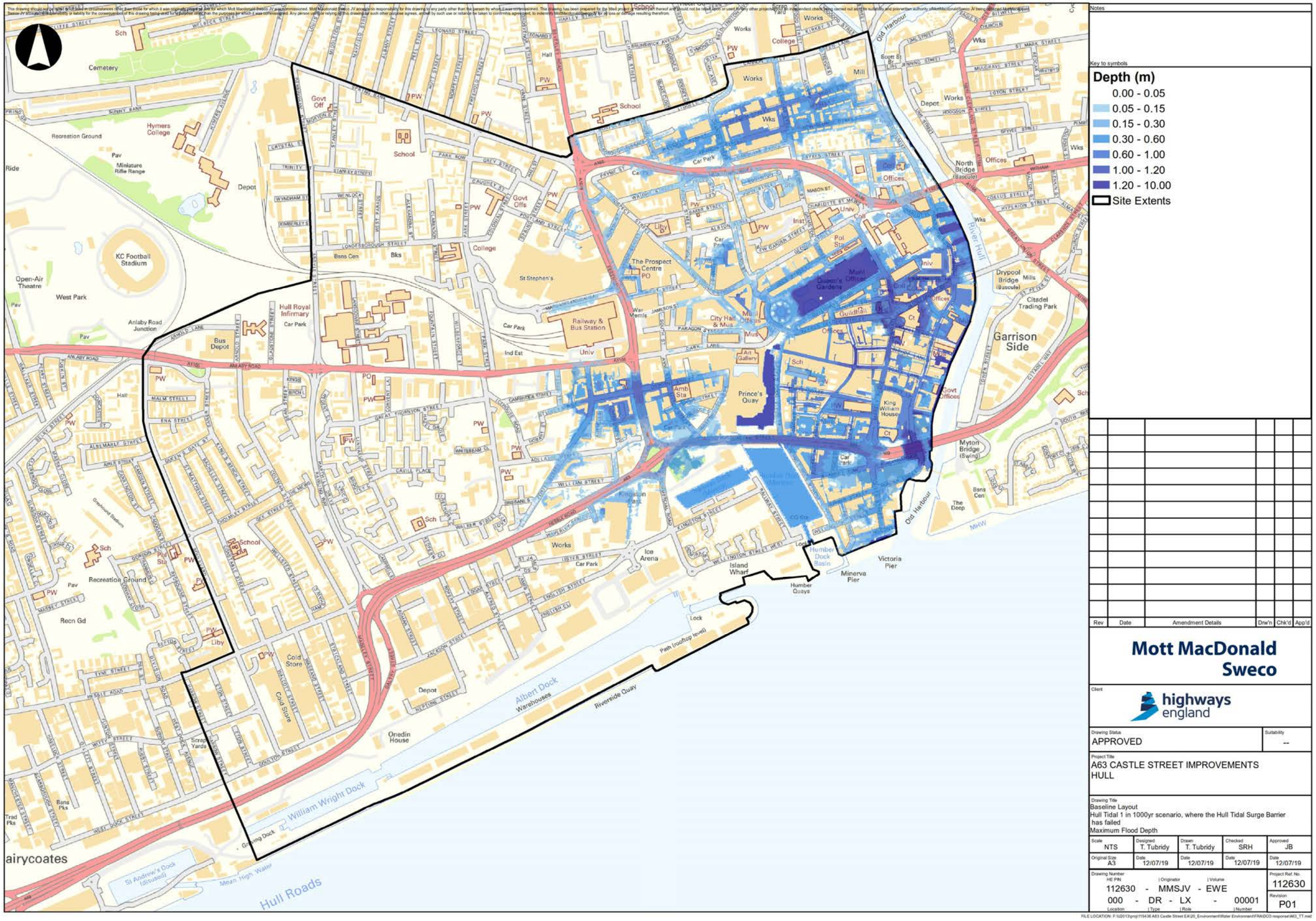


Figure 13.45 1 in 1000-year River Hull tidal flooding maximum flood depth for Scheme layout (Hull Tidal Surge Barrier open)

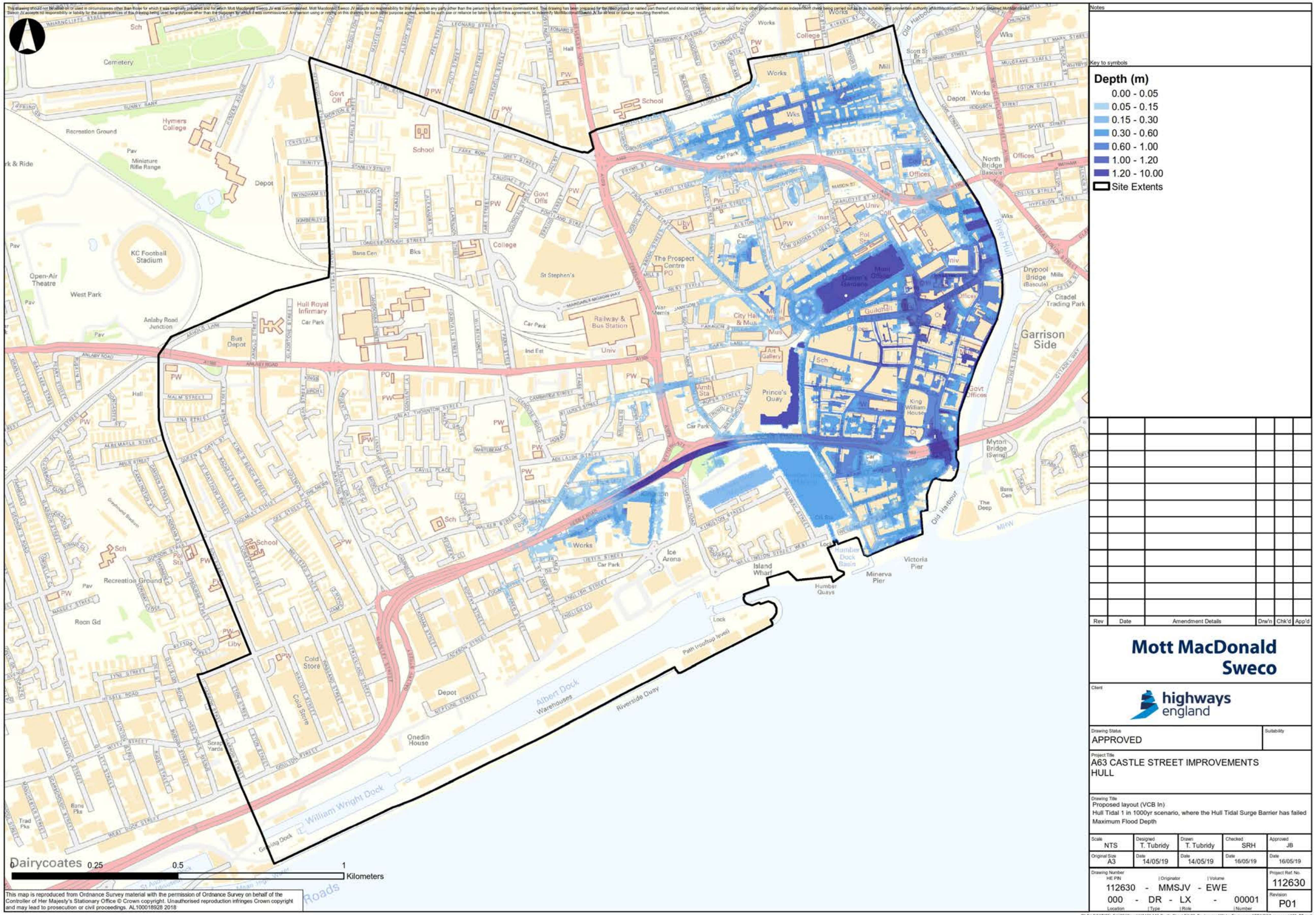


Figure 13.46 1 in 1000-year River Hull tidal flooding maximum flood depth difference (Hull Tidal Surge Barrier open)

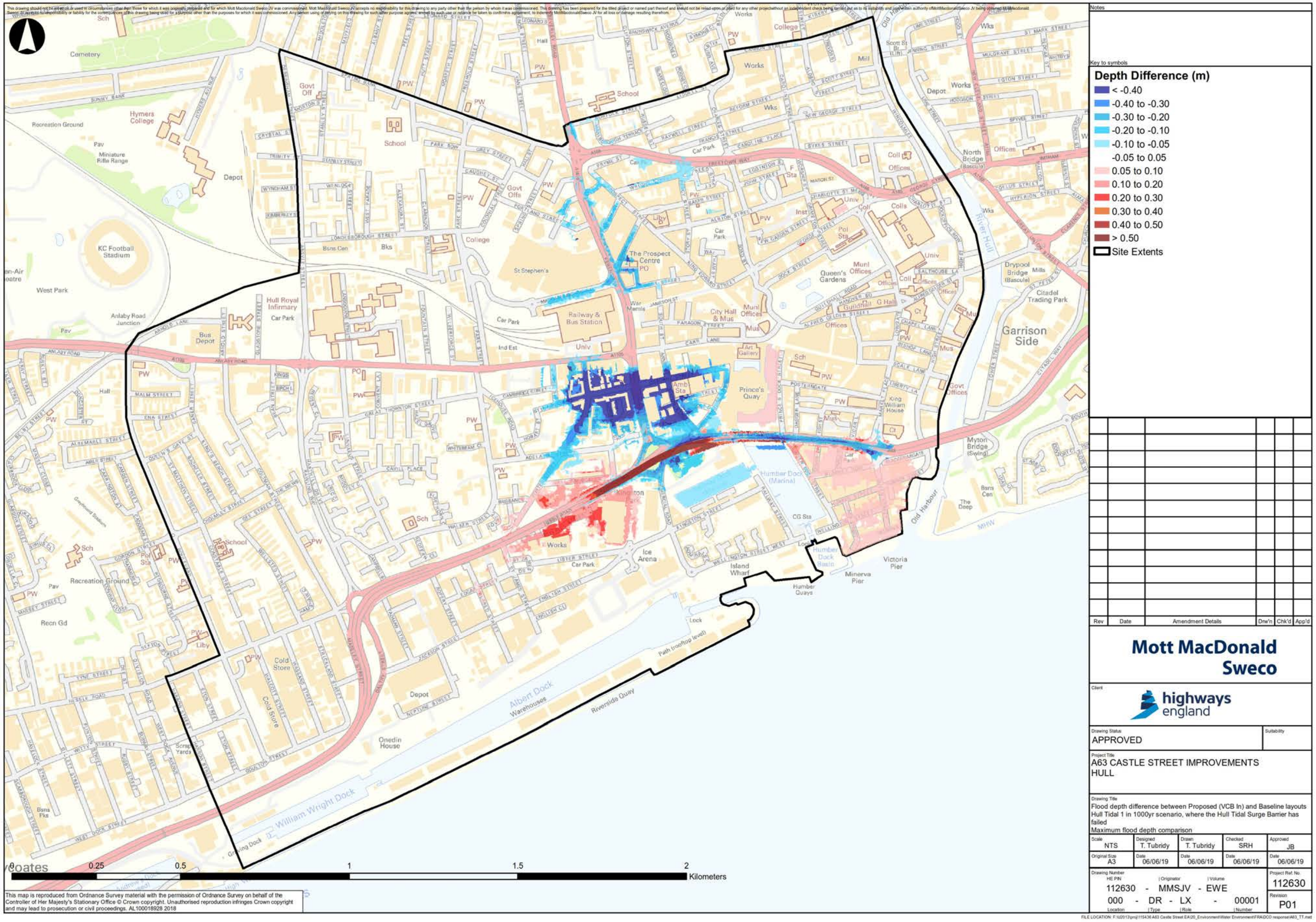


Figure 13.47 1 in 200-year River Hull tidal flooding maximum flood hazard rating for existing layout (Hull Tidal Surge Barrier open)

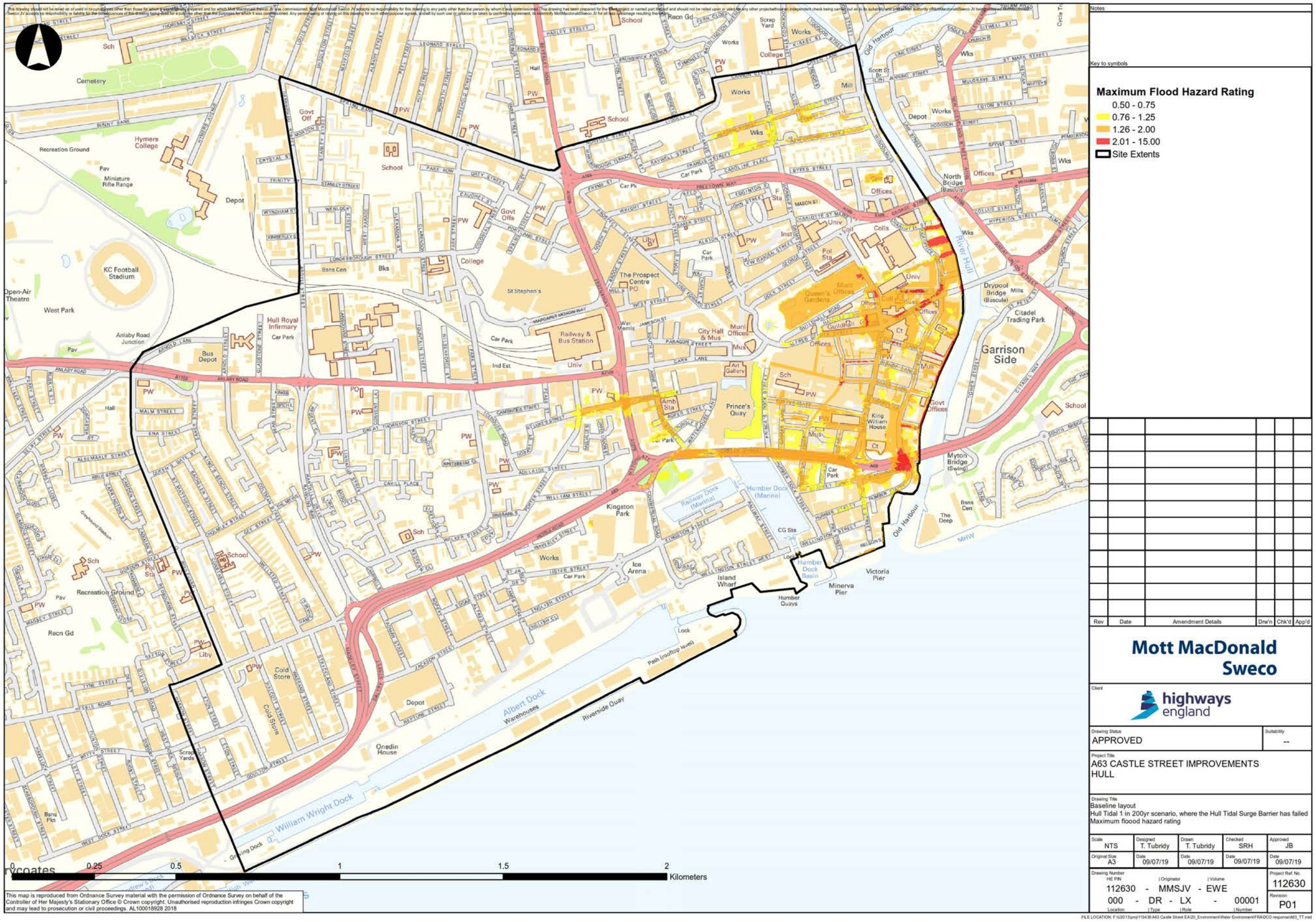


Figure 13.48 1 in 200-year River Hull tidal flooding maximum flood hazard rating for Scheme layout (Hull Tidal Surge Barrier open)

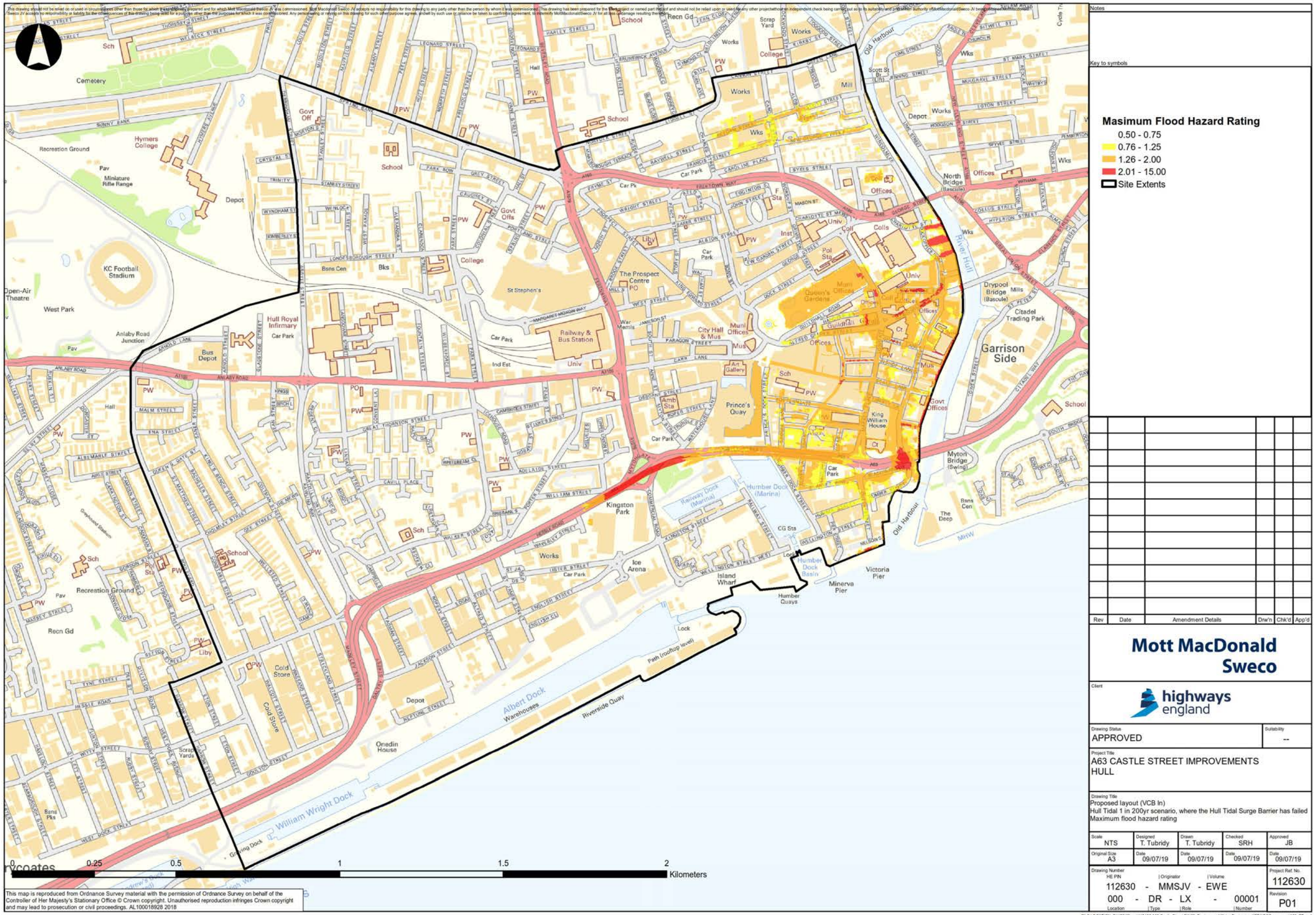


Figure 13.49 1 in 1000-year River Hull tidal flooding maximum flood hazard rating for existing layout (Hull Tidal Surge Barrier open)

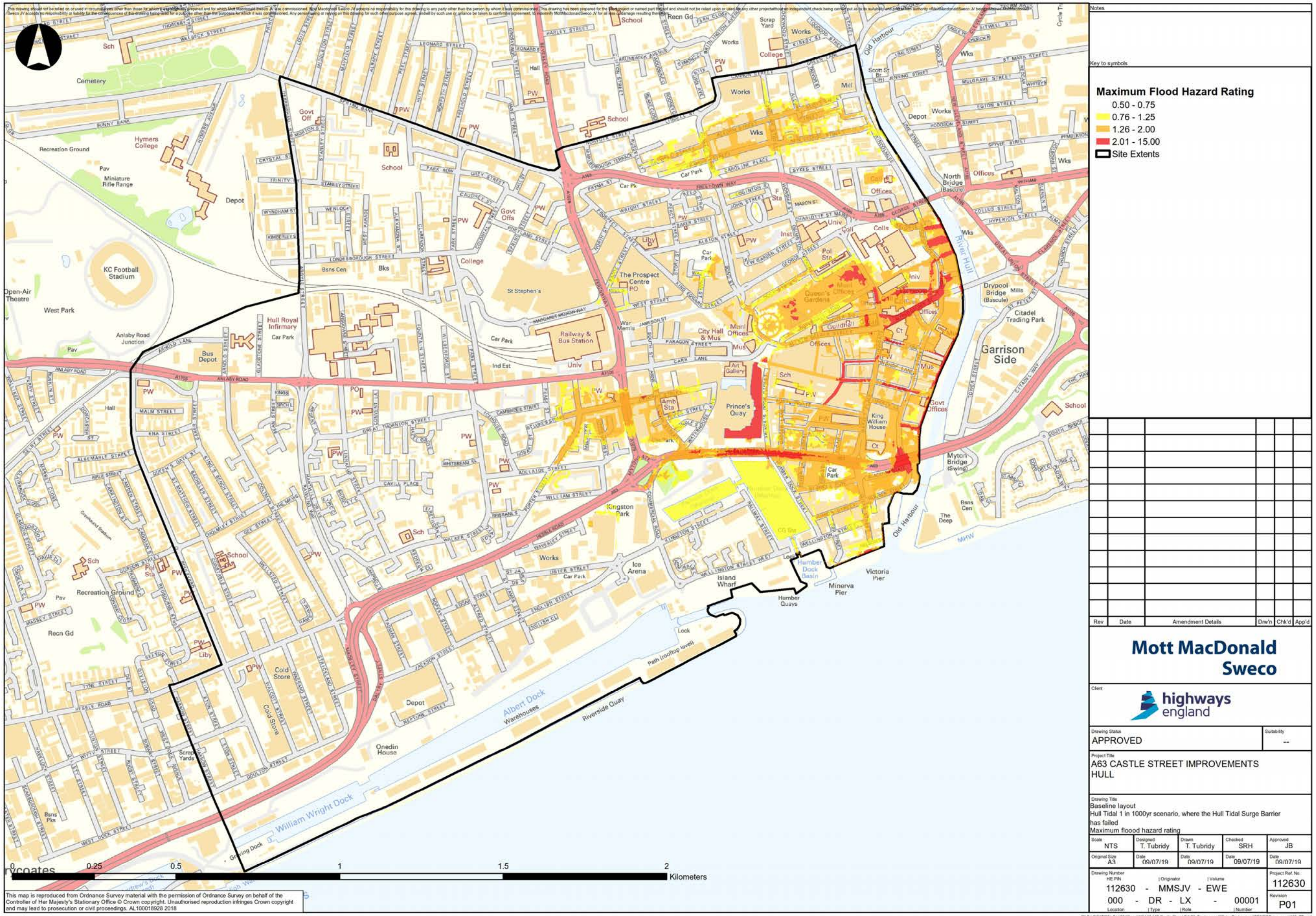


Figure 13.50 1 in 1,000-year River Hull tidal flooding maximum flood hazard rating for Scheme layout (Hull Tidal Surge Barrier open)

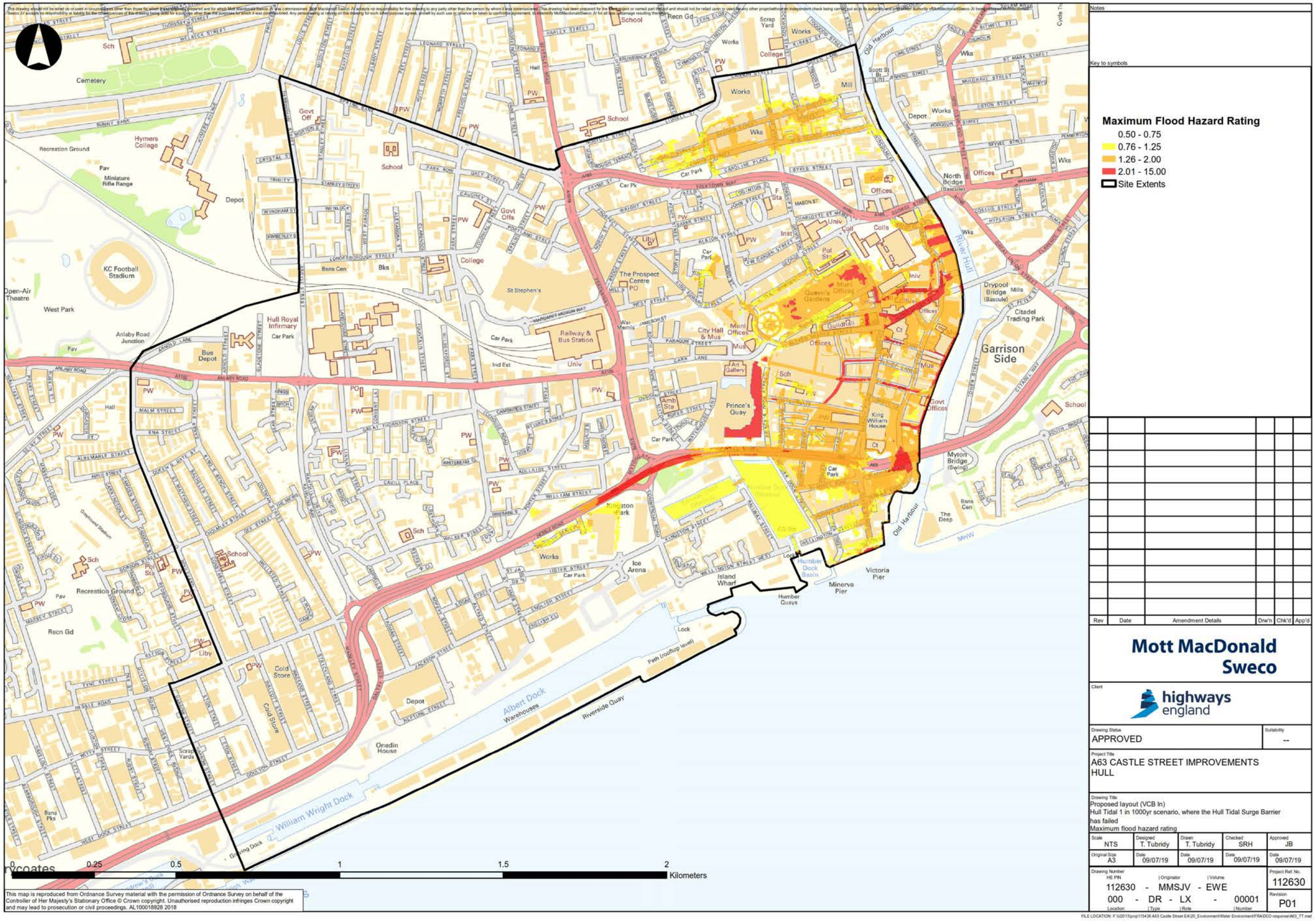


Figure 13.51 1 in 200-year River Hull tidal / fluvial flooding maximum flood depth for existing layout (Hull Tidal Surge Barrier open)

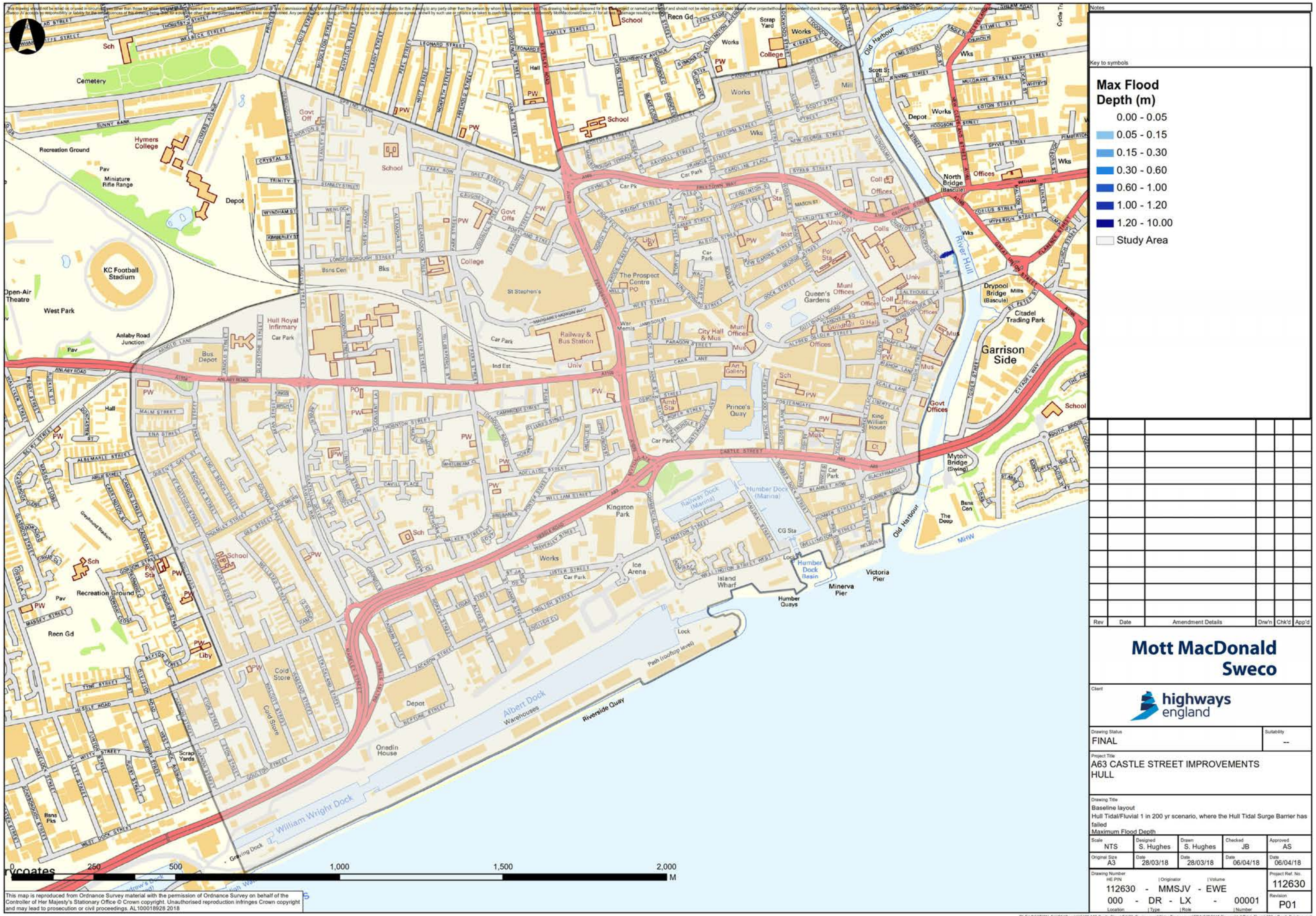


Figure 13.52 1 in 200-year River Hull tidal / fluvial flooding maximum flood depth for Scheme layout (Hull Tidal Surge Barrier open)

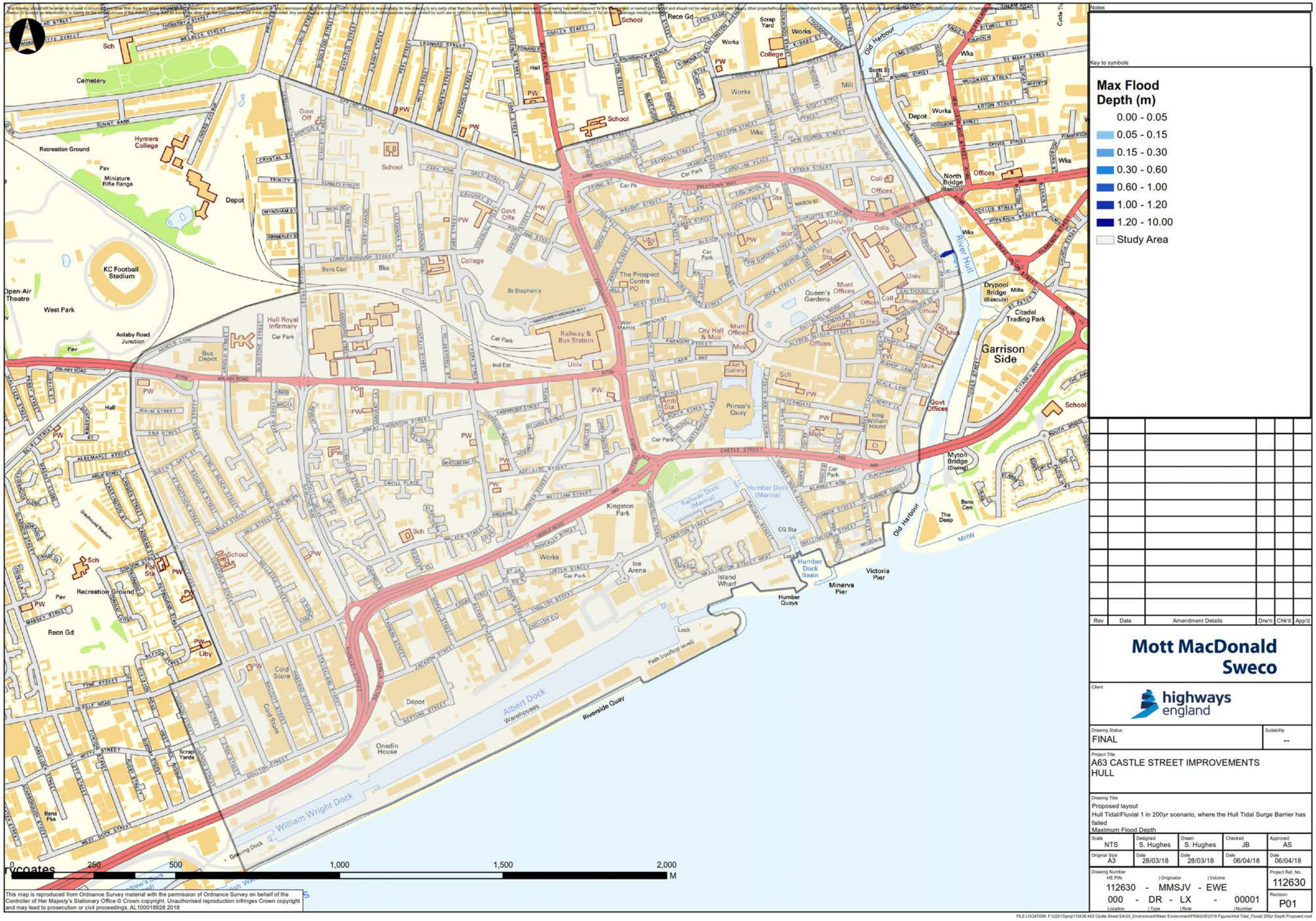


Figure 13.53 1 in 200-year River Hull tidal / fluvial flooding maximum flood depth difference (Hull Tidal Surge Barrier open)

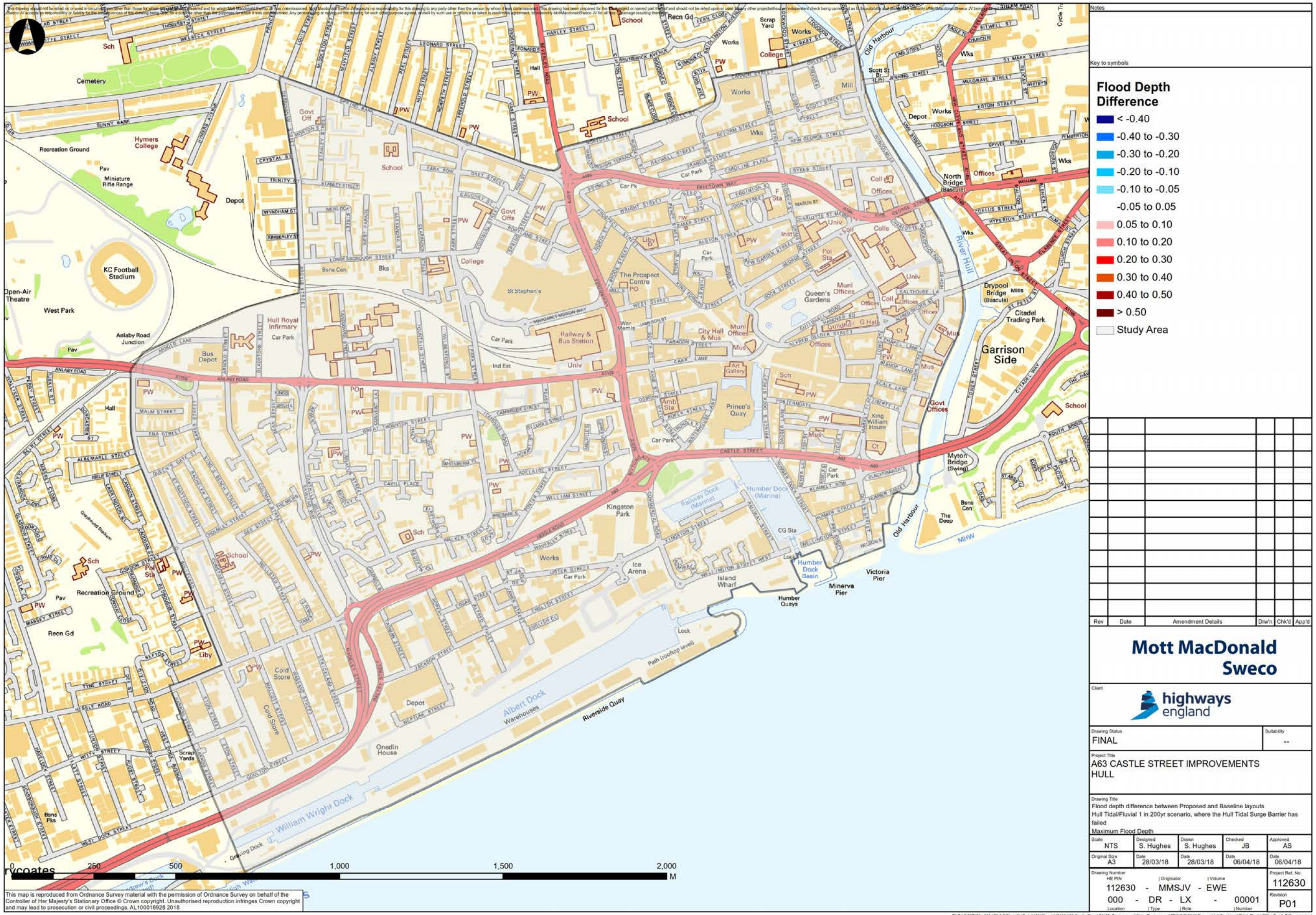


Figure 13.54 1 in 1000-year River Hull tidal / fluvial flooding maximum flood depth for existing layout (Hull Tidal Surge Barrier open)

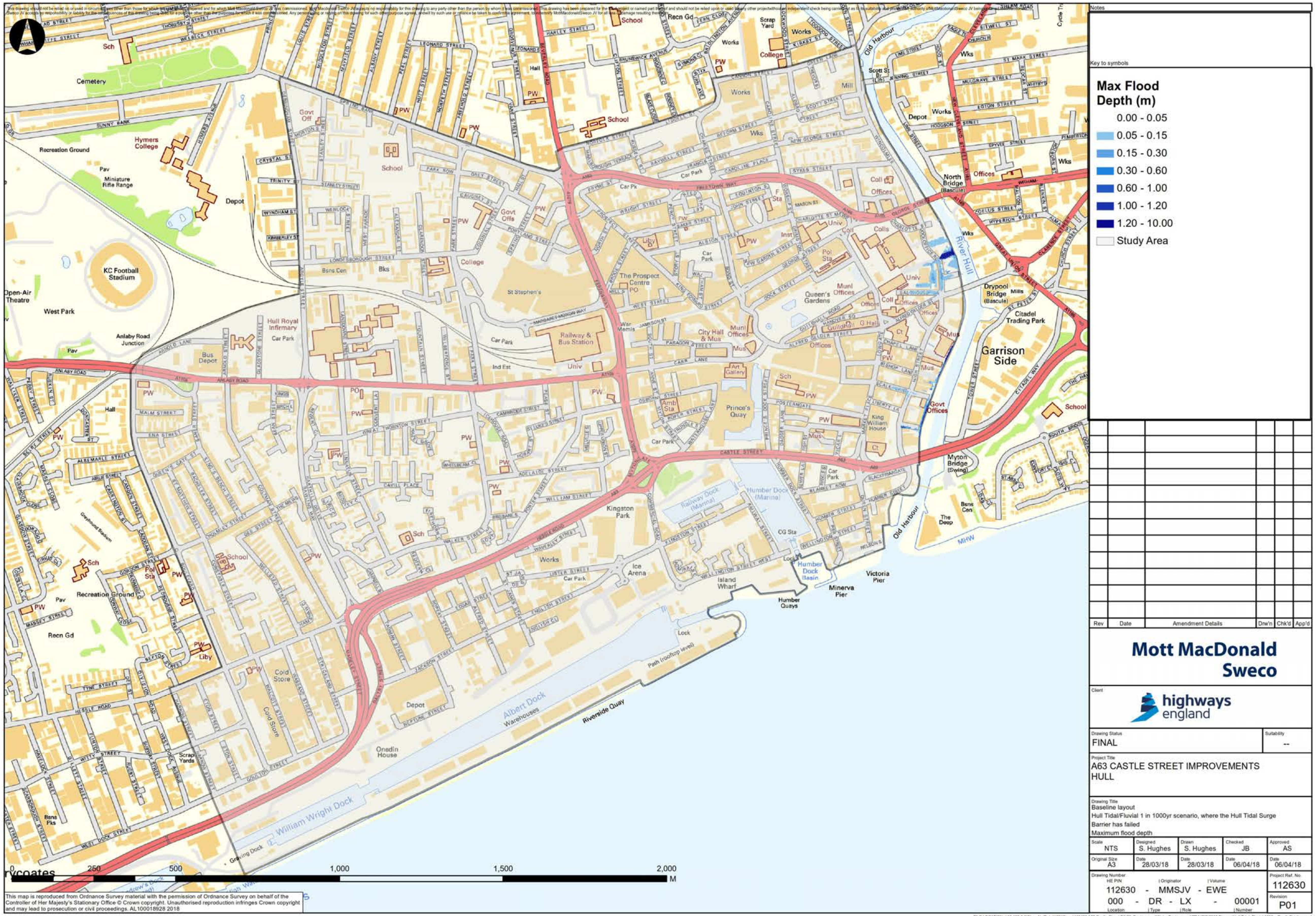


Figure 13.55 1 in 1,000-year River Hull tidal / fluvial flooding maximum flood depth for Scheme layout (Hull Tidal Surge Barrier open)

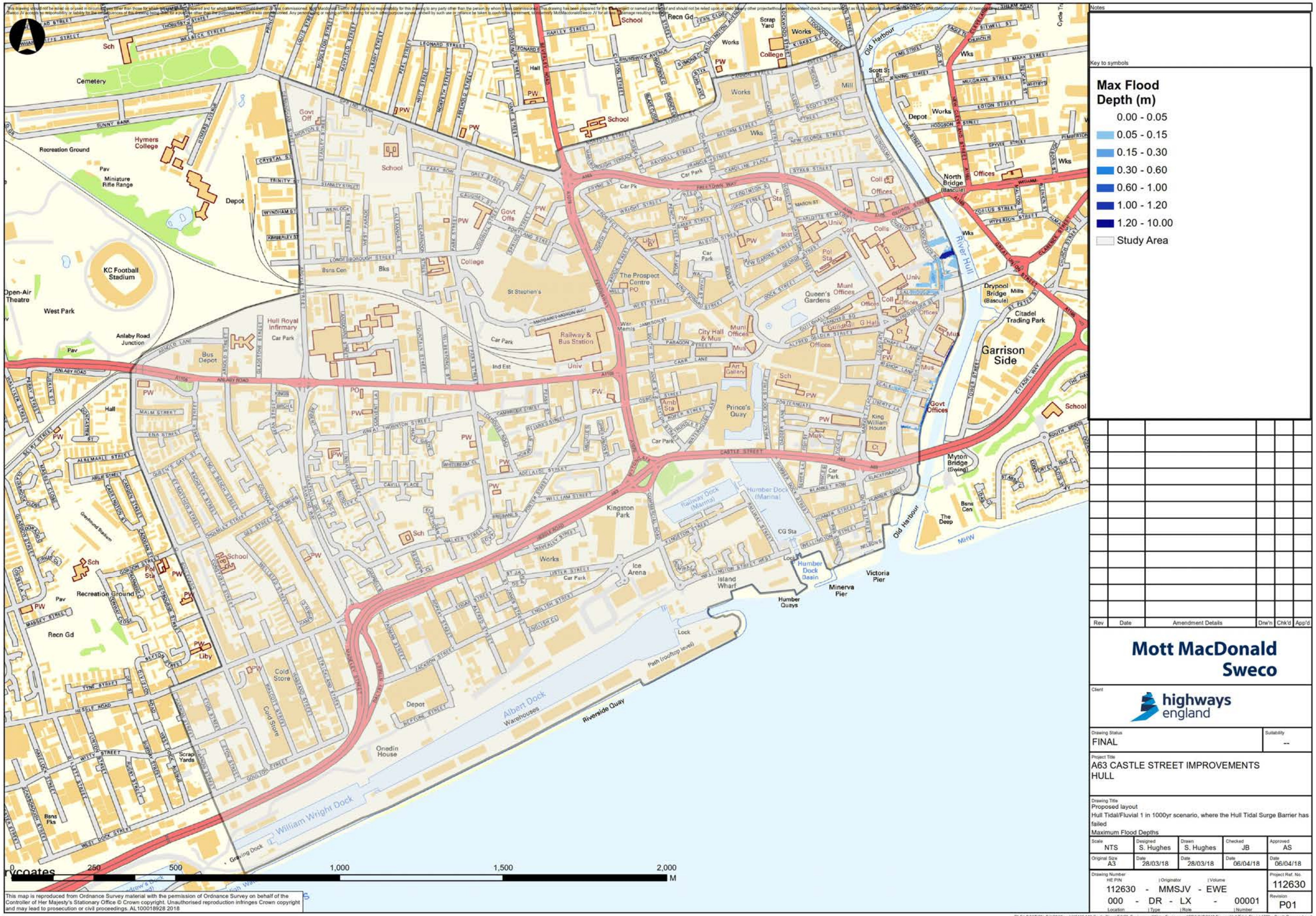


Figure 13.56 1 in 1,000-year River Hull tidal / fluvial flooding maximum flood depth difference (Hull Tidal Surge Barrier open)

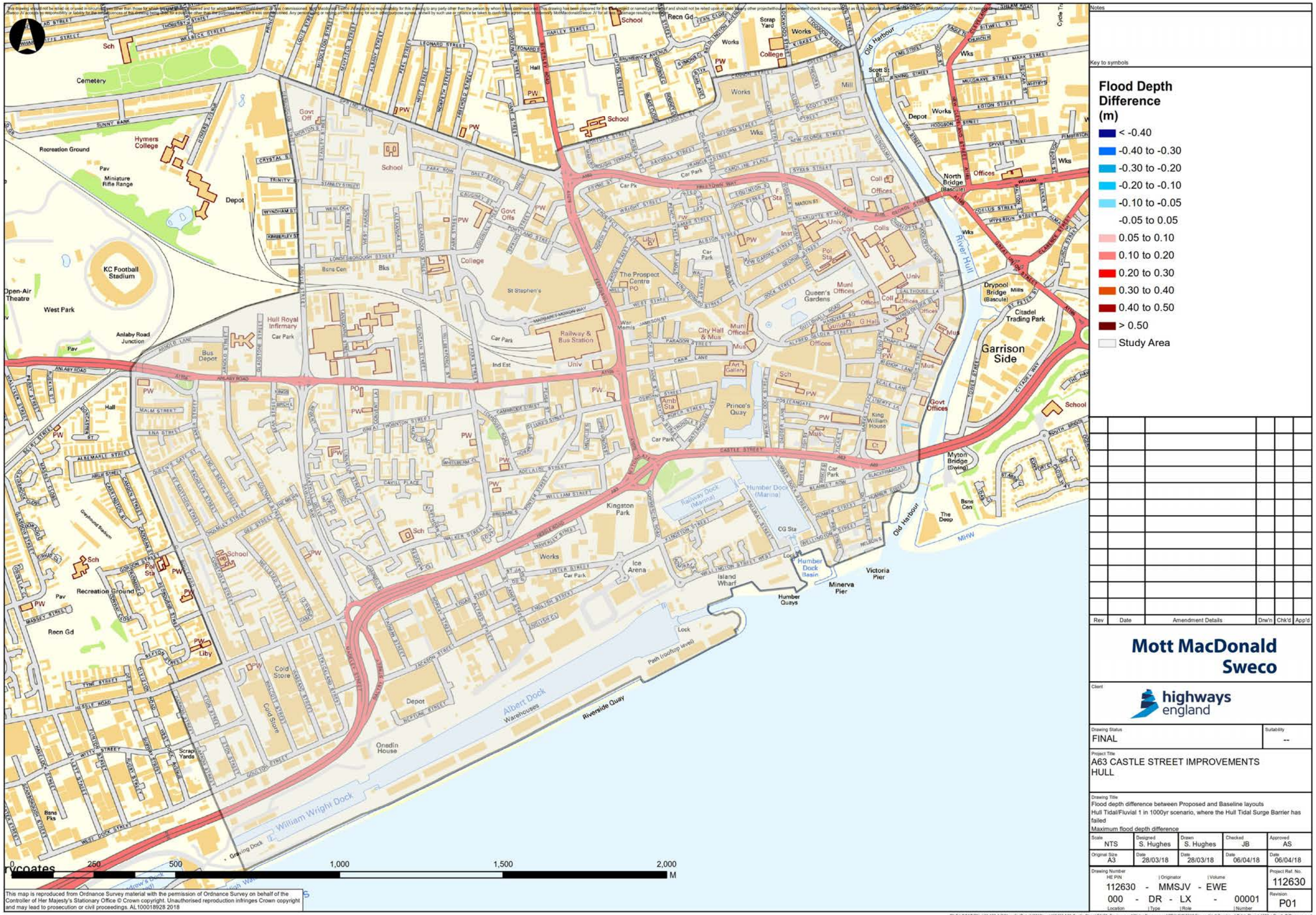


Figure 13.57 1 in 200-year River Hull tidal / fluvial flooding maximum flood hazard rating for existing layout (Hull Tidal Surge Barrier open)

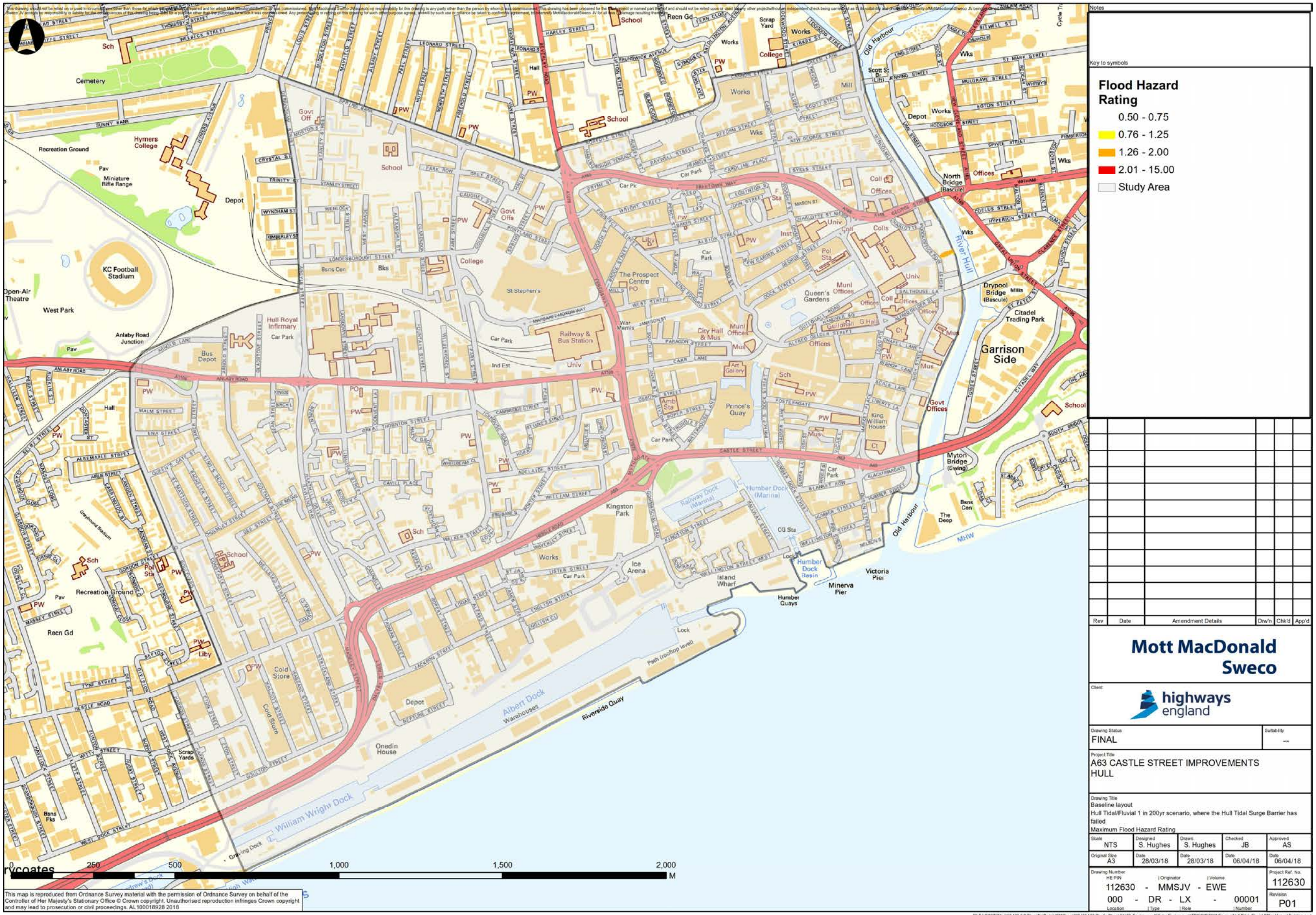


Figure 13.58 1 in 200-year River Hull tidal / fluvial flooding maximum flood hazard rating for Scheme layout (Hull Tidal Surge Barrier open)

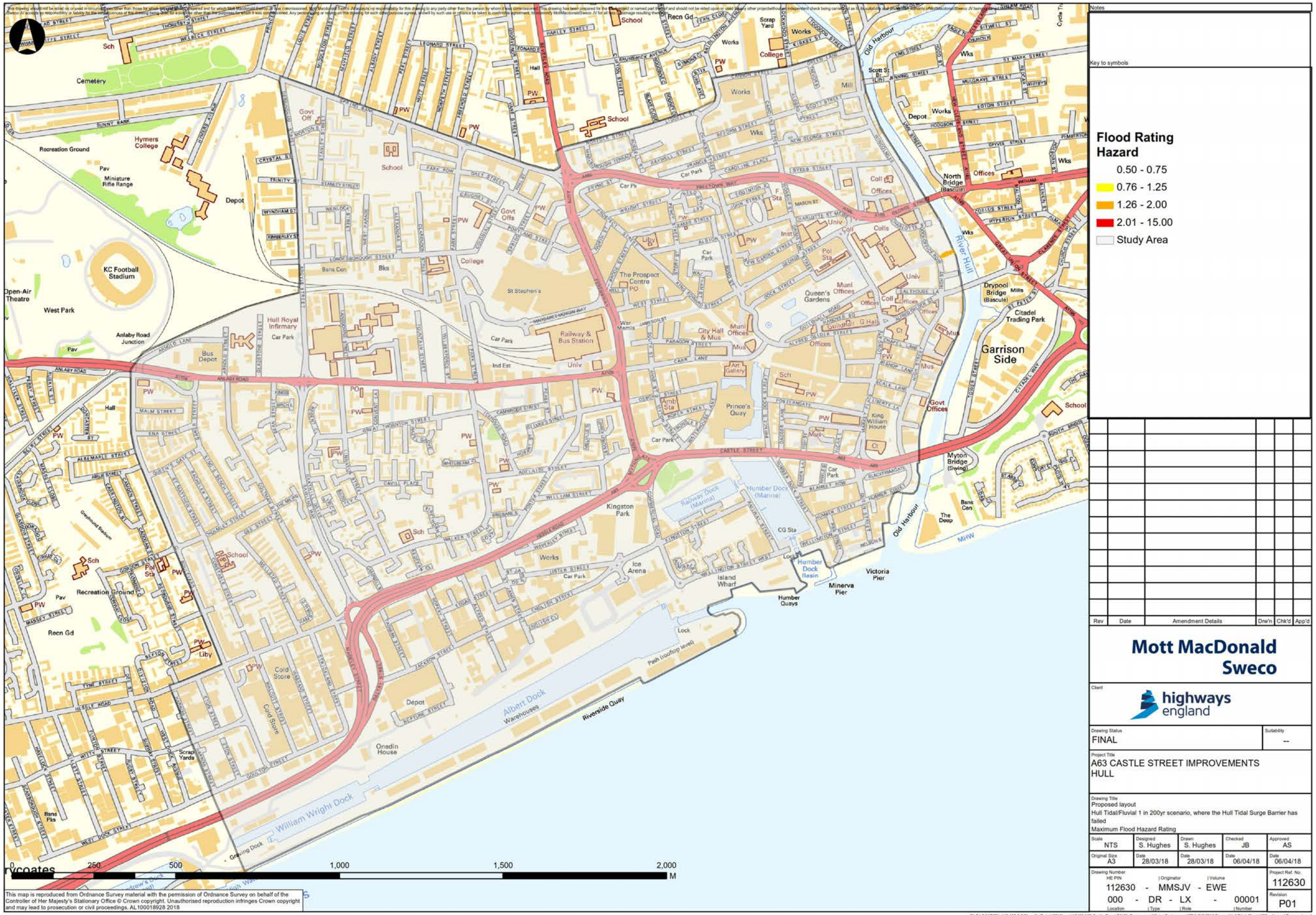


Figure 13.59 1 in 1,000-year River Hull tidal / fluvial flooding maximum flood hazard rating for existing layout (Hull Tidal Surge Barrier open)

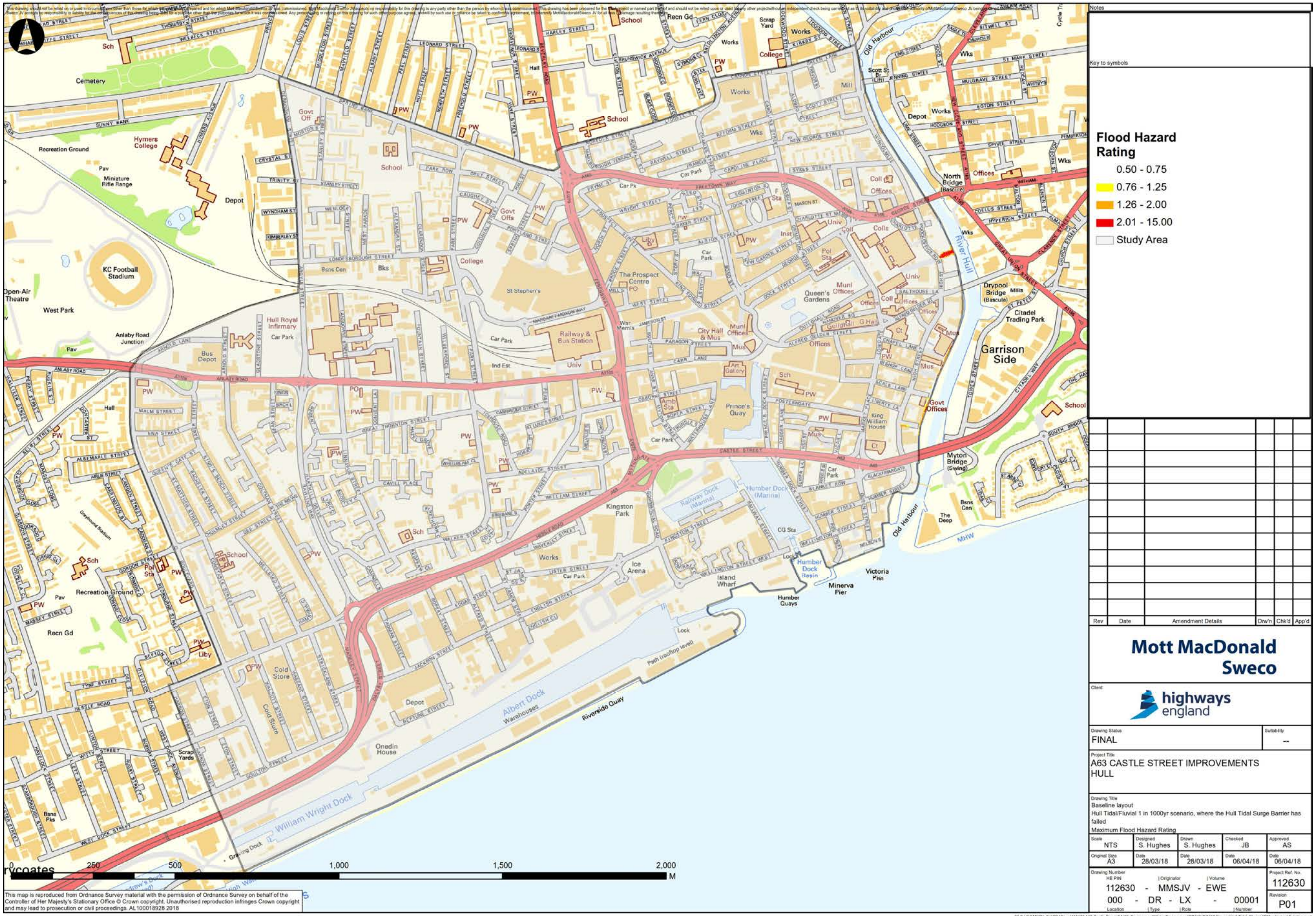


Figure 13.60 1 in 1,000-year River Hull tidal / fluvial flooding maximum flood hazard rating for Scheme layout (Hull Tidal Surge Barrier open)

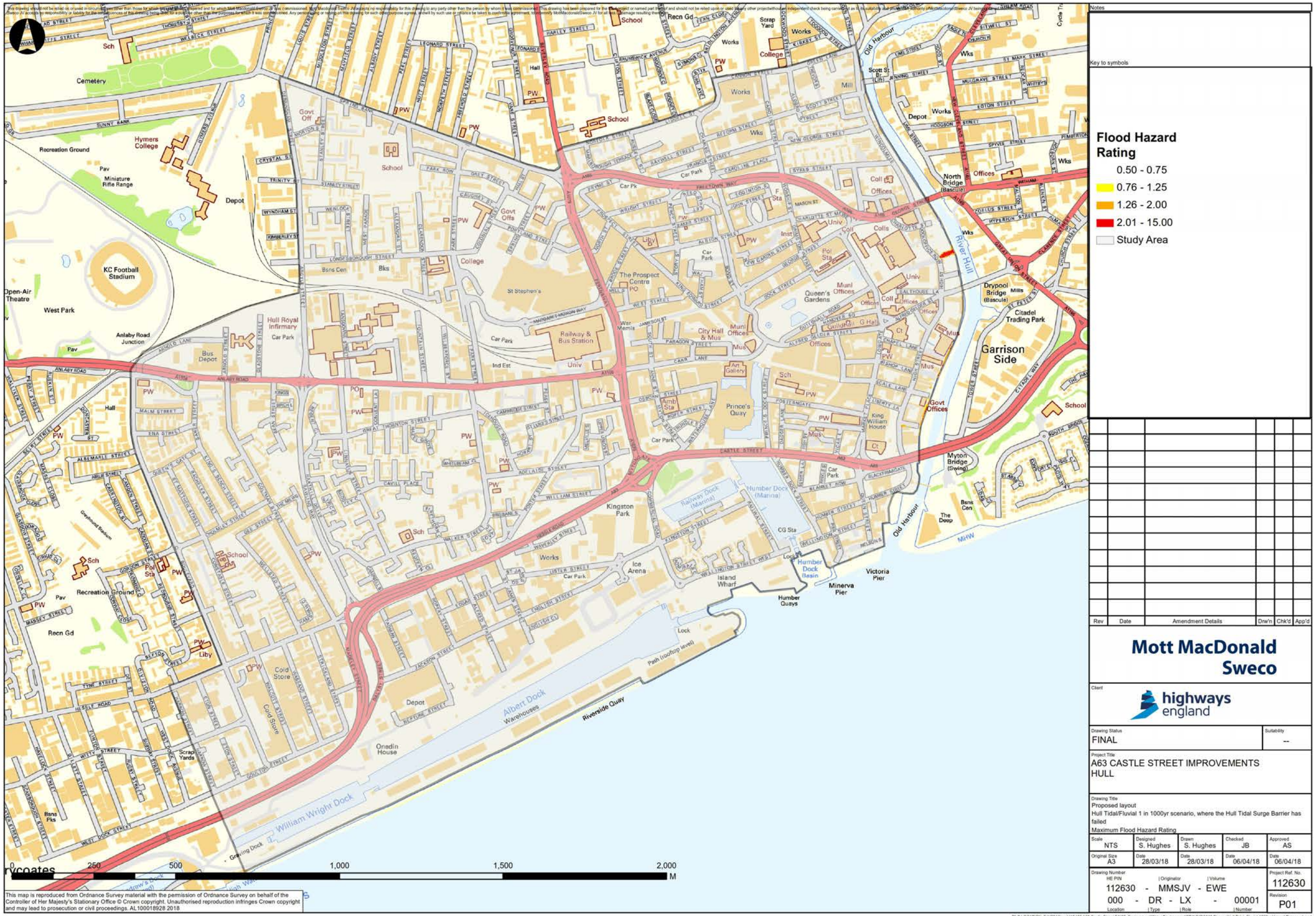


Figure 13.61 1 in 200-year Humber wave overtopping maximum flood velocity for Scheme layout

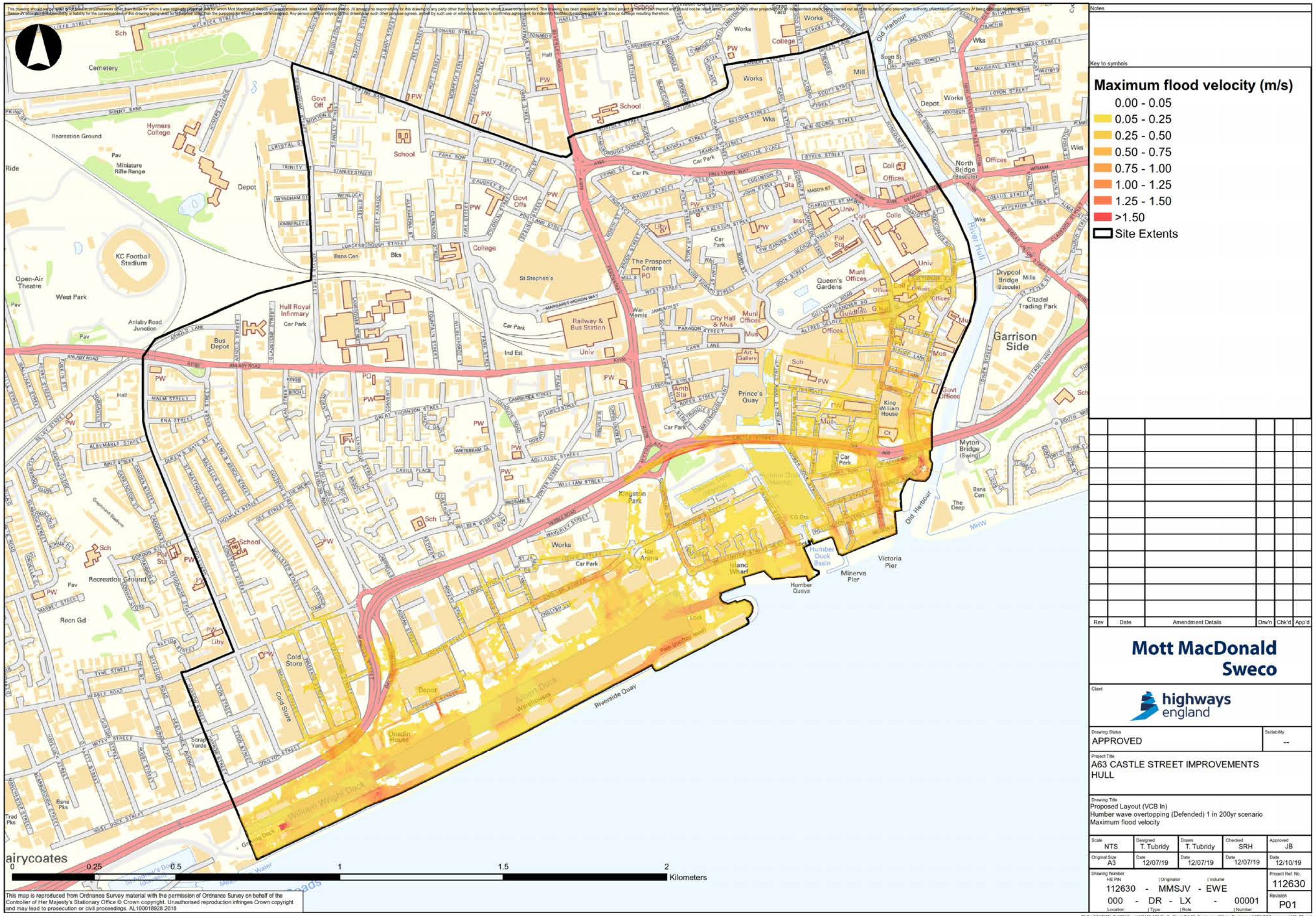


Figure 13.62 1 in 200-year River Hull tidal flooding maximum flood velocity for Scheme layout

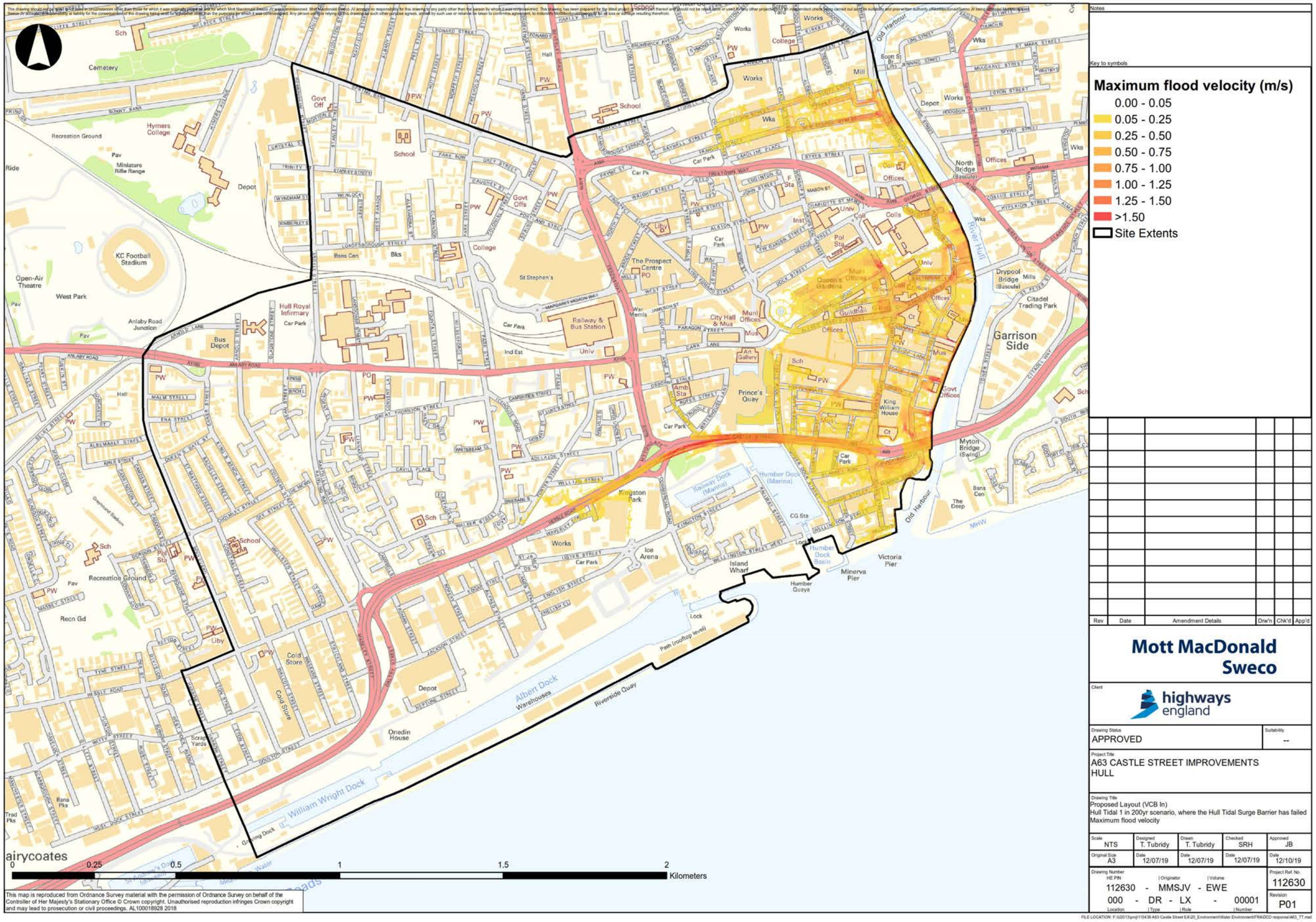


Figure 13.63 1 in 200-year plus climate change (2115) maximum flood depth for defence breach (composite of breaches 05, 06, HB24 and HB25) for existing layout

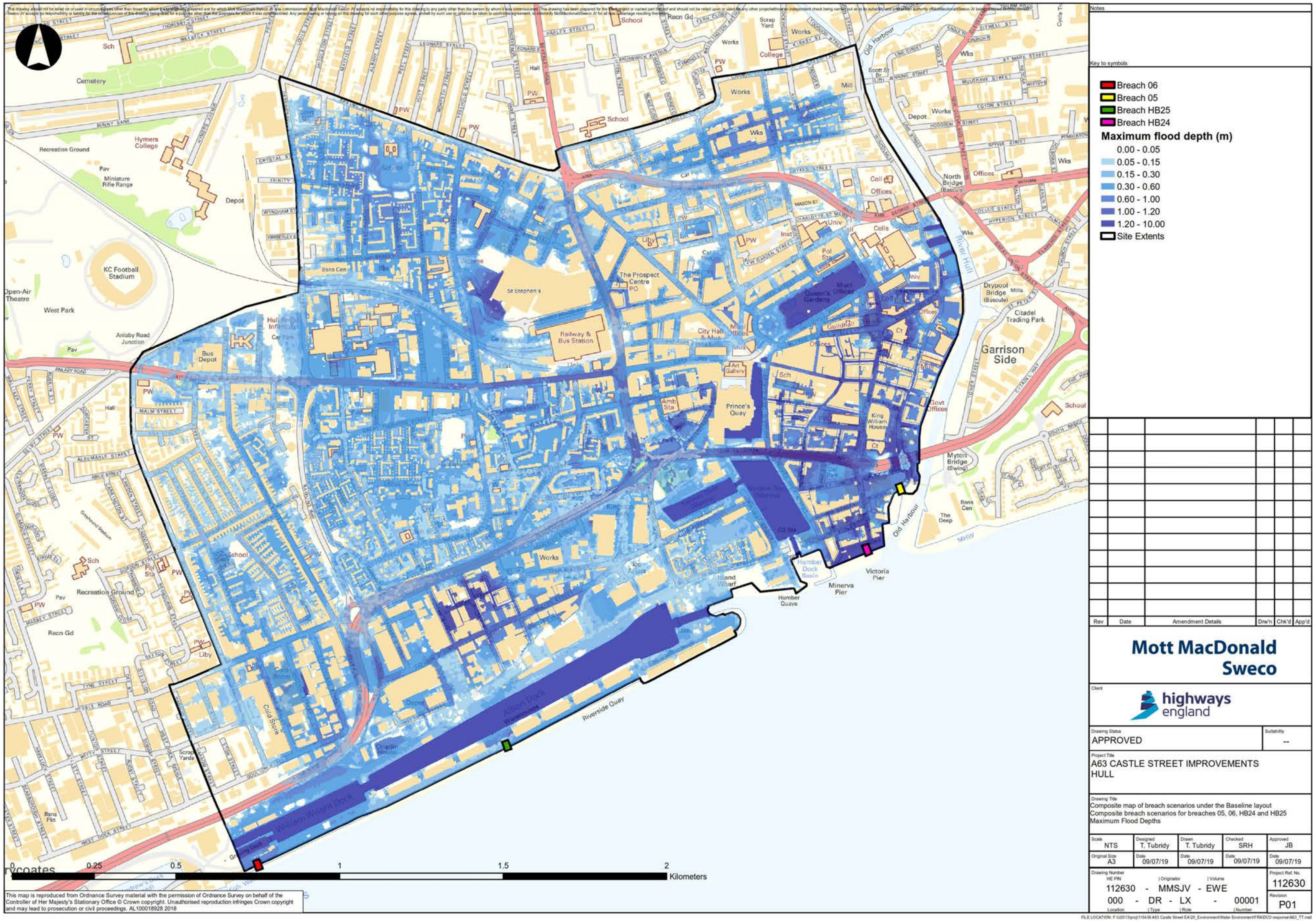


Figure 13.64 1 in 200-year plus climate change (2115) maximum flood depth for defence breach (composite of breaches 05, 06, HB24 and HB25) for Scheme layout

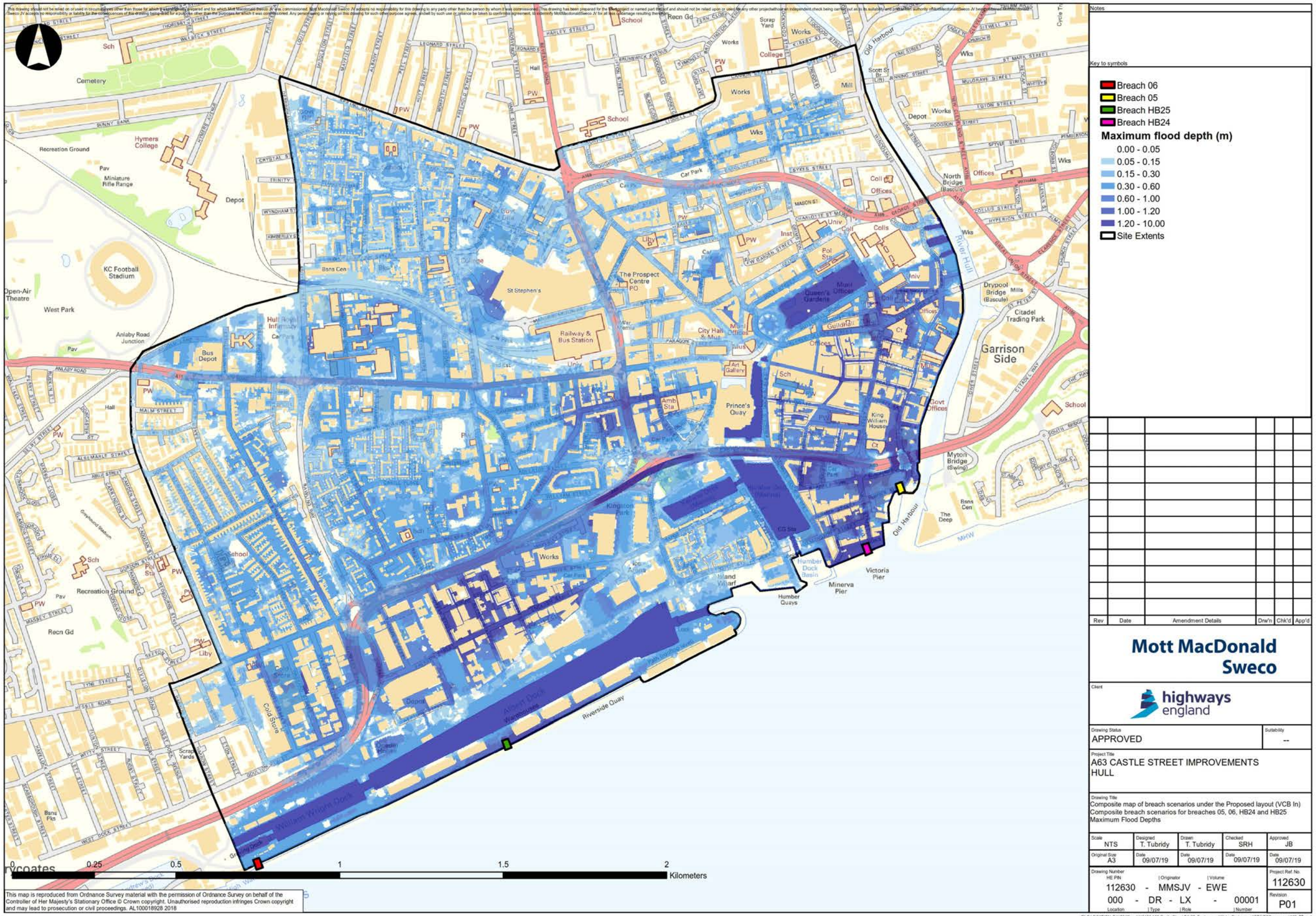


Figure 13.65 1 in 200-year plus climate change (2115) maximum Flood Hazard Rating for defence breach (composite of breaches 05, 06, HB24 and HB25) for existing layout

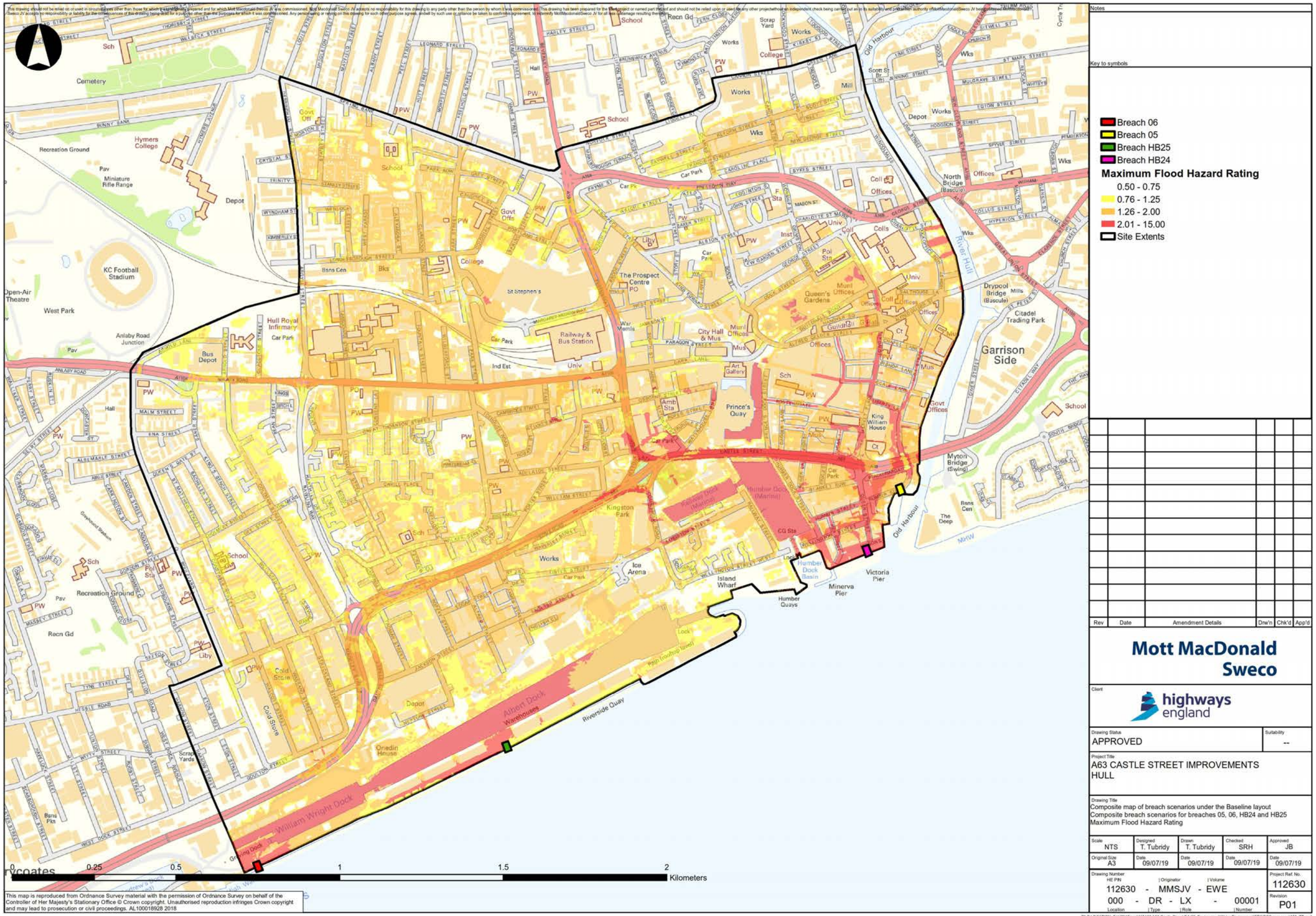


Figure 13.66 1 in 200-year plus climate change (2115) maximum Flood Hazard Rating for defence breach (composite of breaches 05, 06, HB24 and HB25) for Scheme layout

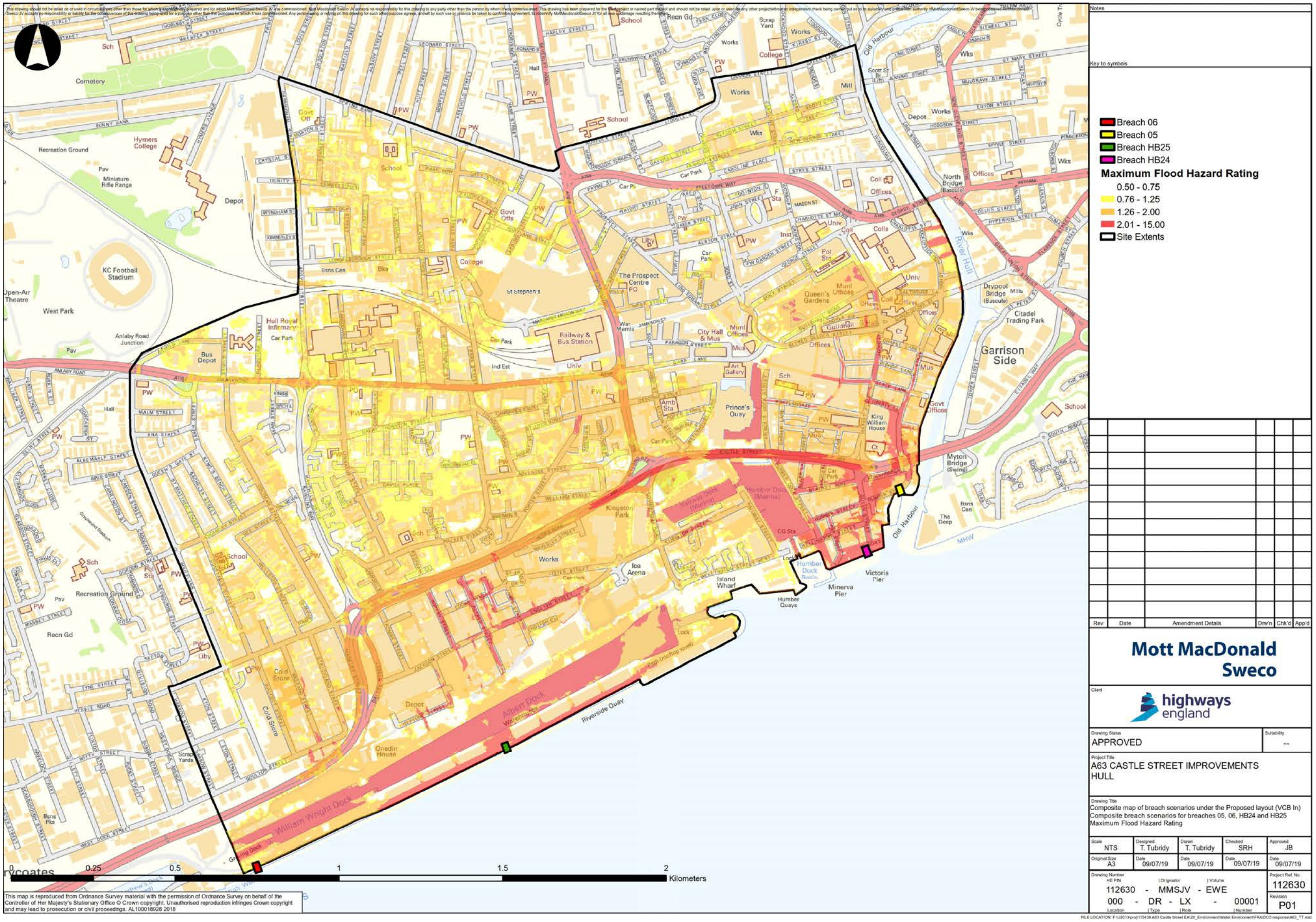


Figure 13.67 1 in 100-year plus 30% climate change pluvial flooding maximum flood depth for Scheme layout (no VCB)

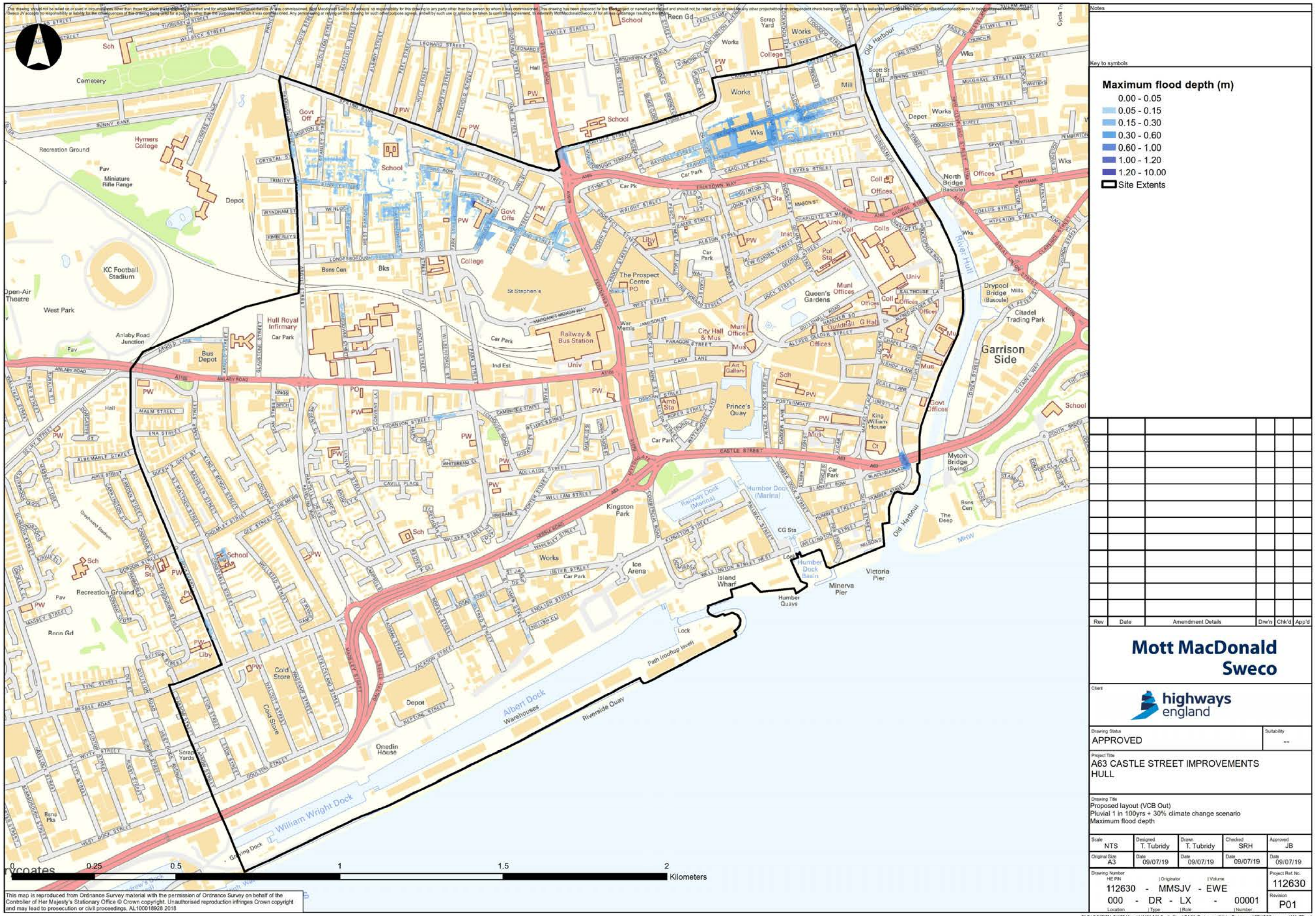


Figure 13.68 1 in 100-year plus climate change pluvial flooding maximum flood depth difference (no VCB)

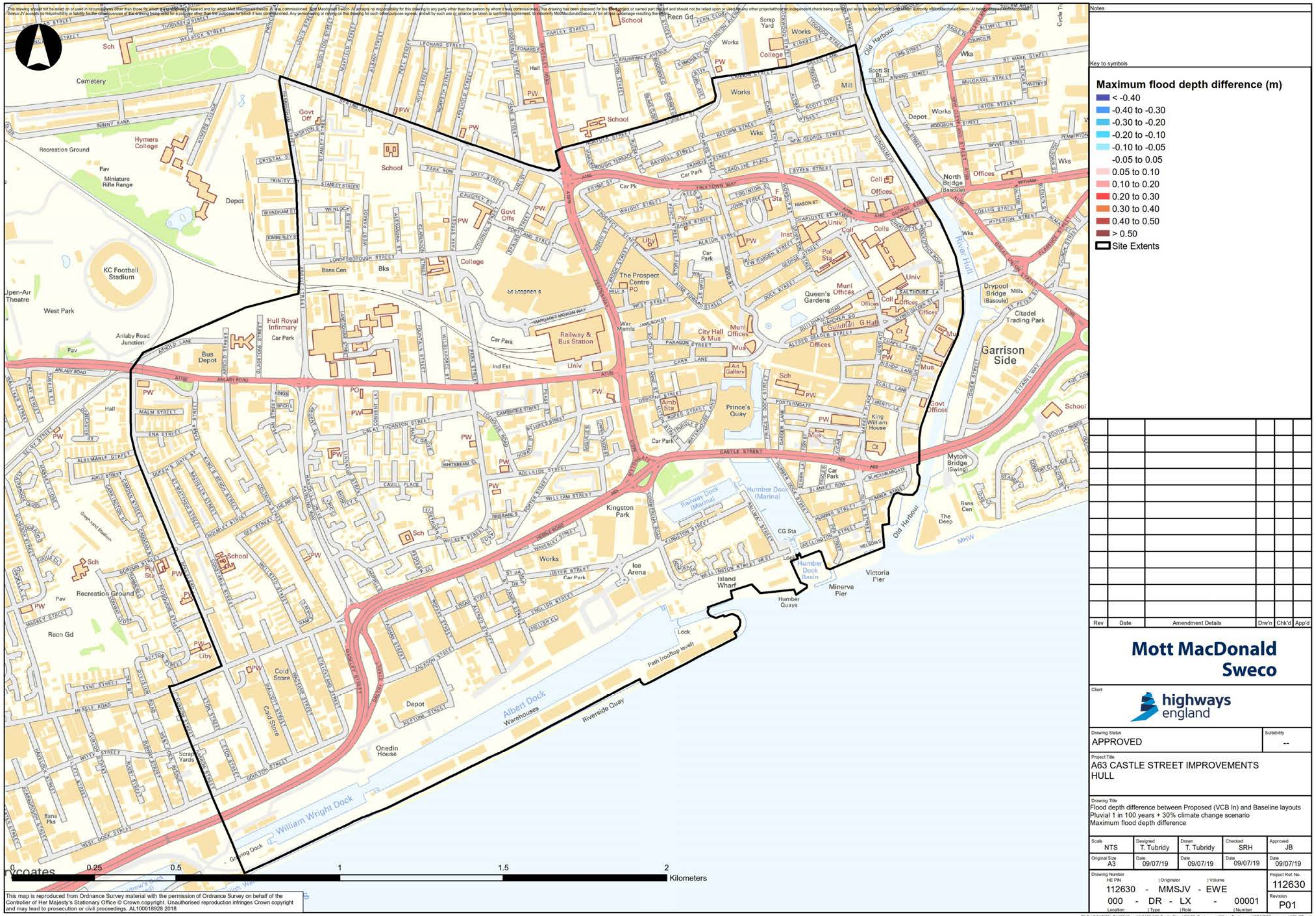


Figure 13.69 1 in 100-year plus 30% climate change pluvial flooding maximum flood hazard rating for Scheme layout (no VCB)

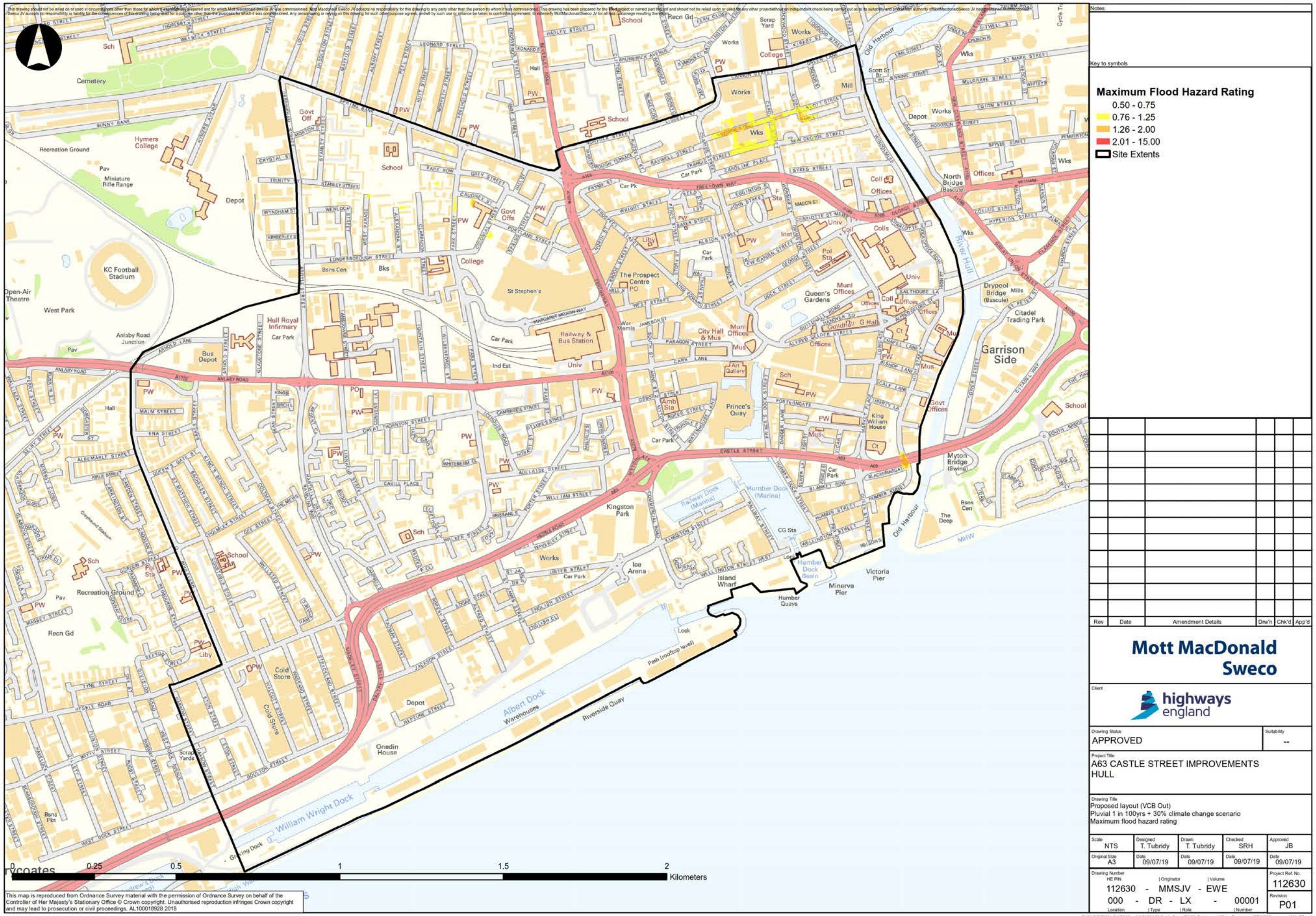


Figure 13.70 1 in 30-year pluvial flooding maximum flood depth for Scheme layout (no VCB)

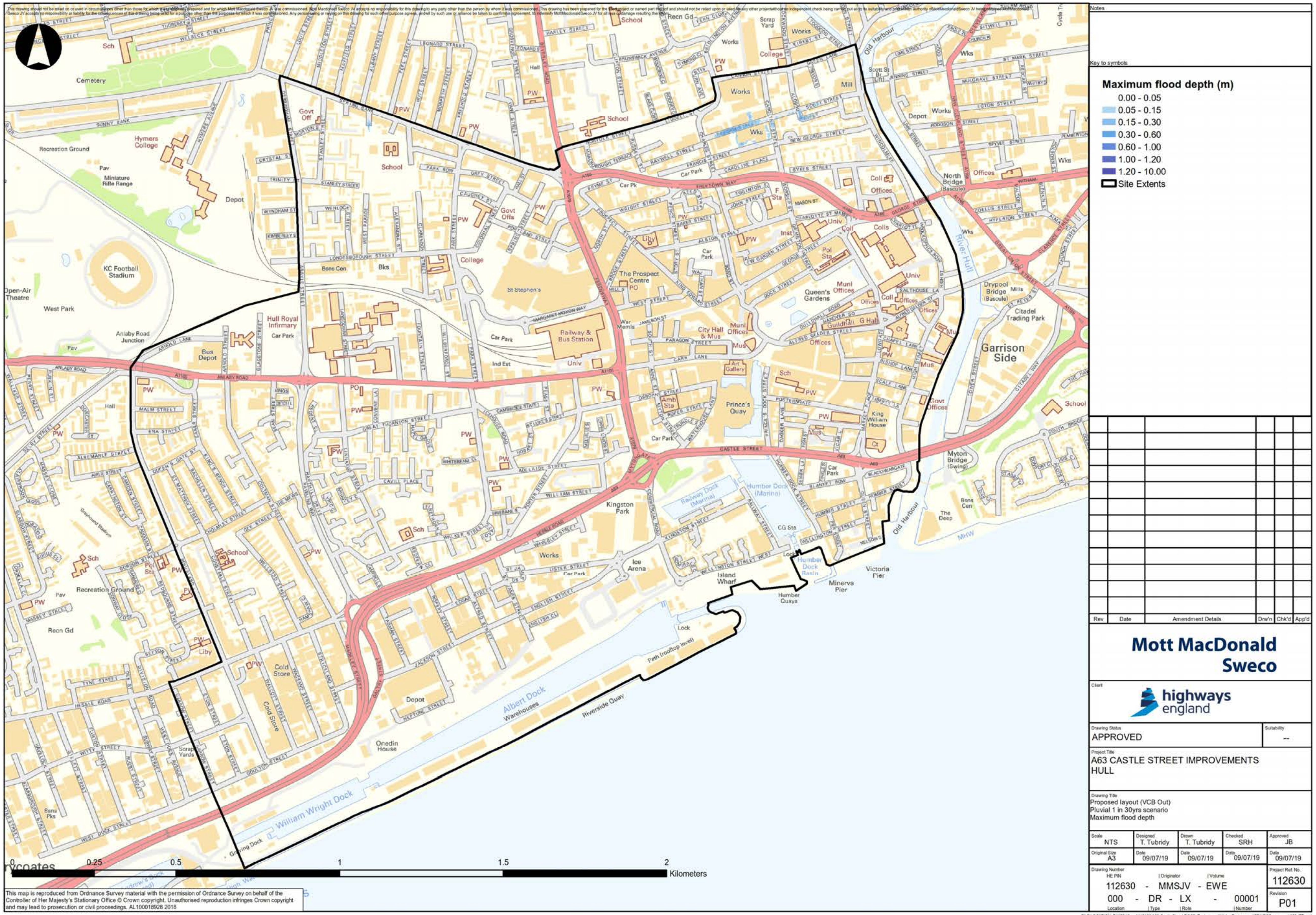


Figure 13.71 1 in 30-year pluvial flooding maximum flood depth difference for existing and Scheme layouts (no VCB)

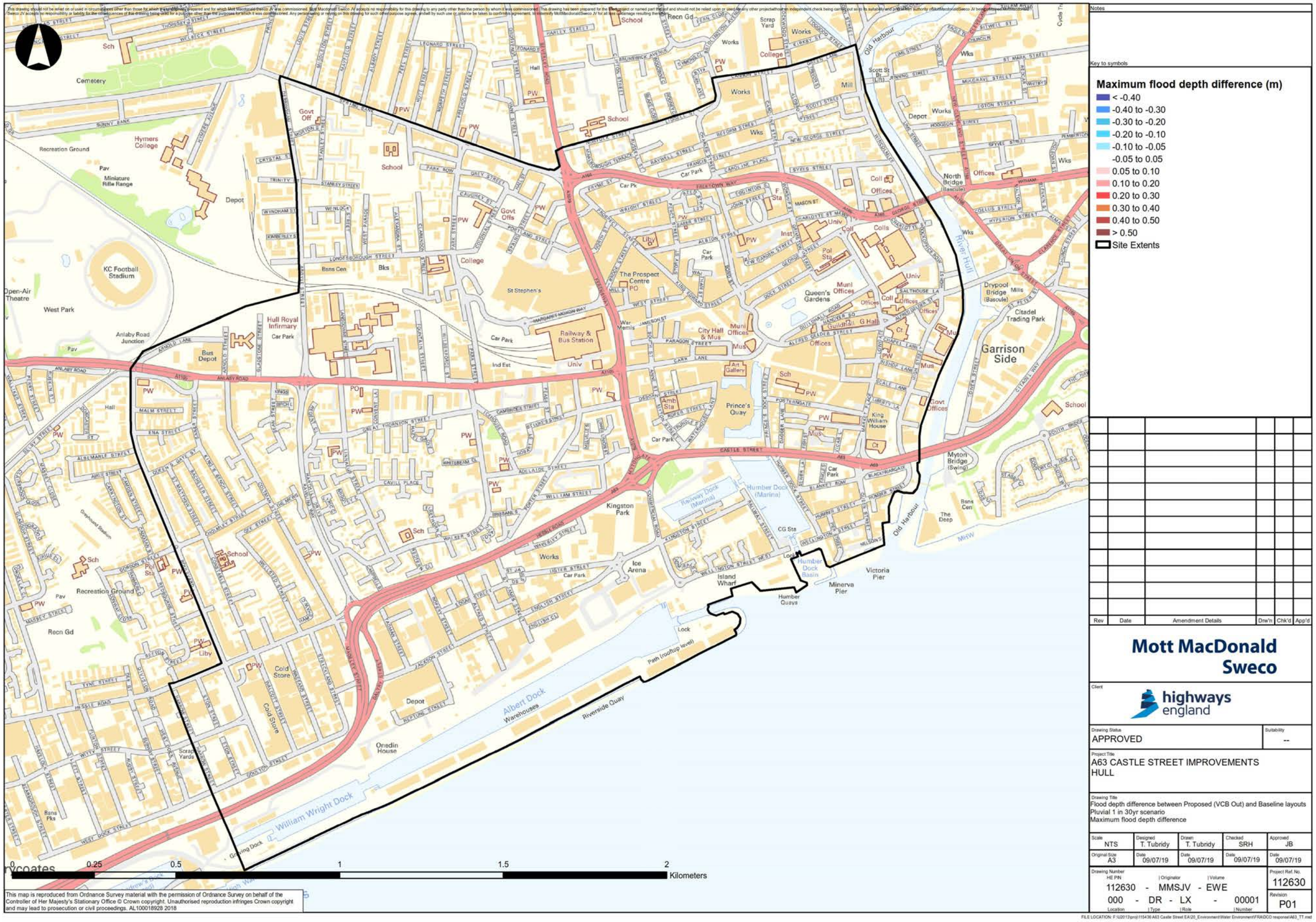


Figure 13.72 1 in 30-year pluvial flooding maximum flood hazard rating for Scheme layout (no VCB)

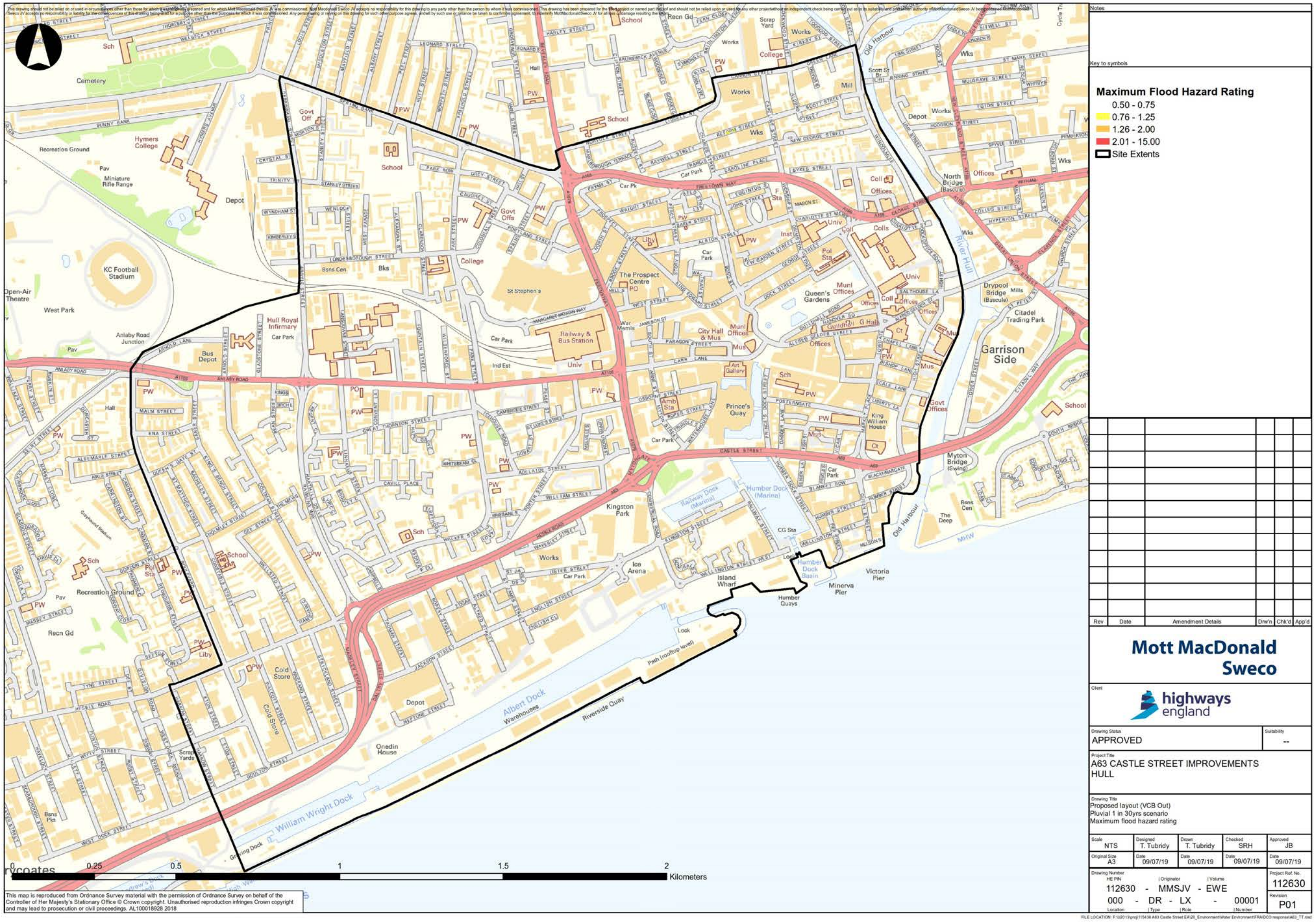


Figure 13.73 1 in 100-year pluvial flooding maximum flood depth for Scheme layout (no VCB)

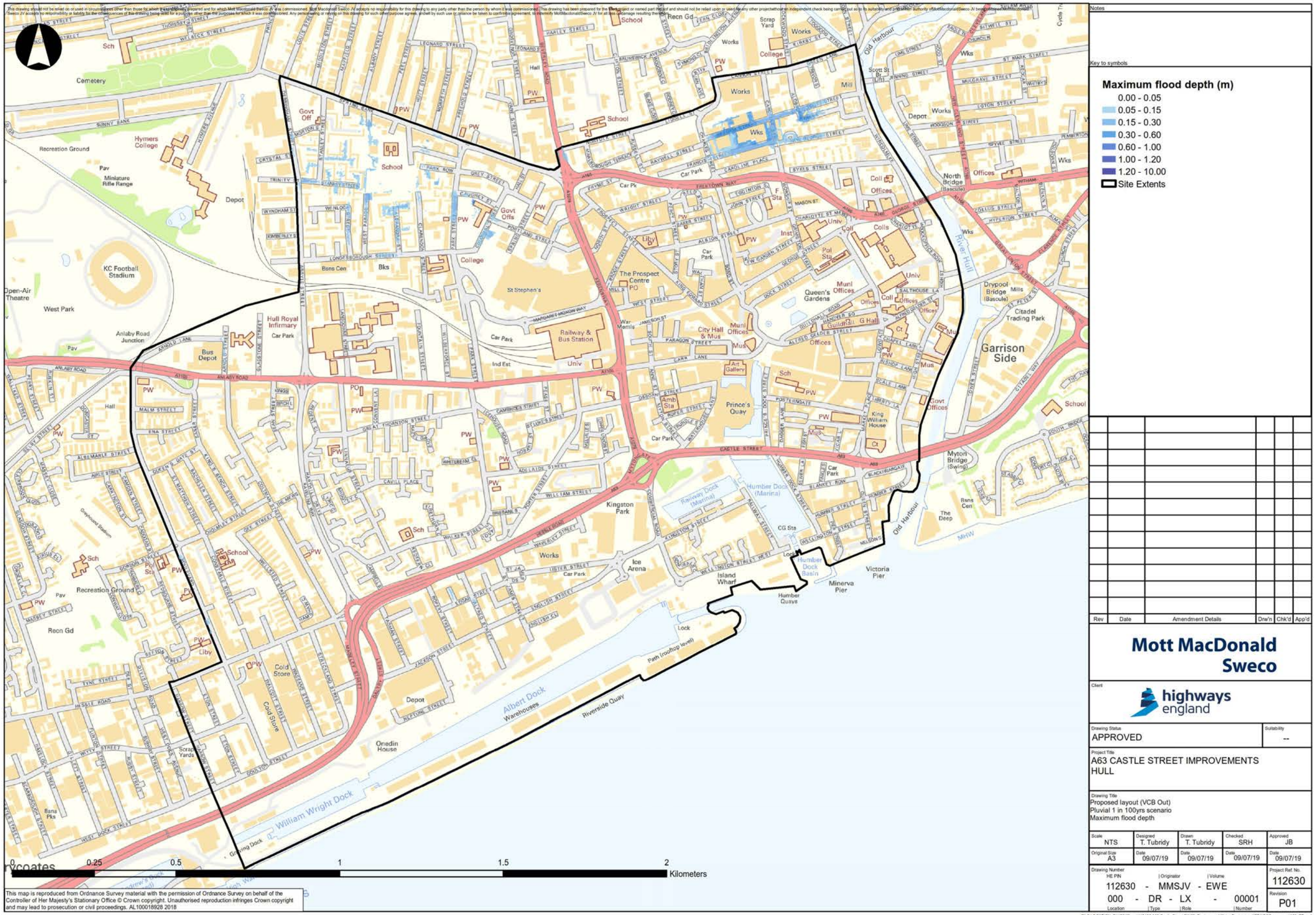


Figure 13.74 1 in 100-year pluvial flooding maximum flood depth difference for existing and Scheme layout (no VCB)

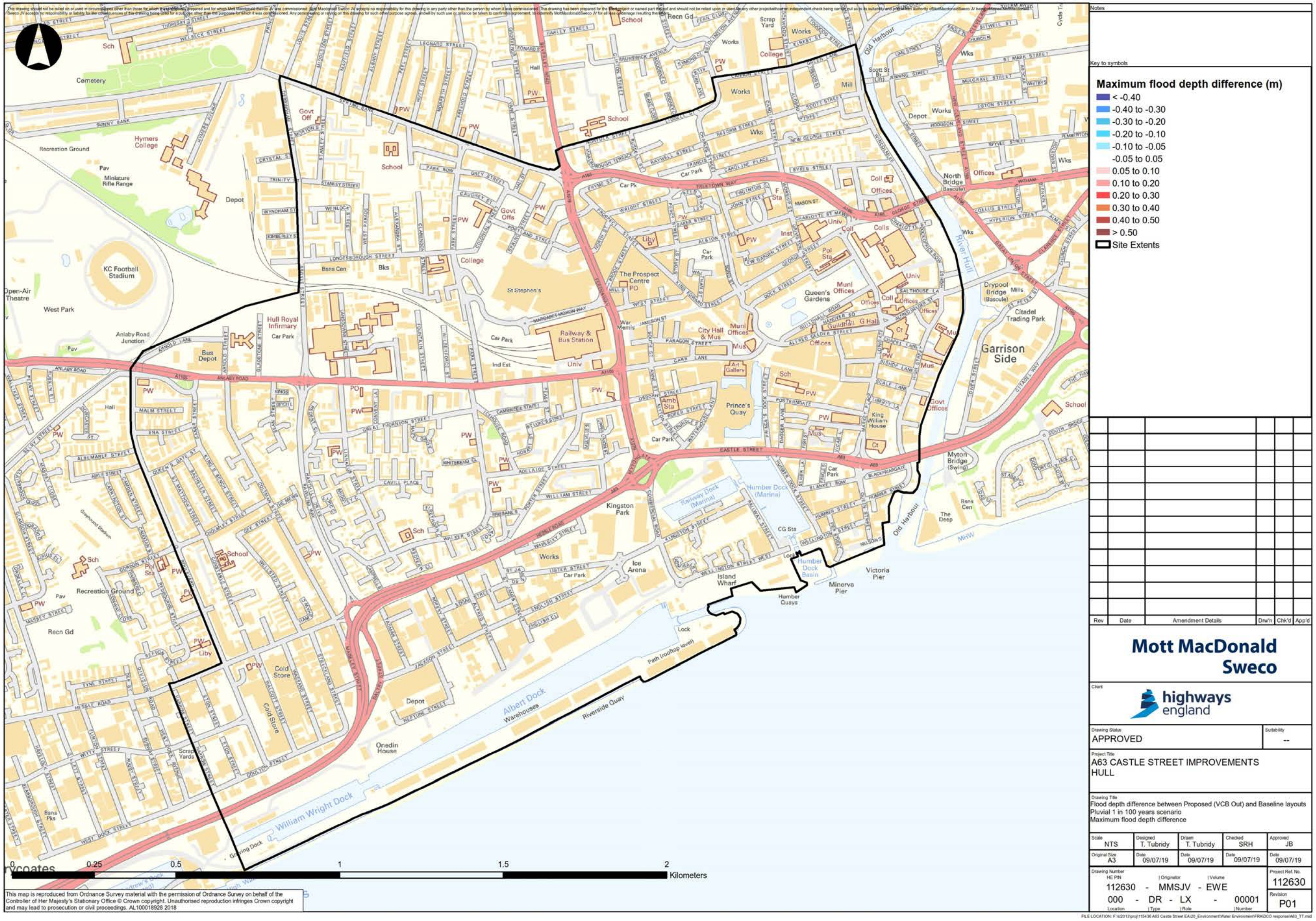


Figure 13.75 1 in 100-year pluvial flooding maximum flood hazard rating for Scheme layout (no VCB)

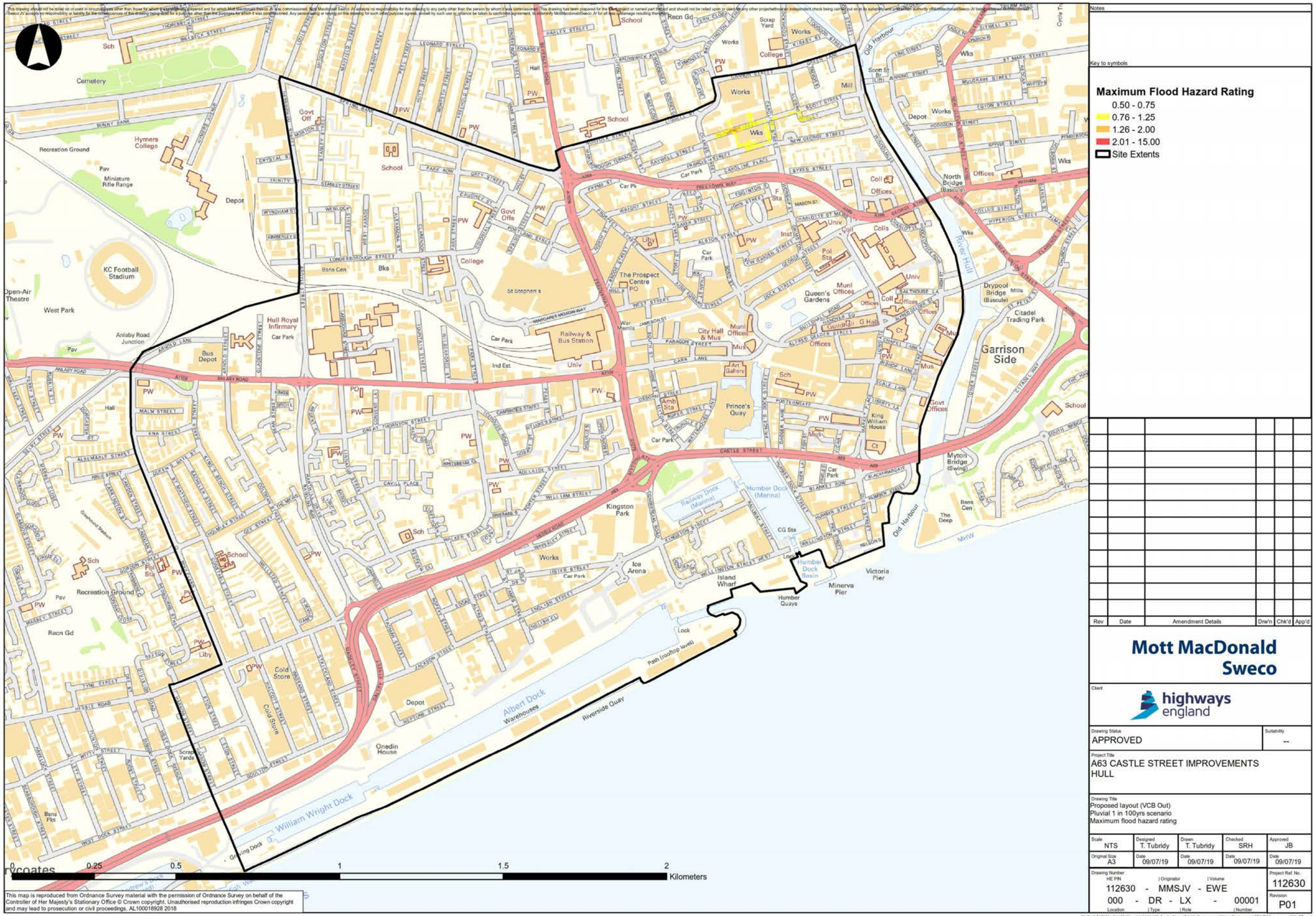


Figure 13.76 1 in 200-year Humber wave overtopping maximum flood depth for Scheme layout (no VCB)

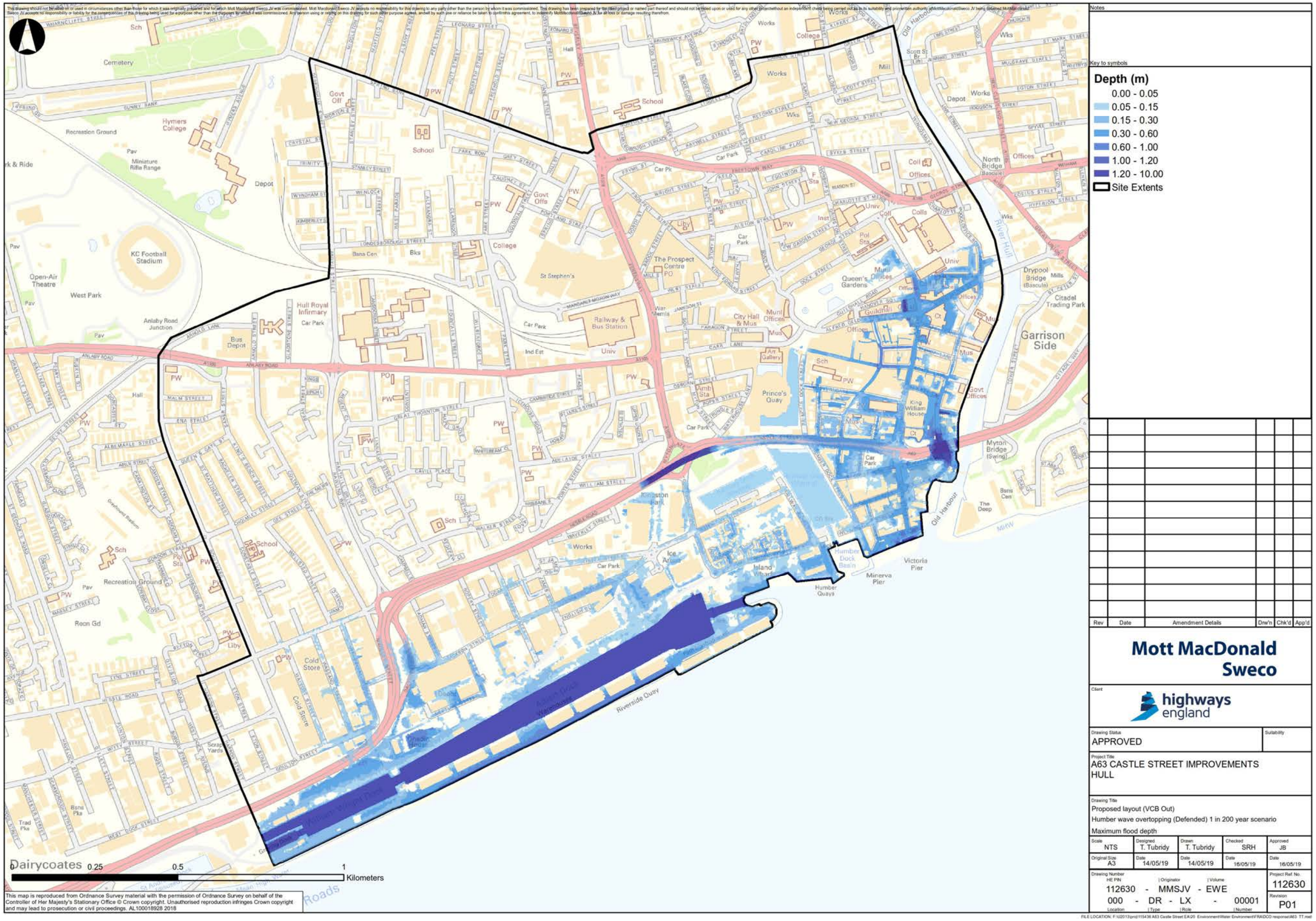


Figure 13.77 1 in 200-year Humber wave overtopping maximum flood depth difference (no VCB)

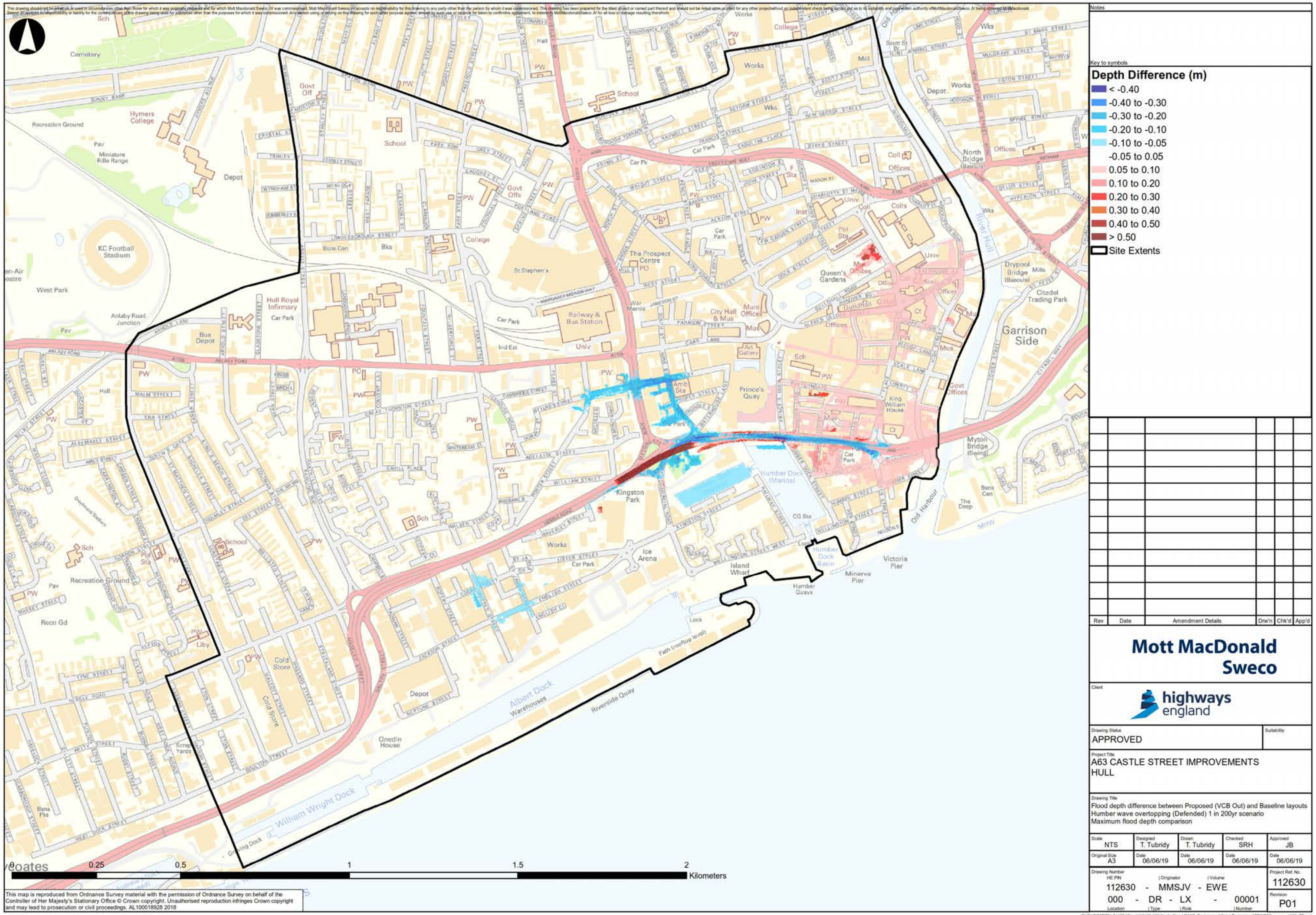


Figure 13.78 1 in 1,000-year Humber wave overtopping maximum flood depth for Scheme layout (no VCB)

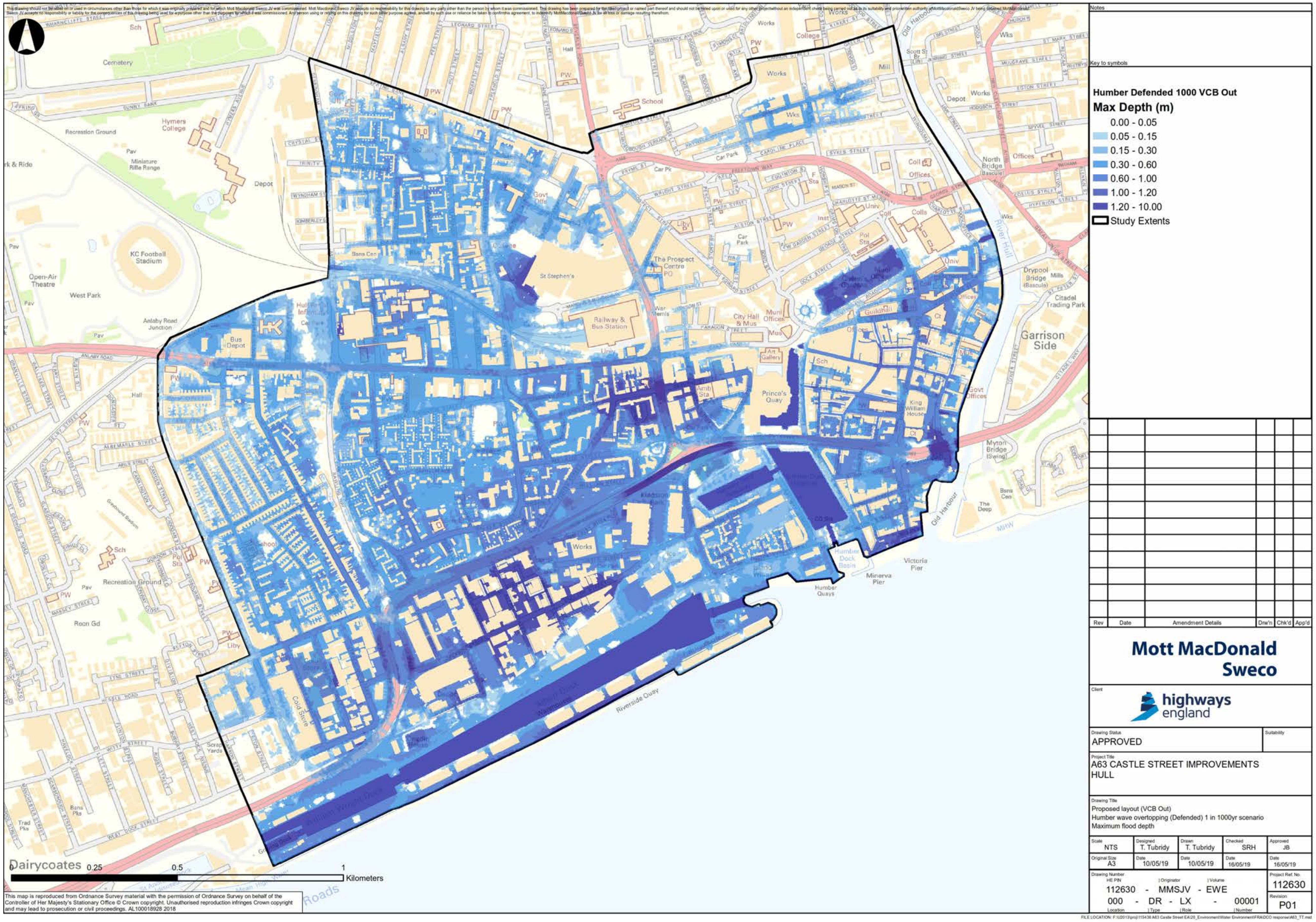


Figure 13.79 1 in 1,000-year Humber wave overtopping maximum flood depth difference (no VCB)

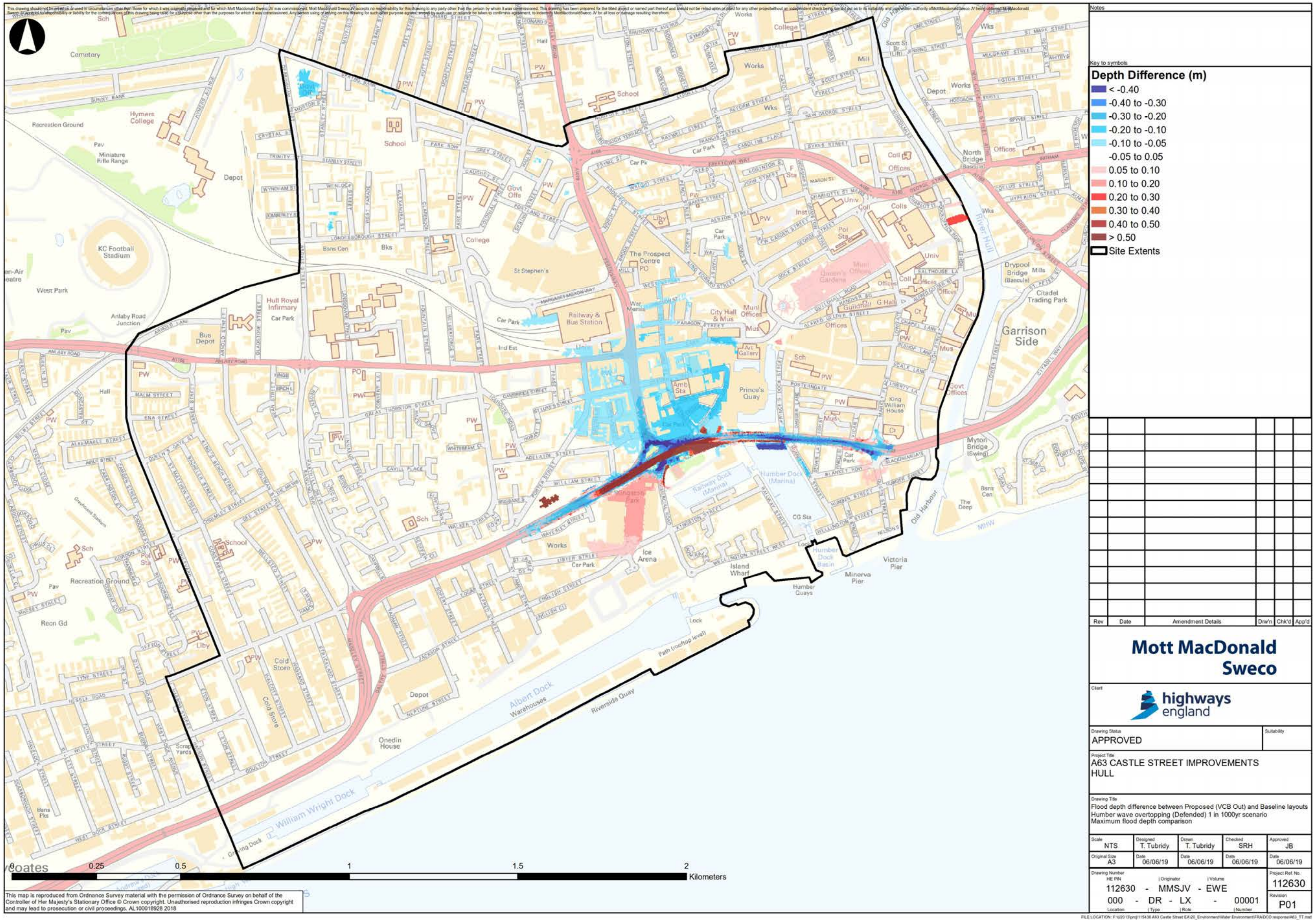


Figure 13.80 1 in 200-year Humber wave overtopping maximum flood hazard rating for Scheme layout (no VCB)

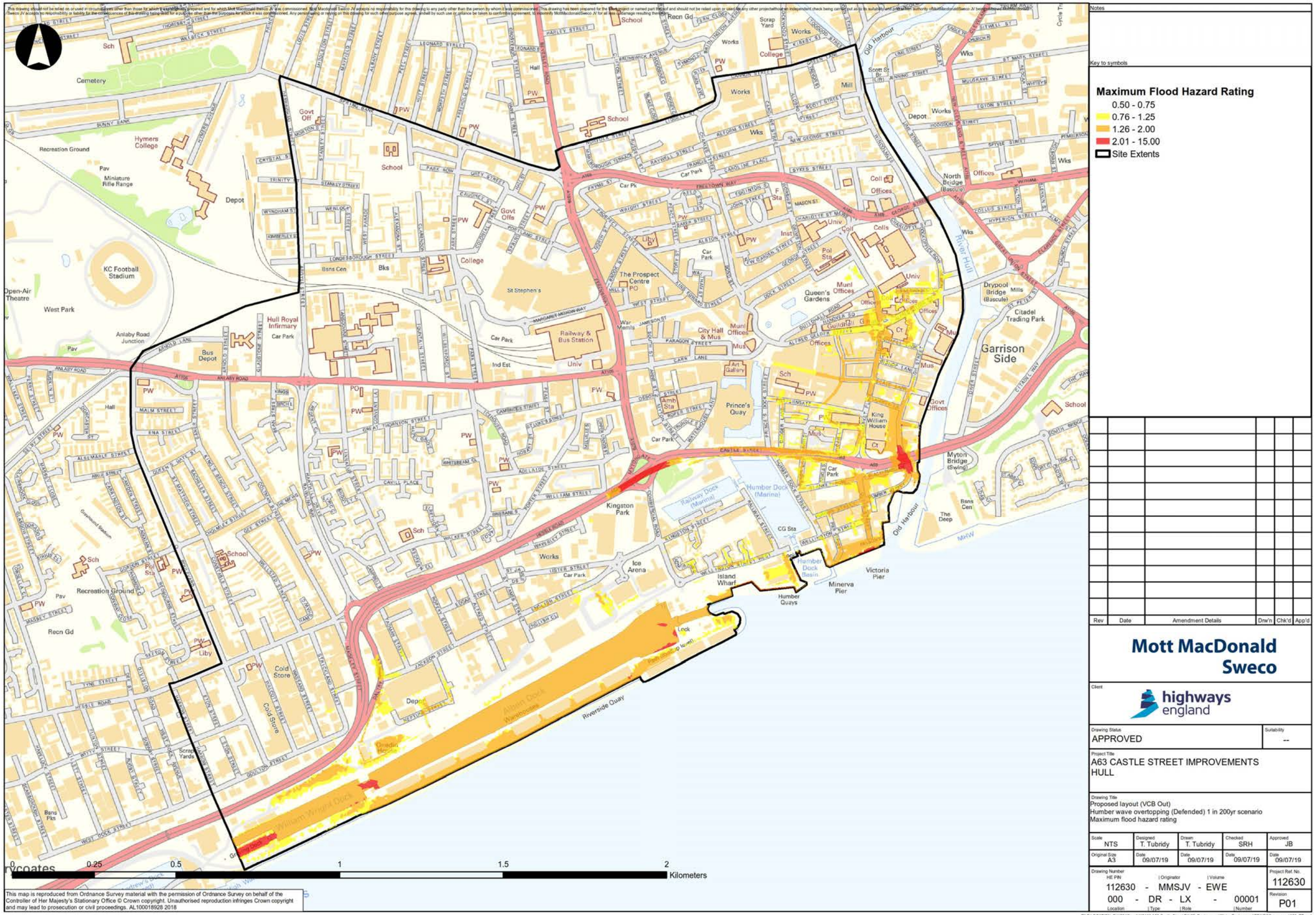


Figure 13.81 1 in 1,000-year Humber wave overtopping maximum flood hazard rating for Scheme layout (no VCB)

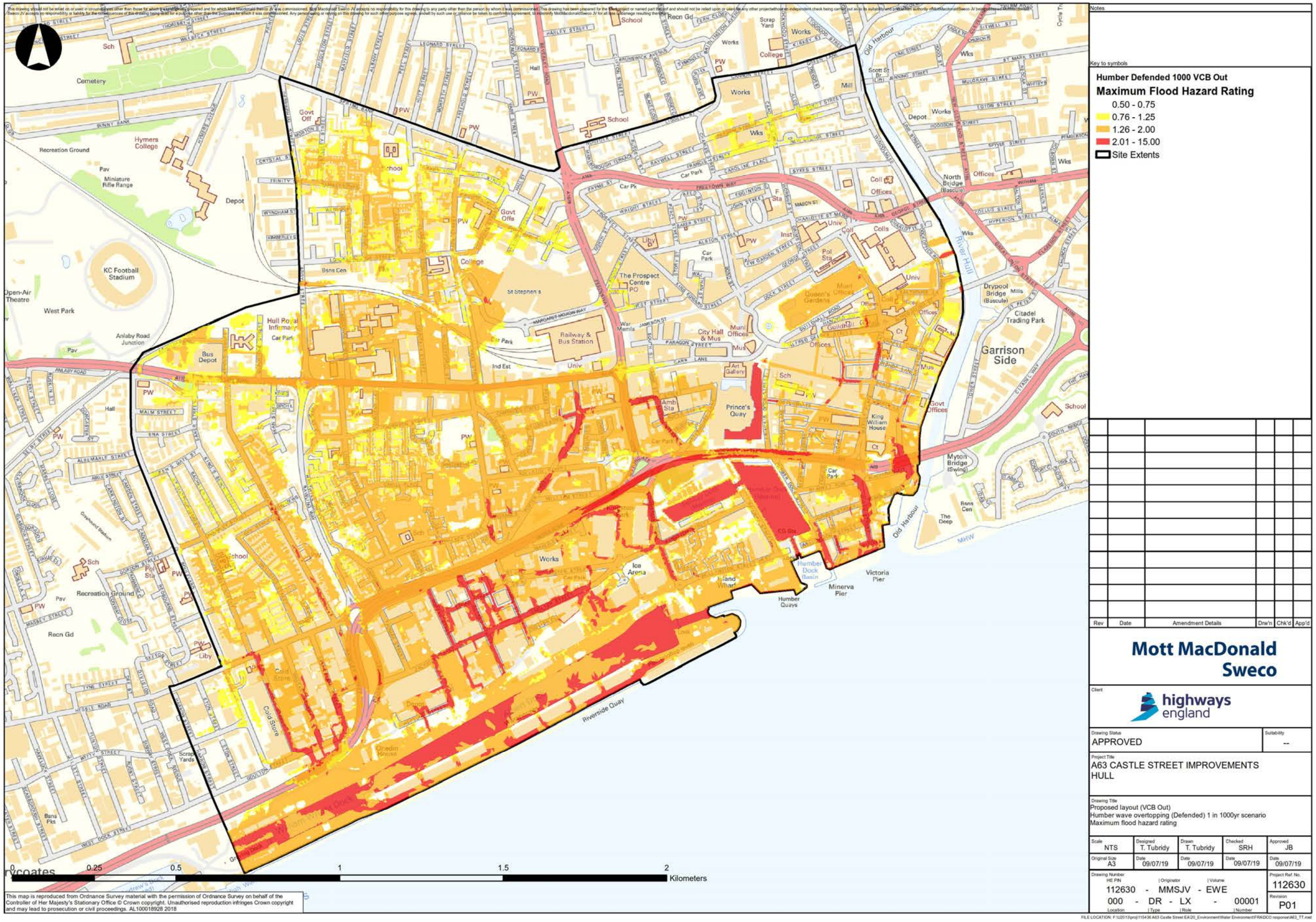


Figure 13.82 1 in 200-year plus climate change (2115) Humber defended wave overtopping maximum flood depth for Scheme layout (no VCB)

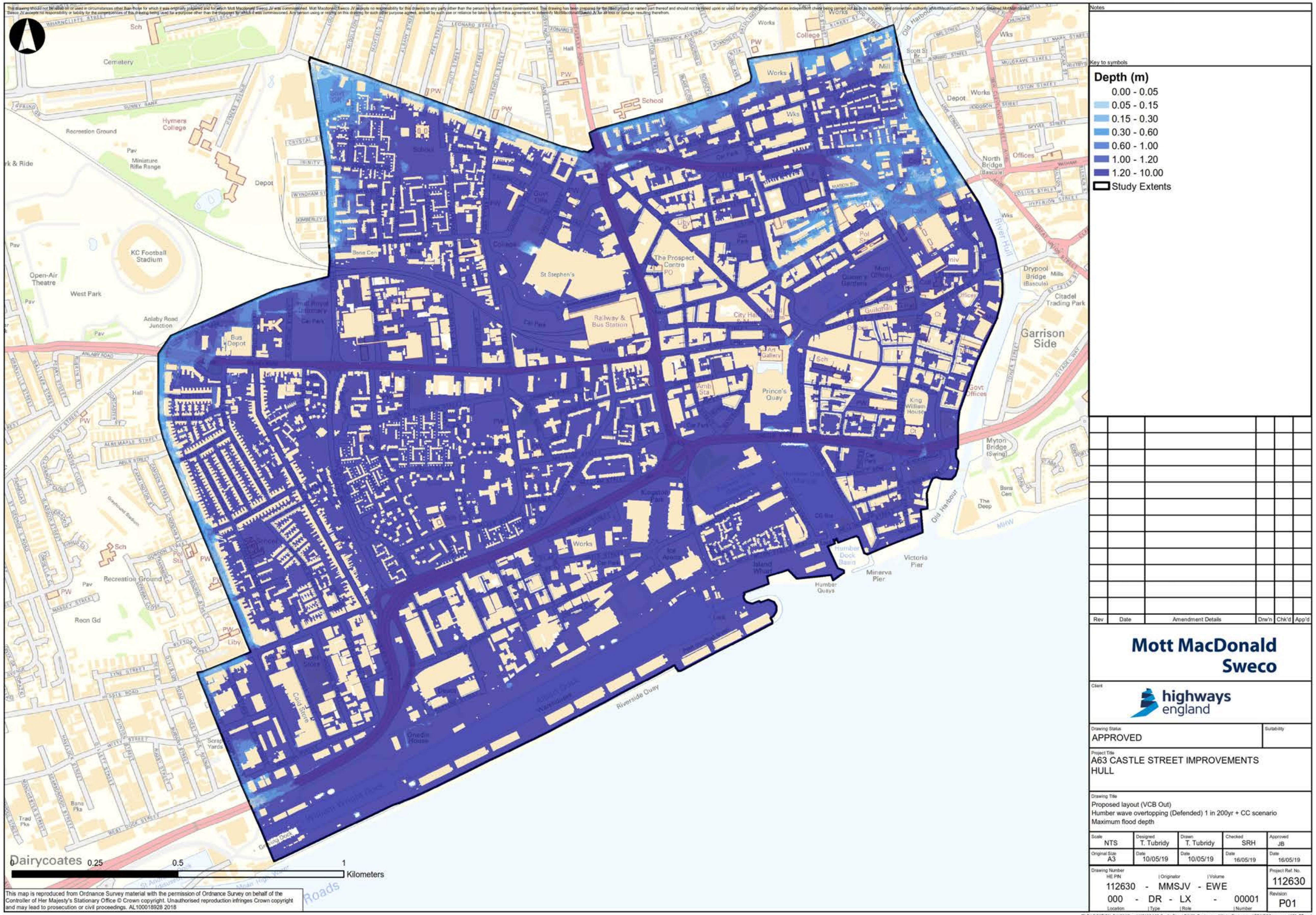


Figure 13.83 1 in 200-year plus climate change (2115) Humber defended wave overtopping maximum flood depth difference (no VCB)

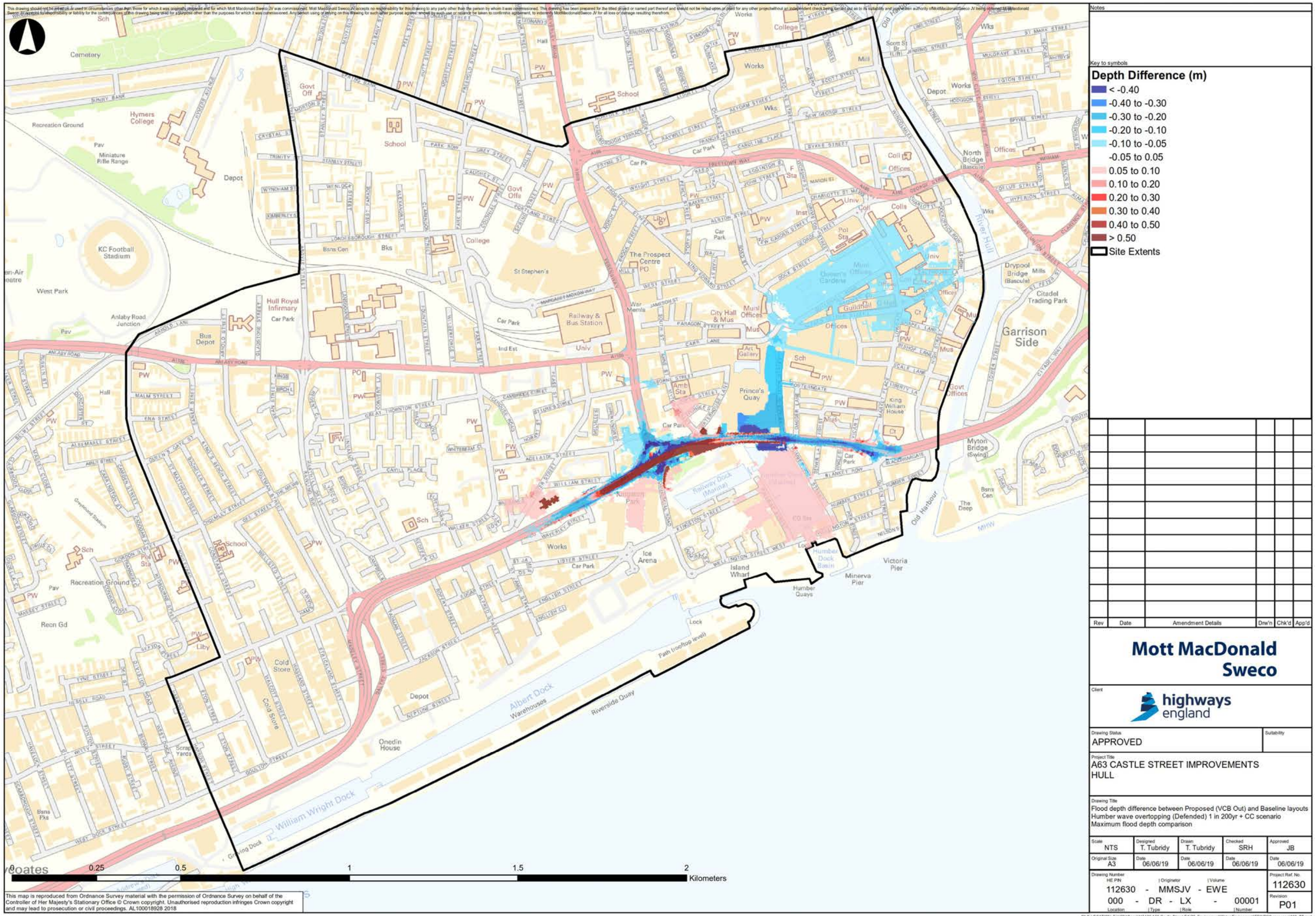


Figure 13.84 1 in 200-year plus climate change Humber wave overtopping maximum flood hazard rating for Scheme layout (no VCB)

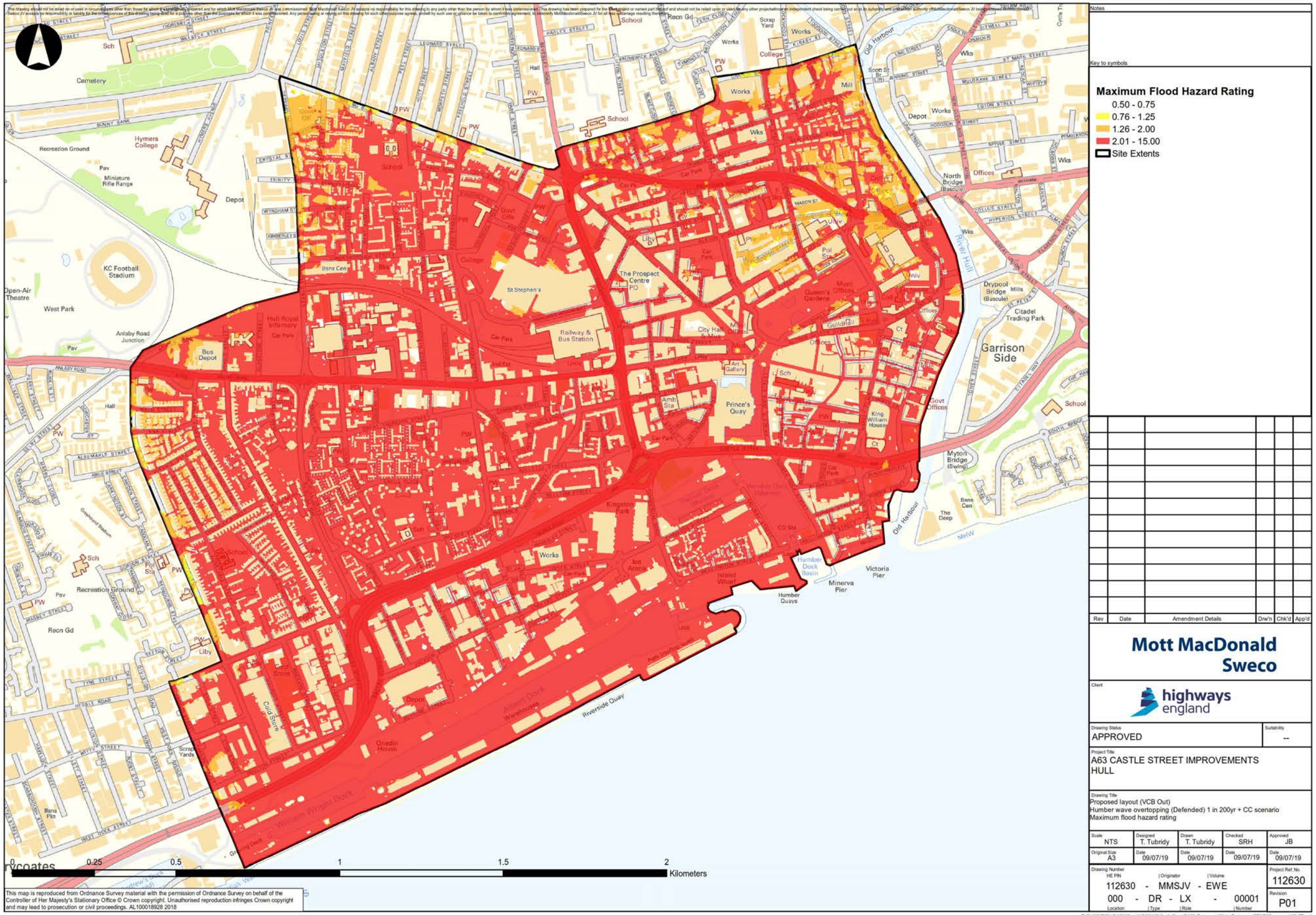


Figure 13.85 1 in 200-year Humber undefended tidal flooding maximum flood depth for Scheme layout (no VCB)

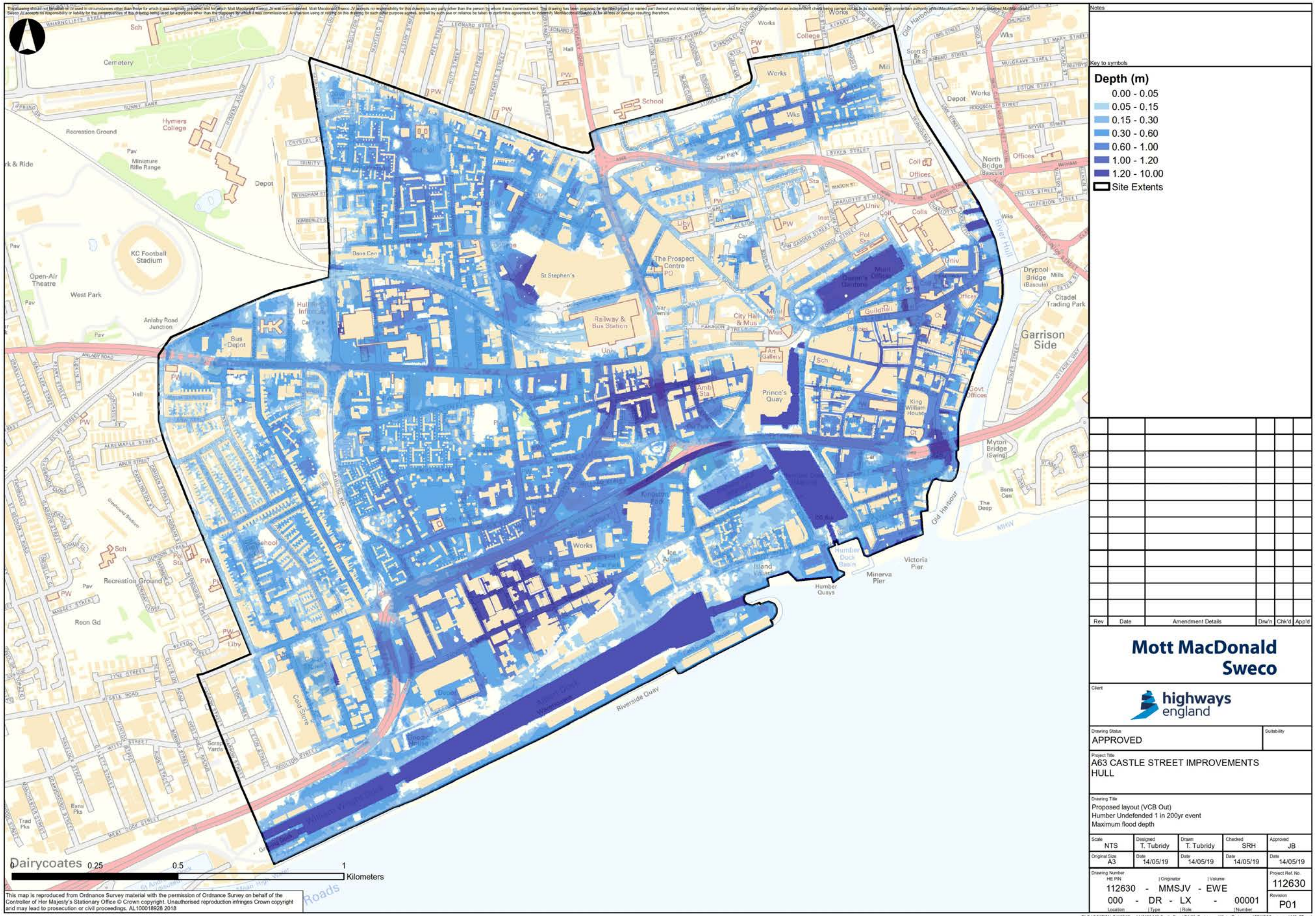


Figure 13.86 1 in 200-year Humber undefended tidal flooding maximum flood depth difference (no VCB)

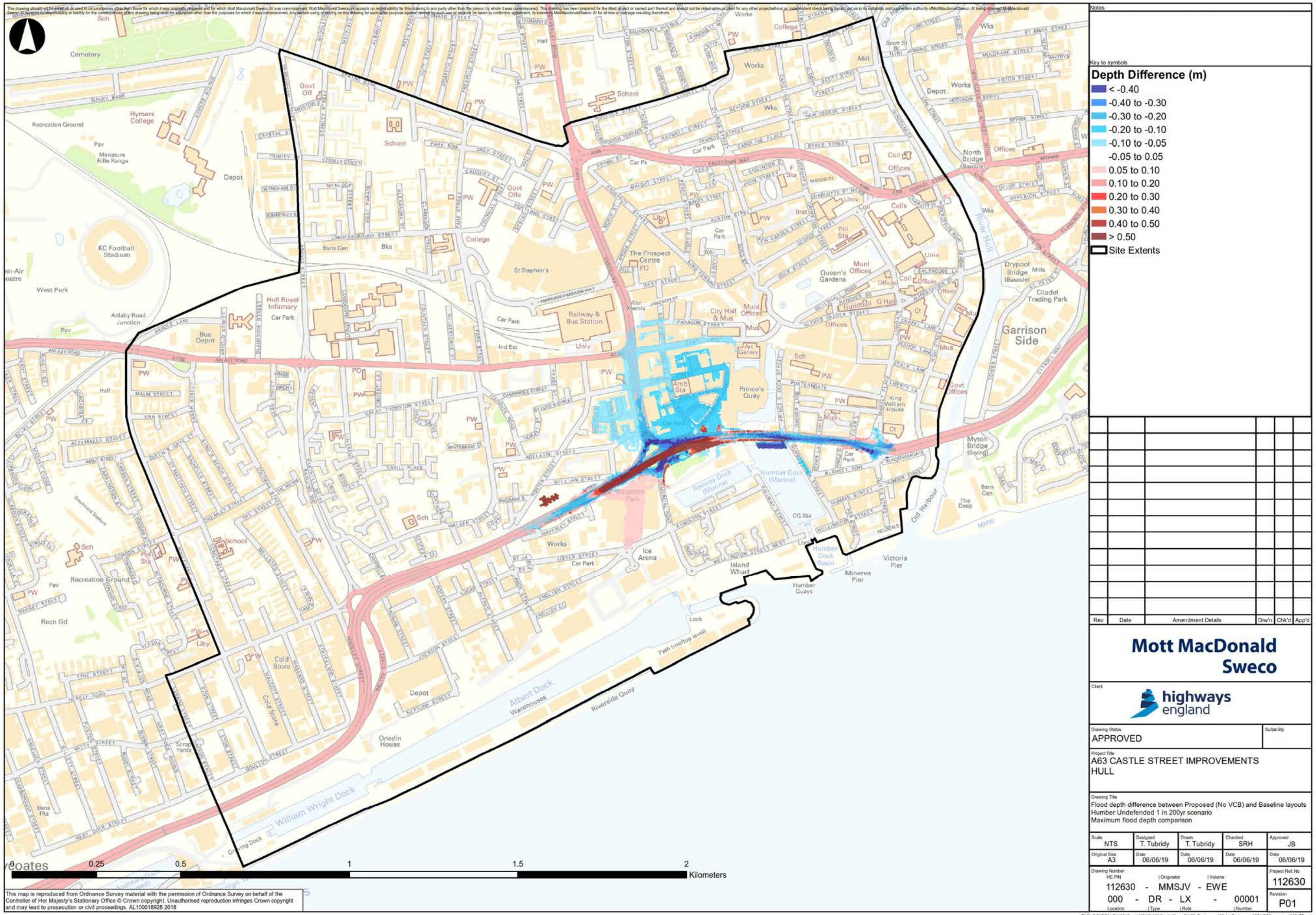


Figure 13.87 1 in 200-year plus climate change (2115) Humber undefended tidal flooding maximum flood depth for Scheme layout (no VCB)

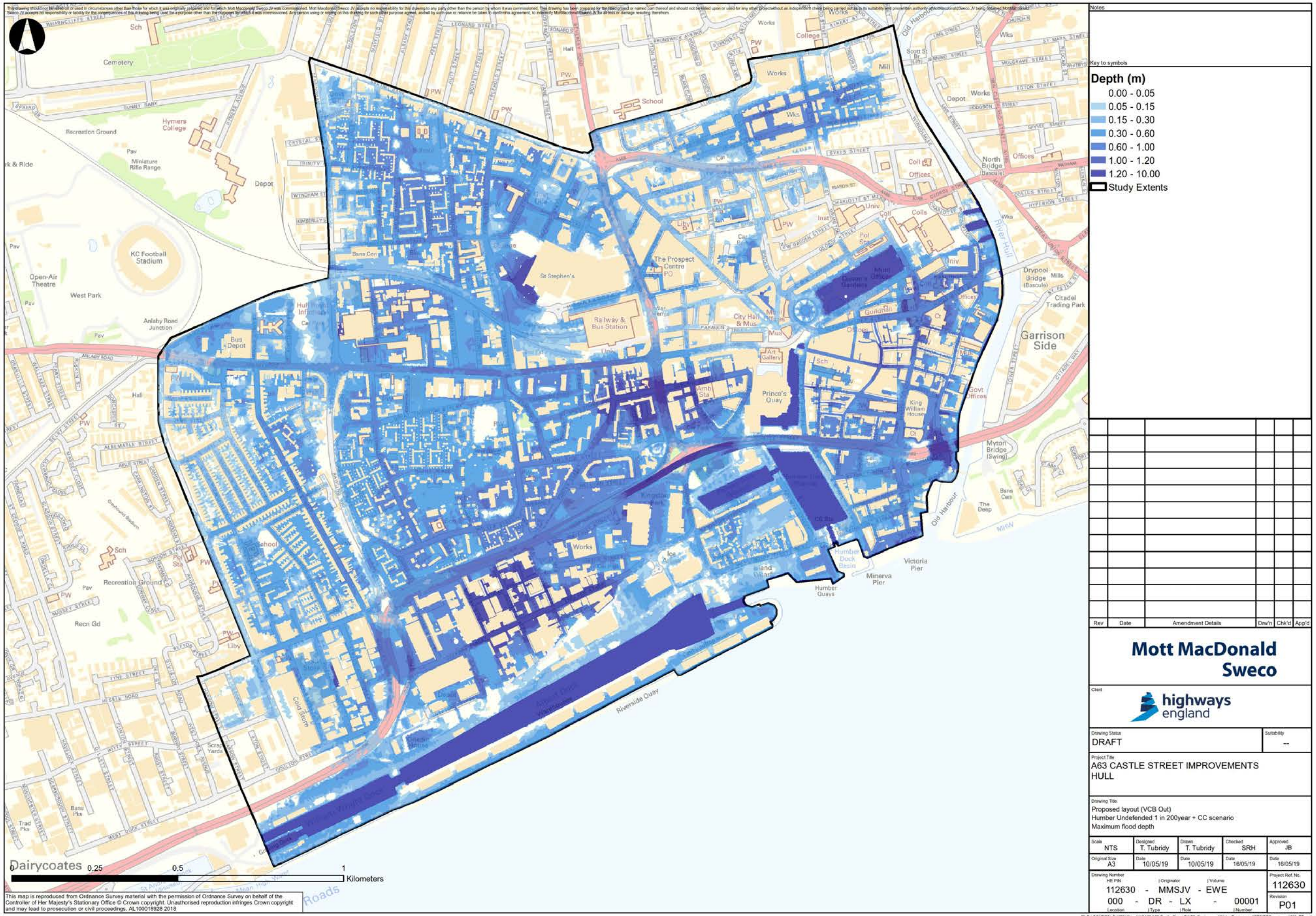


Figure 13.88 1 in 200-year plus climate change (2115) Humber undefended tidal flooding maximum flood depth difference (no VCB)

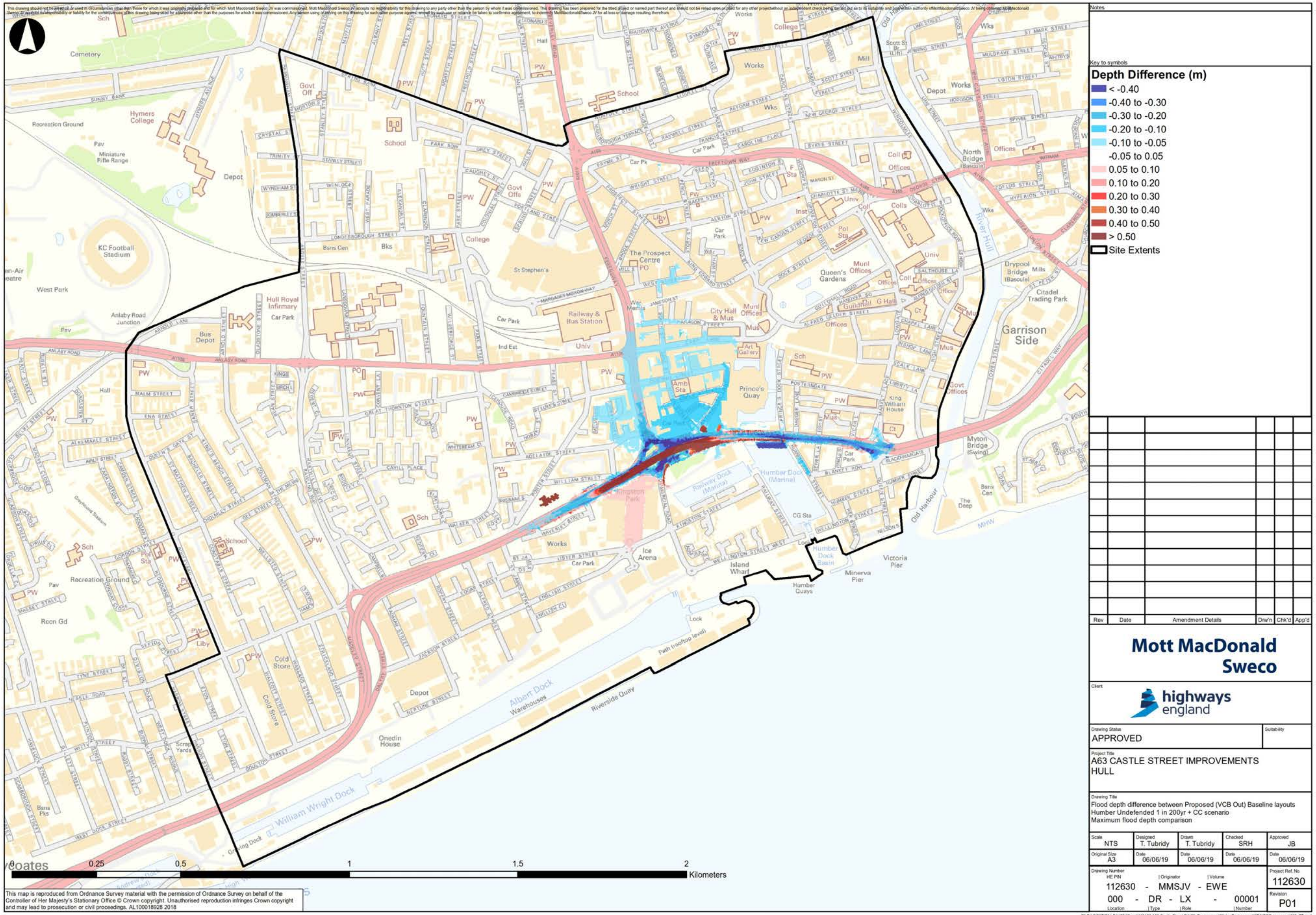


Figure 13.89 1 in 200-year Humber undefended tidal flooding maximum flood hazard rating for Scheme layout (no VCB)

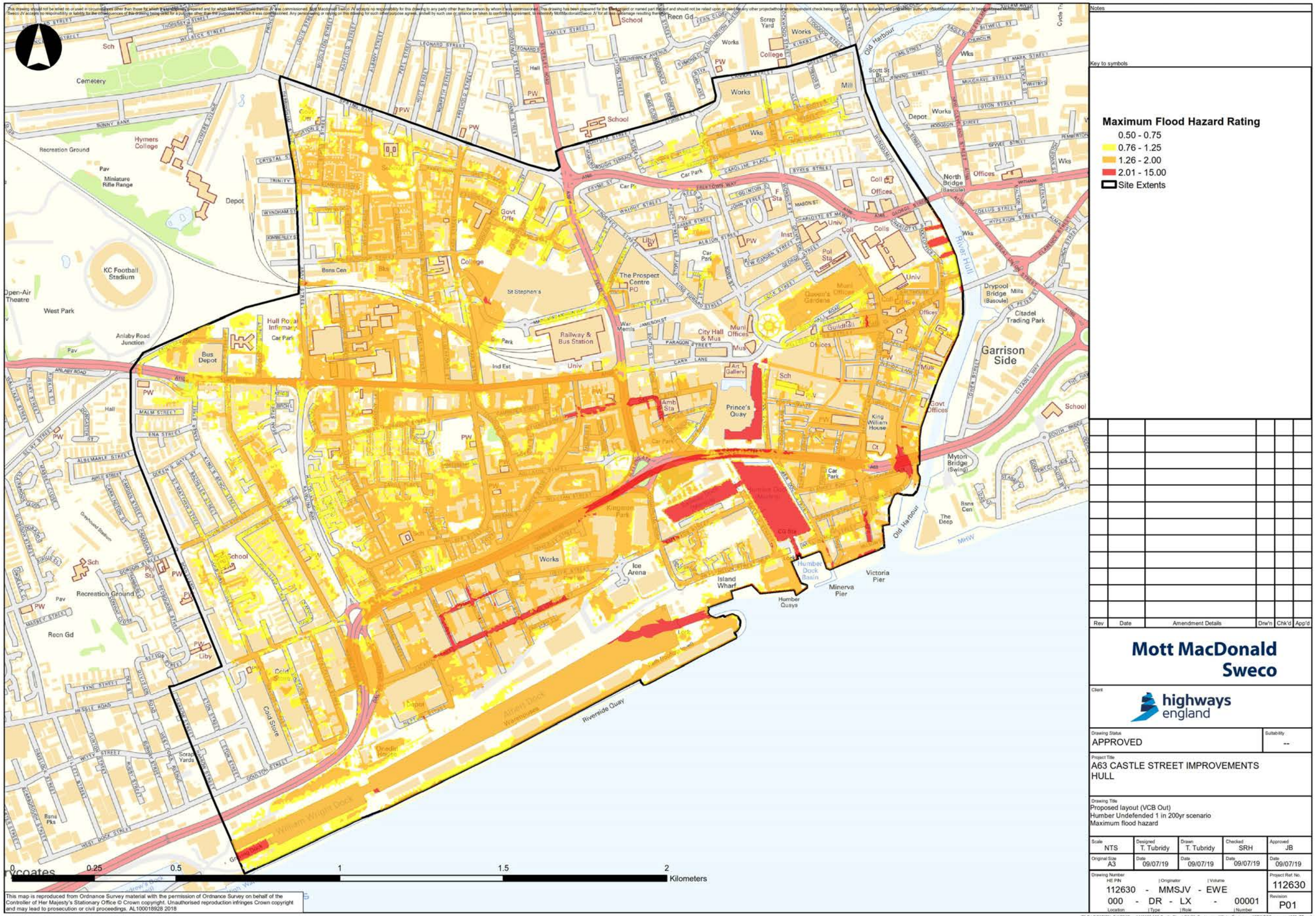


Figure 13.90 1 in 200-year plus climate change (2115) Humber undefended tidal flooding maximum flood hazard rating for Scheme layout (no VCB)

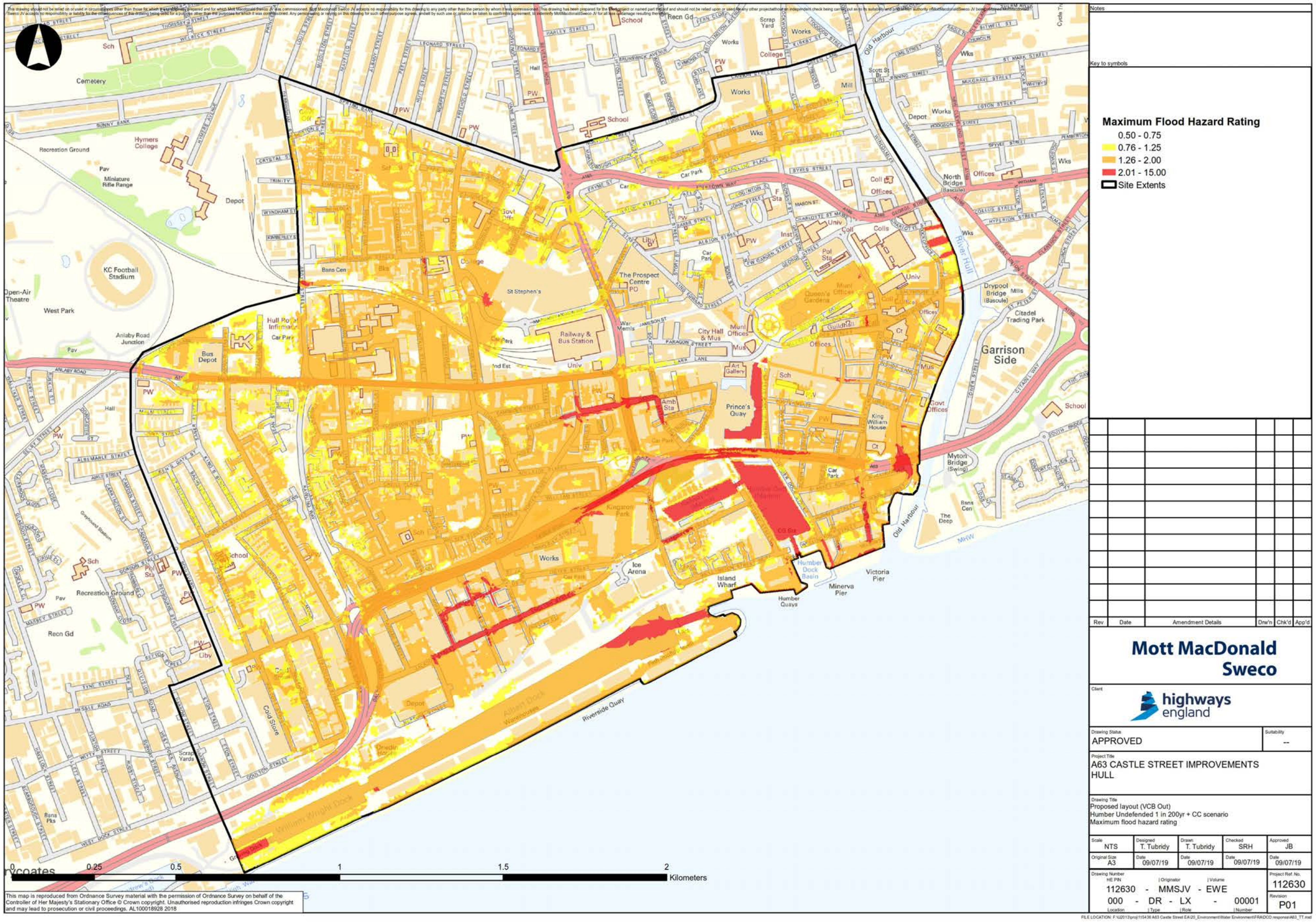


Figure 13.91 1 in 200-year River Hull tidal flooding maximum flood depth for Scheme layout (no VCB) (Hull Tidal Surge Barrier open)

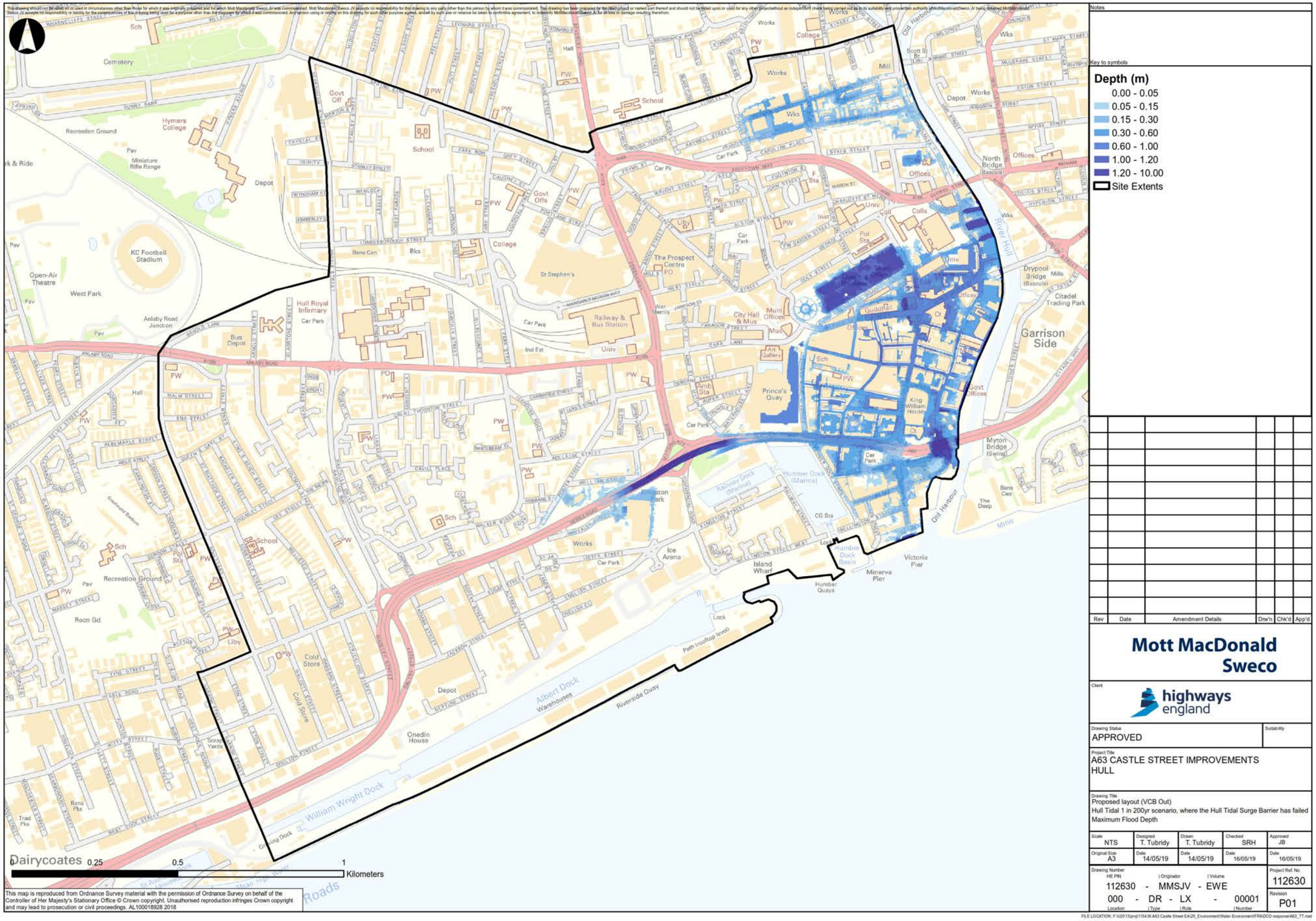


Figure 13.92 1 in 200-year River Hull tidal flooding maximum flood depth difference (no VCB) (Hull Tidal Surge Barrier open)

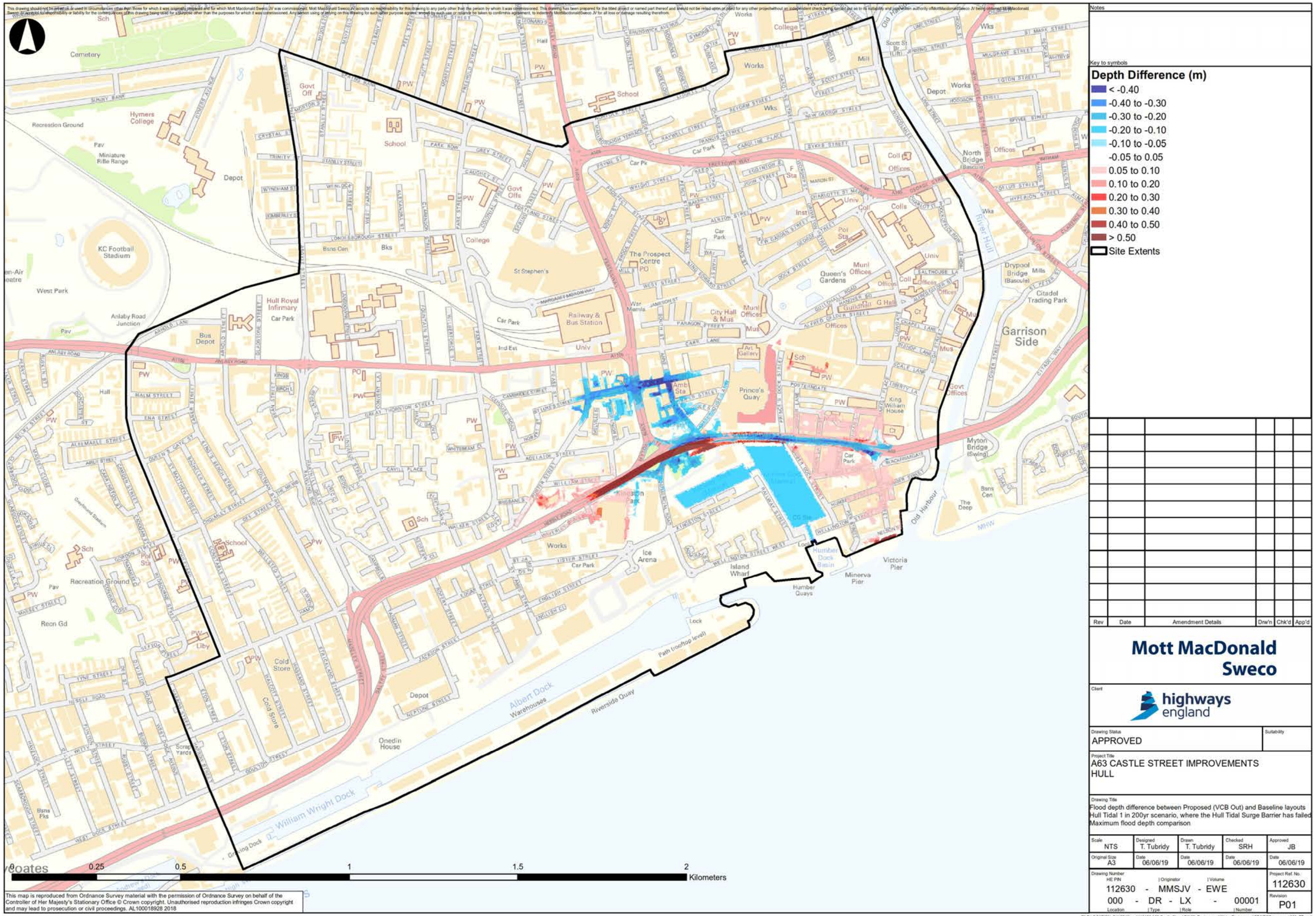


Figure 13.93 1 in 1,000-year River Hull tidal flooding maximum flood depth for Scheme layout (no VCB) (Hull Tidal Surge Barrier open)

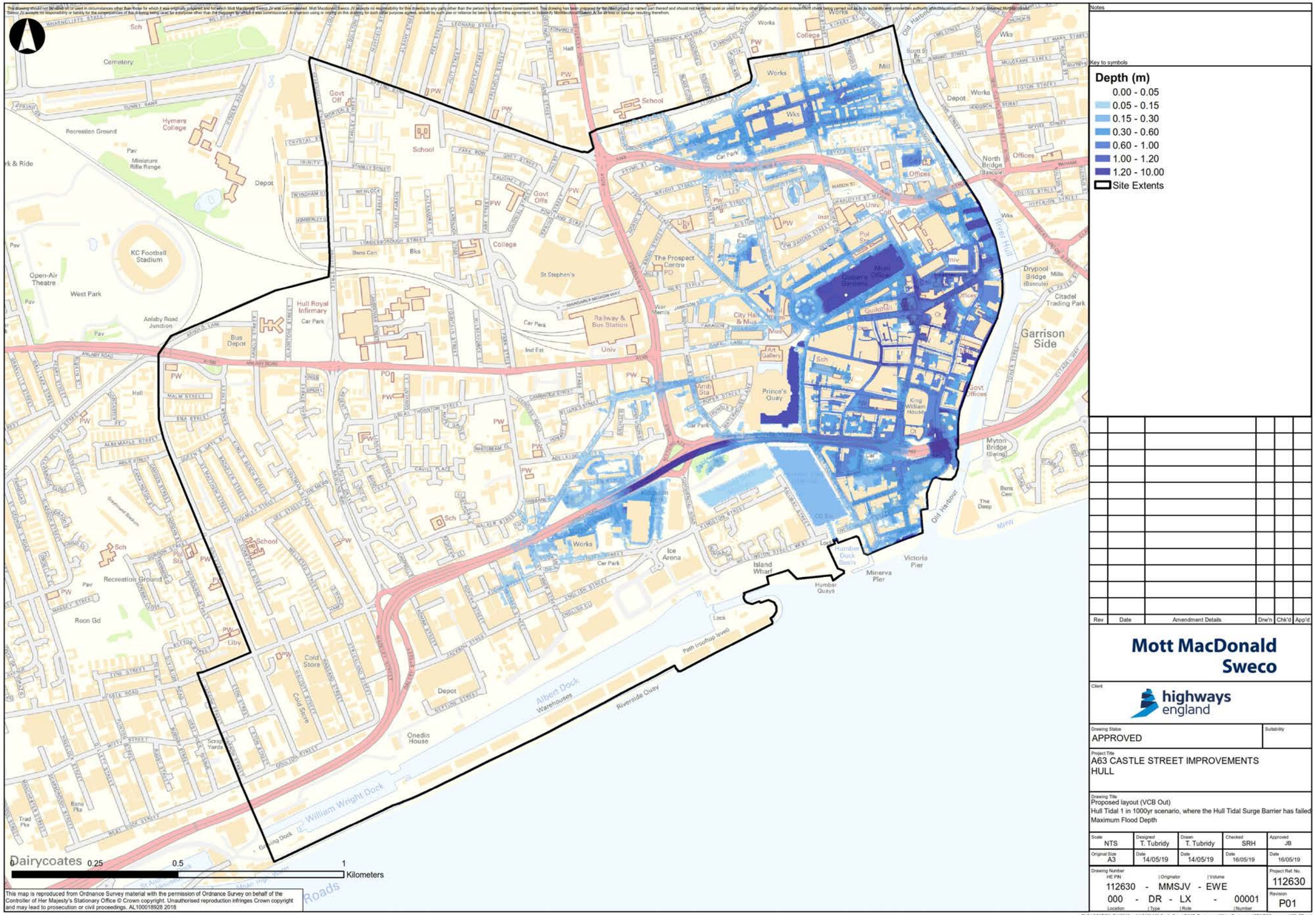


Figure 13.94 1 in 1,000-year River Hull tidal flooding maximum flood depth difference (no VCB (Hull Tidal Surge Barrier open))

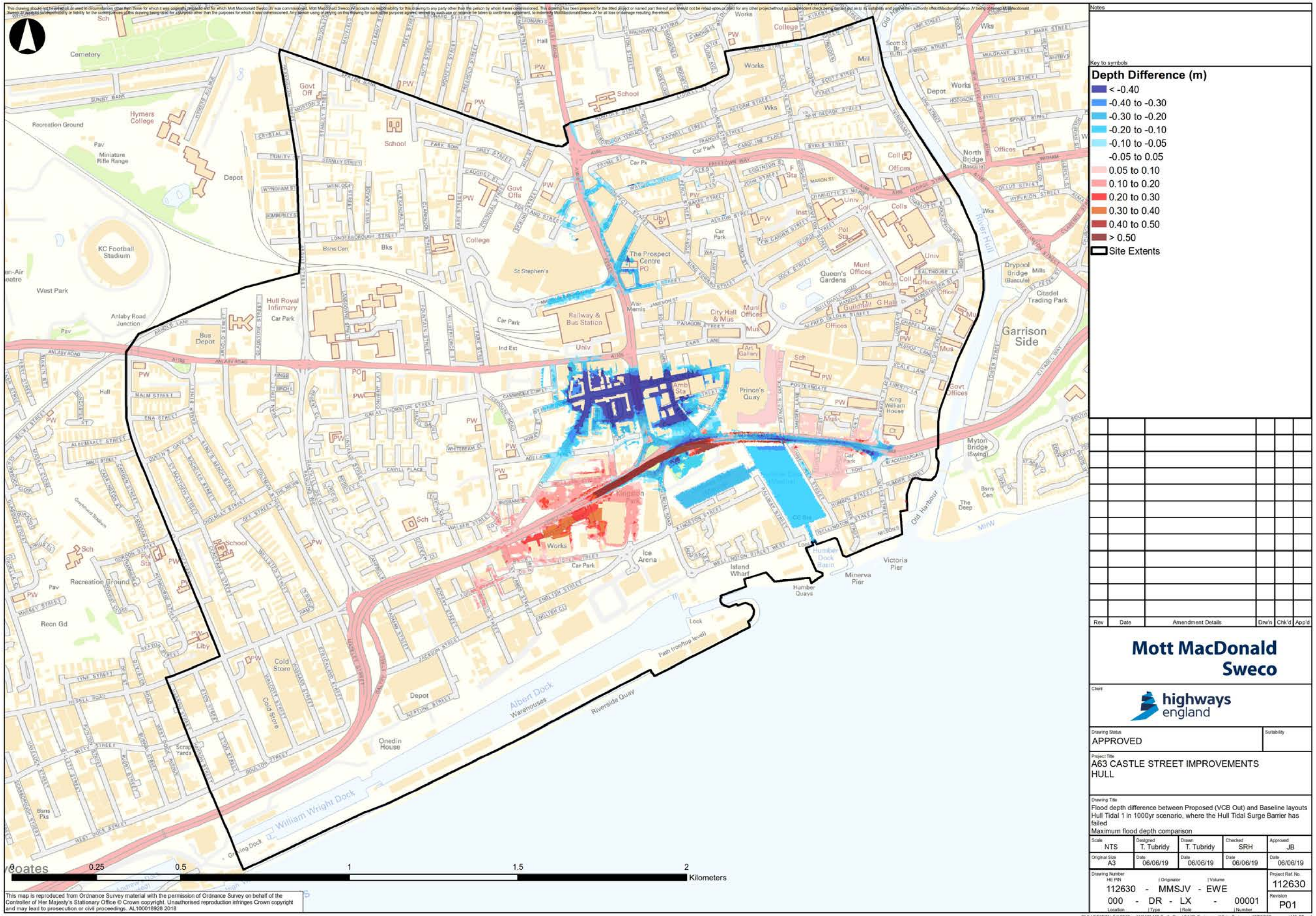


Figure 13.95 1 in 200-year River Hull tidal flooding maximum flood hazard rating for Scheme layout (no VCB) (Hull Tidal Surge Barrier open)

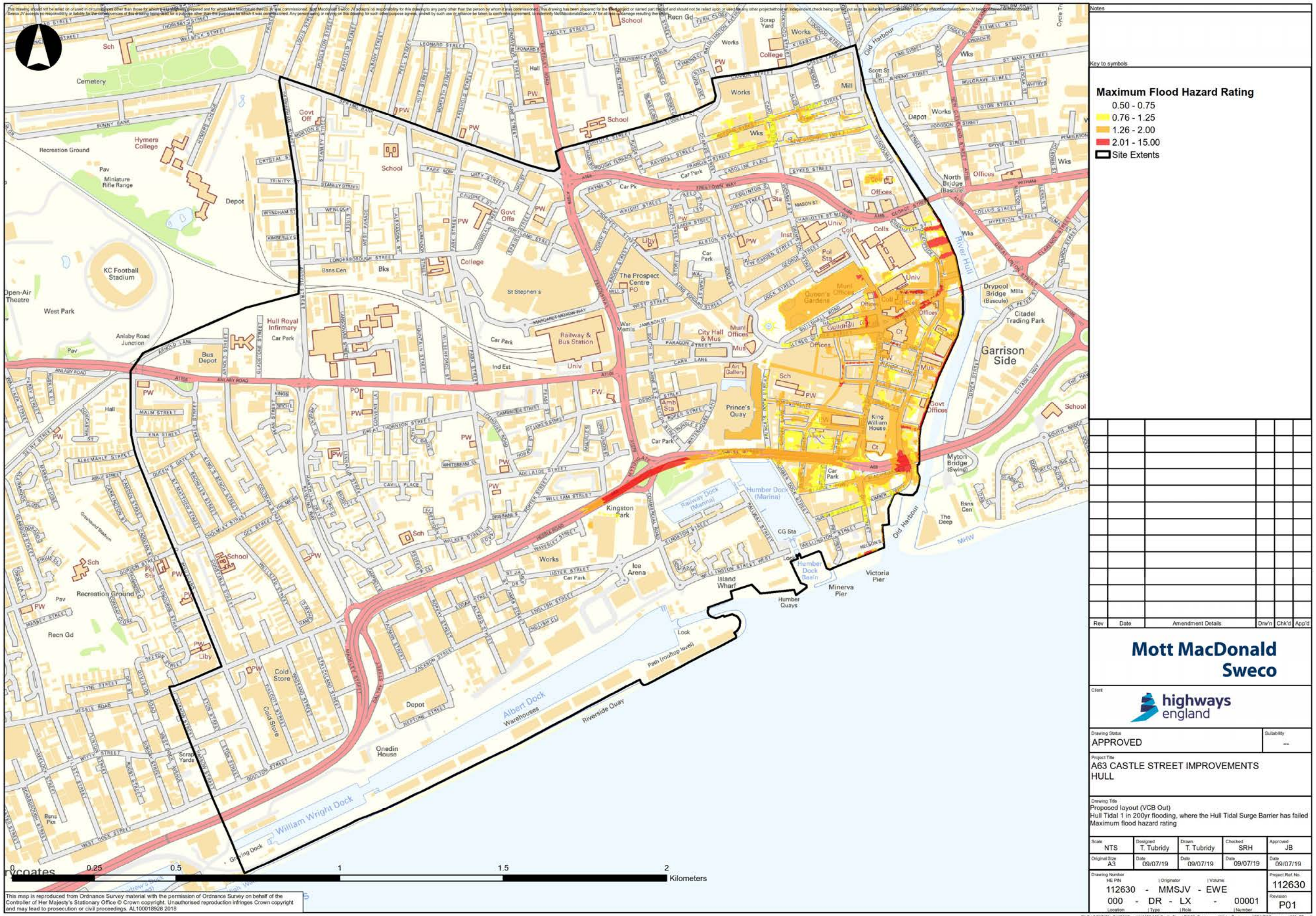


Figure 13.96 1 in 1,000-year River Hull tidal flooding maximum flood hazard rating for Scheme layout (no VCB) (Hull Tidal Surge Barrier open)

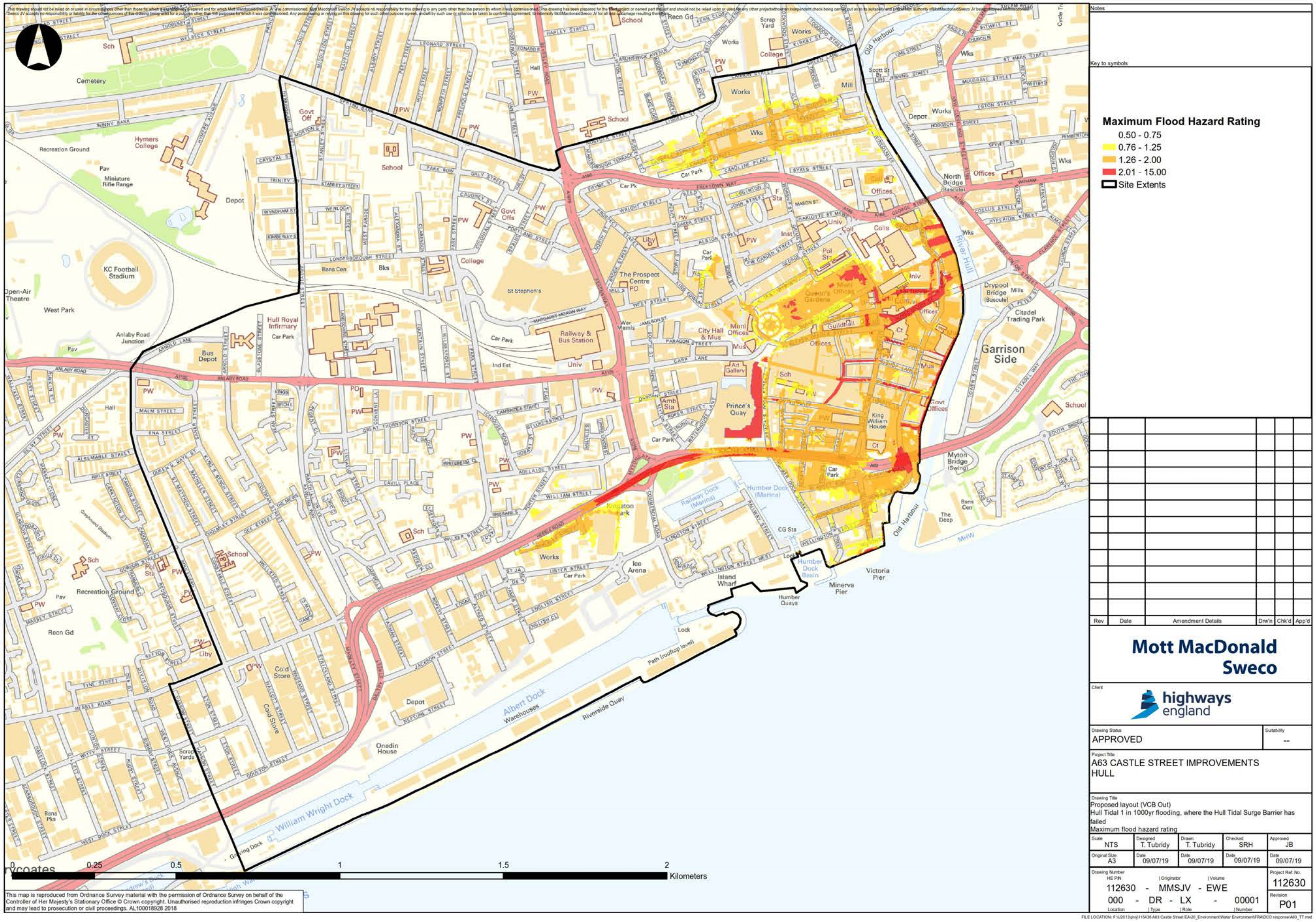


Figure 13.97 Flood extent comparison for 1 in 30-year pluvial flooding between existing and Scheme (VCB In) scenario

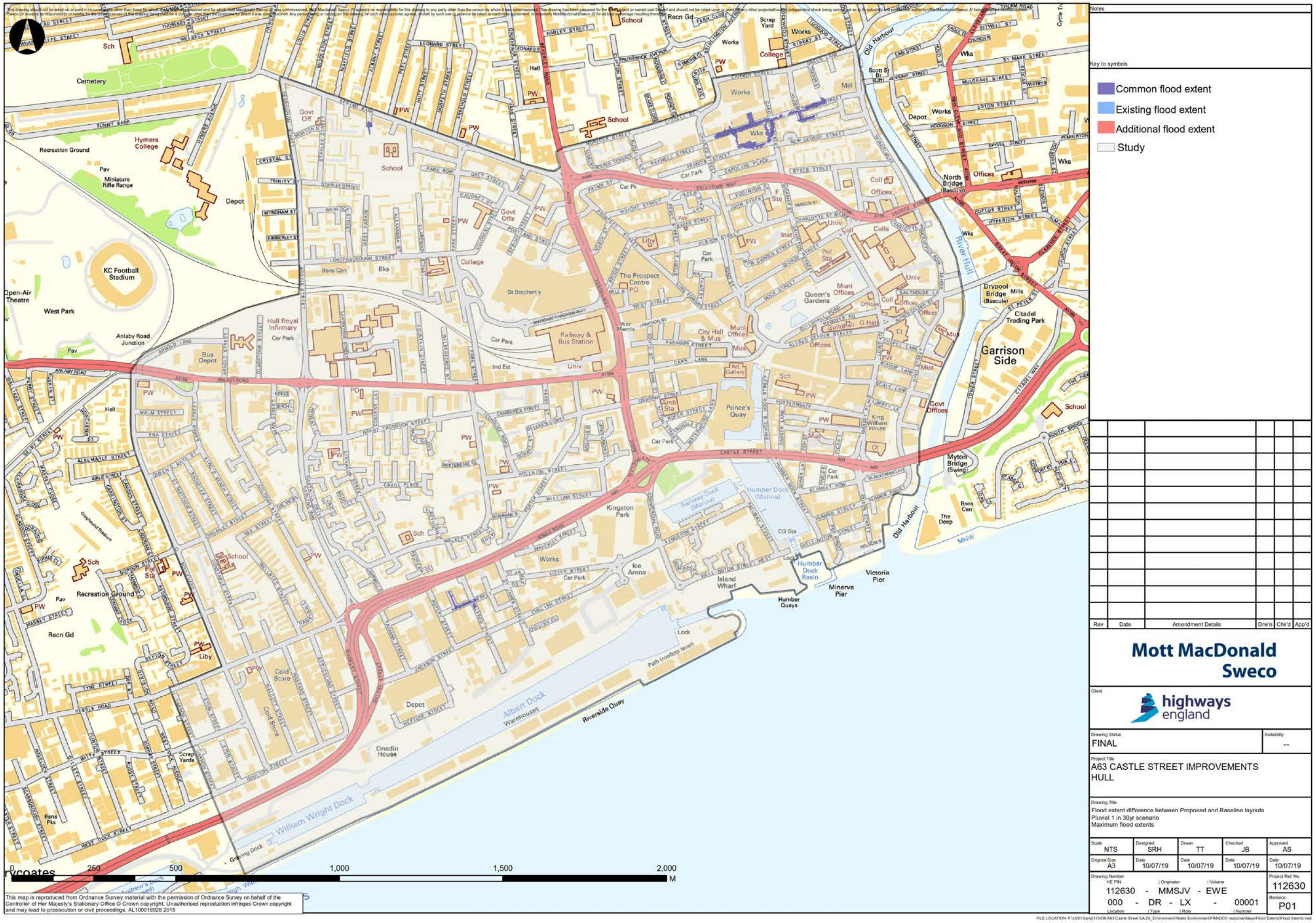


Figure 13.98 Flood extent comparison for 1 in 100-year pluvial flooding between existing and Scheme (VCB In) scenario

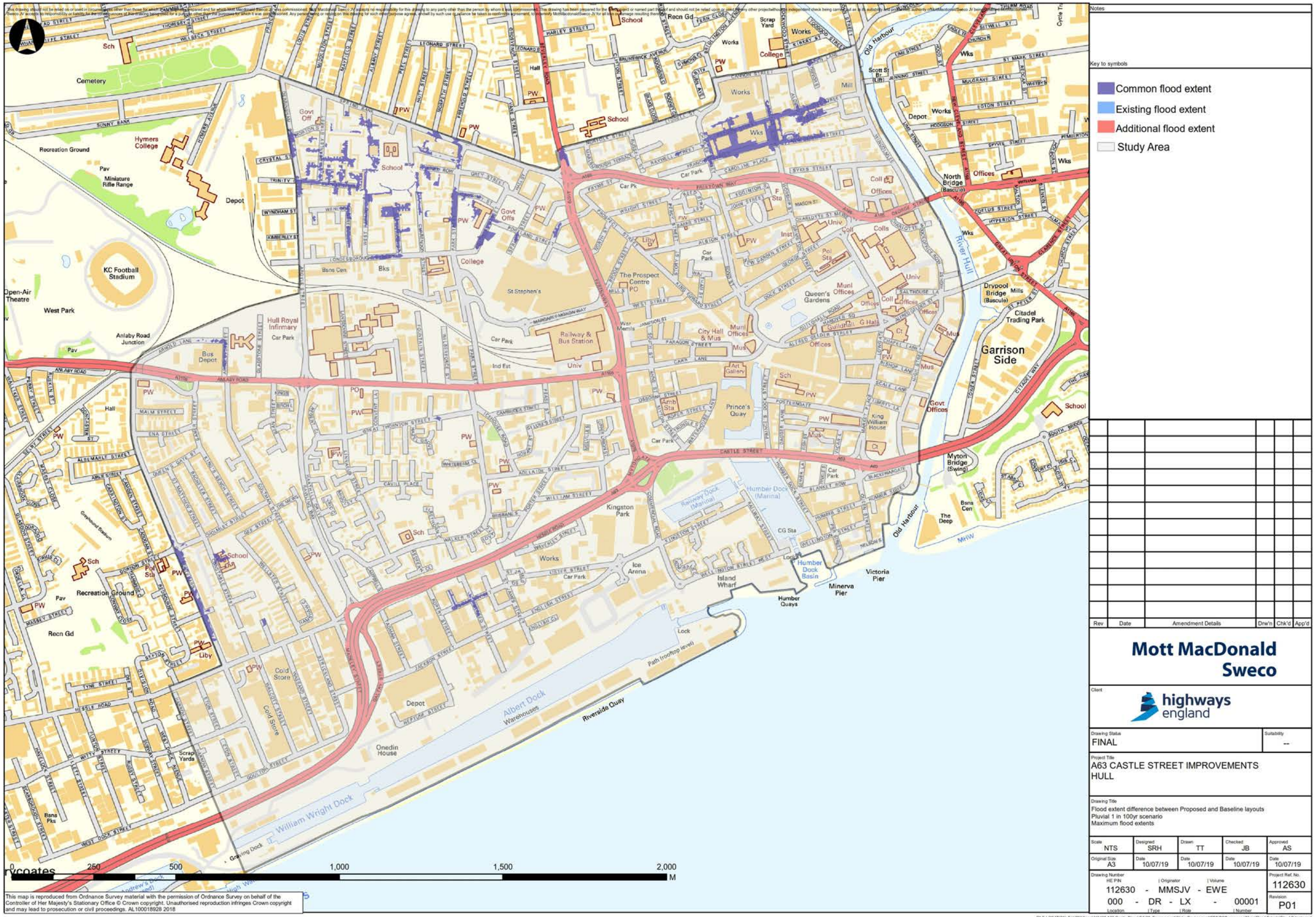


Figure 13.99 Flood extent comparison for 1 in 100-year (plus 30% climate change) pluvial flooding between existing and Scheme (VCB In) scenario

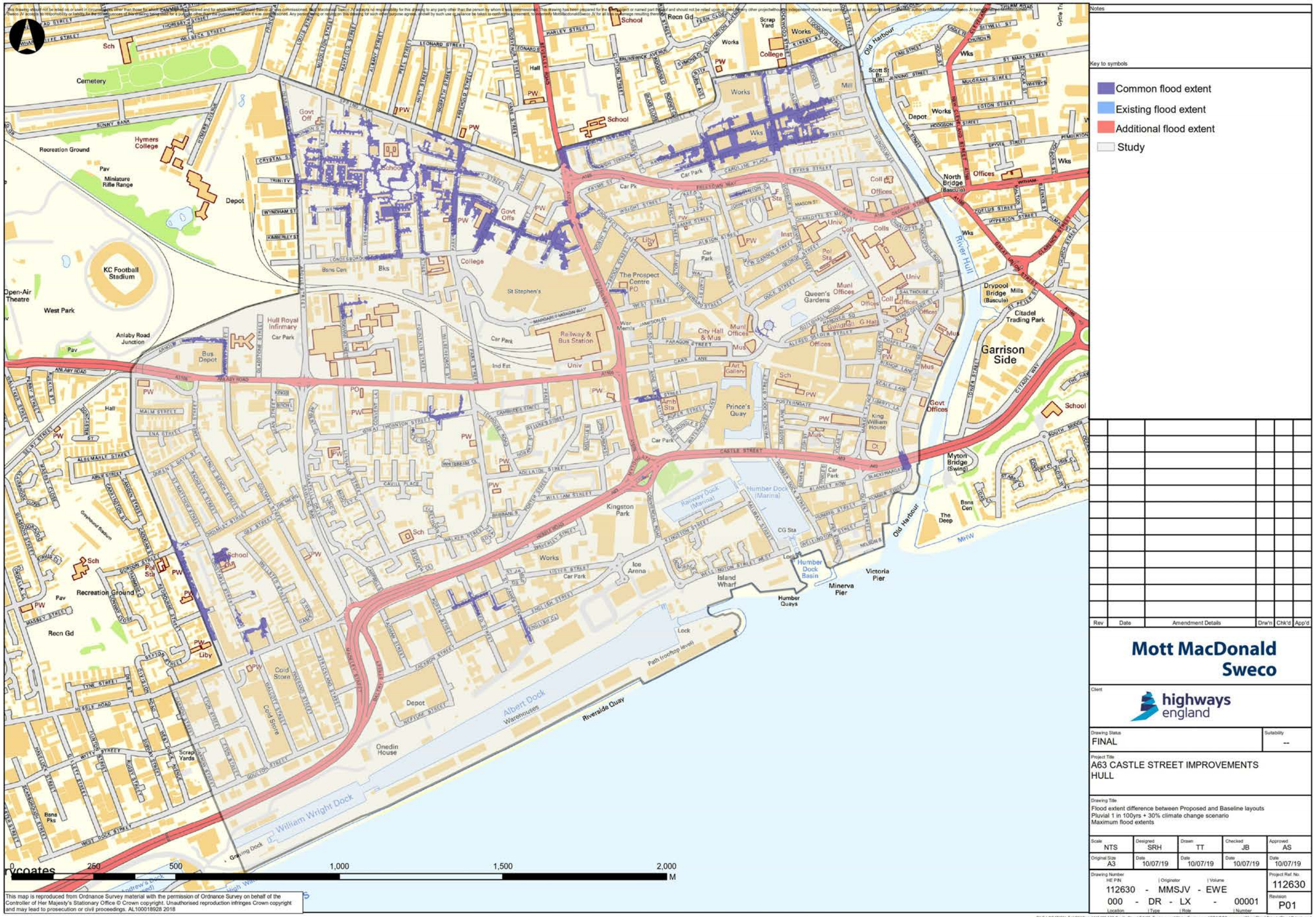


Figure 13.100 Flood extent comparison for 1 in 200-year Humber defended wave overtopping flooding between existing and Scheme (VCB In) scenario

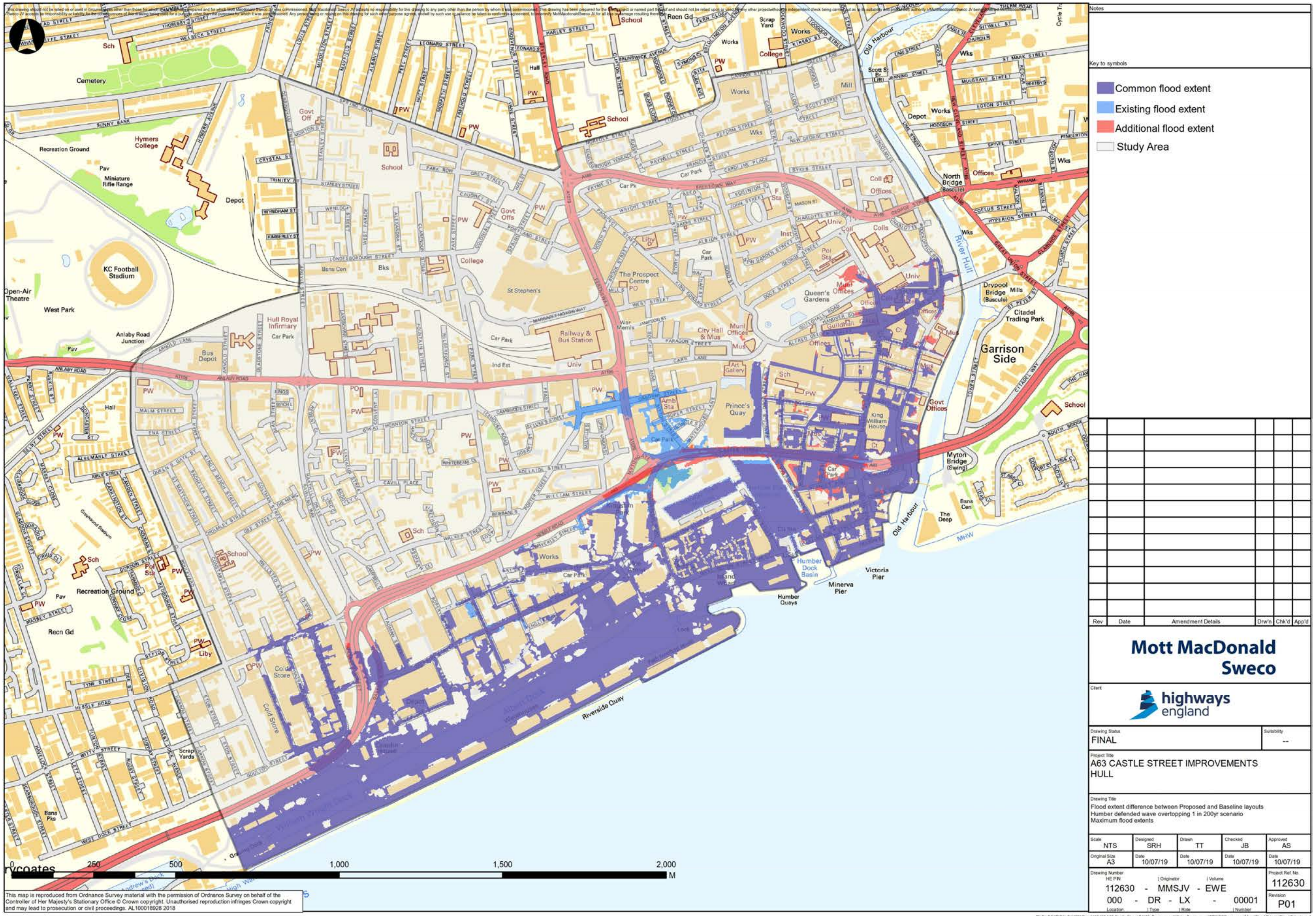


Figure 13.101 Flood extent comparison for 1 in 1,000-year Humber defended wave overtopping flooding between existing and Scheme (VCB In) scenario

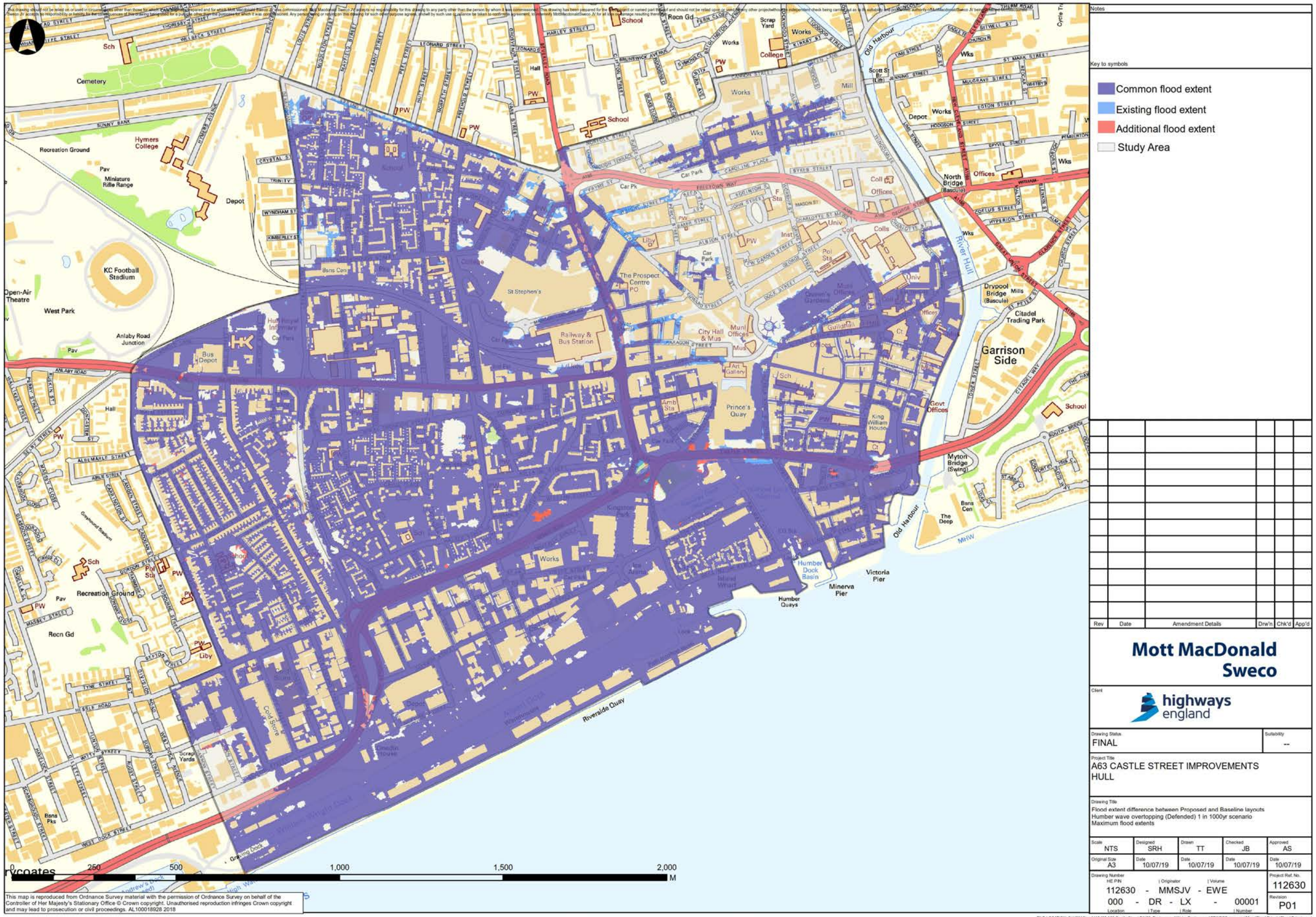
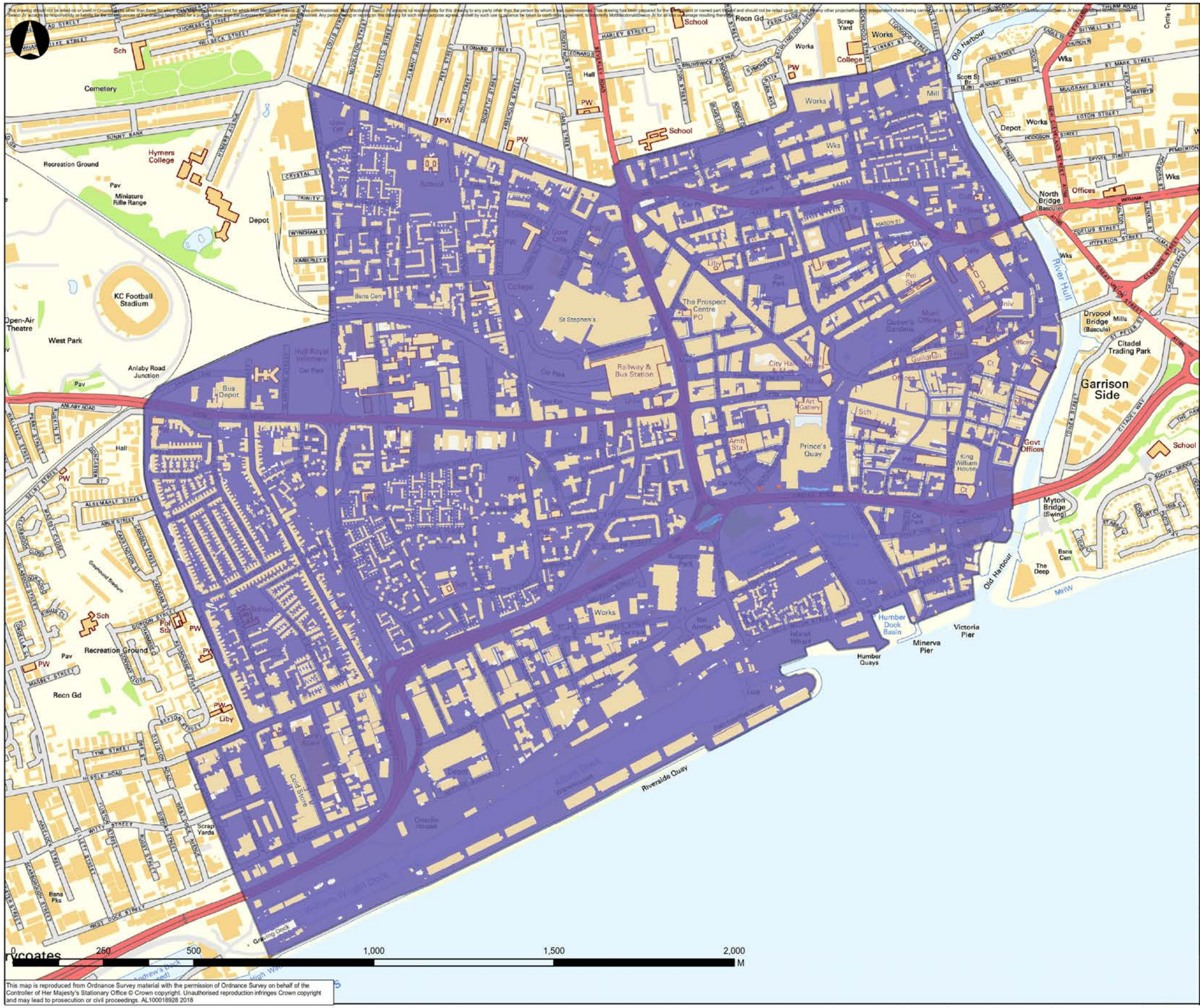


Figure 13.102 Flood extent comparison for 1 in 200-year plus climate change (2115) Humber defended wave overtopping flooding between existing and Scheme (VCB In) scenario



Notes

Key to symbols

- Common flood extent
- Existing flood extent
- Additional flood extent
- Study

Rev	Date	Amendment Details	Drw'n	Chk'd	App'd

Mott MacDonald Sweco

Client: highways england

Drawing Status: FINAL | Suitability: --

Project Title: A63 CASTLE STREET IMPROVEMENTS HULL

Drawing Title: Flood extent differences between Proposed and Baseline layouts Humber wave overtopping (Defended) 1 in 200yr flooding + 2115 Climate Change scenario Maximum flood extents

Scale	Designed	Drawn	Checked	Approved
NTS	SRH	TT	JB	AS
Original Size: A3	Date: 10/07/19	Date: 10/07/19	Date: 10/07/19	Date: 10/07/19

Drawing Number: HE PIN 112630 - Originator MMSJV - Volume EWE / Location 000 - Type DR - Role LX - Number 00001

Project Ref. No. 112630

Revision P01

FILE LOCATION: F:\U2013\proj\115436 A63 Castle Street EA\20_Environment\Water Environment\FRA\DCO response\Maps\Flood Extents\Flood Extents.mxd

Figure 13.103 Flood extent comparison for 1 in 200-year Humber undefended tidal flooding between existing and Scheme (VCB In) scenario

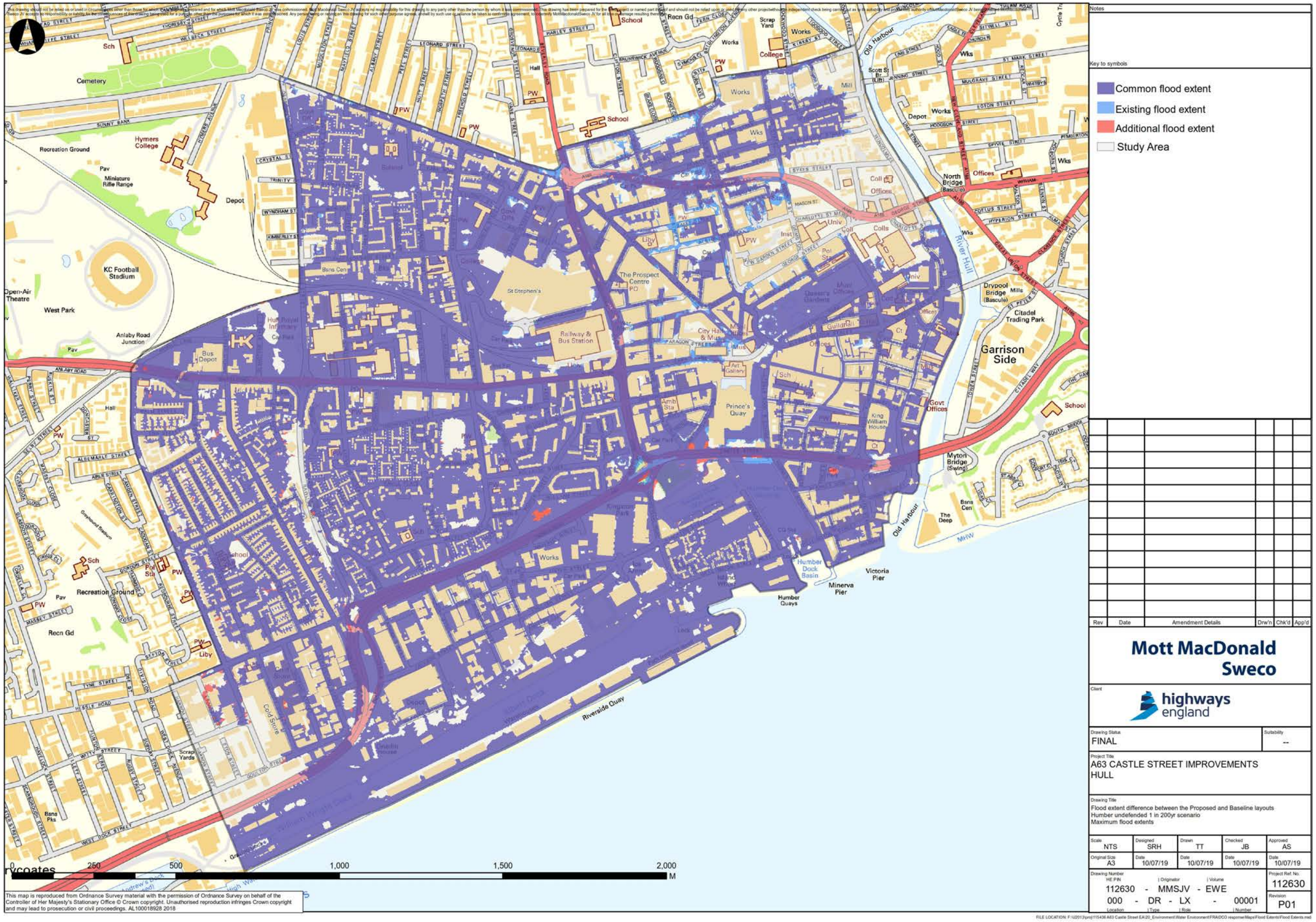


Figure 13.104 Flood extent comparison for 1 in 200-year plus climate change (2115) Humber undefended tidal flooding between existing and Scheme (VCB In) scenario

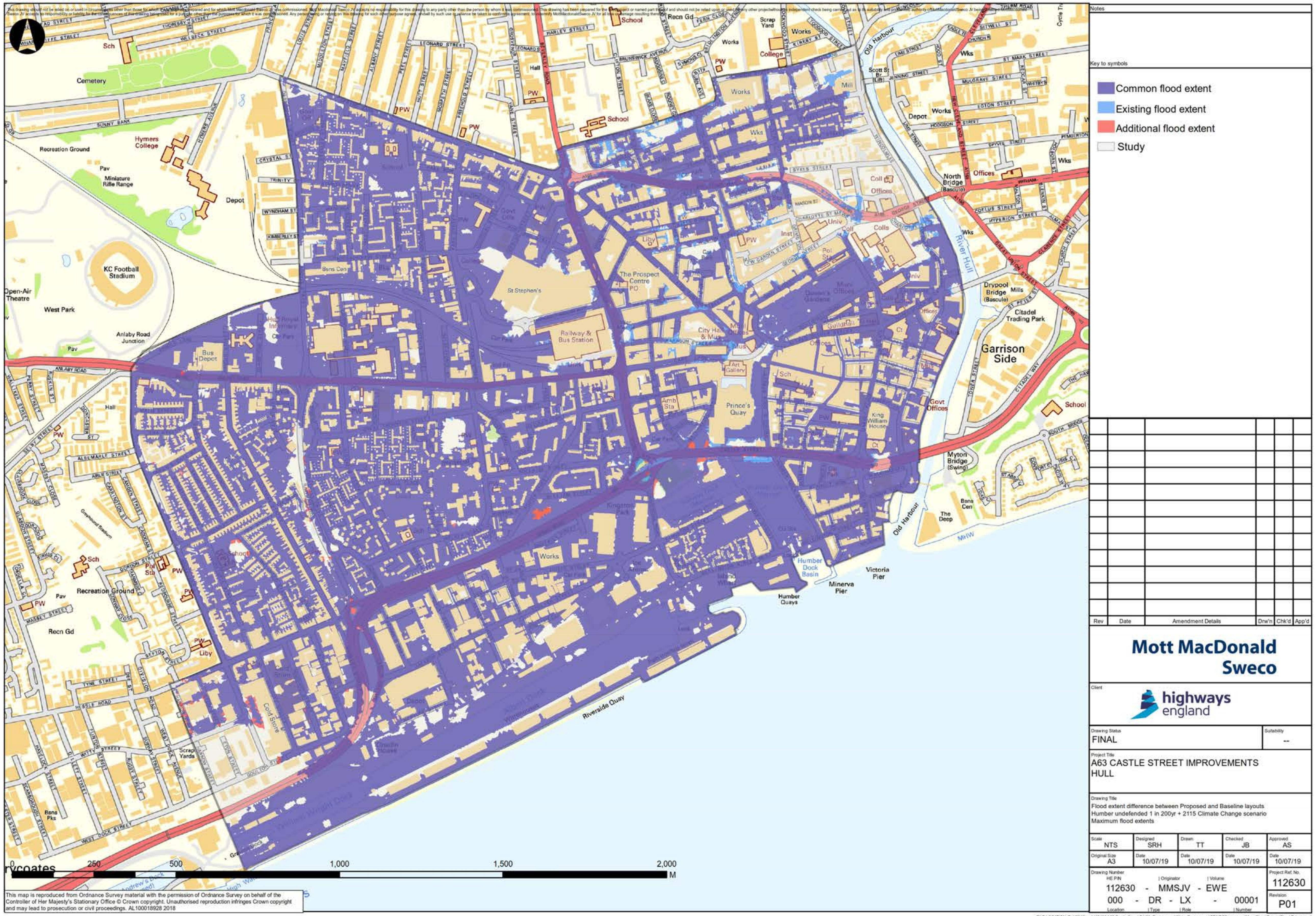


Figure 13.105 Flood extent comparison for 1 in 200-year River Hull tidal flooding between existing and Scheme (VCB In) scenario (Hull Tidal Surge Barrier open)

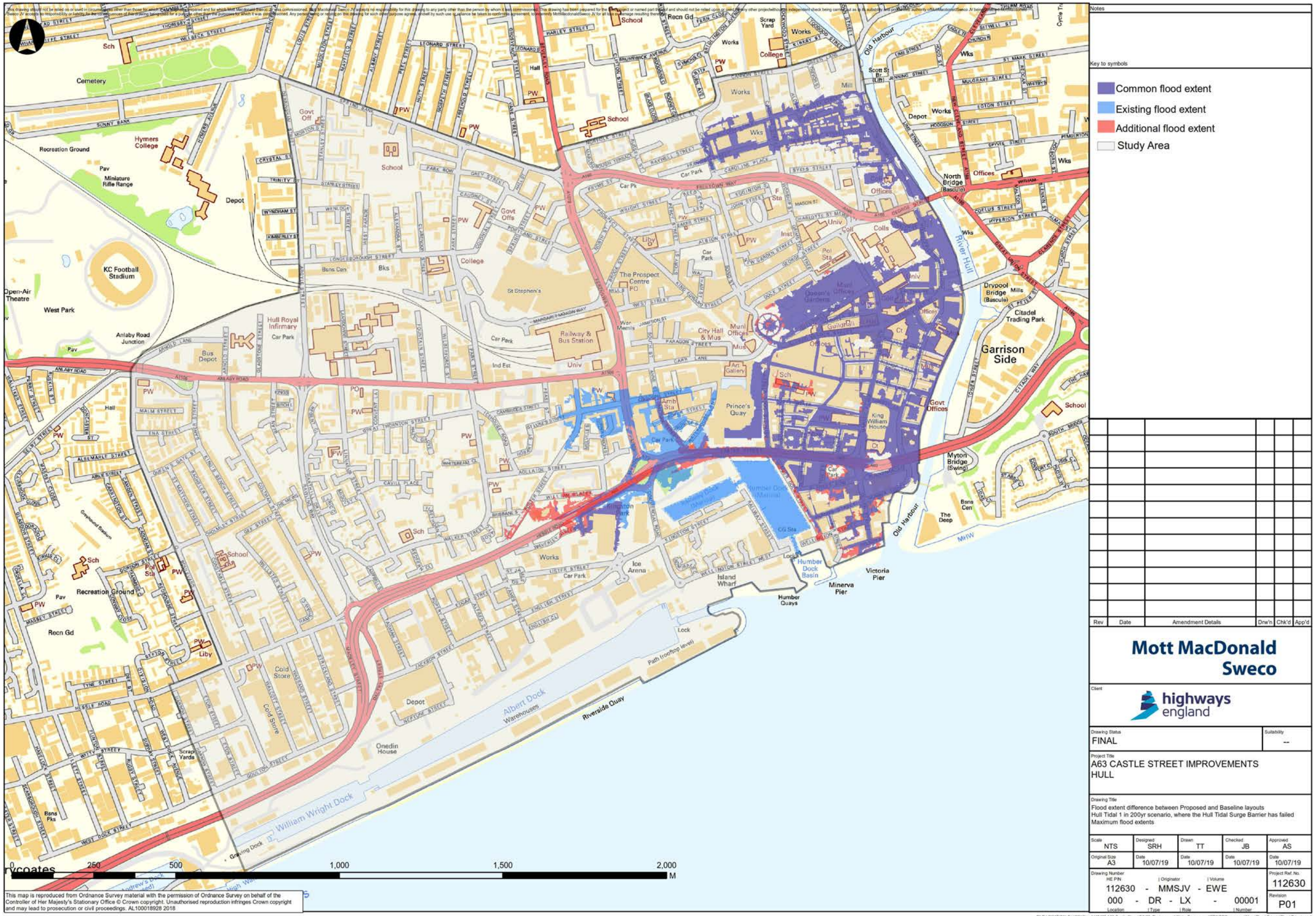


Figure 13.106 Flood extent comparison for 1 in 1,000-year River Hull tidal flooding between existing and Scheme (VCB In) scenario (Hull Tidal Surge Barrier open)

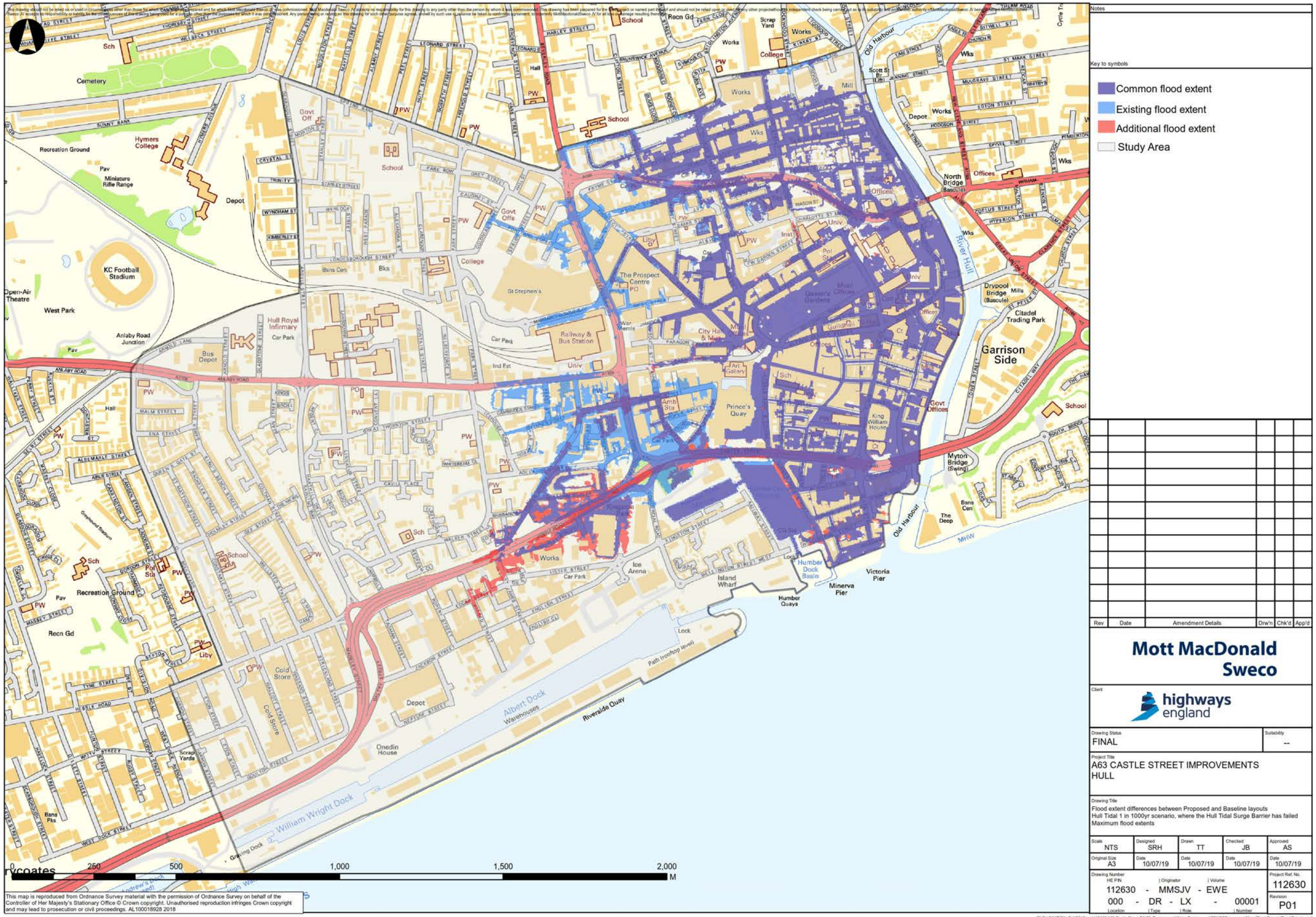


Figure 13.107 Maximum flood depth changes at Hull City Council allocated development sites for a 1 in 30-year pluvial flooding event

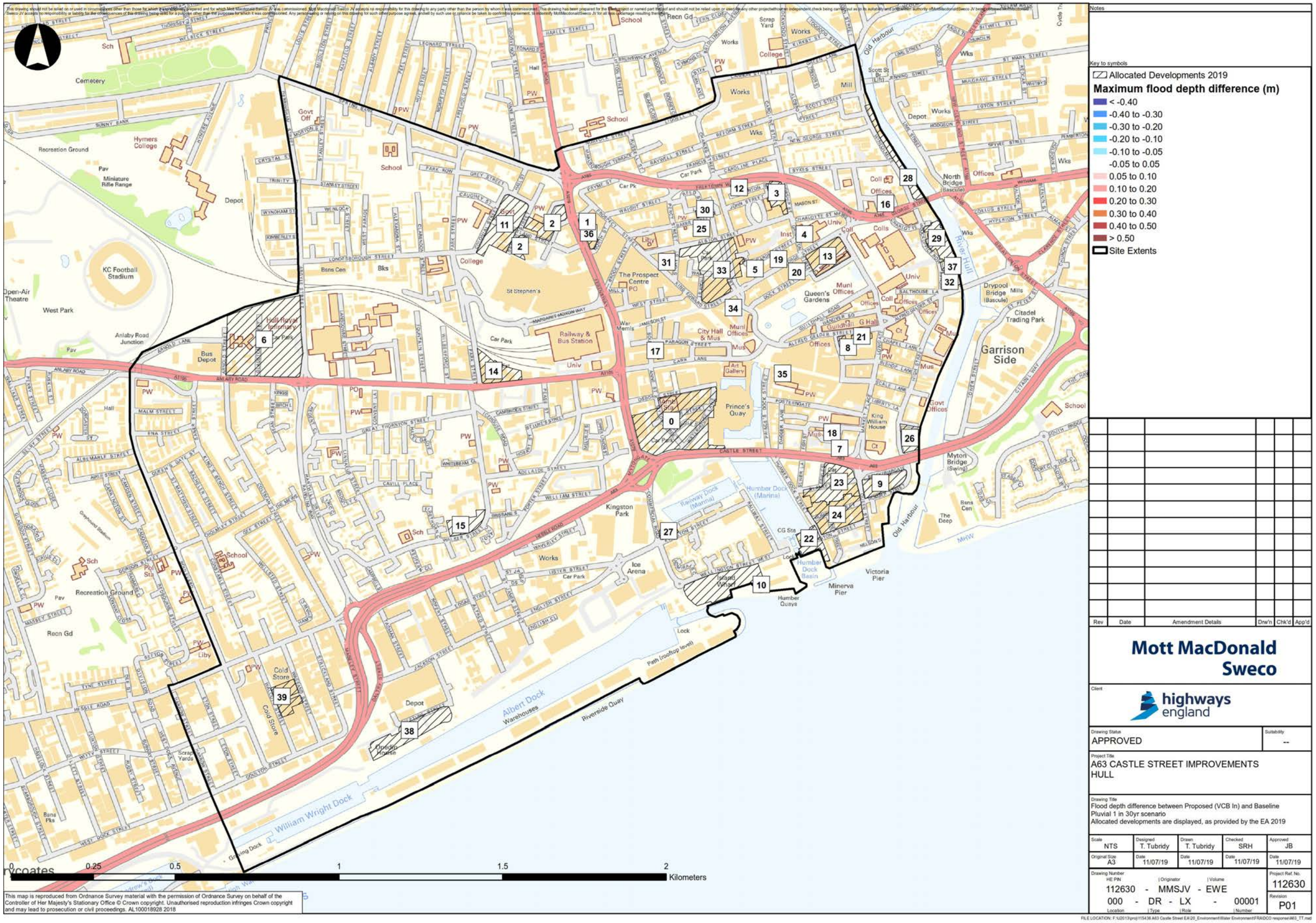


Figure 13.108 Maximum flood depth changes at Hull City Council allocated development sites for a 1 in 100-year pluvial flooding event

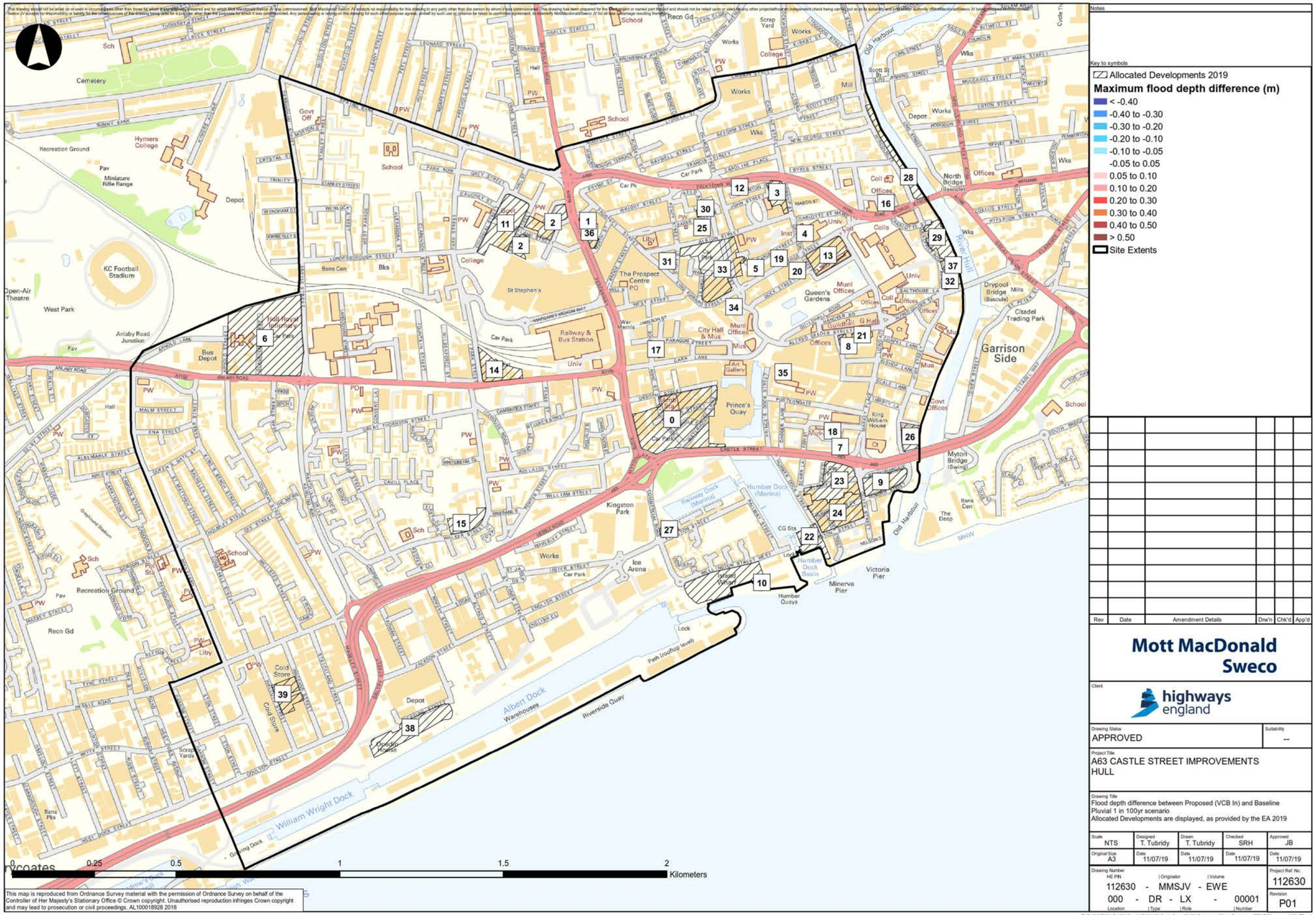


Figure 13.109 Maximum flood depth changes at Hull City Council allocated development sites for a 1 in 100-year plus 30% climate change pluvial flooding event

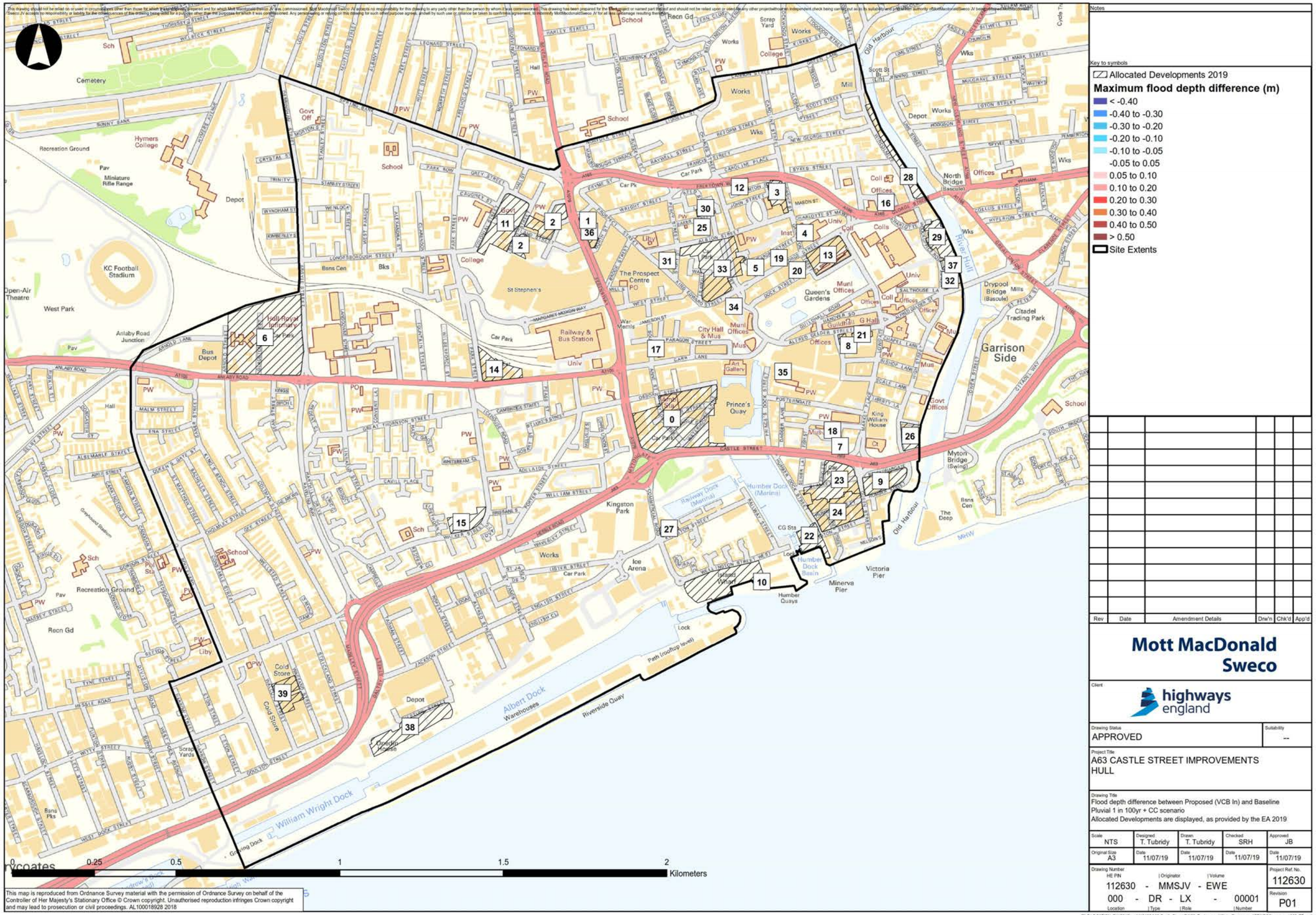


Figure 13.110 Maximum flood depth changes at Hull City Council allocated development sites for a 1 in 200-year Humber Estuary wave overtopping (defended) flooding event

Figure 13.111 Maximum flood depth changes at Hull City Council allocated development sites for a 1 in 1,000-year Humber Estuary wave overtopping (defended) flooding event

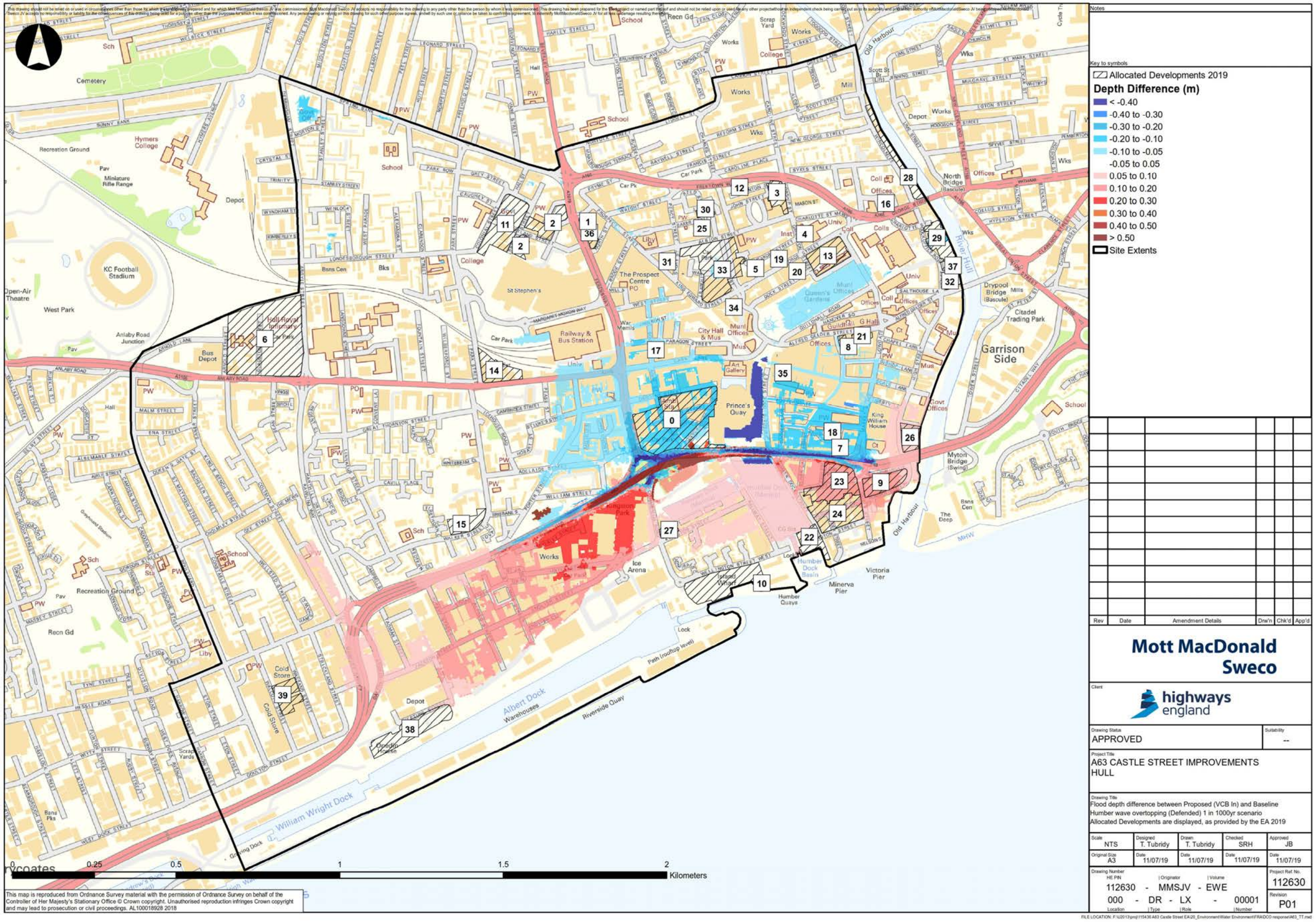


Figure 13.112 Maximum flood depth changes at Hull City Council allocated development sites for a 1 in 200-year plus climate change (2115) Humber Estuary wave overtopping (defended) flooding event

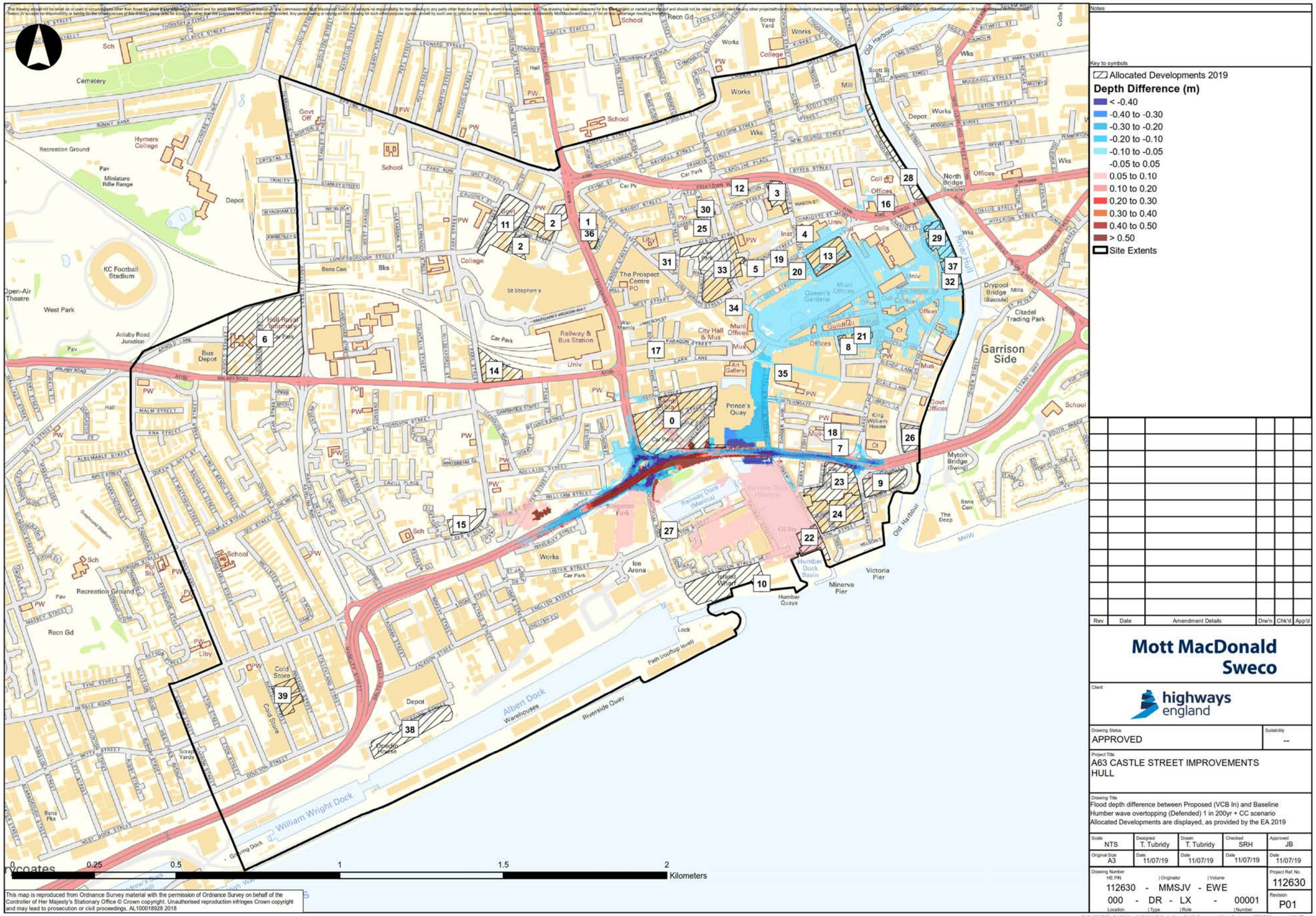


Figure 13.113 Maximum flood depth changes at Hull City Council allocated development sites for a 1 in 200-year Humber Estuary tidal (undefended) flooding event

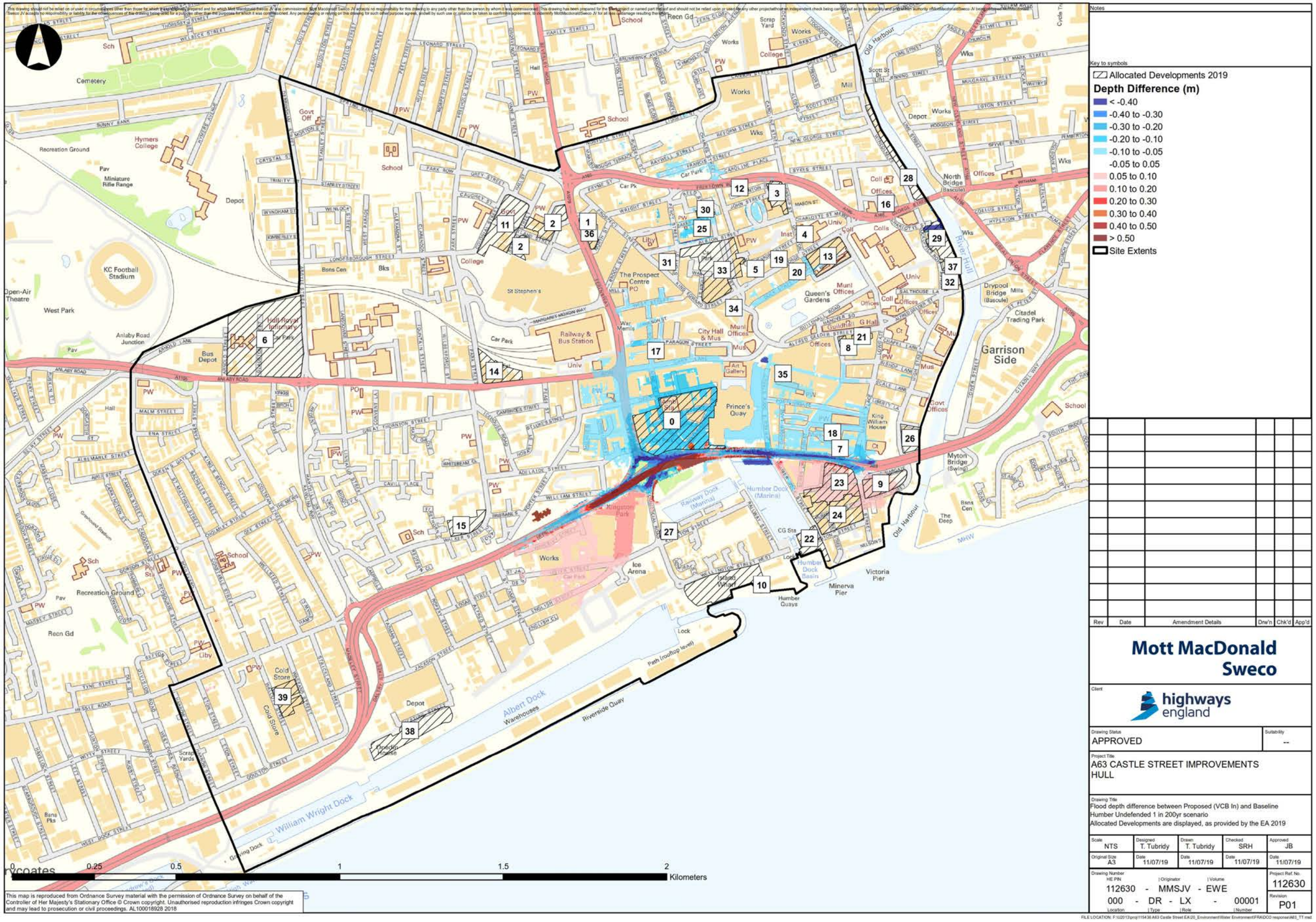


Figure 13.114 Maximum flood depth changes at Hull City Council allocated development sites for a 1 in 200-year plus climate change (2115) Humber Estuary tidal (undefended) flooding event

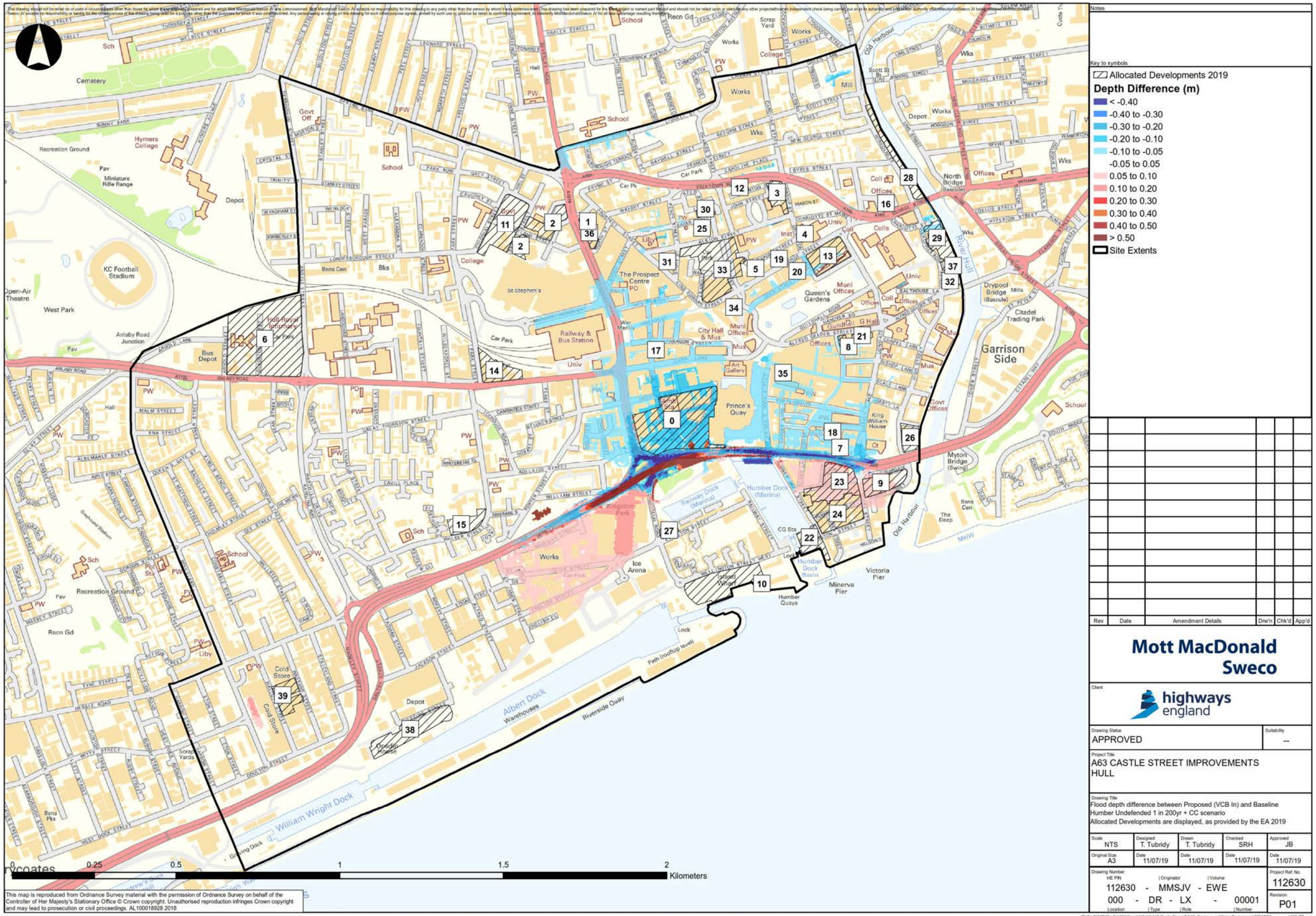


Figure 13.115 Maximum flood depth changes at Hull City Council allocated development sites for a 1 in 200-year River Hull tidal flooding event (Hull Tidal Surge Barrier open)

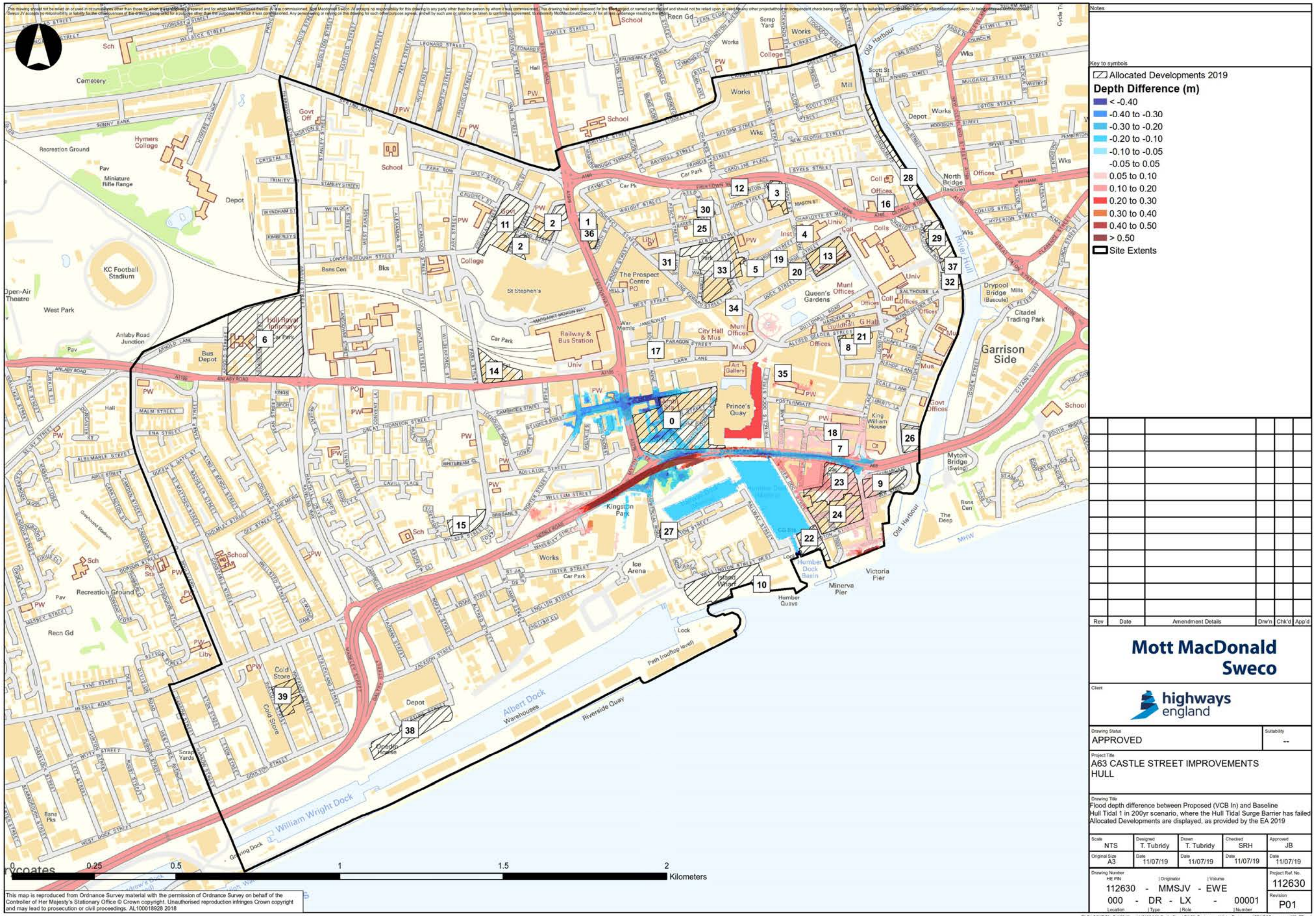


Figure 13.116 Maximum flood depth changes at Hull City Council allocated development sites for a 1 in 1,000-year River Hull tidal flooding event (Hull Tidal Surge Barrier open)

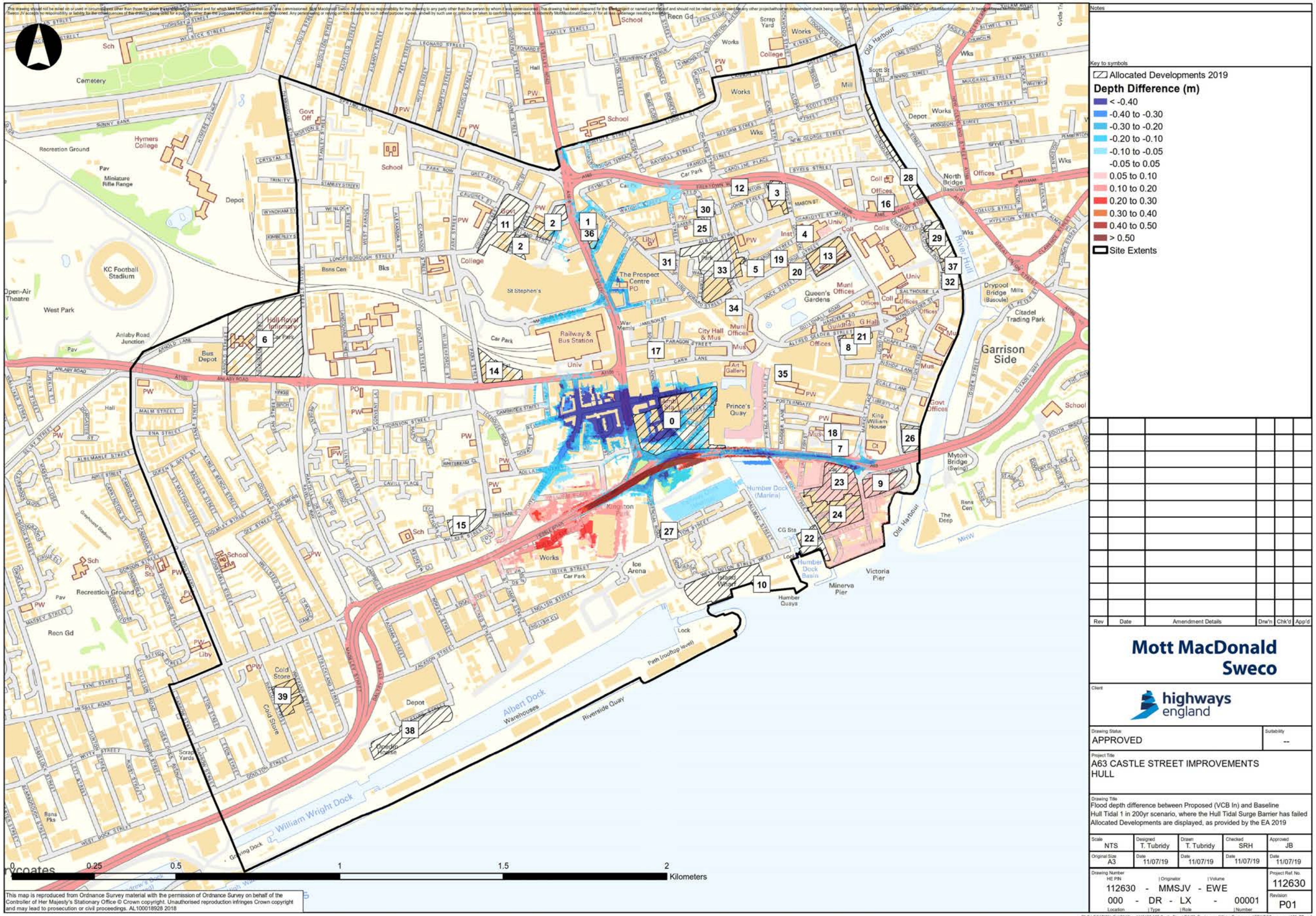


Figure 13.117 Maximum flood hazard rating change at strategic diversion routes for a 1 in 30-year pluvial flooding event

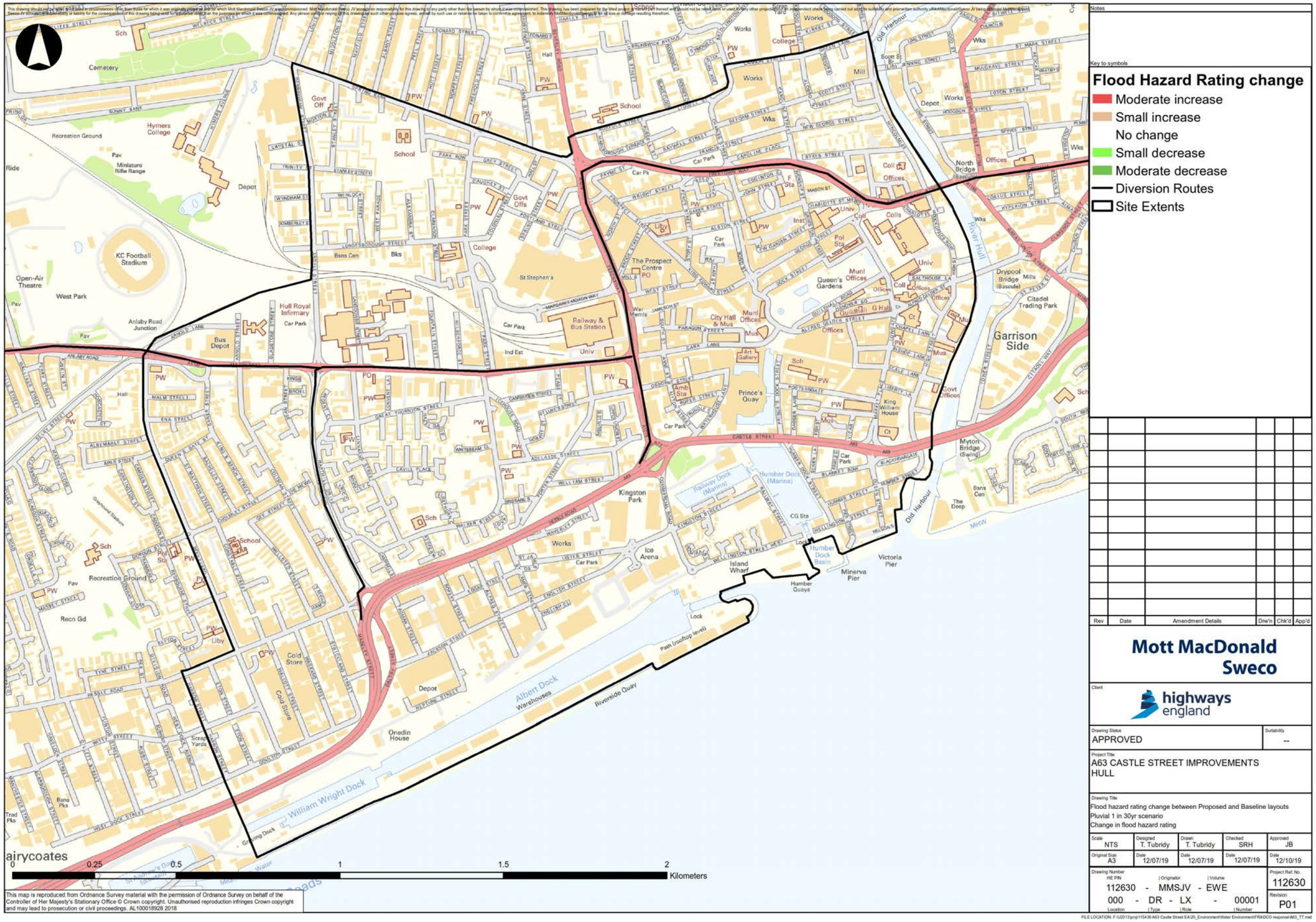


Figure 13.118 Maximum flood hazard rating change at strategic diversion routes for a 1 in 100-year pluvial flooding event

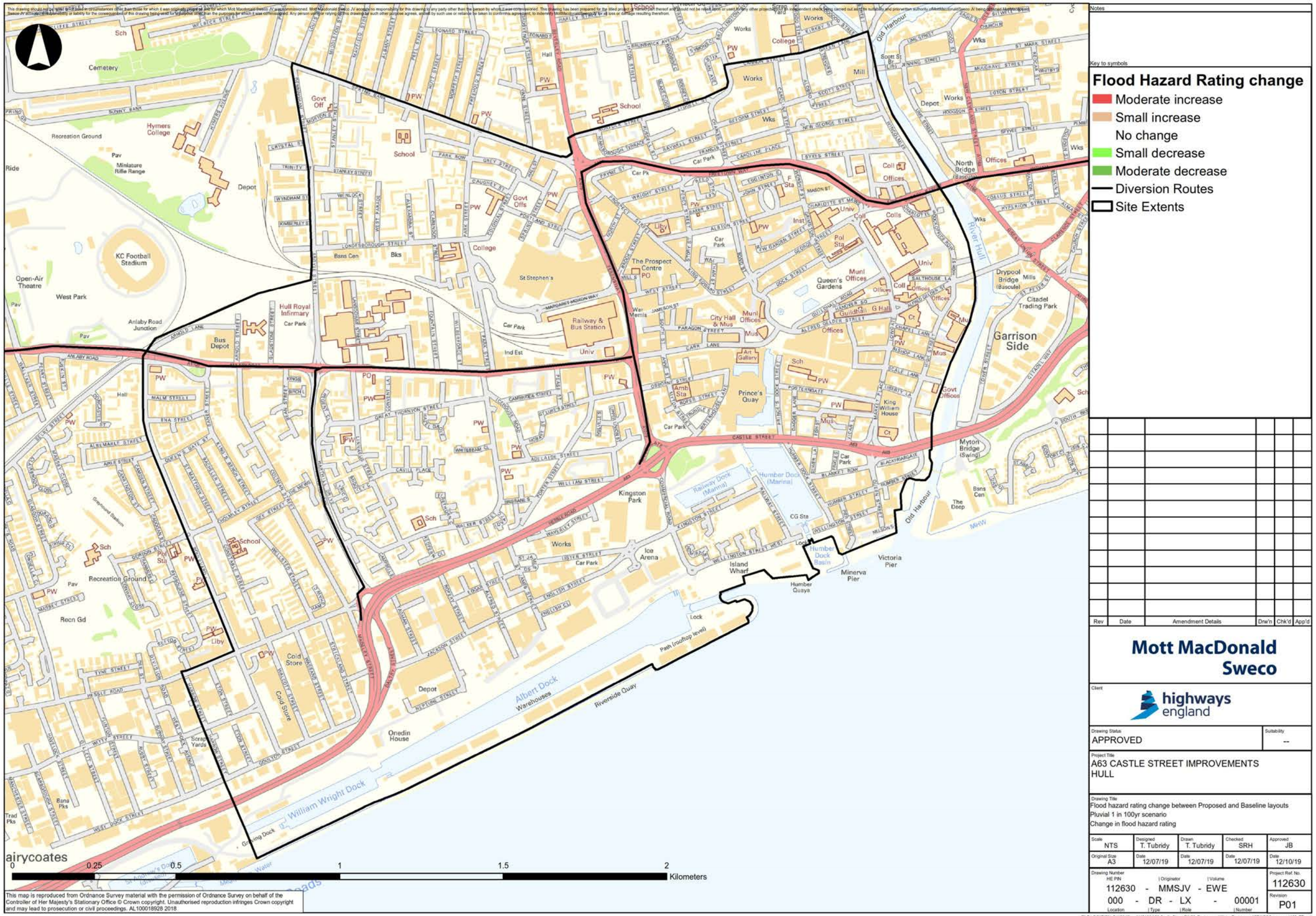


Figure 13.119 Maximum flood hazard rating change at strategic diversion routes for a 1 in 100-year plus 30% climate change pluvial flooding event

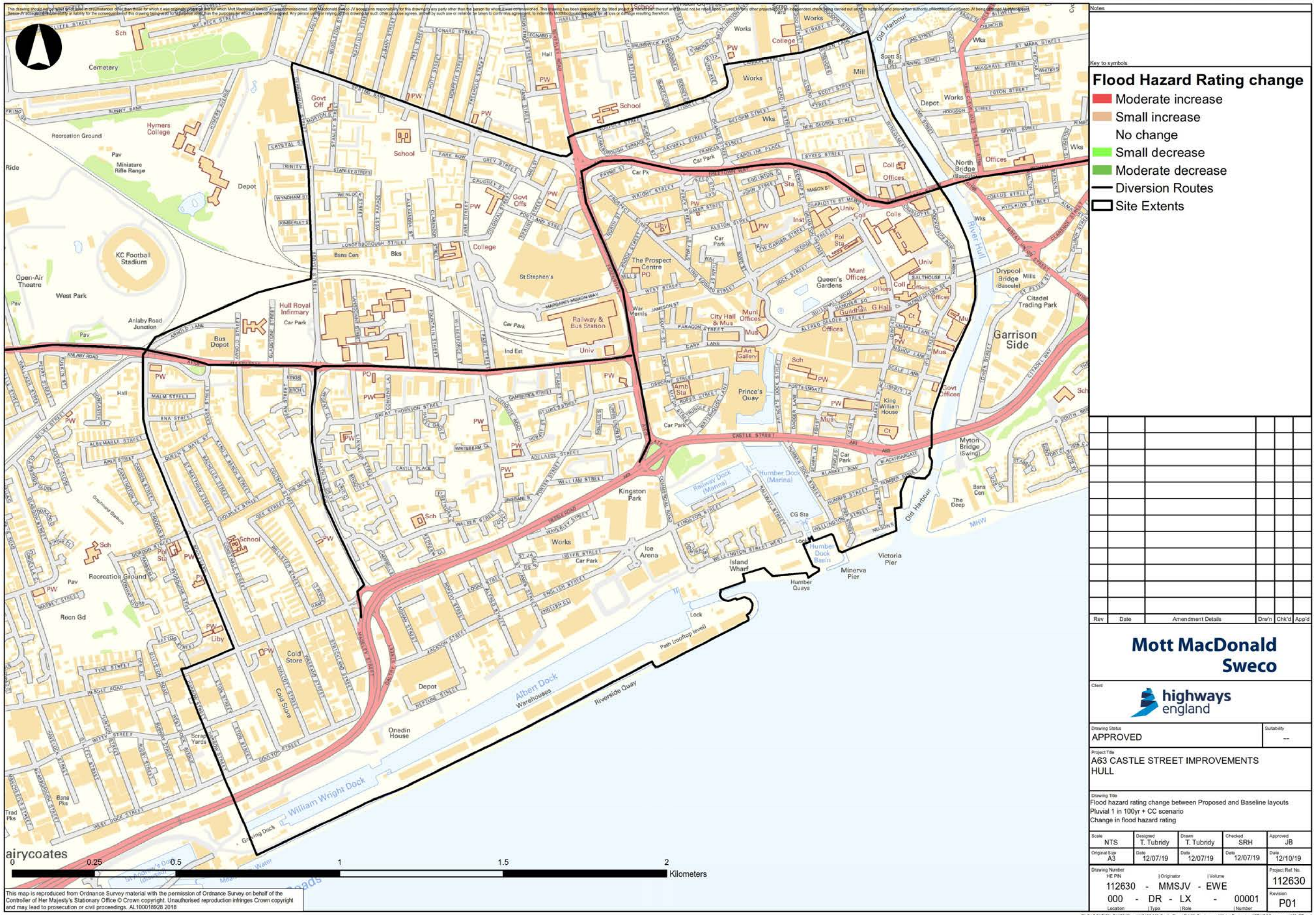


Figure 13.120 Maximum flood hazard rating change at strategic diversion routes for a 1 in 200-year Humber Estuary wave overtopping (defended) flooding event

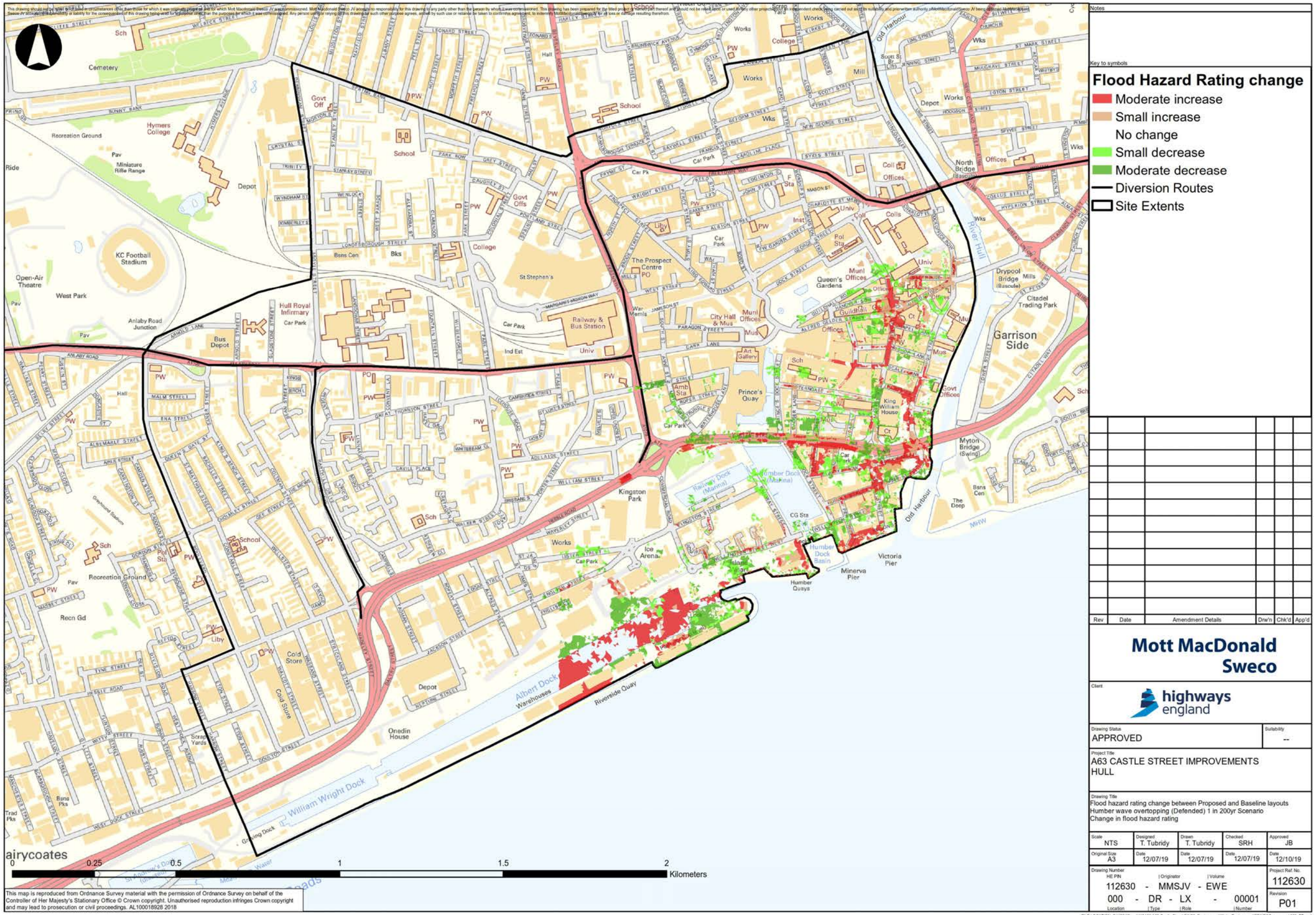


Figure 13.121 Maximum flood hazard rating change at strategic diversion routes for a 1 in 1,000-year Humber Estuary wave overtopping (defended) flooding event

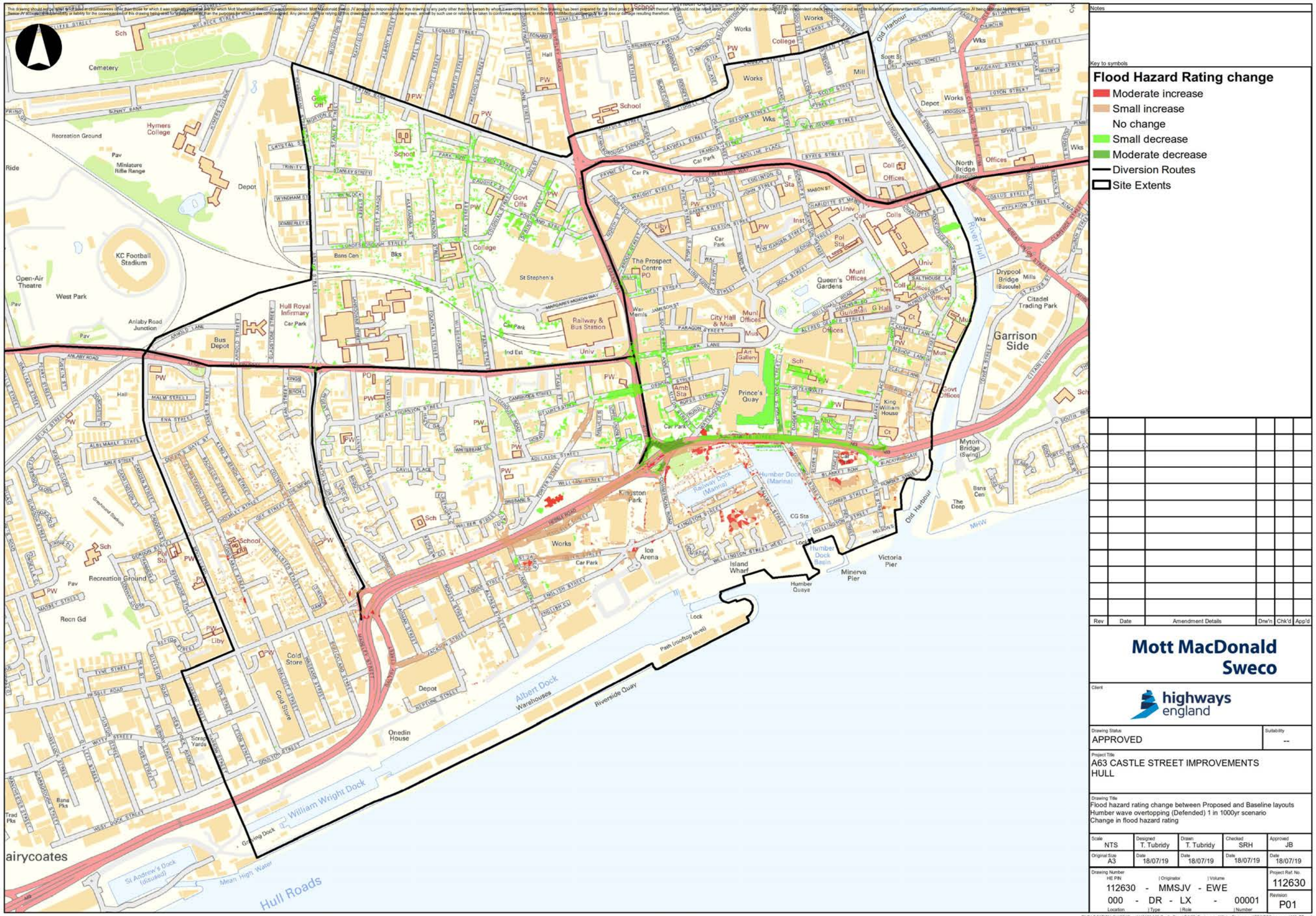


Figure 13.122 Maximum flood hazard rating change at strategic diversion routes for a 1 in 200-year plus climate change (2115) Humber Estuary wave overtopping (defended) flooding event

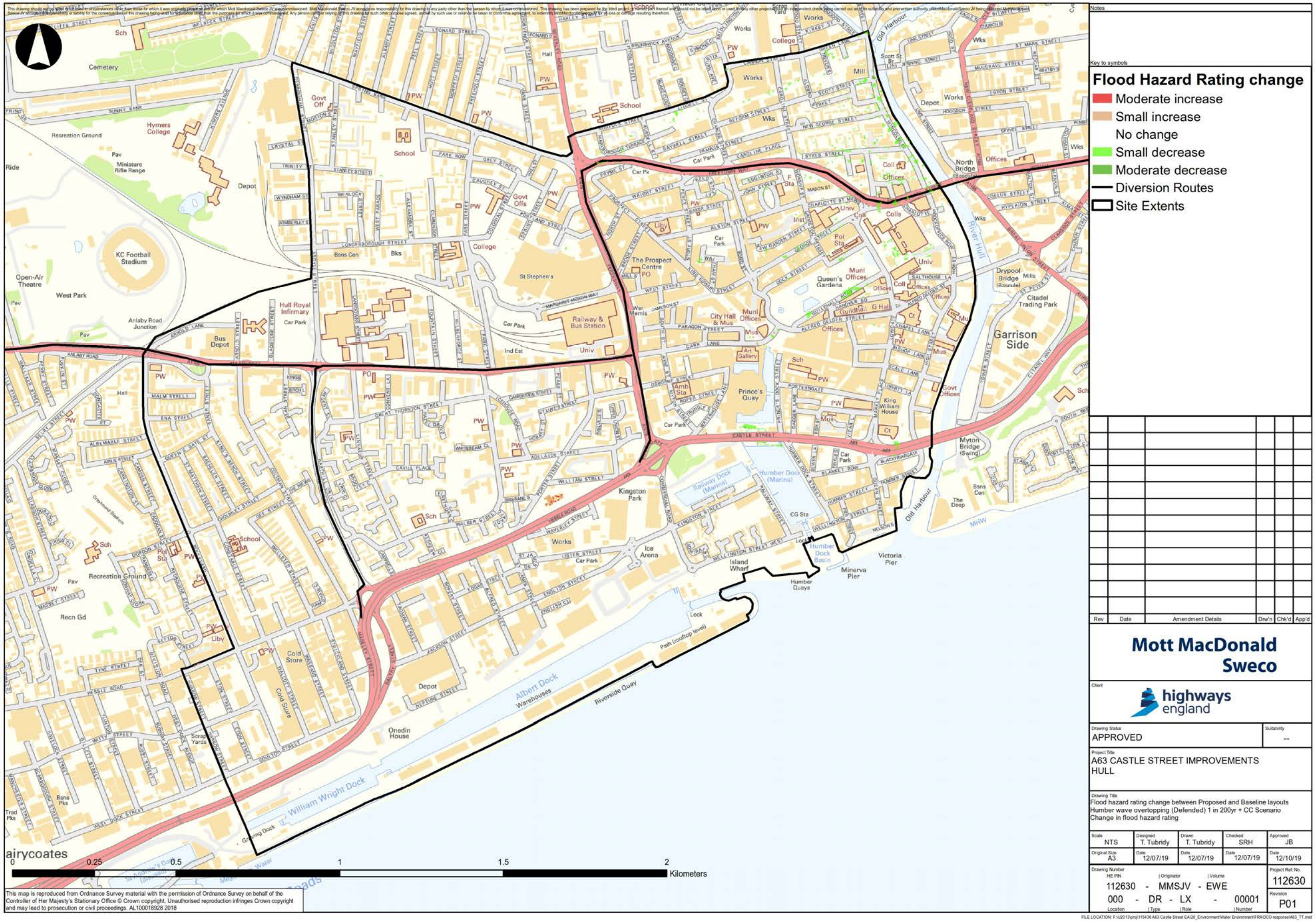


Figure 13.123 Maximum flood hazard rating change at strategic diversion routes for a 1 in 200-year Humber Estuary tidal (undefended) flooding event

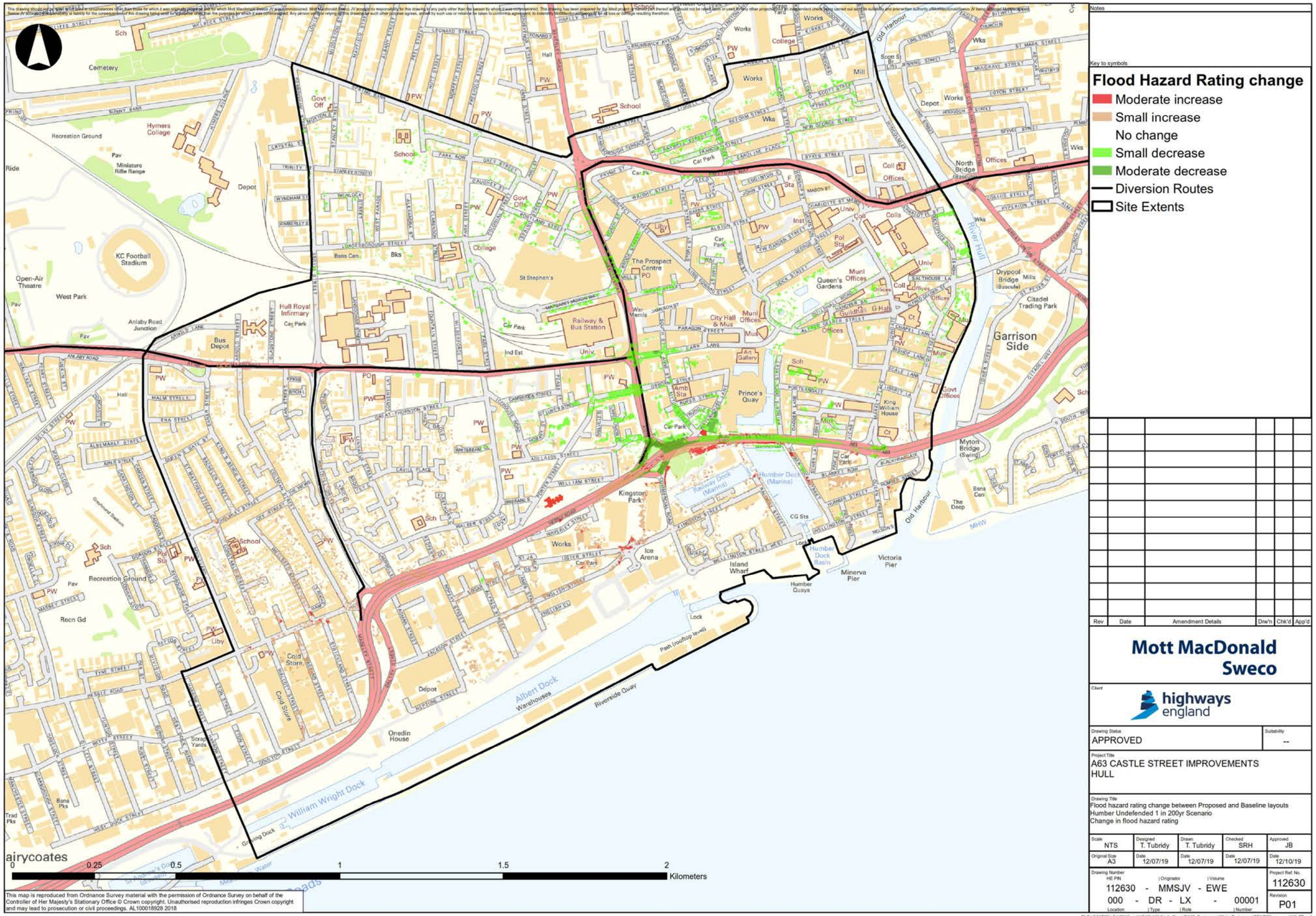


Figure 13.124 Maximum flood hazard rating change at strategic diversion routes for a 1 in 200-year plus climate change (2115) Humber Estuary tidal (undefended) flooding event

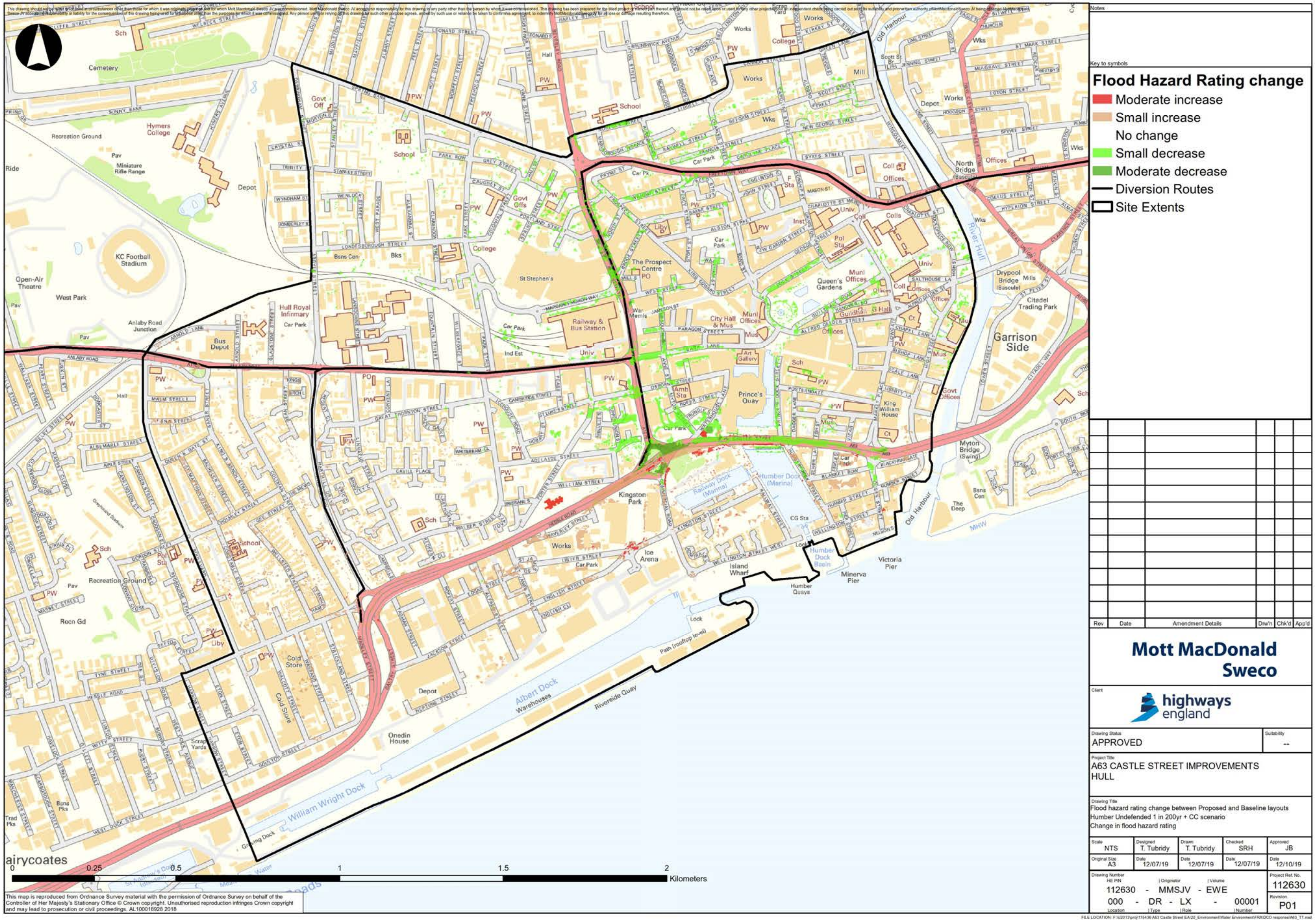


Figure 13.125 Maximum flood hazard rating change at strategic diversion routes for a 1 in 200-year River Hull tidal flooding event (Hull Tidal Surge Barrier open)

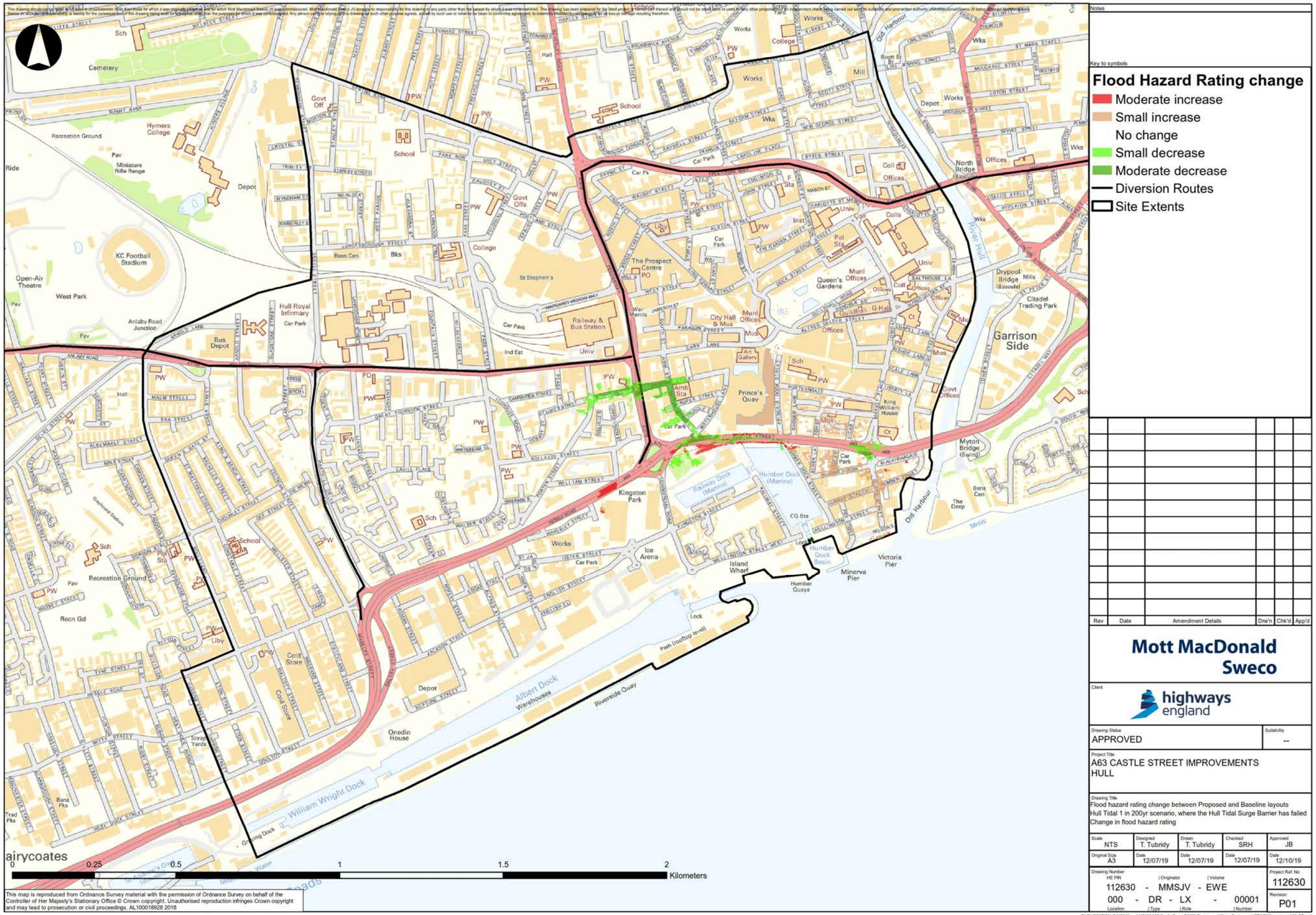


Figure 13.126 Maximum flood hazard rating change at strategic diversion routes for a 1 in 1,000-year River Hull tidal flooding event (Hull Tidal Surge Barrier open)

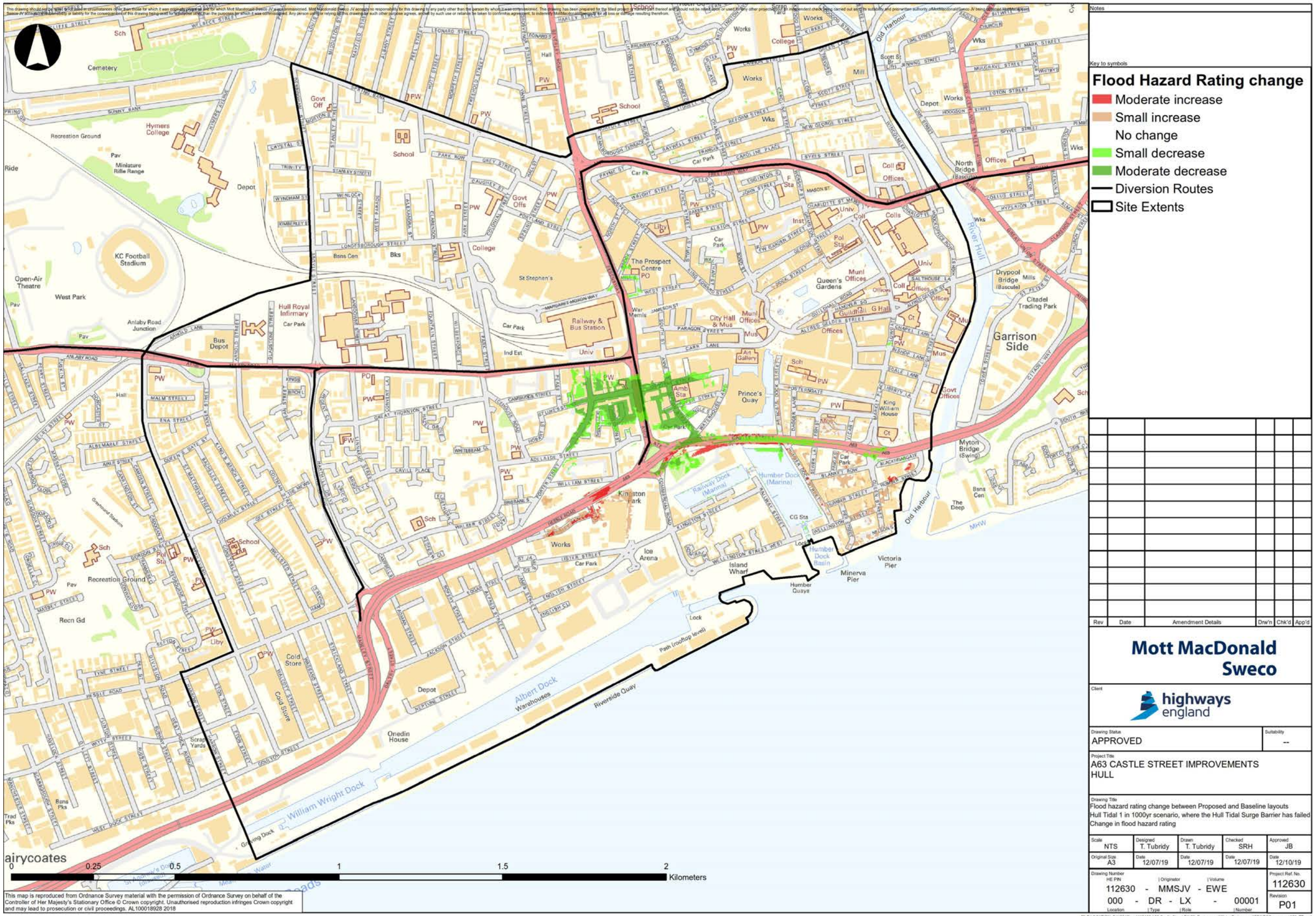


Figure 13.127 1 in 200-year plus climate change H++ (2115) maximum flood depth from Humber Estuary (undefended) for existing layout

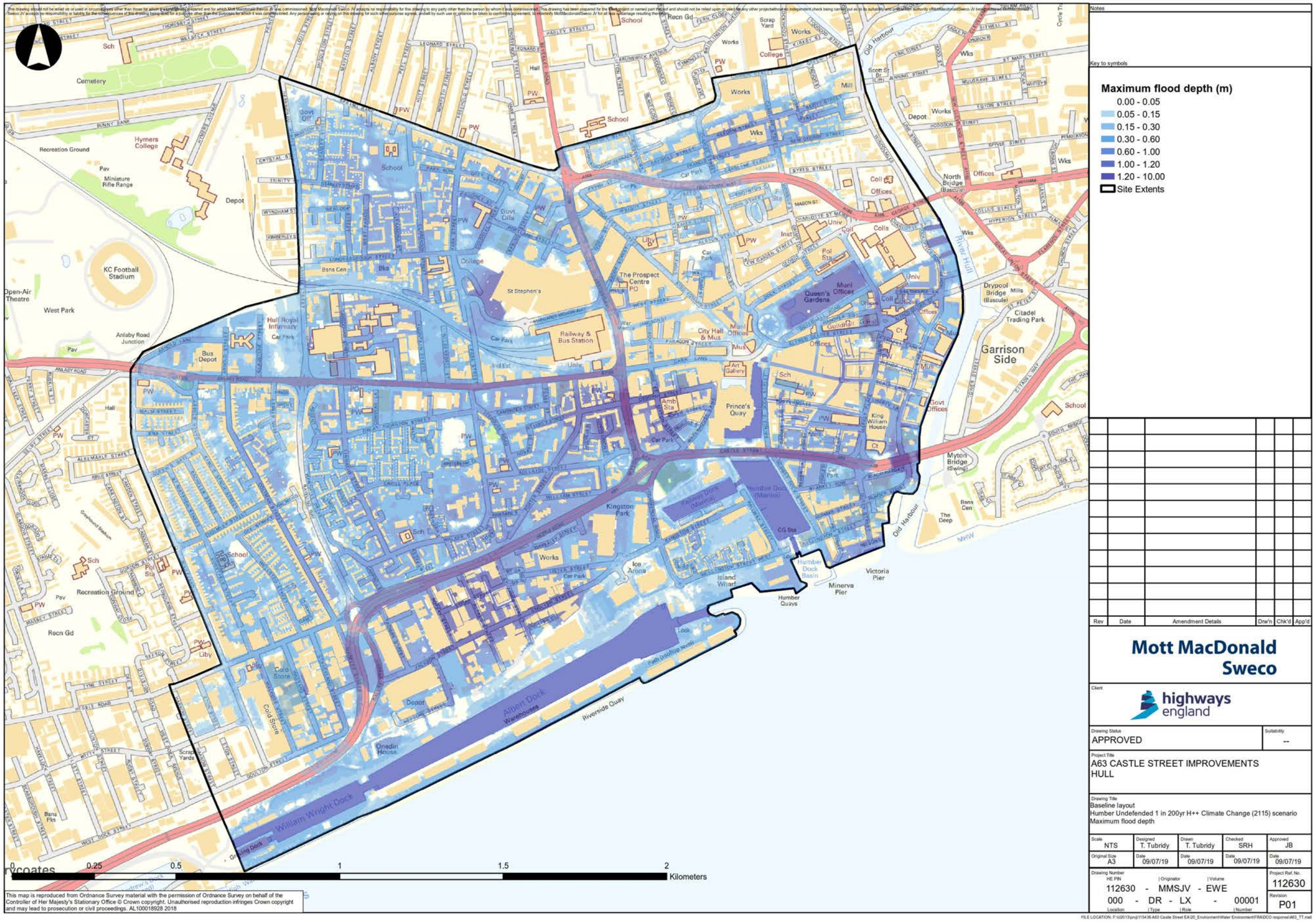


Figure 13.128 1 in 200-year plus climate change H++ (2115) maximum flood depth from Humber Estuary (undefended) for Scheme layout

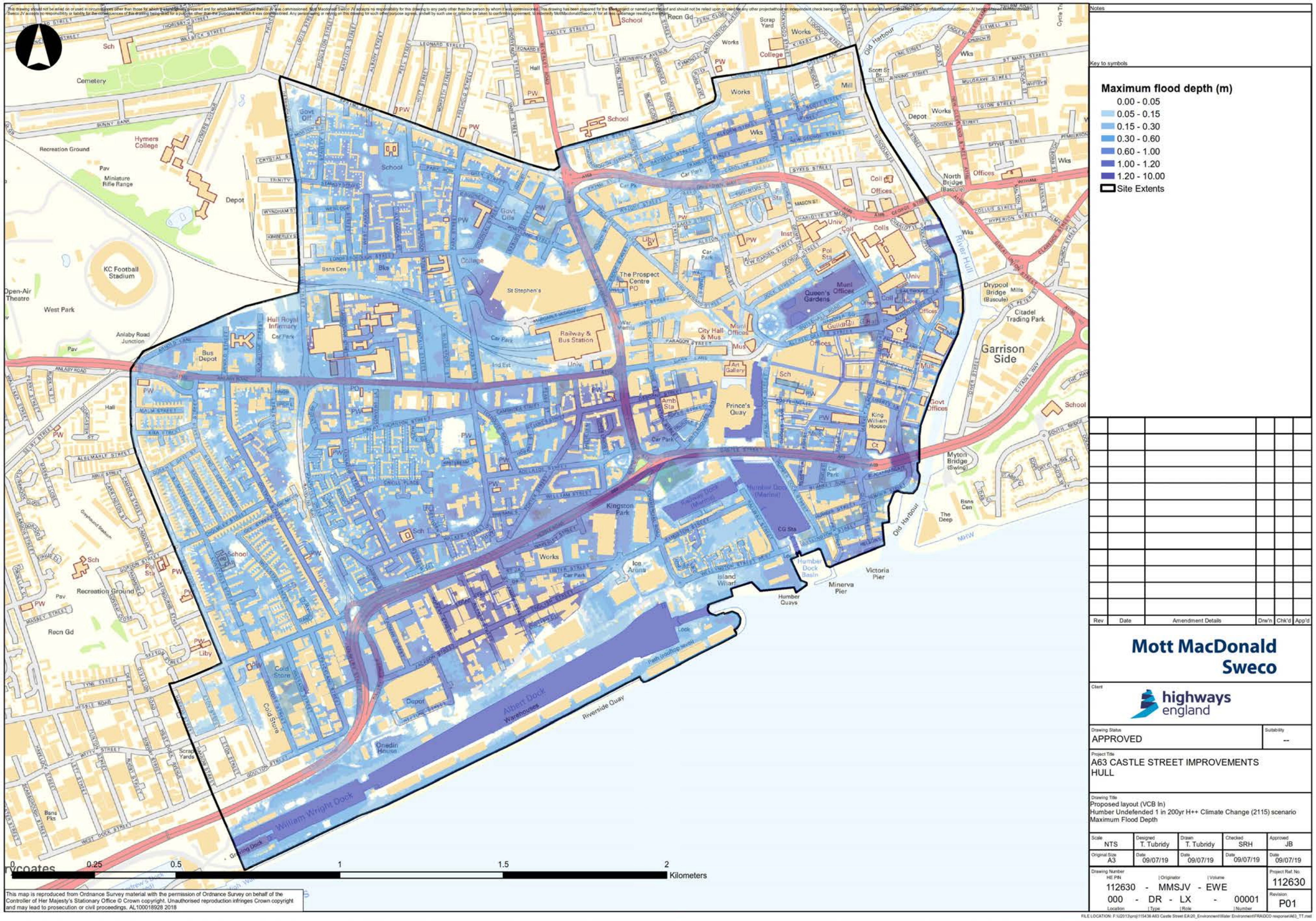


Figure 13.129 1 in 200-year plus climate change H++ (2115) maximum flood depth difference

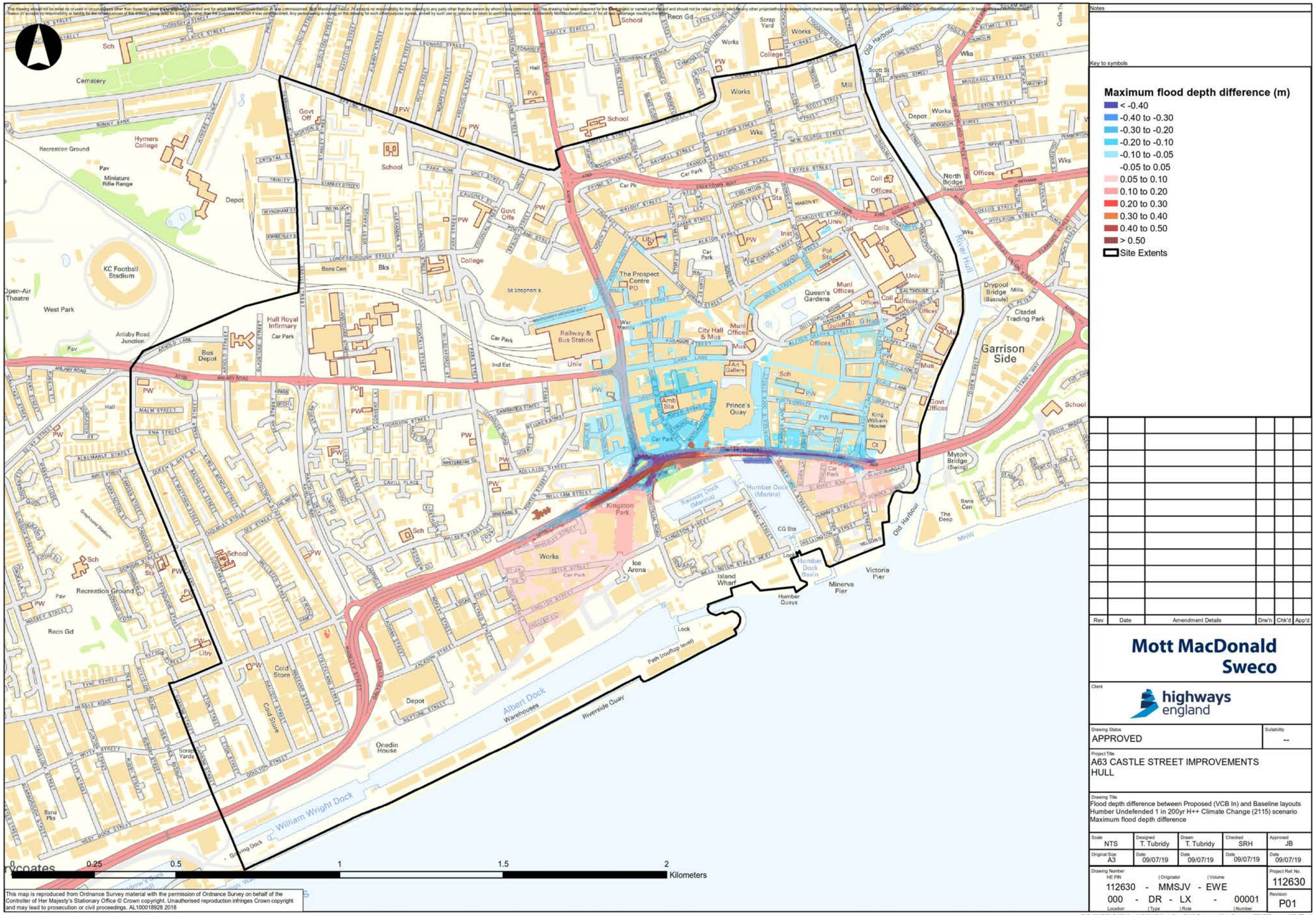


Figure 13.130 1 in 200-year plus climate change H++ (2115) maximum flood hazard rating from Humber Estuary (undefended) for existing layout

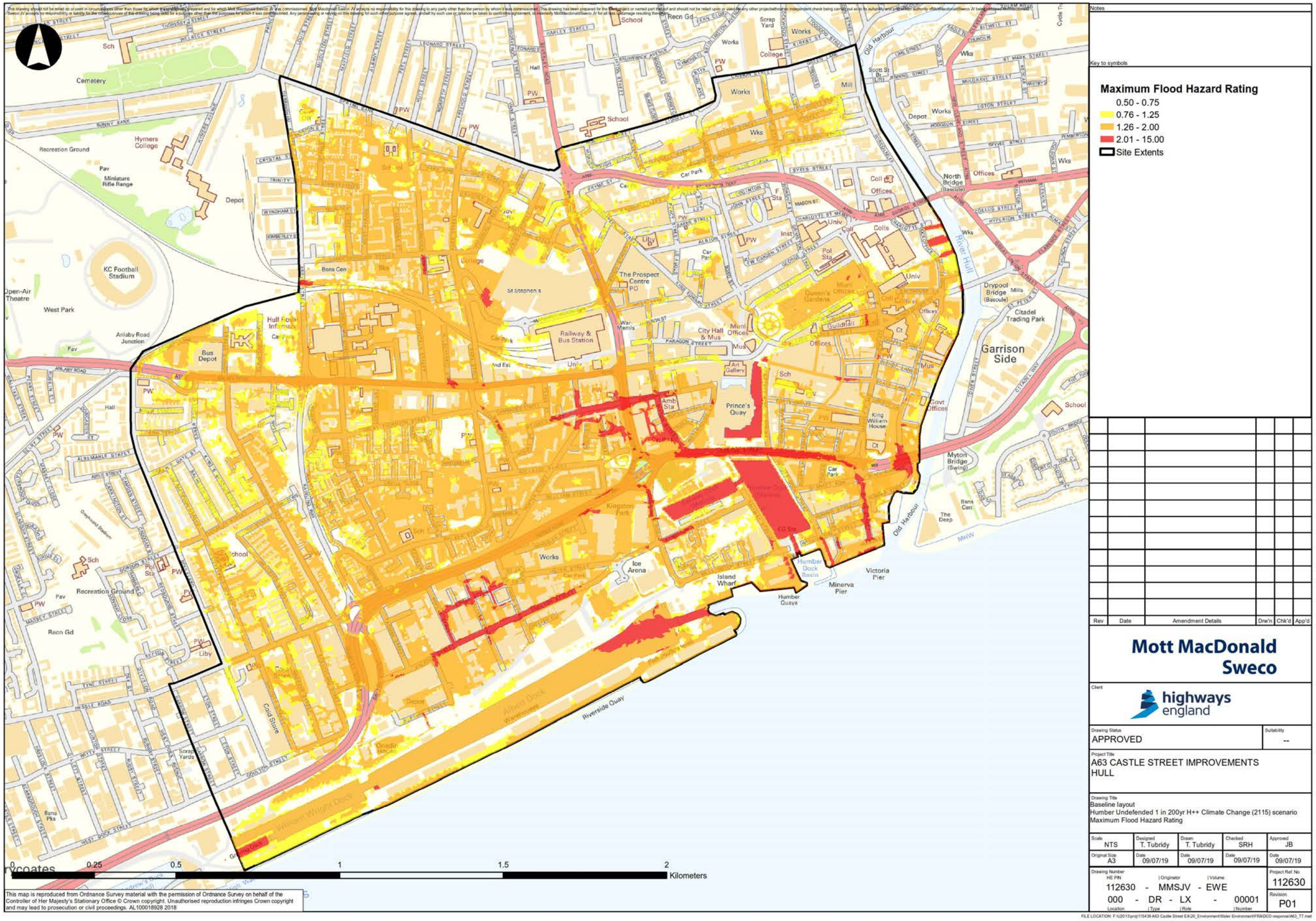
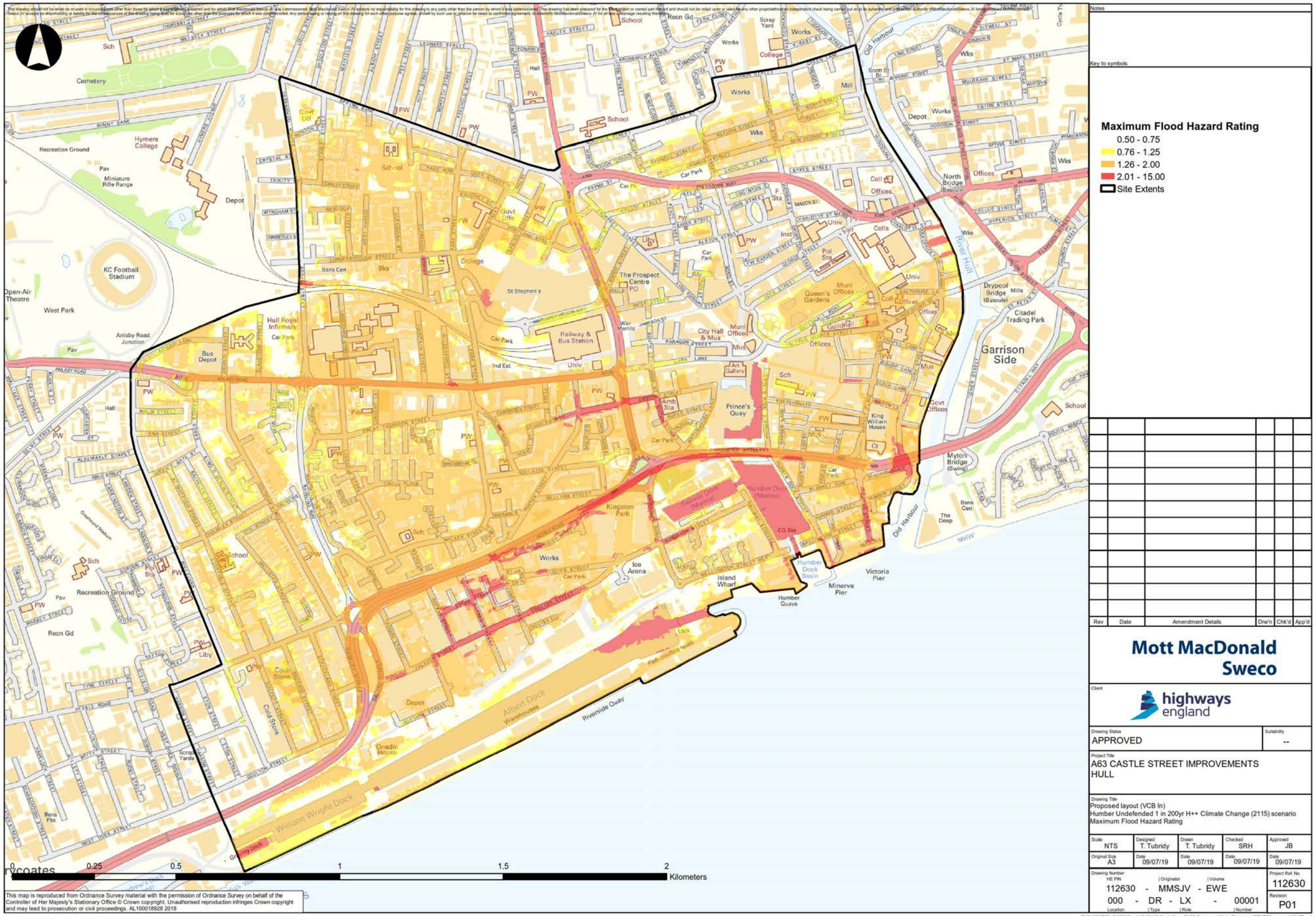


Figure 13.131 1 in 200-year plus climate change H++ (2115) maximum flood hazard rating from Humber Estuary (undefended) for Scheme layout



14. Appendix B: Flood emergency and evacuation plan report

Highways England

A63 Castle Street Improvement Scheme

Flood Emergency and Evacuation Plan Report

P03 | July 2019

Job number 237912-00

Ove Arup & Partners Ltd
Admiral House Rose Wharf
78 East Street
Leeds LS9 8EE
United Kingdom
www.arup.com

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Document Verification

ARUP

Job title	A63 Castle Street Improvement Scheme			**Job number** 237912-00
Document title	Flood Emergency and Evacuation Plan Report			**File reference**
Document ref				

Revision	**Date**	**Filename**	Flood Emergency Evacuation Plan Report.docx		
Draft 1	May 2018	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	Adriaan van den Berg	Andrew Drake	Sonam Norbu
		Signature			
P01	June 2018	**Filename**	HE514508-ARP-EGN-S0-RP-CD-000001		
		Description	First Issue		
			Prepared by	Checked by	Approved by
		Name	Tom Haller	Adriaan van den Berg	Sonam Norbu
		Signature			
P02	June 2019	**Filename**	HE514508-ARP-EGN-S0-RP-CD-000001		
		Description	Updated to respond to EA queries		
			Prepared by	Checked by	Approved by
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Environment Agency Relevant Representation Response: Pumping Station Flood Resilience

1 Introduction

The A63 Castle Street Improvements scheme involves grade-separation of the currently at-grade Mytongate junction of the A63 with Ferensway. The grade separation of the junction will feature east and westbound entry and exit slip roads, enabling all movements. The scheme also features the provision of a number of pedestrian footbridges which will replace at-grade pedestrian crossing points along the A63 Castle Street.

1.1 Purpose of the Document

This document aims to identify and assess the potential risk of flooding within the area of the scheme. The document describes the emergency and evacuation procedures to respond to such a flood event.

1.2 Scheme Description

The A63 Castle Street comprises approximately 1.5km of dual carriageway which runs through the centre of Hull. The current layout is dual-2 lane all-purpose trunk road with no hard shoulder which runs in an east-west direction to the south of Hull city centre, from Rawlings Way Junction to Market Place. The route is an important link between the M62, Humber Bridge and Port of Hull. The current speed limit is 40mph.

As the primary access to the Port of Hull on the strategic road network, Castle Street handles large volumes of traffic, and congestion is exacerbated by two at-grade junctions at Mytongate and Market Place. Difficulties with the current A63 Castle Street route through Hull city centre is characterised in two ways: it acts as a substantial barrier, creating severance between the city centre to the north and the area targeted by Hull City Council (HCC) for development and regeneration to the marina and market area on the south side of the A63. Secondly, sited through the middle of Hull city, capacity problems and signalised junctions severely hinder free flowing traffic.

The proposed scheme includes the following highways interventions:

- Lowering the level of the road into a cutting by approximately 7 metres at Mytongate Junction;
- Raising Ferensway and Commercial Road by approximately 1 metre creating a grade-separated junction;
- Widening the eastbound carriageway to three lanes between Princes Dock Street and Market Place, with the nearside lane being marked for local weaving traffic;
- Provision of bridges for pedestrians, cyclists and disabled users at Porter Street;

- Provision of an enhanced / iconic crossing structure for pedestrians, cyclists and disabled users in front of Princes Quay;
- Upgrading an existing route that runs underneath the A63 at Market Place to allow people to cross underneath the A63; and
- Restricting access to the A63 by closing some junctions and restricting movements on some side roads to improve safety.

The scheme objectives are as follows:

- Improve access to the Port of Hull;
- Reduce congestion;
- Improve safety; and
- Reduce severance between the city centre and the waterfront area.

2 Flood Risk Assessment

The Flood Risk Assessment produced by Mott MacDonald Sweco JV identified the following sources of flooding that pose a potential risk to the Scheme:

- Tidal
- Fluvial
- Pluvial
- Sewer and Drainage
- Groundwater

2.1 Conclusions from Flood Risk Assessment

The Flood Risk Assessment concluded the following:

1. Currently the greatest risk of flooding to the Project area is from wave overtopping of existing flood defences on the north bank of the Humber.

2. Flooding from the River Hull requires the failure of the Hull Tidal Surge Barrier to close. This is unlikely as it incorporates a system to automatically close the barrier in the event of a power failure. However, under the 1 in 200-year event the underpass structure is completely flooded but this prevents flood flows reaching the area north and west of Mytongate junction, particularly around the junction of Ferensway and Anlaby Road reducing flood risk in this location. For this scenario, there is a minor increase in flood risk in the area between the Docks and the River Hull north and south of the Project from the slight change in the elevation of the road. This results in the diversion of flood flows into Princes Quay.

3. Widespread and significant flooding is predicted for the Humber 1 in 1000-year wave overtopping event and the Humber undefended tidal

flooding scenarios. The impact of a flood of this magnitude would be significant, not just for the Project but for the whole of Hull. During such an event, the A63 would be completely closed west of Mytongate junction regardless of whether or not the Project goes ahead.

4. Probability of flooding from combined sources (high sea levels in the River Hull and Humber during high fluvial baseflow conditions in the River Hull) was also considered in the study. However, the analysis indicates that the dependence between the different sources of flooding within the area is very low.

5. The underpass drainage is designed for a 1 in 100-year critical duration rainfall event including a 30% allowance for climate change. The model predicts negligible increases in surface water flooding from such a rainfall event as a result of the Project.

6. The risk of groundwater flooding to the Project and from the Project is considered to be slight. The walls of the underpass structure are estimated to discharge an average of 1.4 m^3 per day into the underpass drainage system. This is equivalent to less than 1 l/s which would be drained by the underpass drainage network.

7. Analysis of flood routes and flow velocities during the extreme tidal events shows the greatest impact of the Project results from the proposed underpass structure. Predicted maximum velocities of water (combined with the depth) flowing into the underpass are classified as ‘danger for all’ under Defra’s Hazard to People Classification.

8. The resilience of the Project to climate change is considered for tidal, fluvial, pluvial and groundwater flooding sources. The underpass drainage is designed to accommodate flows generated from a 1 in 100-year event with a 30% increase in rainfall intensity for climate change impacts. Consequently, the pluvial events with consideration of climate change result in only negligible increases in flooding to areas outside the Project outline.

9. Climate change impacts on tidal flooding scenarios from the Humber are more significant, flooding not only the Project area but significant parts of Hull city centre. This is a result of tidal water levels exceeding the level of the existing Humber defences.
10. For extreme tidal flooding events such as those witnessed on 5 December 2013, there is an existing procedure in place whereby flood alerts from the Environment Agency (EA) are issued to the Highways England Emergency Planning team who consider an appropriate response, for example, the closure of the underpass. This report is a review of this process and makes recommendations to accommodate future technology introduced by the Project.

2.2 Flood Defence Structures

This section addresses current and future flood defence structures in the vicinity of the project.

2.2.1 River Hull Flood Defences

The SFRA (Arup, 2016) states that the flood defence infrastructure on the River Hull is in variable condition with some parts being in poor condition. Defences in poor condition may not necessarily have a low standard of protection (based on probability of over topping and vice versa. Figure 1 of the SFRA (Arup, 2016) indicates that the flood defences along the banks of River Hull have a standard of protection, excluding freeboard, of greater than 1 in 200 (0.5% annual probability) assuming the Hull tidal barrier operates as intended. Defences are maintained at a level as defined within the Kingston upon Hull Act 1984.

The SFRA (2016) reports there are isolated low points in the flood defences where the standard of protection is between 1 in 75 and 1 in 100 (1.33% and 1% annual probability). The locations of these low points are identified in the area between Ferry Lane Bridge and the railway line bridge.

The River Hull is further protected by the Hull Tidal Surge Barrier. The Hull Tidal Surge Barrier protects the City of Hull along the lower reaches of the River Hull by providing a 1 in 200-year standard of protection from tidal flooding. The barrier provides protection from a tidal flooding event with a return period of up to 1 in 1000 years, although it is not designed to protect the area from a 1 in 200-year event with consideration of climate change.

It is understood from consultation with Environment Agency staff that the Hull Tidal Surge Barrier is lowered between 1 to 3 hours in advance of high water when the tide level is predicted to exceed 4.4mAOD. If there is a power failure the barrier will automatically close to ensure flood protection is provided.

2.2.2 River Humber Flood Defences

As stated in the SFRA (Arup, 2016), the current standard of protection, excluding freeboard allowance, of the Humber defences adjacent to the City of Hull varies from 1 in 200 or greater in the west to less than 1 in 5 adjacent to Victoria Pier and the western part of Victoria Dock village (which is outside of the boundary of the study area). No inspection location plans have been provided, but records show that defects in the defences are typically of a relatively minor nature. Further details of the Humber defences can be found in Volume 3, Appendix 11.3 Flood risk modelling technical report of the A63 Castle Street Improvement, Hull – Environmental Statement.

New flood defences were constructed in 2015 at Albert Dock following the December 2013 tidal surge. These defences provide a standard level of protection of between 1 in 100 and 1 in 200 years (Arup, 2016) with an approximate top of defence level at 6.05mAOD.

2.2.3 Future Flood Defences

In May 2019, construction began on the upgrades to 19km of tidal flood defences on the north bank of the Humber Estuary; this scheme is known as the Humber Hull Frontages. The upgraded defences will protect Hull from the effects of flooding from the Humber Estuary from a 1 in 200-year event with an allowance for the effects of climate change up to 2040. Beyond 2040, the effects of climate change will be considered through a 'managed adaptive' approach. The proposed completion data for the Humber Hull Frontages is 2021. As such, the scheme will be in place and provide additional protection to the A63 Castle Street Improvement Scheme.

However, at the time of the preparation of the Flood Risk Assessment, no details on residual flood risk from the Humber Hull Frontages scheme were available and as such, the proposals have not been included as part of this assessment.

3 Flood Emergency and Evacuation Plan

3.1 Existing Flood Emergency and Evacuation Plan

This Flood Emergency and Evacuation Plan needs to link into and build on existing plans in place for the specific network.

The Humber Local Resilience Forum has already produced a detailed plan that proposed the required procedures to follow during a flooding incident. The Humber LRF Multi Agency Flood Plan (Version 3.0 June 2017), has been attached as Appendix A.

In addition to this plan, Highways England requires their Asset Maintenance and Operational Service Provider needs to respond to incidents on the network. These plans are listed below:

- Area 12 Incident Response Plan:

  http://assets.highways.gov.uk/freedom-of-information/disclosure-log/Area-maintenance-plans-693546/Area12-REDACTED-IRP-Update-Nov2012.pdf

- Area 12 Service Provider Contingency Plan:

  https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/395837/Redacted-Area-12-Contingency-Plan-April-2013.pdf

- Area 12 Severe Weather Plan:

  http://assets.highways.gov.uk/freedom-of-information/disclosure-log/Area-maintenance-plans-693546/Area12-REDACTED-Severe-Weather-Plan201213-Rev0(2).pdf

3.2 Environment Agency Flood Warning Service

The Scheme is located within the following Environment Agency Flood Warning Areas:

- 122FWF112 Hull City Centre, and;
- 122FWT024 North Bank of the Humber Estuary in the West of Hull.

In addition, the following Flood Warning Areas border the Scheme to the west:

- 122FWF118 River Hull at Old Town, Dry Pool and Sutton Fields, and;
- 122FWT041 River Hull and Humber Estuary at Hull City Centre.

Records from the Environment Agency show the following warnings have been issued:

- 05/12/13 122FWT024 Flood Warning issued at 18:13;
- 05/12/13 122FWT024 Severe Flood Warning issued at 18:53;
- 02/03/14 122FWT024 Flood Warning issued at 10:48, and;

- 12/01/17 122FWT024 Flood Warning issued at 14:46.

The 2013 Severe Flood Warning was issued during the December 2013 tidal surge flooding event.

3.3 Flooding History

The Environment Agency Recorded Flood Outlines dataset confirms the Scheme area has been flooded previously:

- The area east of Princes Quay was flooded in September 1969 due to a tidal flood overtopping the River Hull defences. This occurred prior to the construction of the Hull Tidal Surge Barrier, and;
- The Scheme area throughout and north to the A1105 were flooded during the December 2013 tidal surge flood event.

3.4 Proposed Flood Emergency and Evacuation Plan

As highlighted from 2.1.12 above, it is essential to develop an integrated flood emergency and evacuation plan that mitigates the risks of these potential flooding scenarios.

For any flood emergency and evacuation plan to be effective, it will have to be responsive and closely linked with the Environment Agency Flood Warnings (EAFW) systems and the Humber LRF Multi Agency Flood Plan. The Environment Agency Flood Warnings are broken into a hierarchy of severity. They are as follows;

- Flood Alert: Flooding is possible; therefore, the affected parties need to be alert. Flood alert issued between two hours to two days in advance of flooding;
- Flood Warning: Flooding is expected. Immediate action is required by affected parties. Flood warnings are issued one hour to one day in advance of flooding, however sometimes they are issued moments before or during if not forecast in advance;
- Severe Flood Warning: Severe flooding, which poses a danger to life.
- Warnings no longer in force: No further flooding is currently expected in the affected area. This is issued when the river or sea conditions being to return to normal.

In addition to the EAFW, there are several additional warning services which can be used to provide a robust warning system. These include the Met Office Weather Warnings, Flood Forecasting Centre Hazard Manager notifications and bespoke Operational Instructions agreed with the EA on pre-defined trigger levels from telemetry. These will need to be agreed as part of the further development of the Humber LRF Multi Agency Flood Plan.

The Underpass Flood Detection Technology Options Report (See Appendix B), outlines two main options for the use of technology in the event of flooding of the underpass. Both of these options propose to transmit information to the North East Regional Control Centre (NERCC) for further action. The following elements have been identified as required from the preliminary technology design:

- Above lane mounted Light-Emitting Diode (LED) signals at the underpass entrance to indicate lane status and show underpass as closed;
- Motorway Signal Mark 4 (MS4) or Variable Message Sign (VMS) message signs (depending on approved option) on approaches to the underpass to advise road users of flooding and redirect them via alternative routes;
- Closed-Circuit Television (CCTV) cameras within the junction to monitor traffic flow and conditions, giving full visibility of the underpass with no blind spots; and
- An alarm output from the pumping station within the underpass, indicating pump failure and a high-water level warning, which will be connected to the NERCC.

Option 2 of the technology report builds on this basic concept with additional functionality which includes additional VMS on the A63 network that indicates emergency diversion routes, dedicated precipitation and water level sensors installed in the underpass, and the potential to interface outputs from the tunnel management subsystem with message updates sent using the Traffic Message Channel.

For this report it is assumed that at a minimum Option 1 proposed in the technology report will be implemented.

Technology Flood Resilience

The scheme takes cognisance of the potential impact different flood scenarios will have on the scheme. With this in mind, it is the intention of the scheme to look at different ways the proposed technology and mechanical equipment can be designed and built to be as flood resilient as reasonably possible. The technology resilience is broken up into three parts:

1. Flood detection technology;
2. Variable Message Signs; and
3. Pumping Station M&E.

All technology will be designed and constructed in accordance with the necessary standards for the scheme location:

- BS 7671 – IET Wiring Regulations, which sets the standards for electrical installation in the UK;

- IP 66 Rating – IP is the ingress protection rating for electrical and technology infrastructure. An IP66 Enclosure rating is IP rated as “dust tight” and protected against heavy seas or powerful jets of water.

Additionally, all the technology and CCTV along the scheme will be directly linked to the NERCC. In the event, there is a power outage, or if any one of the specific equipment fails, the NERCC will get a notification. As part of the NERCC’s emergency plan, which forms part of the adoption of any new technology on their network, they will inform the Area Maintenance Contractor on the network to investigate immediately. The AMC will then be able to assess the danger of the event/incident and determine whether further action is necessary.

This is a separate emergency plan, but follows the same principles as the FEEP. Linking this with any flood warnings, the technology systems will be quite robust to address any event.

Flood detection technology

The proposed flood detectors are designed to work in wet conditions and maintenance performance requirements shall be as per maintenance access arrangements, including remote access.

In terms of the designing technology, the detection equipment shall be designed to provide continuous operation for a minimum service life of 15 years and the detection equipment will have a minimum of 5 years maintenance, based on the reliability data handbook of Highways England. This information will have to be confirmed by the supplier.

Variable Message Signs

During the design development, different information signage systems were reviewed to support the objectives of the scheme. The option to deploy Fixed Text Message Signs, that could be rotated to display three different messages to advise closures was considered, however as an alternative the suggestion to install reduced size MS4 type message signs was thought a more practical solution. Both require electrical connections, which could potentially be interrupted in a flood scenario, however the MS4s would offer greater flexibility in terms of the tactical and strategic network. Additionally, these will be able to tie into the Hull City Council’s wider VMS aspirations.

An alternative signage strategy that is being considered is the prism signage system. These signs can display multiple messages and claim to be robust enough to withstand adverse weather conditions and require little maintenance. However, these signs still require power, especially when rotating messages.

It is not yet clear which of these solutions is best suited for Highways England and Hull City Council’s needs.

Pumping Station M&E

The pumping station AIP, which was produced as part of the preliminary design, provides protection for a 1-in-200-year flood event. However, it is deemed necessary to provide some additional resilience for the pumping station building.

1. If the water level during the flood is less than 1m above the finished floor level: -
    a. It will be worthwhile investigating if the building can be protected from flooding (i.e. flood defences) to prevent water ingress. The flood defences would need to protect the substation, the generator and the MCC.
    b. If the entire building cannot be protected, it would be worth investigating whether the MCC could be raised and include an additional temporary generator connection point on the MCC to allow temporary generators to be hired in and then utilise the existing pumps. Providing the MCC was not submerged.
2. If the water level during the flood is greater than 1m above the finished floor level
    a. Construct a two-story building to allow all the plant within the building to be housed on the second story to protect against any first story flooding. This option is probably not feasible in terms of planning permission but would be an option for flood protection in the future.
    b. Traditional type of flood recovery by hiring temporary pumps and temporary generators and use those to pump until the fixed plant has been replaced.

Based on the FRA models, Figure 14.35 shows a 1-in-200-year plus climate change Humber undefended tidal flooding maximum flood depth for existing layout. The figure shows that the flood depth at the pumping station area is less than 1.0m. Therefore, it seems plausible that scenario 1.a above would provide sufficient resilience for such a flood event. Additionally, the building can be future proofed, to design the foundations of the building in such a way, that it will accommodate a scenario 2.a or 2.b, if Hull City Council or the Environment Agency require additional flood protection in the future. See Appendix F for further details.

Power outage resilience

During discussions with the Environment Agency, they raised their concern regarding the technology's resilience to power outages and how the scheme aims to mitigate the potential for vehicles to enter a flooded underpass without the pre-warnings provided by the MS4 signs.

The design team reviewed the potential of providing Uninterruptible Power Supplies (UPS) for each of the signs or CCTV's, however, based on their experience UPS aren't feasible solutions. They are cumbersome and unreliable for this application.

Based on discussions, the design team imagines that there are two scenarios for when the signage will be out due to power failure:

- Scenario 1: Power failure due to flooding – In the event that there is a power failure due to flooding, there would have been an advanced warning as per the FEEP. The area maintenance contractor would have been mobilised to the underpass to be ready to respond to the different flood events.

- Scenario 2: Power failure no flooding – In the event that there is a power failure not caused by flooding, the same response process applies. Secondly, in the event that there is a no-warning flood event, there is still 2.5 hours before the flood water reaches the underpass during a wave overtopping event. This provides sufficient time to mobilise the area maintenance contractor.

Both the above scenarios will be precipitated by substantially raised water levels within the Humber Estuary which would provide sufficient warning to mobilise the area, maintenance contractor.

Flood Warning Scenarios

It should be noted that the CCTV and pump alarm will only notify the NERCC if no prior warning occurred. They therefore are not preventative measures, but reactionary measures in the unlikely event all other warning measures did not happen.

The table below shows the Evacuation and Emergency plan for each of the Environment Agency Flood Warning scenarios:

Flood Risk Level	
Flood Alert (Level 1)	• EAFW, Local Authority or another partner identifies a potential flood scenario and convenes a Humber LRF Flood Advisory Cell (FAC) teleconference. Highways England (and the Area Maintenance Team) invited to participate; • The FAC teleconference makes a decision whether to escalate to a Tactical Co-ordinating Group (TCG) or to keep monitoring; • EAFW issues Flood Alert to NERCC; • NERCC records Flood Alert on system; • NERCC monitors risk identified by Flood Alert and logs the potential risk of flood; • Area Maintenance Team moves into position to be ready to respond to Flood Warnings; • HE High volume pump stood up by the NERCC ready to deploy; • If Flood Alert escalates to Flood Warning, see Flood Warning action below; and • In the event that Flood Alert subsides wait for ***Warnings no longer in force*** notification.

Flood Risk Level	
Flood Warning (Level 2)	• EAFW, Local Authority or another partner identifies a potential flood scenario and convenes a Humber LRF Flood Advisory Cell (FAC) teleconference. Highways England (and the Area Maintenance Team) invited to participate; • A Tactical Co-ordinating Group (TCG) will be arranged whilst monitoring the situation; • EAFW issues Flood Warning to NERCC; • NERCC activates VMS on network and redirects traffic away from A63 underpass, or any other areas in danger; • Area Maintenance Team to physically close underpass with appropriate Traffic Management. The closure of the underpass will be done in accordance with the AMT's Incident Response Plan and Severe Weather Plan; • HE High Volume Pump is deployed to Hull; • NERCC and EAFW monitor flood and coordinate with Partner Agencies; • Monitor route via CCTV and communications from Emergency Services; and • Monitor situation until ***Warnings no longer in force*** notification is issued.

Flood Risk Level	
Severe Flood Warning (Level 3)	• EAFW, Local Authority or another partner identifies a potential flood scenario and convenes a Humber LRF Flood Advisory Cell (FAC) teleconference. Highways England (and the Area Maintenance Team) invited to participate; • EAFW issues Severe Flood Warning to NERCC; • NERCC triggers closure of A63 underpass, activates VMS on network and redirects traffic away from A63 underpass; • The Area Maintenance Team to physically close underpass with appropriate Traffic Management. The closure of the underpass will be done in accordance with the AMT's Incident Response Plan and Severe Weather Plan; • A Tactical Co-ordinating Group (TCG) will be arranged. The TCG/SCG and FAC will relate as much information on the Severe Flood Warning as possible, e.g. potential flood type, direction of flood and determine potential areas of immediate impact.; • NERCC informs Humberside Police, • NERCC and EAFW monitor flood and coordinate with Partner Agencies; • HE High Volume Pump is located in Hull ready to operate as required • Monitor route via CCTV and communications from Emergency Services; and • Monitor situation until ***Warnings no long in force*** notification is issued.

Flood Risk Level	
Warnings no longer in force	• EAFW issues ***Warnings no longer in force*** notification; • NERCC records ***Warnings no longer in force*** notification on system; • Coordinate with Partner Agencies and assess safety of flooding situation; • If it is agreed with Partner Agencies that flooding risk is safe, the SCG will trigger the Recovery Scenario (See Humber LRF Multi Agency Flood Plan – Section 9); • The High-Volume Pump, in coordination with the Underpass Pumping Station will be used to drain the underpass from flood water; • Area Maintenance Team to assess condition of route and identify any damage or risk to public; • Area Maintenance Team to record all potential issues and risks and inform NERCC; • Area Maintenance Team, with assistance of NERCC, Traffic Officer Service and Emergency Services to clear route and make it safe for traffic; and • Once AMT, NERCC, Traffic Officer Service and Emergency Services are in agreement about safety of route the road can be opened for traffic again. This includes changing VMS signage to remove diversion routes. • HE High Volume Pump recovers to its depot

All three evacuation plans rely heavily on the Environment Agency Flood Warning system. To ensure that the evacuation and emergency plan is robust and allows for a contingency in the event that communication between the EAFW and NERCC doesn't work, it is proposed that the following measures are taken:

- High-water level warning in the pumping station;
- CCTV in the underpass and on network;
- Area Maintenance Team notice potential flood risk and informs NERCC;
- Emergency Services become aware of flood risk and informs NERCC; and
- The potential of adding in the dedicated precipitation and water level sensors installed in the underpass.

All of these measures would provide notification to the NERCC to put into action the appropriate Flood Risk Level Scenario.

Flood Event with No Warning

Despite best efforts to have a robust and proactive warning system in place, there is a potential for flood events to occur with little or no warning. It is therefore important to understand the evacuation procedures in such an event, especially if the underpass and the rest of network is completely congested.

Flood models indicate that during a wave overtopping event, it will approximately take 1.0 to 1.5 hours for the flood water to reach the underpass from Albert Dock wall. Modelling of defence breach scenarios suggest a time to inundation of the underpass following such a breach would be approximately 1 hour. Therefore, the plan needs to be address this concern and allow for closure of the underpass with minimal warning. It must be noted that either a wave overtopping event, or a breach event would be precipitated by substantially raised water levels within the Humber Estuary. As such, it may be possible in such situations to enact the Level 1 Flood Alert procedures to enable a more rapid response in the event of a breach or no warning flood event.

Worst-case Scenario

As part of the discussions with the Environment Agency, they requested we highlight what we consider to be the worst-case scenario for the flooding of the underpass and to highlight the resilience of the proposed solution to respond to such an event. The scenario below is a possible worst-case scenario and requires for all these failures to occur at the same time:

- No-warning flood event not preceded by substantially raised water levels in the Humber Estuary (Monitored by Environment Agency and emergency services);
- Failure or overtopping of the flood defences (Monitored by Environment Agency and emergency services);
- Sensors in the underpass pumping station failure (which will activate the trigger to the NERCC);
- None of the triggers worked, and no-one from the emergency services, NERCC or Humber LRF Flood Advisory Cell (FAC) notified the area maintenance contractor (Area maintenance contractor to dial into calls); and
- Area maintenance contractor unable to mobilise a team within the 1.5 hours it will take for the flood water to reach the underpass.

Flood Risk Level	
No Warning	• Overtopping wave or breach event occurs without any warning; • EAFW, Local Authority or another partner identifies flood event and convenes a Humber LRF Flood Advisory Cell (FAC) teleconference. Highways England (and the Area Maintenance Team) invited to participate; • EAFW issues Severe Flood Warning to NERCC; • NERCC triggers closure of A63 underpass, activates VMS on network and redirects traffic away from A63 underpass; • The Area Maintenance Team to physically close underpass with appropriate Traffic Management. The closure of the underpass will be done in accordance with the AMT's Incident Response Plan and Severe Weather Plan; • A Tactical Co-ordinating Group (TCG) will be arranged. The TCG/SCG and FAC will relate as much information on the Severe Flood Warning as possible, e.g. potential flood type, direction of flood and determine potential areas of immediate impact.; • NERCC informs Humberside Police, • NERCC and EAFW monitor flood and coordinate with Partner Agencies; • HE High Volume Pump is located in Hull ready to operate as required • Monitor route via CCTV and communications from Emergency Services; and • Monitor situation until ***Warnings no long in force*** notification is issued.

Refer to Highways England Crisis Management Manual (Version 2.1) – "has been developed to provide the guidance and instructions for responding to significant disruption within any part of the company across all levels of the business, including Strategic Road Network related issues such as Major traffic incidents and Severe weather impacts.

The possibility of producing a Traffic Management Outline (TMO) for the scheme would be considered. This TMO could look at the maximum length of queueing on the network before VMS should be turned on, therefore diverting traffic away from the A63 underpass and relieving congestion in the underpass. This will hopefully mitigate the risk in the event of a flood event with no warning.

Closure of underpass

The closure of the underpass is done by a combination of measures. These measures are as follows:

- Above lane mounted Light-Emitting Diode (LED) signals at the underpass entrance to indicate lane status and show underpass as closed;
- Motorway Signal Mark 4 (MS4) or Variable Message Sign (VMS) message signs (depending on approved option) on approaches to the underpass to advise road users of flooding and redirect them via alternative routes; and
- Physical closure of the underpass by the Area Maintenance Contractor.

The review of providing a physical barrier was discounted at an early stage for the following reasons:

- It will be too complex to provide automated, or fixed closure barriers on the proposed Scheme due to the constraints imposed by the Scheme such as available space and the design implications on the underpass retaining walls and concrete base;
- The maintenance of such barriers will impose disproportionate obligations on the existing area maintenance contractor;
- The additional maintenance requirements will put the area maintenance contractor at risk on a more regular basis;
- Automated or fixed closure barriers will impose a safety risk for drivers if the barriers are activated without adequate warning systems in place. The complexity of the hazard it introduces exceeds the value that it could have;
- Due to the urban location of the scheme, providing physical barriers will be exposed to vandalism and anti-social behaviour, which in turn could pose a significant risk to drivers; and
- The cost of incorporating such technology would make the scheme unaffordable.

Ultimately it was agreed by Highways England, their Area Maintenance Contractor and the Emergency Services, that the road will be closed in line with the Area Maintenance Contractors approved Incident Response Plan and Severe Weather Response Plan. This includes the appropriate Traffic Management depending on the level of closure required.

Recovery after flooding

In the event of a severe flood, the underpass and majority of Hull will be completely flooded. The pumping station solution will not be able to prevent flooding of the underpass but will be able to assist in the recovery of the underpass. The pumping station will only be able to pump water into the Yorkshire Water network at a maximum discharge rate of 200 l/s.

Therefore, it was recommended by the NERCC, that a high-volume pump could be sourced from Area 14 to further assist in the recovery process. Once requested, it would take approximately three to four hours for this pump to arrive in Hull. The high-volume pump has 3 km of discharge pipe available to relocate the flood water to a suitable location. The Humber Estuary at Albert Dock is less than 600m away from the underpass. Ideally, it would be preferable to agree with the Environment Agency to discharge directly into the Humber Estuary in the event of such an emergency. Additionally, it was recommended that an agreement be reached with the Humberside Fire and Rescue Service, which will be able to pump water to their preferred location.

Secondly, as part of the Combined Operations report, it will be necessary to provide details for traditional flood recovery procedures such as the hiring of temporary pumps and temporary generators until the fixed plant has been replaced.

All these details will be developed as part of the Detailed Design stage of the scheme.

4 Plan Ownership

4.1 Ownership

Highways England will be the designated owners of the Flood Emergency and Evacuation Plan. They will be responsible to ensure that the NERCC is adequately informed and enabled to implement the plan.

4.2 Plan Review

The plan will have to be reviewed and updated on a regular basis with consultation with the Environment Agency, NERCC, Emergency Services and Area Maintenance Teams.

The interval of review will have to be determined. A current recommendation would be that a formal review will have to be done every three years, and after each flood alert or warning.

4.3 Plan Testing

The plan needs to be tested annually to ensure that all the responsible individuals are well aware of their roles and responsibilities. The test can be done by recording the time of response for each step of the plan, including time of notification, recording of notification, informing emergency services and the time it takes for emergency services to respond.

5 Consultation

5.1 Parties Consulted

During the development of the Flood Emergency and Evacuation Plan, the following individuals were consulted:

Name	Organisation	Role	Email	Telephone No.
Alan Bravery	Humber Emergency Planning Services		heps@eastriding.gov.uk	0148 239 3058
Lizzie Griffiths	Environment Agency	Sustainable Place, Planning Advisor	lizzie.griffiths@environment-agency.gov.uk	0203 025 8439
Dave Bristow	Humberside Fire and Rescue	Station Manager	mailto:dbristow@humbersidefire.gov.uk	0780 703 1737
Darren Storr	Humberside Police	Traffic Management Officer	darren.storr@humberside.pnn.police.uk	0148 222 0034
Sarah Atkinson	Yorkshire Ambulance Services	Admin Support Officer	Sarah.Atkinson7@nhs.net	0190 466 6110
Rachel Glossop	Hull City Council	Flood Risk Planning Manger	rachel.glossop@hullcc.gov.uk	0148 261 2129
Frances Oliver	Highways England	Assistant Project Manager	Frances.Oliver@highwaysengland.co.uk	0300 470 2527
Christopher Addy	Regional Control Centre (RCC)	Operations Manager - Deputising	Christopher.Addy@highwaysengland.co.uk	0300 470 6283
Andrew Charnick	North East RCC	Emergency Planning Manager	Andrew.Charnick@highwaysengland.co.uk	0300 470 6326
Mark Booth	A-one+	Area Maintenance Manager S.E.	Mark.Booth@aone.uk.com	0192 422 5795

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Minutes of the Consultation Meetings have been attached in Appendix E.

These minutes are only in Draft form, as they have not been approved by all parties present. However, all the comments received from the various parties after the meetings have been incorporated in the report.

5.2 Exceptions

During the consultation process, the following items were identified that needs further consultation and confirmation prior to the start of construction. It was agreed that these items will be recorded and prioritised during the Detailed Design Stage.

The exceptions are as follows:

- Diversion routes and physical signage for diversion routes;
- Extent of responsibility of Area Maintenance Team during emergency situations;
- Further consultation regarding high-volume pump used in emergencies;
- Further consultation and development of technology in underpass; and
- Positioning of Area Maintenance Team standby area in preparation of Emergency event.

5.3 DCO Hearings Requirements

During the DCO Issue Specific Hearing 2 on Wednesday, 5 June 2019, the following points were raised to be resolved prior to the start of the Detail Design. These items need to be resolved through collaborative coordination between Hull City Council, Environment Agency, Highways England and their Area Maintenance Contractor:

- Environment Agency and Hull City Council need to provide their preferred location where water will be discharged to during an emergency. The FEEP will then be updated to include this location as a specific requirement for responding to emergency situations;
- Hull City Council raised concerns about the design of the pumping station building and the visual impact this will have around the area. The building and pumping station compound landscaping design will be done in consultation with both the Environment Agency and Hull City Council, to ensure the design adheres to their requirements. These requirements will need to consider the potential flood risk, ensuring the building is flood resilient, whilst remaining in keeping with the area's aesthetic narrative. Hull City Council need to provide visual design requirements, that will inform the proposed design. Secondly, the building design levels need to be agreed with both parties to mitigate potential flooding. See Appendix F for further context; and

- Additional discussions need to be had regarding the signage for diversion routes across Hull. It was mentioned, that potentially an additional VMS sign could be provided near the Humber Bridge, to divert traffic onto the A164. Unfortunately, this area falls outside the current DCO redline boundary and can’t be included in the scope of this scheme. However, Highways England have indicated that they are happy to look at potentially providing this sign through some other mechanism. Hull City Council to produce a plan to show the propose location, which will then be considered by Highways England.

6 Conclusion

The Flood Emergency and Evacuation plan needs to be a robust and adaptable plan that can respond adequately to emergency flooding situations including those with minimal or no prior warning. The plan should be clear enough for any team member to take action, but not too prescriptive as to hinder the effective and vast implementation of the plan. Safety of drivers, general public, Emergency Services and Area Maintenance Teams are of utmost importance.

Appendix A

Humber LRF Multi Agency Flood Plan

A1

Humber LRF Multi Agency Flood Plan

Version 3.0
June 2017

Contents

Section 1 - Scope

Coastal, tidal, fluvial and pluvial flooding are all classified as Very High risk within the Humber LRF Community Risk Register. In accordance with national guidance, Humber LRF has therefore prepared this incident specific emergency plan.

The document sets out the how the Humber Local Resilience Forum will respond to a flooding event that causes, or has the potential to cause, an emergency as defined by the Civil Contingencies Act.

The document sets out the flooding specific triggers that will establish existing command and control structures that can be used to respond dynamically to the situation.

The document explains the site specific and incident specific flooding arrangement that are in place. It sets out arrangements for convening a Flood Advisory Service Teleconference to share flooding intelligence prior to a flood and a Flood Advisory Cell that will help to provide intelligence during a flood.

This plan does not replace dedicated plans owned by individual agencies, but links are provided to existing arrangements where appropriate.

Location specific flood plans and other information are referenced in this document and stored on Resilience Direct, including:

- Environment Agency Flood Warning Areas
- Zones 2 and 3 Environment Agency Flood Mapping
- Local authority surface water flooding hot spots
- 2007/2017 Level Risk East Coast Flooding Maps
- 1953 Scenario East Coast Tidal Inundation Plan
- Humber Flood Defence Height Levels

Review of the Document

Humber Emergency Planning Service is responsible for co-ordinating the review of the document.

Humber Emergency Planning Service, on behalf of the Humber Local Resilience Forum, will initiate a full document review every two years or in the event of significant changes to procedures or a flooding emergency.

Queries
Any queries on this plan should be addressed to Humber Emergency Planning Service [redacted].

Section 2 - Background Information: Flood Risk in the Humber area - Critical Information

Who is the national lead?	Department for the Environment, Food and Rural Affairs.
Who leads the Strategic Coordinating Group / Tactical Coordinating Group	Humberside Police will chair the first meeting of the Tactical Coordinating Group and will retain the chair for all incidents that present a risk to human life. Humberside Fire and Rescue Service may lead if rescue is the main focus of the response. The local authority may lead if the response has a community impact but no risk to life. For a full overview of which agencies can lead a response please see the Humber Emergency Procedures Manual.
Who initiates the Humber Response	The decision on whether to invoke this plan will be either by an Environment Agency led FAS teleconference, or by any responding organisation receiving flood guidance statements / warnings as outlined in the plan.
Who notifies partners within the Humber area of a flood event?	Partners will be notified by the Environment Agency and Met Office when flooding is forecast or possible. Actual flooding on the ground can be reported by any organisation or

	members of the public once it has happened.
What communication methods will be used to alert partners?	Environment Agency and Met Office will issue warnings and notifications to responders through usual channels. The Humber LRF Mass Notification System will be used to inform partners of any TCG / SCG meetings convened as a result of the warnings.
Who will co-ordinate the media?	The LRF Media Cell will be convened as part of the TCG activation process. Humberside Police will usually co-ordinate by chair their media cell, but this lead can pass to any other organisation as appropriate.

Section 2 - Background Information - an Overview of the Flood Risk in the Humber Area.

The following key flood risks have been identified in the Humber area:

- Major coastal and tidal flooding - sea surge, spring tides, gale force winds and/or heavy rainfall, some defences overtopped or failing at multiple locations.
- Severe fluvial flooding affecting more than two UK regions - single massive fluvial event or multiple concurrent regional events following a sustained period of heavy rainfall extending over two weeks (perhaps combined with snow melt and surface water flooding).
- Local/urban flooding due to fluvial or surface water run off(sustained period of heavy rainfall extending over two weeks, possible combining with snow melt, result in flash flooding and steadily rising river levels that could threaten an urban town.
- Local Pluvial Flooding. Very high intensity rainfall over one village or community overwhelms drainage system, resulting in flooding of properties before water enters watercourses - very high.
- Regional Pluvial Flooding - Heavy and prolonged rainfall across a wide area (large urban areas affected) overwhelms drainage systems, resulting in flooding of properties before water enters watercourse.
- Heavily localised flooding in steep valley catchments leading to extremely hazardous flash flooding.
- Critical waste water asset flooding caused by third party blockage, exceptional wet weather incapacity or loss of pumping capacity.
- Failure of above ground service reservoirs which are subject to the Reservoirs Act (above 25Ml) and the Flood & Water Management Act.

Key Historical evidence for these risks in the Humber includes:

- January 2017 tidal storm surge which whilst not as significant as the December 2013 event, caused property flooding in Hornsea and road flooding in Withernsea and parts of Hull.
- December 2013 - Biggest tidal surge on the Humber in 60 years, with a level of 5.8m reached at the Hull Barrier. Over 650 properties flooded,

more evacuated, and approximately 10sqkm of agricultural land affected.

- December 2012 - Pluvial - Dec - A number of homes in Burton Fleming flooded after rising groundwater levels at Gypsey Race at Boynton.
- June/July 2007 - Pluvial and Fluvial flooding across England. Severe rainfall events, during an extremely wet summer, led to some 49,000 households and 7,300 businesses being flooded across England. The June/July floods were marked by the extraordinarily large number of properties flooded by surface water (mainly in Hull).
- 2007 - High alert and widespread media interest in forecast storm surge on east coast.
- 2002 - Fluvial flooding of properties from Setting Dyke (Urban Watercourse) 2002 due to blockage.
- 2000 - Overtopping of the Lower River Derwent.
- 1981 - 23 Sq Km of the Ancholme Valley suffered serious flooding and 30+ properties were flooded in Grimsby as a result of the River Freshney overtopping.
- 1978 - Breaching of the Sea Wall in Cleethorpes.
- 1969 - Very high levels in the Humber - flooding of over 1,000 properties in Hull City Centre (pre-barrier).
- January 1953 - Extensive flooding along entire East Coast (over 1,000 miles). Thousands of properties destroyed and flooded. 307 people lost their lives while thousands became homeless.

The primary and secondary impacts of flooding include:

- Drowning of people, pets and livestock.
- Flooding of large numbers of properties.
- Major damage to property, businesses and surrounding land.
- Closure or washing away of roads, bridges, railway lines.
- Major pollution risk from chemical plants because of the concentration of such sites on the Humber.
- Risk of explosion(s) if water inundates high temperature petro-chemical processes.
- Loss of (and possible damage to) telephone, electricity, gas and water supplies.

- Pollution/health risks from sewerage systems, chemical stores, fuel storage tanks.
- Shortage of fuel.
- Evacuation and temporary/long term accommodation need.
- Need for recovery strategy in aftermath of major flood.
- Disruption of economic life and major costs of rebuilding infrastructure.
- Possible loss of employment should businesses affected choose to close down or move.
- Public need for information, advice, benefits/emergency payments.
- Insurance implications including help for the uninsured.
- Safety assessments/possible demolition of damaged buildings and structures.
- Shortage/overstretch of key resources (equipment and personnel) and agencies, including the emergency services.
- Overstretch of normal communications links including mobile phones.

Managing Flood Risk

A number of organisations are responsible for managing the strategic flood risk before an emergency happens. Most of the powers are permissive, rather than being duties to provide.

- **Defra** has overall national responsibility for policy on flood and coastal erosion risk management, and provides funding for flood risk management authorities through grants to the Environment Agency and Local Authorities.

- **The Environment Agency** is responsible for taking a strategic overview of the management of all sources of flooding and coastal erosion. This includes, for example, setting the direction for managing the risks through strategic plans; providing evidence and advice to inform Government policy and support others; working collaboratively to support the development of risk management skills and capacity and providing a framework to support local delivery. The Agency also has operational responsibility for managing the risk of flooding from main rivers, reservoirs, estuaries and the sea, as well as being a coastal erosion risk management authority.

- **Lead Local Flood Authorities** - Unitary authorities are responsible for developing, maintaining and applying a strategy for local sources of flooding in their areas and for maintaining a register of flood risk assets. They also have lead responsibility for managing the risk of flooding from surface water, groundwater and ordinary watercourses.

- **Internal Drainage Boards -** are independent public bodies responsible for water level management in their areas, working in partnership with other authorities to actively manage and reduce the risk of flooding. A significant proportion of the Humber area is covered by an internal drainage board, who are invited to the LRF Flood Group and the Flood Cell teleconference.

- **Highway Authorities** are responsible for providing and managing highway drainage. This includes road gullies in adopted highways, although those often rely on other bodies to take water away (i.e. water companies, IDB, Riparian Owners). Roadside ditches are responsibility of riparian owners / adjacent landowners.

- **Riparian Owners** - A riparian owner is someone who has any river, stream or ditch within or adjacent to any boundary of their property. Under the flood and water management act, riparian owners maintain all the duties and responsibilities for watercourses in their land set out in the Land Drainage Act.

- **Water and Sewerage Companies** are responsible for managing the risks of flooding from water and foul or combined public sewer systems; which serve two or more properties or any sewers serving a single property from the point beyond the property curtilage.

  See Appendix E for more information.

These organisations will not, however, normally be responsible for leading the multi-agency response to a declared emergency. For flooding these can be expected to be:

- Humberside Police for all land based incidents that present an immediate threat to human life, a serious risk of injury, potential evacuation of homes and businesses or significant numbers of fatalities.

- Local Authorities for any incident that is not immediately life threatening but that will have a significant impact on the community or local economy

- Humber Fire and Rescue Service for emergency on land where search and rescue is the main focus of the response, where life is still believed to be viable, and where no other agency is better suited to coordinating.

A full list of o pre-identified lead responders are listed in the Emergency Procedures Manual.

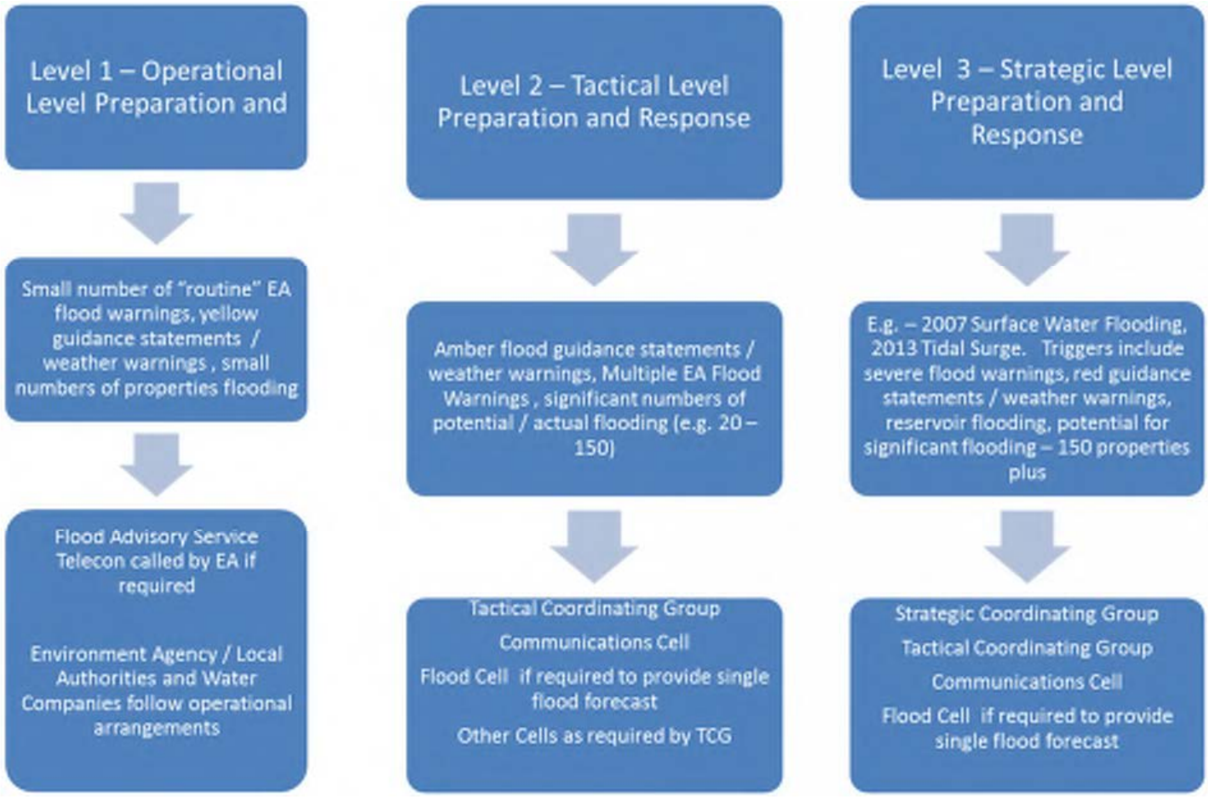
Section 3 - Background Information - Preparation and Supporting Cells

There are multiple products available to Category 1 and 2 responders which forecast the potential for flooding. These include:

- Met Office Weather Warnings.
- Environment Agency Flood Warnings.
- Flood Forecasting Centre Flood Guidance Statements.

Many of these forecasts will give days or hours' notice of a potential flood, which will often allow preparations to take place before the event.

Not all flooding events will lead to the declaration of an emergency. Some will be managed effectively by responding organisations own operational plans. The diagram below show the various flood response levels.



Local Flood Advisory Service

The Local Flood Advisory Service is a teleconference arranged and chaired by the Environment Agency (EA), based upon and prompted by forecasts in the Flood Guidance Statement (FGS) to provide early situational awareness of potential flooding to multi agency partners. The MET Office, Local Authorities, water companies and other partners will add any intelligence that they have on the situation.

The teleconference allows partners to ensure that they have appropriate operational arrangements in place and allows consideration to be made on whether the situation should be escalated to a Tactical Co-ordinating Group (TCG).

Individual agencies can request a Flood Advisory Service Teleconference if they believe there is a flood risk that the EA and MET Office have not identified.

Humber LRF Flood Advisory Cell

The Humber LRF Flood Advisory Cell is a teleconference of flooding technical officers from the Environment Agency, Local Authorities, Met Office, water companies and internal drainage boards. It will convene in the event of a flooding emergency to provide a single source of technical advice on flooding to the Tactical Co-ordinating Group (TCG). It will also provide advice to the Science and Technical Advice Group (STAC) when it is sitting, so that the STAC can provide a single source of all technical advice to the Strategic Co-ordinating Group (SCG).

The teleconference will be triggered when one organisation (usually either Environment Agency or Local Authority) working in isolation is not able to provide the necessary levels of advice. It will usually be triggered at the request of the TCG, or recommended by a Flood Advisory Service teleconference, or by the Environment Agency or Local Authority. In the absence of a FAC, responding organisations will arrange for advice and updates to be provided through their representatives at the TCG as normal.

The role of the FAC cell is to support the Tactical Co-ordinating Group by:

- Pooling available information and providing, as far as possible, a single source of advice to the TCG on the likelihood, impact and potential consequences of a flooding event in the Humber area.
- Assess the various forecasts and models available (worst case, most likely etc.) and provide the TCG with a description on what the FAC thinks will happen.
- Provide a single source of flooding advice to the TCG throughout the emergency.
- Identify other agencies/individuals with specialist advice who should be invited to join the cell in order to inform the response.
- Liaise between agencies represented in the cell and any regional/national advisors to ensure consistent advice is presented locally and nationally.

Humber Emergency Planning Service will initiate a FAC through the Humber LRF Mass Notification system.

The FAC will be chaired by either the Environment Agency or a Local Authority depending on the source of flooding. The most appropriate organisation to chair will be reviewed at the end of each meeting.

A standard agenda, pre-identified teleconference codes and a group email list are shown at Section 6.The FAC is likely to meet for up to 30 minutes to agree forecast and impacts and then the Chair will arrange for a map and narrative to be provided to the TCG.

The Chair of the FAC will be responsible for briefing the TCG unless agreed otherwise during the meeting. The briefing will be in the form of a telephone conversation or by use of Resilience Direct.

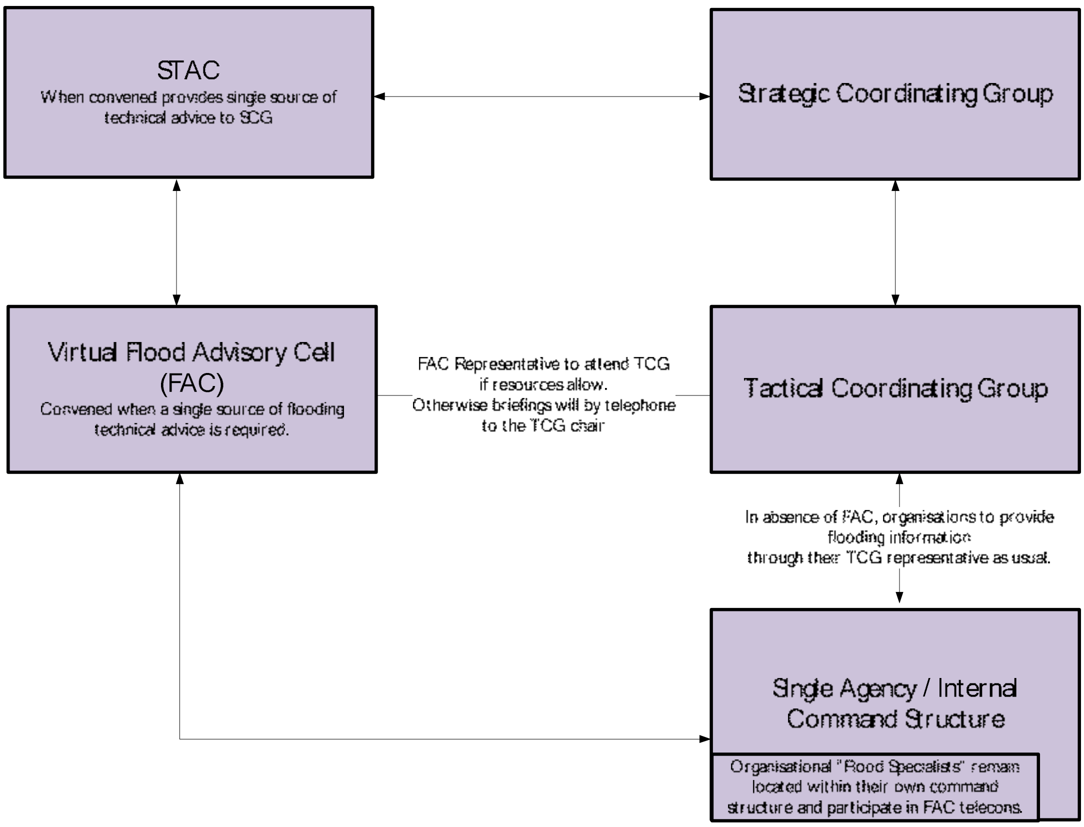
Representation on the FAC does not replace the requirement for an individual organisation to be represented at the TCG meeting. Caution should be taken by FAC members not to undermine the role of their liaison officer at the TCG.

The first FAC will always initially be Humber wide. There may be some circumstances when it is most appropriate to hold one FAC for Hull and East Riding and one FAC for North and North East Lincolnshire. This will be agreed following the first joint FAC meeting. Where the flooding/flood risk is localised to one particular area, this will be made clear in the invite to the group and organisations not affected will not need to attend.

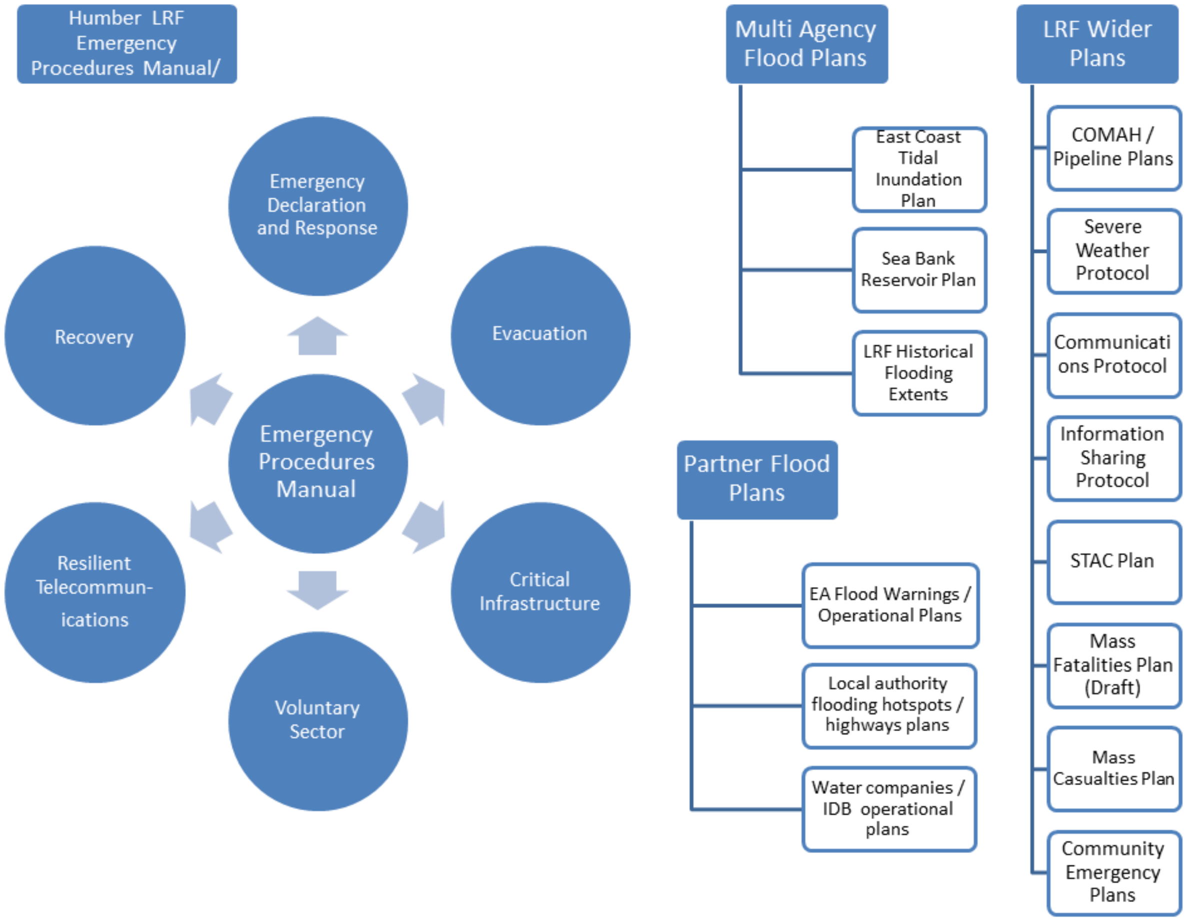
The FAC will close when there is no longer any need to provide forecasting information on the likelihood, impact and potential consequences of the flooding event.

Partners should note that this cell has the potential is likely to need to meet by teleconference at least three times a day. This will usually be during "daylight" hours but could be at any time of the day or night.

Diagram of Flood Advisory Cell following declaration of an Emergency



Section 4: Linkages to other Emergency Plans



Some more detailed flooding information in support of this plan is available on Resilience Direct [redacted] including:

- The Humber LRF East Coast Tidal Inundation Plan, which sets out the arrangements for responding to a 1953 scale flooding event.
- 2017 Level Risk East Coast Flooding Maps.
- Each Local Authority has a plan showing areas that most commonly flood during surface water flooding.
- The reservoir specific plan for Hensall reservoir.
- Maps that show the indicative coastal, fluvial and pluvial flooding extents on Resilience Direct.
- The Humber Flood Defence Height levels maps.
- The Environment Agency Flood Warning Zones.

The responses to many flooding emergencies are likely to rely on the generic capabilities outlined in other LRF multi agency emergency plans. Some of the key arrangements are listed below:

Evacuation

The Humber LRF Emergency Procedures Manual outlines how an evacuation will be managed in the event of an emergency. An evacuation cell within the TCG, or at the incident scene, will often be established. Responding organisations, usually the Police and the Fire and Rescue Service, will provide staff to door knock residents to be evacuated, where necessary. Local Authorities hold information leaflets that advise residents on the steps to take to evacuate. Local Authorities will arrange emergency transport and arrangements for emergency shelter in "Rest Centres". Rest Centres will usually be the nearest sports hall to the area to be evacuated. In areas with a community emergency plan, local town and parish councils may be asked to open their pre-identified shelters, which are often village halls and church halls.

Vulnerable People at risk from Flooding

The Humber LRF Vulnerable People protocol sets out the process for gathering and sharing information on vulnerable people and is available on Resilience

Direct. The process will usually involve using Resilience Direct mapping to identify postcodes of the affected properties, which are then shared with Local Authorities, NHS organisations and utility providers. These organisations will then provide the name and contact information of potentially vulnerable people in that area.

Multi Agency Strategic Holding Area

Should a holding area be required, for example to coral national resources deployed, the Humber Bridge Car Park has been identified as this area's multi agency strategic holding area. Please see the Multi Agency Strategic Holding Area Plan.

Information Sharing Protocol

Outlines the agreed process for sharing information on vulnerable people between Category 1 and 2 responders.

External Tier COMAH Plans

Some of the area's External Tier COMAH plans are located close to the Humber estuary and could be affected by coastal flooding. Their COMAH upper tier plans would be triggered by the COMAH operators as normal as required and available on Resilience Direct [redacted]

Scientific, Technical and Advisory Cell

Arrangements for Public Health England or Local Authority Director of Public Health to chair a group which will provide a single point of scientific and technical advice to the SCG during an emergency.

Mass Fatalities Plan

Arrangements for establishing an emergency mortuary and wider associated supporting functions in the event that an emergency overwhelms the capacity of the existing mortuary provision.

Mass Casualties Plan

Arrangements for setting up extraordinary arrangements for dealing with in excess of 100 casualties following a declared emergency.

Community Emergency Plans

There are more than 120 community emergency plans in the Humber area, where Town and Parish Councils have identified emergency shelters, local resources and access to local information. Local authorities will usually trigger these plans but any organisation can request more information / access through Humber Emergency Planning Service.

Recovery

The Humber Local Authorities will usually lead the recovery phase of an emergency. The process is outlined in the Emergency Procedures Manual.

Section 5 – Triggering an SCG / TCG

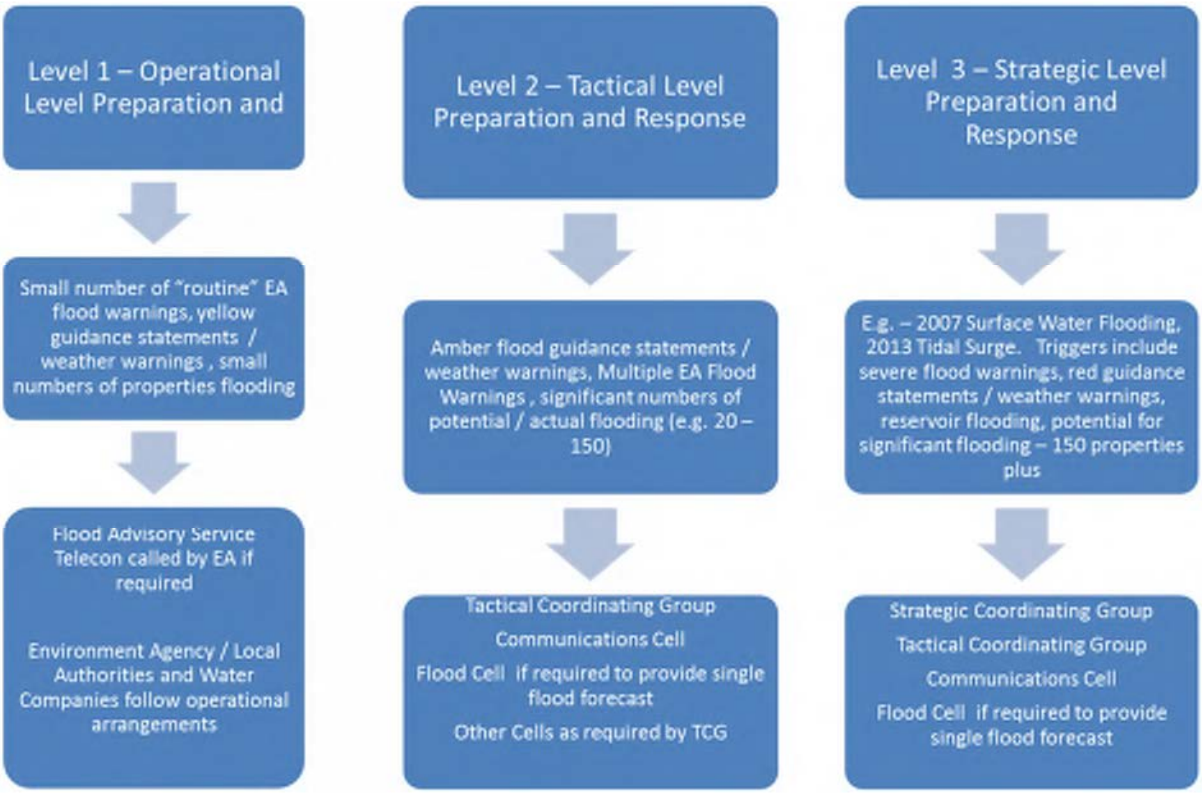
Triggering a Humber Tactical Coordinating Group

There are normally three local levels of response to flooding; operational, tactical and strategic.

The operational level is where the management of the immediate work is undertaken at the flooding site or other affected area. This may include steps like closing flood gates, clearing trash screens or deployment of pumps / flood defences etc. Most flooding situations are dealt with at this level

A Tactical Level is established when additional resources and coordination is required in addition to the operational activities. For example, when flooding requires homes to be evacuated and people require rescue.

A Strategic Level is established when the situation has, or could have, significant resource implication to responding organisations, a significant impact on the community or significant impact to the environment.



A TCG will be convened if it appears that the flood could or is causing an emergency. The following are **automatic triggers**:

- Intelligence (usually from the Flood Advisory Service) suggests that there is the potential for substantial flooding.
- Amber Flood Guidance Statement for river/surface water flooding.
- Amber MET Office Rainfall Alert.

Humber Emergency Planning Service will usually liaise with Humberside Police and arrange for a TCG meeting to be held following receipt of one of the above triggers. A TCG may also be triggered in the event following conversation with partners if:

- There are reports of large numbers of property flooding.
- Multiple flood warnings affecting large numbers of properties are issued, or likely to be issued.
- On advice from the Flood Advisory Service Teleconference.
- Flooding threatens key critical infrastructure, or the failure of flood mitigating critical infrastructure

If any Cat 1 or 2 responder becomes aware that a trigger has been met and that a TCG has not been convened they should contact Humber Emergency Planning Service Duty Officer or Humberside Police.

Humberside Police will usually chair the first meeting of the TCG and determine whether it should be a physical meeting or a teleconference. Often a teleconference is appropriate if discussing forecasting a few days in advance.

Humber Emergency Planning Service will arrange for a mass notification message to be sent to all responders to confirm the details of the TCG meeting.

If a TCG Teleconference is required, the dial in details are:

- Dial in Number: [redacted]
- Host PIN: [redacted]
- Participant PIN: [redacted]

Automatic Triggers for a Humber SCG meeting

The Chair of the Tactical Co-ordinating Group will usually consider whether a Strategic Co-ordinating Group is required, using the definition set out in the Emergency Procedures Manual.

However, if one of these automatic triggers for an SCG list below is received, then Humberside Police will arrange for an SCG meeting to be convened. Humber Emergency Planning Service will send out the mass notification message:

- A Severe Flood Warning is issued.
- Advanced warning of significant/catastrophic flooding (this includes attendance at a ResCG).
- An Amber warning of east coast flooding.
- A Red Flood Guidance Statement.
- Reports of reservoir flooding.
- MET office red warning of heavy rain.
- Intelligence suggesting that there is the potential for significant/catastrophic flooding.

If any Cat 1 or 2 responder becomes aware that a trigger has been met and that a TCG has not been convened they should contact Humber Emergency Planning Service Duty Officer or Humberside Police.

If an SCG Teleconference is required, the dial in details are:

Dial in Number: [redacted]
Host PIN: [redacted]
Participant PIN: [redacted]

There is a detailed spreadsheet and GIS layer on Resilience Direct [redacted] showing the identified critical infrastructure in the area.

It will usually be necessary to prioritise electricity infrastructure, on advice of Northern Powergrid, to ensure other flooding critical infrastructure operates.

Failure of Yorkshire Water's East or West Hull pumping stations would lead to major flooding.

More detailed flooding critical infrastructure information will appear here in due course.

Section 6 – Warning and Informing: Multi Agency Media Cell

Considerations for the Multi Agency Media Cell

- The Environment Agency will usually lead on river and coastal communication messages. The Humber LRF Communications Group will usually promote these messages and individual responders issue information on their own actions - eg A164 closed due to flooding.

- For other types of flooding, or if the Environment Agency are not able to issue public information messages, there are some key messages listed below:

  Key Flooding Messages

  - Avoid walking on coastal paths and promenades during coastal flooding.
  - Don't go into flood water. Never let children play in flood water. There could be hidden dangers like sharp objects, missing manhole covers and pollution. Just 150mm (six inches) of fast flowing water can knock an adult off their feet.
  - If you must go into flood water to protect your property or to help others, take care. Never enter flood water that is moving or more than 100mm deep (four inches). Don't enter flood water unless you can see the ground. Consider using a pole/brush handle to test the ground in front of you. Never walk through a flooded basement.
  - Don't drive into flood water. A car can float in just 600mm (two feet) of water.
  - If you touch flood water always wash your hands afterwards with hot water and soap.
  - Don't touch any electrical appliances, cables or equipment while standing in flood water, or any appliances that have been immersed in flood water.
  - Carbon monoxide kills. Make sure you have good ventilation if using portable indoor heating appliances to dry out indoor spaces. Never use petrol or diesel generators or other similar fuel-driven equipment indoors as the exhaust gases contain carbon monoxide, which can kill.

<u>If your house is about to flood right now</u>

- Call 999 if you or your neighbours are in danger.
- Lock your house and leave. If you have time, grab some essentials you might need for the next few days. Stay with family or friends, or call your insurance provider for temporary accommodation or ask a responder where the nearest emergency shelter is.
- If it is not safe to leave your house, move your family and pets upstairs or to a high place with a means of escape.
- If you have time, turn off gas, electricity and water supplies. Never touch sources of electricity when standing in flood water.
- Check in with your vulnerable neighbours and relatives, if it is safe to do so.

<u>If you have some time to prepare before your house floods</u>

- Have Radio Humberside 95.9FM playing in the background while you prepare in case there are any warning messages issued by the emergency responders.
- Gather essential items you might need if you have to leave your home for a few days. Items will differ from person to person, but think about:
    - Copies of key documents such as passport, birth certificates.
    - Home and car insurance phone numbers and policy details.
    - Medication, prescriptions and a first aid kit.
    - Toiletries, wet wipes and/or antibacterial hand gel.
    - Torch.
    - Any special items for babies, children etc.
    - A vacuum flask and hot water bottle.
    - Spare glasses/contact lenses.
    - Spare set of keys.
    - Snacks and drink.
    - Mobile phone/charger.
    - Books or other forms of entertainment to pass the time.
    - Small amount of cash/credit cards.
- If you have pets, suitable carriers for small animals, a water bowl, bedding, pet medication and a supply of food.

- If there is a chance you might need to shelter in your house during a flood, take some basic provisions upstairs. Fill jugs and saucepans with clean water.
- Protect what you can. Take items upstairs or to a safe place in your property. Think about:
    - Items of personal value like photos, family films or treasured mementos.
    - Important papers like insurance documents and passports.
    - Possessions that are expensive or hard to replace.
    - Moving drawers if furniture is too heavy to move.
    - Taking curtains down or wrapping them around the curtain pole.
    - Focusing on light items that can be moved quickly and easily.
    - Pulling furniture that can't be moved elsewhere away from the walls and weighing it so it doesn't float and damage walls and windows.
    - Raising furniture that can't be moved elsewhere onto bricks and fastening plastic bags around the legs.
- If possible, move your outside belongings to higher ground. Think about:
    - Outdoor pets and their cages, food and bedding.
    - Moving your car if roads are not already flooded.
    - Equipment in shed/garage.
- Try and stop water entering your home:
    - Brush away any leaves that might be blocking the gullies near to your home.
    - If you have any flood protection equipment, such as floodboards or airbrick covers, put them in place.
    - Put plugs in sinks and baths and weigh them down with something heavy. Try to weigh down the toilet seat too.
    - If you do not have non-return valves fitted, plug water inlet pipes with towels or cloths and disconnect any equipment that uses water (like washing machines and dishwashers).

Sandbags

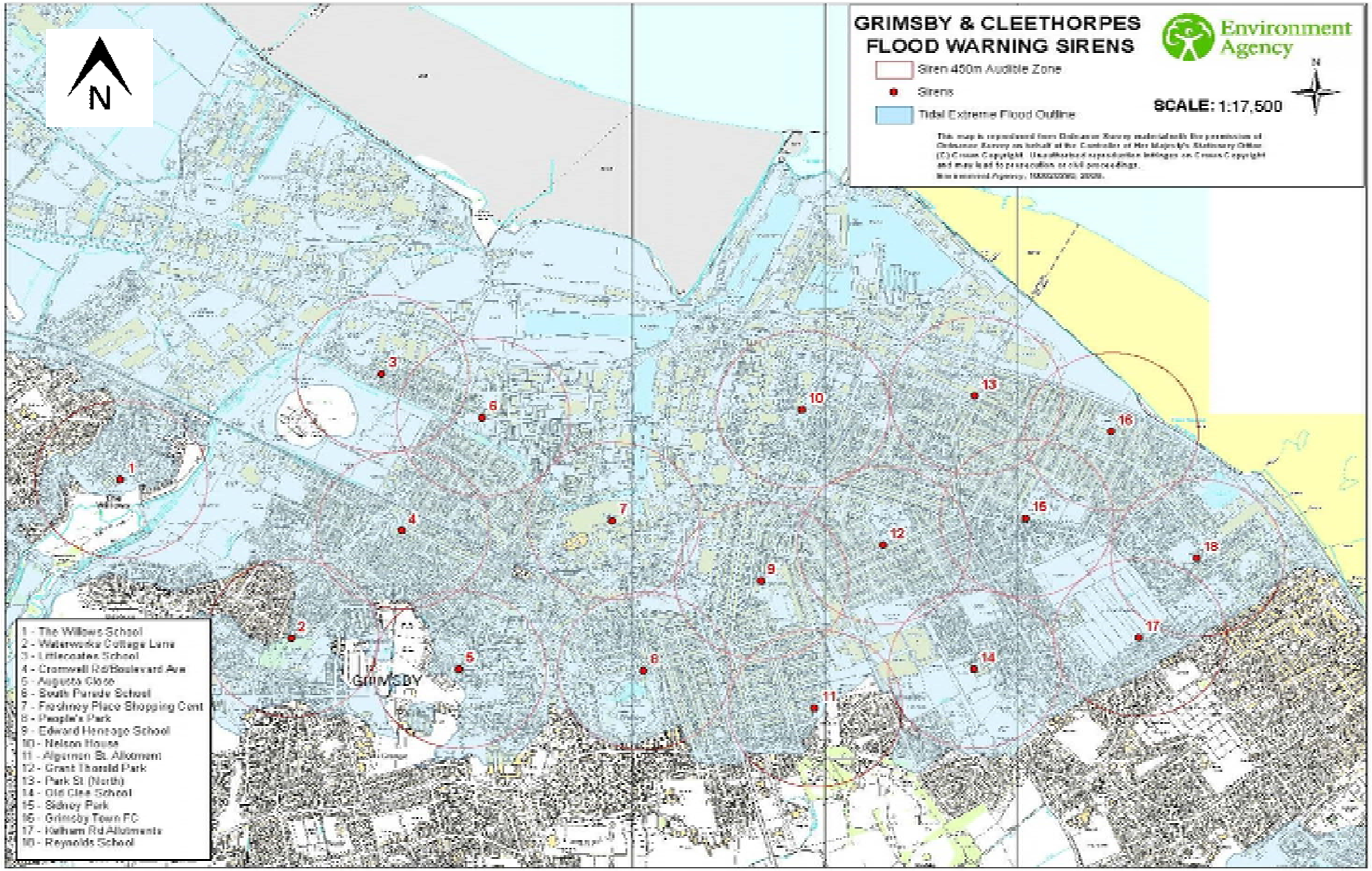
- Sandbags are of limited use. They can help divert the path of running water and they might keep water out of your property for a little while if you use them with plastic sheeting to block doorways, drains and other openings into properties. But you will need lots of them. They seep water and they will not stop water coming up through floor boards or from neighbouring properties.
- Sandbags are of no use if your property is already flooded.
- If you don't have any sandbags you can make your own by filling pillow cases or refuse sacks with garden soil. You can use silicone sealant to block cable entry points.
- Because sandbags are of limited use, your time may be better spent moving your belongings out of harm's way.
- If you have time, please try and help your neighbours prepare.

Section 7 - Grimsby Flood Sirens

Grimsby and Cleethorpes are relatively unique in having dedicated flood sirens that will be sounded by the Environment Agency when a Severe Flood Warning is issued. The Grimsby and Cleethorpes Flood Warning Sirens comprise a network of 18 siren units, located at sites to provide optimum coverage of domestic residential properties within the tidal flood risk area. All 18 sirens are intended to be used together to warn of significant tidal flooding. In addition one siren (No. 1 - The Willows) is located within a fluvial risk area and should be used to warn residents at risk from the New Cut Drain in the Willows and Wybers Wood estate areas of Grimsby.

Location (s)	1 The WillowsPrimary School, Queensway 2 Waterworks, Cottage Lane 3 LittlecotesPrimary School, Harlow St. 4 Cromwell Rd./Boulevard Av. 5 Augusta Close 6 SouthParadeJuniorSchool 7 Freshney Place Shopping Centre 8 PeoplesPark, Park Av. 9 EdwardHeneagePrimary School, Edward St. 10 Nelson House, Albion St. 11 Algernon St Allotment 12 Grant Therold Park, Durban Rd./Roberts St. 14 OldCleeJuniorSchool, Colin Av. 13 Park St. 15 Sidney Park, Brereton Av. 16 Grimsby Town FC 17 Kelham Road Allotments 18 ReynoldsJuniorSchool, Machray Place
Ownership	Environment Agency.
Trigger for activation	Issue of a 'Flood Warning' or 'Severe Flood Warning' for the Willows Estate Siren (No 1) and issue of a 'Severe Flood Warning' in a tidal inundation event.
Who approves the activation?	Sounding the sirens is a multi-agency decision that will be led by technical flood forecasting information from the Environment Agency. It is likely that the decision will be

	approved at Gold control or at a Flood Advisory Service Telecon if Gold is not sitting. Where there is not sufficient time before flooding will occur (eg breach of defence) the Environment Agency will sound the sirens and then inform multi-agency partners.
What does it mean?	To warn customers that flooding is expected. They should take immediate action to protect themselves and/or their property (Flood Warning) and/or to warn customers of significant risk to life or significant disruption to the community caused by widespread or prolonged flooding (Severe Flood Warning).
What will the sirens say?	Tidal Warning; "This is a Severe Flood Warning from the Environment Agency. There is extreme danger. Listen to local radio. Contact Floodline. Act now. Listen to local radio. Contact Floodline. Act now." Fluvial Warning; "This is a flood warning from the Environment Agency for the New Cut Drain, Wybers Wood and Willows Estates. Call Floodline or tune in to your local radio. Act now."
What action is required and by whom?	Once the approval has been given, the Environment Agency will sound the sirens. Multi-agency partners will then progress evacuation.


GRIMSBY & CLEETHORPES FLOOD WARNING SIRENS
Environment Agency
Siren 450m Audible Zone
Sirens
Tidal Extreme Flood Outline
SCALE: 1:17,500
N
GRIMSBY
1 - The Willows School
2 - Waterworks Cottage Lane
3 - Littlecoates School
4 - Cromwell Rd/Boulevard Ave
5 - Augusta Close
6 - South Parade School
7 - Freshney Place Shopping Cent
8 - People's Park
9 - Edward Heneage School
10 - Nelson House
11 - Algernon St. Allotment
12 - Grant Thorold Park
13 - Park St (North)
14 - Old Clee School
15 - Sidney Park
16 - Grimsby Town FC
17 - Kelham Rd Allotments
18 - Reynolds School

Section 8 Environment Agency Assets

The Environment Agency has a national store of 40 kilometres of temporary barriers and other mobile equipment, which can be requested through a SCG.

National Flood Rescue Assets

The Fire and Rescue Service National Coordination Centre (FRSNCC), London Fire Brigade provides a single point of contact for the Flood Rescue National Asset Register. This provides a comprehensive list of all accredited flood rescue teams that have declared their compliance with the team typing requirements set out in the Defra Concept of Operations, and who maintain availability for deployment on an on-going basis.

Whilst the bulk of these teams are provided by the FRS, a significant minority are drawn from the voluntary sector, including the RNLI, Mountain Rescue England and Wales, and a range of local groups eg Humber Rescue. All have committed to deliver the standard teams as set out in the ConOp, and should be treated as interchangeable for all planning and deployment purposes. The Asset Register represents the only resources which can be firmly relied upon for pre-planning.

Process for Reporting a Major/Wide Area Event and Requesting Mutual Aid

- The emergency response authority affected by the flood identifies risk of a flood event requiring additional specialist flood rescue assets.

- The Impacted Authority requests assistance via the Fire and Rescue Service National Coordination Centre (FRSNCC) in London Fire Brigade. For validation purposes, the call to the FRSNCC must be made by a Fire and Rescue Service Control Room.

- The FRSNCC verifies the identity of the caller as a representative of an Impacted Authority and records the details of the mutual aid request (as outlined below).

- The FRSNCC will decide the most appropriate course of action, including assembling typed teams from the National Asset Register to meet the request for assistance, having liaised as appropriate with the:

    i. Impacted Authority.
    ii. Lead Government Department (which is Defra).

iii. CCC (Regional Civil Contingencies Committee) (if activated).
iv. Chief Fire and Rescue Adviser Duty Officer and/or DCLG Emergency Room (if established), National Resilience Assurance Team (NRAT) Advisor and Tactical Advisors (TacAd's).

- All flood rescue assets on the Register will be requested by FRSNCC who will contact flood rescue responder organisations via their agreed contact for mobilisation requests (for FRS flood rescue assets this is likely to be individual Fire and Rescue Services; for non-FRS flood rescue responders this is likely to be the organisation's control room).
- The FRSNCC will maintain a national overview of all flood rescue assets on the National Asset Register and will provide a 365/24/7 function and through allocated TacAd's supporting NRAT Advisors will provide any strategic advice that might be necessary.
- FRSNCC and TacAd's supporting NRAT Advisors will maintain a forward looking strategic overview of likely rescue requirements in consultation with the Flood Forecasting Centre and any other strategic co-ordination functions that have been established, eg Lead Government Department (Defra).
- When formally "stood down", the FRSNCC will communicate with all deployed teams on the National Asset Register.

During widespread flood related Emergencies the Fire & Rescue Service will under normal circumstances be the lead agency in the co-ordination, "overall command" and deployment of local Flood Rescue Boat Assets. The ability of an organisation to respond will be subject to the particular agencies personnel & asset availability. The capability to respond to the designated RV point and potential subsequent operational deployment will be dependent on any on-going or immediately foreseeable incidents the organisation may already be committed too.

It is stressed that although the FRS will have overall command of the incident, sector etc. each organisation will retain command of their own assets.

This protocol will only be instigated when additional Flood Rescue Boat Assets may be foreseeably required to assist with inland Flood Rescue activities such as pre-determined evacuation, search operations, lead outs and potentially flood rescues.

In order to assess the capability of an organisation to be deployed during flood related emergencies, each organisation agree to operate and declare their assets and number of trained personnel they would expect to be available in advance and in accordance with the current ***DEFRA Flood Rescue Concept of Operations.***

Assets will be "credentialed" whenever possible by a FRS Level 6 National Flood Rescue Tactical Advisor and any subsequent deployments will be in accordance with the team's capability (both personnel & assets). In order to achieve this more effectively Rescue boat assets will be "credentialed" beforehand based on information compiled in Appendix A below. Organisations should include a proposed overview of the assets and number of trained personnel they would reasonably foresee is available to respond. These details will be held on a secure Fire Service Database.

During the response phase to an emergency organisations will declare their availability prior to responding to the pre-determined RV point. This will be dependent on the type & location of the incident but this will normally be Humberside Fire & Rescue Service HQ, Summergroves Way, Hessle HU4 7BB (a designated Strategic Holding Area or Forward Operating Base). FORM 1 should again be completed (on the day) and forwarded to FRS Control as soon as possible prior to mobilising to the designated RV point.

To assist and speed up this process during the response phase of any incident FRS Service Control will be contacted (number required) and assets verbally declared. This must be supported by an e-mailed copy of Appendix A including the actual names and details of the responding crew. (e-mail address required) As per agreed national protocols whenever possible a level 6 Flood TacAd will confirm the asset capability prior to deployment and brief teams accordingly in relation to command and communication protocols/networks to be utilised.

Once deployed teams will operate and report directly to the Fire & Rescue Service on-scene incident commander (where applicable) and operate to the agreed safe system of work. This will include an agreed communications protocol where plain English communications will be utilised.

Each agency will retain ultimate command of their individual resources.

Section 9- Recovery

When the emergency has been brought under control and enters the recovery phase, the Lead Responder will hand over the co-ordination to the Local Authorities to lead on the recovery efforts.

The emergency is thought to have entered the recovery phase when:

- There is no known further risk to life.
- There are no known serious public order or crime prevention issues which impact on the co-ordination of the recovery phase.
- All responding organisations are now operating response activities at a level, which does not necessitate a Strategic Co-ordinating Group or Tactical Co-ordinating Group to co-ordinate and facilitate their activity.
- There are no known scenarios which are likely to give rise for the requirement to reinstate the Strategic or Tactical Co-ordinating Group in the foreseeable future in relation to the incident.

In broad terms, recovery can be broken down into the following categories:

- Community Assistance.
- Repair to Infrastructure/Site Clearance.
- Environmental Clean-Up.
- Business Assistance.

Each affected Local Authority will appoint a Recovery Manager and an internal recovery group to lead the recovery process in their area. If multi agency co-ordination is required then a Humber LRF Recovery Co-ordinating Group (RCG) will be established, often by teleconference.

The recovery group's agenda and shared recovery aim and objectives are contained in the Humber Emergency Procedures Manual. The Communications Cell established as part of the response may continue into recovery, under the Chair of the Local Authority leading the RCG.

Section 10 - Humber LRF Flood Advisory Cell Contacts

East Riding of Yorkshire Council		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]	[redacted]	[redacted]			[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]			[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]					[redacted]	[redacted]
Hull City Council		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]	[redacted]	[redacted]			[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]			[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]			[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]			[redacted]	[redacted]	[redacted]

North Lincolnshire Council		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]			[redacted]		[redacted]		[redacted]
[redacted]	[redacted]			[redacted]		[redacted]	[redacted]	[redacted]
[redacted]	[redacted]			[redacted]		[redacted]	[redacted]	[redacted]
[redacted]	[redacted]			[redacted]		[redacted]	[redacted]	[redacted]
[redacted]	[redacted]			[redacted]		[redacted]	[redacted]	[redacted]
North East Lincolnshire Council		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]				[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]				[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]				[redacted]	[redacted]		[redacted]
Environment Agency		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]		[redacted]	[redacted]			[redacted]		[redacted]
				[redacted]	[redacted]	[redacted]		
Anglian Water		Knowledge of area				Contact Details		

Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]				[redacted]	[redacted]	[redacted]		
[redacted]	[redacted]			[redacted]			[redacted]	[redacted]
Severn Trent Water		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]				[redacted]		[redacted]		[redacted]
Yorkshire Water		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email

[redacted]		[redacted]	[redacted]			[redacted]	[redacted]	[redacted]

Internal Drainage Boards

Aire, Don & Ouse Consortium – Dempster, Rawcliffe, Cowick & Snaith		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]	[redacted]				[redacted]	[redacted]	[redacted]
Shire Group of IDB's - Goole & Airmyn IDB		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]	[redacted]				[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]				[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]				[redacted]	[redacted]	
Lindsey Marsh Group		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]				[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]					[redacted]	[redacted]	
[redacted]	[redacted]					[redacted]	[redacted]	
[redacted]	[redacted]					[redacted]	[redacted]	
[redacted]	[redacted]					[redacted]	[redacted]	
[redacted]	[redacted]					[redacted]	[redacted]	
North East Lindsey Drainage Board		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]				[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Ouse & Humber IDB		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]	[redacted]	[redacted]				[redacted]	[redacted]
[redacted]	[redacted]	[redacted]				[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]				[redacted]	[redacted]	[redacted]
South Holderness IDB		Knowledge of area				Contact Details		

Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]	[redacted]				[redacted]	[redacted]	[redacted]
Thorntree IDB		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]						[redacted]	[redacted]	[redacted]
The Shire Group of IDB's - Ancholme IDB		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]	[redacted]		[redacted]		[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]		[redacted]	[redacted]	[redacted]
[redacted]	[redacted]			[redacted]		[redacted]	[redacted]	[redacted]
[redacted]	[redacted]			[redacted]		[redacted]	[redacted]	[redacted]
[redacted]	[redacted]			[redacted]		[redacted]	[redacted]	[redacted]
The Water Management Consortium – Isle of Axeholme WLB		Knowledge of area				Contact Details		

Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]					[redacted]	[redacted]	[redacted]
York Consortium of Drainage Boards – Beverley & North Holderness		Knowledge of area				Contact Details		
Name		ER	Hull	N Lincs	NE Lincs	Work	Mobile(s)	Email
[redacted]	[redacted]	[redacted]				[redacted]	[redacted]	[redacted]

Appendix A - Flood Advisory Cell Teleconference Codes

The teleconference codes will be confirmed and sent out via SMS message at the time of an incident

Primary Teleconference Number

Dial in Number: [redacted]
Chair PIN: [redacted]
Participant PIN: [redacted]

Back up Teleconference Number (also for use as South Bank FAC number if required)

Dial in Number: [redacted]
Host PIN: [redacted]
Participant PIN: [redacted]

Group Email Address

Sending an email to [redacted] will automatically be forwarded onto all members of the Flood Cell.

Email Address for TCG Chair

[redacted]

Contact Humber Emergency Planning Service to send an SMS message to all participants to convene a Flood Advisory Cell teleconference.

Appendix B – Flood Advisory Cell
STANDARD AGENDA

1. Roll Call of Attendees - Chair.

2. Forecasts/Information/Analysis

    a. Brief/Specific Requests from the TCG/SCG - Where available
    b. MET Office Forecast/Information/Analysis
    c. Environment Agency Forecast/Information/Analysis
        i. Yorkshire
        ii. Lincolnshire and Northamptonshire

    - Local Authority Forecast/Information/Analysis
        i. East Riding of Yorkshire Council
        ii. Hull City Council
        iii. North Lincolnshire Council
        iv. North East Lincolnshire Council

    - Water Company Forecast/Information/Analysis
        i. Yorkshire Water
        ii. Anglian Water
        iii. Severn Trent Water

    - Internal Drainage Board Forecast/Information/Analysis

    - Any other update

3. Summary of advice to be provided to TCG (including availability of maps and other briefing tools).

4. Agree how information will be provided.

5. Review of lead organisation/consider benefit of splitting to North Bank and South Bank meetings/date and time next meeting/teleconference.

Appendix C - Humber Flood Advisory Cell - Advisory note to the chair of the Tactical Co-ordination Group

This note was prepared at 0945 on Thursday, 29 October using information available at that time. The next advisory note will be issued at 0945 on Friday,30 October.

High level summary of key messages - highlight anything out of the ordinary, note critical infrastructure at risk, specific local risks (ie defence breach or failure potential), make recommendations to TCG. Give advice on evacuation, if appropriate, or suggest key messages to the public.

Best estimate (most likely) scenario

There is high/medium/low confidence in this scenario occurring.

Paragraph to summarise scenario, covering nature of risk and distinguishing key factors - is this water level or is it wind and waves?

Up to X Flood Alerts and Y Warnings could be issued in this scenario. This means that between X and X properties could receive a Flood Warning. Locations at risk include place/community/infrastructure site.

	Time of peak (GMT)	Height of peak (mAOD at Immingham)	Other factors (wind, wave, spray)
Tide 1	0600 on 30/02/16		
Tide 2			
Tide 3			

Reasonable Worst Case scenario

There is high/medium/low confidence in this scenario occurring.

Paragraph to summarise scenario, covering nature of risk and distinguishing key factors - is this water level or is it wind and waves?

Up to X Flood Alerts and X Warnings could be issued in this scenario. This means that between X and X properties could receive a Flood Warning. Locations at risk include place/community/infrastructure site.

	Time of peak (GMT)	Height of peak (mAOD at Immingham)	Other factors (wind, wave, spray)

Tide 1	0600 on 30/02/16		
Tide 2			
Tide 3			

Appendix D – Flood Preparation and Response – Triggers and Actions

Level 2 - Flood Preparation - Triggers and Actions

TRIGGERS FOR FLOOD PREPARATION

- Intelligence suggests that there is the potential for substantial flooding.
- Amber Flood Guidance Statement for river/surface water flooding.
- Amber MET Office Rainfall Alert.
- Reports of large numbers of property flooding.
- Multiple flood warnings affecting large numbers of properties issued, or likely to be issued.
- On advice from the Flood Advisory Service Teleconference.
- Problems have been identified with a reservoir or flood defence with potential to cause an emergency
- Credible reports in the media are focused on potential widespread flooding in the area

↓

ACTIONS TO CONSIDER FOR FLOOD PREPARATION

All organisations should:

- **Report** any observations of properties or infrastructure flooding to the relevant lead flood body
- **Contact** Humberside Police or Humber Emergency Planning Service to request a TCG meeting if one has not already been arranged.

All organisations consider:

- **Assess** the severity and decide whether an SCG is needed to manage the strategic response.
- **Manage staff** to deal with a potential incident. This may involve placing staff on standby, assessing availability for the next 3-5 days and briefing key operatives internally.
- **Prepare to implement** operational response plans.
- **Prepare to protect your critical assets**
- **Check your organisations control centre** is fully prepared to be opened if necessary
- **Prepare for potential media interest.** Consider issuing proactive press releases providing advice to the public on how to prepare for flooding.
- **Check your BCM plans** to ensure your organisation's critical business activities can still be met, if flooding were to occur.
- **Keep a watching brief** on the situation and up-to-date with the latest flood forecasts.

Strategic Flood Response - Triggers and Actions

TRIGGER FOR STRATEGIC RESPONSE

A Strategic Coordinating Group will be considered if any of the responding organisations are unable to prevent, reduce, control, or mitigate the declared emergency's effects without establishing strategic co-ordination to:

- establish a strategy to which the Tactical Coordinating Group(s) will work
- give support to the Tactical Coordinating Group(s) by the provision of resources,
- consider the prioritisation of requests from Tactical Coordinating Group(s) and others.

A Strategic Coordinating Group **should** always be considered by the Chair of the Tactical Coordinating Group if the declared emergency creates, or has the potential to create:

- a significant resources implication to the responding organisations
- a significant impact to the community
- a significant impact to the environment

↓

AIM FOR STRATEGIC CO-ORDINATION GROUP

The Aim for the SCG and some strategic considerations are shown in Appendix H and I of this document.

Appendix E -Managing Flood Risk - Who is Responsible?

The table below shows which organisations manage flood risk day-to-day; this is not to be confused with which organisations might lead during the response and recovery phases. Flooding is a complex hazard and so this table is only indicative. Different sources of flooding often happen together and impact one another.

Flood risk type / Organisation	Main rivers (large rivers)	Ordinary watercourses (small rivers)	Surface water	Ground water	Coastal Flooding	Sewer flooding	Road drainage	Canals and artificial waterways
Environment Agency	Y				Y			
Lead Local Flood Authorities		Y	Y	Y			Y (Non M or major roads)	
Internal Drainage Board		Y						
Highways Engand							Y (M Roads and major roads)	
Water and Sewerage Companies						Y		

Canal and Rivers Trust								Y
Riparian Owners		Y	Y	Y				

Appendix F - Properties Flooded Data

- During a widespread flood event the need for real time properties flooded data is key for reporting, allocating resources, evacuating communities, mobilising flood rescue efforts and planning recovery to name a few.
- Although collating properties flooded data is an operational and tactical responsibility, it features within this plan for two reasons. To ensure that across the area we have a consistent way to define and record property flooding. And to put in place a mechanism for sharing this information and reporting it centrally during a wide area flood event.
- As per the Flood and Water Management Act it is the responsibility of the LLFA to collate properties flooded information for their area. This will be done through the Recovery phase and support from the Environment Agency, Fire and Rescue Service, Police and other partners will be required to pull together this information during the response phase.
- When recording properties flooded it is important to capture:

1 **The address.**

2 **Flooding type:** fluvial (river), surface water, groundwater, tidal, reservoir, sewers, canals, highways drainage, etc.

3 **Flooding extent:**
- Internal
- Basement
- Garage (attached or not attached onto main building)
- Occupied caravans
- Park homes
- Gardens
- Driveways
- Outhouses and sheds

These can then be separated out into the following categories:

- **Internal property flooding:** water has entered the property. This includes basements and below ground level floors. Garages are included if attached onto the main building. Occupied caravan and park homes are also included.
- **External property flooding:** where water has entered gardens, driveways, outhouses, garages (that are separate from the main building) and sheds.

(National Flood Emergency Framework, DEFRA, 2015).

It is important to capture as much information as possible when recording and reporting properties flooded data.

Appendix G – Overview of the risk of flooding in the Humber area

An Overview of the Risk of Flooding in Hull

The City of Hull is low lying, with over 90% of its area lying below high tide level. Large parts of Hull are built upon reclaimed marshland and some areas (notably East Carr and Orchard Park) are below sea level. To the west of the City the outlying villages of Cottingham and Hessle are situated upon higher ground that drains eastwards into the City of Hull.

Due to its low elevation the drainage system of Hull is entirely pumped. Prior to 1949 it consisted of a large number of open drains that were largely gravity driven, with tidal gates at drain outlets that closed at high tides.

This prevented outflow from the drains into the Humber and led to problems with flooding. In the 1950's, 60's and 70's the drainage and sewerage system of Hull was comprehensively overhauled with a system of gravity fed trunk combined effluent and storm water sewers replacing nearly all of the surface drains.

These sewers were emptied by two large pumping stations at West Hull and East Hull. As a result, compared to other historical UK cities, Hull has a modern sewage and drainage infrastructure. This system is combined and was designed and consented to pump untreated sewage into the Humber at West and East Hull. From 1996 to 2001 Yorkshire Water developed and implemented the 'Humber Care' system that saw the construction of a 10.5 km trunk sewer running across the city from the West Hull pumping station, linking East Hull and on to a new sewage treatment works at Saltend. This is known as the Hull Tunnel. Gravity fed, flowing from west to east, under normal conditions this link allows Saltend to treat all of the city's effluent. Some pumping capacity is retained at West and East Hull for storm and emergency conditions.

East Hull pumping station is jointly operated by Yorkshire Water and the Environment Agency. Yorkshire Water pumps provide storm and emergency sewage pumping capacity, whilst the Environment Agency pumps provide fluvial pumping capacity for the Holderness Drain to discharge to the River Humber, if required. In the event that one party loses pumping capacity, the station is designed such that the other party can provide standby capacity, subject to operational needs. This would require a multi-agency decision between Yorkshire Water and the Environment Agency.

Bransholme has its own storm water drainage system. Constructed in the 1950's and later upgraded in 2016, a surface water pumping station discharges surface water directly into the River Hull, with the option to store water in a lagoon during high river flows. Sewage was treated at this site, but is now transferred to Saltend for treatment. Only water discharged from Bransholme is pumped into the River Hull. The pumping station includes fail safes, however in the event of asset failure and if storage lagoon capacity is likely to be exceeded, a multi-agency decision would need to be considered to utilise the spillway for relief.

Its low elevation and reliance upon pumped drainage place Hull in a unique position compared to other UK cities. Whilst all major UK conurbations can be liable to flooding caused by heavy rainfall, Hull is especially vulnerable, as it has limited natural methods of drainage. Its reliance on pumping increases its vulnerability to flood damage should the pumps malfunction or fail.

Furthermore, due to its low elevation Hull is also vulnerable to tidal flooding. Hull has significant and effective flood protection defences but these are designed to protect from flooding from the River Hull or from tidal flooding breaching estuary defences.

Combined Sewer Overflows provide consented storm relief to various watercourses to alleviate the risk of sewer flooding. The outfall pipes are generally fitted with flap valves, to prevent sea water entering and inundating the sewer network which if removed could present a residual flood risk.

There are a limited number of service reservoirs in Hull which are currently subject to the Reservoirs Act and the Flood & Water Management Act and would pose an inundation risk if breached.

An Overview of the Risk of Flooding in the East Riding of Yorkshire

The East Riding of Yorkshire is at a particular risk of flooding owing to the topography and geology of the area. The topography is dominated by the chalk Wolds ridge which runs in a sweep from Bridlington to Hessle. To the east, the chalk is overlaid with glacial clays of the Holderness Plain and to the west are the silts and peats built up by the flood plains of the river systems which feed into the Humber Estuary.

The land of Holderness and the Derwent valley is primarily reclaimed marsh dependent upon artificial drainage systems. The fact that it is reclaimed land, and therefore very low lying makes it particularly susceptible to flooding.

The drainage infrastructure that has been built requires maintenance, which in itself creates further challenges for organisations operating in the area. However without maintenance the drainage will not operate effectively, and if not, flooding will be experienced.

The hydrology of the East Riding is dependent on the capacity of the Wolds catchment to absorb rainfall. The underlying chalk acts as a significant ground water reservoir.The ground water levels fluctuate resulting in errant streams and springs. When saturated the runoff from the watershed rapidly inundates the flat heavy land to both the East and West. The East Riding is particularly vulnerable to rapid surface water flooding due to this.

There are several major rivers such as the Derwent and Hull which drain the Vales of York and Holderness to the Humber Estuary. There is a history of these rivers overtopping and despite major investment in flood defences, particularly along the Derwent, the risk remains high. There is a similar risk resulting from the numerous man made drainage channels such as Barmston, Burstwick and Holderness drains.

Much of the coastline of Holderness is low lying and relatively unprotected. It is subject to significant coastal erosion and risk of flooding from the sea. The area is at particular risk from East Coast tidal surges such as occurred in 1953 and 2013. Tidal surges and overtopping can also occur along the Humber Estuary. Some areas, such as Goole, are at a high risk, due to both the low lying land and from the Humber Estuary.

There are a limited number of service reservoirs in the East Riding of Yorkshire which are currently subject to the Reservoirs Act and the Flood & Water Management Act and would pose an inundation risk if breached.

An Overview of the Risk of Flooding in North East Lincolnshire

The following open watercourses have the potential to present a major risk of flooding to domestic property or industry.

- River Freshney
- Buck Beck
- New Cut Drain
- Goosepaddle drain
- Waithe Beck
- Laceby Beck

These watercourses accept surface water from public surface water sewers, land drains and highway drains. As a consequence, a full open watercourse may result in surcharged pipes and thus incapacitate parts of the surface water drainage system, resulting in flooded roads, gardens or even properties. In addition, the surface water systems were designed to cope with a specific rainfall event such as a 1 in 10 year storm (for example) when a rainfall event exceeds this, flooding may occur at various locations throughout the borough.

The foreshore of Grimsby, Cleethorpes and Humberston is situated near the mouth of the River Humber (where the estuary is 5km wide) 8km west of Spurn Point. This provides a sheltered location from the more severe wave action emanating from the North Sea.

However, a significant flood risk remains from high tidal events when combined with certain weather conditions along this coastal flood zone. Defences are in place such as the North Wall, North and Central promenades as well as dunes and embankments to the South of Cleethorpes and Humberston which are enhanced by rock filled gabions.

An Overview of the Risk of Flooding in North Lincolnshire

Within North Lincolnshire all areas are at some risk of flooding from any or all of the following: tidal, fluvial, pluvial and groundwater, as demonstrated by the events of June 2007.

Predominantly rural in nature the main drainage system is that of the River Ancholme and tributaries. In the upper reaches typical winter run-off is about 37% of rainfall. Through North Lincolnshire the rivers cross a flat clay covered valley in heavily embanked channels where the surrounding land is predominantly drained by pumping stations.

The river embankments are of earth and over the years several breach failures have occurred during high flows. This risk is increased during certain high tides when the water level in the Humber prevents gravity discharge through the sluices at South Ferriby.

To the east the land is underlain by limestone and typical winter run-off is about 20% of rainfall. In extreme conditions ground water levels can rise rapidly leading the

An Overview of the Risk of an East Coast Tidal Inundation

A major East Coast flood could be triggered by a Storm Surge event, where a vigorous cyclonic Atlantic depression tracks into the North Sea.

The combination of very strong winds (which push sea water into a temporary dome) and very low atmospheric pressure (which allows sea water to rise) create a surge. The surge can be amplified as it passes over shallow areas in the North Sea.

If such a surge occurs in combination with high spring tides then the scale and risk of flooding is increased. Spring tides (which are not related to the spring season) occur during full and new moons every month, causing high astronomical tides which are very predictable.

Extremely strong on-shore winds can cause large waves. These, combined with a large surge on top of high astronomical tides have the potential to cause overtopping (waves breaking over the top of defences and causing flooding as water is unable to escape) or overflowing (sea levels are higher than defence levels) of sea defences along the UK East Coast.

Either of these conditions might lead to breaches occurring. Subsequent high tides can cause additional impacts making repairs and recovery difficult. Once coastal flooding happens the removal of large volumes of flood water can be very difficult as many coastal areas are below normal sea level and will not drain by gravity.

Although several areas along the East Coast have cliffs, dunes and no man-made defences, those areas with defences consist of either earth embankments or concrete and rock embankments with floodwalls on top. Both types are inspected regularly by the Environment Agency. The defences provide varying standards of protection with urban areas generally having better protection than rural areas.

It is likely that an East Coast Surge will be accompanied by some or all of the following:

- High winds inland, which could disrupt evacuation arrangements and lead to the loss of power and communication.
- Increased river flows, which could disrupt access routes and shelter/holding area sites.
- Localised surface water flooding.

The extent of flooding following an East Coast storm surge event is therefore based on a number of factors, such as:

- The nature of the surge and the exact locations of overtopping.

- Whether over topping creates breaches, and the location and number of breaches.
- The extent of other types of flooding caused by the metrological conditions.

Appendix H - Specific SCG Considerations

ISSUE	CONSIDERATIONS
Infrastructure <u>National Infrastructure</u> This is defined as: “those facilities, systems, sites and networks necessary for the functioning of the country and the delivery of the essential services upon which daily life in the UK depends”. <u>Critical National Infrastructure</u> There are certain “critical” elements of national infrastructure that if lost would lead to severe economic or social consequences or to loss of life in the UK. These critical elements make up the critical national infrastructure (CNI).	• Identify which CNI has been impacted or is at risk. • Assess the direct and indirect impacts on: o Energy. o Food. o Water. o Waste. o Transportation. o Communications. o Emergency services capability. o Health care. o Financial services/Government. • Consider the scale and duration of loss. • Prioritise CNI sites. • Identify mitigation measures and alternative supplies. • Consider the knock-on consequences and how these will be managed. • Assess resource requirement and whether military aid is needed.
Evacuation and Shelter	

<table>
<tr><th>ISSUE</th><th>CONSIDERATIONS</th></tr>
<tr><td>Evacuation may not always be the safest option for those potentially at risk. At times it may be safer for residents to seek refuge in the upper storey of a building rather than run the risk of being overcome by flood water.

The decision to evacuate an affected area will be the responsibility of the Police.</td><td>• Evacuation arrangements are detailed in the Humber LRF Emergency Procedures Manual and will apply to evacuation due to flooding.
• Consider basement dwellings.
• Prioritise areas for evacuation.
• Assess impact on receiving areas.
• Provide guidance on funding for accommodation.
• Agree on the ground evacuation communications and circulate this operationally ie what to advise people upon a refusal to evacuate.
• Assess resource requirement and whether military aid is needed.
• Consider the need to re-provide displaced services ie local health care and social services.</td></tr>
<tr><td>Vulnerable People and Areas

Vulnerable people may be less able to help themselves in an emergency than self-reliant people. Those who are vulnerable will vary depending on the nature of the emergency.

In general, those with mobility or mental health difficulties and dependants that receive medical care in their own homes</td><td>• Identify vulnerable areas based upon building service eg schools, nursing homes, hospitals, prisons, basement dwellings etc.
• Consider:
o Issuing specific communications.
o Prioritising vulnerable areas.
o Mitigating the impact accordingly eg temporary defences, evacuation.
o Safety and ability to evacuate.</td></tr>
</table>

ISSUE	CONSIDERATIONS
or children may be especially vulnerable in a flood.	
Waste Removal Expect to see a major increase in the amount of waste that needs to be disposed of as a result of severe flooding. Normal waste collection and disposal arrangements will probably be disrupted.	• A strategy to manage increased waste removal, such as: o Contaminated and hazardous materials. o Sandbags. o Environmental eg dead animals. o Household waste (residential). o Building recovery eg flood damaged items. o Commercial businesses. • Communicate waste disposal advice to the public.
Sewerage Network Disruption Flood water ingress into the sewerage network may cause sewerage flooding. Therefore sewerage disposal might be disrupted during a flood event.	• Consider: o Other methods such as portaloos (950 portaloos were deployed during 2007 summer floods). o Minimise sewer flooding by tankering or pumping. o The need for evacuation. • Keep the community continually informed.
Health Advice	• Consider:

ISSUE	CONSIDERATIONS
Risks include: drowning, electrocution, carbon monoxide poisoning, physical trauma, chemical contamination, fire, infectious diseases from contaminated water etc.	o Health risks related to flooding (see health advice box opposite). o Remedial or mitigation solutions for contamination or pollution. o Long-term recovery needs including surveillance, screening and mental health wellbeing. • Brief: o General public on risks associated with flooding. o Responders on the ground around health and safety requirements.
Recovery A longer-term activity of rebuilding, restoring and rehabilitating the community.	• Consider the long-term recovery needs of communities affected by flooding.
Public Messages It is important public communications from all organisations are co-ordinated to ensure there is no contradicting information issued.	• Develop a media strategy. • Disseminate: o Take action messages. o Public advice. o Service updates. o Joined-up messaging between responding agencies through the SCG media cell.
Mutual Aid	

ISSUE	CONSIDERATIONS
Successful response to emergencies in the UK has demonstrated that joint working and support can resolve very difficult problems that fall across organisational boundaries.	• Assess mutual aid requirement for: o Evacuation. o Rest centres. o Protecting assets. o Inputting mitigation measures. o Managing major traffic disruption. o Dealing with injuries. o Flood rescue. o Managing the media.
Political and Government Liaison Incidents in Humber Area attract media attention.	 • Concise and timely information on scale and duration of impact. • Managing media and political scrutiny. • Cost recovery.

Appendix I - TCG Chair Resources

This section contains flooding specific considerations for the TCG Chair, a suggested TCG Flooding Agenda and Flooding Specific Aim and Objectives.

Tactical Coordinating Group

Standard Initial Flood Meeting Agenda

1. Introduction of Attendees, Role and Responsibilities - Chair.

2. Situation Report -

    a. MET Office Weather Update

    b. ENVIRONMENT AGENCY Update on Coastal/Fluvial Flooding

        - Yorkshire and North East Region
        - Anglian Region
        - Midlands Region

    c. LOCAL AUTHORITY - Update on Surface Water Flooding

        - East Riding of Yorkshire
        - Hull City Council
        - North East Lincolnshire Council
        - North Lincolnshire Council

    d. EMERGENCY SERVICES - Update on rescue/evacuation/pumping operations

        - Police
        - Fire
        - Ambulance

    e. Resources Available (temporary flood defences/pumps/sandbags etc)

    f. Any other updates

3. Agree aims and objectives - All.

4. Actions required to deliver objectives - All.

5. Warning and informing the public - Chair.

6. Mutual aid/military aid requirements.

7. Time of next and subsequent meetings.

Generic Flooding Aim and Objectives

Aim

To mitigate the impact of the flooding emergency.

Objectives

- Saving and protecting life and relieving suffering.
- Understanding the scale and extent of the flooding, and any potential future flooding.
- Pre-deploy/deploy resources to areas likely to be flooded/being flooded.
- Maintaining flood defences to limit the emergency.
- Protecting critical infrastructure.
- Providing the public with warnings, advice and information on how to protect themselves and their property from flooding.
- Maintaining a visible presence in flooded areas.
- Protecting the health and safety of personnel.
- Maintaining or restoring critical services.
- Safeguarding the environment.
- Protecting property.
- Providing the public with warnings, advice and information on how to restore their properties following flooding.
- Facilitating the physical, social, economic and psychological recovery of the community.
- Promoting and facilitating self-help in the community.
- Facilitating investigations and inquiries (eg by preserving the scene and effective records management).

TCG Chair Considerations

- Many of the flooding risks faced in the Humber area will result in a wide area emergency that involves all parts of the Humber area to some extent. This means that wide area command and control arrangements may need to be put into place.

- The primary impacts of flooding are likely to involve:

   i. Drowning of people, pets and livestock.
   ii. Flooding of large numbers of properties.
   iii. Evacuation and temporary/long term accommodation need (Local Authorities can provide emergency shelters, either through their own assets or by accessing community emergency plans).
   iv. Major damage to property, businesses and surrounding land.
   v. Closure or washing away of roads, bridges, railway lines.
   vi. Major pollution risk from chemical plants because of the concentration of such sites on the Humber/risk of explosion(s) if water inundates high temperature petro-chemical processes (there is contact information for all Upper Tier COMAH plans on Resilience Direct).
   vii. Loss of (and possible damage to) telephone, electricity, gas and water supplies.
   viii. Pollution/health risks from sewerage systems, chemical stores, fuel storage tanks.
   ix. Disruption of economic life and major costs of rebuilding infrastructure.
   x. Public need for information, advice, benefits/emergency payments.

- There are a number of different agencies that can usually provide hazard specific advice about flooding:

   1. The **Environment Agency** can usually provide flooding information for river, coastal and tidal flooding.
   2. The **Local Authorities** can usually provide flooding information for surface water flooding. They have surface water flooding maps that show “hot spot” areas.
   3. **Internal Drainage Boards** (can usually be accessed through the Local Authority or Environment Agency) can provide drainage and flood impact advice for their IDB area.
   4. **Water companies** (Yorkshire Water for Hull and East Yorkshire and Anglian Water and Severn Trent Water for North and North East Lincolnshire) will be able to provide valuable information for both types of flooding.

5. **The MET Office** can provide rainfall predictions.

- The TCG Chair can request a **Humber LRF Flood Advisory Cell** made up of the organisations listed above, who will then provide a single source of flooding advice to the TCG/SCG. Humber Emergency Planning Service can convene this teleconference.
- It will often be helpful to set TCG meetings around the times that forecasts become available from the EA and MET Office. This is usually around 11am and 2:30pm.
- There is a separate multi agency plan for East Coast Tidal Flooding and for Hensall Reservoir on Resilience Direct.
- There are known local critical infrastructure at risk of flooding. The **LRF critical infrastructure list**, which is available on Resilience Direct, shows their locations.
- Bridges will usually carry utilities. Loss of a bridge during a flooding emergency is therefore likely to result in wider consequences.
- Sandbags are usually in great demand during an emergency. The general Local Authority approach to sand bags is that they will be used first to protect critical infrastructure, then in support of vulnerable people, and then as determined by the dynamics of the emergency. They will not normally be issued on request to residents.
- Flooding presents significant health and safety risks from operating near to water, and from damage caused to buildings, bridges etc. It will be imperative for all responders to regularly review Health and Safety. It will also often be necessary to withdraw staff from at risk areas prior to high tide when responding to coastal flooding.
- Skywatch, the RAF and the Police may be able to provide real time aerial information on the locations affected. Local Authorities and the Fire and Rescue Service may be able to provide access to aerial photography (drones) but these can only operate in relatively settled whether.
- Community Emergency Plans - Many of the Town and Parish Councils in the Humber area have a community emergency plan and are able to mobilise a community emergency team that may be able to :
    - Provide access to local buildings such as village halls for use as emergency shelters or for emergency service

- Provide local knowledge and advice – for example on flooding or location of vulnerable people
- Mobile local volunteers to help with the response

There are flood sirens in Grimsby and Cleethorpes that will be sounded by the Environment Agency when a Severe Flood Warning is issued. The Grimsby and Cleethorpes Flood Warning Sirens comprise a network of 18 siren units, located at sites to provide optimum coverage of domestic residential properties within the tidal flood risk area. All 18 sirens are intended to be used together to warn of significant tidal flooding. In addition one siren (No. 1 - The Willows) is located within a fluvial risk area and should be used to warn residents at risk from the New Cut Drain in The Willows and Wybers Wood estate areas of Grimsby.

Appendix B

Underpass Flood Detection Technology Options Report

B1

Highways England

A63 Castle Street Improvements, Hull
Underpass Flood Detection Technology Options

Report Ref: HA514508-ARP-XX-XX-RP-YI-00004
P01 | 15 December 2017

Document Verification

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			Prepared by	Checked by	Approved by
		Name	Tim Morris	Wayne McNulty	
		Signature	[redacted]		

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Contents

1.0 Introduction

The A63 Castle Street Improvements scheme involves grade-separation of the currently at-grade Mytongate junction of the A63 with Ferensway. The grade separation of the junction will feature east and westbound entry and exit slip roads, enabling all movements. The scheme also features the provision of a number of pedestrian footbridges which will replace at-grade pedestrian crossing points along the A63 Castle Street.

1.1 Purpose of the Document

This consultation document has been prepared to inform Highways England, and other project stakeholders, of the possible options of providing a technology solution to give early warning of flooding of the proposed underpass.

Due to concerns raised by the Environment Agency about the potential risk of the underpass flooding, an emergency response system is being considered so that the underpass can be closed and traffic redirected in the event of a closure.

1.2 Scheme Description

The A63 Castle Street comprises approximately 1.5km of dual carriageway which runs through the centre of Hull. The current layout is dual-2 lane all-purpose trunk road with no hard shoulder which runs in an east-west direction to the south of Hull city centre, from Rawlings Way Junction to Market Place. The route is an important link between the M62, Humber Bridge and Port of Hull. The current speed limit is 40mph.

As the primary access to the Port of Hull on the strategic road network, Castle Street handles large volumes of traffic, and congestion is exacerbated by two at-grade junctions at Mytongate and Market Place. Difficulties with the current A63 Castle Street route through Hull city centre is characterised in two ways: it acts as a substantial barrier, creating severance between the city centre to the north and the area targeted by Hull City Council (HCC) for development and regeneration to the marina and market area on the south side of the A63. Secondly, sited through the middle of Hull city, capacity problems and signalised junctions severely hinder free flowing traffic.

The proposed scheme includes the following highways interventions:

- Lowering the level of the road into a cutting by approximately 7 metres at Mytongate Junction
- Raising Ferensway and Commercial Road by approximately 1 metre creating a grade-separated junction
- Widening the eastbound carriageway to three lanes between Princes Dock Street and Market Place, with the nearside lane being marked for local weaving traffic
- Provision of bridges for pedestrians, cyclists and disabled users at Porter Street
- Provision of an enhanced / iconic crossing structure for pedestrians, cyclists and disabled users in front of Princes Quay
- Upgrading an existing route that runs underneath the A63 at Market Place to allow people to cross underneath the A63
- Restricting access to the A63 by closing some junctions and restricting movements on some side roads to improve safety

The scheme objectives are as follows:

- Improve access to the Port of Hull
- Reduce congestion
- Improve safety
- Reduce severance between the city centre and the waterfront area

1.3 Background to Underpass Flood Detection System

Following initial discussion with stakeholders during preliminary design for the scheme, several options were considered, including the deployment of physical barriers to close the underpass. The outcome of discussions was a consensus that, assuming marked police vehicles could be used to close the A63 in the event of flooding, there would be no need for physical barriers to be installed.

The option to deploy Fixed Text Message Signs, that could be rotated to display 3 different messages to advise of closures, was also considered, however as an alternative the suggestion to install reduced size MS4 type message signs was thought a more practical solution. MS4s would offer greater flexibility in terms of the tactical and strategic information that could be displayed to road users, as well as providing more effective visibility of information pertaining to closures.

Hull City Council have existing VMS installed in and around the city centre cordon, and the opportunity exists to explore the potential for any signs deployed as part of the A63 Castle Street scheme to interface with existing VMS signs in Hull, to provide a more integrated traffic management capability across the local and strategic road networks. Further information of the location of existing VMS has been requested from Hull CC.

The option of installing sensors to detect rising water levels in the underpass was also discussed. The possibility of connecting the alarm from the proposed wet well pump system in the underpass to the NERCC, to provide automated flooding alerts, was the preferred method of achieving flood detection, and was deemed to warrant further investigation.

Hull CC currently control traffic management on Castle street under SCOOT UTC operation. As part of the scheme two mainline pedestrian crossings will be removed early in construction, and replaced with footbridges. The removal of these crossings, and the introduction of the signalised Mytongate junction, will necessitate a re-evaluation of SCOOT timings for the nodes on the Castle Street link.

Taking these needs in to consideration as the basis for the core technology requirements for the scheme, this report sets out to establish options and recommendations for the provision and operation of an underpass flood detection system, for further consideration by the client and scheme stakeholders.

2.0 Technology Requirements

In addition to options for a flood detection system, the following elements have been identified as required from the preliminary technology design:

- Provision of CCTV to provide full visibility of the Mytongate junction and underpass, and the Myton Swing Bridge. Operators at the NERCC would have primary control of the cameras, with Hull CC having visibility and the potential for lower-level control via the HECCTV system.

- Full traffic signal design and installation for control of Mytongate junction, connected in to Hull's UTC system. The proposed control method needs to be established with Hull CC and HE, to ensure the design is fit for purpose.

- Procurement of communications links for CCTV and signal installations to connect to the relevant control centre, and provision of a communications link to connect flood detection sensors in to the local communications network, and in to the RCC meteorological sub-system.

- Installation of loop based traffic counting sites to monitor flows and speeds on Castle Street.

2.1 Technology Options

The suggested technology solutions are divided in to the two options shown in the table below. The options are presented for further consideration, and individual elements can be adopted to provide the required level of control and safety within budget availability.

Option 1	Option 2
Above lane mounted LED signals at the underpass entrance to indicate lane status and show underpass as closed.	As per option 1, with the addition of: 5 reduced size MS4 VMS, linked to the NERCC and positioned on the A63 in advance of the agreed Emergency Diversion Routes. This offers the ability to manage traffic coordination on the wider local road network in the event of a closure of the A63 Castle Street, and enables potential coordination with Hull's local VMS strategies.
2 reduced size MS4 message signs, one on each approach located upstream of the diverge nosing, with the capability to display text messages and pictograms to advise road users of flooding and redirect them across the Mytongate overpass. The signs will be linked to the NERCC COBS message sign sub-system, giving RCC operators full control and visibility of messages.	A tunnel management subsystem, to include incident detection, to enable conditions in the underpass to be monitored. This could be connected in to the COBS in the NERCC, allowing pre-defined messages and management strategies to be set using the Operator Interfaces.
	*Explore the potential to interface outputs from the tunnel management subsystem with message updates sent using the Traffic Message Channel, so road users receive in-vehicle safety and closure information in advance of entering Castle Street. This would enable sat navs to redirect vehicles to by-pass Castle Street. (A review of previous work done by HE in this area would be required to determine if this could be within feasible scope for the project).
Two CCTV camera on masts within the junction to monitor traffic flow and conditions, giving full visibility of the underpass with no blind spots. The cameras would be connected to the NERCC and/or Hull City Council Control Room. CCTV would also be provided to give full visibility of the junction, so signal timings could be adjusted remotely to accommodate additional traffic diverted from the mainline A63 if necessary.	
An alarm output from the pumping station within the underpass, indicating pump failure and a high-water level warning, could be connected to the NERCC meteorological subsystem, where it could be configured to correspond to ascending alert levels.	Dedicated precipitation and water level sensors installed in the underpass and linked to a controller for transmission of water level data to the NERCC, where it can be used to monitor conditions and automatically set alarms accordingly.

2.2 Options Assessment

Option 1

As a minimum level of intervention, to alert maintainers and network operators to rising water levels in the underpass, the proposed wet well pump alarm output could be transmitted to the NERCC, via a 2mbps data link, to interface with the existing meteorological sub-system and provide ascending alerts that can be displayed on

Control Room Operator Interfaces, notifying them to monitor CCTV cameras on site.

If desired, an increased level of automation could be introduced in to this system, so that alerts from the meteorological sub-system are programmed to trigger auto positioning of CCTV cameras to monitor the underpass as a priority. It is understood that this functionality already exists in the RCC Met/CCTV systems.

If provided, message signs could also be automatically set to display messages appropriate to the level of response required, depending on the severity of the water level alert being transmitted at a particular time. When not being used to advise of flooding in the underpass, the signs could be utilised to display traffic information for the A63 and the Hull area more widely, interfacing with Hull's existing VMS network.

CCTV would be designed to provide full visibility of the underpass, the Mytongate junction, and the Myton Swing Bridge, so that operators have a holistic view of the A63 scheme area.

Option 2

To provide a more enhanced network management solution, up to a further 5 reduced size MS4s could be installed at key diversion trigger points on the highway network in Hull. Provisional locations for these signs were identified during preliminary design, and can be further discussed and analysed in the next design stage.

In addition, a more comprehensive tunnel management sub-system could be integrated in to the underpass, to provide more accurate information of precipitation and rising water levels, enabling a more staged response to be provided depending on the current conditions. This would give the option of automatically implementing strategies to control traffic and set message signs, relative to rising and falling water levels in the underpass. Whilst this would provide a more dynamic system for traffic management, the cost of installing suitable sensors is likely to be high in comparison to configuring alerts from the alarm in the wet well pumping station.

3.0 Technical Considerations

Communications Infrastructure

There is no existing NRTS ducted infrastructure serving the A63 Castle Street site, and any technology deployed as part of the scheme will require connecting to the NERCC using either existing third party or new, dedicated services, or a combination of the two.

The nearest NRTS Transmission Station to the scheme is located near J35 of the M2, west of Hull. The option of providing a cabled or wireless link to the TS, where it can be connected in to the NRTS network, should be assessed in terms of feasibility and cost.

Hull is relatively unique in terms of telecoms infrastructure, in that large parts of the communications network is owned and operated by KCOM, a private telecommunications and IT provider. Whilst BT do operate plant in the area currently, they are proposing to install new ducted fibre plant to complement the highway alignment changes imposed by the scheme. It may be possible to use the BT network to provide SC7 managed connections to the NERCC for CCTV, VMS and Flood Detection equipment, depending on local access.

Hull's Urban Traffic Control centre is understood to be connected to on-street traffic signal infrastructure via KCOM's network. It may be possible to procure circuits on the KCOM network locally, to connect technology equipment in to the regional network operated by BT, for connection in to the RCC.

Further investigation and understanding of the existing and proposed telecoms infrastructure, the possible connectivity options, and potential costs for connection to the NERCC should be undertaken, to enable a full comparison to be made.

The latency between activation of the flood alarm and the closure of the underpass needs to be considered. Any intention to close the underpass would merit further traffic modelling to determine the implications of the increased traffic flows through Mytongate junction.

Signal Phasing and Timing

Signal phasing and timing for control of Mytongate junction will require re-calibrating to ensure efficient throughput during periods when the underpass is closed and when diversionary routes are active. This will require close coordination with Hull's UTC team.

4.0 Recommendations

To provide an appropriate level of detection, and enable a timely and effective response to flooding in the underpass, it is recommended that, as a minimum, the option to connect the proposed wet well pump alarm to a telemetry system that can provide an input to the Meteorological sub-system in the NERCC. This would enable a 3-stage output to be configured, to reflect rising water levels in the underpass, and alert Control Room Operators to monitor the situation. To support the ability to be able to close the underpass in an emergency, it is recommended that a minimum of 2 MS4 type Variable Message Signs are installed on the east and west approaches to the underpass. These can then be used to manually or automatically set messages advising of current conditions, indicating closure of the underpass when required, and providing diversionary information.

In terms of next steps, it is recommended that a full review of costs is undertaken, to enable a comparison of the potential communications and installation options, as well as an assessment of the viability of connecting on site equipment to the NERCC. This exercise should include full stakeholder engagement, to identify any efficiencies or enhanced network

Confirmation was received from James Leeming (HE Senior Project Manager) on 28/03/2018 that option 1 would be the preferred choice in terms of technology deployment. The design will be progressed based on this assumption, and confirmed during consultation at the next stage.

management opportunities that could be achieved through greater coordination with Hull City Council’s existing and proposed traffic management strategies.

Appendix C

Hull Variable Message Signs and Emergency Diversion Routes

C1

NOTES:

- MAIN DIVERSION ROUTE
- LINK FROM JUNCTION TO MAIN DIVERSION ROUTE
- CLOSED ROAD SECTION
- LOCAL HIGHWAY AUTHORITY BOUNDARY
- 5 LOCATION OF DIVERSION TRIGGER SIGNS

REV.	DATE	AMENDMENT DETAILS	ORIG	CHK'D	ENG	CAT II	APP'D

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HIGHWAYS AGENCY

PROJECT
A63 CASTLE STREET IMPROVEMENTS

TITLE
VMS FOR EMERGENCY DIVERSION ROUTE EAST

STATUS
FOR INFORMATION

DRAWN	CHECKED	APPROVED
SB	-	-
DATE 18/03/2013	DATE -	DATE -
DRAWING SCALE N.T.S		ORIGINAL DRAWING SIZE 841 x 594 - A1
DRAWING No 112630-06-150-SK-001		REV. P1

NOTES:

- MAIN DIVERSION ROUTE
- LINK FROM JUNCTION TO MAIN DIVERSION ROUTE
- CLOSED ROAD SECTION
- LOCAL HIGHWAY AUTHORITY BOUNDARY
- 5 LOCATION OF DIVERSION TRIGGER SIGNS

REV.	DATE	AMENDMENT DETAILS	ORIG	CHK'D	ENG	CAT II	APP'D

Mott MacDonald Grontmij
Grove House
Mansion Gate Drive
Leeds
LS7 4DN
Tel : +44 (0)113 262 0000
Fax: +44 (0)113 262 0737
www.grontmij.co.uk

CLIENT
HIGHWAYS AGENCY

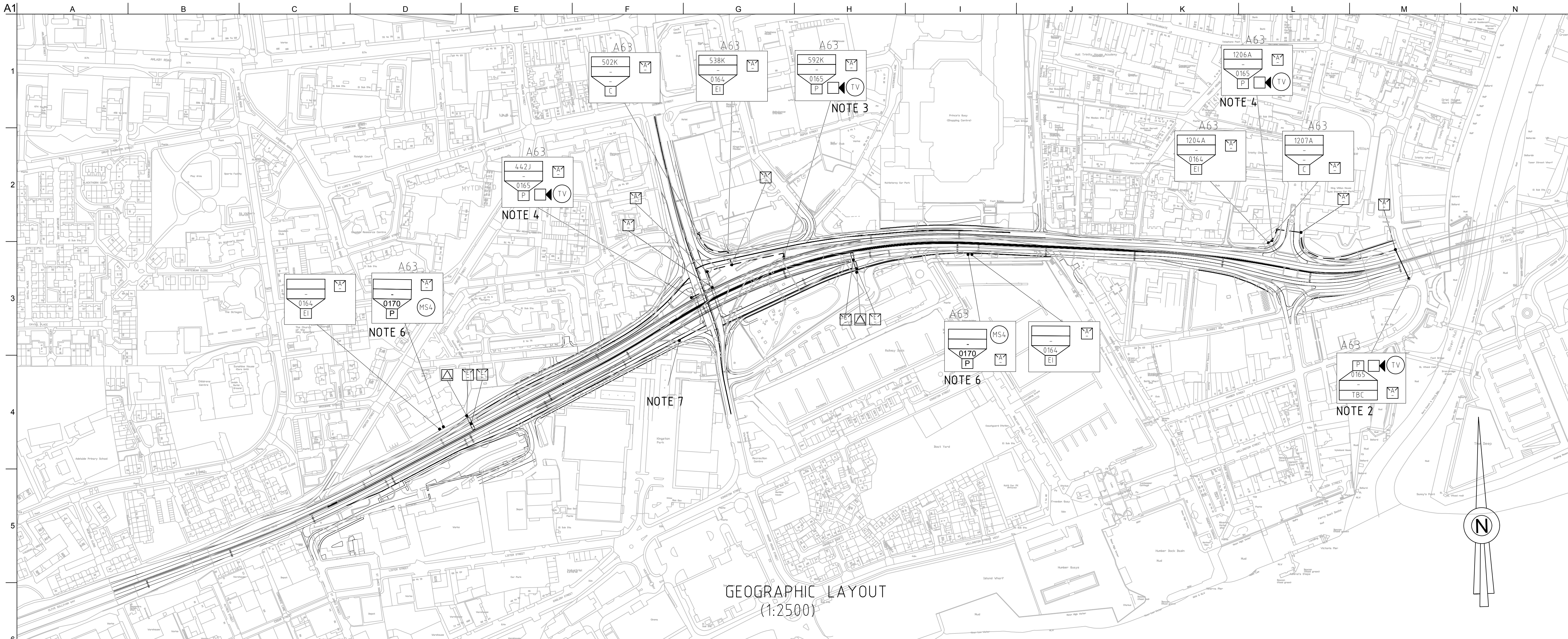
PROJECT
A63 CASTLE STREET IMPROVEMENTS

TITLE
VMS FOR EMERGENCY DIVERSION ROUTE WEST

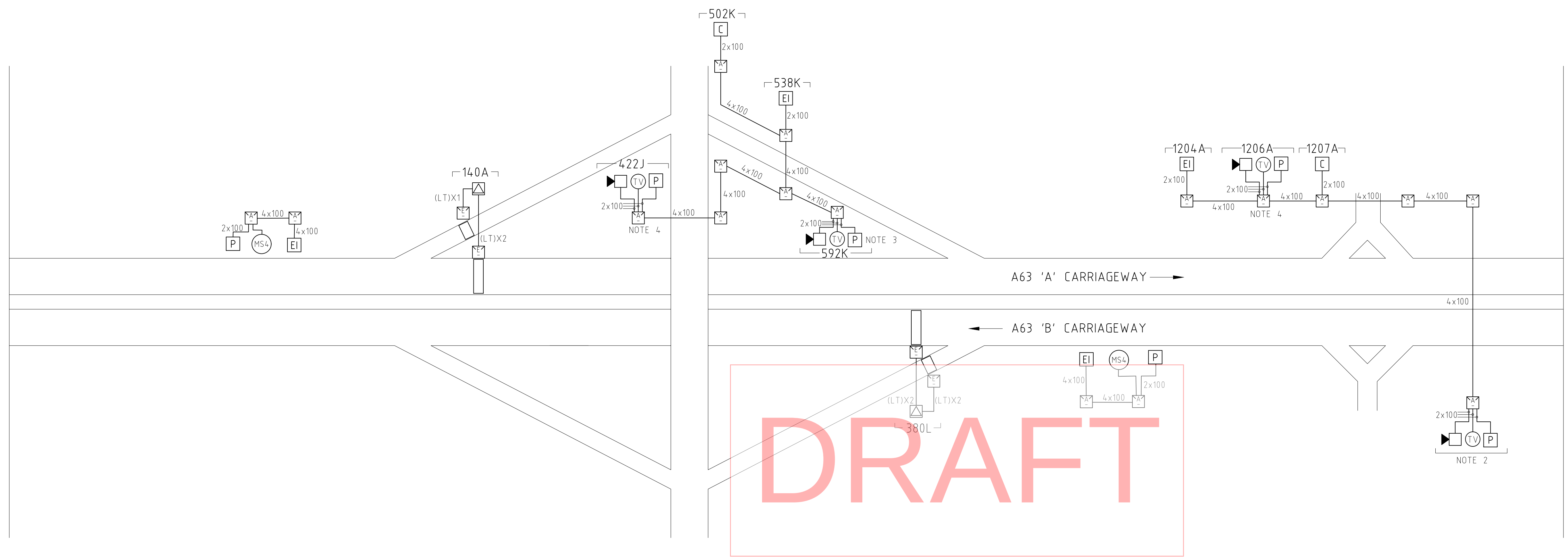
STATUS
FOR INFORMATION

DRAWN	CHECKED	APPROVED
SB	-	-
DATE 18/03/2013	DATE -	DATE -
DRAWING SCALE N.T.S.		ORIGINAL DRAWING SIZE 841 x 594 - A1
DRAWING No 112630-06-150-SK-002		REV. P1

F:\U2013\proj\112630 A63 Castle Street\06 Highways\150 Technology\112630-06-150-SK-001-002 EDR Proposals.dwg [AutoCAD Location]



GEOGRAPHIC LAYOUT
(1:2500)



SCHEMATIC
NOT TO SCALE

LEGEND

CABINET 609 VARIANT IN GEOGRAPHIC LAYOUT ONLY

- MARKER POST LOCATION
- OFFSET FROM KERB IN METRES
- MCX DRAWING NUMBER
- VARIANT
- CABINET LOCATION

CABINET 609 VARIANT IN SCHEMATIC LAYOUT ONLY

- EI — CABINET 609 (USED AS ELECTRICITY BOARD INTERFACE CABINET)
- P — CABINET 609 (USED AS POWER SUPPLIES OTHER THAN AS INTERFACE)
- C — CABINET 609 (USED FOR COMMUNICATIONS EQUIPMENT)

CABINET 600 IN GEOGRAPHIC AND SCHEMATIC LAYOUT

- TV — CABINET 600 (USED FOR CCTV)

MISCELLANEOUS SYMBOLS IN GEOGRAPHIC/SCHEMATIC LAYOUT

- TYPE 'A' CHAMBER
- TYPE 'E' CHAMBER
- CCTV CAMERA
- LOOP SITE
- TCC TRAFFIC MONITORING LOOP EQUIPMENT
- MS4 - Variable Message Sign

NOTES

1. COMMUNICATIONS CONNECTIONS YET TO BE DEFINED.
2. CCTV COVERAGE AT HIGH STREET UNDERPASS AND MARKETPLACE TO BE DETERMINED.
3. CCTV TO BE CANTILEVER MOUNTED ON TOP OF RETAINING WALL. THE CANTILEVER HEIGHT IS YET TO BE DEFINED.
4. PTZ CCTV MOUNTED ATOP 15M MAST.
5. TME TRAFFIC DETECTOR LOOPS, BESPOKE SET-UP TO BE CONFIRMED BY NIS. EXACT LOCATIONS TO BE CONFIRMED WITH NTIS.
6. MS4 VMS: TYPE, POWER SOURCE AND LOCATION TBC.
7. UNDERPASS FLOOD DETECTION SYSTEM SPECIFICATION TO BE AGREED WITH CLIENT.

Rev	Date	By	Chkd	Appd
P01.3	16/05/18	TM		
P01.2	07/01/15	MM	WMc	WMc
P01.1	---	---	---	---
Issue 2				

ARUP

Balfour Beatty Civil Engineering

Admiral House, Rose Wharf
78 East Street, Leeds, LS9 8EE
Tel +44(0)113 242 8498 Fax +44(0)113 242 8573
www.arup.com

Client
HIGHWAYS AGENCY

Project Title
A63 Castle Street

Drawing Title
A63 Technology - Geographic and

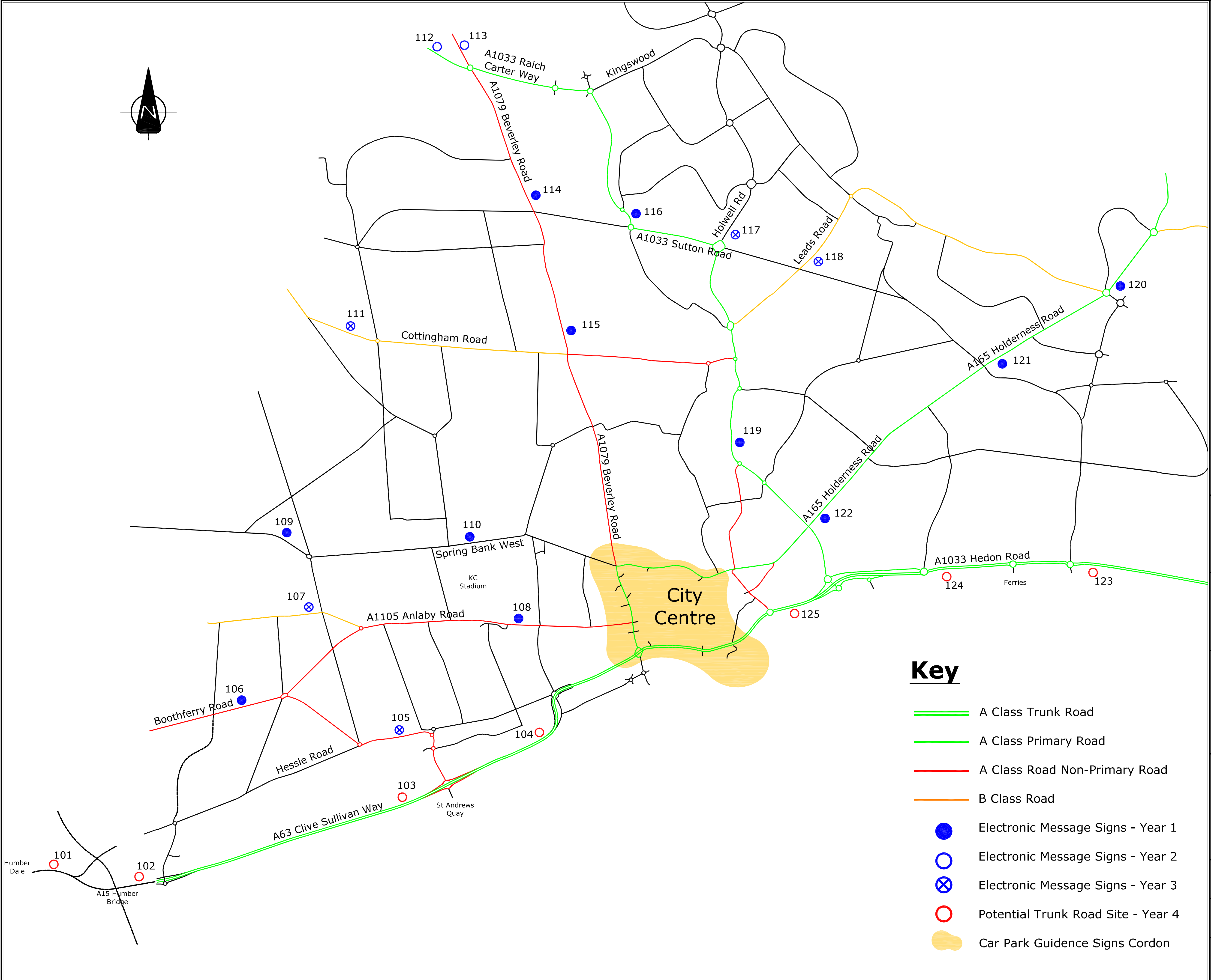
Scale at A1: NTS
Role: Specialist Designer - Telecommun
Suitability: S0 - Initial non-contractual

Arup Job No: 237912-00
Rev: P01.1

Name
514508-ARP-XX-XX-DR-YI-01506

Do not scale

pw:\\MCCNTS04.global.arup.com:PW_ARUP_UK\Documents\A63 Castle Street\01 Arup\YI\DR\514508-ARP-XX-XX-DR-YI-01506



A4

Client

Hull City Council
Traffic Services

Scheme

Hull Variable Message Signs

Title

EMS Locations Overview

local transport projects

Traffic Engineering and Transport Planning

Units 10-11
East Riding Business Centre
Annie Reed Road
Beverley
East Yorkshire
HU17 0LF

Tel: (01482) 679911
Fax: (01482) 880442
Web: www.local-transport-projects.co.uk

Date	Scale
25/4/07	NTS

Drawn	Checked	Approved
AM	CW	TK

Drawing No.

Version 8

Appendix D

Flooding Maps

D1

Flooding Maps were taken from the Humber Tidal Impact Maps, Edition 1.0 (20.03.14).

Only the maps showing the scheme have been included in this appendix.

For more detailed flood maps, please refer to the Appendix 11.2 Flood Risk Assessment in the A63 Castle Street Improvements, Hull Environmental Statement (Ref: 1168-10-215-RE-001-PD3)

Humber Tidal Impact Maps

Edition 1.0 (20.03.14)

Flood Resilience Team Leader

Coverdale House

Clifton Moor

York YO30 4GZ

Tel: 01904 822579

Fax: 01904 693480

Humber Tidal Impact Maps

Introduction

The Humber Tidal Impact Maps have been produced to show the areas which may be effected by an East Coast Tidal Surge event.

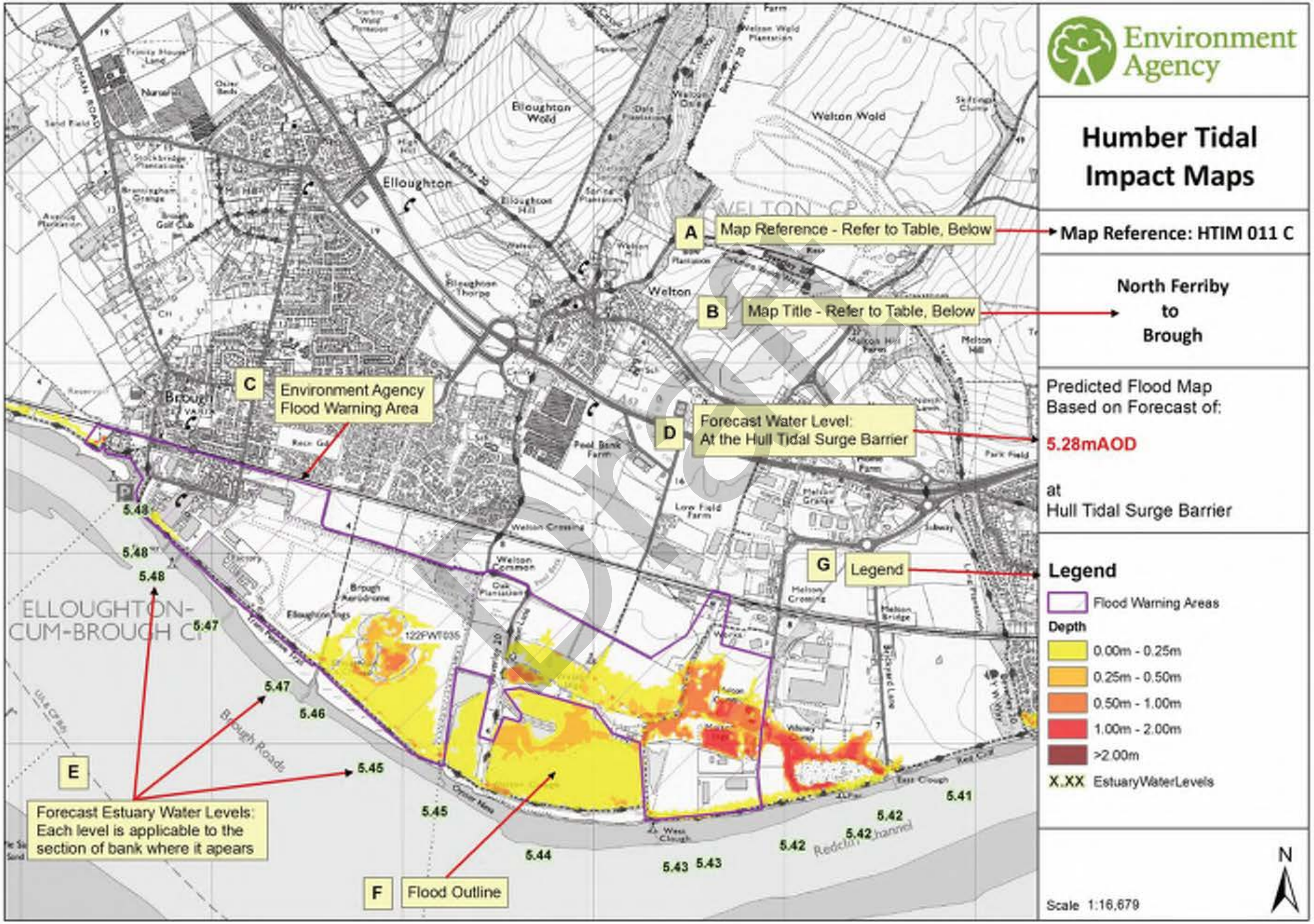
The maps show the extent of flooding that we would expect to see for various forecast sea levels in the Humber Estuary.
The maps also show the predicted depths of the flood water, and the forecast water levels in the Humber Estuary.

Using the maps

The tables at the end of this document provide a lookup for the user to know which map reference number to use for a given forecast level at the Hull Tidal Surge Barrier (HTSB), and for the geographic area in question. For example, to assess the impacts of potential flooding at North Ferriby (for a forecast level of 5.28mAOD at the HTSB) map no. "**HTIM 011 C**" would be required. See example, below.

The maps contain the following information:

A. The Map Reference Number – to be used with the tables provided at the end of this document.
B. The Map Title – to be used with the tables provided at the end of this document.
C. The Flood Warning Areas – as issued by the environment agency. These warnings are 'triggered' by certain forecast water levels, ad are issued if flooding is expected.
D. The Forecast Water Level at the HTSB – this level is the most commonly forecast water level, and provides an anchor point for the rest of the Estuary Water Levels given on the map (see 'E', below)
E. The Estuary Water Levels – this gives the expected water level at a given geographical point on the map, and relates back to the forecast water level at the HTSB: *water levels in a river or estuary 'slope' downward from upstream to downstream, known as the 'Long Profile'. Therefore if a level is quoted at the HTSB of 5.0m, we would expect the water level to be slightly higher than this upstream of the HTSB (IE closer to Goole), and slightly lower than this downstream of the HTSB (IE closer to Spurn Point). This causes the Estuary Water Levels shown in green on the map to increase slightly toward the left hand side of the page, though they always correlate directly with the forecast given for the HTSB.*
F. The Flood Outline – shows the expected area of inundation from flood water, based on the Estuary Water Levels.
G. The Legend – used to assess how deep the flood water shown in the Flood Outline will be.



Prepared by: Jonathan Boyes – Regional Modelling, Forecasting & Hydrology Group

Humber Tidal Impact Map Index

Forecast Water Level at Hull Tidal Surge Barrier = **5.14mAOD**

Forecast Water Level at Hull Barrier	Map Reference	Location
5.14mAOD	HTIM 001 A	Kilnsea to Skeffling
5.14mAOD	HTIM 002 A	Skeffling to Patrington Channel
5.14mAOD	HTIM 003 A	Sunk Island
5.14mAOD	HTIM 004 A	Keyingham Drain to Paull Holme Sands
5.14mAOD	HTIM 005 A	Paull Village
5.14mAOD	HTIM 006 A	Salt End Jetties to Alexandra Dock
5.14mAOD	HTIM 007 A	Victoria Dock Village to Hull Tidal Surge Barrier
5.14mAOD	HTIM 008 A	Albert Dock to St. Andrews Quay
5.14mAOD	HTIM 009 A	St. Andrews Quay to Hessle
5.14mAOD	HTIM 010 A	Hessle to North Ferriby
5.14mAOD	HTIM 011 A	North Ferriby to Brough
5.14mAOD	HTIM 012 A	Brough to Blacktoft

Forecast Water Level at Hull Tidal Surge Barrier = **5.18mAOD**

Forecast Water Level at Hull Barrier	Map Reference	Location
5.18mAOD	HTIM 001 B	Kilnsea to Skeffling
5.18mAOD	HTIM 002 B	Skeffling to Patrington Channel
5.18mAOD	HTIM 003 B	Sunk Island
5.18mAOD	HTIM 004 B	Keyingham Drain to Paull Holme Sands
5.18mAOD	HTIM 005 B	Paull Village
5.18mAOD	HTIM 006 B	Salt End Jetties to Alexandra Dock
5.18mAOD	HTIM 007 B	Victoria Dock Village to Hull Tidal Surge Barrier
5.18mAOD	HTIM 008 B	Albert Dock to St. Andrews Quay
5.18mAOD	HTIM 009 B	St. Andrews Quay to Hessle
5.18mAOD	HTIM 010 B	Hessle to North Ferriby
5.18mAOD	HTIM 011 B	North Ferriby to Brough
5.18mAOD	HTIM 012 B	Brough to Blacktoft

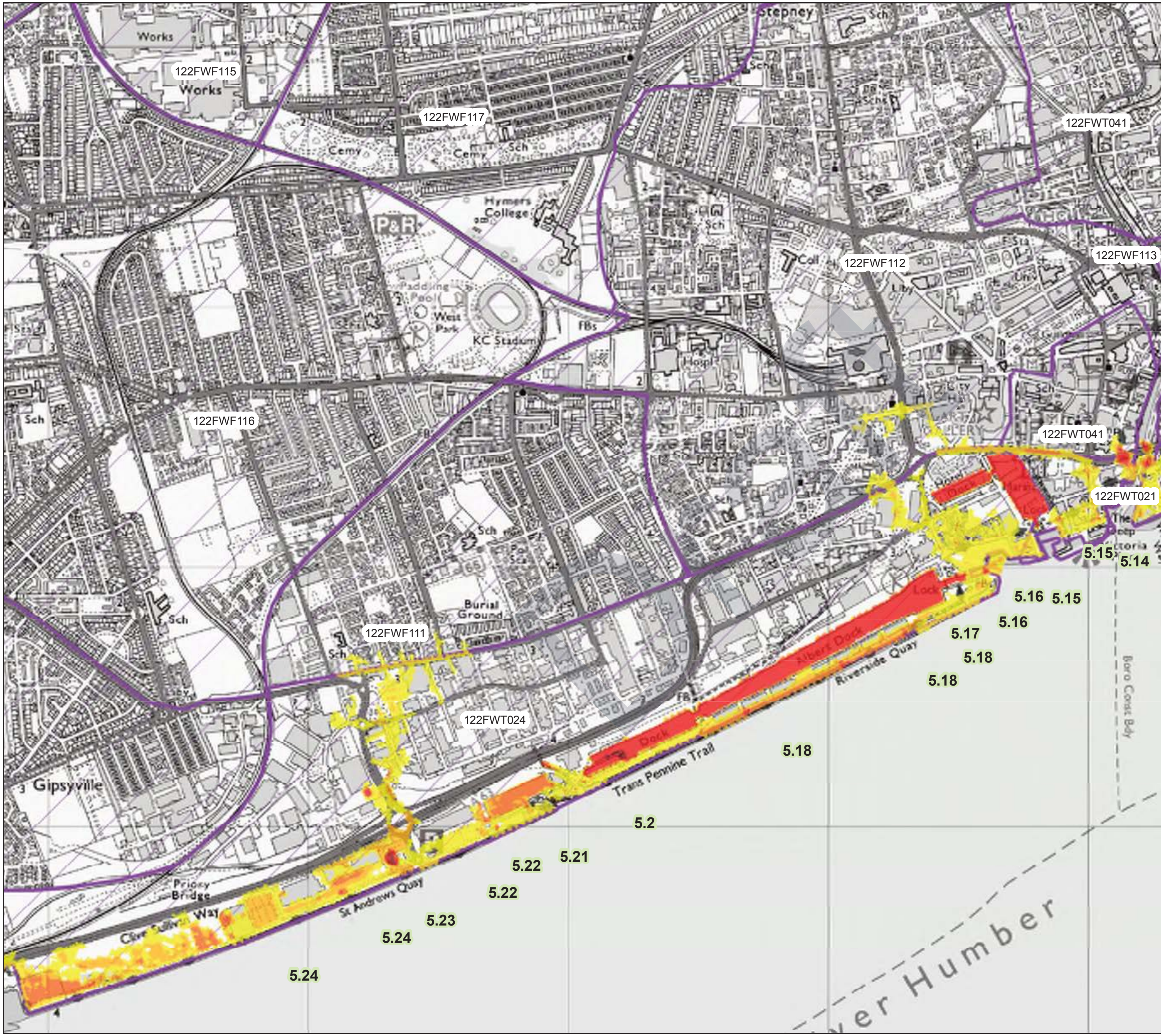
Humber Tidal Impact Maps

Forecast Water Level at Hull Tidal Surge Barrier = **5.28mAOD**

Forecast Water Level at Hull Barrier	Map Reference	Location
5.28mAOD	HTIM 001 C	Kilnsea to Skeffling
5.28mAOD	HTIM 002 C	Skeffling to Patrington Channel
5.28mAOD	HTIM 003 C	Sunk Island
5.28mAOD	HTIM 004 C	Keyingham Drain to Paull Holme Sands
5.28mAOD	HTIM 005 C	Paull Village
5.28mAOD	HTIM 006 C	Salt End Jetties to Alexandra Dock
5.28mAOD	HTIM 007 C	Victoria Dock Village to Hull Tidal Surge Barrier
5.28mAOD	HTIM 008 C	Albert Dock to St. Andrews Quay
5.28mAOD	HTIM 009 C	St. Andrews Quay to Hessle
5.28mAOD	HTIM 010 C	Hessle to North Ferriby
5.28mAOD	HTIM 011 C	North Ferriby to Brough
5.28mAOD	HTIM 012 C	Brough to Blacktoft

Forecast Water Level at Hull Tidal Surge Barrier = **5.44mAOD**

Forecast Water Level at Hull Barrier	Map Reference	Location
5.44mAOD	HTIM 001 D	Kilnsea to Skeffling
5.44mAOD	HTIM 002 D	Skeffling to Patrington Channel
5.44mAOD	HTIM 003 D	Sunk Island
5.44mAOD	HTIM 004 D	Keyingham Drain to Paull Holme Sands
5.44mAOD	HTIM 005 D	Paull Village
5.44mAOD	HTIM 006 D	Salt End Jetties to Alexandra Dock
5.44mAOD	HTIM 007 D	Victoria Dock Village to Hull Tidal Surge Barrier
5.44mAOD	HTIM 008 D	Albert Dock to St. Andrews Quay
5.44mAOD	HTIM 009 D	St. Andrews Quay to Hessle
5.44mAOD	HTIM 010 D	Hessle to North Ferriby
5.44mAOD	HTIM 011 D	North Ferriby to Brough
5.44mAOD	HTIM 012 D	Brough to Blacktoft



Environment Agency

Humber Tidal Impact Maps

Map Reference: HTIM 008 A

**Albert Dock
to
St Andrews Quay**

Predicted Flood Map
Based on Forecast of:

5.14mAOD

at
Hull Tidal Surge Barrier

Legend

Depth

- 0.00m - 0.25m
- 0.25m - 0.50m
- 0.50m - 1.00m
- 1.00m - 2.00m
- >2.00m
- X.XX EstuaryWaterLevels
- Flood Warning Areas

N

Scale 1:13,736

Environment Agency

Humber Tidal Impact Maps

Map Reference: HTIM 008 B

Albert Dock to St Andrews Quay

Predicted Flood Map
Based on Forecast of:

5.18mAOD

at
Hull Tidal Surge Barrier

Legend

Depth

- 0.00m - 0.25m
- 0.25m - 0.50m
- 0.50m - 1.00m
- 1.00m - 2.00m
- >2.00m
- X.XX EstuaryWaterLevels
- Flood Warning Areas

N

Scale 1:14,515

Environment Agency

Humber Tidal Impact Maps

Map Reference: HTIM 008 C

Albert Dock to St Andrews Quay

Predicted Flood Map
Based on Forecast of:

5.28mAOD

at
Hull Tidal Surge Barrier

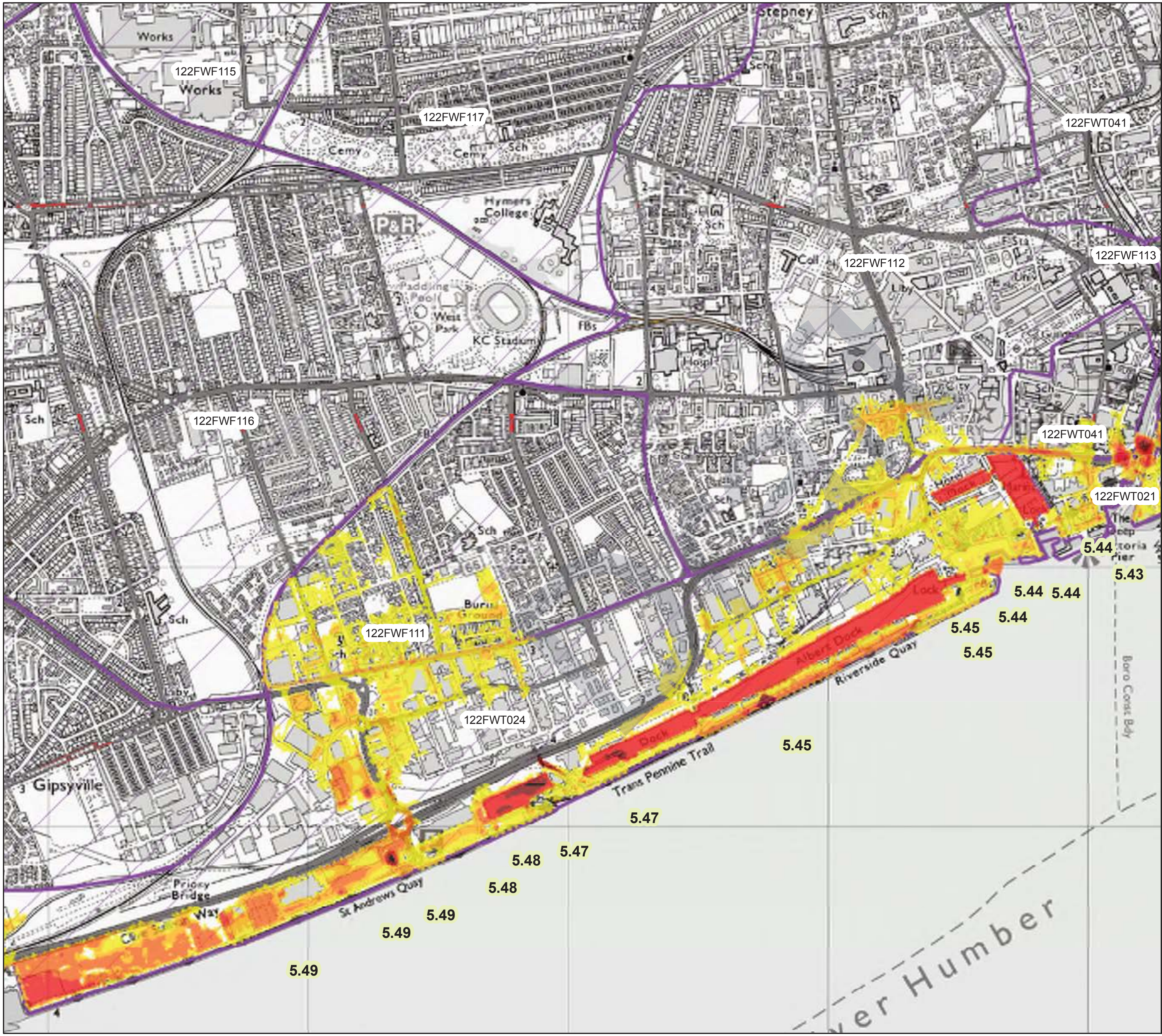
Legend

Depth

- 0.00m - 0.25m
- 0.25m - 0.50m
- 0.50m - 1.00m
- 1.00m - 2.00m
- >2.00m
- X.XX EstuaryWaterLevels
- Flood Warning Areas

N

Scale 1:14,515



Environment Agency

Humber Tidal Impact Maps

Map Reference: HTIM 008 D

Albert Dock to St. Andrews Quay

Predicted Flood Map Based on Forecast of:

5.44mAOD

at Hull Tidal Surge Barrier

Legend

Depth

- 0.00m - 0.25m
- 0.25m - 0.50m
- 0.50m - 1.00m
- 1.00m - 2.00m
- >2.00m
- X.XX Estuary Water Level
- Flood Warning Areas

N

Scale 1:13,736

Appendix E

Minutes of Meetings

E1

HA PSF MMS JV

Mott MacDonald Sweco

Draft 1 Minutes of the Flood Emergency and Evacuation Plan Meeting 25/05/18

Date and Time Friday 25 May 2018 16:00 – 17:00	**Project Title** A63 Castle Street Improvement
Location Hull Central Fire Station, Pearson Street, Hull HU2 8NH	**Project Number** 112630
	File reference 13/301

Attendees

Name	Organisation	Role	
James Leeming	Highways England	Senior Project Manager	1.
Adriaan van den Berg	Arup	Senior Engineer, Highways	2.
Stephen Hughes	MMS		3.
Jason Ball	MMS	Principal Consultant	4.
Katie Foulkes	MMS	Assistant Public Liaison Officer	5.
Dave Bristow	Humberside Fire and Rescue	Station Manager	6.
Darren Storr	Humberside Police	Traffic Management Officer	7.
Alan Bravey	Humber Emergency Planning Services	Emergency Planning Manager	8.
Rachel Glossop	Hull City Council	Flood Risk Planning Manager	9.

Apologies

Name	Organisation	Role	
Rob Small	MMS	Public Liaison Officer	1.
Nicki Loker	Yorkshire Ambulance Service	Locality Manager	2.
Christopher Addy	Regional Control Centre	Operations Manager – Deputising	3.
Lizzie Griffiths	Environment Agency	Sustainable Place Planning Advisor	4.

Item		Action
1.	<u>**Welcome and Introduction**</u> For the benefit of those who had not met before. Adriaan Van Den Berg explained how the purpose of the meeting was to discuss and agree the Flood Emergency and Evacuation Plan for the A63 Castle Street.	None.
2.	<u>**A63 Castle Street Scheme Update**</u> The A63 Castle Street main scheme works will commence in March 2020 and there will be a 5-year construction programme to March 2025. The Princes Quay Bridge will	None.

Draft 1 Minutes of the Flood Emergency and Evacuation Plan Meeting 25/05/18

Item		Action
	be built ahead of the main scheme, with current plans for construction to begin in October 2018. Highways England intend to submit the Development Consent Order (DCO) in September 2018. Following this, there will be an 18-month acceptance period.	
3.	**Flood Emergency Evacuation Plan** The Environment Agency (EA) has requested the production of a Flood Emergency and Evacuation Plan as part of the Environmental Statement included in the DCO submission. A high-level document has been produced and circulated previously, and Arup have used this as a basis for the new document. A main requirement from the Environment Agency is to see that the Flood Emergency and Evacuation Plan is agreeable to all the relevant stakeholders. This is a fundamental part of the DCO.	None.
4.	**Underpass Technology** The current CCTV proposals for the A63 Castle Street involve CCTV located at the Mytongate junction and CCTV located at Market Place / Queen Street looking in both directions. It is likely that the Market Place CCTV will be obstructed by Princes Quay Bridge, and the CCTV at the Mytongate junction will cover the other side. This will therefore ensure there is full CCTV visibility of the junction. Rachel Glossop explained how there will probably be CCTV at The Venue, but it is unknown if this has been installed this year. The CCTV at the moment in the area is networked through Hull. After receiving a flood warning, the underpass can be closed via Variable Message Signage (VMS) technology. Highways England cannot install an underpass barrier, as discussed in previous meetings with the emergency services. Variable Message Signage will be very important for getting people out of the city in the event of an emergency. There is not much VMS technology located along the A63 at the moment. The current proposal is to install 2 Variable Message Signs at Mytongate. There is a proposal for the installation of additional VMS to the rear of the Flood Emergency and Evacuation Plan document. Above lane technology will be used to indicate lane closures in the underpass. Darren Storr questioned whether overhead lights have ever been considered, and advised that these can be used in an emergency situation. Adriaan Van Den Berg to look into this. (A1)	(A1) Adriaan Van Den Berg

Item		Action
	There will be a pumping station installed to deal with flooding, with two pumps located in the underpass.	
5.	**Underpass Closure** Darren Storr hopes that a response can be initiated from A-one+ to perform a road closure rather than relying on the emergency services. A flood should be treated as any other incident on the network. The first request will go out to HETOC. HETOC and A-one+ would be sent out first, and would be expected to be out in 1 hour. Humberside Police and the emergency services are then a backup, but Humberside Police do not have the resources to close the road for a long period of time. In an emergency, Humberside Fire would balance priorities and decide where the flooding is / where the greatest risk to life is. The difficulty is going to be making a decision based on a flood warning. Rachel Glossop explained how tidal flooding is hard to predict as it is based on buoys in the estuary, where wind can change direction. There have been a lot of warnings in the Humber area and not many incidents. It is important not to overreact, however, if a severe flooding warning was issued then the road would need to close as soon as possible. Darren Storr explained how he would not want the underpass closing unnecessarily and confidence being lost in the scheme. Humberside Police would be called in if both pumps failed. With 2 pumps installed in the underpass, it will be unlikely that cars will float during severe flooding. In the event of failure of both pumps, Darren Storr advised there would likely be time for resources to reach the underpass.	None.
6.	**Agree Roles of Various Parties and Key Contacts in the Case of an Event** Usually with a Flood Emergency Evacuation Plan, any development should not rely on the emergency services. Depending on the flood alert, it will be a reactive process getting the right people in the right place. Adriaan Van Den Berg explained how Highways England could locate resources close by if there is a warning, and this needs to be discussed with A-one+. Adriaan Van Den Berg explained how there is a need to alter the audience of the Flood Emergency and Evacuation Plan document to focus on the roles of A-one+ and Highways England.	None.

Draft 1 Minutes of the Flood Emergency and Evacuation Plan Meeting 25/05/18

Item		Action
	As flooding emergencies do not happen on a regular basis, it can be a panic when they do. Rachel Glossop explained how Highways England need to ensure that someone is there to take the call when emergency flooding occurs.	
7.	**<u>Agree Diversion Routes and Process</u>** Rachel Glossop to find the existing emergency diversion routes (EDRs) that are currently used in an emergency incident and send to Highways England (A2). These may need revising. Highways England have a lot of EDRs currently in place, a lot of small EDRs. It is likely that this scheme would require one strategic EDR. Darren Storr explained how an emergency route through the city centre would not be ideal as the emergency services need to be able to respond. Ideally, the public will be routed out of this area to free this up for the emergency services.	(A2) Rachel Glossop
8.	**<u>Discuss sharing and assessing of flood risk in emergency</u>** The Environment Agency will issue flood warnings or guidance which triggers a Flood Advisory Cell Teleconference. Rachel Glossop advised that Highways England should dial into the Flood Advisory Cell Teleconference. This is something that is easy to get involved in. The Environment Agency send out flood warnings to which stakeholders then respond. There will be warnings sent out for a breach of defences. Flooding in Hull is likely to happen first and no alerts may be issued, then there will be a sudden need to react. Humberside Fire and Rescue services receive responses routinely, and are proactive / reactive to flooding. As Adriaan Van Den Berg understands, flood warnings will be sent to the Regional Control Centre (RCC), so a discussion needs to take place to discuss how RCC respond. The RCC are aware of the technologies and are on board with how information feeds back. The RCC are aware of alerts. Highways England will therefore be well informed of any flood warnings relating to the A63.	None.

Item		Action
9.	**<u>Role of Area Maintenance Team in an Emergency</u>** Following a flood warning, the first request will go out to HETOC, then A-one+.	None.
10.	**<u>Lesson Learned from the 2013 Flood</u>** There was a 10-minute notice for the flood in 2013. The warning for this went out after the breach. Rachel Glossop explained how pumps would not be able to cope with the flooding that happened in 2013 as it would happen quickly. The probability of this happening is low, but it did happen in 2013 and could happen again. A-one+ currently have and held a contract with Highways England in 2013, however, this may have changed by the time the scheme is complete.	None.
11.	**<u>Agree frequency of Plan review</u>** Future discussions will be required as the underpass is a unique thing for Hull.	None.
12.	**<u>Agree Frequency and Plan for Testing FEEP</u>** Whatever the plan, there would need to be regular tests to ensure everyone knows their roles. Rachel Glossop suggested a test every year to ensure those operating know what to do in the event of an emergency.	None.
13.	**<u>Alternative Emergency Situation</u>** Darren Storr explained how there are technology plans in place and hopefully advance warnings in the event of flooding, however, collisions along the road will be the biggest issue. Members of the meeting questioned if an emergency such as a collision in the underpass would require a different response to the flooding response. Dave Bristow advised this would be a more likely scenario than a flood. Adriaan Van Den Berg to add a table into the Flood Emergency and Evacuation Plan report highlighting the plan for an emergency situation such as a collision in the underpass. (A3) Dave Bristow questioned how a fire in the underpass would be dealt with. Adriaan Van Den Berg to look into this. (A4)	(A3) Adriaan Van Den Berg (A4) Adriaan Van Den Berg

Draft 1 Minutes of the Flood Emergency and Evacuation Plan Meeting 25/05/18

Item		Action
14.	**AoB** Questioned if the Humber LRF will need updating as there is no current mention of Highways England dialling into the Flood Advisory Cell Teleconference. Alan Bravey to look into this. (A5) Darren Storr questioned bridge design height with reference to the recent bridge strikes that have taken place along the A63. Adriaan Van Den Berg explained how this has been looked into and Arup have undertaken headroom clearance checks. James Leeming advised that Andrew Charnick works in Health and Safety at Highways England and is the Emergency Planning Manager for Area 12. Rachel Glossop advised that flood warnings do not include surface water.	None. (A5) Alan Bravey
15.	**Way Forward** Rachel Glossop thinks the Flood Emergency and Evacuation Plan document is fine and makes perfect sense, just requires a few comments regarding everyone being aware of individual roles and Highways England dialling into the Flood Advisory Cell Teleconference. (A6) Rachel Glossop will return comments on the document to reinforce these points. (A7) A-one+, Regional Control Centre, HETOC and OD to get involved with the Flood Emergency and Evacuation Plan. Katie Foulkes to arrange a second meeting with A-one+, Regional Control Centre, HETOC and OD (Mark Ramsden's Team). (A8) Any member of the meeting with comments or questions on the document to send to Adriaan Van Den Berg. The Flood Emergency and Evacuation Plan will be a living, fluid document, and will be updated. Katie Foulkes to recirculate the Flood Emergency and Evacuation Plan to meeting attendees. (A9) Rachel Glossop advised that Richard Townend or Graham Lownsborough from Hull City Council may be good to get involved in the discussion along with someone from the Traffic Management Team at Hull City Council. James Leeming advised Highways England are already in contact with Ruth Stephenson and Paul Robinson from Hull City Council.	(A6) Highways England (A7) Rachel Glossop (A8) Katie Foulkes (A9) Katie Foulkes

Draft 1 Minutes of the Flood Emergency and Evacuation Plan Meeting 25/05/18

Item		Action
	James Leeming accepted the underpass is a new concept for the emergency services in Hull, and suggested they could learn from other emergency services around the country regarding how they deal with similar scenarios, such as those in Birmingham.	

Action List		
Ref	**Action Required**	**By Whom**
A1	Adriaan Van Den Berg to look into the use of overhead lighting in the underpass for use in the event of an emergency.	Adriaan Van Den Berg
A2	Rachel Glossop to find the existing diversion routes that are currently used in an emergency incident and send to Highways England.	Rachel Glossop
A3	Adriaan Van Den Berg to add a table into the Flood Emergency and Evacuation Plan report highlighting the plan for an emergency situation such as a collision in the underpass.	Adriaan Van Den Berg
A4	Adriaan Van Den Berg to look at how a fire in the underpass would be dealt with.	Adriaan Van Den Berg
A5	Alan Bravey to look into whether the Humber LRF will need updating as there is no current mention of Highways England dialling into the Flood Advisory Cell Teleconference.	Alan Bravey
A6	Highways England to organise dialling in to the Flood Advisory Cell Teleconference in the event of an emergency.	Highways England
A7	Rachel Glossop to return comments on the Flood Emergency and Evacuation Plan document.	Rachel Glossop
A8	Katie Foulkes to arrange a second meeting with A-one+, Regional Control Centre, HETOC and OD (Mark Ramsden's Team) to discuss the Flood Emergency and Evacuation Plan.	Katie Foulkes
A9	Katie Foulkes to recirculate the Flood Emergency and Evacuation Plan to meeting attendees.	Katie Foulkes

Matters Agreed			
Ref	**Subject Area**	**Agreed Position**	**Date Agreed**
MA1	FAC Teleconference	Agreed that Highways England should dial into the Flood Advisory Cell Teleconference	25/05/18
MA2			
MA3			
MA4			

Matters Not Agreed			
Ref	**Subject Area**	**Attendees Position**	**Applicants Position**
NA1			
NA2			
NA3			
NA4			

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Matters Under Discussion			
Ref	**Subject Area**	**Attendees Position**	**Applicants Position**
MD1			
MD2			
MD3			
MD4			

E2

HA PSF MMS JV

Mott MacDonald Sweco

Draft 1 Minutes of the Flood Emergency and Evacuation Plan Meeting 2 15/06/18

Date and Time Friday 15 June 2018 10:00 – 12:00	Project Title A63 Castle Street Improvement
Location Arup, Admiral House, Rose Wharf, 78 East Street, Leeds LS9 8EE	**Project Number** 112630
	File reference 13/309

Attendees

Name	Organisation	Role	
Frances Oliver	Highways England	Assistant Project Manager	1.
Adriaan van den Berg	Arup	Senior Engineer, Highways	2.
Stephen Hughes	MMS		3.
Katie Foulkes	MMS	Assistant Public Liaison Officer	4.
Christopher Addy	Regional Control Centre	Operations Manager – Deputising	5.
Paul Mitchinson	A-one+	Highways Asset Manager	6.
Andrew Charnick	RCC	Emergency Planning Manager	7.
Mark Booth	A-one+	Area Maintenance Manager	8.

Apologies

Name	Organisation	Role	
James Leeming	Highways England	Senior Project Manager	1.
Jason Ball	MMS	Principal Consultant	2.
Mark Ramsden	Highways England	Service Delivery Team Leader	3.
Rob Small	MMS	Public Liaison Officer	4.
Nigel Yeatman	A-one+	Asset Development Team Manager	5.
Stuart Rigby	A-one+	Area 12 ASC	6.

Item		Action
1.	**Welcome and Introduction** For the benefit of those who had not met before. Adriaan van den Berg explained how the aim of this meeting was to understand the roles and responsibilities in the event of an emergency situation.	None.
2.	**A63 Castle Street Scheme Update** The A63 Castle Street scheme involved the construction of an underpass at the Mytongate junction. There are currently 6 sets of traffic lights / crossing points along this section of the A63, which will be removed to prevent any	None.

Item		Action
	stoppages and allow free flowing traffic. Two bridges will be constructed over the A63 – the Porter Street Bridge and the iconic Princes Quay Bridge, designed to be a gateway to the city. In addition, Highways England will be upgrading the route under the A63 at High Street. The Earl de Grey (Grade II listed building) will be permanently moved back by 3m. Highways England have been in PCF Stage 3 since late 2012. The scheme has suffered an air quality challenge, and more recently an affordability challenge. Due to the affordability challenge, the scheme had to go through Department for Transport change control to get the revised budget and programme approved. This was signed off in January 2018. The current intention is to submit the Development Consent Order (DCO) on 20 September 2018. This is one of the final dates that Highways England can submit the DCO to achieve the start of works date of March 2020. The A63 Castle Street main scheme has a 5-year construction programme. The first two years of the scheme will be statutory undertaker diversions and the Trinity Burial Ground exhumation work. Highways England will need to acquire 1/3 of Trinity Burial Ground, which will involve the exhumation of 19,000 remains. The final three years of the construction period will involve the construction of the slip roads and the underpass. Various compounds are required to construct the scheme. Due to the urban nature of the scheme, finding compounds has been challenging. Highways England has a slight disagreement with Hull City Council over site compound matters. During construction right turns will not be possible at Mytongate junction. Highways England have a budget put aside for improvements to key junctions in Hull's network. There will be phased traffic management in place for the construction period.	
3.	**Princes Quay Bridge Update** The Hull MP Emma Hardy considers the current crossing of the A63 by Princes Quay Shopping Centre to be unsafe.	None.

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Item		Action
	The Secretary of State and Emma Hardy have agreed to construct Princes Quay Bridge early, ahead of the main scheme. The planning permission for Princes Quay Bridge expires on 6 October 2018, therefore the works will need to commence before this date. The construction of Princes Quay Bridge early will provide a crossing facility for the main scheme construction period. The Spurn Lightship will need moving for the Princes Quay Bridge works. This is currently open as a museum. The moving of the Spurn Lightship for the scheme has been publicised by Hull City Council as they will need to close the museum. Subject to obtaining land by agreement the Princes Quay Bridge works will commence in October 2018.	
4.	**<u>Discuss the FEEP and Agree Processes</u>** The Environment Agency (EA) have requested a Flood Emergency and Evacuation Plan (FEEP) agreed by relevant stakeholders as part of the Environmental Statement. Initially, the FEEP document considered flooding, however, following previous discussions with Hull emergency services, the document now examines how to respond to a number of alternative incident scenarios.	None.
5.	**<u>Agree Roles of Various Parties and Key Contacts in the Case of an Event</u>** In the previous Flood Emergency and Evacuation Plan meeting, Darren Storr from Humberside Police indicated they are not in a position to close the road and suggested a conversation needed to be held with the Regional Control Centre (RCC) and A-one+. All at the meeting agreed that A-one+ would be best suited to close the underpass. There are three levels of response: 1. No response, 2. A-one+ move to a close location, 3. A quick response with little warning.	None.
6.	**<u>Agree Diversion Routes and Process</u>**	

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Item		Action
	The technology recommended for the underpass includes Variable Message Signs (VMS) in advance of the junction. Adriaan van den Berg stated how the Mytongate slip roads will be able to be used as a diversion to keep things moving in the event of an underpass closure. VMS will be able to indicate underpass closure, and by having this ahead of the junction, be able to redirect the traffic. It will be important to assess the severity of the flooding. If it is just flooding in the underpass then it will be possible to use slip roads. However, a closure will need to be implemented at the junction before the underpass, as there needs to be a wider approach. Paul Mitchinson advised the underpass will need to be physically closed to prevent vehicles entering the underpass as people make mistakes. It was agreed A-one+ would be ideally suited to implement this closure. A discussion was held around signage of the underpass closure / diversions, and how far in advance of the underpass signs would need to be provided. Andrew Charnick and Christopher Addy raised concerns regarding emergency diversion routes. The diversion may need to start at Daltry Street, and the closure will need to be implemented at the junction before the underpass. Andrew Charnick questioned if the scheme will be signing a diversion route. Fran Oliver responded, stating that in a normal diversion, the diversion route would be signed. At the moment, if there are temporary closures on the A63, Highways England are using the existing agreed emergency diversion routes. Adriaan van den Berg explained how he would like to create an Action List for Stage 4 and Stage 5 of the scheme, such as agreeing diversion routes and flood responses (A1). If the FEEP can be agreed in principle then it can be submitted to the Environment Agency and discussions can continue.	(A1) Adriaan van den Berg
7.	**<u>Underpass Closure</u>** Andrew Charnick advised it will be important to close the underpass before it floods if there is an advanced warning. Mark Booth explained how the process will involve agreeing the Emergency Diversion Routes (EDRs) and then A-one+ will respond to an incident. Paul Mitchinson advised it is important the EDRs are agreed and in place. In the event of a warning, it will be important to have people in the area ready to close the underpass. Finding a possible location for this is difficult as there is not much space along the network to set up a standby area allowing	

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Item		Action
	a quick response. Adriaan van den Berg suggested the pumping station next to Trinity Burial Ground may be a possible location for this as there may be space there. Stephen Hughes advised this may not work as the pumping station may be utilised at the time of a flood, so this may not be possible. Action (A7). Identify standby area.	 (A7) Adriaan van den Berg
8.	**Water pumping** Pumps have been built into the A63 design proposals, in addition to a pumping station. Andrew Charnick suggested bringing the high-volume pump from Area 14 if required. It would take approximately 3 – 4 hours for this pump to arrive in Hull. For this, it would need to be agreed where to pump the water to. Adriaan van den Berg advised the team are currently in the process of agreeing with Yorkshire Water to pump water into their network, so it is likely the same agreement could be established in the case of an emergency. Paul Mitchinson advised Yorkshire Water systems may not be ideal. They may not be able to cope with the water as it is likely they will be inundated themselves. The high-volume pump has 3km of discharge pipes. This pump is a national asset, but there is control over how this pump is used rather than it just being controlled nationally. Further into the process, a discussion needs to take place to agreed where to locate the high-volume pump. (A2) Andrew Charnick advised if you give the pump to Humberside Fire and Rescue Service, they can pump wherever they like. The fire service charge £10,000 per day for using their high-volume pump.	(A2) Adriaan van den Berg
9.	**Discuss Sharing and Assessing of Flood Risk in an Emergency** Upon the receipt of warnings, Andrew Charnick or his colleague Hayley dial into the Humber LRF. Moving forward, A-one+ could dial in as well. A-one+ could also take part in the TCG's. Andrew Charnick advised there would be internal calls hosted if a Level 1 warning was raised. A-one+ Silver should be included in the internal calls in future.	

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Item		Action
	Adriaan van den Berg questioned how warnings are disseminated for localised rain water, as the Environment Agency would not be aware of these. The underpass pumping station has trigger warnings, if both pumps fill, it will send a warning to the Regional Control Centre (RCC). Christopher Addy advised this warning does not go to the RCC, it goes to A-one+. Adriaan van den Berg to check who receives underpass trigger warnings for rain water with the technical department. (A3)	(A3) Adriaan van den Berg
10.	**<u>Lessons Learned from the 2013 Flood</u>** There was not much warning for the 2013 flooding. In the previous Flood Emergency and Evacuation Plan meeting, Rachel Glossop from Hull City Council explained how it is hard to predict tidal flooding as wind can change direction. Stephen Hughes explained how a tidal surge topped the north bank of the Humber flood defences in place at the time and reached the A63 in the 2013 flooding. The Flood Emergency and Evacuation Plan document plans for a large event (1 in 200 years), as this is the requirement from the Environment Agency. The flood defences have been raised since the 2013 flood, but the estimates of flooding have also increased due to climate change. The Environment Agency recognise that Hull is at risk from flooding, and the 7m deep underpass presents a unique risk. Stephen Hughes explained how the main risk of flooding is from a wave overtopping the flood defences.	None.
11.	**<u>Agree Frequency of Plan Review</u>** Following the submission of the Flood Emergency and Evacuation Plan to the Environment Agency, discussions will continue regarding the document.	None.
12.	**<u>Agree Frequency and Plan for Testing the FEEP</u>** In terms of testing the Flood Emergency and Evacuation Plan, Andrew Charnick advised the LRF take part in flood exercises every couple of years, and the A63 FEEP should be included. Flooding is a multi-agency event, so this is the only way to test. Andrew advised that when they look to re-do the LRF plan, the A63 FEEP will be included. Ultimately, the A63 FEEP will form part of the LRF Humberside plan.	None.
13.	**<u>AoB</u>** Paul Mitchinson questioned how maintenance of the road will be dealt with during the construction period, advising	

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Item		Action
	the simplest move would be to hand the whole thing to the contractor. Frances Oliver to look into this and respond to Paul Mitchinson, copying Mark Booth into the email. (A4) Mark Booth questioned if Highways England had thought about A-one+ dealing with wider roads. Adriaan van den Berg explained the FEEP focuses on the underpass.	(A4) Frances Oliver
14.	**<u>Way Forward</u>** Attendees of the meeting to comment on the Flood Emergency and Evacuation Plan and return comments to Adriaan van den Berg by Tuesday 19 June 2018 (A5) to allow Adriaan to make the relevant alterations to the document. Adriaan van den Berg to send a word document of the FEEP on Friday 15 June to make it easier for attendees to add comment. (A6) Following the receipt of comments, Adriaan van den Berg can look to start creating the Action List for Stage 4 and Stage 5 of the process. (A1)	(A5) Christopher Addy / Mark Booth / Paul Mitchinson / Andrew Charnick (A6) Adriaan van den Berg (A1) Adriaan van den Berg

Action List

Ref	Action Required	By Whom
A1	Adriaan van den Berg to create an Action List for Stage 4 and Stage 5 of the scheme, highlighting things such as agreeing diversion routes and flood responses.	Adriaan van den Berg
A2	Adriaan van den Berg to discuss where to locate the high-volume pump if it is brought to Hull for the underpass.	Adriaan van den Berg
A3	Adrian van den Berg to check who receives underpass trigger warnings for rain water with the technical department.	Adriaan van den Berg
A4	Frances Oliver to look into how the maintenance of the A63 will be dealt with for the construction period and respond to Paul Mitchinson / Mark Booth.	Frances Oliver
A5	Attendees of the meeting to comment on the Flood Emergency and Evacuation Plan and return comments back to Adriaan van den Berg by Tuesday 19 June 2018	Christopher Addy / Mark Booth / Paul Mitchinson / Andrew Charnick
A6	Adriaan van den Berg to circulate a word document of the FEEP on Friday 15 June	Adriaan van den Berg
A7	Identify standby area.	Adriaan van den Berg

Matters Agreed

Ref	Subject Area	Agreed Position	Date Agreed
MA1	Underpass closure	All at the meeting agreed A-one+ would be best suited to close the underpass.	15/06/2018
MA2			
MA3			
MA4			

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Matters Not Agreed			
Ref	**Subject Area**	**Attendees Position**	**Applicants Position**
NA1			
NA2			
NA3			
NA4			

Matters Under Discussion			
Ref	**Subject Area**	**Attendees Position**	**Applicants Position**
MD1			
MD2			
MD3			
MD4			

Appendix F

Environment Agency Relevant Representation Response: Pumping Station Flood Resilience

F1

Technical Note

ARUP

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Project title	A63 Castle Street Improvement Scheme	Job number	237912-00
Cc	Adela Sadler Jason Ball Sonam Norbu Eileen Longworth Stephanie Dye	File reference	HE514508-ARP-EAC-S0_JN_HI-FN-CD-000001
Prepared by	Luke Harrison Stephanie Dye Stephen Hughes	Date	July 2019
Subject	Environment Agency relevant representation response: Pumping station flood resilience		

This Technical Note has been prepared in response to the Environment Agency's Relevant Representation comments on the Flood Risk Assessment[1] that was submitted on 20 December 2018.

1 Environment Agency Comment:

"Risk to Surface Water Pump

Section 2.6.30 of the FRA states that a water storage and pumping station structure would be required to collect the drainage of the underpass and pump it away for discharge. Drawing no. TR010016/APP/2.6(M) Rev 0 shows the proposed pumping station receptor, located to the south east of the proposed Mytongate Bridge. However, we have been unable to find any detailed plans or information relating to the control room, generator room and sub-station. Without this, we are unable to determine whether the pumping station is sufficiently resilient to flooding, to allow continued operation in a flood event. Details on the level of operating equipment above ground should be included within the FRA."

[1] https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/a63-castle-street-improvement-hull/?ipcsection=relreps&relrep=31932

2 Response:

As part of the Pumping Station Approval in Principle (AIP) document, a Mechanical and Electrical (M&E) Equipment AIP was prepared to highlight the preliminary design considerations that will inform the detailed design. Below are key extracts and summaries from this M&E AIP which are relevant to flood risk resilience.

Additionally, this response also includes an overview of different flood risks pertaining to the proposed pumping station control room, generator room and proposed relocated sub-station.

However, it should be noted that it was always the intention of this scheme to address these three components as part of the detailed design. We would therefore be open to review and address and concerns raised by the Environment Agency in respect to these buildings. It is our intention to develop these designs in a collaborative manner to ensure we deliver a reliable and safe asset.

2.1 General description

The modified highway will be within an underpass with a grade separated junction. A new bridge will span over the underpass to carry traffic between Ferensway and Commercial Road. Access on and off the A63 is provided in all directions by slip roads in the four corners of the new junction. Mytongate pumping station is required to collect surface drainage from the underpass and discharge via a rising main. The pumping station is located to the south east of the Mytongate Junction Bridge as shown below:

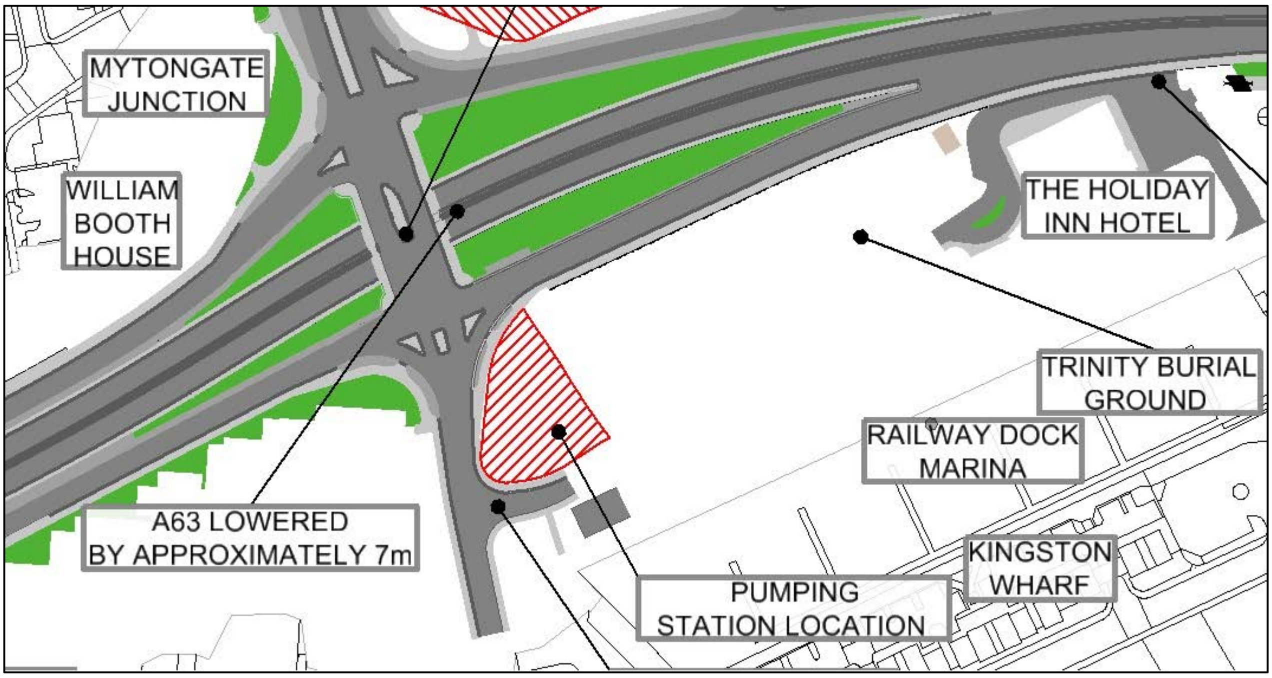

Figure 1: Proposed Site Layout

The design of the pumping station and approach to balancing pumped discharge rate with storage volume has sought to balance the following factors: -

- The high flow rates generated by the 1-in-100-year design storm mandated by the EA, which will generate significant volumes of runoff;
- The extremely challenging ground conditions at the site, which will significantly increase the cost and risk of constructing the pumping station civil works and disproportionately increase the cost of storage-based solutions versus pump-rate-based ones;
- The need to mitigate the impact of flow rates on the YW sewer network; and
- The need to maintain operational flexibility and resilience.

Mindful of the constraints above, it is proposed that the pumping rate be based on the peak flow rate from a 1-in-5-year storm event. The modelled flow from the catchment for such an event is 202.9 l/s, and therefore a design pumping rate of 200.0 l/s has been selected. It is anticipated that this will be provided by three pumps operating in a duty/assist/standby configuration. The proposed approach is considered optimal for the following reasons: -

- The proposed flow rate is accommodated within the overall site peak flow rate of not more than the existing;
- Higher pumping rates would only result in marginal reductions in the volume of the pumping station wet well, whilst increasing the impact on the YW network;
- Lower pumping rates would result in disproportionate cost of construction due to the volume of the civil works; and
- Lower pumping rates would reduce the resilience of the drainage system to storm events beyond the design criteria and would increase the time taken to drain the underpass in the event of flooding.

It should be noted, that the pumping station is not intended to keep the underpass free from of flooding during a big tidal flood.

2.2 Brief description of structure operation and maintenance framework

2.2.1 Type of structure

The purpose of the structure is to collect surface drainage water from the underpass, provide a water storage volume and housing for a pumping system, which will discharge water to a rising main.

The structure itself is a circular reinforced concrete shaft with a provisional internal diameter of 11.45m to accommodate the desired pump size and water storage volume. A buried pipe approximately 39m long and 600mm internal diameter will connect the underpass to the pumping station.

For details of the proposed pumping station refer drawing HE514508-ARP-SSPS0_ ML_PS-RP-CB-000001.

2.2.2 Accommodation of M&E services

The M&E services relevant to this AIP are restricted to those associated with the Mytongate pumping station serving as part of the surface water drainage of the underpass.

The Mytongate pumping station is located to the south east of the Mytongate Junction Slip Road, adjacent to the Trinity Burial Ground. The proposed highway layout in this area is shown below.

2.2.3 Location of monitoring centre and maintenance buildings

The control building for the Mytongate pumping station would be adjacent to the pumping station shaft as illustrated on drawing HE514508-ARP-SSP-S0_ML_PS-RPCB-000001.

2.2.4 Proposed arrangements for inspection and maintenance

This access hole will be of sufficient dimensions to accommodate a winched man-rider lift system, which can lower maintenance personnel down the shaft to a safe landing platform at the base of the shaft. The access arrangements and details of any landing platforms, access chambers, folding safety covers, etc., will be further developed during the detailed design period in consultation with the maintaining authority.

Details will be developed in accordance with industry "best practise" including the recommendations of authoritative documents including "Sewers for Adoption - 7th Edition" and "CIRIA C686 - Safe access for maintenance and repair".

The pumps and level instruments in the shaft would be normally lifted in and out of position (by lifting chains or similar) through a separate ground level access hole(s) with removable cover(s) without requiring any access into the shaft itself. The lifting equipment (chains/winches) required will be determined by the weight of the pumps, which will be confirmed when final flow rates are agreed.

In the case of failed/jammed lifting equipment or other situation where access is required within the shaft, the same arrangements for accessing the structure would be used as described above.

Access to the pump control panel and other electrical items would be via the secure kiosk/building provided at ground level. Access would be simply by foot from the paved area provided. The pump shut-off valves would also be accessed from ground level via a hatch to a valve chamber just below the paved surface.

The shaft will be classified as a Confined Space and all access should be by safe working procedure including access equipment, planning, trained personnel and personal gas detection (e.g. Carbon Monoxide, Hydrocarbons and Oxygen) with pre-entry gas checks. Access will be via a removable cover in the shaft roof which is sized to permit a man riding basket to be lowered to the invert of the sump. The cover will be positioned to facilitate safe access to and from the basket once inside. Pump lifting, and removal is proposed to be by use of a HIAB or other suitable vehicle.

Due to the depth of the sump and the weight of the pumps a removable davit is unlikely to be appropriate and permanent lifting equipment would be at risk of vandalism in a publicly accessible location therefore vehicle access and direct lifting is the most suitable method.

The same considerations apply for accessing the pumping equipment during a tidal flood event, thus providing some resilience to respond during such an event.

2.2.5 Location of services building

The control building for the Mytongate pumping station would be adjacent to the pumping station shaft as shown on drawing HE514508-ARP-SSP-S0_ML_PS-RPCB-000001.

2.2.6 Design working life of M&E services

The design working life of the major M&E components is expected to be:

- Pumps 20 years
- Control Panel 20 years
- Generator 20 years

2.3 Electrical power supply and distribution

2.3.1 General description

A secure kiosk/control building will be provided at ground level to house the control panel, standby generator (with fuel store) and other electrical equipment. The power supply will be confirmed following the detailed design of the pumping station and equipment selection.

2.3.2 Supply distribution

The power supply for the Pumping Station is to be provided from an existing substation which will be re-located and will retain the existing demands with the addition of further load from the pumping station. The location of the substation is in design development, but currently it is proposed to be sited adjacent to the Pumping Station.

2.3.3 Emergency arrangements

Due to the criticality of the pumping station for maintaining drainage a standby generator will be installed, sized for the same power rating to ensure the whole pumping station is operational in the event of a grid power failure. It is proposed that there will be a fuel supply that is sufficient for 48 hours full pumping station operation. It is anticipated that fuel will be stored in a double skinned below ground storage tank with secure external connection facility for deliveries.

Based on a 200kVA generator the estimated fuel storage requirements for 48h operation at full load are approximately 2400 litres. The generator sizing will be confirmed during detailed design and fuel storage capacity adjusted to suit.

The generator will be installed within a building and external noise limited by the building structure.

2.3.4 Cabling

Cable routes will be confirmed at detailed design. These will be ducted, and routes selected to reduce the risk of damage due to vehicle movements or vandalism. External drawpits will be avoided where possible to reduce security risks.

Within the sump cables are suspended by cable support grips, which are secured to a bracket at the top of the shaft. These will be accessed through the pump lifting covers and lifted with the associated pump.

This will provide access and resilience during an emergency flood event.

2.4 Services buildings and plant rooms

2.4.1 General description

The pumping station control equipment and standby generator shall be housed within a secure kiosk/building at ground level near to the pumping station shaft.

2.4.2 Design criteria and layout

The notional layout is as per the drawing in Appendix B, to be confirmed during detailed design.

2.4.3 Building security and protection

The building specification is expected to be a minimum of LPCB Level 3, details of doors, louvers and structural security measures will be confirmed by security risk assessment during detailed design.

The current landscaping proposal is to provide Hedgerow around the entire perimeter of the Pumping Station compound, with vehicle access on Commercial Road. This vehicle access also provides vehicle access to the Trinity Burial Ground via a grasscrete route. It would be possible to provide either a gate or lockable bollards at the entrance to prohibit unauthorised vehicles from entering the site.

2.5 Flood Levels Review

During the design development, additional modelling was done to a sensitivity test on the flood levels for different central reservation barriers that were being investigated. The results of the flood levels at the pumping station compound are recorded in the tables below.

Table 1: No Central Concrete Barrier

No Central Concrete Barrier	***Max flood level (mAOD)***	***Max flood depth (m)***
Humber Defended 200	3.323	0.272
Humber Defended 200+CC	7.300	4.206
Humber Defended 1000	4.108	0.970
Humber Undefended 200	4.056	0.758
Humber Undefended 200+CC	4.089	0.834
Hull Tidal 200	0.000	0.000
Hull Tidal 1000	0.000	0.000

Table 2: Full Central Concrete Barrier

Full Central Concrete Barrier	***Max flood level (mAOD)***	***Max flood depth (m)***
Humber Defended 200	3.325	0.274
Humber Defended 200+CC	7.306	4.212
Humber Defended 1000	4.181	1.026
Humber Undefended 200	4.072	0.786
Humber Undefended 200+CC	4.112	0.863
Hull Tidal 200	0.000	0.000
Hull Tidal 1000	0.000	0.000

Balfour Beatty and Arup have used the initial maximum flood levels for a Defended 1-in-1000 year flood event, as highlighted in Table 1 and Table 2 above as our recommended design flood level. The Max flood level (mAOD) for the two central barrier scenarios are as follows:

- No central barrier – 4.108 (mAOD) – 0.970m flood depth;
- Full Central Concrete Barrier – 4.181 (mOAD) – 1.026m flood depth.

The current pumping station compound layout requires the regrading of the area to accommodate access to maintenance vehicles off of Commercial Street, as can be seen in Figure 3 and Figure 4 below. The proposal is to provide a grasscrete (or similar) treatment to allow maintenance/service vehicles to turn in this area. The top level, where the grasscrete meets the pumping station building, is at approximately 3.55 (mAOD), which is currently 0.631m below the maximum flood level described above. The current proposal looks at raising the MCC equipment inside the pumping station building by 1m to a level of 4.55 (mOAD), which lifts it above the 4.181 (mAOD) level. As part of the detail design, we will look at how we can regrade this area further, to try and lift the grasscrete area and the building even higher. During the detail design stage, the project team will engage with the Environment Agency and Hull City Council to look at further opportunities of building in additional flood resilience.

However, it should be noted that the design team is still awaiting the design criteria from Hull City Council for the pumping station building. Once these requirements have been obtained from Hull City Council, the requirements will be assessed and the implications on design levels and flood resilience communicated to the Environment Agency.

2.6 Landscape Proposals for Pumping Station Compound

Preliminary landscaping proposals have been produced for the pumping station compound area. Indicative visualisations of these are shown in the images below:

- Figure 2: Shows a visualisation of the proposed Mytongate Junction and the pumping station compound area. The pumping station, with the service buildings is shown in the bottom right hand corner;
- Figure 3: Existing location where the proposed pumping station will be installed; and
- Figure 4: A visualisation of the proposed pumping station and associated buildings.

Figure 2: Proposed Mytongate and pumping station layout

Figure 3: Existing location of proposed pumping station

Figure 4: Visualisation of proposed pumping station and associated buildings

2.7 Design Review Comments Sheet

The following are extracts from the Design Review Comments Sheet, which formed part of the Pumping Station AIP approval process:

Comment No.	Design Review Comment (C) / Observation (O)		BB/Arup Response
17.4	Given the location close to the waterfront, has the risk of sea water flooding due to a tidal surge been assessed? (Tidal surges seem to happen more frequently nowadays).	Covered by response to Comment 18. How will the substation, generator and control kiosk be protected from flooding?	In 2014 Mott MacDonald Grontmij produced a Flood Risk Assessment that reviewed the various flood risk impact of the scheme. The following flooding scenarios were reviewed for specific Return Periods: - Pluvial @ 1:100 plus climate change - Tidal from River Hull (with Hull barrier open) @ 1:1000 - Combined fluvial and tidal from River Hull (with Hull barrier open) @ 1:1000 - Wave overtopping (defended) from River Humber @ 1:200 plus climate change - Tidal (undefended) from River Humber @ plus climate change The report concluded that the scheme will be protected by the flood defences in events up to 1:200 years. There is a risk of fluvial flood events arising in a 1:100 year event. However, the pumping station building is situated higher than the rest of the scheme, and most flood models indicate little to no flooding for 1:100 year flood events.
18	Section 3.1: I note that the pumping station has now been relocated to a position just south of the proposed Westbound off-slip road and Mytongate bridge. The GA drawings contained in Appendix B appears to show that the surface level of the cover slab is at 0.00 AOD. Taking into account the proximity of the pumping chamber to the coastline and the 120 year design life of the structure, is it considered that the pumping station and Kiosk is protected against extreme weather events including tidal surge?		Firstly, we would like to highlight that the surface of the level of the cover slab isn't at 0.00m AOD as quoted in the comment. The actual surface level is in the order of 3.50m AOD. Secondly, according to the FRA prepared by Mott MacDonald Grontmij, the likelihood of a tidal surge exceeding the Hull Tidal Surge Barrier minimum level of 4.43m AOD. The flood models indicate that the flood depth (m) will not exceed 1.0m at the proposed pumping station location during a 1 and 1000 year period undefended tidal flooding from River Hull (See Figure 10.54).

Additional flood risk modelling and assessments were done after the submission and approval of the Pumping Station AIP, which supersedes some of the comments that are highlighted above. The additional modelling will be incorporated in the detailed design of the pumping station and associated buildings.

3 Conclusion

It is clear from the preliminary design, flood risk modelling and consultation that additional work is required during the detailed design stage to make the pumping station and associated buildings as flood resilient as reasonably possible.

Further consultation is required to help inform the detailed design and will be done as part of Stage 5 design.

DOCUMENT CHECKING (not mandatory for File Note)

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