URS

Stage 3 Strategic Flood Consequence Assessment

Additional Site Assessments

March 2014

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Prepared for: Newport City Council

UNITED KINGDOM & IRELAND

Newport CITY COUNCIL

CYNGOR DINAS Casnewydd

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1. INTRODUCTION

1.1.1 URS Infrastructure & Environment UK Limited (URS) completed the Newport City Council (NCC) Stage 3 Strategic Flood Consequence Assessment (SFCA) in March 2013 for eight sites identified for inclusion within the Deposit Local Development Plan (LDP). This provided a detailed analysis of flooding mechanisms and consequences for a set of agreed scenarios using the Newport Tidal Model (provided by Natural Resources Wales (NRW)[1]).

1.1.2 In January 2014, the Welsh Government issued a letter to Chief Planning Officers regarding planning policy on flood risk and insurance industry changes**2** and a summary of what Technical Advice Note (TAN) 15 requires for highly vulnerable development (houses) to be considered acceptable. NCC identified sites that have extant planning permission for housing with a development lifetime of 50 years in February 2014. With changes to planning policy regarding development lifetime, if development is not commenced and planning permission lapses, sites could be potentially constrained by flood consequences and impact on the feasibility of the sites inclusion within the Revised Deposit LDP Designations for housing.

1.1.3 NCC has identified seven additional sites to be assessed that have extant planning permission for housing. The same approach has been adopted as within the Stage 3 SFCA undertaken in March 2013 with some minor alterations (see Section 3). A summary table is provided in Section 5 to aid NCC in application of the Justification Test in line with TAN15 were planning permission to lapse.

[1] Formerly Environment Agency Wales

[2] See: http://wales.gov.uk/topics/planning/policy/dear-cpo-letters/flood-risk-and-insurance-changes/?lang=en

2. OVERVIEW

2.1 Extant Planning Permissions

2.1.1 Following the issue of revised guidance regarding development lifetime for housing, NCC undertook a review of extant planning permissions where development has not commenced. NCC have identified an additional seven sites for assessment within the Stage 3 SFCA process (see Appendix A), these are:

- H5 - Glebelands;
- H9 - Frobisher Road;
- H15 - Victoria Wharf;
- H16 - Penmaen Wharf;
- H21 - Former Floors 2 Go;
- H23 - Traston Lane;
- H32 - Former Sainsburys.

2.2 Hydraulic Modelling Data

2.2.1 NRW provided hydraulic modelling data relevant to the area of interest within the NCC administrative area for the Stage 3 SFCA. URS undertook a review[3] of the Newport Tidal Model v3.1 (Newport Strategic Flood Risk Mapping Update) to identify its suitability and limitations for application within the previous Stage 3 SFCA and inform the methodology provided in Section 3 in 2012. NRW was consulted regarding updates to the Newport Tidal Model since the Stage 3 SFCA in 2012. Whilst minor amendments have been made (v3.2), results from the v3.1 model used in 2012 have not been updated (only confidence intervals results). To ensure consistency with the Stage 3 SFCA, results for the v3.1 model have been used within the assessment of additional sites.

2.2.2 The model extent represents a significant portion of the NCC administrative area including Newport City Centre. A fluvial upstream boundary and a tidal downstream boundary have been applied for the River Usk to represent flows within the model. The model has been simulated for a total time of 50 hours; incorporating 4 tidal peaks (see Figure 2.1).

The reference of 'time' within the flood event scenario summary tables for each site provided in Section 4 of this report refers to time from start of model simulation.

2.2.3 The River Usk is represented by a one-dimensional model (ESTRY) which is truncated and hydraulically linked to the land domain using a two-dimensional model (TUFLOW). The model format is considered suitable for the purpose of defining areas of flood inundation within the model extents. A breakdown of the key information following the model review is provided in Table 2.1.

[3] Stage 3 Strategic Flood Consequence Assessment, Data Review and Proposed Stage 3 Methodology, December 2012, prepared by URS for Newport City Council

Table 2.1: Newport Tidal Model Key Information

Model Name	Review Comments
Newport Tidal Model	**1** Appropriate hydraulic representation of the Tidal River Usk only. The flood risk is considered to be predominantly from tidal sources, therefore considered suitable for the Stage 3 SFCA. Model results provided for 1 in 200 year (including climate change scenarios for 100 year lifetime), 1 in 1000 year (including climate change scenarios for 100 year lifetime), 1 in 200 year present day for 5 separate breach locations. However, breach scenarios for climate change were not included therefore required running.
	2 No fluvial hydrology of the River Usk has been undertaken apart from inflows represented by the 1 in 2 year (Qmed) return period. The flood risk is considered to be predominantly from tidal sources, therefore representation of the fluvial flows by the 1 in 2 year combined with a range of tidal return periods is considered appropriate.
	3 No channel cross section representation of the Ebbw River within the model is included. The Ebbw River is represented using LiDAR only with no upstream hydrology. This model cannot presently be used for the representation of the Ebbw River. However, this does not affect the extant planning permission identified for the additional site assessments required for the Stage 3 SFCA.
	4 TUFLOW 2D aspect of the model is multi domain where all areas, except for the Crindau region on the right bank of the River Usk (5m), has been modelled at a 10m grid resolution. This is considered appropriate at the strategic level.
	5 No evidence of model sensitivity has been provided. However, because this has been used by NRW to update Flood Zone designations it is assumed that appropriate sensitivity analysis has been undertaken.

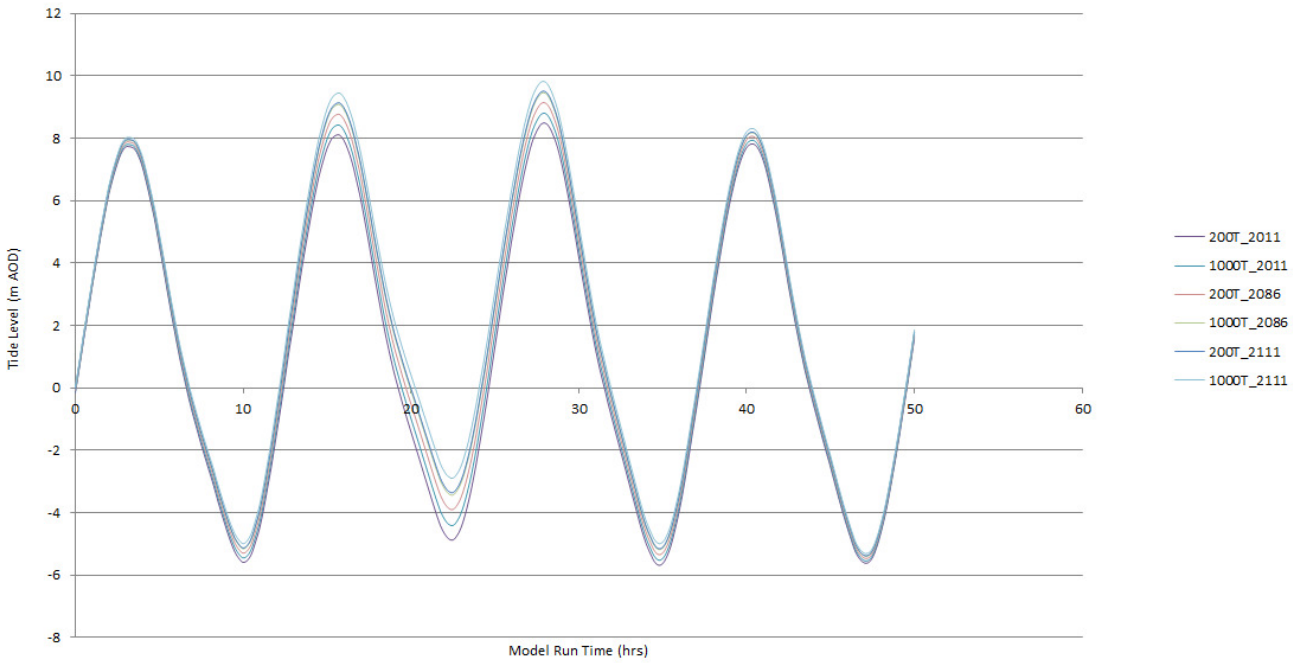


Figure 2.1: Tidal Curve – Newport Model Downstream Boundary

3. SITE ASSESSMENT METHODOLOGY

3.1 Overview

3.1.1 This section provides the methodology for undertaking the additional site assessments and is consistent with the work undertaken for the previous Stage 3 SFCA with minor alterations. The Newport Tidal Model will be utilised to inform the flood consequences at an appropriate spatial scale for the additional sites identified in Section 2.1. This approach allows efficient use of best available existing data whilst providing sufficient information to NCC to inform decisions in the allocation of future development sites where extant planning permission exists.

3.1.2 The adopted approach is based on the review of the Newport Tidal Model undertaken for the previous Stage 3 SFCA and assumes that the dominant risk to sites is from tidal flood sources. The methodology was previously agreed with NCC and NRW for the previous Stage 3 SFCA. Due to the additional sites having extant planning permission, information regarding proposed finished floor levels (where available) was also reviewed.

3.2 TAN15 Requirements

3.2.1 Appendix 1 of TAN15 provides guidance on how the potential consequences of flooding should be considered including technical requirements. Additional guidance regarding development lifetime issued in January 2014 by the Welsh Government has also been accounted for within this assessment. It is noted that there is no specific guidance for SFCAs, however, the following information is provided based on TAN15 and the available data from the Newport Tidal Model:

- Mechanism of flooding (overtopping or breach of existing defences);
- Source of flooding (tidally dominated system);
- Depth of flooding (including time to maximum depth);
- Time of inundation (including time to first and maximum inundation);
- Assessment of flood hazard (combination of depth and velocity);
- Commentary on escape / evacuation routes.

3.2.2 These allow NCC to make an informed decision with regard to Part iv of the Justification Test (see Section 6, TAN15) in the event that the extant planning permission lapses. Part i to Part iii of the Justification Test should be part of NCCs decision process but they are not included within the Stage 3 SFCA.

3.3 Methodology

3.3.1 The following methodology has been adopted to meet the requirements of TAN15 utilising the existing information from the Newport Tidal Model.

1) Based on the spatial location of the additional sites identified for assessment, depth and hazard mapping outputs have been grouped together to provide five sets of figures:

   - H32 Former Sainsbury's / H5 Glebelands Area (Appendix B);
   - H15 Victoria Wharf / H21 Former Floors 2 Go (Appendix C);
   - H9 Frobisher Road (Appendix D);
   - H16 Penmaen Wharf (Appendix E);

- H23 Traston Lane (Appendix F).

2) The maximum depth and hazard mapping for the scenarios provided in Table 3.1 were used to investigate the flood consequences at each of the Revised Deposit LDP Designations. For the purposes of assessing the additional sites only, Scenarios 1, 3, 4, 6, 7 and 9 have been used within this report to account for a 100 year development lifetime for housing.

   The flood hazard classification was generated using modelling outputs in line with the Defra R&D Technical Report FD2320/TR2 (Flood Risk Assessment Guidance for New Development) and accompanying supplementary guidance issued in May 2008 by the Environment Agency and HR Wallingford. The flood hazard is expressed as a combination of flood depth and velocity and is divided into low, moderate, significant or extreme hazard. The maximum flood hazard for a given location can be experienced at any stage of a flood.

   Where overtopping or a breach occurs, high velocities are likely to be experienced and the highest hazard is likely to be experienced at the time of peak velocity. Further from an overtopping or defence breach location, the level of hazard will depend on local factors affecting both the depth and velocity of floodwaters during a flood event. Peak depth and velocities occur predominantly during the peak tidal cycle that is the largest of the four which have been simulated by the hydraulic model (Figure 2.1).

Table 3.1: Scenarios assessed for Stage 3 Assessment

Scenario[1]	Breach[2]	Overtopping	Tidal Return Period	Allowance for Climate Change
1	No	Yes	200 year	-
~~2~~	~~No~~	~~Yes~~	~~200 year~~	~~2086~~
3	No	Yes	200 year	2111
4	No	Yes	1000 year	-
~~5~~	~~No~~	~~Yes~~	~~1000 year~~	~~2086~~
6	No	Yes	1000 year	2111
7	Yes	Yes	200year	-
~~8~~	~~Yes~~	~~Yes~~	~~200year~~	~~2086~~
9	Yes	Yes	200year	2111

[1]Scenarios that have been struck through have not been assessed for additional sites, however scenario numbering has been kept consistent with the previous Stage 3 SFCA to ease cross referencing with the 2013 report.

[2] Breach Location 1 for H5 Glebelands and H32 Former Sainsbury's, Breach Location 3 for H9 Frobisher Road, H21 Former Floors 2 Go and H15 Victoria Wharf; and Breach Location 5 for H16 Penmaen Wharf and H23 Traston Lane.

The review of the Newport Tidal Model identified five breach locations that were modelled. Based on the location of the additional sites and breach locations used within the previous Stage 3 SFCA, an assessment of the effects of breaching of flood defences has been undertaken at Breach Location 1 for H5 Glebelands and H32 Former Sainsbury's, Breach Location 3 for H9 Frobisher Road, H21 Former Floors 2 Go and H15 Victoria Wharf; and Breach Location 5 for H16 Penmaen Wharf and H23 Traston Lane. The locations of these breaches are provided within the relevant site assessment section (see Section 4).

The Newport Tidal Model does not include potential breach locations on the right hand bank of the River Usk and therefore sites located on the right bank are unlikely to be affected (Former

Sainsbury's, Victoria Wharf and Penmaen Wharf). It is likely that the reason for no breach locations on the right hand bank of the River Usk is because there is limited potential flood extent under overtopping conditions when compared with the potential flood extent on the left hand bank.

3) A general summary of the modelling results has been undertaken for each site identified and provides:

   - Flood propagation and depth of overtopping for present day and climate change scenarios;
   - Flood propagation and depth of breach (and overtopping) results for present day and climate change scenarios;
   - Flood hazard.

4) For a representative selected point in each site, a summary table has been provided for each scenario that provides the maximum depth, time of maximum depth, maximum hazard and time of first inundation.

5) For each site, an assessment of the potential escape / evacuation route has been undertaken with reference to the 1 in 200 year event including climate change. This includes an assessment of the time of first overtopping, time of first inundation at the site and the potential escape / evacuation route available. This has also been assessed alongside the availability of the Flood Warnings Direct service.

6) For each site, a high level review of the Flood Consequence Assessment (FCA) has been undertaken, where available, with regard to Finished Floor Levels.

7) Following the above assessments, other considerations have been provided with regard to potential mitigation requirements and suitability for passing the Justification Test to aid NCC in their decision making process.

3.3.2 A summary of the additional site assessed as part of the Stage 3 SFCA is provided in Section 5 of this document.

3.4 Assumptions and Limitations

3.4.1 The following assumptions and limitations have been made based on the review of the model, budgetary and time constraints for NCC and the strategic nature of the study:

- The Newport Tidal Model has been reviewed by NRW and was used to undertake Strategic Flood Risk Mapping, it is understood appropriate sensitivity tests have been undertaken with regard to model confidence intervals;
- The dominant flood risk to the additional sites identified is tidal. Fluvial flood risk is not to be considered as significant as the consequences of tidal flooding. With the exception of the boundary conditions (1 in 2 year fluvial inflow), no fluvial events are considered;
- The methodology is appropriate for the strategic nature of the study and the recent change in policy with regard to development lifetime for housing, in particular, because extant planning permissions may be progressed prior to lapsing and therefore would not form part of the Revised Deposit LDP;
- Assessment of the structural adequacy of existing flood defences and the cost of future maintenance are not considered as part of this assessment;

- With the exception of Scenarios 8 and 9 in Table 3.1, no additional hydraulic model runs have been undertaken. In addition, it is not considered pragmatic to undertake breach scenarios for the 1 in 1000 year event and therefore these have not been included.

4. RESULTS

4.1 Overview

4.1.1 Additional sites identified for assessment through the Stage 3 SFCA process have been grouped into five areas. For each site the results of the Newport Tidal Model (Scenarios 1, 3, 4, 6, 7 and 9) have been used to determine the potential consequences of flooding.

4.1.2 To assess residual risk posed to each site due to defence failure, breach analysis results from the Newport Tidal Model have been used. Suitable breach locations have been selected for each site based on the previous Stage 3 SFCA work.

4.1.3 For each site a description of the flood event scenario results is provided, including guidance on safe escape and evacuation, flood hazard and suitability for development in terms of TAN15. Other site specific considerations are also provided on a site by site basis.

4.2 Former Sainsbury's / Glebelands Area

4.2.1 The Former Sainsbury's / Glebelands Area consists of two sites located to the north of the city centre with one site on the right bank of the River Usk (Former Sainsbury's) and one on the left bank (Glebelands). Figure 4.1 provides an overview of the site locations and indicative flood defences.

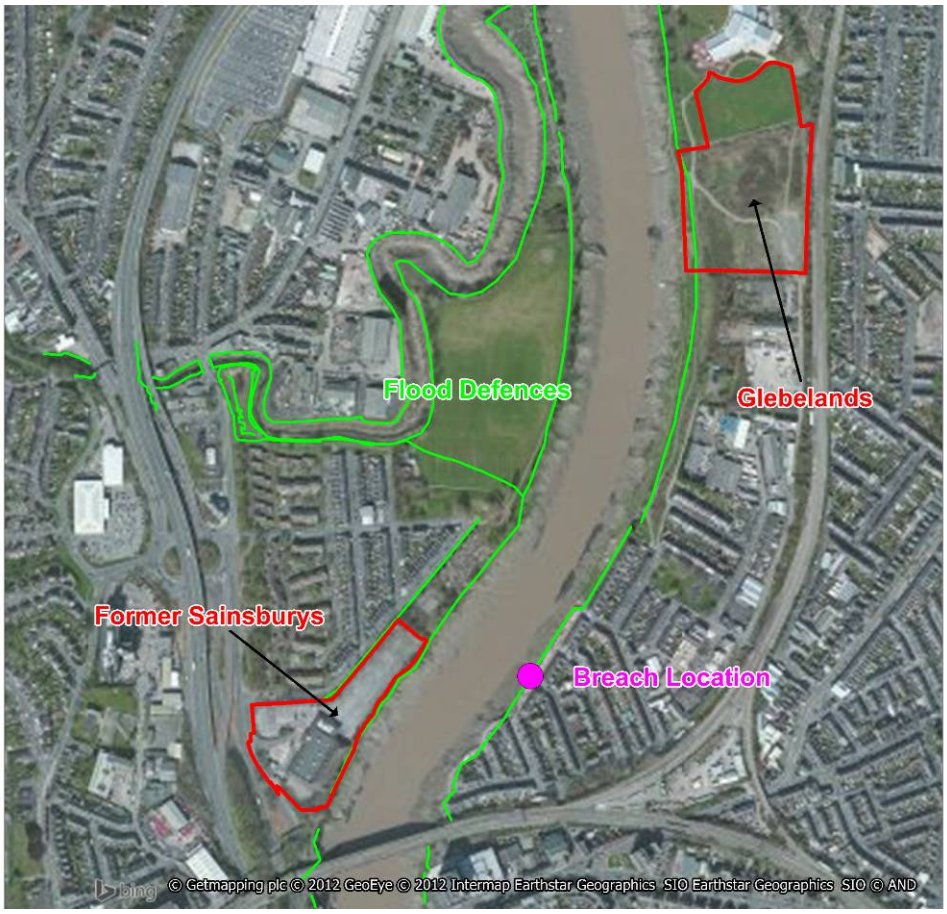


Figure 4.1 – Former Sainsbury's and Glebelands – SFCA Site Locations
(bing © Getmapping plc © 2012 GeoEye © 2012 Intermap Earthstar Geographics SIO Earthstar Geographics SIO © AND)

4.2.2 The National Flood and Coastal Defence Database (NFCDD) dataset indicates that formal defences (earth embankment) exist along the left bank of the River Usk, within close proximity to the Glebelands site. Earth embankments (including those that are not considered as formal defences) range in height from 7.2m AOD and 8.9m AOD on the right bank and between 8.4m AOD and 9.8m AOD on the left bank. These offer flood protection against tidal inundation from the estuary.

4.2.3 The Environment Agency Flood Map indicates that the majority of the Glebelands site is located within an area benefitting from defence, suggesting that existing tidal defences offer a 1 in 200 year Standard of Protection.

4.2.4 In agreement with the NRW, Breach Location 1 (see Figure 4.1), has been selected to assess the impact of a defence breach on each of the Revised Deposit LDP Designations.

4.3 Former Sainsbury's Site (H32)

4.3.1 The Former Sainsbury's site is located on Wyndham Street / Pugsley Street directly adjacent to the right bank of the River Usk. Due to the size and shape of the site, it has been split into two areas. These are identified in Figure 4.2 and are represented as the 'Eastern Region' and 'Western Region'. The figure also shows the points where the depth and hazard calculations were taken from and provided in Table 4.1 and Table 4.2.

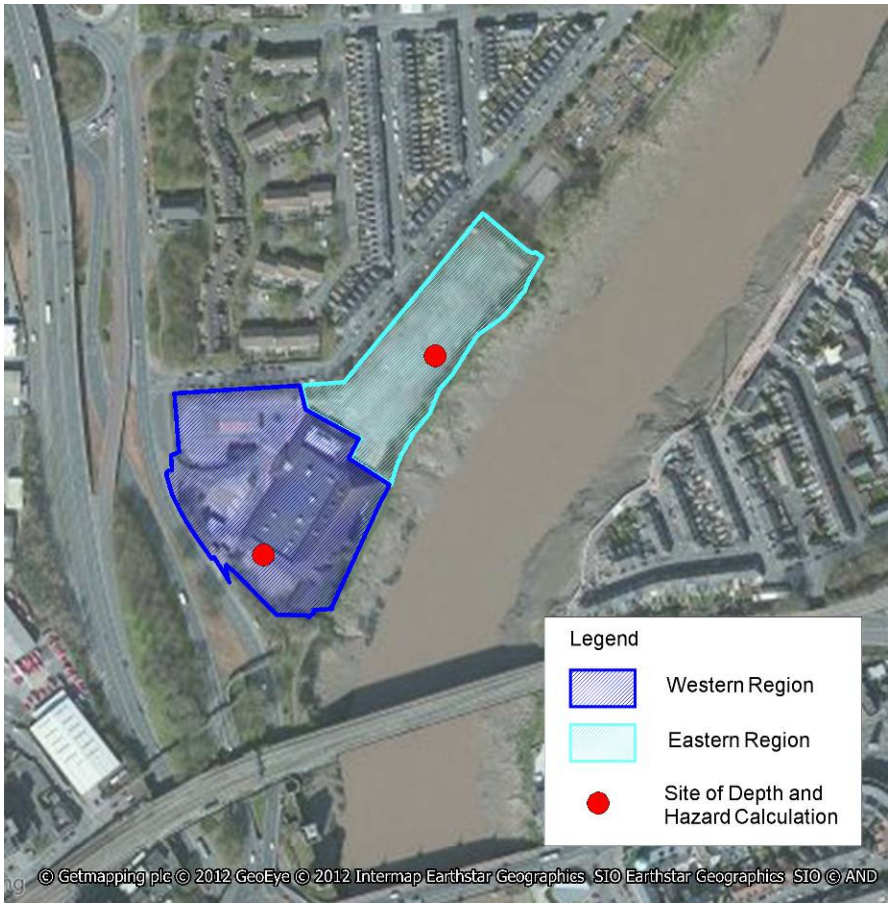


Figure 4.2 – Former Sainsbury's Site – Eastern and Western Region
(bing © Getmapping plc © 2012 GeoEye © 2012 Intermap Earthstar Geographics SIO Earthstar Geographics SIO © AND)

Former Sainsbury's Site (H32) – Eastern Region

4.3.2 A summary of the tidal flood risk for the eastern region of the site is provided in Table 4.1 and flood depth and hazard figures are provided in Appendix B.

Table 4.1: Former Sainsbury's Site – Eastern Region – Flood Event Scenario Summary

Scenario	Maximum Depth (m)	Time of Maximum Depth (hr)	Maximum Hazard	Time of Overtopping (hr)	Time of first Inundation (hr)
1	0.35	28.0	Moderate	15.5	28.0
3	1.28	28.0	Significant	15.0	15.0
4	0.67	28.0	Significant	15.0	15.0
6	1.54	28.0	Extreme	15.0	15.0
7*	0.35	28.0	Moderate	15.5	28.0
9*	1.29	28.0	Significant	15.0	15.0
* a breach to the right bank may result in increased flood consequences					

Present Day (2011)

4.3.3 **200 year Tidal (Scenario 1)** – during Scenario 1, the majority of the eastern region experiences flooding. Table 4.1 indicates that the maximum depth of flooding is 0.35 m. Overtopping first occurs to the north-east approximately 115 m from the site at approximately 15.5 hours into the simulation (second tidal cycle). However, inundation of the site does not occur until 28.0 hours into the simulation which equates to the peak of the third tidal cycle.

4.3.4 **1000 year Tidal (Scenario 4) –** during Scenario 4, the entire eastern region of site becomes inundated with maximum depths of approximately 0.67 m. Similar to Scenario 1, the maximum depth is experienced at 28.0 hours which coincides with the third tidal cycle. Due to the location adjacent to the River Usk, time of overtopping and first inundation occur simultaneously (15.0 hours). Water overtops the southern boundary which is adjacent to the River Usk.

4.3.5 **200 year Tidal: Breach (Scenario 7)** – due to the breach location being situated on the left bank of River Usk, flood consequences from this breach location do not affect the eastern region of the site. However a breach to the right bank may result in increased flood consequences.

Climate Change (2111)

4.3.6 Accounting for climate change up to 2111, the extent and depth of flooding is significantly increased for both the 200 year tidal (Scenario 3) and 1000 year tidal (Scenario 6) flood events. During these events, the majority of the Former Sainsbury's site becomes inundated.

4.3.7 **200 year Tidal (Scenario 3)** – the maximum depth of flooding (1.28 m) within the eastern region of the site is experienced during the third tidal cycle. First overtopping and first inundation occur simultaneously, approximately 15.0 hours into the simulation (second tidal cycle), with overtopping occurring along the southern boundary.

4.3.8 **1000 year Tidal (Scenario 6)** – the maximum depth of flooding during this scenario increases to 1.54 m. Similar to Scenario 3, first overtopping and first inundation occur simultaneously, approximately 15.5 hours into the model simulation.

4.3.9 **200 year Tidal: Breach (Scenario 9)** – The effects of climate change in conjunction with the breach of defences does not significantly affect the flood depth or hazard rating at the site due to the location of the breach on the left bank of the River Usk. However a breach to the right bank may result in increased flood consequences.

Flood Hazard

4.3.10 Flood hazard maps for the scenarios discussed above are provided in Appendix B and illustrate the low, moderate, significant or extreme hazard based on model outputs.

4.3.11 For all present day scenarios (including breach scenarios) the flood hazard ranges from moderate to significant. During the 200 year tidal climate change scenarios (including breach scenarios) the flood hazard is considered significant (i.e. danger for most people). Only during the 1000 year tidal climate change scenario does an extreme hazard rating occur (i.e. danger for all).

Former Sainsbury's Site (H32) – Western Region

4.3.12 A summary of the tidal flood risk for the western region of the site is provided in Table 4.2 and flood depth and hazard figures are provided in Appendix B.

Table 4.2: Former Sainsbury's Site – Western Region – Flood Event Scenario Summary

Scenario	Maximum Depth (m)	Time of Maximum Depth (hr)	Maximum Hazard	Time of Overtopping (hr)	Time of first Inundation (hr)
1	-	-	None	15.5	-
3	1.25	28.0	Significant	15.0	15.5
4	0.40	29.0	Low	15.5	28.0
6	1.50	28.0	Significant	15.0	15.5
7	-	-	None	15.5	-
9	1.25	28.0	Significant	15.0	15.5
* a breach to the right bank may result in increased flood consequences					

Present Day (2011)

4.3.13 **200 year Tidal (Scenario 1)** – No flooding is observed within the western region of the site during this event. Overtopping is experienced during the third tidal cycle within the vicinity but floodwater does not propagate into the site boundary.

4.3.14 **1000 year Tidal (Scenario 4) –** During this scenario maximum flood depths of approximately 0.40 m are experienced which occur during the third tidal cycle. Overtopping within the western region occurs 15.5 hours into the simulation; however widespread inundation of the site is not experienced until 28.0 hours. Inundation occurs from two overtopping locations located to the north-east and south-west. Flooding occurs around the site boundary with a large area within the centre of the site remaining dry.

4.3.15 **200 year Tidal: Breach (Scenario 7)** – Due to the breach being situated on the left bank of River Usk, flood consequences from the breach location do not affect the site. However a breach to the right bank may result in increased flood consequences.

Climate Change (2111)

4.3.16 Accounting for climate change up to 2111, the extent and depth of flooding is significantly increased for both the 200 year tidal (Scenario 3) and 1000 year tidal (Scenario 6) flood events. During these events, the majority of the western region of the site becomes inundated.

4.3.17 **200 year Tidal (Scenario 3)** – During this scenario, first overtopping occurs 15.0 hours into the simulation with inundation occurring in the western region at 15.5 hours. Maximum flood depths reach approximately 1.25 m during the third tidal cycle (28.0 hours).

4.3.18 **1000 year Tidal (Scenario 6)** – the maximum depth of flooding within the western region of the site during this Scenario increases to 1.50 m. Similar to Scenario 3, first overtopping occurs at 15.0 hours into the simulation, with first inundation occurring at 15.5 hours.

4.3.19 **200 year Tidal: Breach (Scenario 9)** – The effects of climate change in conjunction with the breach of defences does not significantly affect the flood depth or hazard rating at the site due to the location of the breach on the left bank of the River Usk. However a breach to the right bank may result in increased flood consequences.

Flood Hazard

4.3.20 Flood hazard maps for the scenarios discussed above are provided in Appendix B and illustrate the low, moderate, significant or extreme hazard based on model outputs.

4.3.21 For all present day scenarios (including breach scenarios) the flood hazard ranges from none to significant within the western region of the site. During the climate change scenarios (including breach scenarios) the predominant hazard rating is significant (i.e. danger for most people).

Escape / Evacuation

4.3.22 To ensure escape / evacuation routes from the site are considered over the development lifetime, the 200 year tidal (2111) (Scenario 3) flood event has been selected.

4.3.23 The primary escape / evacuation route from the site is north along Hoskins Road and then immediately west along Evans Street (see Figure 4.3).

4.3.24 The access and egress for the site has been assessed at the time of first overtopping in the region. At this time, with adequate warning, the evacuation route shown in Figure 4.3 (i) is achievable. In the unlikely event that no prior flood warning is given, the model results indicate that from the first time of overtopping (15 hours), a 0.5 hour period is available for site evacuation via the escape / evacuation route identified. After this time, the escape / evacuation route becomes inundated with floodwater (Figure 4.3 (ii)). With no mitigation, potential access routes at the peak of the flood event are unachievable.

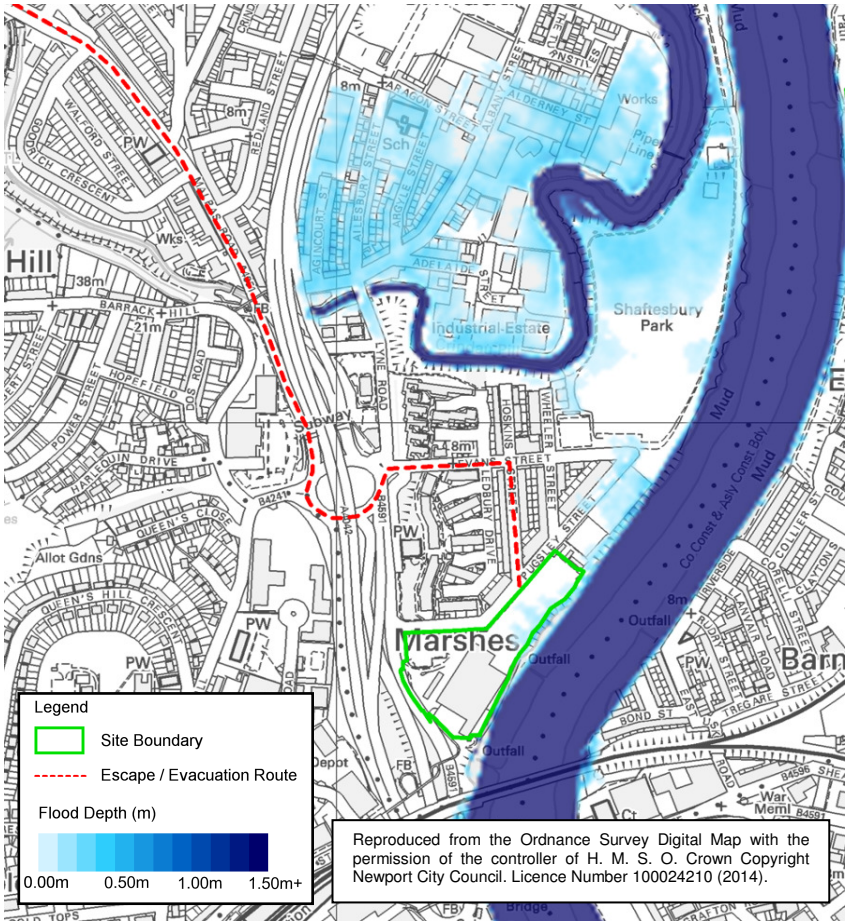


Figure 4.3 (i) – Escape / Evacuation Route – Former Sainsbury's

- 200 year Tide Return Period (2111)
- Time of First Overtopping of Region
- 15.0 Hours

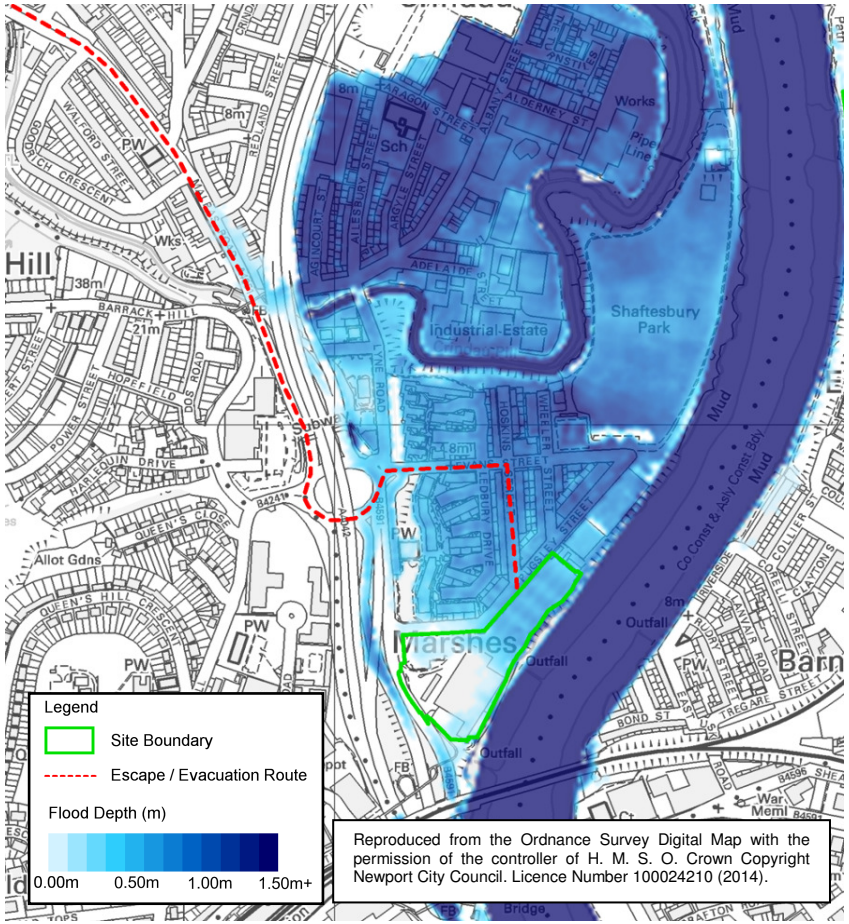


Figure 4.3 (ii) – Escape / Evacuation Route – Former Sainsbury's

- 200 year Tide Return Period (2111)
- Time when Escape / Evacuation Route becomes inaccessible
- 15.5 Hours

TAN15 Justification of Development

4.3.25 TAN15 Appendix 1 provides indicative guidance on the return period threshold for different types of development, including acceptability criteria, in terms of what is considered tolerable conditions. The site is currently included within the Revised Deposit LDP Designations as a potential housing site and therefore the acceptability criteria for residential development based on the 200 year tidal (2111) event has been selected to assess the sites suitability for development.

4.3.26 TAN15 Appendix 1 indicates that the maximum flood depth considered tolerable within a residential development is 0.6 m. Figure 4.4 indicates areas across the site with flood depths less than 0.6 m (shaded green), between 0.6 m and 1.0 m (shaded blue) and greater than 1.0 m (shaded purple).

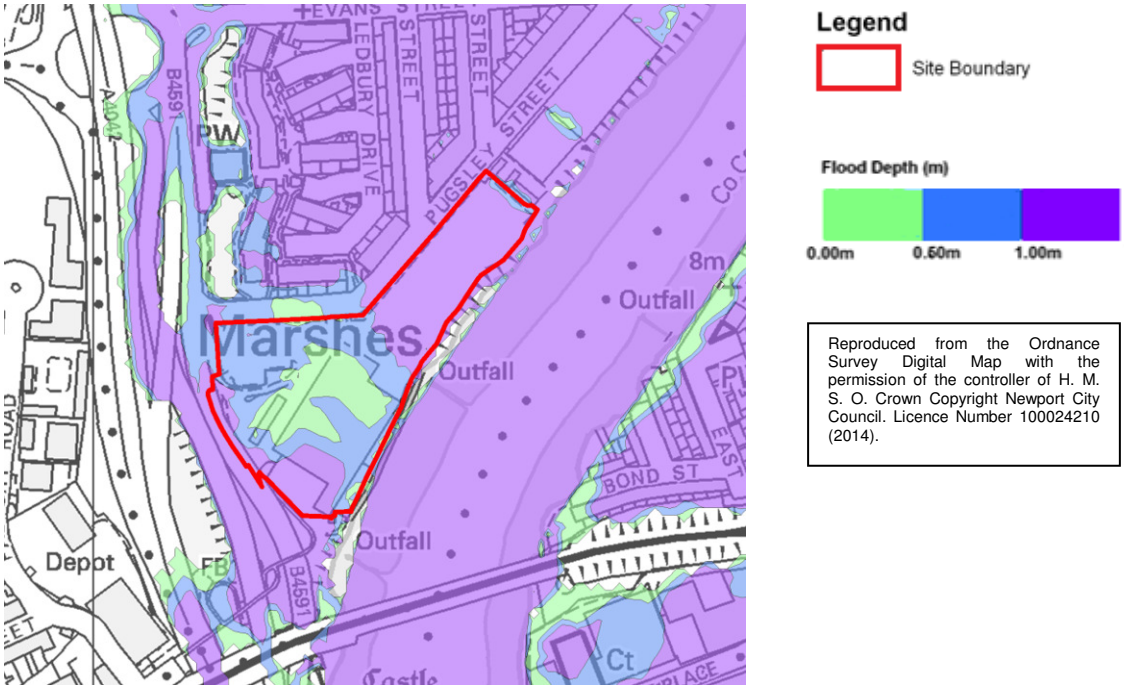


Figure 4.4: Scenario 3: 200 year Tide (2111) - Flood Depth Bands

4.3.27 Figure 4.4 indicates that the majority of the eastern region of the site experiences a depth of 1.0m or greater, indicating that climate change poses constraints to the development within this area of the site. Furthermore, the hazard associated with Scenario 3 (Appendix B) indicates that the site experiences a hazard rating of 'Significant' within this region. However, in the western region there are areas where flood depths are less than 0.6 m which is within the tolerable threshold for residential development.

4.3.28 TAN15 Appendix 1 also indicates the maximum speed of inundation of flood risk considered tolerable for residential development (4 hours). As discussed above, during the 200 year tidal (2111) event without mitigation the maximum speed of inundation of flood risk at the site is considered to be outside tolerable limits set out within TAN15 Appendix 1.

4.3.29 Although small areas of the site are suitable for residential development, substantial mitigation measures would still be required to enable development of the entire site to justify

development in line with part iv of the Justification Test in TAN15. Mitigation measures may include raising flood defences, raised ground levels or finished floor levels. However, the viability of delivering such measures is not tested within this SFCA. Furthermore, a breach to the right bank may further increase the level of risk to the site.

4.3.30 The Flood Warnings Direct service covers this area and would provide advance warning of flooding for evacuation of the site or retreat to a safe position, before the onset of flood waters.

Existing Flood Consequence Assessment

4.3.31 A Flood Consequence Assessment (FCA) for the site was undertaken in 2008 (a high level assessment) to inform potential development proposals. This identifies that the site would require significant land raising to a minimum of 9.55 mAOD for property finished floor levels and a minimum of 9.26 mAOD for access. Evacuation routes and velocity of flood water have not been assessed within the FCA.

Other Considerations

4.3.32 If this site is considered by NCC to pass the other elements of the Justification Test and becomes adopted within the LDP, a detailed site specific FCA will be required to support the planning application in line with the revised TAN15 Guidance. Consultation with the NRW and other relevant stakeholders will be required to ensure the layout and design of the site is safe for the lifetime of the development. In addition, the following considerations should also be made:

- Surface water management measures should include SuDS (see Stage 2 SFCA for general details), should ensure flood risk to third parties is not increased and that the site does not pose a flood risk to itself.
- Detailed breach analysis may be required to further understand the residual risk posed to areas on the right bank of the River Usk (including the Former Sainsbury's site) and inform development design and layout;
- Raising of ground levels at this site would be required to ensure maximum flood depth threshold is not exceeded in line with TAN15 Appendix 1. A review of minimum ground and finished floor levels provided within the existing FCA is required due to recently updated modelling data superseding information within the FCA;
- Floodplain compensation is unlikely to be required at this location due to the predominant flood source being tidal;
- A site evacuation and escape plan would be required to ensure the safety of occupiers and users.

Former Sainsbury's Conclusions

4.3.33 The following conclusions for the Former Sainsbury's Site have been made:

- Under present day conditions (i.e. no inclusion of climate change) tidal overtopping is the most significant cause of flooding;
- The effect of a breach in the (right bank) embankment defence has not been undertaken but it is recommended that this should be completed within any future site specific studies;

- Climate change is the predominant control upon future flooding;
- The location of the site situated adjacent to the existing embankment defence line, there is a strong correlation between the time of overtopping and the time of first inundation;
- The site experiences a varying degree of flood depth, hazard and time to first inundation dependant on the flooding scenario. When considering climate change, the hazard rating is significant to extreme depending on location within the site;
- Where land is allocated for development, a detailed site specific FCA will be required, building on the information in this report and in consultation with NRW. This should incorporate additional information on mitigation of residual risk and emergency planning procedures to ensure escape / evacuation for the lifetime of the development.

4.4 Glebelands (H5)

4.4.1 The proposed Glebelands site is located on the left bank of the River Usk, north of Herbert Road and directly south of Glan Usk Primary School. The site is located immediately adjacent to the River Usk. A summary of the tidal flood risk at the site is provided in Table 4.3.

Table 4.3: Glebelands Site – Flood Event Scenario Summary

Scenario	Maximum Depth (m)	Time of Maximum Depth (hr)	Maximum Hazard	Time of first Overtopping (hr)	Time of first Inundation (hr)
1	-	-	-	-	-
3	2.01	28.5	Extreme	15.5	15.5
4	-	-	-	-	-
6	2.45	29.5	Extreme	16.5	16.5
7	-	-	-	15.5	-
9	2.07	28.5	Extreme	15.5	15.5

Present Day (2011)

4.4.2 **200 year Tidal (Scenario 1 and 4)** – No flooding is observed at the site during this event. Existing defences (raised embankment) along the eastern bank of the River Usk provide protection from overtopping during this event.

4.4.3 **200 year Tidal: Breach (Scenario 7)** – Similar to Scenario 1, no flooding is observed at the site in the event of a defence breach. Inundation occurs at the breach location (approximately 500 m south of the site) during the second and third tidal cycle and floodwater propagates north but does not affect the site.

Climate Change (2111)

4.4.4 Accounting for climate change up to 2111, the extent and depth of flooding is significantly increased for both the 200 year tidal (Scenario 3) and 1000 year tidal (Scenario 6) flood events within the vicinity of the site.

4.4.5 **200 year Tidal (Scenario 3)** – during this climate change scenario, the site experiences inundation from tidal floodwater. With the site located immediately adjacent to the River Usk, first overtopping and first inundation occur simultaneously, approximately 15.5 hours into the simulation. Maximum depths on site are approximately 2.0 m which occur during the third tidal cycle (28.5 hours). To the north of the site there is an area where flood depths are slightly less at approximately 0.5 m or less.

4.4.6 **1000 year Tidal (Scenario 6)** – first overtopping and first inundation occur simultaneously approximately 16.5 hours (second tidal cycle) into the model simulation. Maximum flood depths increase to approximately 2.45 m during the third tide cycle (29.5 hours).

4.4.7 **200 year Tidal: Breach (Scenario 9)** – The effects of climate change and the breach location does not provide a notable difference in flood depth and time of inundation. Inundation occurs at the same time of overtopping (15.5 hours) and is not associated with the breach. Maximum flood depths on site are approximately 2.07 m (experienced during the third tidal cycle), which is slightly greater than those experienced in Scenario 3. This slight increase is due to the location of the breach which allows floodwater to propagate north.

Flood Hazard

4.4.8 Flood hazard maps for scenarios discussed above are provided in Appendix B and illustrate the low, moderate, significant or extreme hazard based on model outputs.

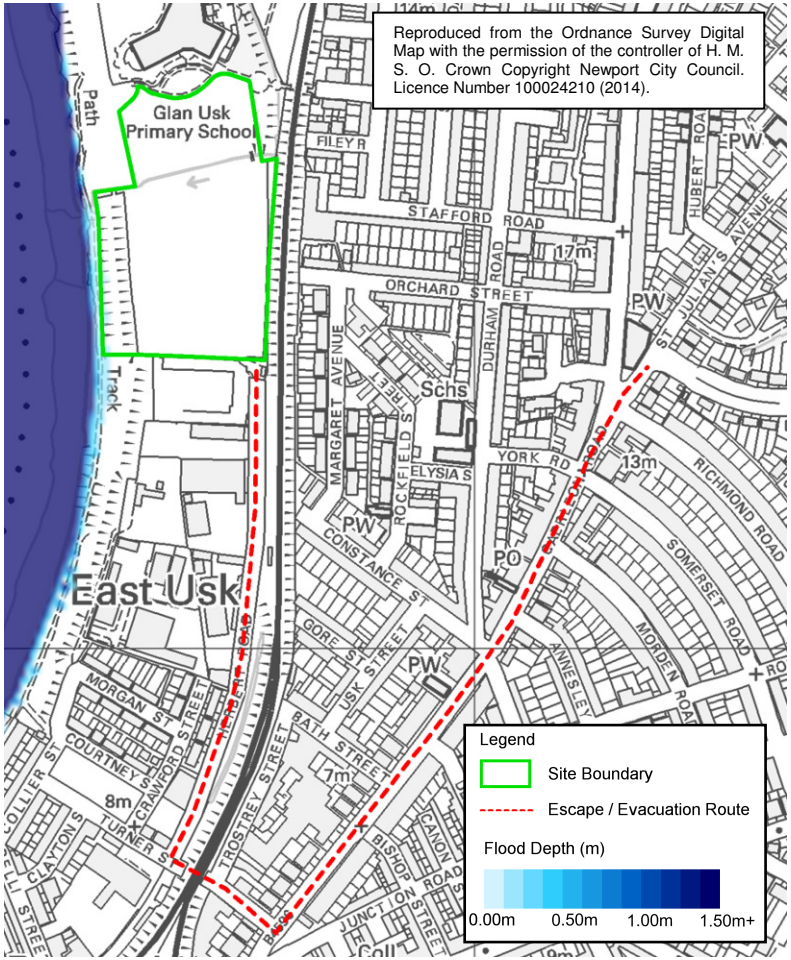
4.4.9 For all present day scenarios (including the breach scenario) the site remains outside of the maximum flood extent and therefore no flood hazard is observed. During the climate change scenarios (including the breach scenario) flood hazard at the site ranges from low to extreme, however, the extreme (i.e. danger for all people) rating is dominant.

Escape / Evacuation

4.4.10 To ensure escape / evacuation routes from the site are considered over the development lifetime, the 200 year tidal (2111) (Scenario 3) flood event has been selected.

4.4.11 The suggested escape / evacuation route from the site is provided via Herbert Road leading south towards Turner Street and left onto the B4595 (Caerleon Road), the closest area which is considered to be within Flood Zone 1 and accessible (Figure 4.5).

4.4.12 The access and egress for the site has been assessed at the time of first overtopping. At this time, with adequate warning the evacuation route shown in Figure 4.5 (i) is achievable. In the unlikely event that no prior flood warning is given, the model results indicate that from the time of first overtopping (15.0 hours), a 1.0 hour period is available for site evacuation via the escape / evacuation route identified (Figure 4.5 (ii)). After this time, the escape / evacuation route from the site becomes inundated with floodwaters.



- **Figure 4.5 (i) – Escape / Evacuation Route – Glebelands**
- - 200 year Tide Return Period (2111)
- - Time of First Overtopping of Region
- - 15.0 Hours

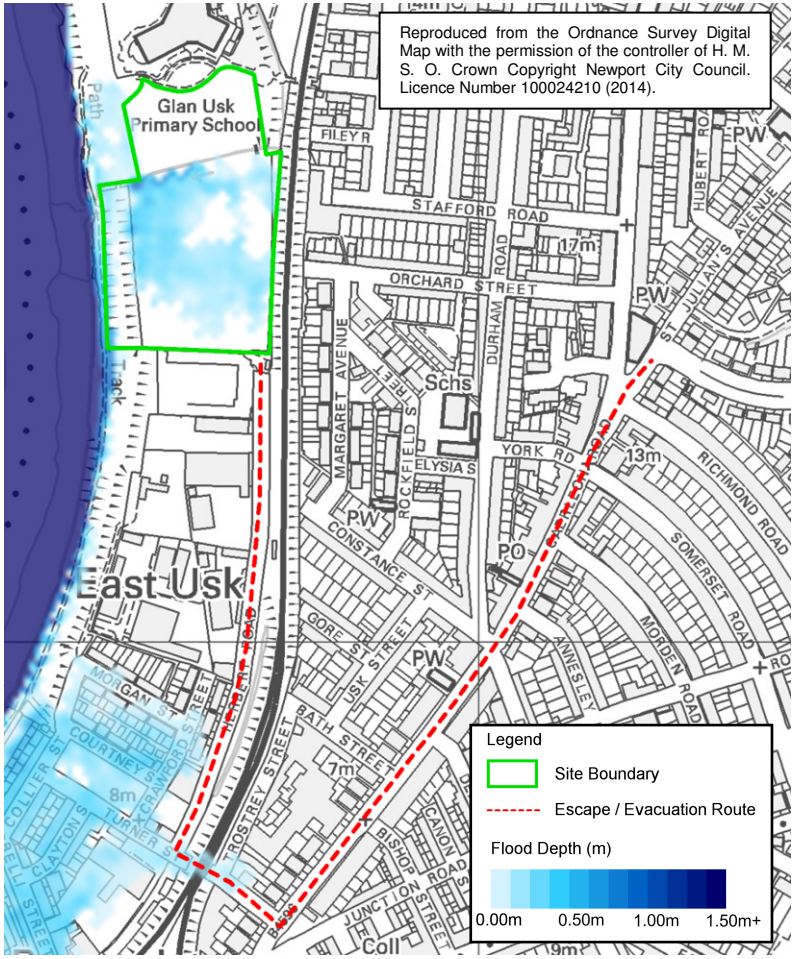


Figure 4.5 (ii) – Escape / Evacuation Route – Glebelands

- 200 year Tide Return Period (2111)
- Time when Escape / Evacuation Route becomes inaccessible
- 16.0 Hours

TAN15 Justification of Development

4.4.13 TAN15 Appendix 1 provides indicative guidance on the return period threshold for different types of development, including acceptability criteria, in terms of what is considered tolerable conditions. The Glebelands site is included within the Revised Deposit LDP Designations as a potential housing site and therefore the acceptability criteria for residential development based on the 200 year tidal (2111) (Scenario 3) event has been selected to assess the sites suitability for development.

4.4.14 TAN15 Appendix 1 indicates that the maximum flood depth considered tolerable within a residential development is 0.6 m. Figure 4.6 indicates areas across the site with flood depths less than 0.6 m (shaded green), between 0.6 m and 1.0 m (shaded blue) and greater than 1.0 m (shaded purple).

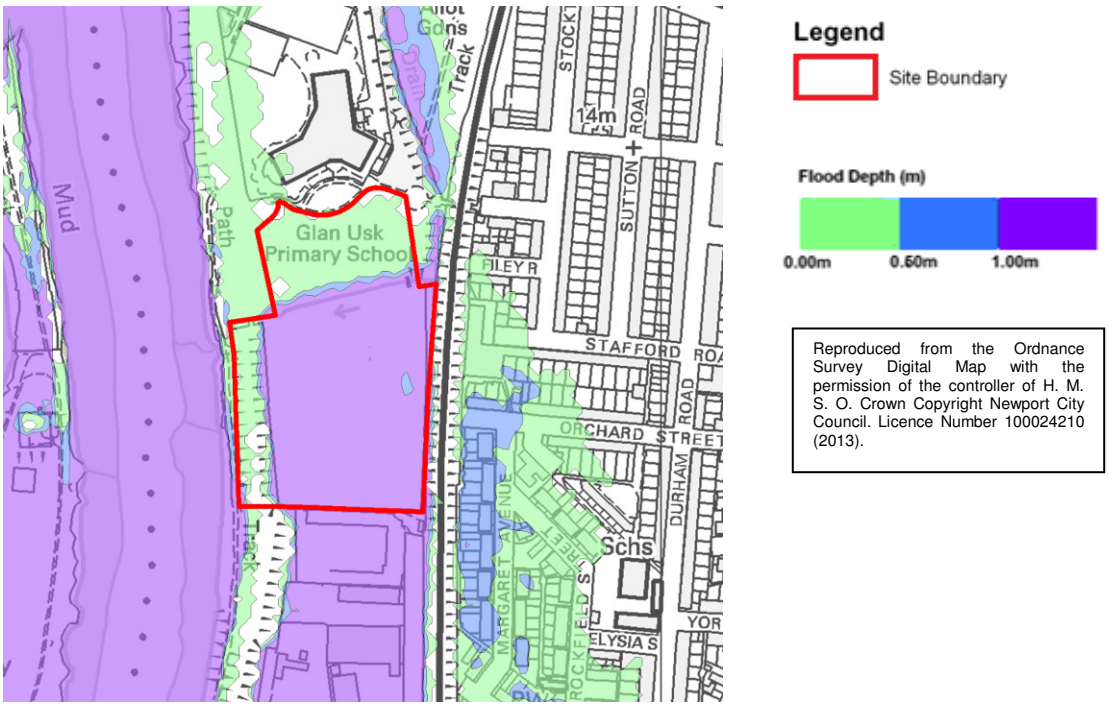


Figure 4.6: Scenario 3: 200 year Tide (2111) - Flood Depth Bands

4.4.15 Figure 4.6 indicates that the majority of the site experiences depths of 1.0 m or greater, indicating that climate change poses a constraint to the development of the site. There is a small area within the north of the site which experiences flood depths of 0.6 m or less. This area is considered to be within the tolerable limits of the TAN15 Appendix 1 acceptability criteria.

4.4.16 TAN15 Appendix 1 also indicates the maximum speed of inundation of flood risk considered tolerable for residential development (4 hours). As discussed above, during the 200 year tidal (2111) event without mitigation the maximum speed of inundation of flood risk at the site is considered to be outside tolerable limits set out within TAN15 Appendix 1.

Existing Flood Consequence Assessment

4.4.17 No FCA was available for the site, however, planning permission was granted in 2000 with associated conditions relating to flood prevention. These have been reviewed and Condition 10: Flood Prevention stated that:

> '*Prior to any construction work occurring on site, the site shall be raised to a level of 9.8 mAOD with the finished floor levels of all development set 600 mm above the 9.8 metres standard in accordance with details which shall first be submitted to and approved in writing by the Local Planning Authority. These details shall include the following: (i) comprehensive cross sectional drawings illustrating existing and proposed land levels across the site, the relationship between existing and proposed development, and confirmation of finished slab levels'.*

4.4.18 In addition, Condition 13 stated that:

> *'No development shall commence on the construction of the approved scheme until a scheme for the disposal of foul and surface water has been submitted to and approved in writing by the Local Planning Authority. No part of the development shall be occupied/used until the scheme has been implemented and completed in accordance with the approved details'.*

Other Considerations

4.4.19 If this site is considered by NCC to pass the other elements of the Justification Test and becomes adopted within the LDP, a site-specific FCA will be required to support a renewed planning application if extant planning permission lapses. Consultation with the NRW and other relevant stakeholders will be required to ensure the layout and design of the site is safe for the lifetime of the development. In addition, the following considerations should also be made:

- Raising of ground levels at the site would be required to ensure that the maximum flood depth threshold is not exceeded, in line with TAN15 Appendix 1. Floodplain compensation is unlikely to be required at this location due to the predominant flood source being tidal;
- Surface water management measures should include SuDS (see Stage 2 SFCA for general details), and should ensure flood risk to third parties is not increased and that the site does not pose a flood risk to itself;
- Surface water management would require taking consideration of potential tide locking of outfalls to the River Usk into the design;

- A site evacuation and escape plan would be required to ensure the safety of occupiers and users.

Glebelands Conclusions

4.4.20 The following conclusions for the Glebelands Site have been made:

- Under present day conditions (200 year tidal including breach scenario and 1000 year tidal) no inundation of the site is experienced;
- Climate change is the predominant factor with regard to future flooding;
- The location of the site, situated adjacent to the existing embankment defence line, results in strong correlation between the time of first overtopping and the time of first inundation for climate change scenarios;
- For the climate change scenarios the predominant hazard rating is extreme;
- Where land is allocated for development and if extant planning permission lapses, a site-specific FCA will be required, building on the information in this report. This should incorporate additional information on mitigation of residual risk and emergency planning procedures to ensure escape / evacuation for the lifetime of the development.

4.5 Victoria Wharf / Former Floors 2 Go

4.5.1 The Victoria Wharf site is located on the right bank of the River Usk and the Former Floors 2 Go site is located on the left bank, approximately 250 m inland from the River Usk, both are within the vicinity of the George Street Bridge. Figure 4.7 provides an overview of the site locations.

4.5.2 The maximum flood depth and hazard maps for all modelled scenarios considered within this are provided in Appendix C.

Figure 4.7 – Victoria Wharf and Former Floors 2 Go – SFCA Site Locations *(bing © Getmapping plc © 2012 GeoEye © 2012 Intermap Earthstar Geographics SIO Earthstar Geographics SIO © AND)*

4.5.3 The predominant flood source within this area is tidal flooding from the River Usk. The NFCDD dataset indicates that no known formal defences are present on either the right or left bank of

the River Usk in the vicinity of the George Street Bridge. However, the Environment Agency Flood Map indicates that the Former Floors 2 Go site is located within an area benefiting from defence, suggesting that existing non-formal flood defences present within this area offer protection to the Former Floors 2 Go site.

4.6 Victoria Wharf (H15)

4.6.1 The proposed Victoria Wharf site is located on the right bank of the River Usk Estuary. The site is accessed via Usk Way (A4042), which borders the western boundary of the site. A summary of the tidal flood risk at the site is provided in Table 4.4.

Table 4.4: Victoria Wharf – Flood Event Scenario Summary

Scenario	Maximum Depth (m)	Time of Maximum Depth (hr)	Maximum Hazard	Time of Overtopping (hr)	Time of first Inundation (hr)
1	<0.1	28	Low	28	28
3	1.1	28	Significant	15	15
4	0.34	28	Moderate	27.5	27.5
6	1.35	28	Significant	15	15
7*	<0.1	28	Low	28	28
9*	1.0	28	Significant	15	15
* a breach to the right bank may result in increased flood consequences					

Present Day (2011)

4.6.2 **200 year Tidal (Scenario 1)** – The majority of the site remains dry during Scenario 1 with shallow flooding (<0.1m in depth) experienced towards the southern boundary adjacent to the 'Jack's Pitt' inlet. Due to the river front location the time of overtopping, first inundation and maximum flood depth occurs simultaneously after 28 hours during the third tidal cycle.

4.6.3 **1000 year Tidal (Scenario 4)** – During the peak of the third tidal cycle, tidal flood waters overtop the river bank and inundate the majority of the site, with a maximum flood depth of 0.34m. Due to the river front location the time of overtopping, first inundation and maximum flood depth all occur within 30 minutes of each other.

4.6.4 **200 year Tidal: Breach (Scenario 7)** – Due to the breach location being situated on the left bank of the River Usk, flood consequences from the breach do not affect the site. However a breach to the right bank may result in increased flood consequences.

Climate Change (2111)

4.6.5 Accounting for climate change up to 2111, the extent and depth of flooding is significantly increased for both the 200 year tidal (Scenario 3) and 1000 year tidal (Scenario 6) flood events.

4.6.6 **200 year Tidal (Scenario 3)** – the maximum depth of flooding at the site (1.1 m) is experienced during the third tidal cycle. However, the time of first overtopping and first inundation for this climate change event is during the second tidal cycle (15 hours).

4.6.7 **1000 year Tidal (Scenario 6)** – the maximum depth of flooding at the site (1.35 m) is experienced during the third tidal cycle. However, the time of first overtopping and first inundation for this climate change event is during the second tidal cycle (15 hours).

4.6.8 **200 year Tidal: Breach (Scenario 9)** – Due to the breach location being situated on the left bank of the River Usk, flood consequences from the breach Location do not affect the site. However a breach to the right bank may result in increased flood consequences.

Flood Hazard

4.6.9 Flood hazard maps for the scenarios shown in Table 4.4 are provided in Appendix C and illustrate the low, moderate, significant or extreme hazard based on model outputs.

4.6.10 The majority of the site is located outside of the 200 year tidal (Scenario 1) flood extent; however the southern area of the site, inundated with floodwaters, is considered to have a maximum flood hazard of low. The 1000 year tidal (Scenario 4) maximum flood hazard at the site is moderate (i.e. danger for some people), although the predominant hazard is low

4.6.11 For all climate change scenarios the predominant (and maximum) flood hazard at the Victoria Wharf site is significant (i.e. danger for most people).

4.6.12 Although the 200year tidal climate change breach scenario (Scenario 9) has a maximum hazard of significant, due to the breach location (Breach Location 3, Figure 4.7) being situated on the left bank of the River Usk, flood consequences from Breach Location 3 do not affect the site. However a breach to the right bank may result in increased flood consequences.

Escape / Evacuation

4.6.13 To ensure escape / evacuation routes from the site are considered over the development lifetime, the 200 year tidal (2111) (Scenario 3) flood event has been selected.

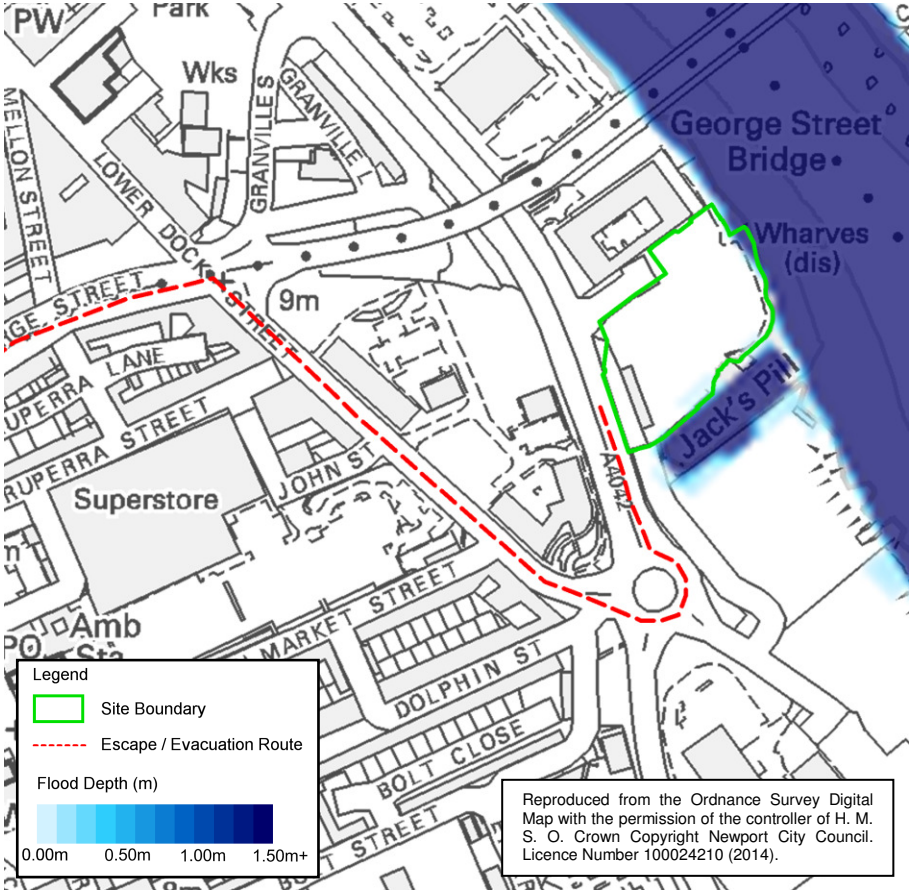


Figure 4.8 (i) – Escape / Evacuation Route – Victoria Wharf

- 200 year Tide Return Period (2111)
- Time of First Overtopping of Region
- 15.0 Hours

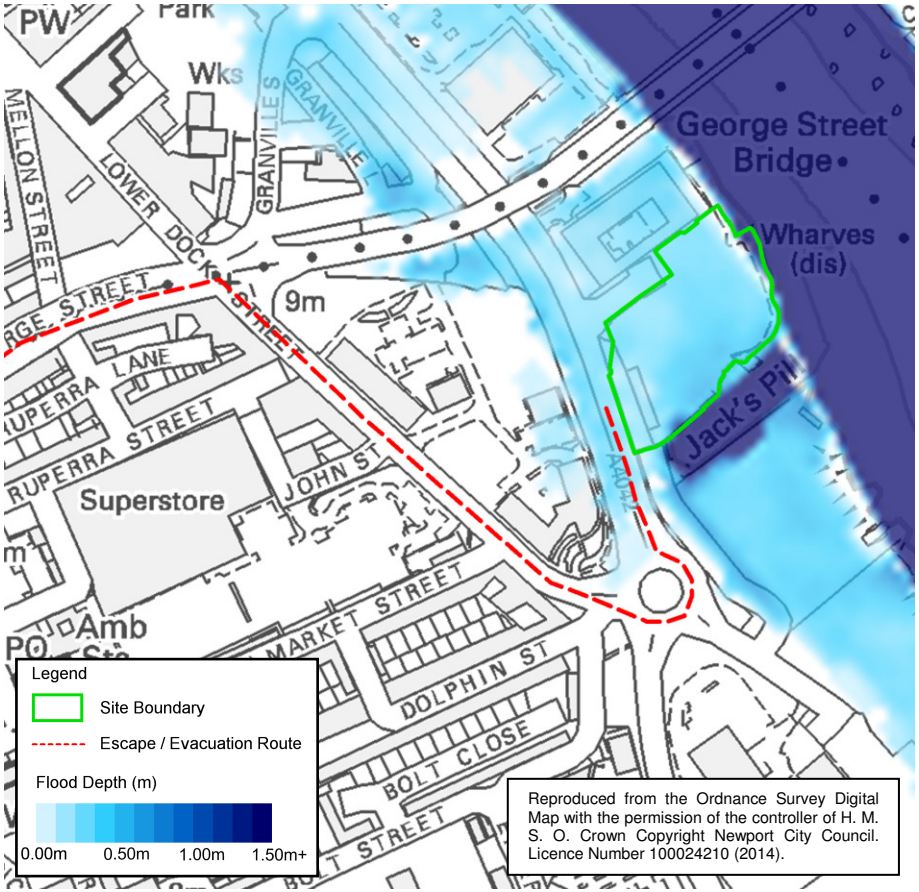


Figure 4.8 (ii) – Escape / Evacuation Route – Victoria Wharf

- 200 year Tide Return Period (2111)
- Time when Escape / Evacuation Route becomes inaccessible
- 15.5 Hours

4.6.14 The suggested escape / evacuation route from the site to the limit of the floodplain is south along Usk Way (A4042), then north-west along Lower Dock Street and then west along George Street (B4237) (Figure 4.8).

4.6.15 The maximum flood depth and hazard mapping for Scenario 3 provided in Appendix C, indicates that the distance of this suggested route to the limit of the floodplain is approximately 600 m, with a maximum hazard of significant (i.e. danger for most people).

4.6.16 In the unlikely event that no prior flood warning is given the model results indicate that there is limited time available to evacuate the site between the time of first overtopping (15 hours) and time when the escape / evacuation route becomes inaccessible (15.5 hours).

4.6.17 Figure 4.8 (ii) indicates the flood extent and associated flood depths after 15.5 hours.

TAN15 Justification of Development

4.6.18 TAN15 Appendix 1 provides indicative guidance on the return period threshold for different types of development, including acceptability criteria, in terms of what is considered tolerable conditions. The Victoria Wharf site is included within the Revised Deposit LDP Designations as a potential housing site and therefore the acceptability criteria for residential development based on the 200 year tidal (2111) event has been selected to assess the sites suitability for development.

4.6.19 TAN15 Appendix 1 indicates that the maximum flood depth considered tolerable within a residential development is 0.6 m. Figure 4.9 indicates that flood depths across the site are predominantly greater than 0.6 m (shaded blue) with flood depths in the south of the site exceeding 1.0m.

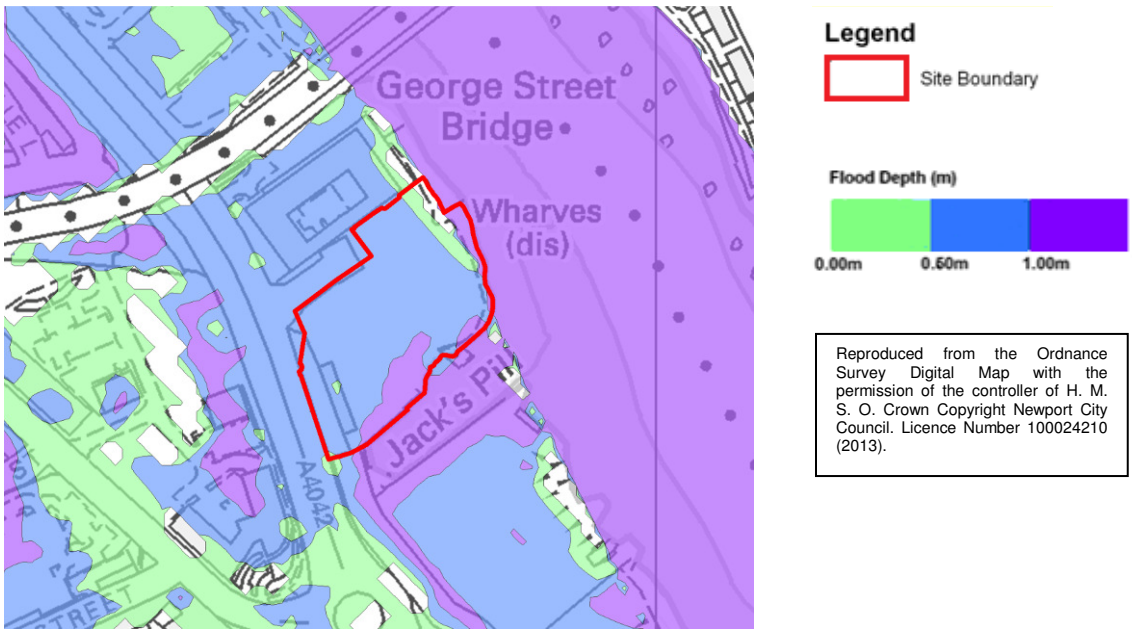


Figure 4.9: Scenario 3: 200 year Tide (2111) - Flood Depth Bands

4.6.20 The results indicate that climate change poses significant constraints to the development of the site. Substantial mitigation measures would be required to justify development in line with Part iv of the justification test in TAN15. Mitigation measures may include a combination of raising flood defences, raising ground levels and ensuring minimum finished flood levels are set sufficiently above the 200 year tidal (2011) flood level to ensure flood depths are within tolerable limits in line with the acceptability criteria within TAN15 Appendix 1. However, the viability of delivering such measures is not tested within this SFCA.

4.6.21 TAN15 Appendix 1 also indicates the maximum speed of inundation of flood risk considered tolerable for residential development (4 hours). As discussed above, during the 200 year tidal (2111) event without mitigation the maximum speed of inundation of flood risk at the site is considered to be outside tolerable limits set out within TAN15 Appendix 1.

Existing Flood Consequence Assessment

4.6.22 It is understood from NCC that planning permission for Victoria Wharf has lapsed. No FCA was available for this site; however, NCC indicated that minimum finished floor levels must be constructed at a level of at least 9.075 mAOD.

Other Considerations

4.6.23 If this site is considered by NCC to pass the other elements of the Justification Test and becomes adopted within the LDP, a site specific FCA will be required to support the planning application. Consultation with NRW and other relevant stakeholders will be required to ensure the layout and design of the site is safe for the lifetime of the development. In addition, the following considerations should also be made:

- Raising of ground levels at this site would be required to ensure that the maximum flood depth threshold is not exceeded, in line with TAN15 Appendix 1. Floodplain compensation is unlikely to be required at this location due to the predominant flood source being tidal;
- Surface water management measures should include SuDS (refer to Stage 2 SFCA for general details) and consideration of potential tide locking of outfalls to the River Usk should be taken into account;
- A site evacuation plan and escape plan would be required to ensure the safety of occupiers and users.

Victoria Wharf Conclusions

4.6.24 The following conclusions for the Victoria Wharf site have been made:

- Under present day conditions the majority of the site remains dry during the 200 year tidal event (including breach scenarios). However, the entire site would be inundated with flood water during the present day 1000 year tidal event;
- Under climate change conditions the flood depths across the entire site increase significantly with a maximum flood depth of 1.1m during the 200 year tidal (2111) event and 1.35m during the 1000 year tidal (2111) event;
- Due to the river bank location of the site, the time of first overtopping and the time of first inundation occurs almost simultaneously. Therefore, without prior flood warning there is currently limited time available to evacuate the site;

- The predominant hazard is significant during the 200 year tidal and 1000 year tidal climate change scenarios;
- Where land is allocated for development, an updated or new site-specific FCA will be required, building on the information in this report. This should incorporate additional information on mitigation of residual risk and emergency planning procedures to ensure escape / evacuation for the lifetime of the development.

4.7 Former Floors 2 Go (H21)

4.7.1 The proposed Former Floors 2 Go site is located on the left bank of the River Usk. The site is accessed via Kelvedon Street, which borders the eastern boundary of the site. A summary of the tidal flood risk at the site is provided in Table 4.5.

Table 4.5: Former Floors 2 Go Site – Flood Event Scenario Summary

Scenario	Maximum Depth (m)	Time of Maximum Depth (hr)	Maximum Hazard	Time of first Overtopping (hr)	Time of first Inundation (hr)
1	-	-	-	-	-
3	1.0	30.5	Significant	15.5	29.5
4	-	-	-	-	-
6	2.21	29	Extreme	15	28.5
7	-	-	-	-	-
9	1.12	29.5	Significant	3	17.5

Present Day (2011)

4.7.2 **200 year Tidal (Scenario 1)** – No flooding is observed at the site during this event. No overtopping of the River Usk is experienced in the vicinity of the site.

4.7.3 **1000 year Tidal (Scenario 4)** – No flooding is observed at the site during this event. No overtopping of the River Usk is experienced in the vicinity of the site.

4.7.4 **200 year Tidal: Breach (Scenario 7)** – No flooding is observed at the site during this event. No overtopping of the River Usk is experienced in the vicinity of the site.

Climate Change (2111)

4.7.5 Accounting for climate change up to 2111, the extent and depth of flooding at the site is significantly increased. The entire site is inundated with flood waters during the 200 year tidal (including breach) and 1000 year tidal flood events.

4.7.6 **200 year Tidal (Scenario 3)** – First inundation and the maximum depth of flooding (1.0m) at the site is experienced during the third tidal cycle. However, the time of first overtopping for this climate change event is during the second tidal cycle (15.5 hours).

4.7.7 **1000 year Tidal (Scenario 6)** – First inundation and the maximum depth of flooding (2.21m) at the site is experienced during the third tidal cycle. However, the time of first overtopping for this climate change event is during the second tidal cycle (15 hours).

4.7.8 **200 year Tidal: Breach (Scenario 9)** – Flood water flows through the breach during the first tidal cycle; however time of first inundation does not occur until the second tidal cycle with maximum depth of flooding (1.12m) experienced during the third tidal cycle.

Flood Hazard

4.7.9 Flood hazard maps for the scenarios shown in Table 4.5 are provided in Appendix C and illustrate the low, moderate, significant or extreme hazard based on model outputs.

4.7.10 No flooding is experienced at the site during the present day scenarios, including the 200 year tidal (Scenario 1), 1000 year tidal (Scenario 4) and the 200 year tidal breach (Scenario 7). Therefore the site is considered safe in terms of tidal flood risk.

During the 200 year tidal (Scenario 4) and 200 year tidal breach (Scenario 9) climate change scenarios the maximum and predominant flood hazard is significant (i.e. danger for most people). During the 1000 year tidal (Scenario 6) the maximum flood hazard is extreme (i.e. danger for all).

Escape / Evacuation

4.7.11 To ensure escape / evacuation routes from the site are considered over the development lifetime, the 200 year tidal (2111) (Scenario 3) flood event has been selected.

4.7.12 The suggested escape / evacuation route from the site to the limit of the floodplain is south-east along Kelvedon Street, north along Willenhall Street, north-west along Corporation Road and then north along Wharf Road (Figure 4.10).

4.7.13 The maximum flood depth and hazard mapping for Scenario 3 provided in Appendix C, indicates that the distance of this suggested route to the limit of the floodplain is approximately 800m, with a maximum hazard of significant (i.e. danger for most people).

4.7.14 In the unlikely event that no prior flood warning is given, the model results indicate that from the time of first overtopping (15.5 hours), to the time at which the escape / evacuation route is first inundated with floodwaters (28 hours), a 13.5 hour period is available for site evacuation via the escape / evacuation route identified.

4.7.15 Figure 4.10 (ii) indicates the flood extent and associated flood depths after 28 hours.

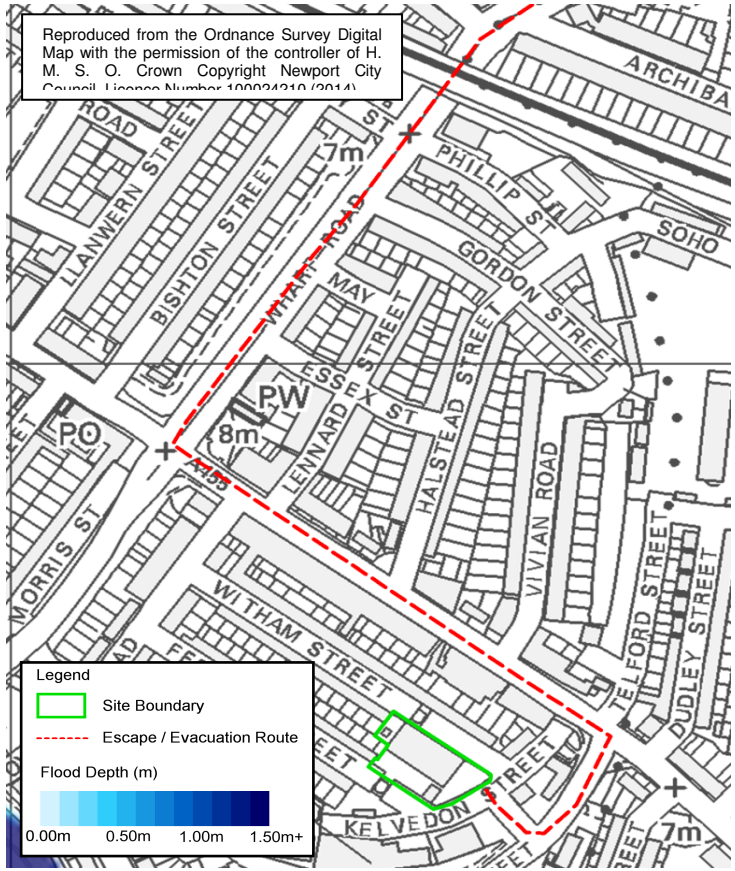


Figure 4.10 (i) – Escape / Evacuation Route – Former Floors 2 Go

- 200 year Tide Return Period (2111)
- Time of First Overtopping of Region
- 15.5 Hours

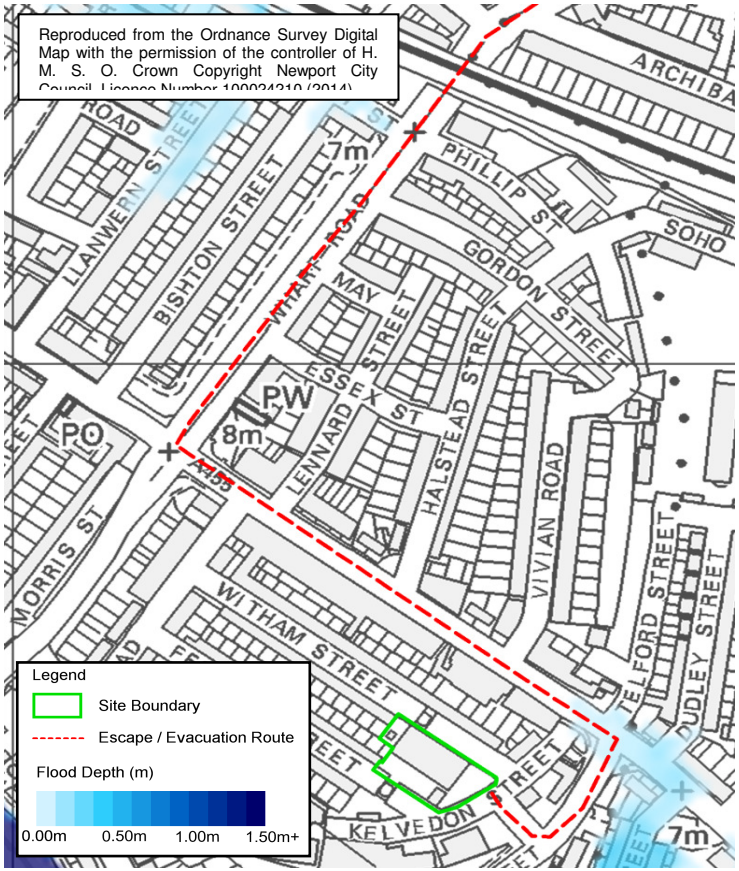


Figure 4.10 (ii) – Escape / Evacuation Route – Former Floors 2 Go

- 200 year Tide Return Period (2111)
- Time when Escape / Evacuation Route becomes inaccessible
- 28.0 Hours

TAN15 Justification of Development

4.7.16 TAN15 Appendix 1 provides indicative guidance on the return period threshold for different types of development, including acceptability criteria, in terms of what is considered tolerable conditions. The Former Floors 2 Go site is included within the Revised Deposit LDP Designations as a potential housing site and therefore the acceptability criteria for residential development based on the 200 year tidal (2111) event has been selected to assess the sites suitability for development.

4.7.17 TAN15 Appendix 1 indicates that the maximum flood depth considered tolerable within a residential development is 0.6 m. Figure 4.11 indicates areas across the site with flood depths less than 0.6 m (shaded green), between 0.6 m and 1.0 m (shaded blue) and greater than 1.0 m (shaded purple).

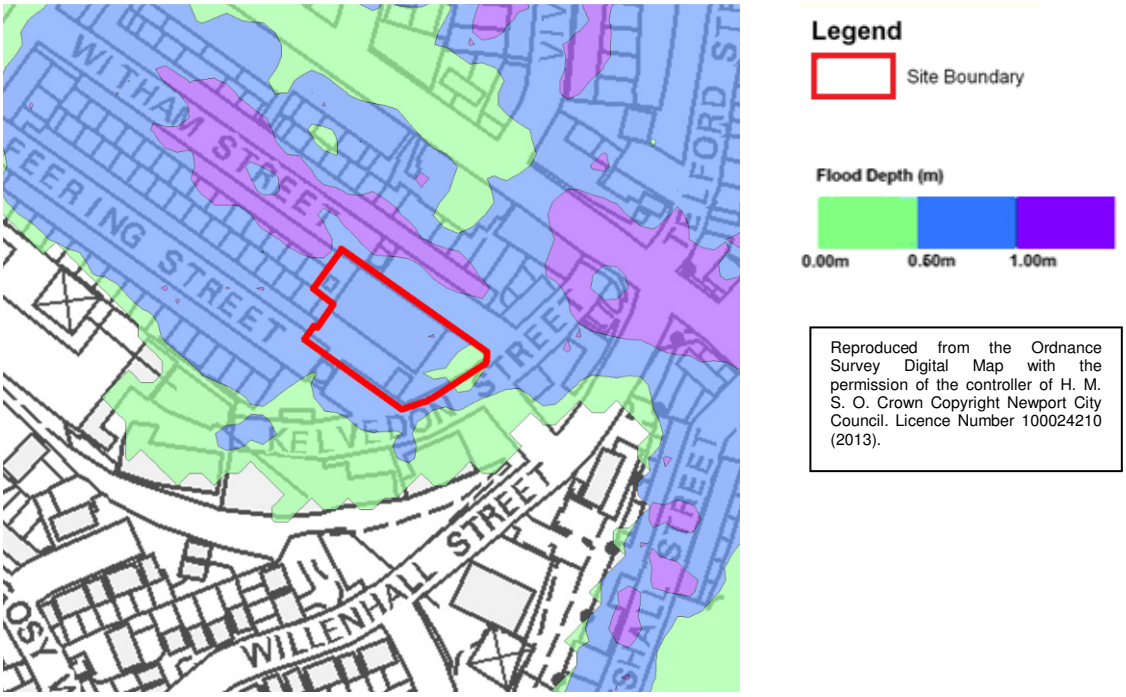


Figure 4.11: Scenario 3: 200 year Tide (2111) - Flood Depth Bands

4.7.18 Figure 4.11 indicates that climate change poses significant constraints to the development of the site. Mitigation measures would be required to justify development in line with Part iv of the justification test in TAN15. Mitigation measures may include a combination of raising flood defences, raising ground levels and ensuring minimum finished flood levels are set sufficiently above the 200 year tidal (2011) flood level to ensure flood depths are within tolerable limits in line with the acceptability criteria within TAN15 Appendix 1. However, the viability of delivering such measures is not tested within this SFCA.

4.7.19 TAN15 Appendix 1 also indicates the maximum speed of inundation of flood risk considered tolerable for residential development (4 hours). As discussed above, during the 200 year tidal (2111) event the maximum speed of inundation at the site is 13.5 hours and therefore considered to be inside the tolerable limits set out within TAN15 Appendix 1.

4.7.20 Furthermore, the Flood Warnings Direct service covers this area, which should provide adequate time to evacuate the site or to retreat to a safe position (i.e. within the site boundary).

Existing Flood Consequence Assessment

4.7.21 It is understood from NCC that the Environment Agency (now NRW) provided the following statement when considering the planning application:

> *'The site lies within Zone C1 but the application must be considered in conjunction with the progress made on implementing the East Bank Landform. An FCA will not be required to support this proposal once the Landform is complete as the Landform will serve to manage the consequences of flooding in an extreme flood event. No objection subject to appropriate controls on development being imposed through the planning permission'.*

4.7.22 In addition, NCC indicated that internal ground floor levels of units within the Former Floors 2 Go site would be 0.2 m above surrounding ground levels.

Other Considerations

4.7.23 If this site is considered by NCC to pass the other elements of the Justification Test and becomes adopted within the LDP, a revised or new site specific FCA will be required to support the planning application if the extant planning permission lapses. Consultation with the NRW and other relevant stakeholders will be required to ensure the layout and design of the site is safe for the lifetime of the development. In addition, the following considerations should also be made:

- Raising of ground levels and setting of minimum finished floor level at this site would be required to ensure that the maximum flood depth threshold is not exceeded, in line with TAN15 Appendix 1. Floodplain compensation is unlikely to be required at this location due to the predominant flood source being tidal;
- Surface water management measures should include SuDS (refer to Stage 2 SFCA for general details) and consideration of potential tide locking of outfalls to the River Usk should be taken into account;
- A site evacuation plan and escape plan would be required to ensure the safety of occupiers and users.

Former Floors 2 Go Conclusions

4.7.24 The following conclusions for the Former Floors 2 Go site have been made:

- Under present day conditions the site remains dry during the 200 year tidal event (including breach scenarios) and 1000 year tidal event.
- The site is significantly constrained under climate change conditions. The entire site would be inundated with flood water during both the 200 year tidal (2111) (including breach scenario) and 1000 year tidal (2111) events.
- During climate change events the flood hazard at the site during the 200 year tidal (2111) event is significant, increasing to extreme during the 1000 year tidal (2111) event.
- Due to the site being set back (250m inland) from the River Usk Estuary, the time between first overtopping and first inundation is approximately 13.5 hours (during

200 year tidal 2111 event). Therefore, the maximum speed of inundation at the site considered to be inside the tolerable limits set out within TAN15 Appendix 1.

- Where land is allocated for development and if extant planning permission lapses, an updated or new site specific Flood Consequence Assessment will be required, building on the information in this report. This should incorporate additional information on mitigation of residual risk and emergency planning procedures to ensure escape / evacuation for the lifetime of the development.

4.8 Frobisher Road (H9)

4.8.1 The Frobisher Road site is located on the left bank of the River Usk Estuary, approximately 900m inland from the main channel. The maximum flood depth and hazard maps for all modelled scenarios at this site are provided in Appendix D.

Figure 4.12 – Frobisher Road – SFCA Site Location
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4.8.2 The predominant flood source within this area is tidal flooding from the River Usk. The NFCDD dataset indicates that no formal defences are present along the River Usk Estuary in the vicinity of the Frobisher Road site.

4.8.3 However, the Environment Agency Flood Map indicates that the Frobisher Road site is located on the edge of an area benefiting from defence, suggesting that existing defences may offer some protection to the site.

Table 4.6: Frobisher Road Site – Flood Event Scenario Summary

Scenario	Maximum Depth (m)	Time of Maximum Depth (hr)	Maximum Hazard	Time of first Overtopping (hr)	Time of first Inundation (hr)
1	-	-	None	-	-
3	0.71	29	Significant	3.5	29
4	-	-	None	-	-
6	1.1	28.5	Significant	3.5	28
7	-	-	None	-	-
9	0.74	28.5	Significant	3.0	28.5

Present Day (2011)

4.8.4 **200 year Tidal (Scenario 1)** – No flooding is observed at the site during this event. No overtopping of the River Usk is experienced in the vicinity of the site.

4.8.5 **1000 year Tidal (Scenario 4)** – No flooding is observed at the site during this event. Overtopping is experienced during the second and third tidal cycles; however the flood extent remains approximately 300m to the south of the site in the vicinity of Ifton Place.

4.8.6 **200 year Tidal: Breach (Scenario 7)** – Similar to Scenarios 1 and 4, no flooding is observed at the site in the event of a defence breach. Floodwater flows through the breach during the second and third tidal cycle, however with the flood extent remains south of Somerton Road.

Climate Change (2111)

4.8.7 **200 year Tidal (Scenario 3)** – With the exception of the southern margins of the site no flooding is observed during this climate change scenario. Overtopping is experienced during the first and second tidal cycle; however the margins of the site do not become inundated until the third tidal cycle. Maximum flood depths at the site are 0.71m.

4.8.8 **1000 year Tidal (Scenario 6)** – With the exception of the northern part of the site (which remains dry), the majority of the site is inundated with flood water during this scenario. Overtopping is experienced during the first tidal cycle (3.5 hrs); however the site does not become inundated until the third tidal cycle (29 hours) with maximum flood depth of 1.1m. This indicates a relatively low speed of onset at the site.

4.8.9 **200 year Tidal: Breach (Scenario 9)** – The southern and western boundaries of the site are inundated with during this scenario. Maximum flood depths at the site are 0.74m. Floodwaters flow through the breach during the first tidal cycle; however the site does not become inundated with flood water until the third tidal cycle.

Flood Hazard

4.8.10 Flood hazard maps for the Scenarios shown in Table 4.6 are provided in Appendix D and illustrate the low, moderate, significant or extreme hazard based on model outputs.

4.8.11 No flooding occurs at the site during the present day scenarios, including the 200 year tidal (Scenario 1), 1000 year tidal (Scenario 4) and the 200 year tidal breach (Scenario 7). For all climate change scenarios the maximum flood hazard is significant (i.e. danger for most people). However, with the exception of the 1000 year tidal event with climate change (Scenario 6), the maximum flood hazard is only experienced at the southern and western margins of the site with the majority of the site remaining dry.

Escape / Evacuation

4.8.12 To ensure escape / evacuation routes from the site are considered over the development lifetime, the 200 year tidal (2111) flood event has been selected.

4.8.13 The suggested escape / evacuation route from the site to the limit of the floodplain is south-west along Frobisher Road and then north along Somerton Road (see Figure 4.13).

4.8.14 The distance of this suggested route to the limit of the floodplain is approximately 700m. The maximum flood depth and hazard mapping for Scenario 3 provided in Appendix D, indicates that the maximum flood hazard along this route is significant (i.e. danger for most people).

4.8.15 In the unlikely event that no prior flood warning is given, the model results indicate that from the time of first overtopping (3.5 hours), to the time at which the escape / evacuation route is first inundated with floodwaters (18.5 hours), a 15.0 hour period is available for site evacuation via the escape / evacuation route identified. Figure 4.12 indicates the flood extent and associated flood depths after 18.5 hours.

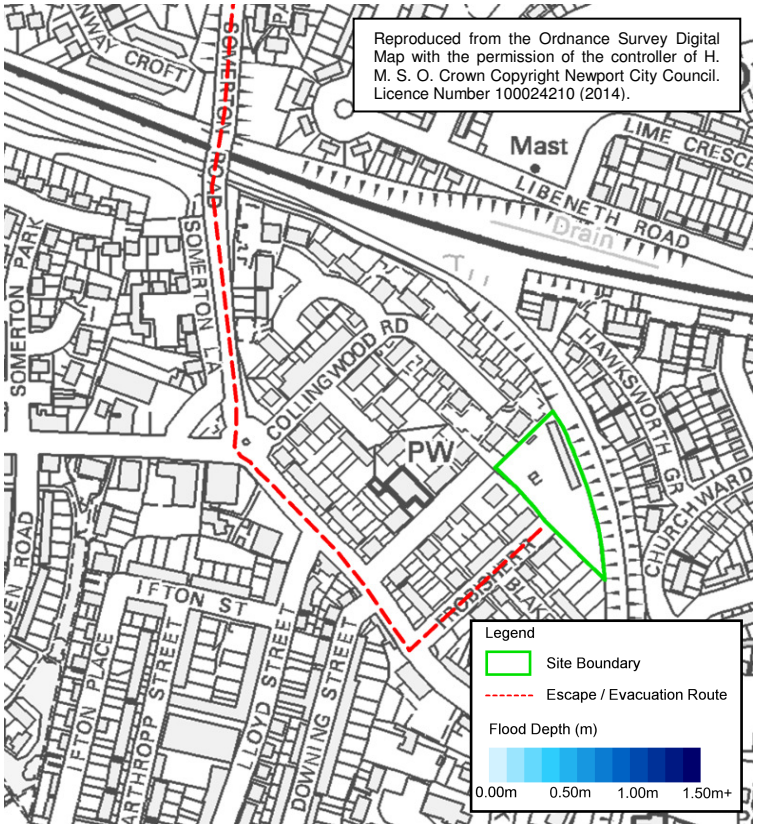


Figure 4.13 (i) – Escape / Evacuation Route – Frobisher Road

- 200 year Tide Return Period (2111)
- Time of First Overtopping of Region
- 3.5 Hours

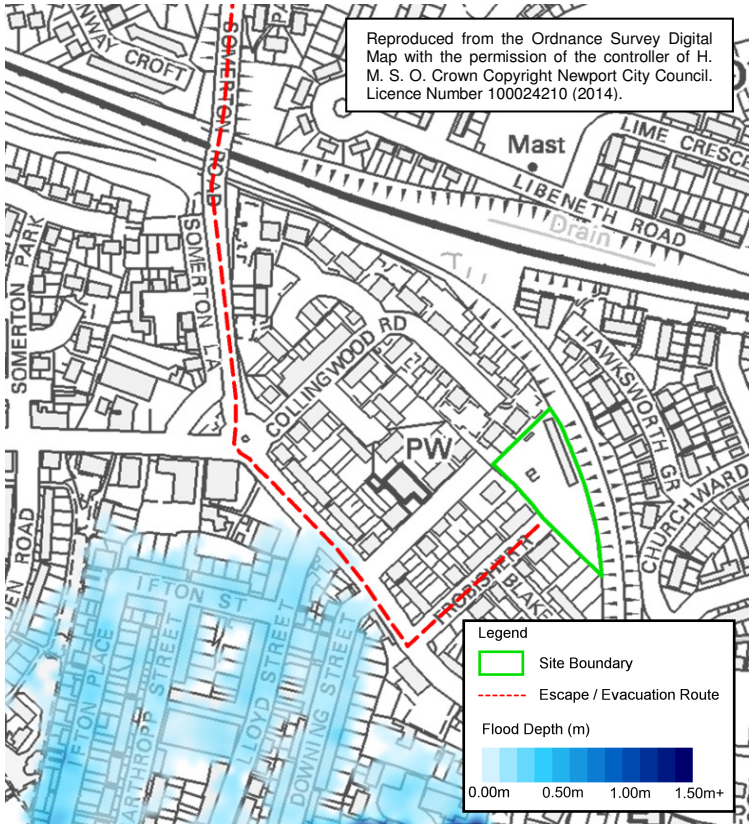


Figure 4.13 (ii) – Escape / Evacuation Route – Frobisher Road

- 200 year Tide Return Period (2111)
- Time when Escape / Evacuation Route becomes inaccessible
- 18.5 Hours

TAN15 Justification of Development

4.8.16 TAN15 Appendix 1 provides indicative guidance on the return period threshold for different types of development, including acceptability criteria, in terms of what is considered tolerable conditions. The Frobisher Road site is included within the Revised Deposit LDP Designations as a potential housing site and therefore the acceptability criteria for residential development based on the 200 year tidal (2111) event has been selected to assess the sites suitability for development.

4.8.17 TAN15 Appendix 1 indicates that the maximum flood depth considered tolerable within a residential development is 0.6 m. Figure 4.14 indicates areas across the site with flood depths less than 0.6 m (shaded green), between 0.6 m and 1.0 m (shaded blue) and greater than 1.0 m (shaded purple).

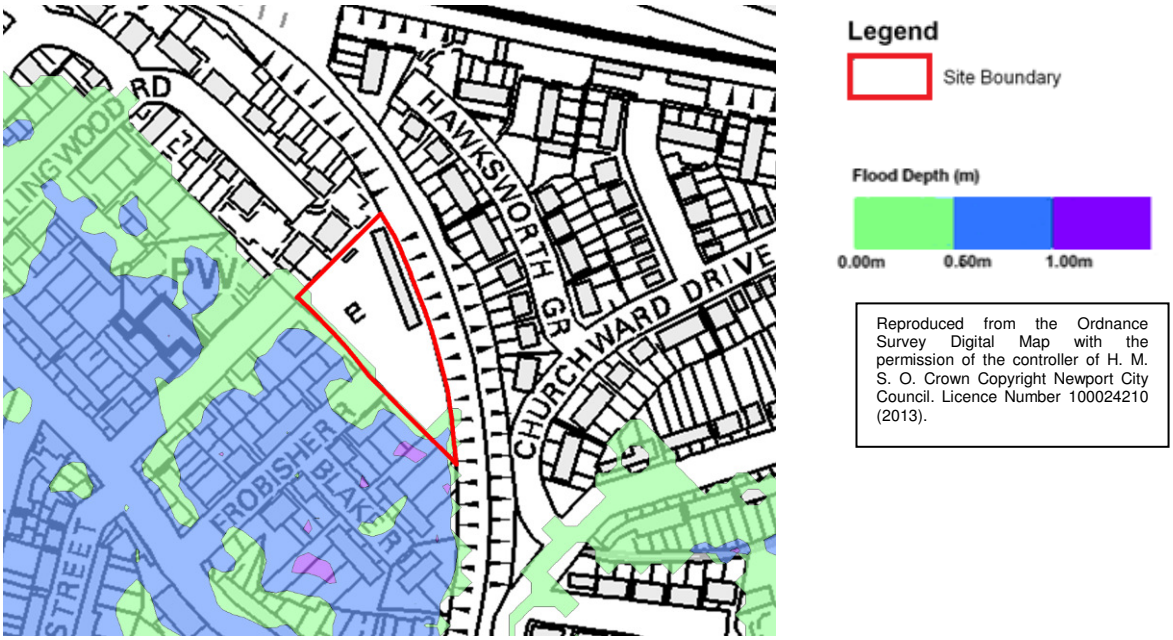


Figure 4.14: Scenario 3: 200 year Tide (2111) - Flood Depth Bands

4.8.18 Figure 4.14 indicates that with the exception of the southern margin of the site, the Frobisher Road site remains dry and beyond the flood extent during the 200 year tidal (2111) event.

4.8.19 TAN15 Appendix 1 also indicates the maximum speed of inundation of flood risk considered tolerable for residential development (4 hours). As discussed above, during the 200 year tidal (2111) event there is a 15 hour period available for site evacuation from the time of first overtopping to the time that the escape / evacuation point becomes inundated. Therefore the speed of inundation is within the tolerable limits indicated in TAN15 Appendix 1.

Existing Flood Consequence Assessment

4.8.20 It is understood from NCC that no reserved matters planning application has been submitted for Frobisher Road and no FCA is available.

Other Considerations

4.8.21 If this site is considered by NCC to pass the other elements of the Justification Test and becomes adopted within the LDP, a site specific FCA will be required to support the planning application. Consultation with the NRW and other relevant stakeholders will be required to ensure the layout and design of the site is safe for the lifetime of the development. In addition, the following considerations should also be made:

- Surface water management measures should include SuDS (see Stage 2 SFCA for general details), should ensure flood risk to third parties is not increased and that the site does not pose a flood risk to itself;
- Depending on proposed layout and design, ground raising (or infilling of lower lying areas) in the southern margins of the site may be required to meet the acceptability criteria set out in TAN15 Appendix 1. Floodplain compensation is unlikely to be required at this location due to the predominant flood source being tidal.

Frobisher Road Conclusions

4.8.22 The following conclusions for the Frobisher Road site have been made:

- No flooding occurs at the Frobisher Road site during the present day scenarios, including the 200 year tidal, 1000 year tidal and the 200 year tidal breach;
- With the exception of the southern margin of the Frobisher Road site no flooding occurs during the 200 year tidal (2111) climate change scenario;
- During the 200 year tidal (2111) breach event the flood extent increases across the site, however the northern part of the site remains dry;
- During the 1000 year tidal (2111) event the majority of the Frobisher Road site is inundated with flood water, with the exception of the northern tip. The maximum flood hazard at the site during this event is significant (i.e. danger for most people);
- During the 200 year tidal (2111) event there is a 15 hour period available for site evacuation from the time of first overtopping to the time that the escape / evacuation point becomes inundated;
- Where land is allocated for development a site specific FCA will be required, building on the information in this report. This should incorporate additional information on

mitigation of residual risk and emergency planning procedures to ensure escape / evacuation for the lifetime of the development.

4.9 Penmaen Wharf (H16)

4.9.1 The Penmaen Wharf site is located within the Pillgwenlly area on the right bank of the River Usk. The site is located to the south of the Southern Distributor Road (A48) directly adjacent to the River Usk. Figure 4.15 provides an overview of the site location.

4.9.2 The maximum flood depth and hazard maps for all modelled scenarios for the site are provided in Appendix E.

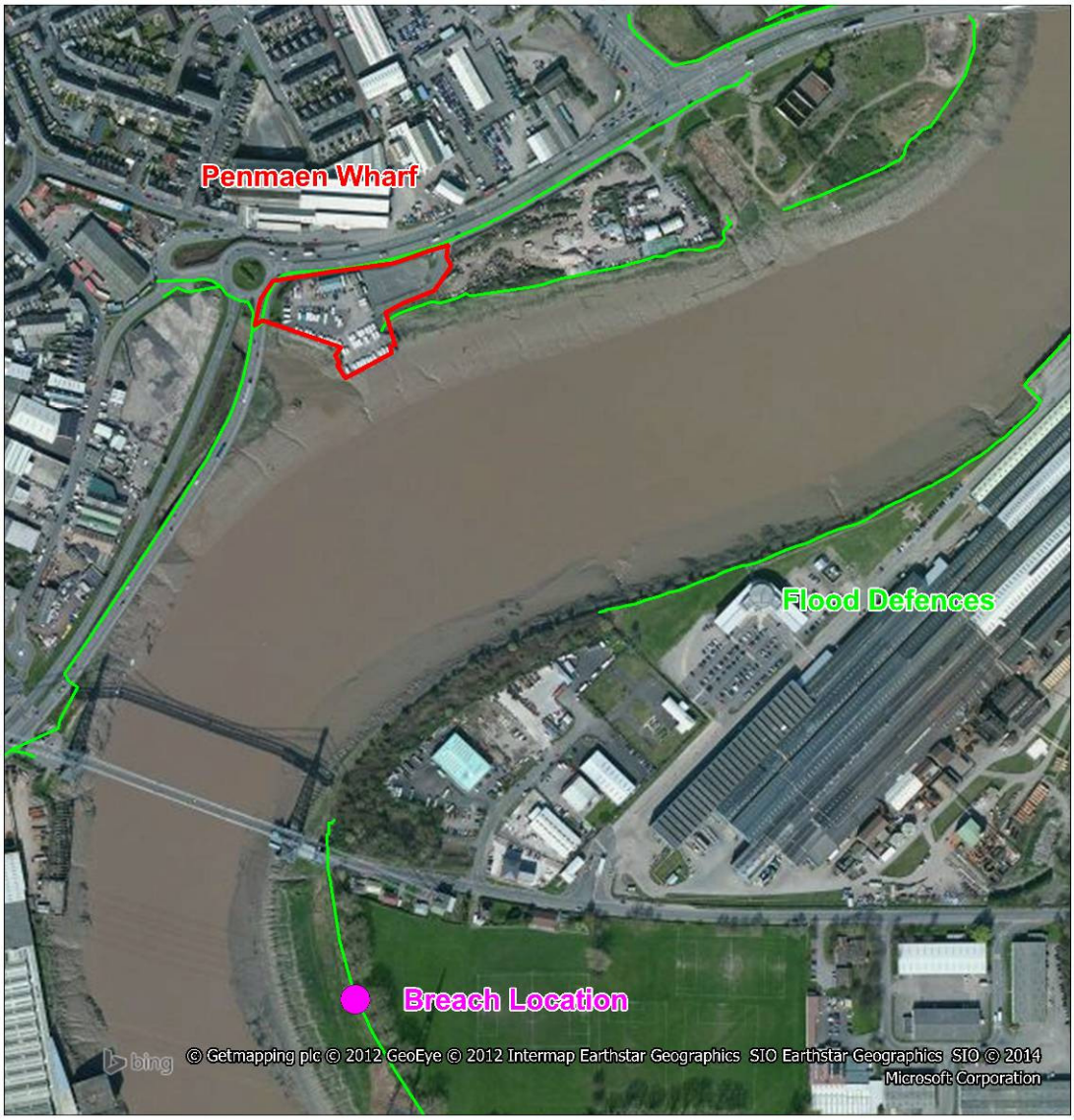


Figure 4.15 – Penmaen Wharf – SFCA Site Location *(bing © Getmapping plc © 2012 GeoEye © 2012 Intermap Earthstar Geographics SIO Earthstar Geographics SIO © AND)*

4.9.3 The predominant flood source within this area is tidal flooding from the River Usk. The NFCDD dataset indicates that no formal defences are present within the vicinity of the site.

Table 4.7: Penmaen Wharf Site – Flood Event Scenario Summary

Scenario	Maximum Depth (m)	Time of Maximum Depth (hr)	Maximum Hazard	Time of first Overtopping (hr)	Time of first Inundation (hr)
1	0.72	28.0	Significant	1.5	1.5
3	1.73	28.0	Extreme	1.5	1.5
4	1.06	28.0	Significant	1.5	1.5
6	2.03	28.0	Extreme	1.5	1.5
7	0.75	28.0	Significant	1.5	1.5
9	1.73	28.0	Extreme	1.5	1.5
* a breach to the right bank may result in increased flood consequences					

Present Day (2011)

4.9.4 **200 year Tidal (Scenario 1)** – Due to the close proximity to the River Usk, first overtopping and first inundation occur during the first tidal cycle at approximately 1.5 hours. At this point, the southern section of the site which extends into the River Usk becomes inundated with the main area of the site becoming inundated when the Pillgwenlly (located to the west of the site) overtops at 3.5 hours. Maximum depths reach approximately 0.72 m, occurring 28 hours into the simulation which equates to the peak of the third tidal cycle. A small area to the north-east of the site remains dry throughout the model simulation.

4.9.5 **1000 year Tidal (Scenario 4)** – Similar to Scenario 1, time of overtopping and first inundation occur at the same time (1.5 hours) due to the location adjacent to the River Usk. The Pillgwenlly overtops at 3.0 hours due to increased water levels. Maximum depths on site increase to 1.06 m but are still experienced during the third tidal cycle (28 hours).

4.9.6 **200 year Tidal: Breach (Scenario 7)** – The effects of climate change in conjunction with the breach of defences does not indicate a significant difference in flood depth or hazard rating at the site. This is due to the location of the breach on the left bank of the River Usk. However a breach to the right bank may result in increased flood consequences.

Climate Change (2111)

4.9.7 Accounting for climate change up to year 2111, the extent and depth of flooding is significantly increased for both the 200 year tidal and 1000 year tidal climate change events, which results in the entire site becoming inundated.

4.9.8 **200 year Tidal (Scenario 3)** – the addition of climate change provides no difference with regards to time of first overtopping and first inundation (when compared with Scenario 1). Maximum flood depths experienced during the third tidal cycle increase to 1.73 m under this scenario.

4.9.9 **1000 year Tidal (Scenario 6)** – the maximum depth of flooding at the site increases to 2.0+ m. Time of first overtopping and first inundation remain at 1.5 hours as other scenarios.

4.9.10 **200 year Tidal: Breach (Scenario 9)** – The effects of climate change in conjunction with the breach of defences does not indicate a significant difference in flood depth or hazard rating at the site due to the location of the breach being on the left bank of the River Usk. However a breach to the right bank may result in increased flood consequences.

Flood Hazard

4.9.11 Flood hazard maps for the scenarios discussed above are provided in Appendix E and illustrate the low, moderate, significant or extreme hazard based on model outputs.

4.9.12 For the present day scenarios the predominant hazard rating is significant (i.e. hazard to most people) with the majority of site becoming inundated. During the climate change scenarios the predominant hazard rating is extreme (i.e. danger to all people) and the entire is inundated. However a breach to the right bank may result in increased flood consequences.

Escape / Evacuation

4.9.13 To ensure escape / evacuation routes from the Penmaen Wharf site are considered over the development lifetime, the 200 year tidal (2111) flood event has been selected.

4.9.14 The suggested escape / evacuation route from the site to the limit of the floodplain is east along the A48, left onto Usk Way and then left onto Frederick Street. The route then takes a right onto Commercial Road and then left onto Capel Crescent (see Figure 4.16).

4.9.15 In the unlikely event that no prior flood warning is given the model results indicate that from the time of first overtopping (1.5 hours) to the time at which the escape / evacuation route is first inundated with floodwaters (15.5 hours), 14.0 hours are available for site evacuation.

4.9.16 Figure 4.16 indicates the flood extent and associated flood depths after 15.5 hours.

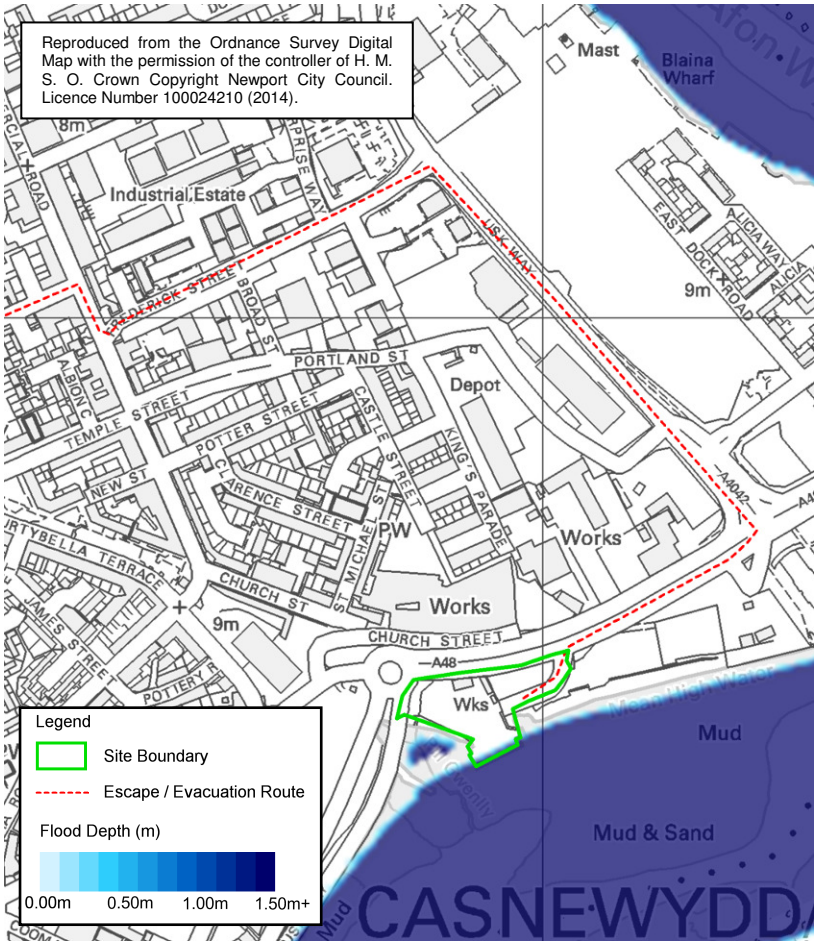


Figure 4.16 (i) – Escape / Evacuation Route – Penmaen Wharf

- 200 year Tide Return Period (2111)
- Time of First Overtopping of Region
- 1.5 Hours

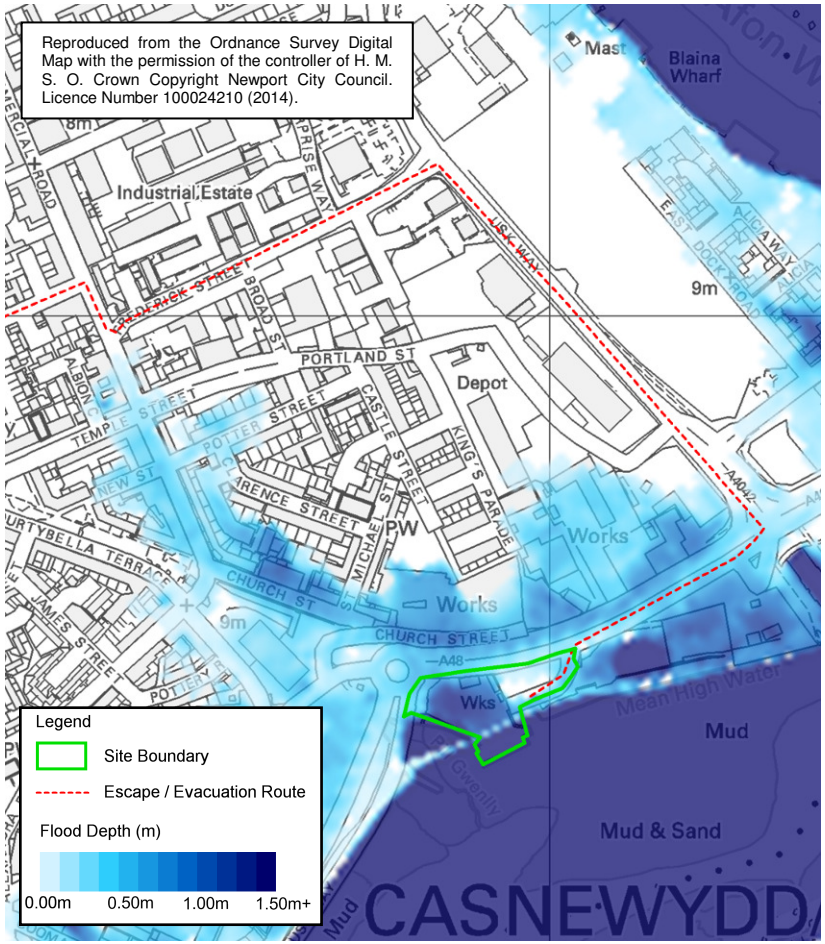


Figure 4.16 (ii) – Escape / Evacuation Route – Penmaen Wharf

- 200 year Tide Return Period (2111)
- Time when Escape / Evacuation Route becomes inaccessible
- 15.5 Hours

TAN15 Justification of Development

4.9.17 TAN15 Appendix 1 provides indicative guidance on the return period threshold for different types of development, including acceptability criteria, in terms of what is considered tolerable conditions. The Penmaen Wharf site is being considered as part of the Stage 3 SFCA as a potential residential Site. The acceptability criteria for residential development based on the 200 year tidal (2111) event has been selected to assess the sites suitability for development.

4.9.18 TAN15 Appendix 1 indicates that the maximum flood depth considered tolerable within a residential development is 0.6 m. Figure 4.17 indicates areas across the site with flood depths less than 0.6 m (shaded green), between 0.6 m and 1.0 m (shaded blue) and greater than 1.0 m (shaded purple).

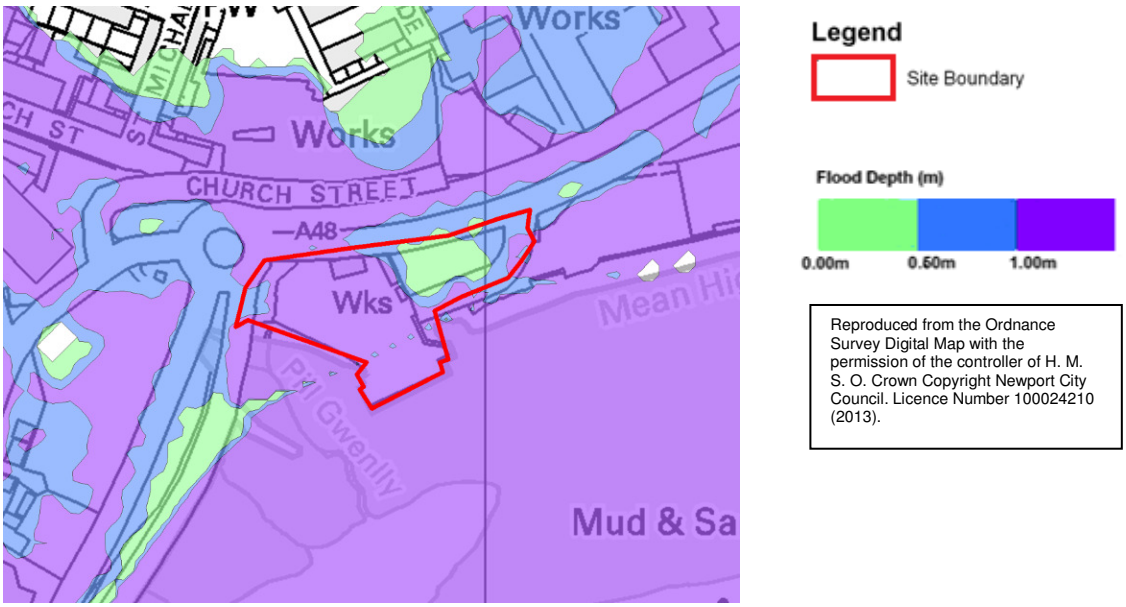


Figure 4.17: Scenario 3: 200 year Tide (2111) - Flood Depth Bands

4.9.19 Figure 4.17 indicates that flood depths across the site are predominantly 1.0 m or greater during the 200 year tidal (2111) event, indicating that climate change poses a constraint to the development of the site. In small areas to the north-east there flood depths that are < 0.60 m.

4.9.20 Substantial mitigation measures would be required to justify development in line with Part iv of the Justification test in TAN15. Mitigation measures may include a combination of raising defences, raising ground levels and ensuring finished floor levels are set sufficiently above the 200 year tidal (2111) flood levels to ensure flood depths are within tolerable limits in line with acceptability criteria within TAN15 Appendix 1. However, the viability of delivering such measures is not tested within this SFCA.

4.9.21 TAN15 Appendix 1 also indicates the maximum speed of inundation of flood risk considered tolerable for residential development (4 hours). As discussed above, during the 200 year tidal (2111) event, the maximum speed of inundation at the site is 14 hours and therefore considered to be inside the tolerable limits set out within TAN15 Appendix 1.

4.9.22 The Flood Warnings Direct service covers the site and provides adequate time to evacuate the site or to retreat to a safe position, before the onset of flood waters.

Existing Flood Consequence Assessment

4.9.23 An FCA for the site was undertaken in 2006 for residential development. This identifies that the site would require land raising to a minimum of 9.10 mAOD for finished floor levels and a minimum of 8.87 mAOD for external areas. It is noted that the FCA only assesses a development lifetime to 2055. However, residential accommodation would be significantly above 9.10 mAOD because Level 1 and Level 2 of the development is identified for residents parking and safe refuge is therefore available. Escape / Evacuation has been considered within the FCA.

Other Considerations

4.9.24 If this site is considered by NCC to pass the other elements of the Justification Test and becomes adopted within the LDP, a revised site specific FCA will be required to support a planning application if extant planning permission lapses. Consultation with the NRW and other relevant stakeholders will be required to ensure the layout and design of the site is safe for the lifetime of the development. In addition, the following considerations should also be made:

- Raising of ground levels at this site would be required to ensure maximum flood depth threshold is not exceeded in line with TAN15 Appendix 1. Floodplain compensation is unlikely to be required at this location due to the predominant flood source being tidal;
- Surface water management measures should include SuDS (refer to Stage 2 SFCA for general details) and consideration of potential tide locking of outfalls to the River Usk should be taken into account;
- A site evacuation plan and escape route would be required to ensure the safety of occupiers and users.

Penmaen Wharf Conclusions

4.9.25 The following conclusions for the site have been made:

- Under present day conditions the majority of the site becomes inundated during the 200 year tidal event (including breach scenario) and the 1000 year tidal event;

- Under the climate change scenarios the entire site becomes inundated with flood depths increasing significantly. For the 200 year tidal (2011) the maximum flood depth increases to 1.73 m whilst for the 1000 year tidal (2111) event it increases to 2.03 m;

- Due to the river bank location of the Penmaen Site, the time of overtopping and the time of first inundation occur simultaneously. Therefore, without prior flood warning there is currently limited time available to evacuate the site, however, inundation does not extend to the escape / evacuation route until 15.5 hours;

- The predominant hazard is extreme during the 200 year tidal and 1000 year tidal climate change scenarios;

- Where land is allocated for development and if extant planning permission lapses, an updated or new site-specific FCA will be required, building on the information in this report. This should incorporate additional information on mitigation of residual risk and emergency planning procedures to ensure escape / evacuation for the lifetime of the development.

4.10 Traston Lane (H23)

4.10.1 The Traston Lane site is located on the left bank, approximately 1 km inland from the River Usk at its closest point. The site is located immediately south of Traston Lane and backs onto Spytty Park Leisure Centre. The surrounding area is predominantly residential. Figure 4.18 provides an overview of the site location.

4.10.2 The maximum flood depth and hazard maps for all modelled scenarios for the Traston Lane site are provided within in Appendix F.

Figure 4.18 – Traston Lane – SFCA Site Location
(bing © Getmapping plc © 2012 GeoEye © 2012 Intermap Earthstar Geographics SIO Earthstar Geographics SIO © AND)

4.10.3 The predominant flood source within this area is tidal flooding from the River Usk. The NFCDD dataset indicates that no formal defences are present on either bank of the River Usk.

4.10.4 Existing raised earth embankments are present on stretches of the left bank of the River Usk which offer flood protection. However, the site is not identified as an area benefitting from flood defences, and therefore the Standard of Protection offered by these raised embankments is considered to be less than a 1 in 200 year design standard.

4.10.5 The breach location at Coronation Park is located approximately 1.7 km to the west of the site has been used to assess the impact of a defence breach.

Table 4.8: Traston Lane Site – Flood Event Scenario Summary

Scenario	Maximum Depth (m)	Time of Maximum Depth (hr)	Maximum Hazard	Time of first Overtopping (hr)	Time of first Inundation (hr)
1	0.14	47.5	Low	15.5	40.0
3	1.04	29.0	Significant	3.0	16.5
4	0.52	31.5	Moderate	3.5	29.5
6	1.45	29.0	Significant	3.0	16.5
7	0.43	31.0	Moderate	2.5	19.0
9	1.02	29.0	Significant	2.5	16.5

Present Day (2011)

4.10.6 **200 year Tidal (Scenario 1)** – First overtopping of the region occurs during the second tidal cycle (15.5 hours) approximately 1.7 km south west of the site. However, the site does not become inundated until the fourth tidal cycle (40.0 hours) with the maximum flood depths (0.14 m) experienced approximately 47.5 hours into the model simulation. During this scenario, central areas of the site become inundated due to local topographic variations.

4.10.7 **1000 year Tidal (Scenario 4)** – The maximum depth of flooding at the site increases to approximately 0.52 m. However, the time of first overtopping (first tidal cycle), first inundation (second tidal cycle) and maximum depth (third tidal cycle) indicates a relatively low speed of onset.

4.10.8 **200 year Tidal: Breach (Scenario 7)** – The effects of a breach in the defences provides a notable difference in terms of depth, overtopping and time of inundation. Inundation through the breach occurs during the first tidal cycle (2.5 hours) with the site experiencing inundation 19 hours into the model simulation. The maximum depth of flooding at the site (0.43 m) is experienced after 31 hours.

Climate Change (2111)

4.10.9 **200 year and 1000 year Tidal (Scenario 3 and 6)** – The effects of climate change present notable differences, especially with flood depths. The maximum depths of flooding are 1.04 m and 1.45 m respectively, both of which occur during the third tidal cycle (29.0 hours). Time of first overtopping (3.0 hours) and first inundation (16.5 hours) occur at the same time during both scenarios.

4.10.10 **200 year Tidal: Breach (Scenario 9)** – The effects of climate change in conjunction with the breach of defences does not provide a significant difference in flood depth or hazard at the site when compared to Scenario 3.

Flood Hazard

4.10.11 Flood hazard maps for the scenarios discussed above are provided in Appendix F and illustrate the low, moderate, significant or extreme hazard based on model outputs.

4.10.12 The majority of the site is located outside of the 200 year tidal (Scenario 1) flood extent; however central areas of the site are inundated with floodwaters, and are considered to have a maximum flood hazard of low. For both the 1000 year tidal (Scenario 4) and the present day breach scenario (Scenario 7), maximum flood hazard is considered moderate (i.e. danger for some people).

4.10.13 For all climate change scenarios (including the breach scenario) the predominant (and maximum) flood hazard at the site is considered as significant (i.e. danger for most people).

Escape / Evacuation

4.10.14 To ensure escape / evacuation routes from the site are considered over the development lifetime the 200 year tidal (2111) (Scenario 3) flood event has been selected.

4.10.15 A potential escape / evacuation route from the site is east along Traston Lane, before heading north on Traston Road. Take a left onto Nash Road then at the roundabout take the 3rd exit onto the A48 (see Figure 4.19).

4.10.16 In the unlikely event that no prior flood warning is given the model results indicate that from the time of first overtopping (3.0 hours) to the time at which the escape / evacuation route is first inundated with floodwaters (16.5 hours), 13.5 hours are available for site evacuation.

4.10.17 Figure 4.19 indicates the flood extent and associated flood depths after 16.5 hours.

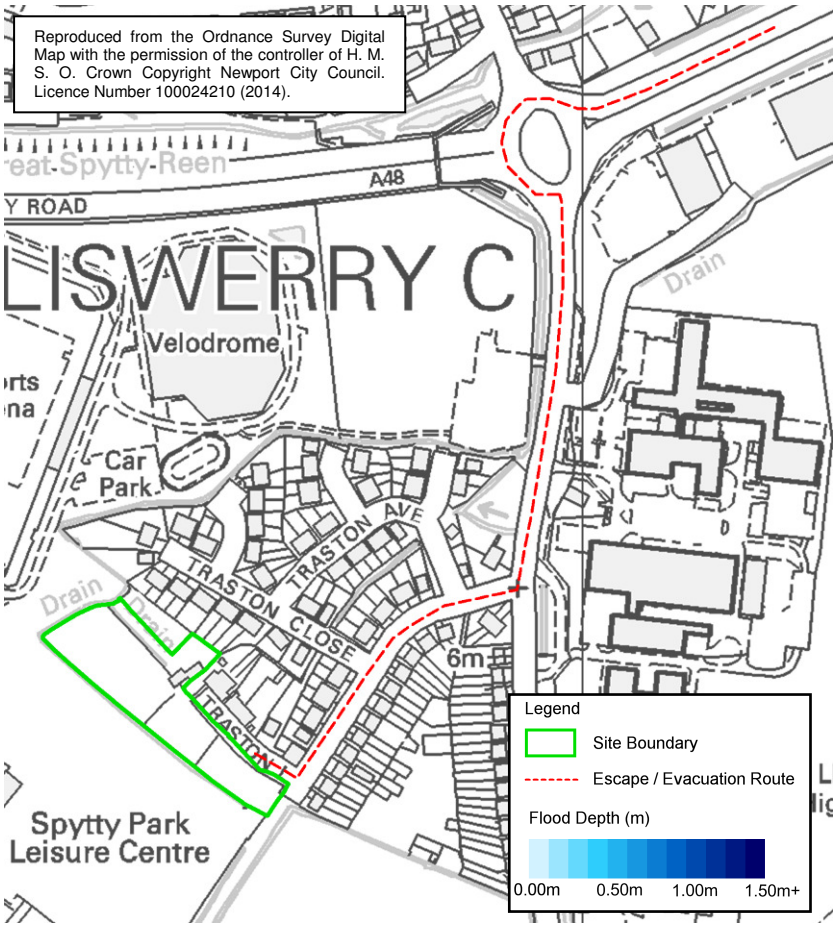


Figure 4.19 (i) – Escape / Evacuation Route – Traston Lane

- 200 year Tide Return Period (2111)
- Time of First Overtopping of Region
- 3.0 Hours

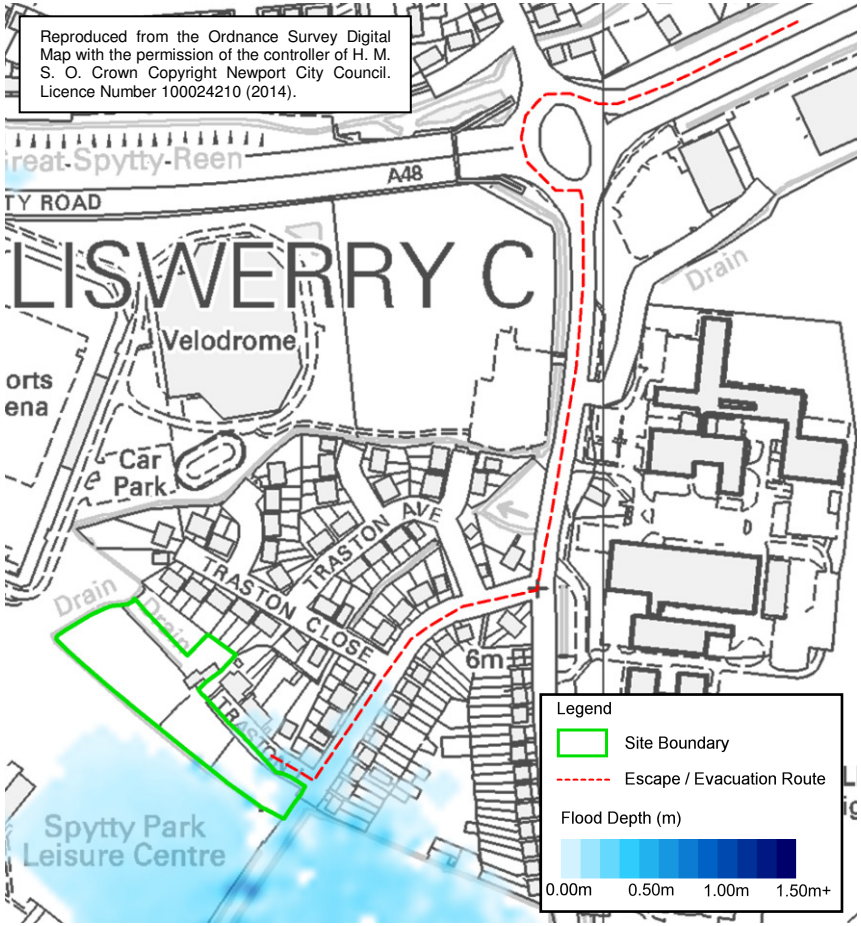


Figure 4.19 (ii) – Escape / Evacuation Route – Traston Lane

- 200 year Tide Return Period (2111)
- Time when Escape / Evacuation Route becomes inaccessible
- 16.5 Hours

TAN15 Justification of Development

4.10.18 TAN15 Appendix 1 provides indicative guidance on the return period threshold for different types of development, including acceptability criteria, in terms of what is considered tolerable conditions. The Traston Lane site is included within the Newport LDP as a potential residential site. The acceptability criteria for residential development based on the 200 year tidal (2111) event has been selected to demonstrate the site's suitability for development.

4.10.19 TAN15 Appendix 1 indicates that the maximum flood depth considered tolerable within a residential development is 0.6 m. Figure 4.20 indicates that flood depths across the site are predominantly greater than 0.6 m (shaded blue).

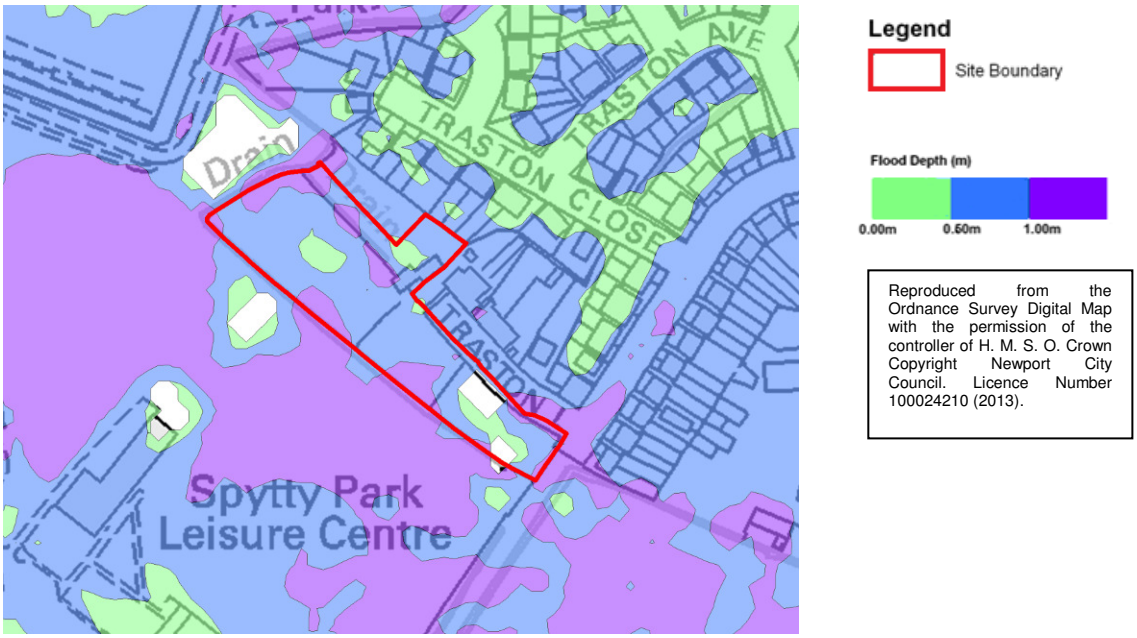


Figure 4.20: Scenario 3: 200 year Tide (2111) - Flood Depth Bands

4.10.20 The results indicate that climate change poses constraints to the development of the site. Mitigation measures would be required to justify development in line with Part iv of the Justification Test in TAN15. These may include a combination of raising flood defences, raising ground levels and ensuring minimum finished flood levels are set within tolerable limits in line with the acceptability criteria within TAN15 Appendix 1. However, the viability of delivering such measures is not tested within this SFCA.

4.10.21 TAN15 Appendix 1 also indicates the maximum speed of inundation of flood risk considered tolerable for residential development (4 hours). As discussed above, during the 200 year tidal (2111) event, a 13.5 hour period is available for site evacuation from time of first overtopping to time of first inundation. Therefore the maximum speed of inundation is considered to be within the tolerable limits indicated in TAN15 Appendix 1.

4.10.22 The Flood Warnings Direct service covers this area and provides adequate time to evacuate the site or to retreat to a safe position, before the onset of flood waters during an extreme event (i.e. 1000 year tidal (2111)).

Existing Flood Consequence Assessment

4.10.23 An FCA for the site was undertaken in 2009 for residential development. This identifies that minimum finished floor levels would be set at 6.80 mAOD with land raising of the site. A qualitative assessment of breach and overtopping has been undertaken including climate change. Evacuation / escape has been considered within the FCA.

Other Considerations

4.10.24 If this site is considered by NCC to pass the other elements of the Justification Test and becomes adopted within the LDP, a site specific FCA will be required to support the planning application if extant planning permission lapses. Consultation with the NRW and other relevant stakeholders will be required to ensure the layout and design of the site is safe for the lifetime of the development. In addition, the following considerations should also be made:

- Raising of ground levels at this site would be required to ensure that the maximum flood depth threshold is not exceeded, in line with TAN15 Appendix 1. Floodplain compensation is unlikely to be required at this location due to the predominant flood source being tidal;
- Surface water management measures should include SuDS (see Stage 2 SFCA for general details), should ensure flood risk to third parties is not increased and that the site does not pose a flood risk to itself;
- A site evacuation plan and escape plan would be required to ensure the safety of occupiers and users.

Traston Lane Conclusions

4.10.25 The following conclusions for the Traston Lane site have been made:

- Under present day conditions the majority of the site remains dry during the 200 year tidal event present day event. However the entire site becomes inundated during the 1000 year tidal event;
- Climate change and breach of defences are the predominant factors with regards to future flooding;

- The predominant hazard rating for present day scenarios is low / moderate, however during climate change scenarios this increases to significant;
- Where land is allocated for development and if extant planning permission lapses, an updated or new site-specific FCA will be required, building on the information in this report. This should incorporate additional information on mitigation of residual risk and emergency planning procedures to ensure escape / evacuation for the lifetime of the development.

5. STAGE 3 SFCA SUMMARY

5.1.1 The flood depth and hazard mapping (see Appendix B, C, D, E and F) and analysis of results (see Section 4) are summarised in Table 5.1.

5.1.2 The TAN15 acceptability criteria for residential development are based on flood conditions during the 200 year tidal event. To ensure the TAN15 acceptability criteria is considered over the development lifetime, Table 5.1 focuses on flood conditions during the future 200 year tidal (2111) (Scenario 3).

5.1.3 In addition to the existing (2011) and future (2111) maximum flood hazard at each site, Table 5.1 indicates whether flood conditions are within maximum depth and time to inundation 'tolerable limits' as identified within TAN15 Appendix 1.

5.1.4 Where the maximum flood depth onsite is noted to exceed TAN15 'tolerable limits' (i.e. greater than 0.6 m), a simple indication of the level of mitigation required (i.e. raising of ground levels) before the site is developable has been provided. The level of mitigation is classified as 'moderate', where the maximum flood depth is greater than 0.6 m, and 'significant', where the maximum flood depth is greater than 1.0 m.

5.1.5 Information regarding time to inundation is important where considering whether sufficient time is available for safe escape / evacuation from the development site prior to the onset of floodwaters. Time of inundation is based on model results from the time of first overtopping to the time at which the escape / evacuation route is first inundated with floodwaters.

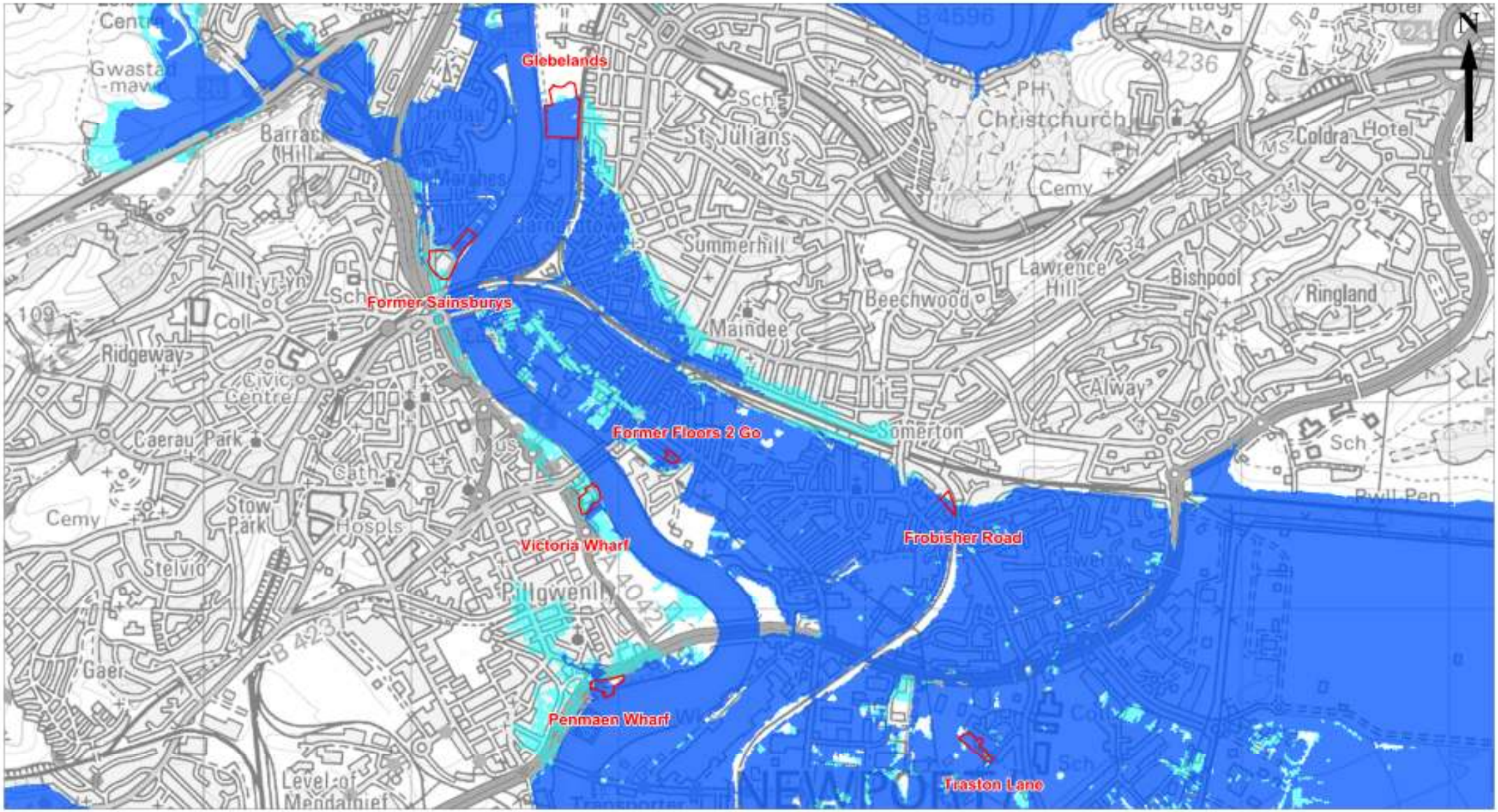
5.1.6 Where the time to inundation of escape / evacuation routes is noted to exceed TAN15 'tolerable limits' (i.e. less than 4 hours), this has been noted in Table 5.1.

Table 5.1: Summary Table of Additional Sites Assessed

[1] Only minor areas of the site require moderate mitigation, the remainder is considered to be within tolerable limits.

Additional Site Assessed	Existing Max Hazard (Scenario 1 - 200yr Tidal 2011)	Future Max Hazard (Scenario 3 - 200yr Tidal 2111)	TAN15 Acceptability Criteria (Future Max Depth) (Scenario 3 - 200yr Tidal 2111)	TAN15 Acceptability Criteria (Future Escape / Evacuation – Time of Inundation) (Scenario 3 - 200yr Tidal 2111)
Former Sainsbury's	Moderate	Significant	Significant Mitigation Required (>1.0 m)	Exceeds Tolerable Limits (< 4 hrs)
Glebelands	-	Extreme	Significant Mitigation Required (>1.0 m)	Exceeds Tolerable Limits (< 4 hrs)
Victoria Wharf	Low	Significant	Significant Mitigation Required (>1.0 m)	Exceeds Tolerable Limits (< 4 hrs)
Former Floors 2 Go	-	Significant	Significant Mitigation Required (>1.0 m)	Within Tolerable Limits (> 4 hrs)
Frobisher Road	-	Significant	Moderate Mitigation Required (>0.6 m)[1]	Within Tolerable Limits (> 4 hrs)
Penmaen Wharf	Significant	Extreme	Significant Mitigation Required (>1.0 m)	Within Tolerable Limits (> 4 hrs)
Traston Lane	Low	Significant	Significant Mitigation Required (>1.0 m)	Within Tolerable Limits (> 4 hrs)

APPENDIX A OVERVIEW MAP OF ADDITIONAL SITE ASSESSMENT LOCATIONS



Legend

Revised Deposit LDP Designations

EA Flood Zones

Flood Zone 3

Flood Zone 2

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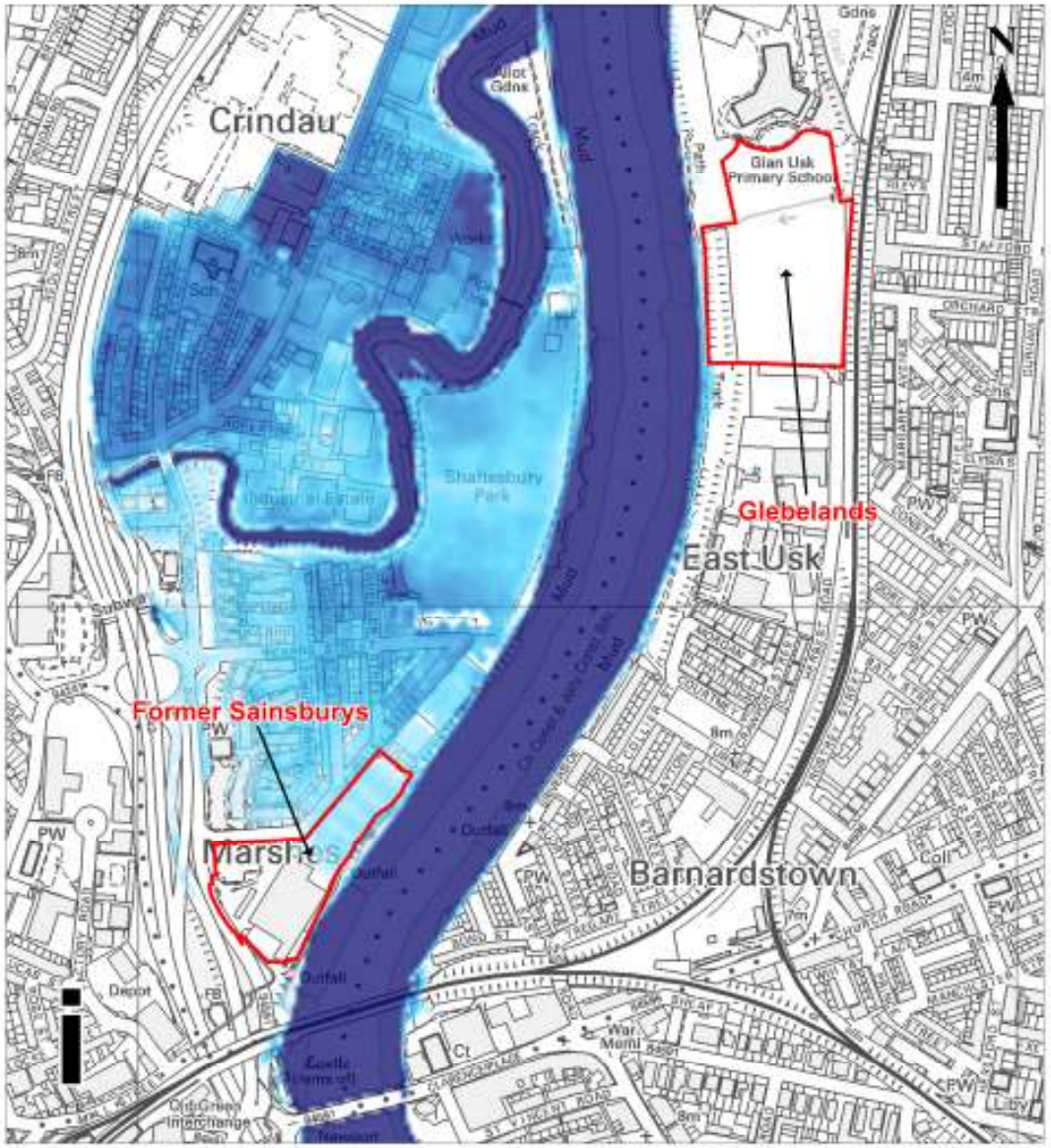
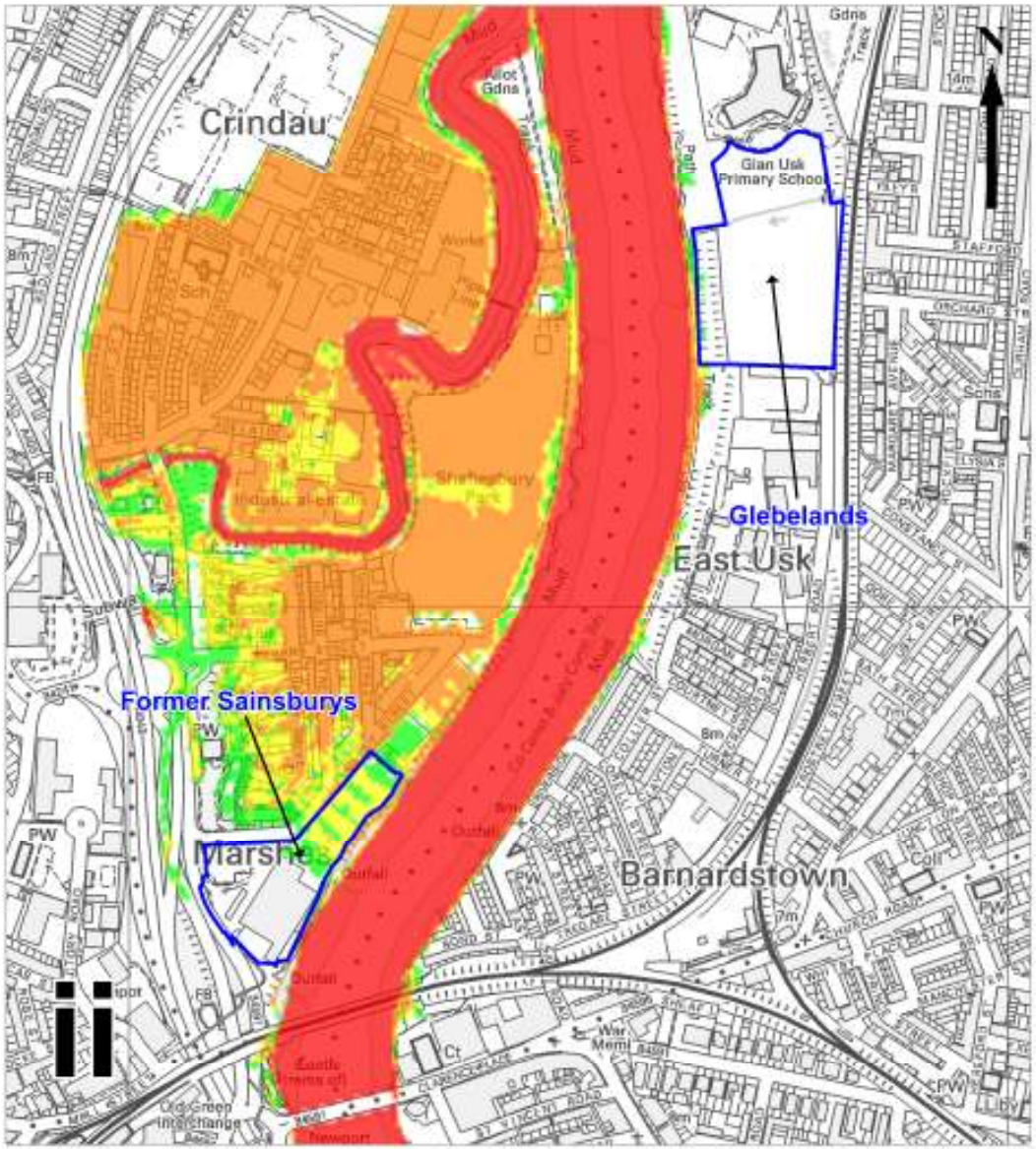
Figure A-1: Site Overview

APPENDIX B DEPTH & HAZARD MAPPING FOR FORMER SAINSBURY'S/GLEBELANDS





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

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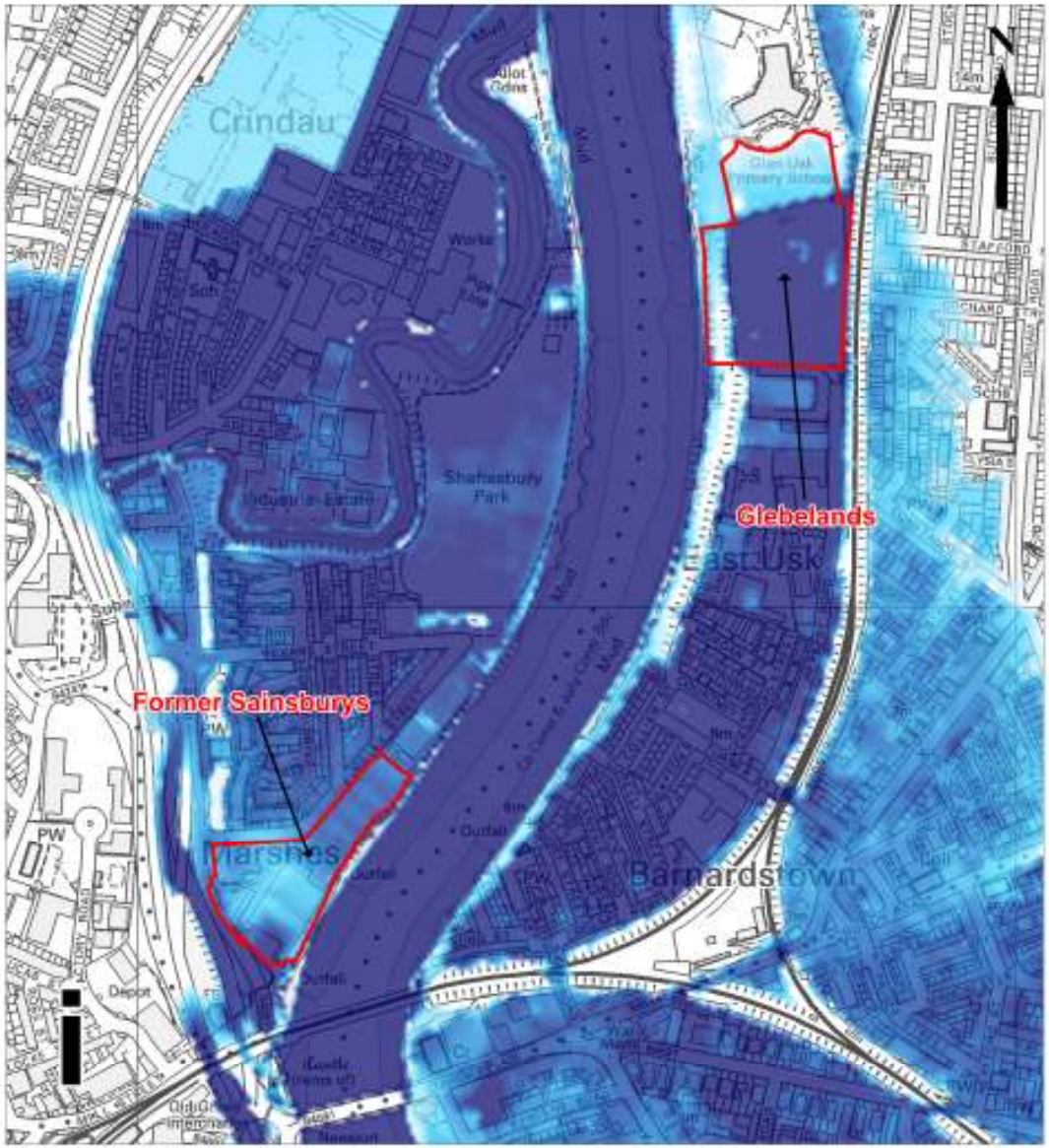
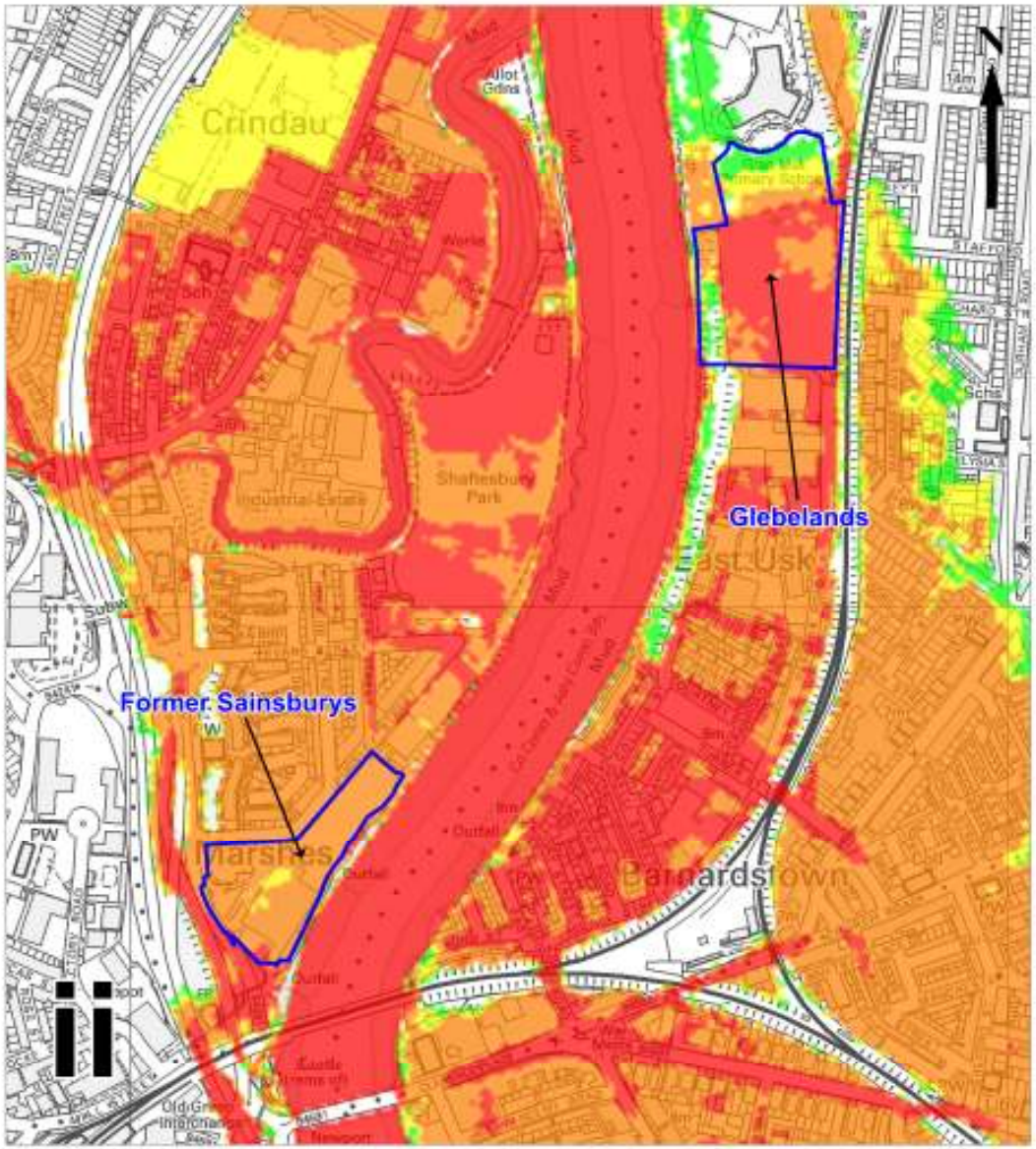
Figure B-1: Scenario 1 (1 in 200 year event)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
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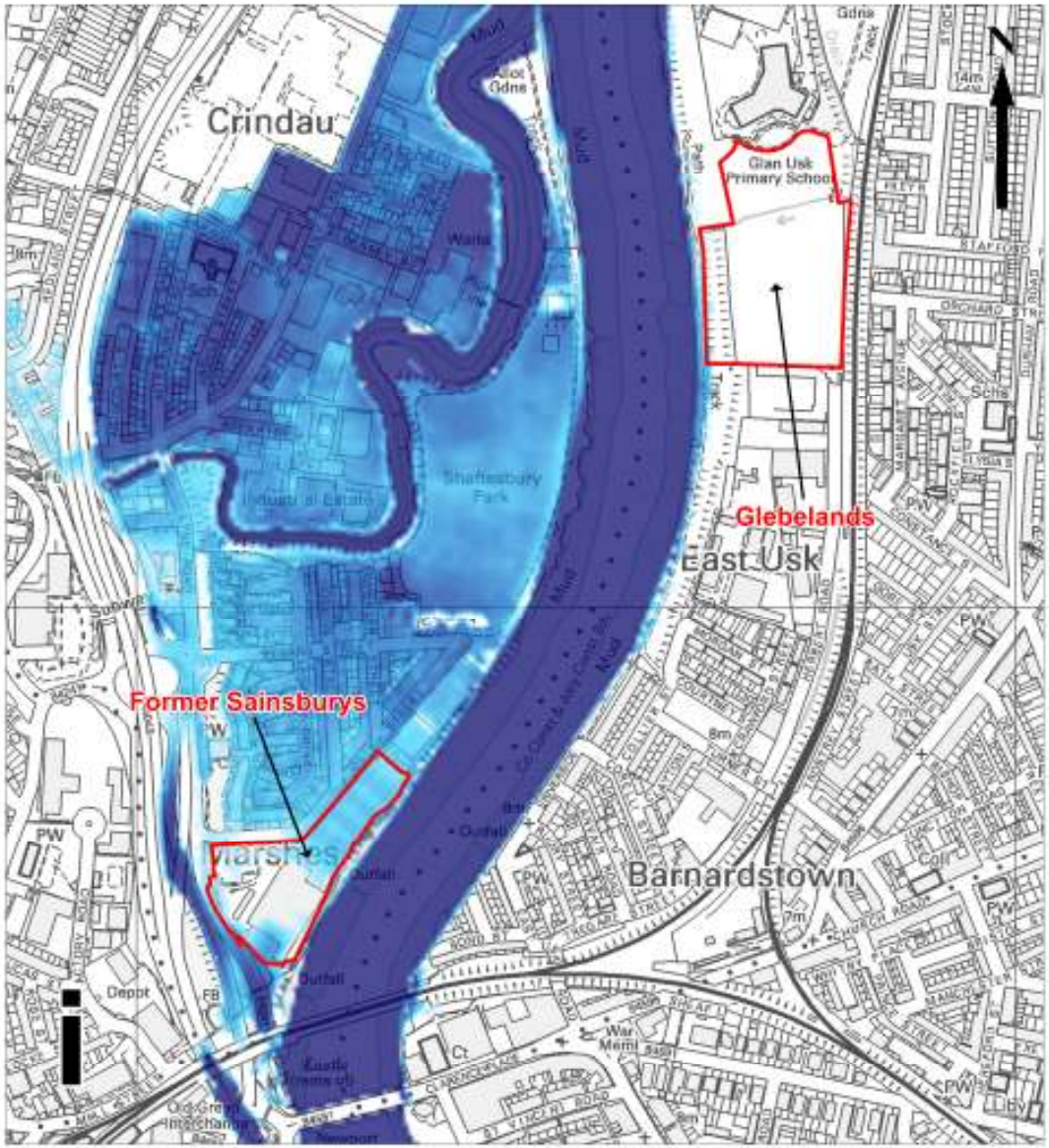
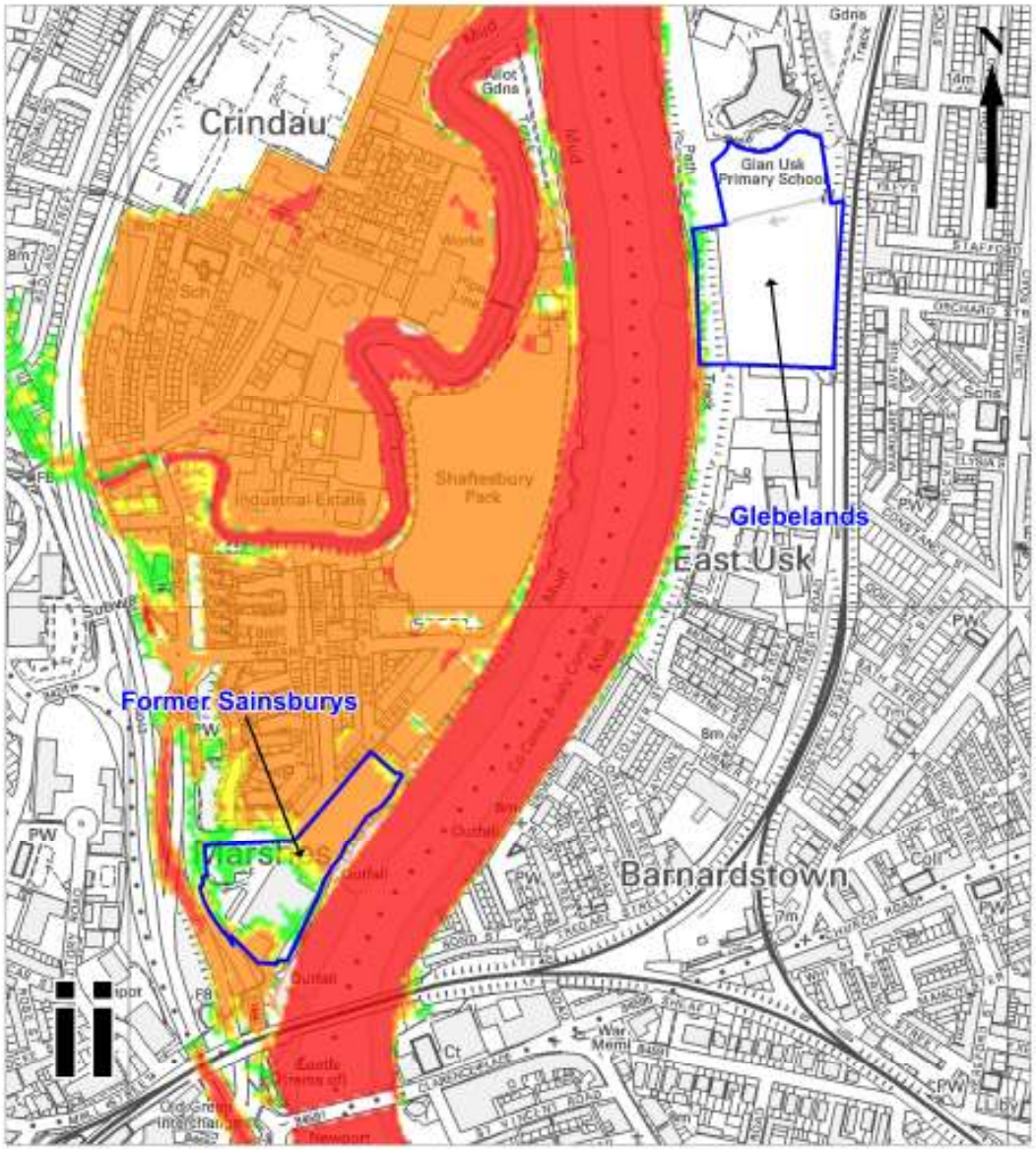
Figure B-2: Scenario 3 (1 in 200 year event - climate change to 2111)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Significant
Moderate
Extreme

Client:
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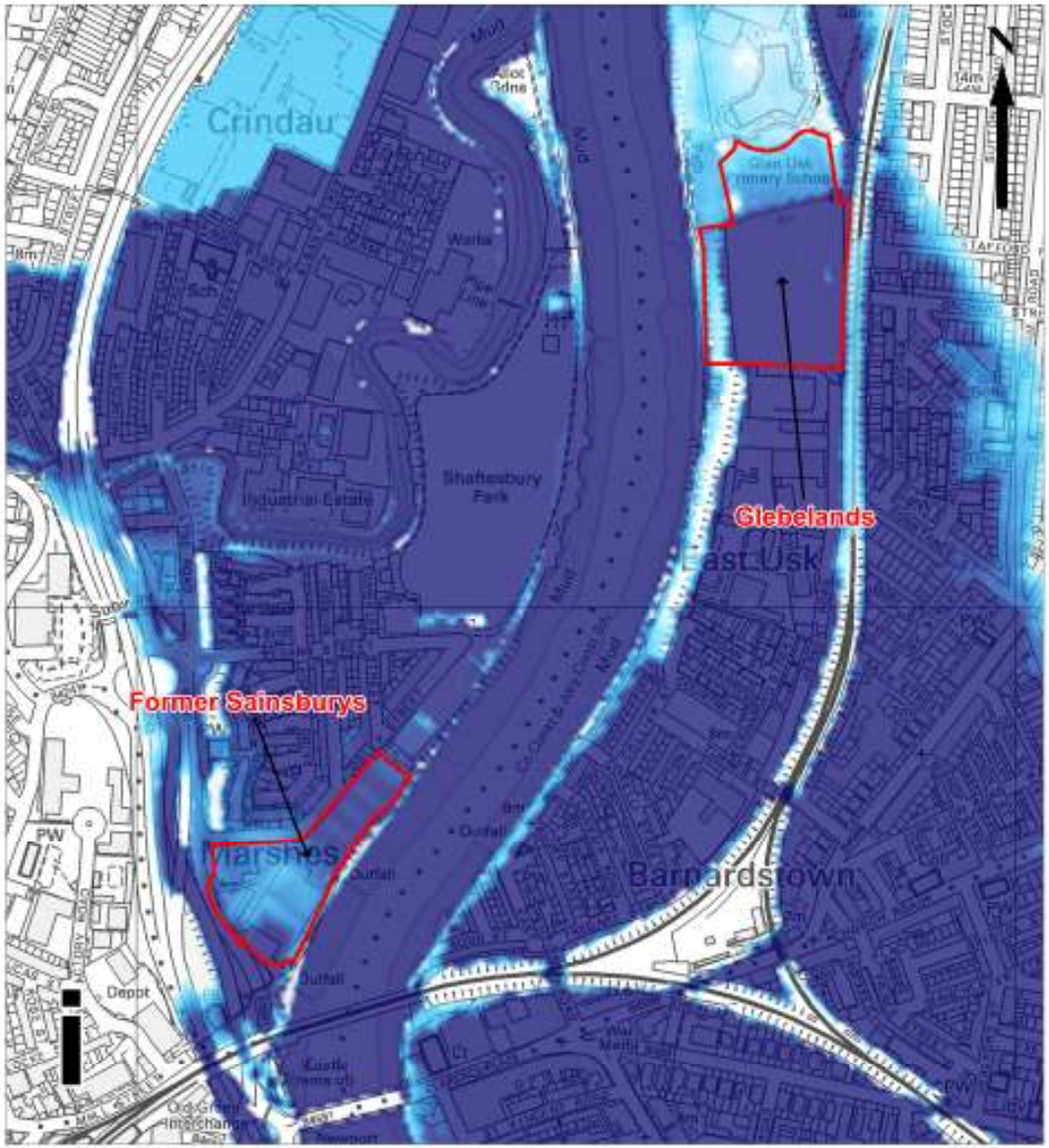
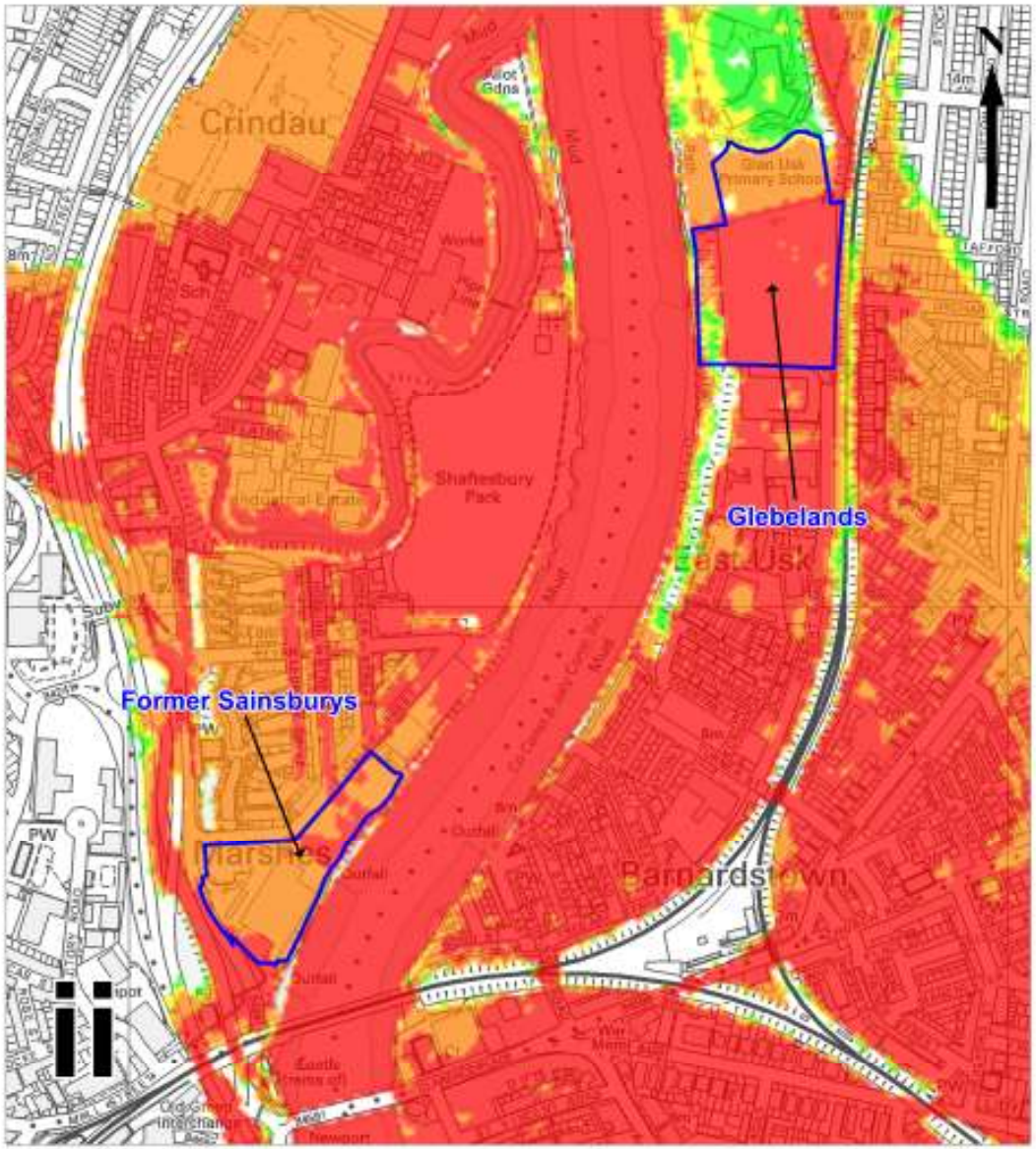
Figure B-3: Scenario 4 (1 in 1000 year event)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m – 0.50m – 1.00m – 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
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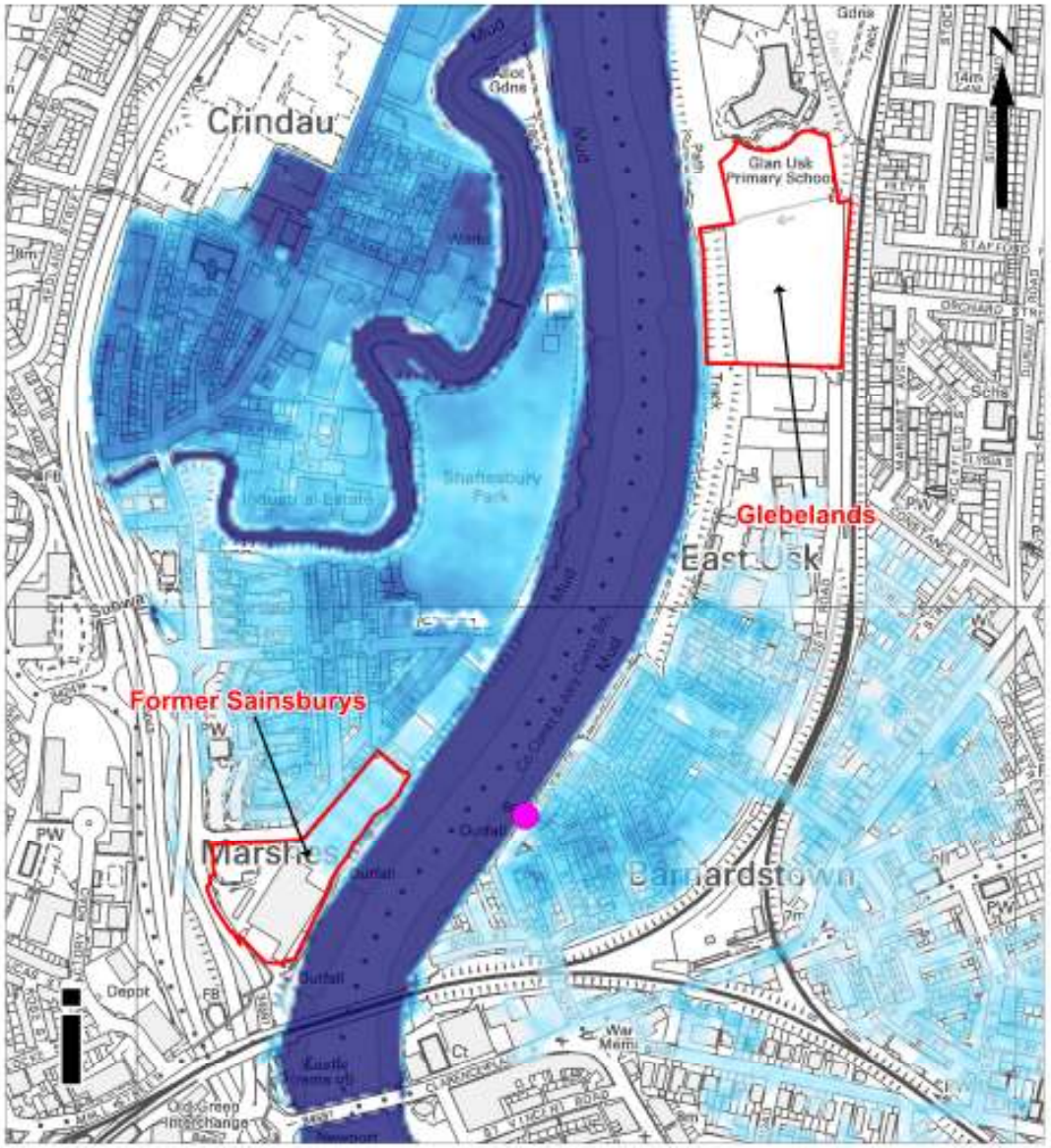
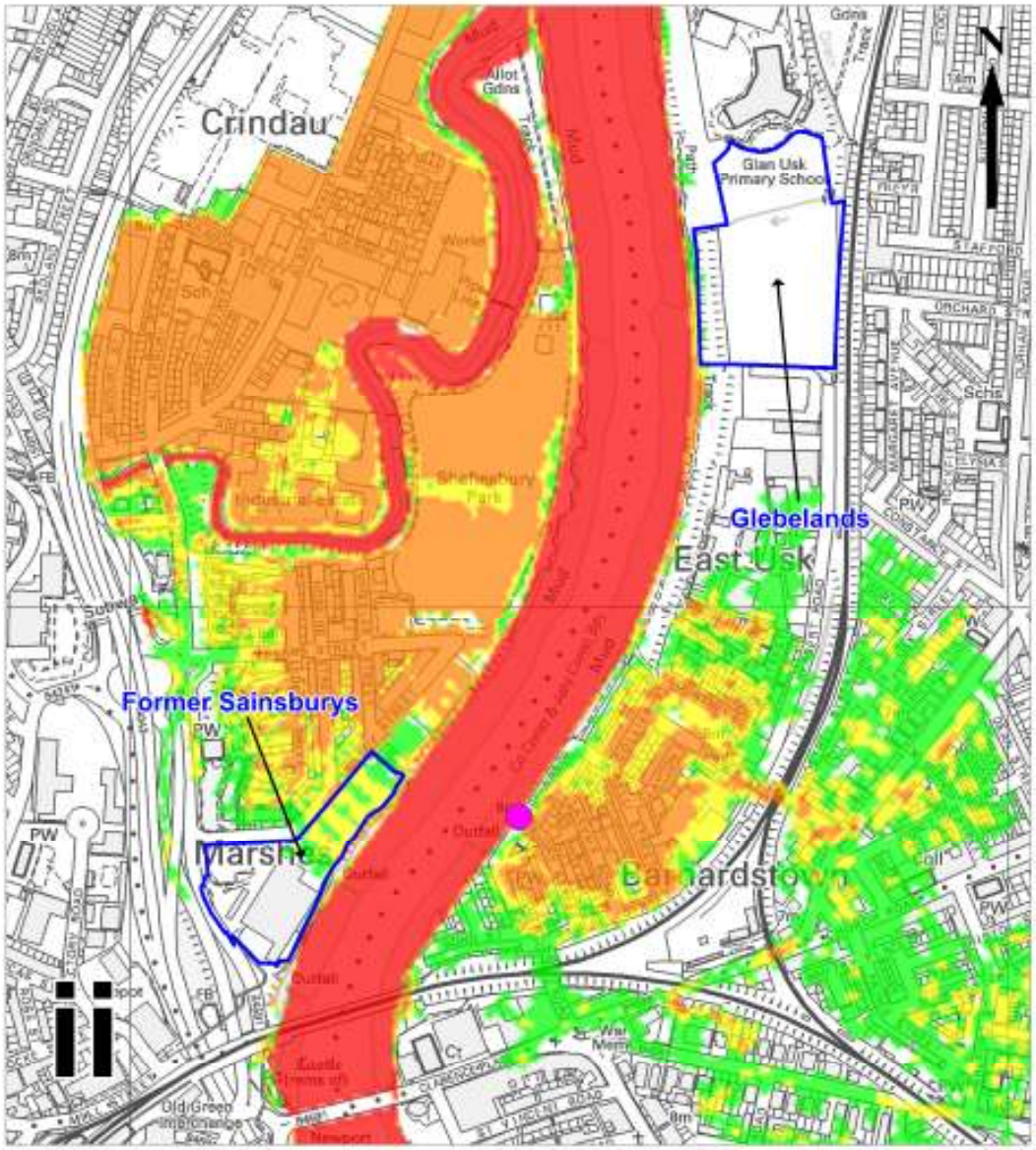
Figure B-4: Scenario 6 (1 in 1000 year event - climate change to 2111)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

- Revised Deposit LDP Designations
- Breach Location

Maximum Flood Depth (m)

0.00m – 0.50m – 1.00m – 1.50m+

Hazard Legend

- Revised Deposit LDP Designations
- Breach Location

Maximum Flood Hazard

- Low
- Moderate
- Significant
- Extreme

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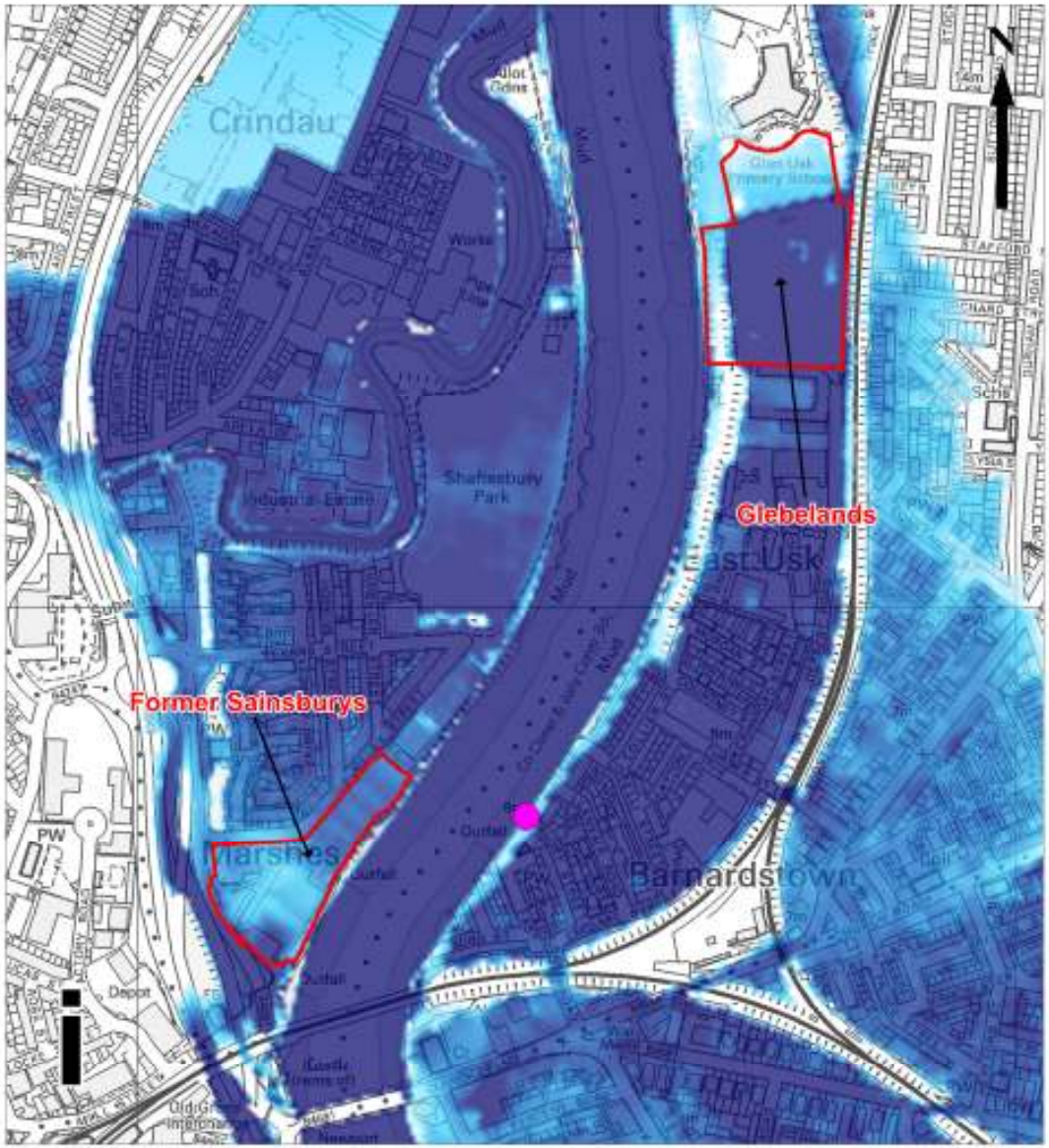
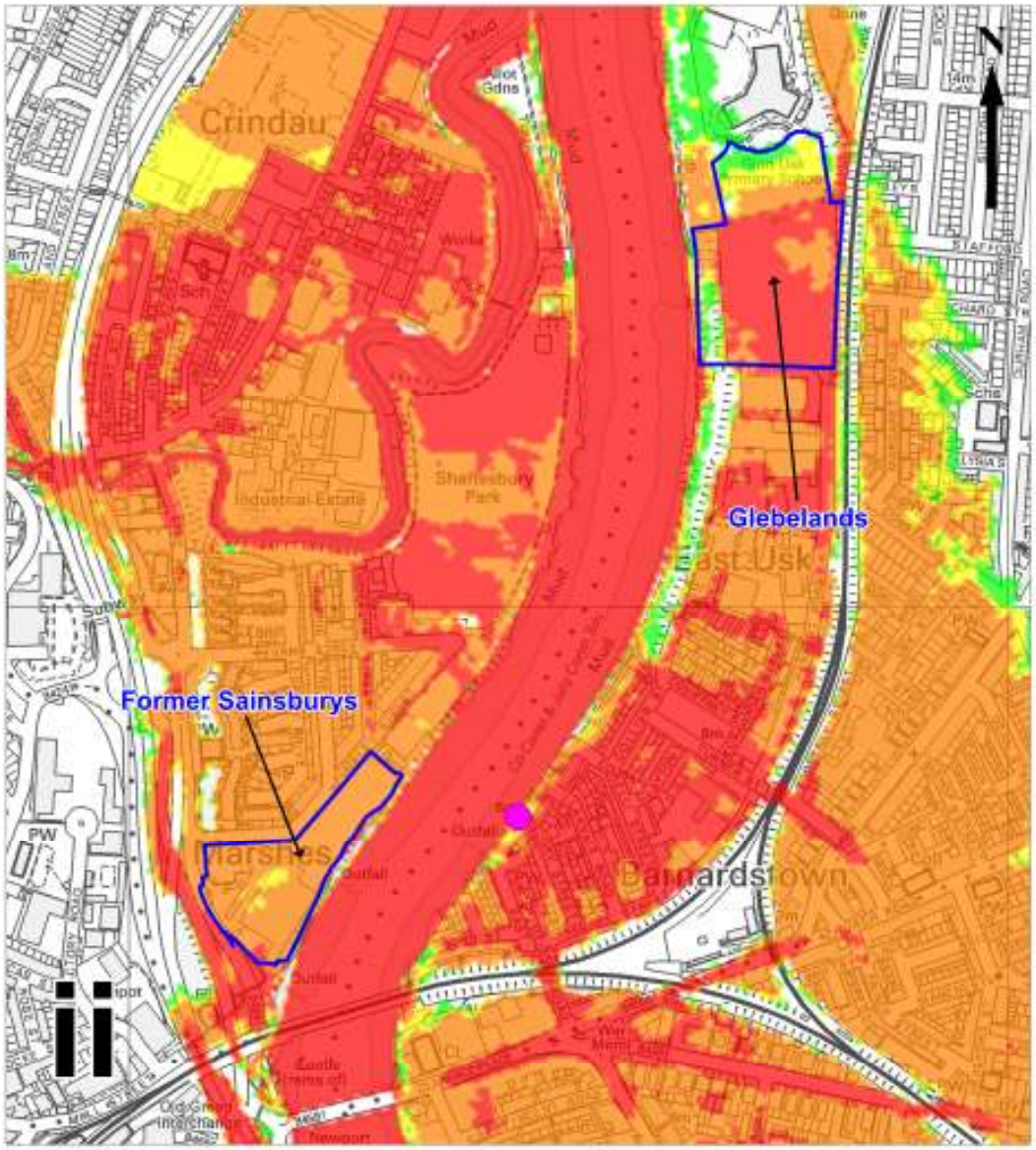
Figure B-5: Scenario 7 (1 in 200 year event with Breach Location)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

- Revised Deposit LDP Designations
- Breach Location

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

- Revised Deposit LDP Designations
- Breach Location

Maximum Flood Hazard

- Low
- Moderate
- Significant
- Extreme

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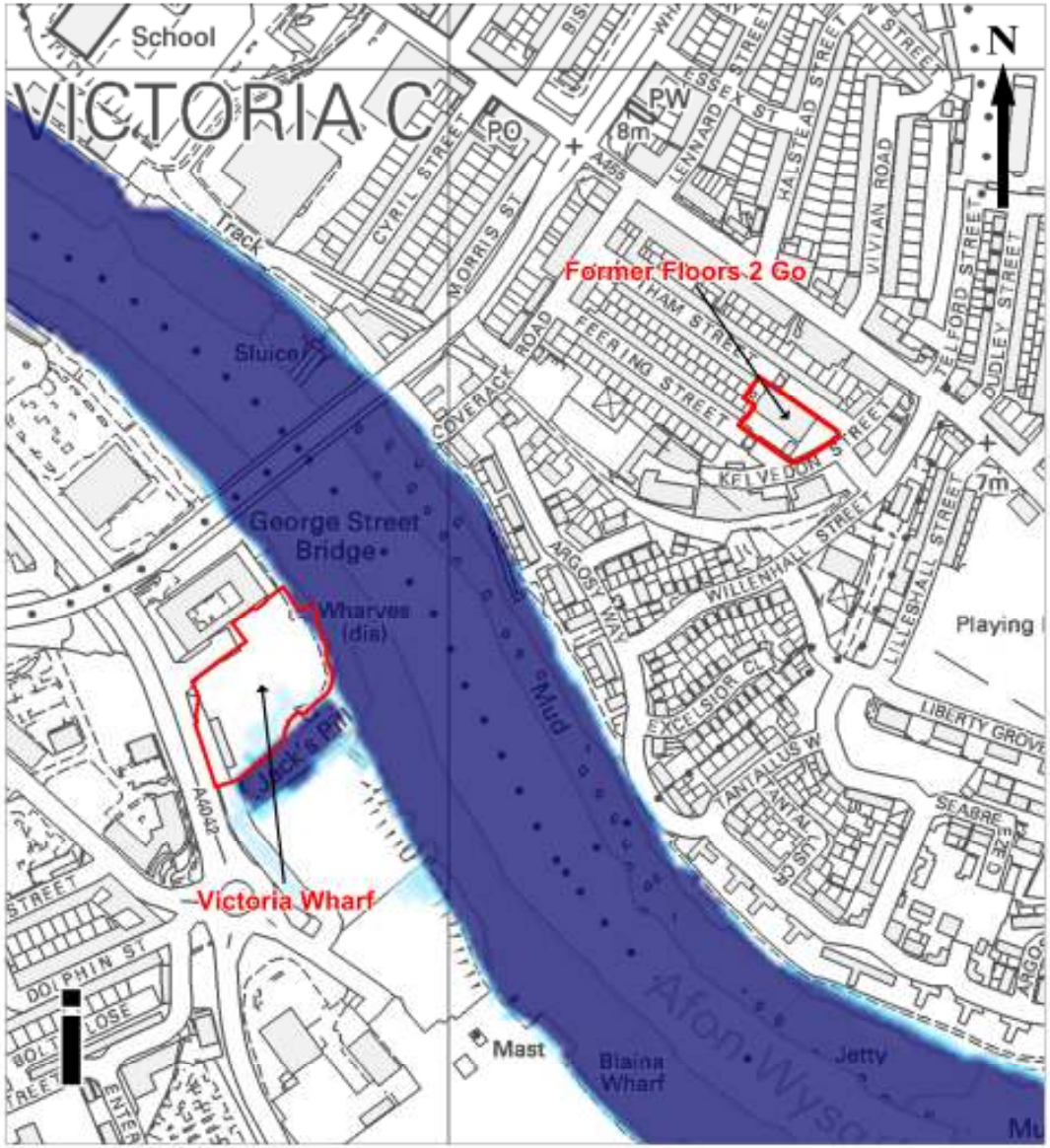
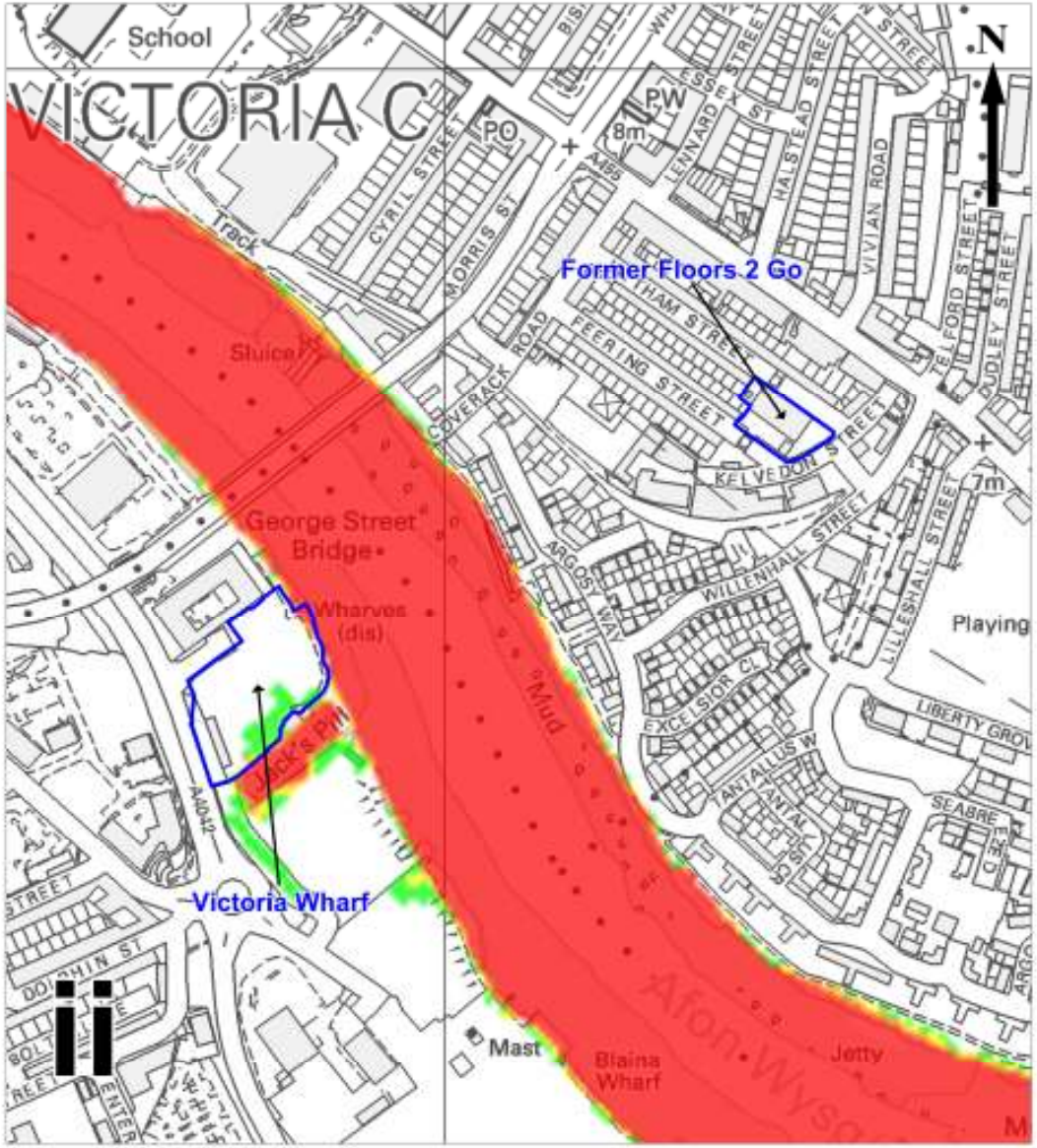
Figure B-6: Scenario 9 (1 in 200 year event - climate change to 2111 with Breach Location). (i) Maximum Flood Depth (ii) Maximum Flood Hazard

APPENDIX C DEPTH & HAZARD MAPPING FOR VICTORIA WHARF/FORMER FLOORS 2 GO





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m – 0.50m – 1.00m – 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

- Low
- Moderate
- Significant
- Extreme

Client:
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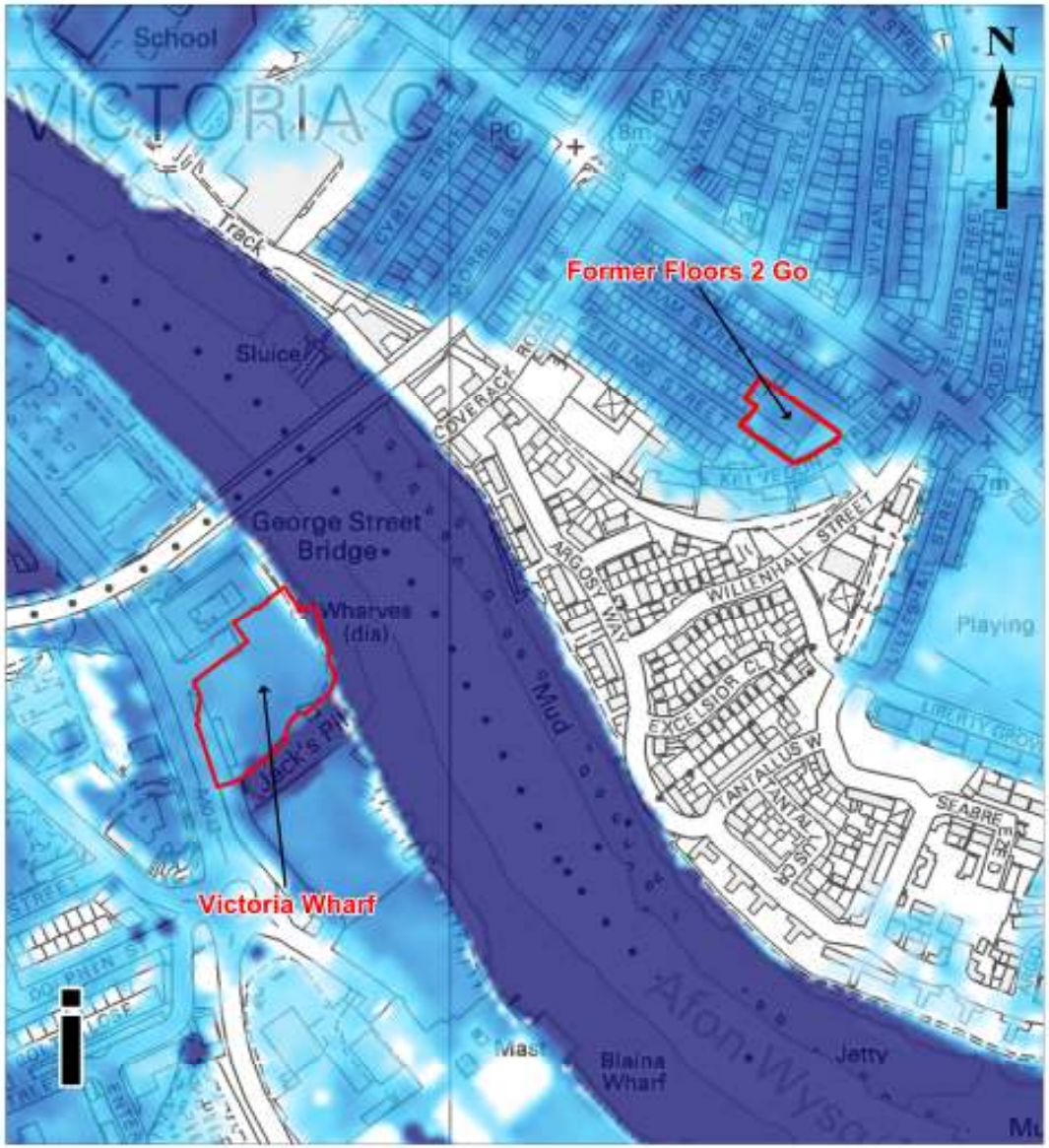
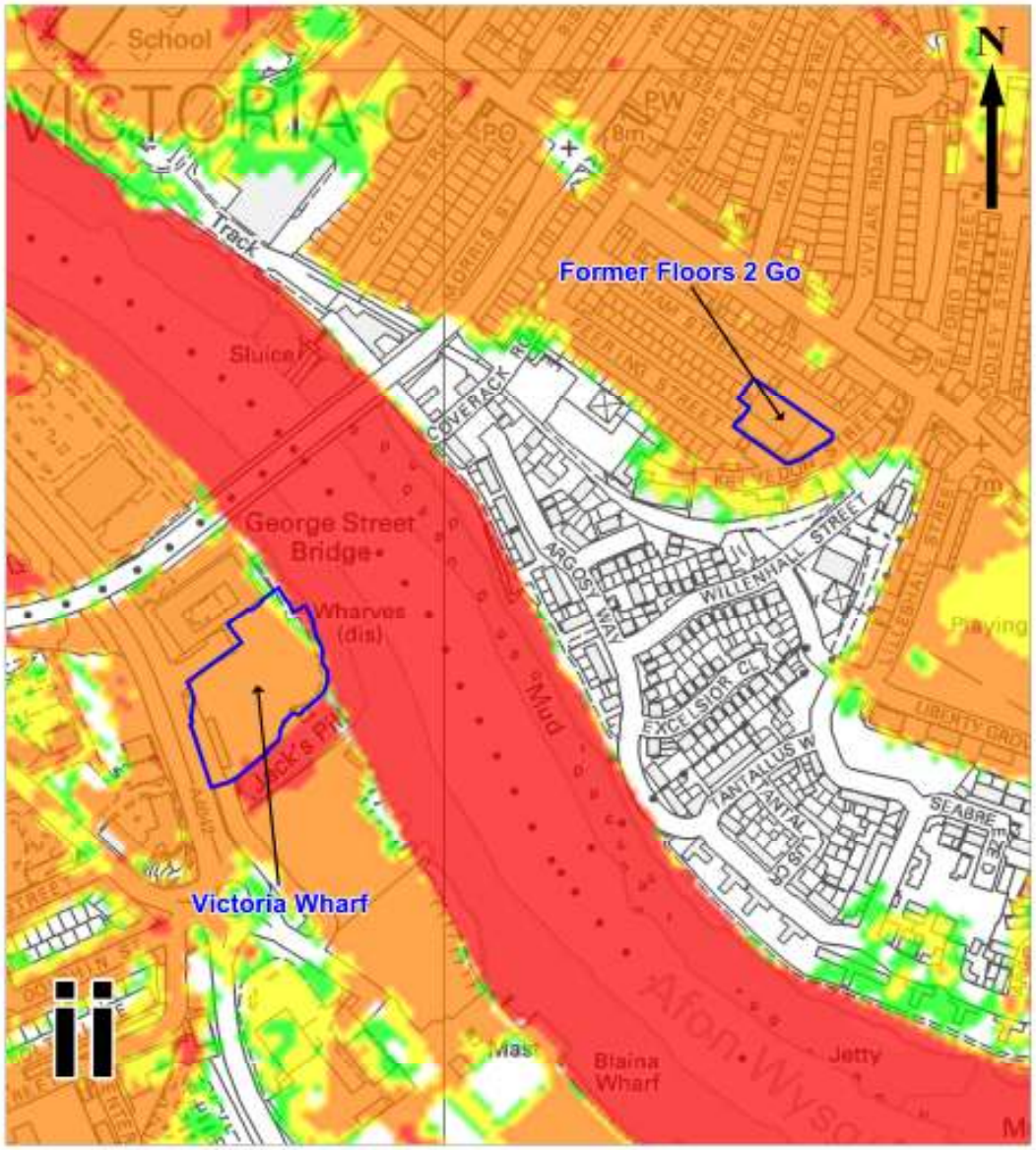
Figure C-1: Scenario 1 (1 in 200 year event)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m – 0.50m – 1.00m – 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

- Low
- Moderate
- Significant
- Extreme

Client:
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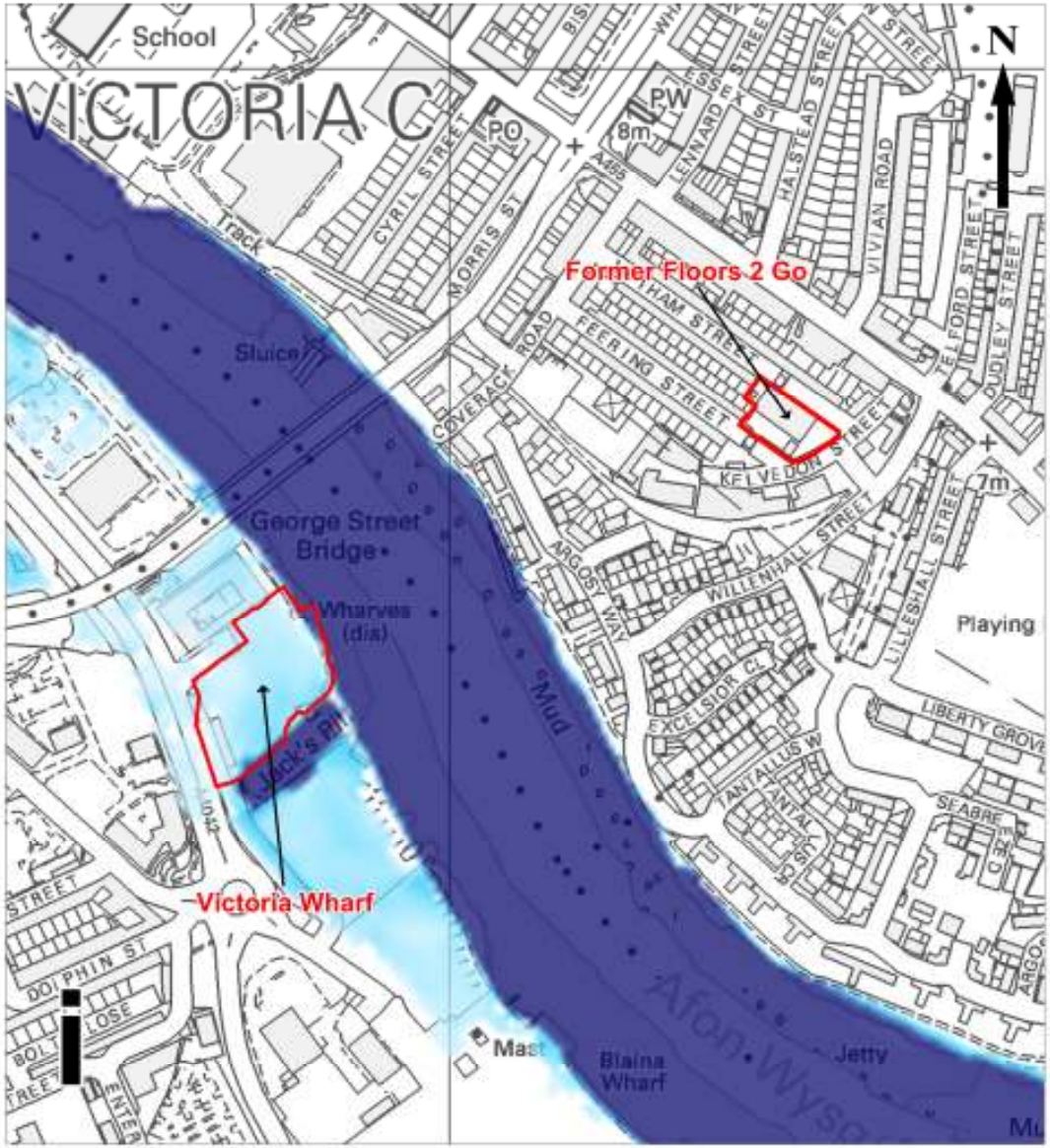
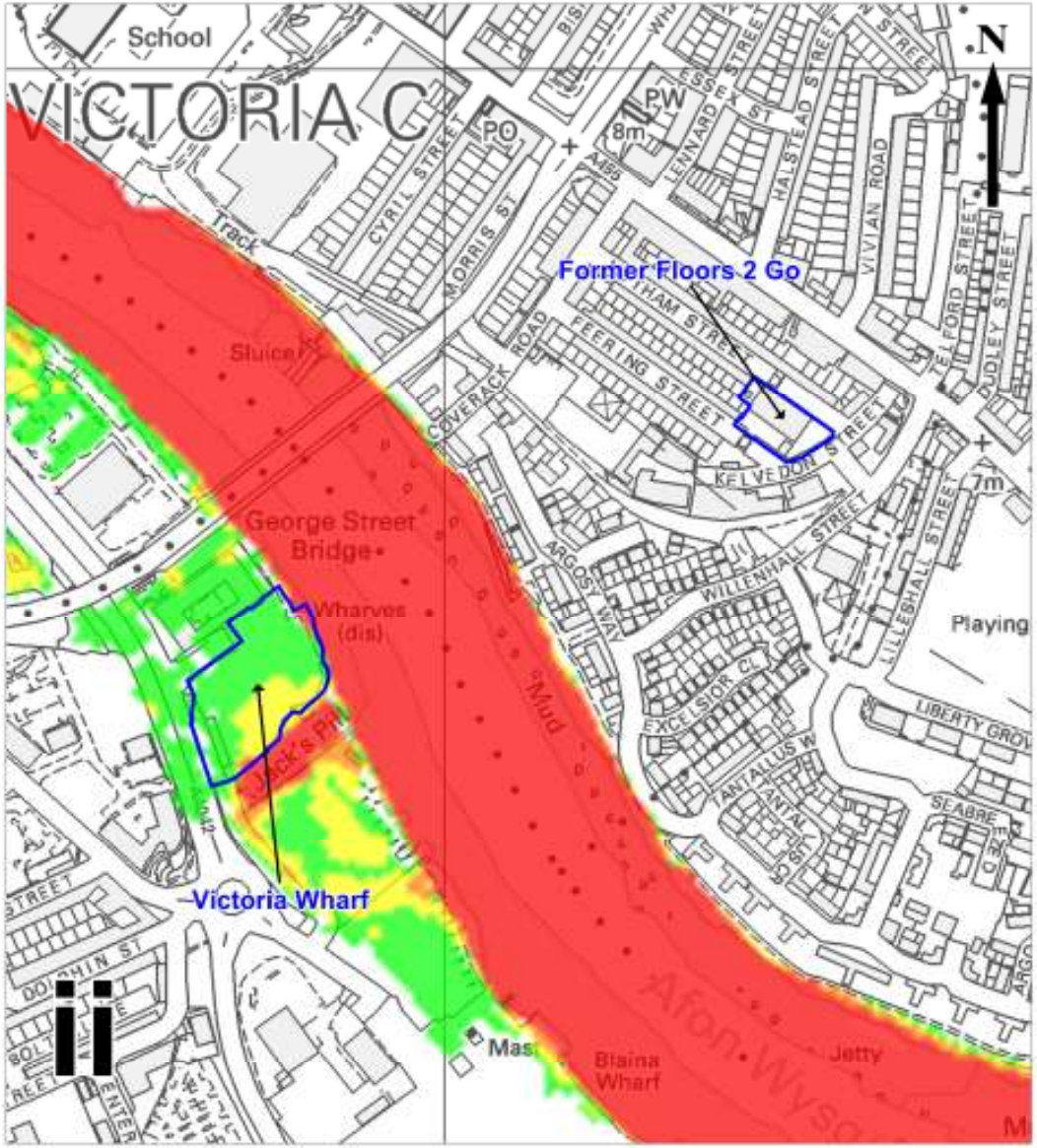
Figure C-2: Scenario 3 (1 in 200 year event - climate change 2111)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Significant
Moderate
Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

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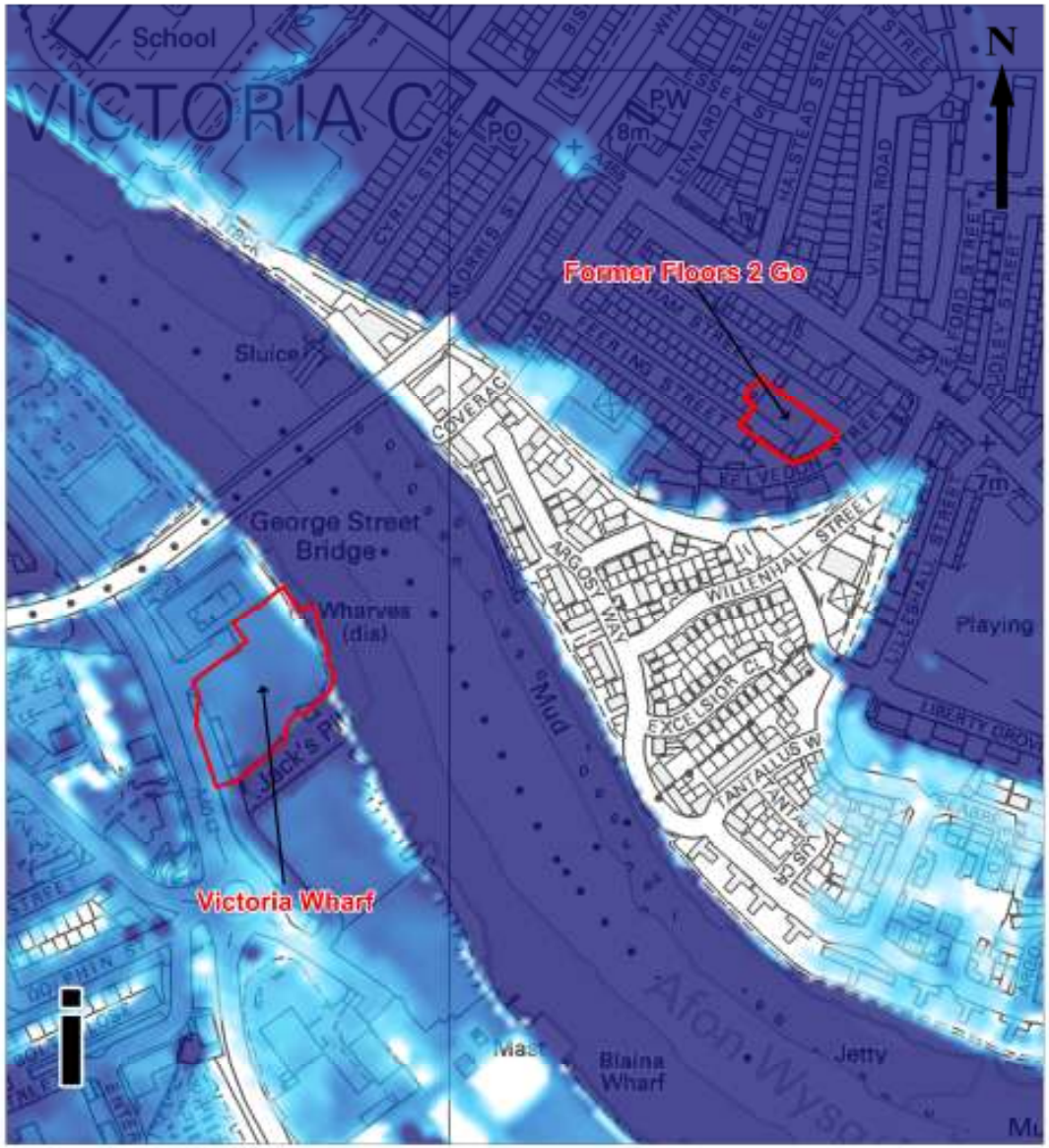
Figure C-3: Scenario 4 (1 in 1000 year event)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard



Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
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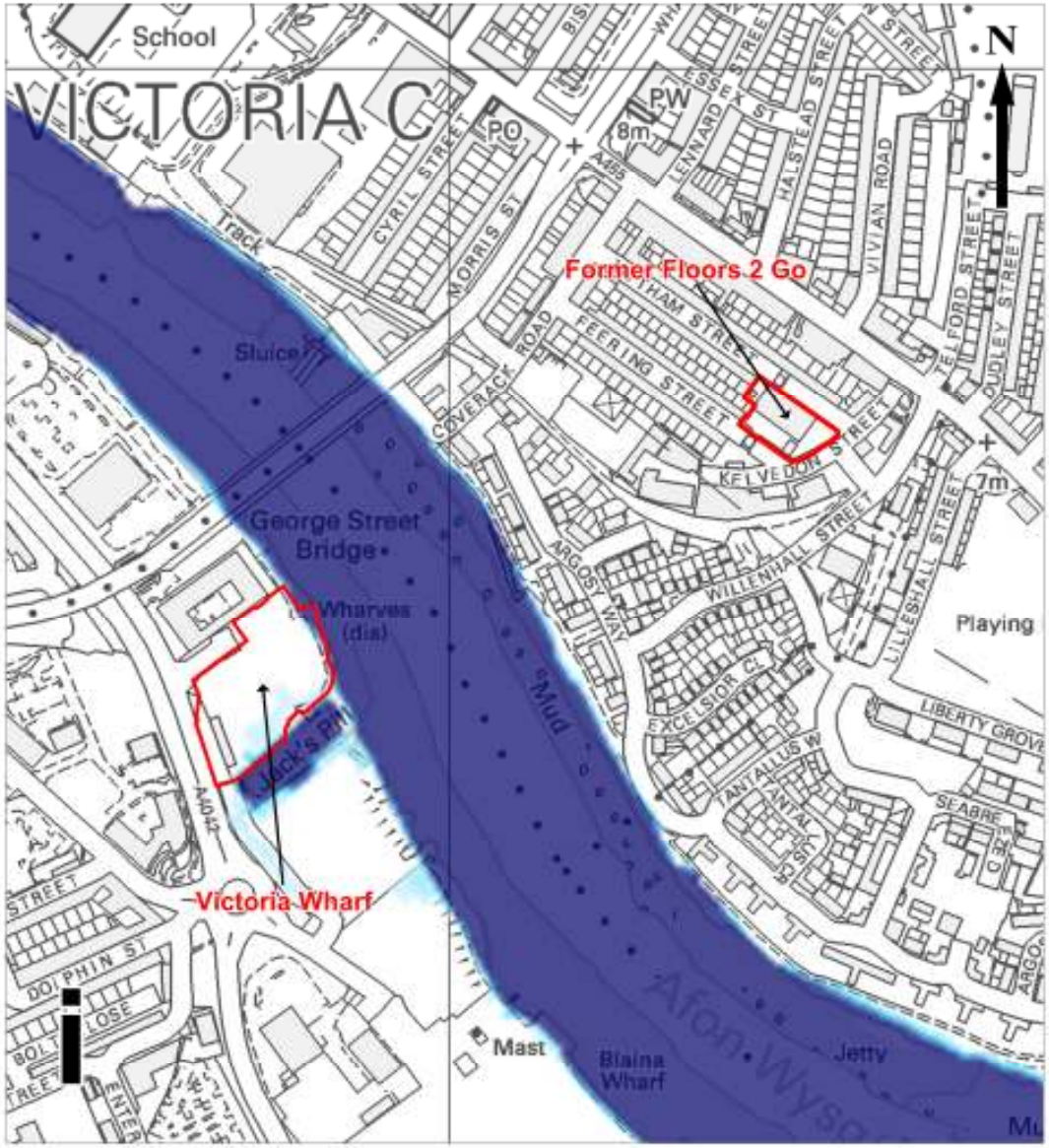
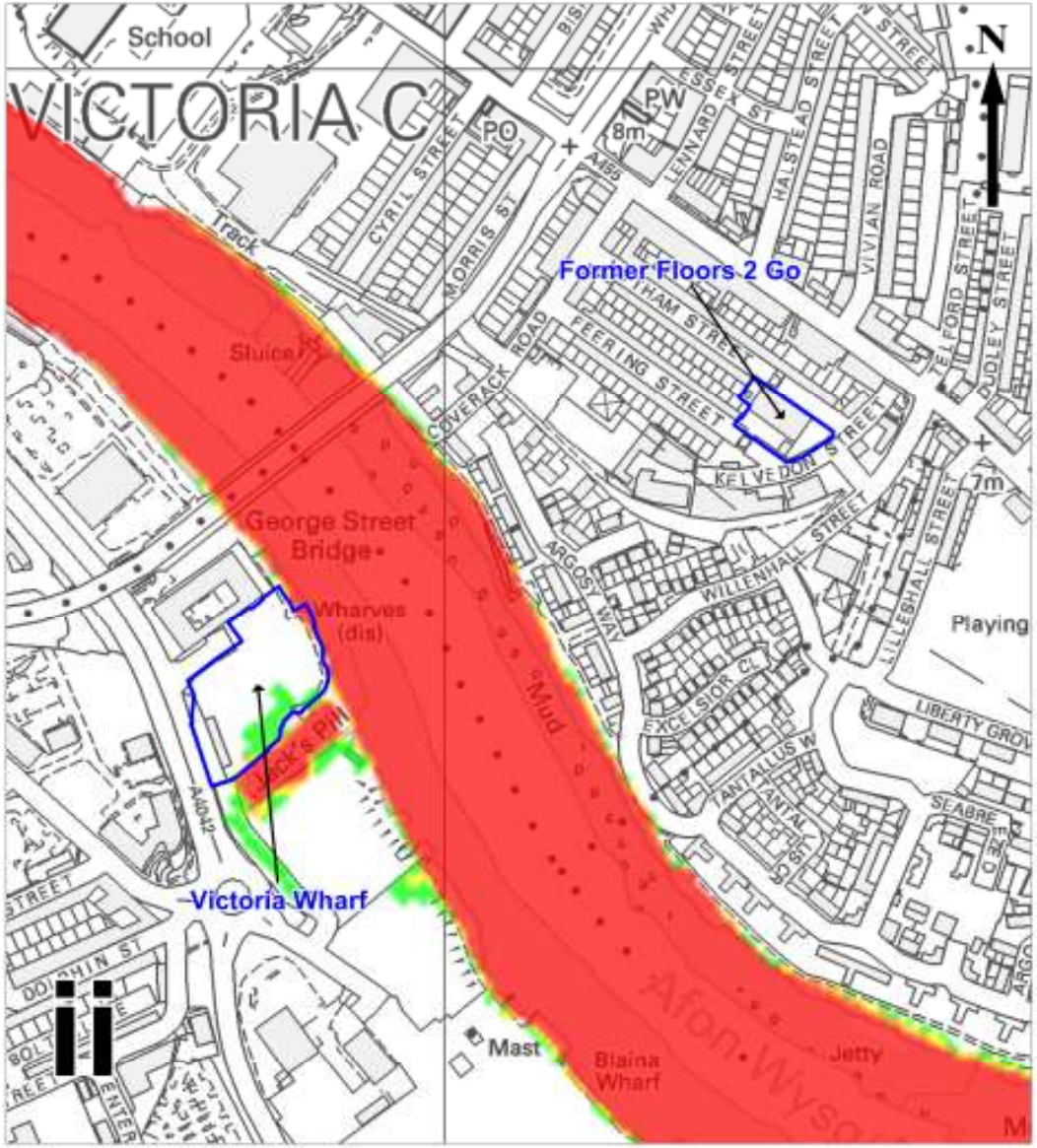
Figure C-4: Scenario 6 (1 in 1000 year event - climate change to 2111)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m – 0.50m – 1.00m – 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

- Low
- Moderate
- Significant
- Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 4,000	Mar 2014	RM	RS

Project:
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Bristol
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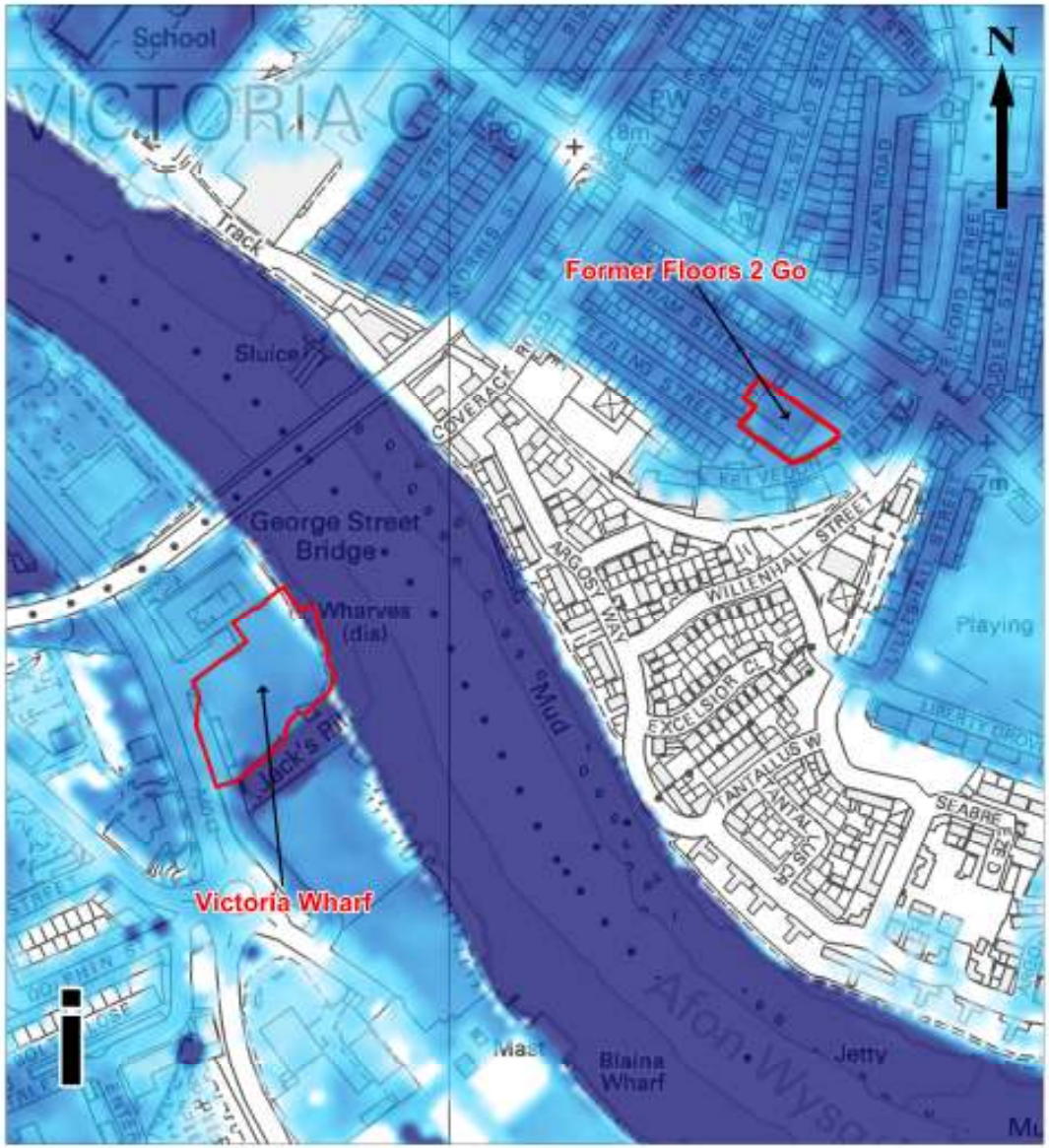
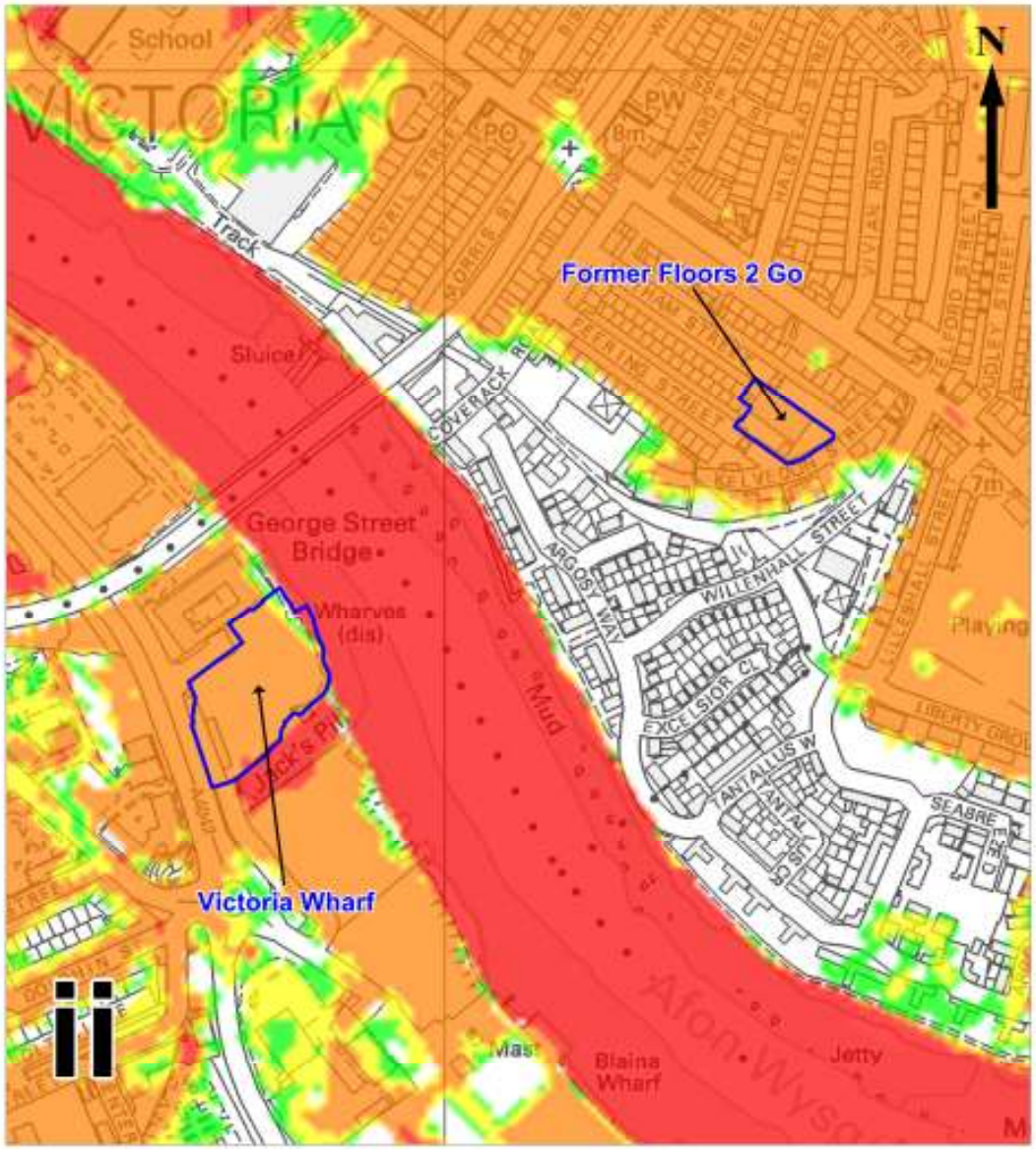
Figure C-5: Scenario 7 (1 in 200 year event with Breach Location)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

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This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 4,000	Mar 2014	RM	RS

Project:
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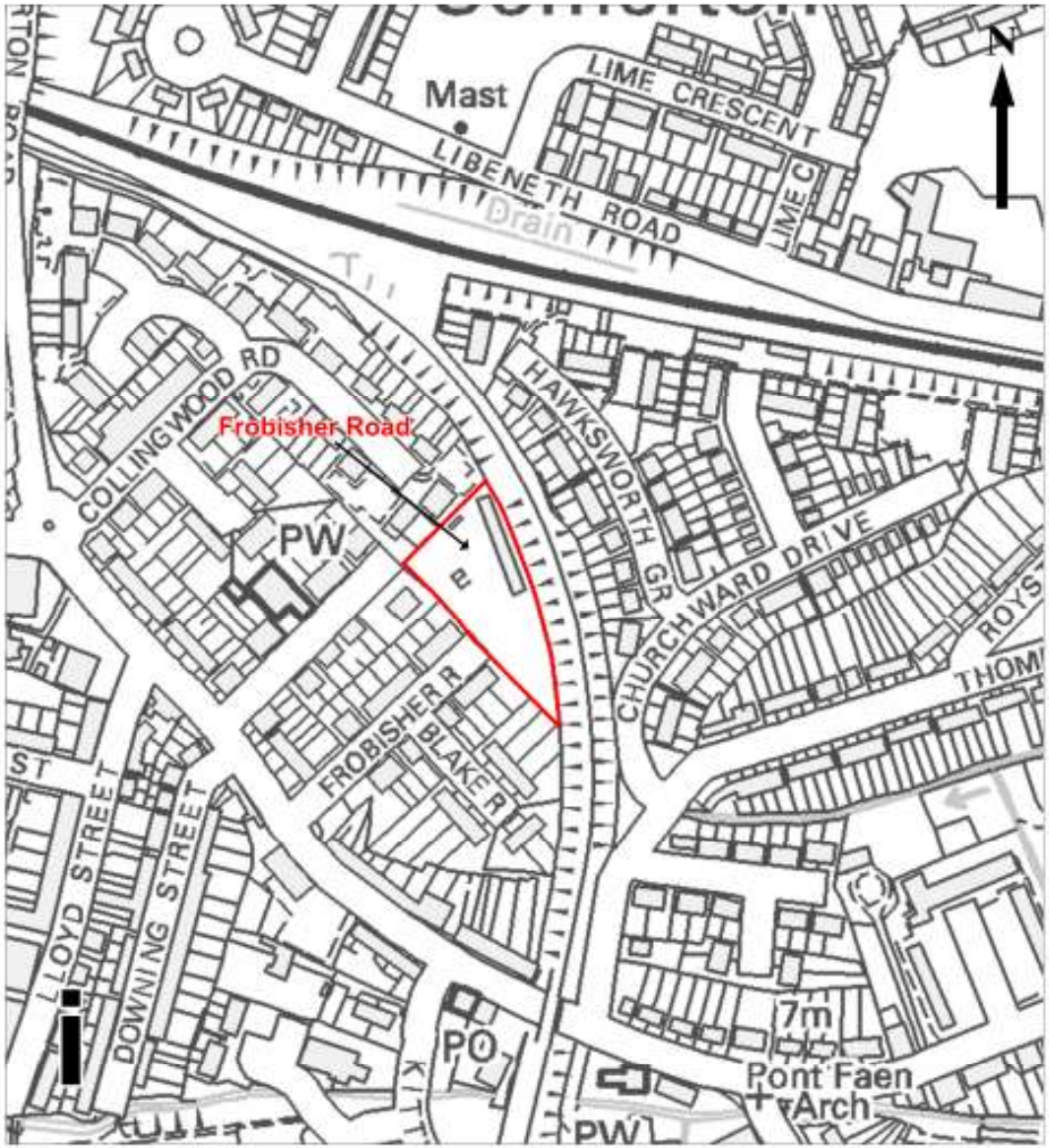
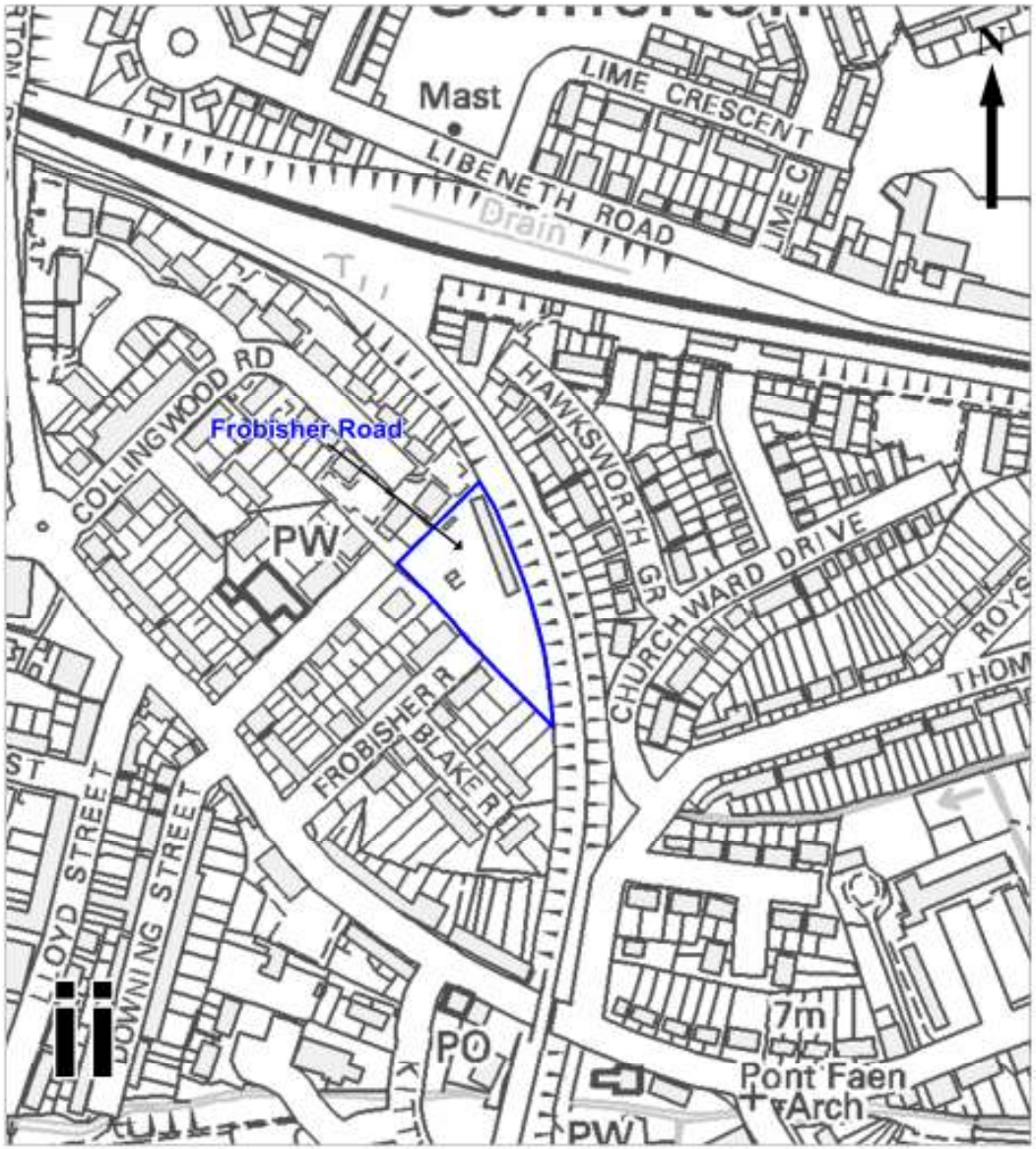
Figure C-6: Scenario 9 (1 in 200 year event - climate change to 2111 with Breach Location). (i) Maximum Flood Depth (ii) Maximum Flood Hazard

APPENDIX D DEPTH & HAZARD MAPPING FOR FROBISHER ROAD





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Significant
Moderate
Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

Project:
Stage 3 Strategic Flood Consequence Assessment

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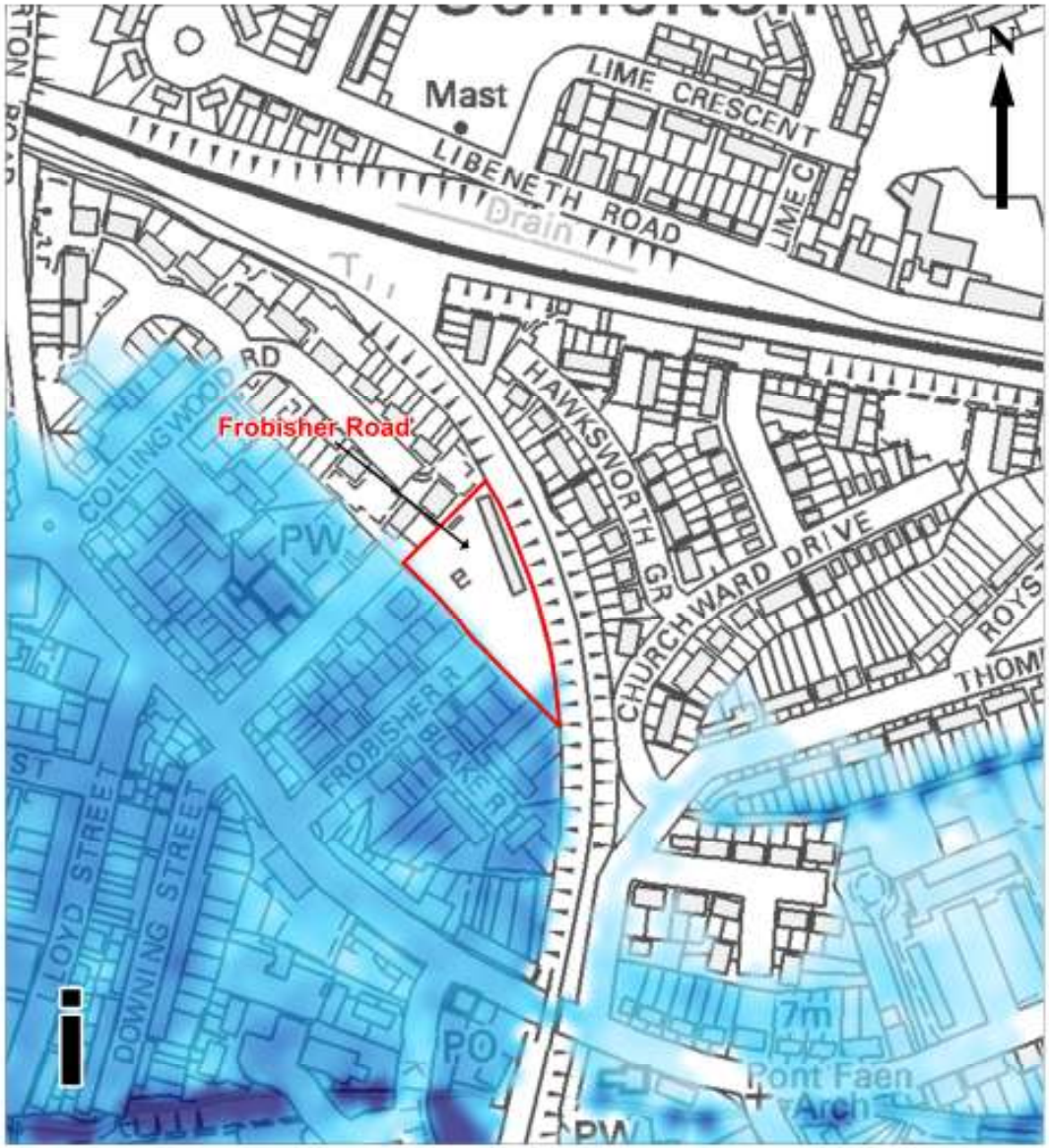
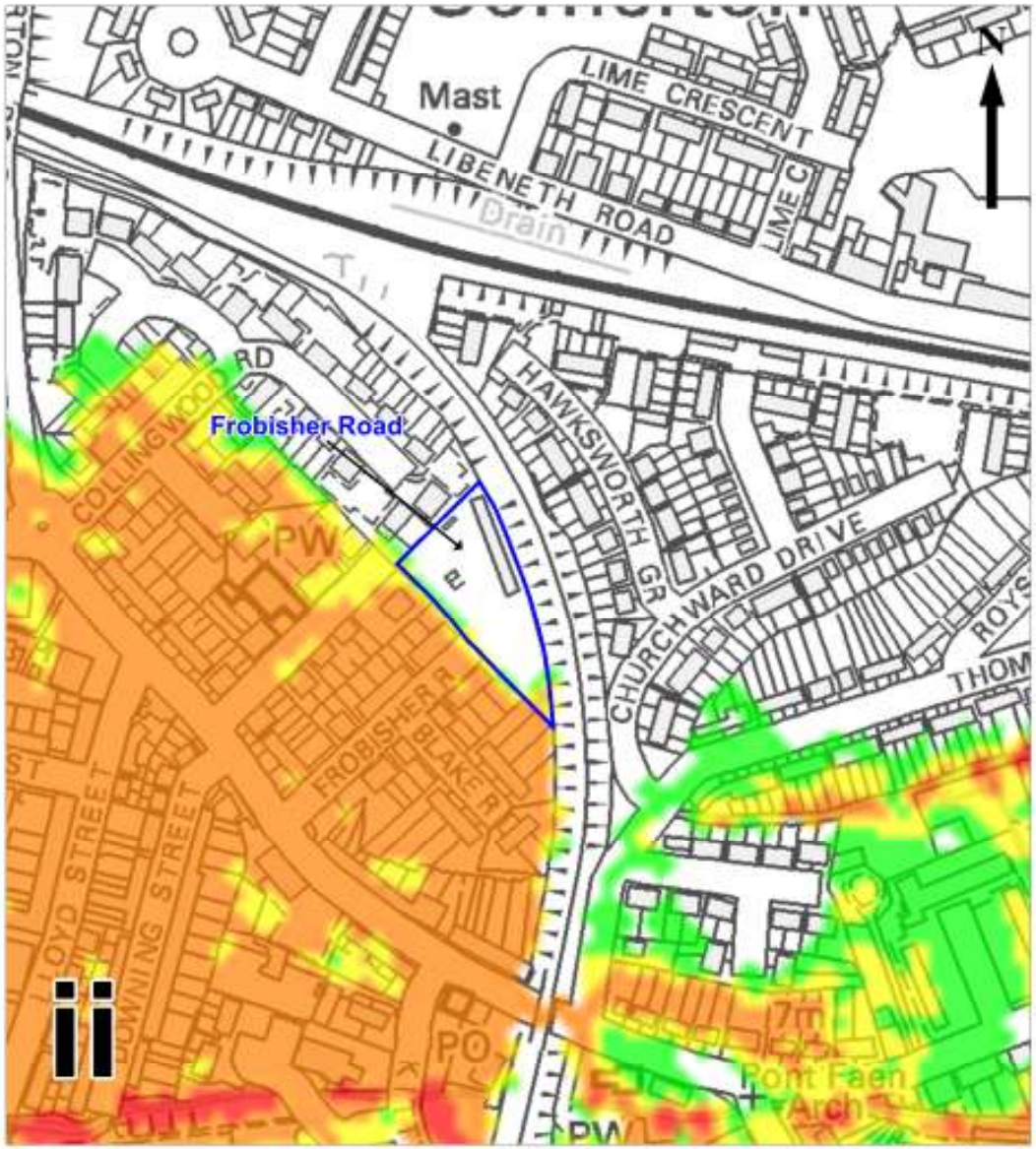
Figure D-1: Scenario 1 (1 in 200 year event)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

Project:
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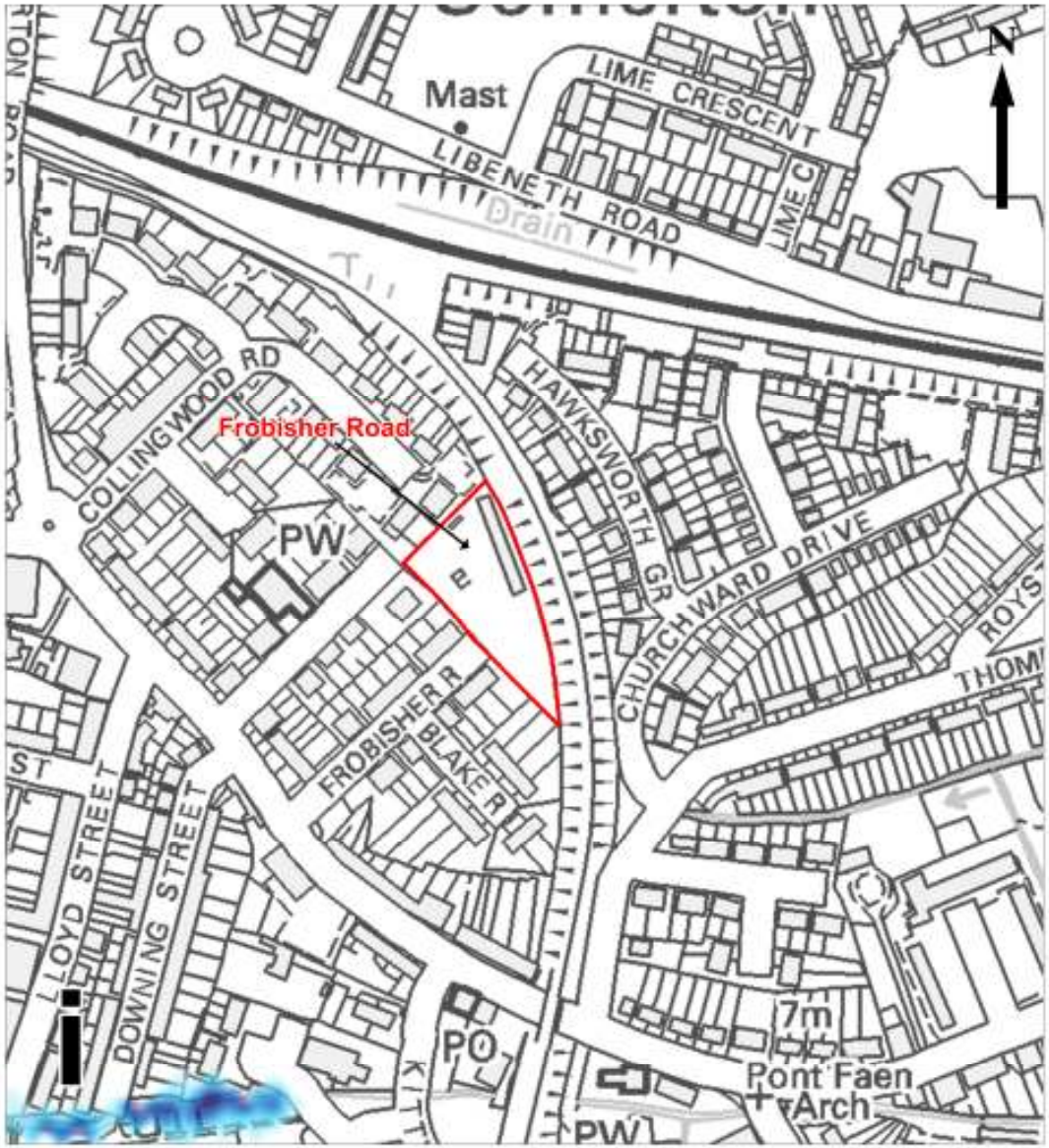
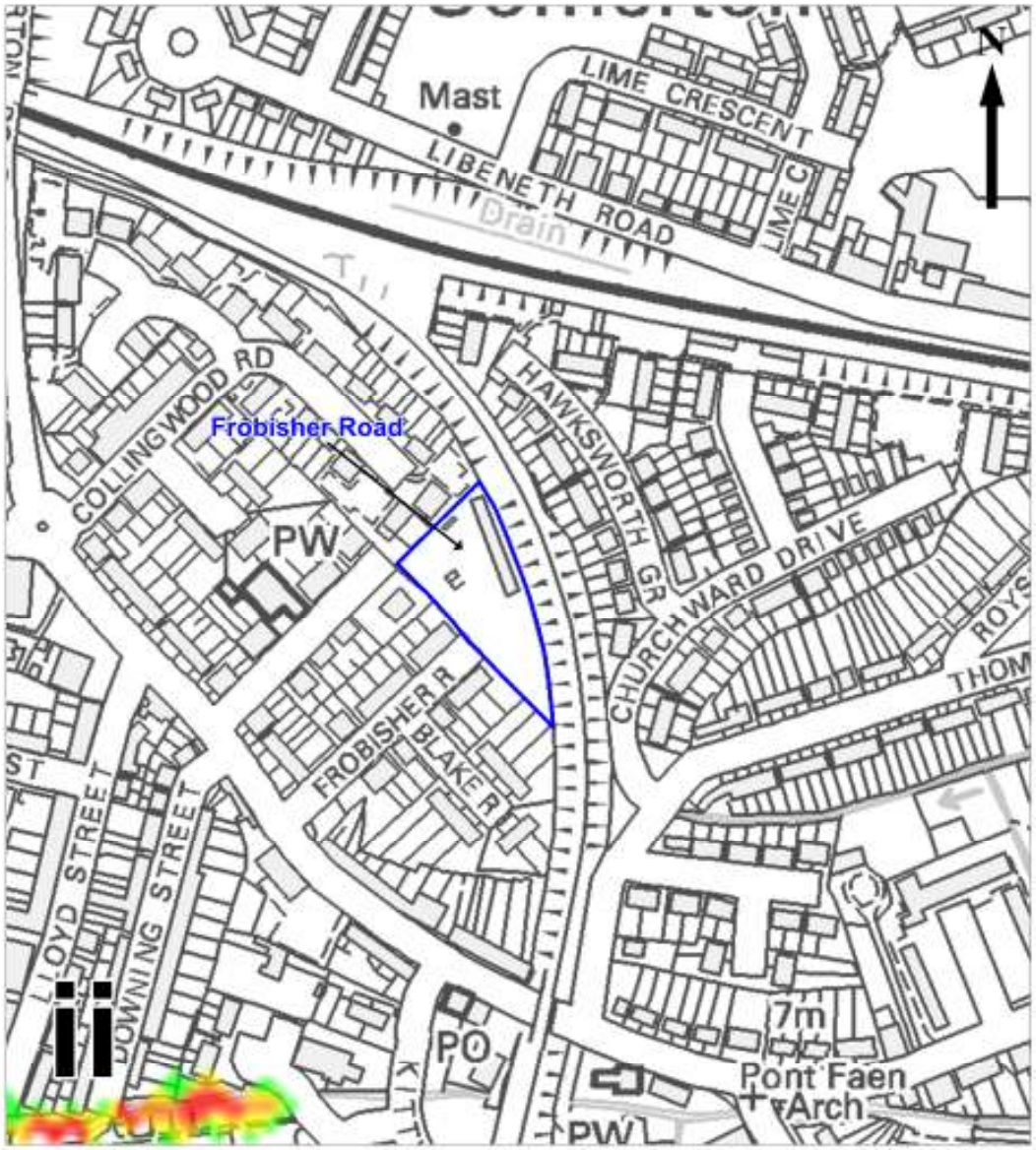
Figure D-2: Scenario 3 (1 in 200 year event - climate change to 2111)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Significant
Moderate
Extreme

Client:
Newport City Council

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This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

Project:
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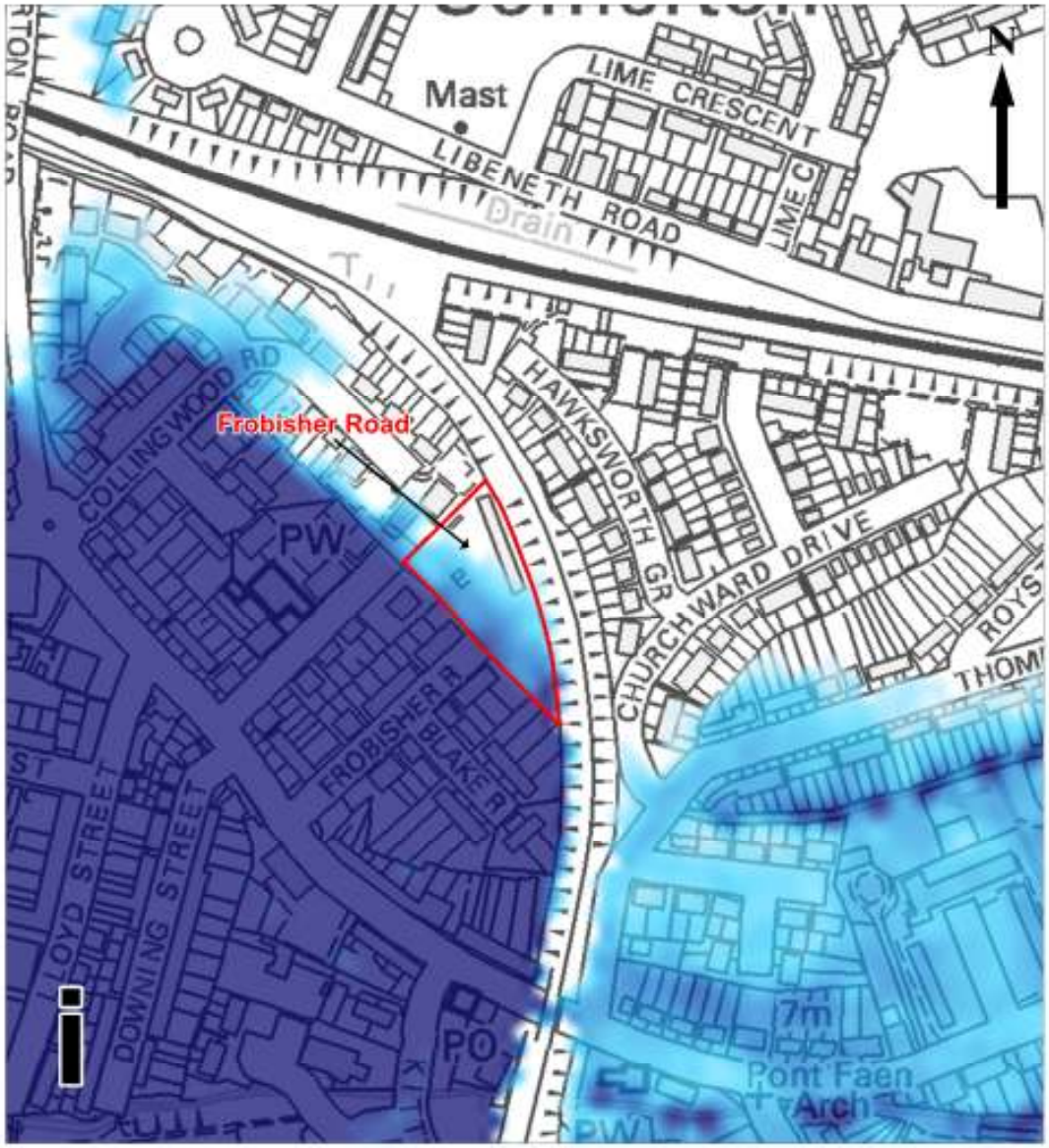
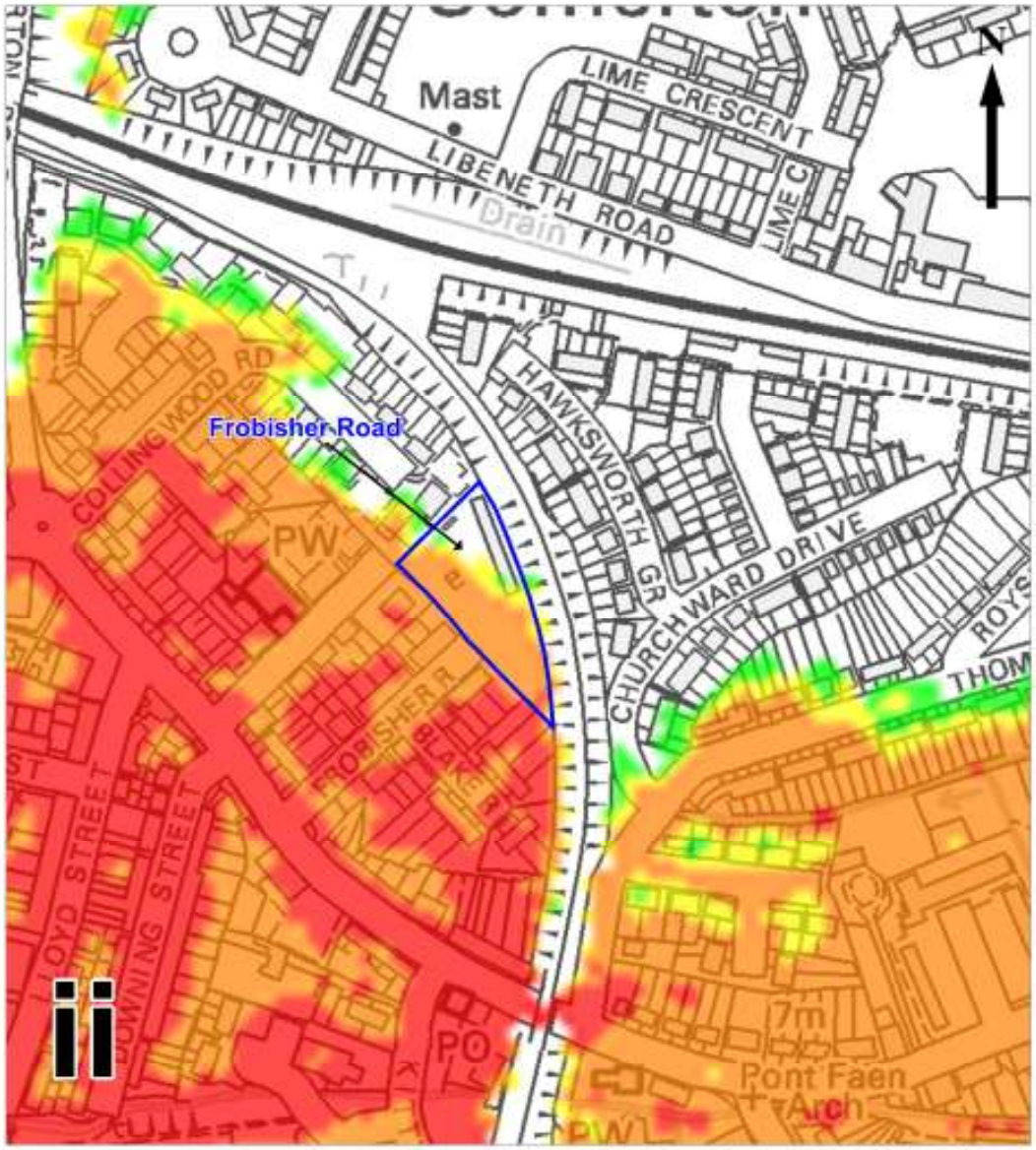
Figure D-3: Scenario 4 (1 in 1000 year event)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

Project:
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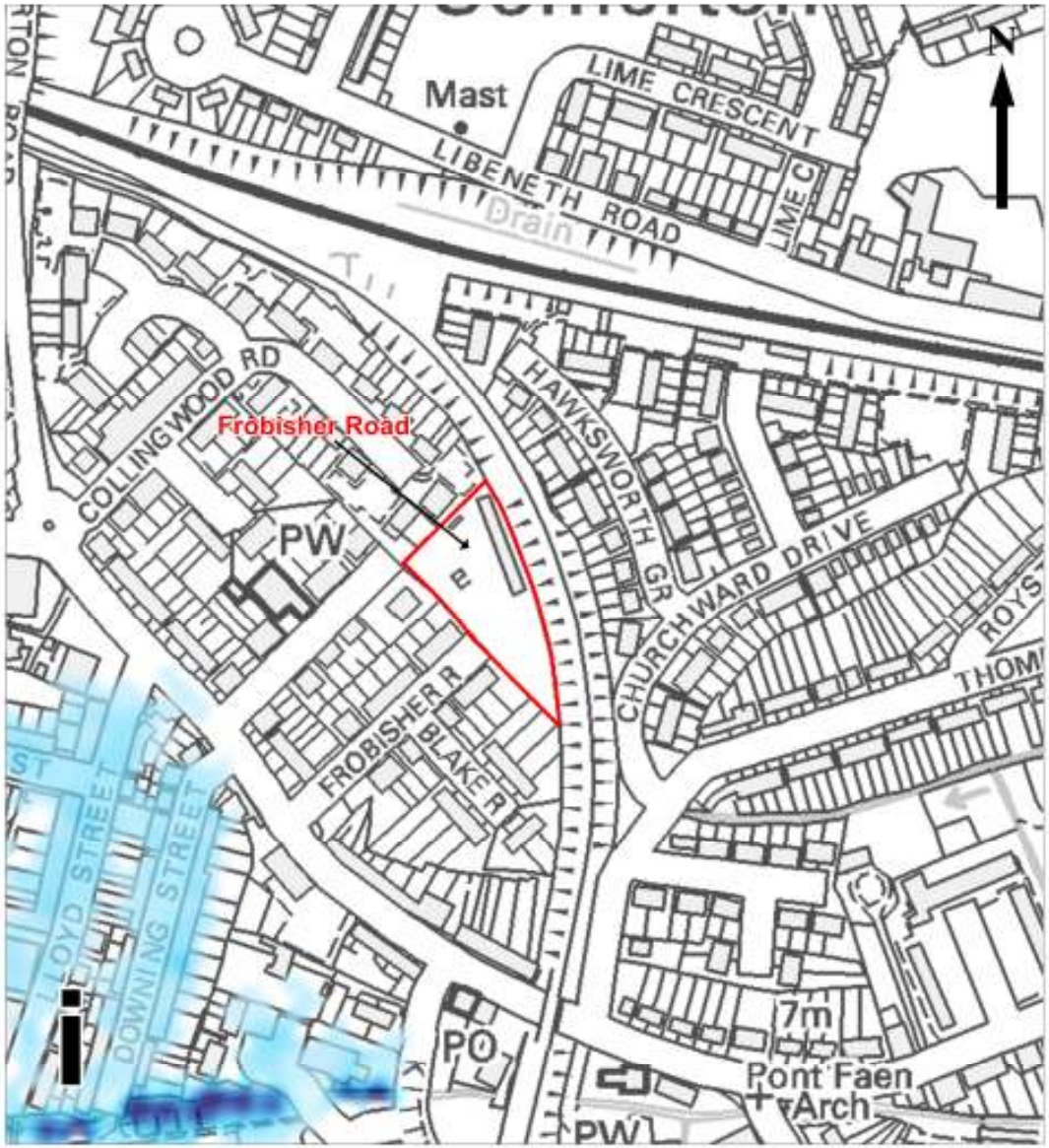
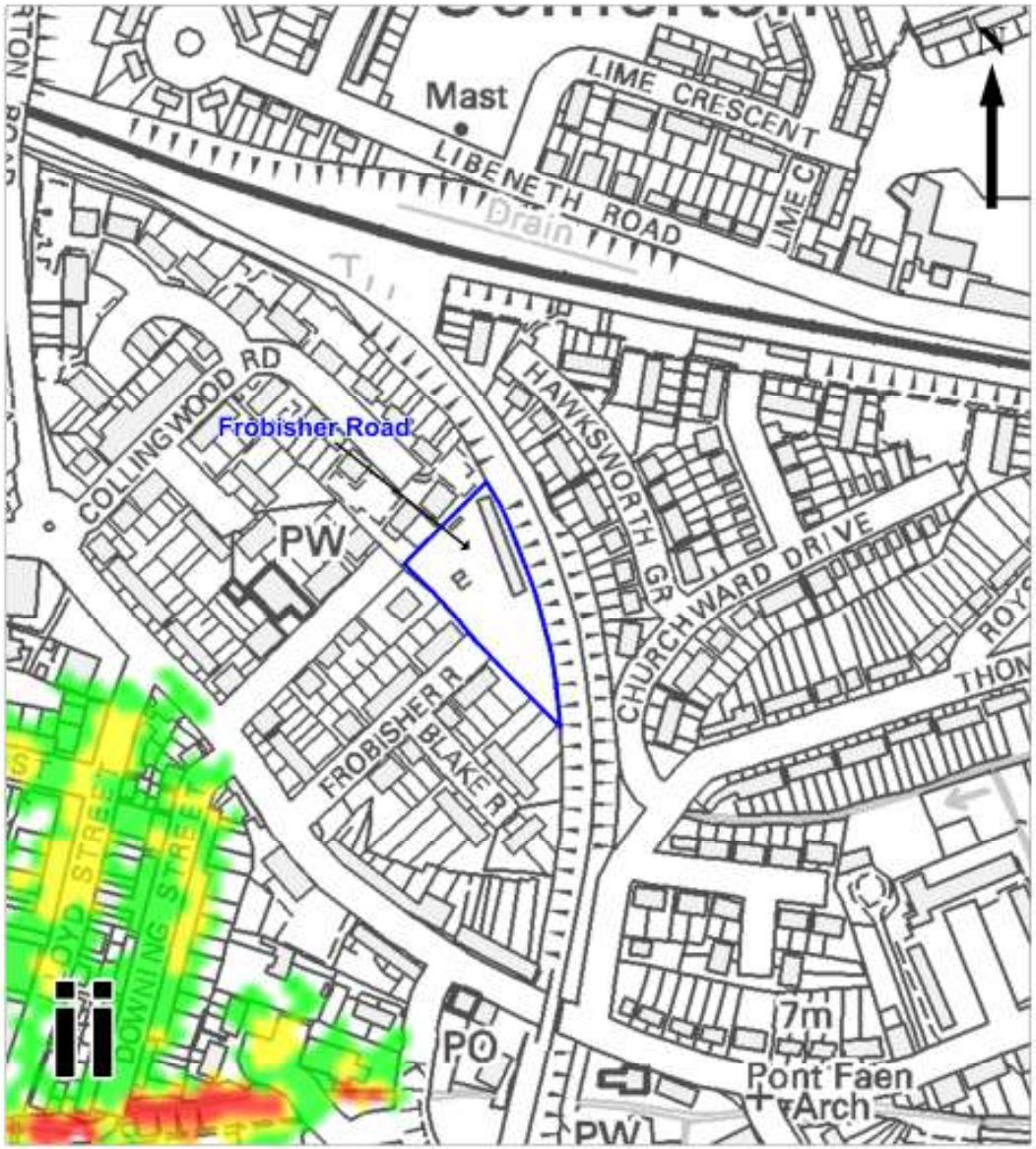
Figure D-4: Scenario 6 (1 in 1000 year event - climate change to 2111)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Significant
Moderate
Extreme

Client:
Newport City Council

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Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

Project:
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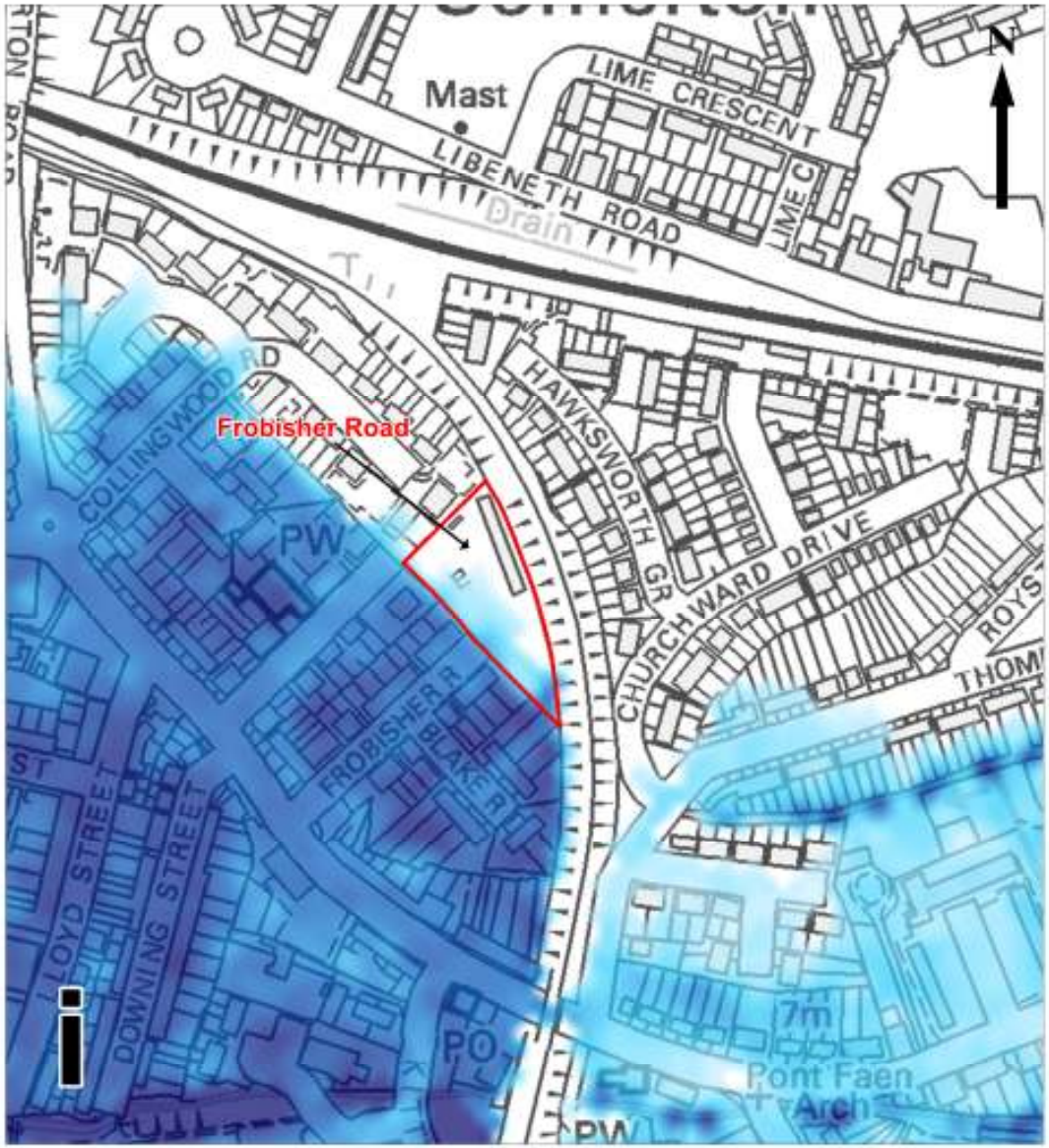
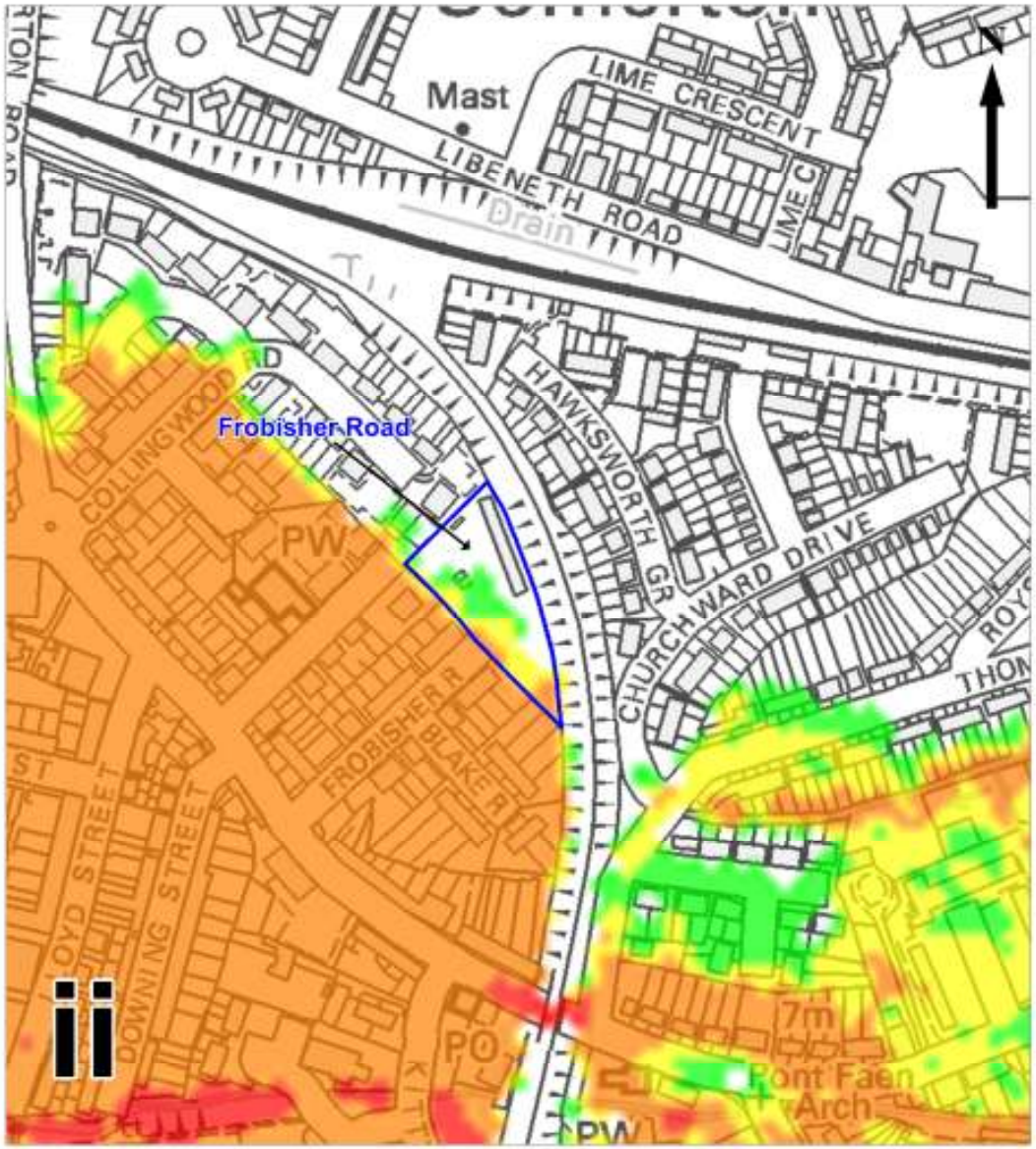
Figure D-5: Scenario 7 (1 in 200 year event with Breach Location)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

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Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

Project:
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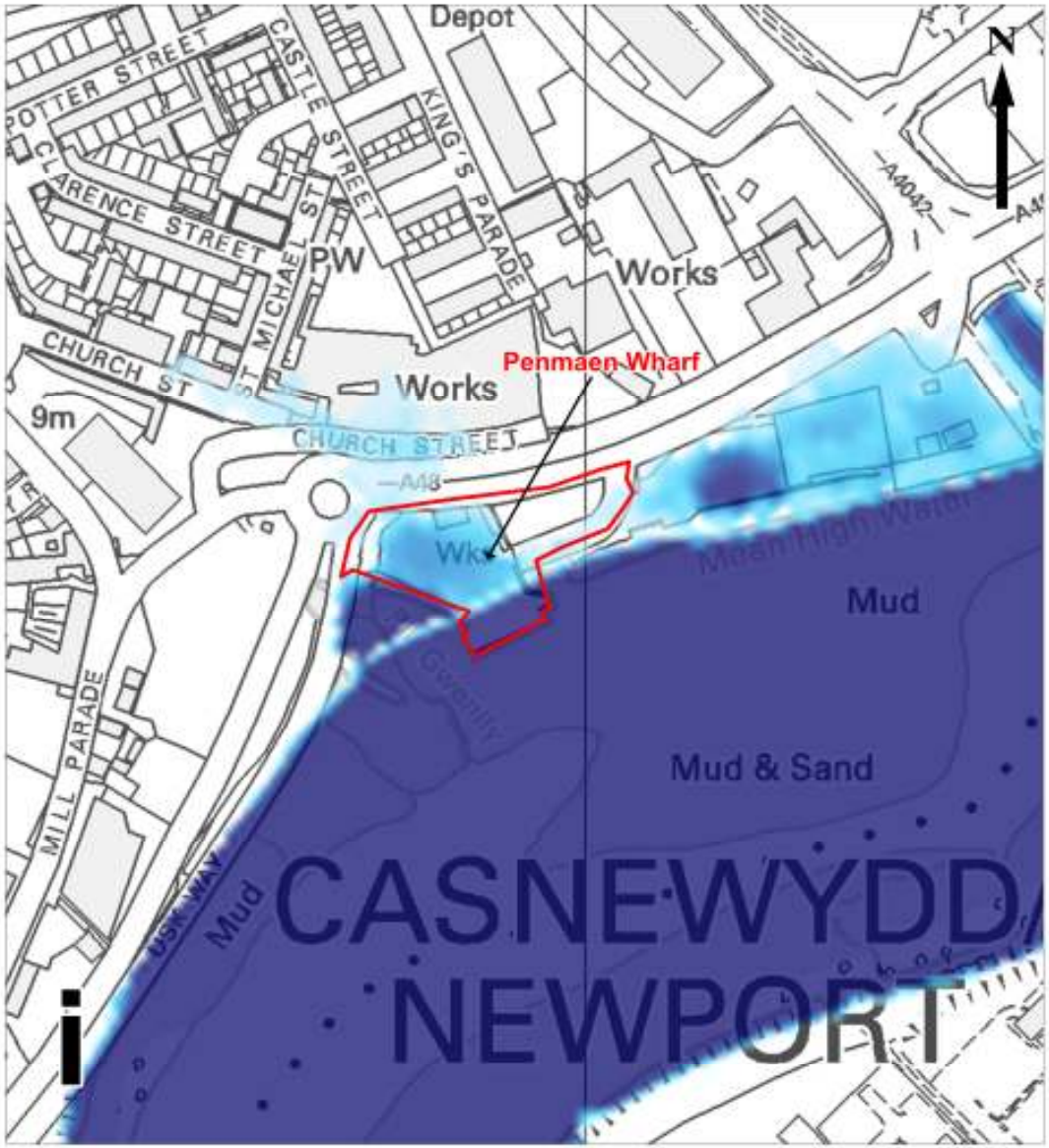
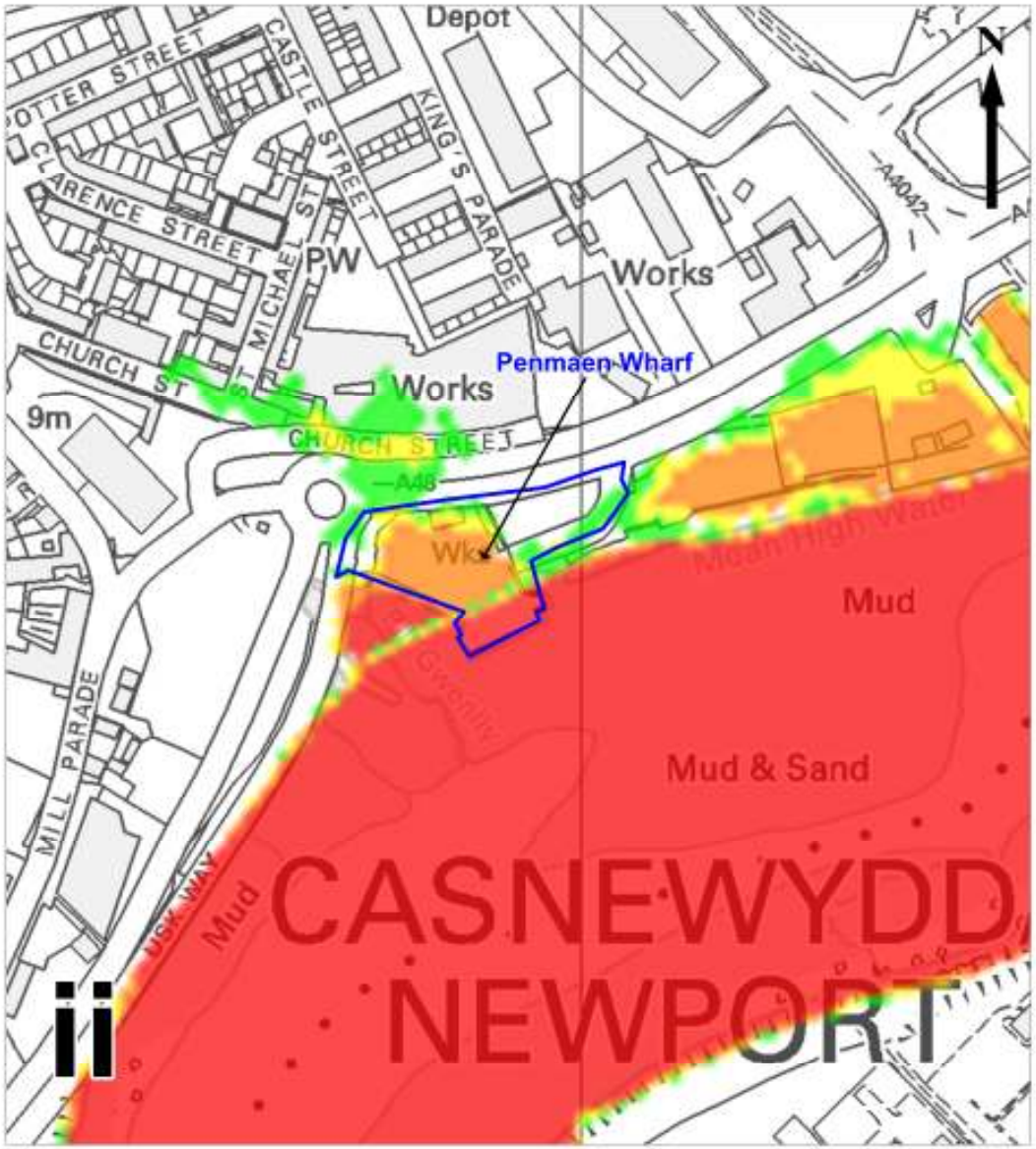
Figure D-6: Scenario 9 (1 in 200 year event - climate change to 2111 with Breach Location). (i) Maximum Flood Depth (ii) Maximum Flood Hazard

APPENDIX E DEPTH & HAZARD MAPPING FOR PENMAEN WHARF





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low

Moderate

Significant

Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 3,000	Mar 2014	RM	RS

Project:
Stage 3 Strategic Flood Consequence Assessment

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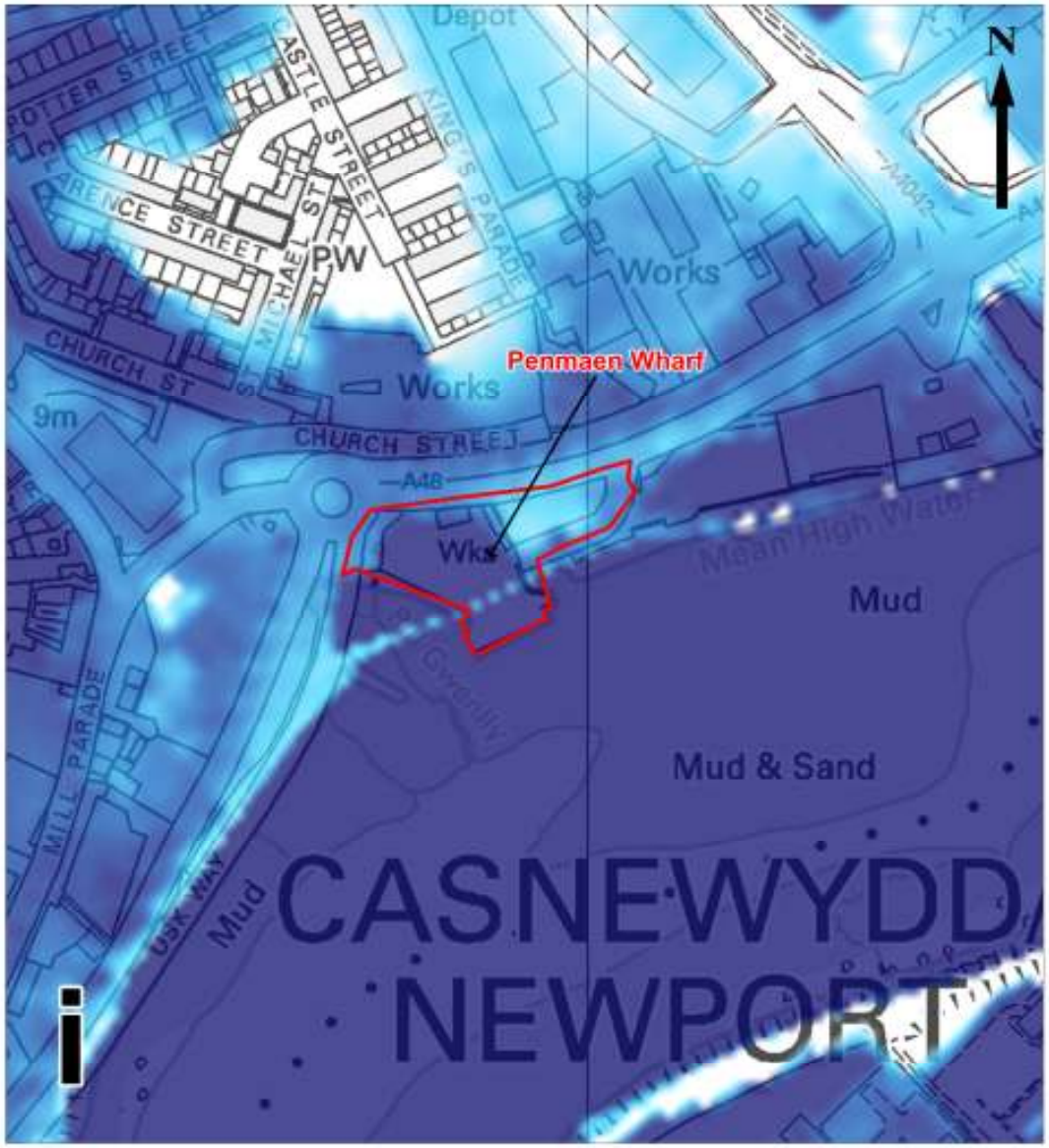
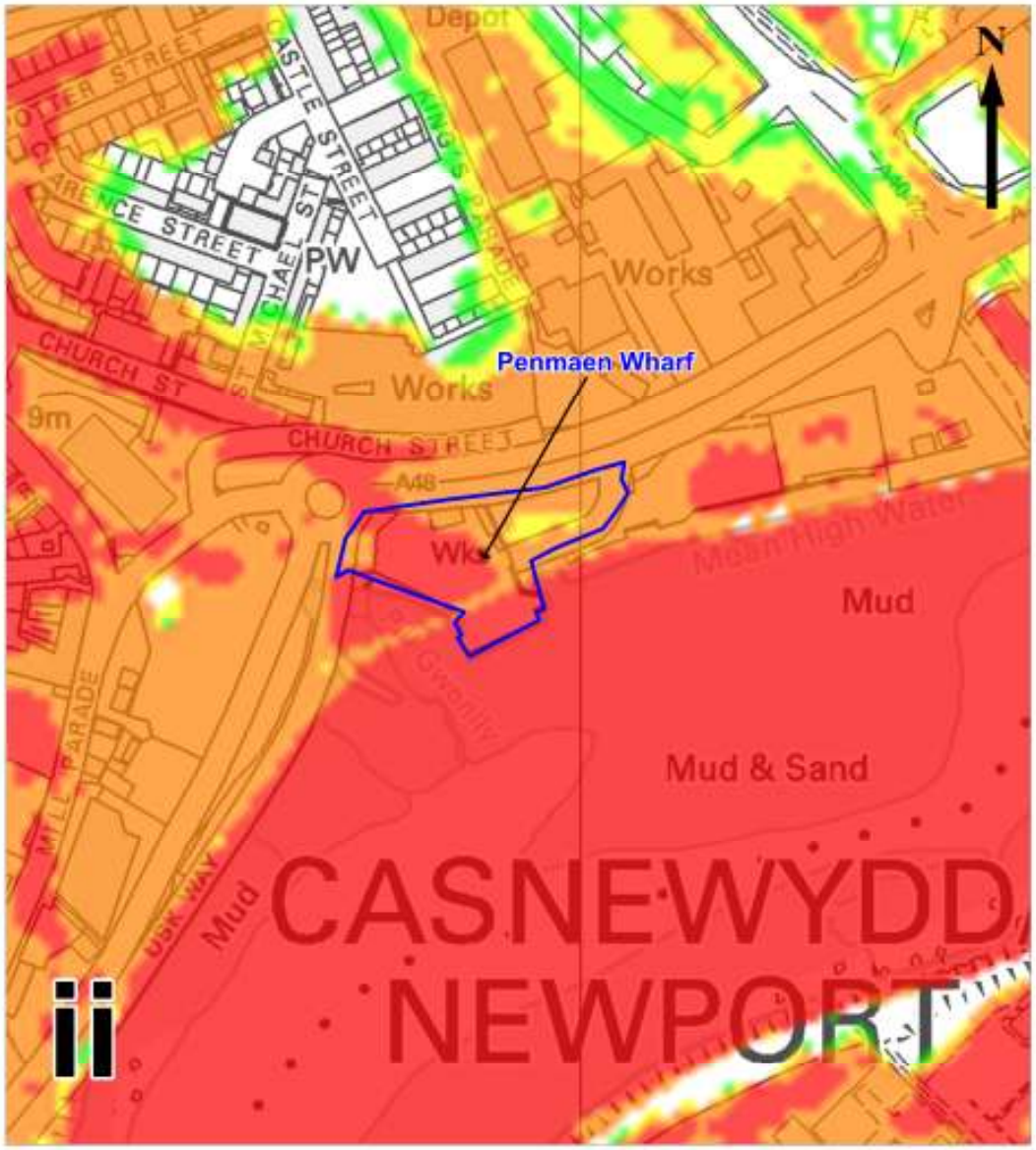
Figure E-1: Scenario 1 (1 in 200 year event)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

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This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 3,000	Mar 2014	RM	RS

Project:
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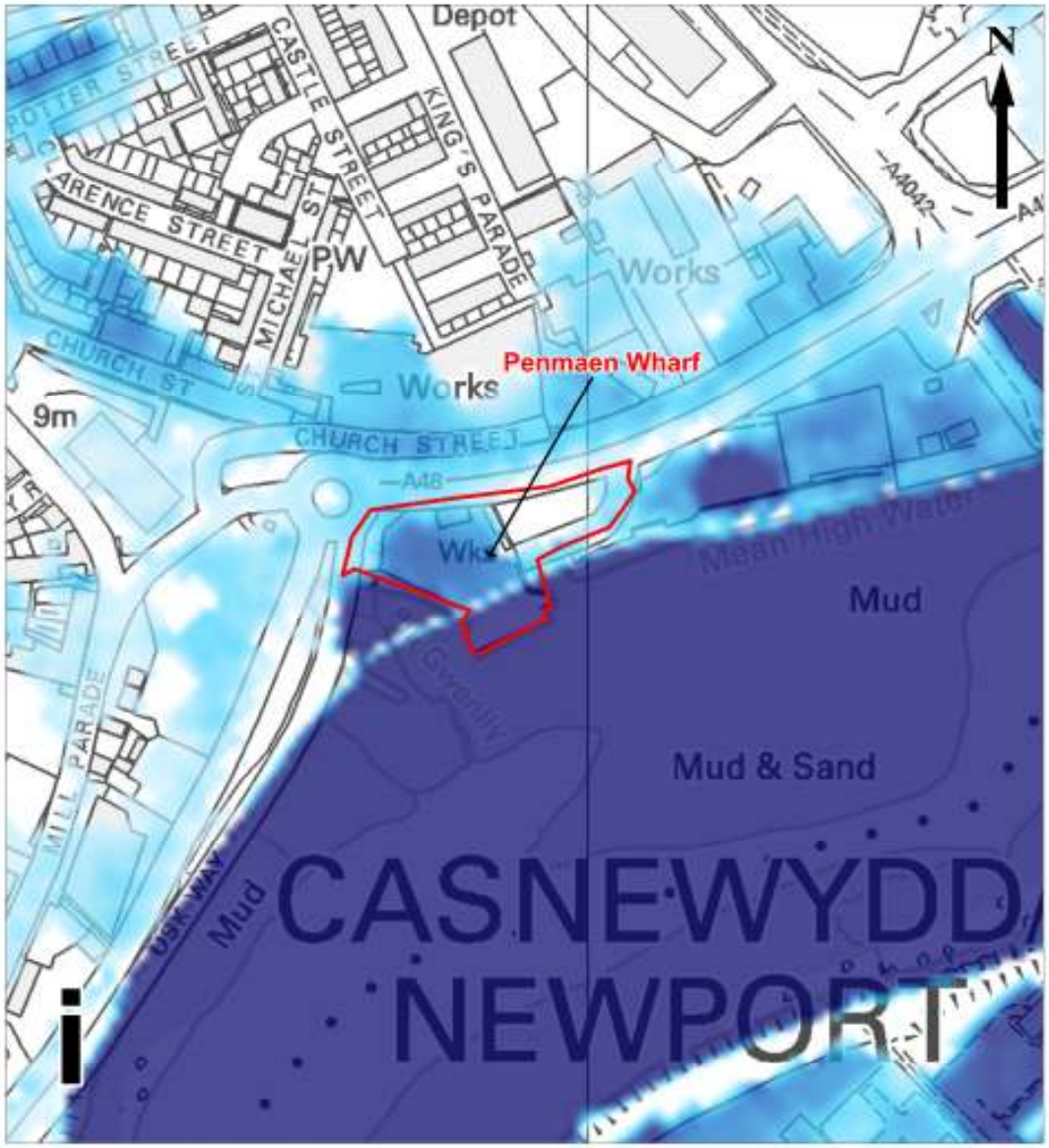
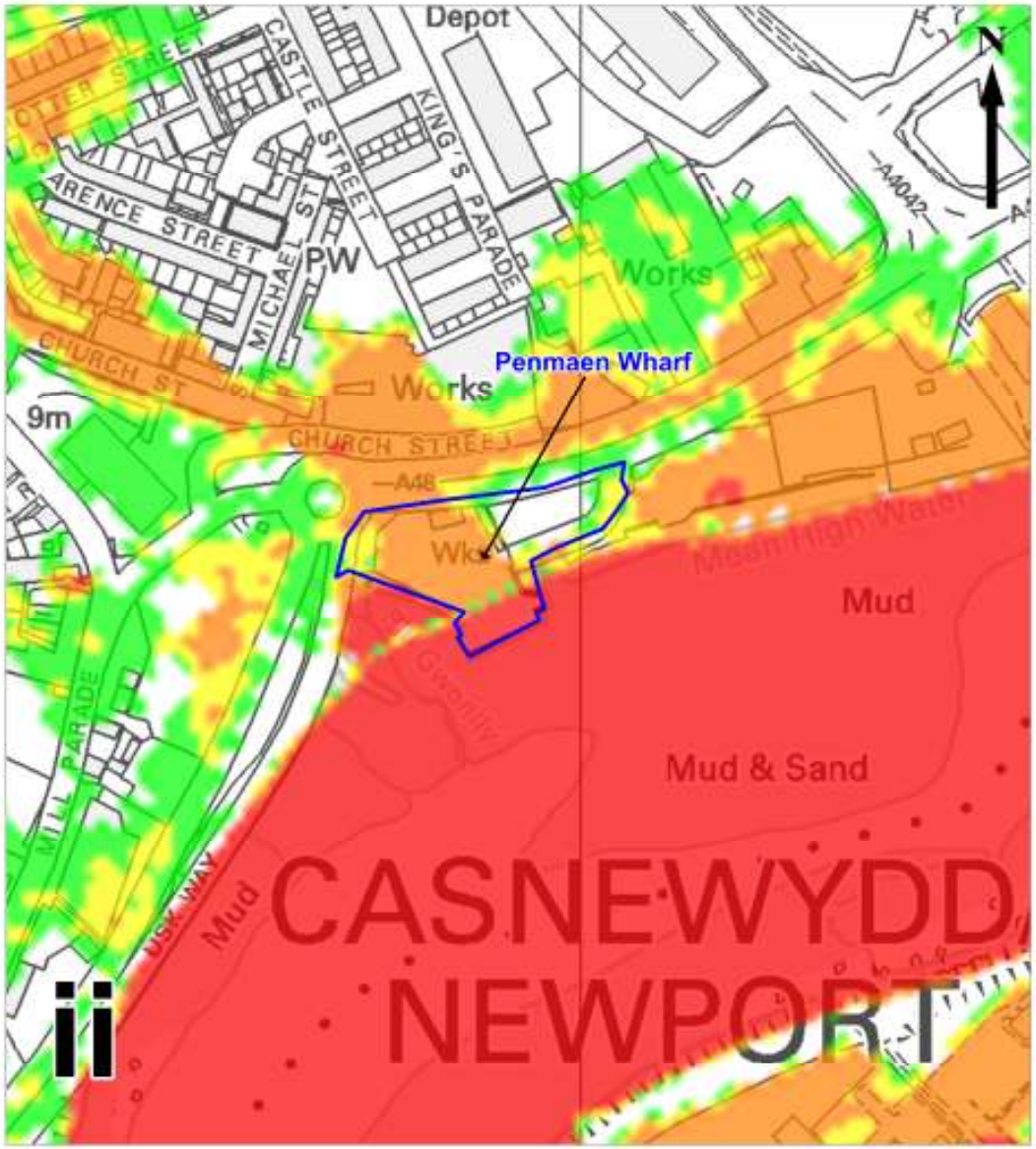
Figure E-2: Scenario 3 (1 in 200 year event - climate change to 2111)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

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Scale at A3:	Date:	Drawn by:	Approved By:
1: 3,000	Mar 2014	RM	RS

Project:
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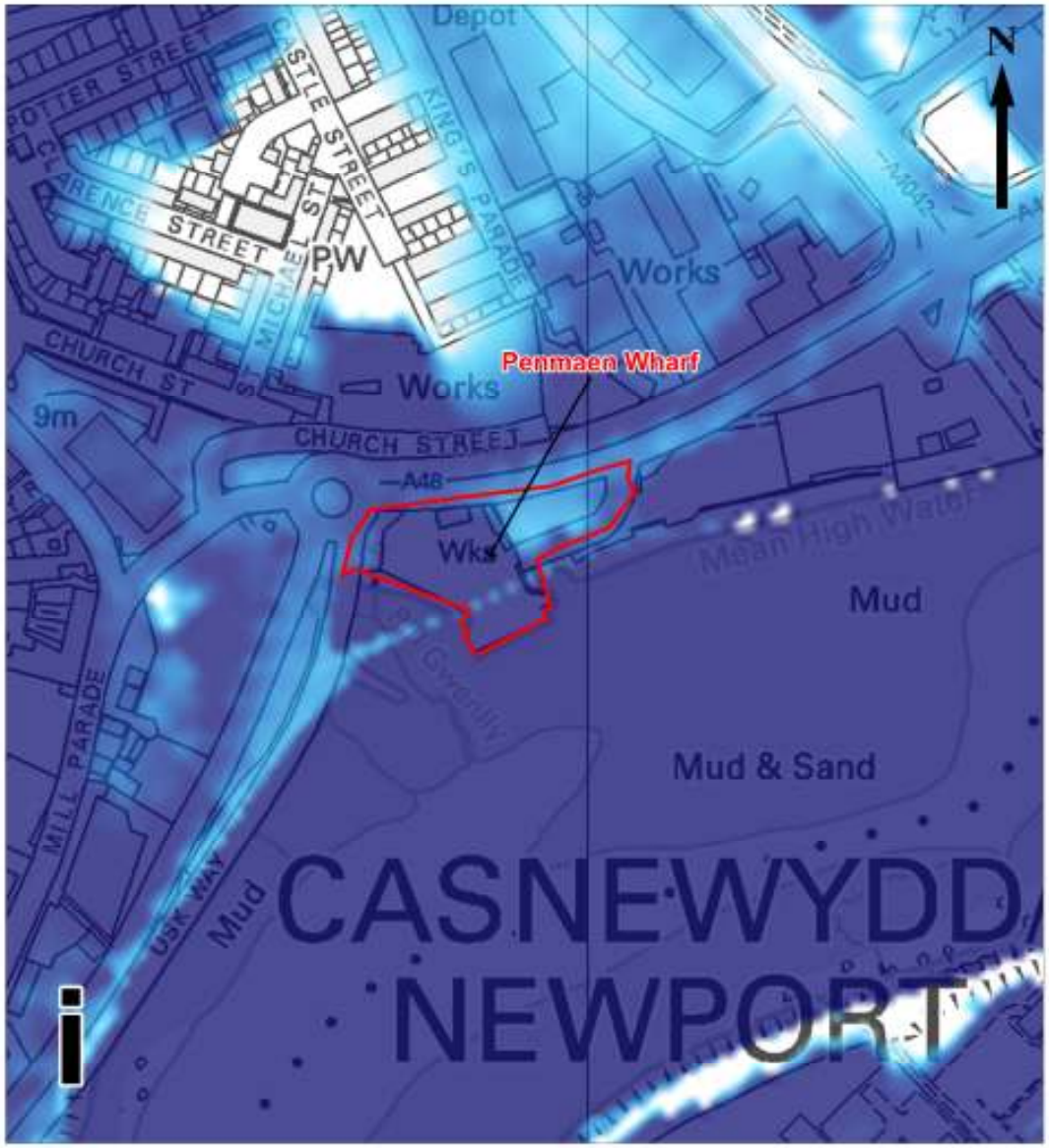
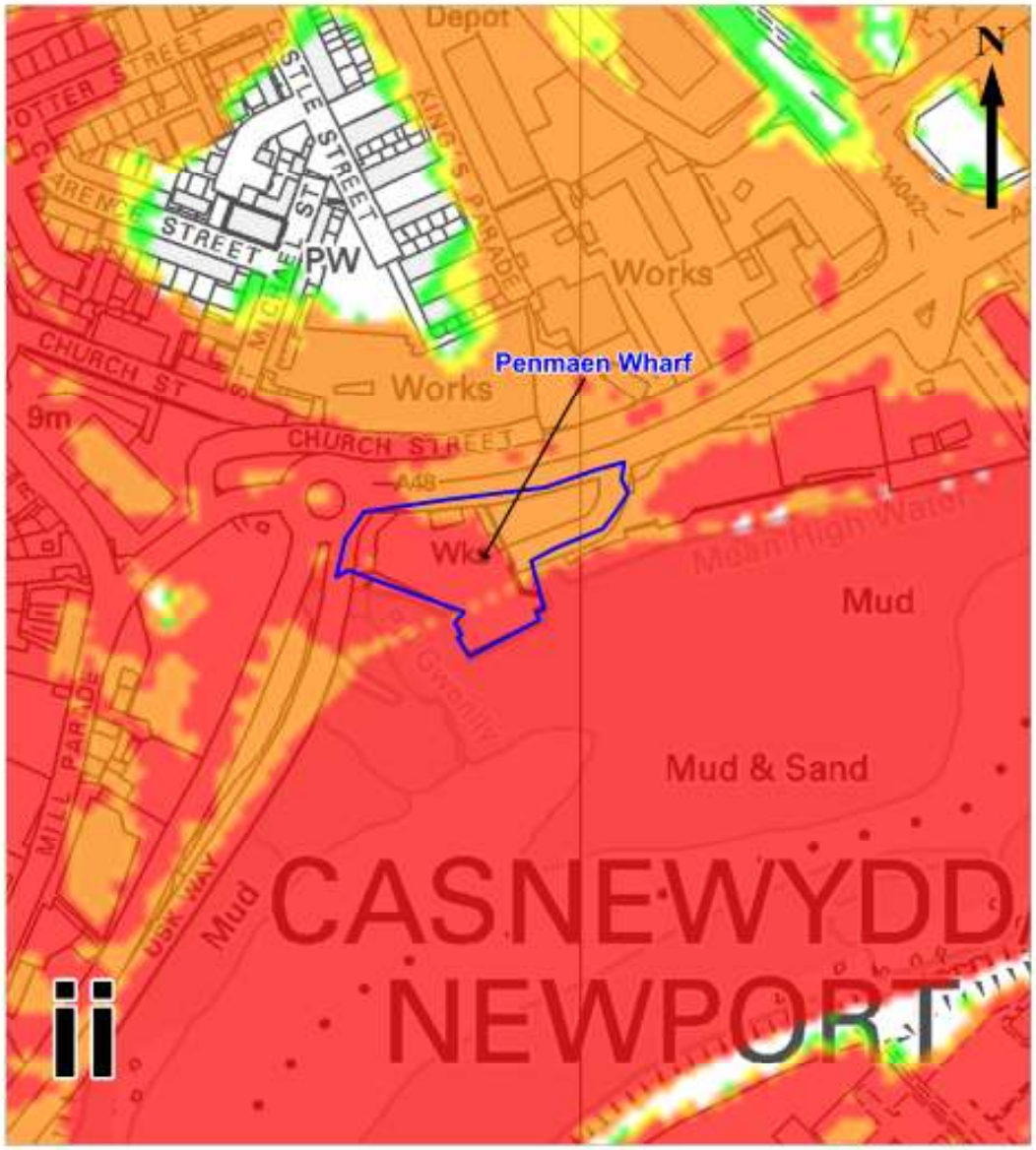
Figure E-3: Scenario 4 (1 in 1000 year event)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

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Scale at A3:	Date:	Drawn by:	Approved By:
1: 3,000	Mar 2014	RM	RS

Project:
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Bristol
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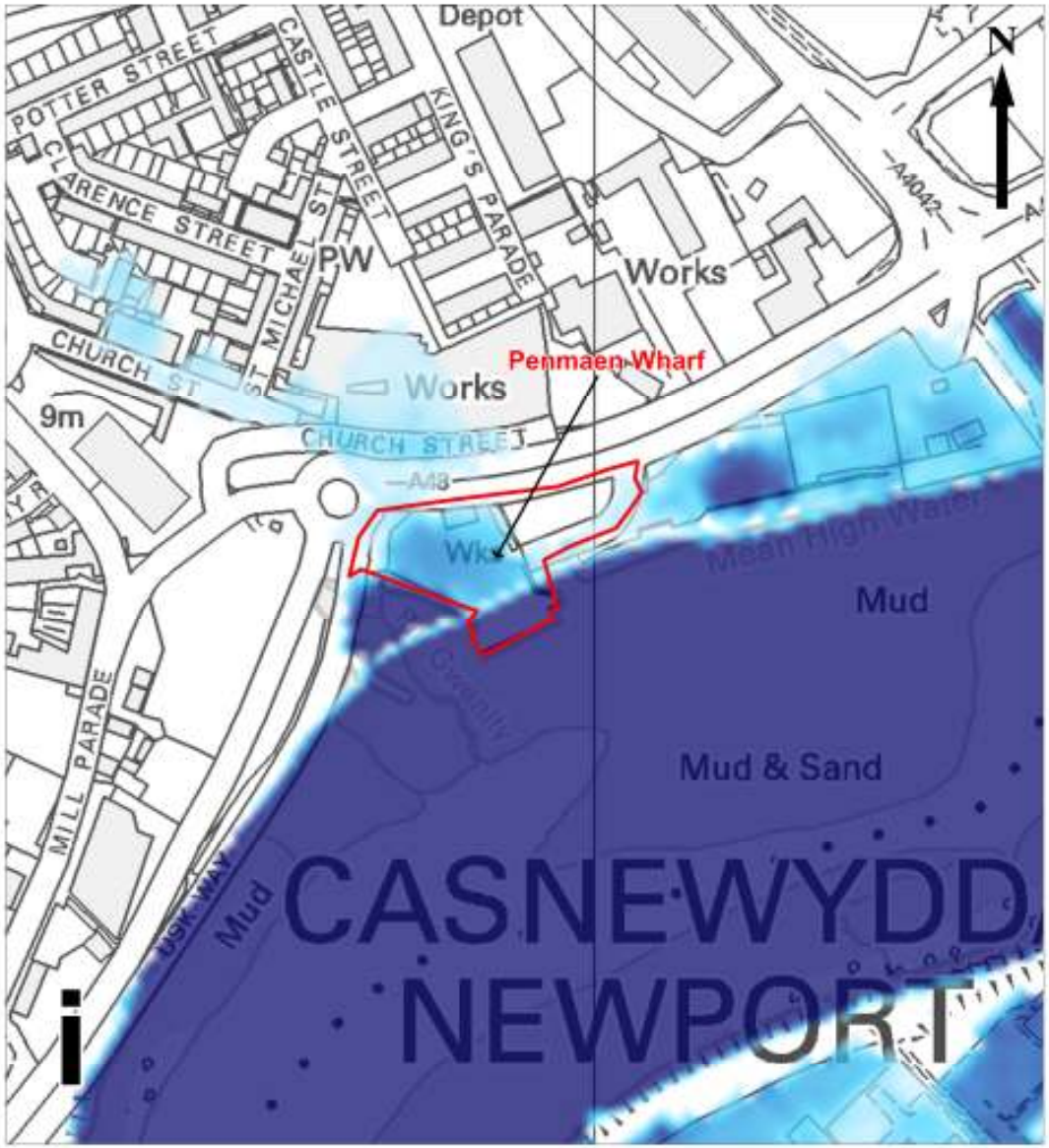
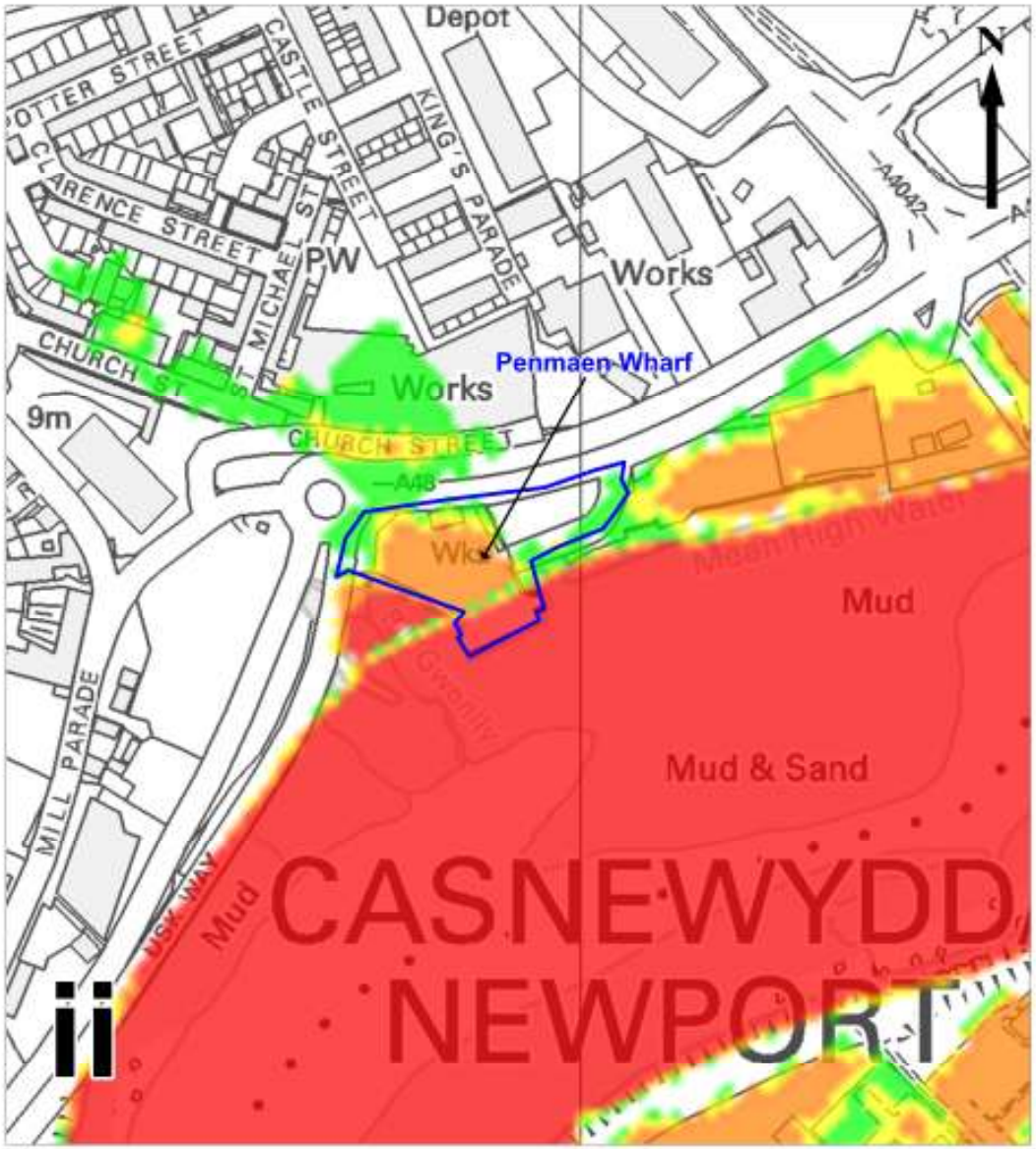
Figure E-4: Scenario 6 (1 in 1000 year event - climate change to 2111)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low

Moderate

Significant

Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 3,000	Mar 2014	RM	RS

Project:
Stage 3 Strategic Flood Consequence Assessment

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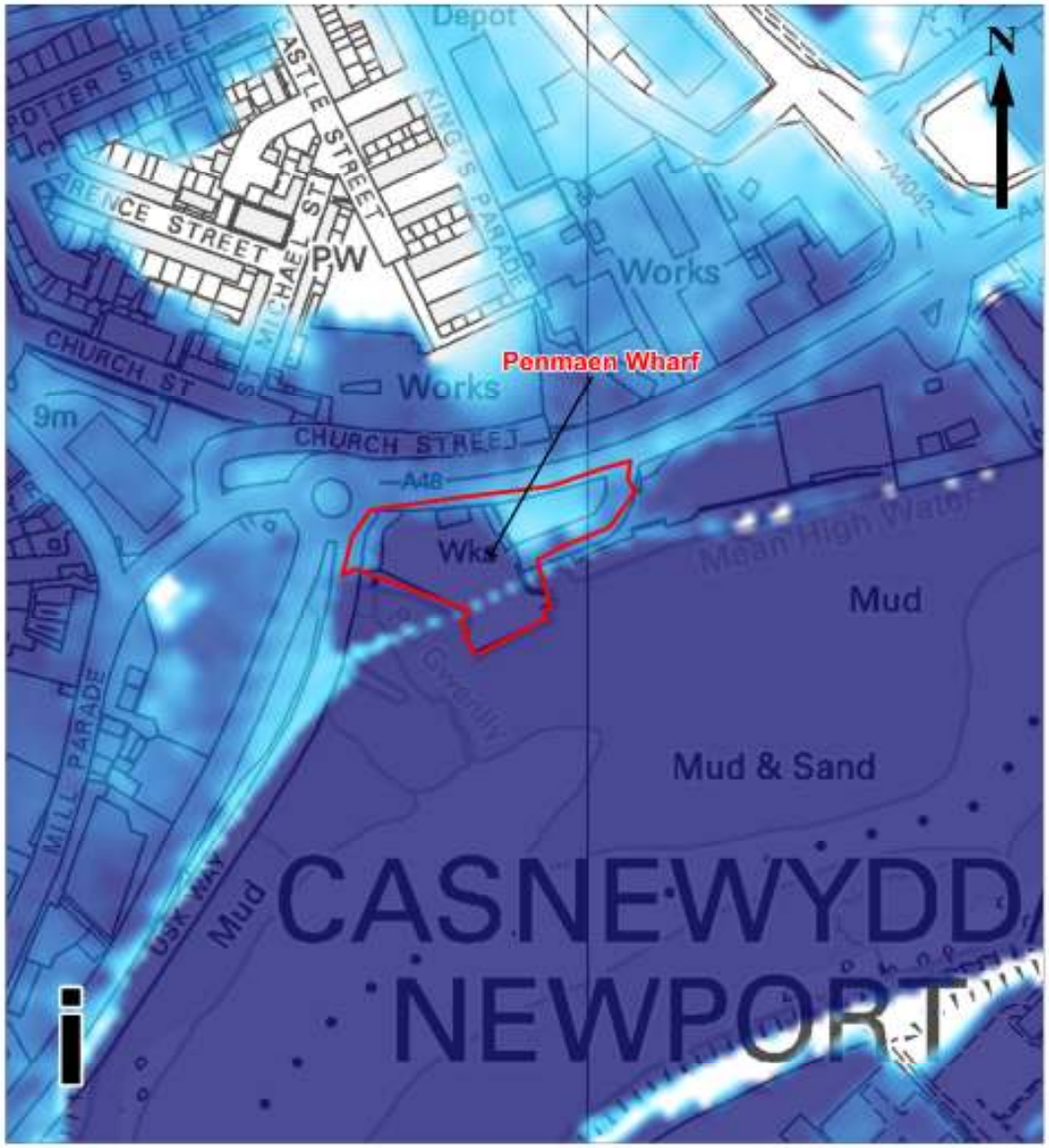
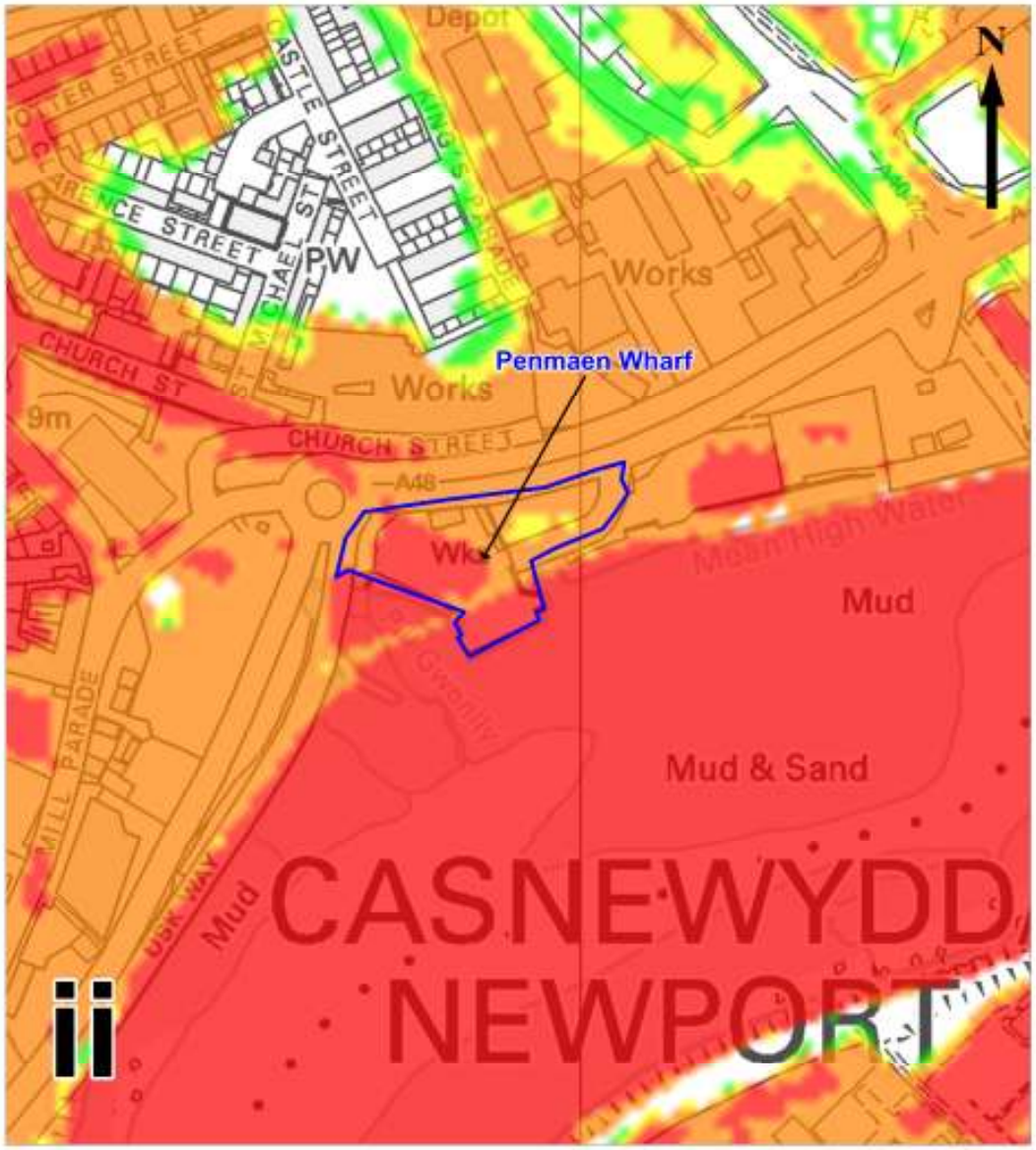
Figure E-5: Scenario 7 (1 in 200 year event with Breach Location)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 3,000	Mar 2014	RM	RS

Project:
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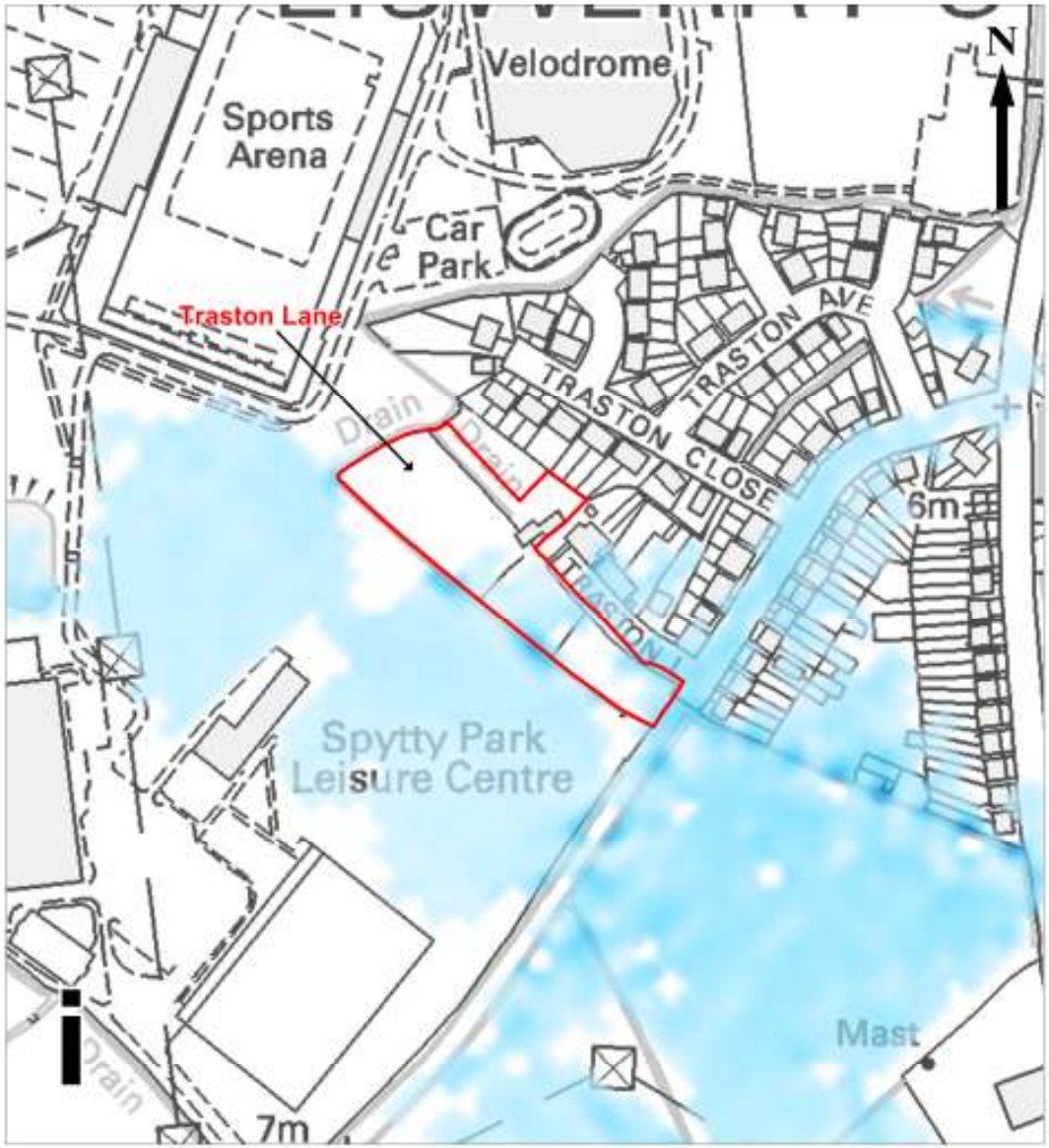
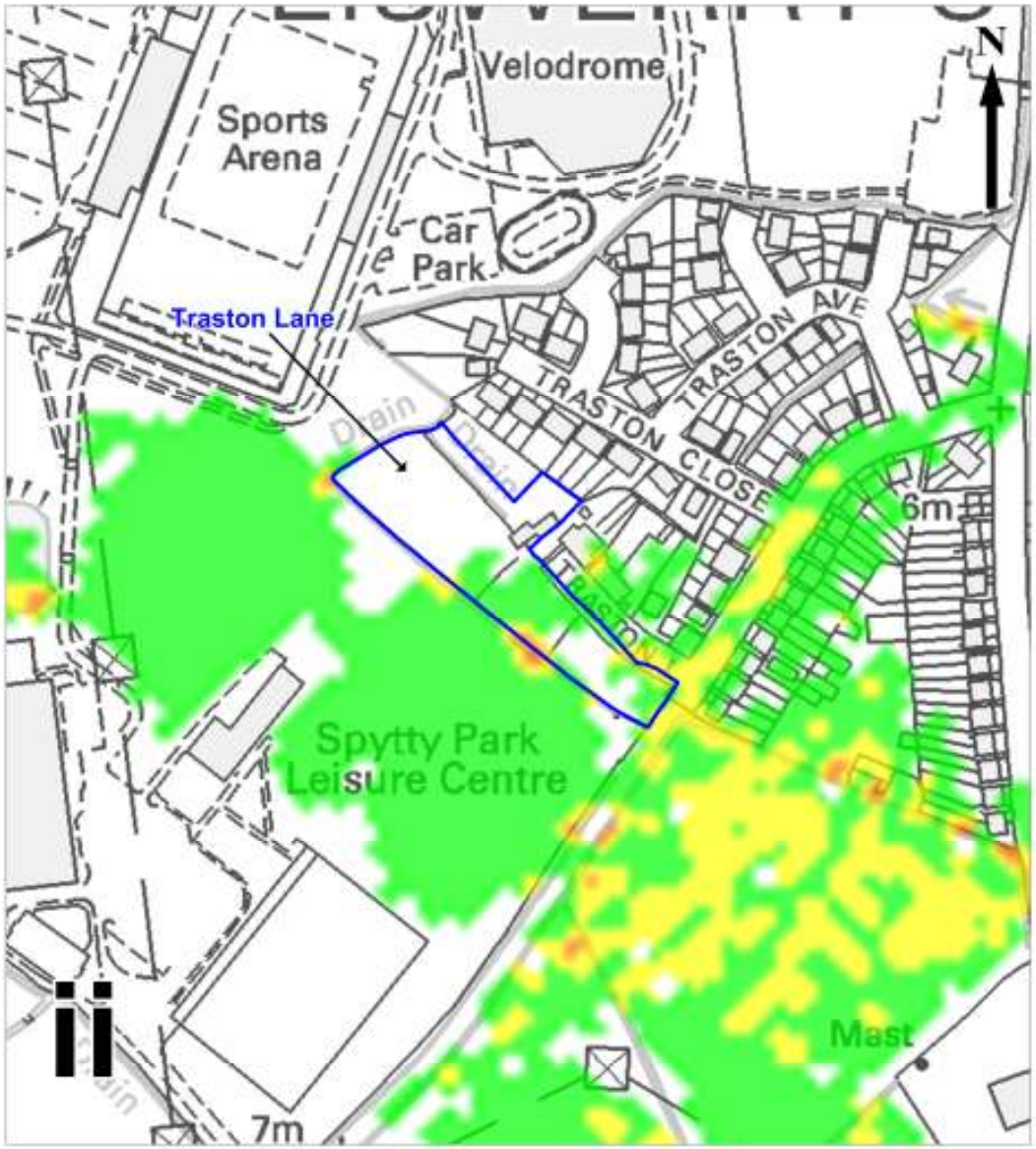
Figure E-6: Scenario 9 (1 in 200 year event - climate change to 2111 with Breach Location). (i) Maximum Flood Depth (ii) Maximum Flood Hazard

APPENDIX F DEPTH & HAZARD MAPPING FOR TRASTON LANE





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

Project:
Stage 3 Strategic Flood Consequence Assessment

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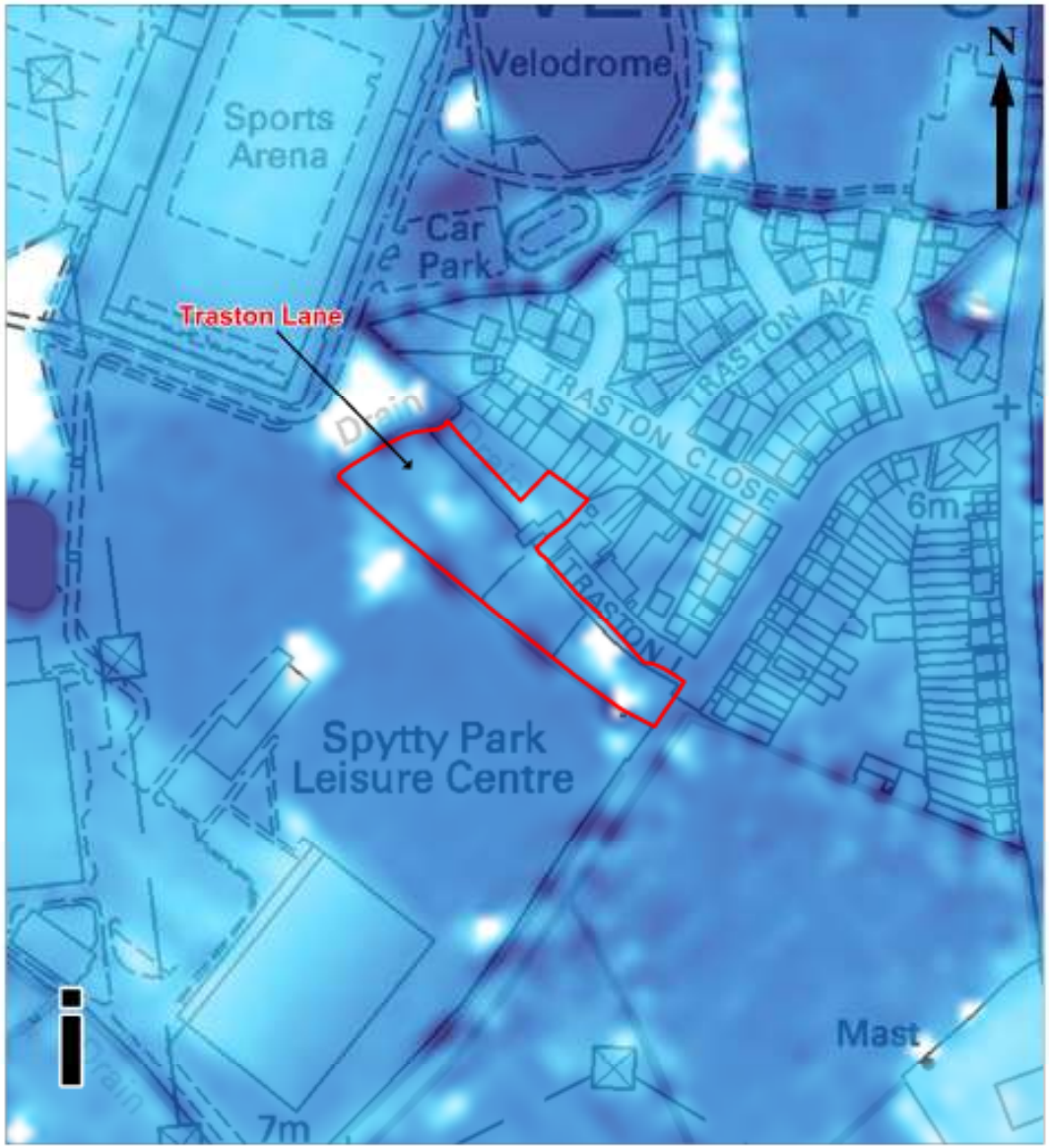
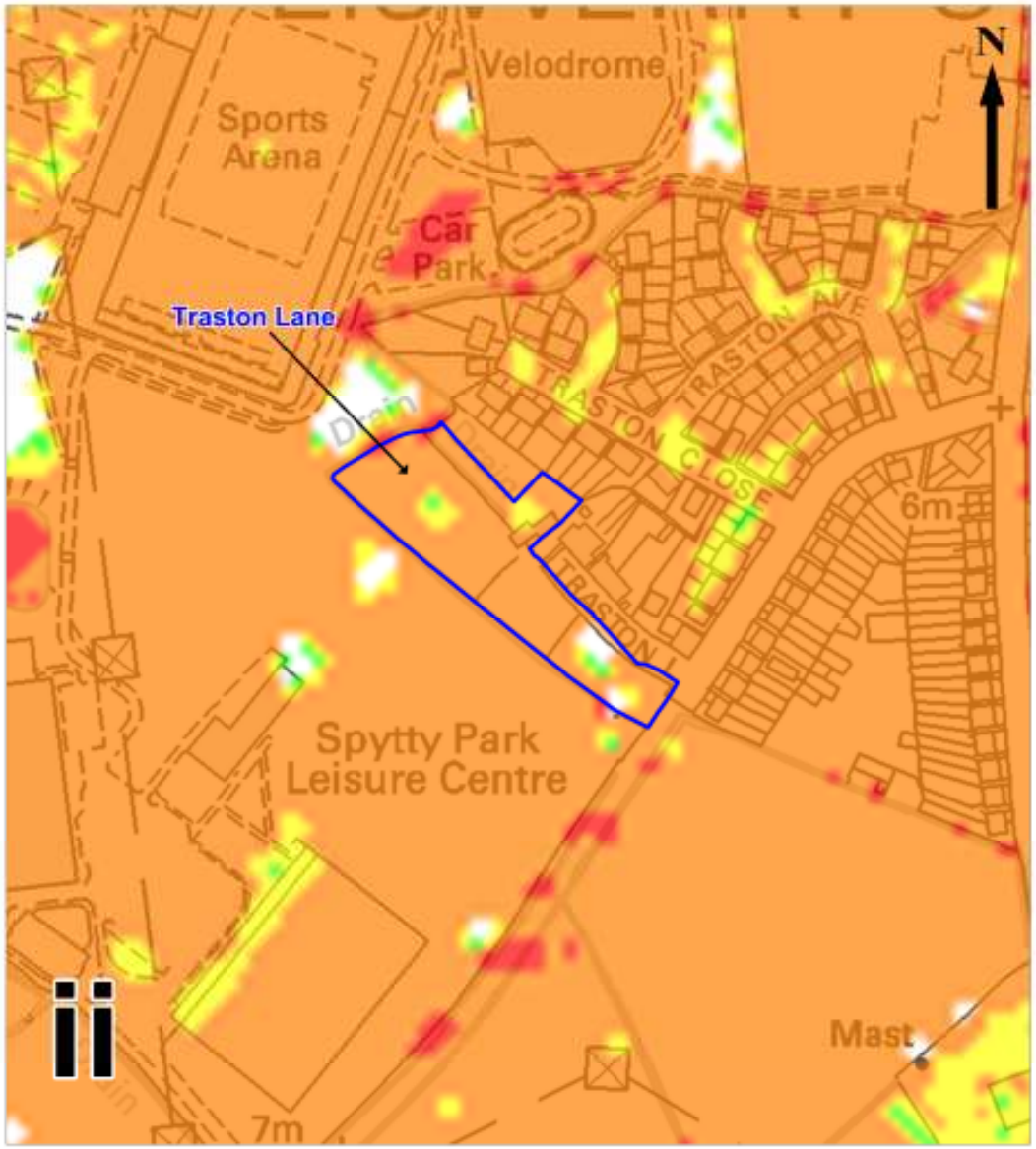
Figure F-1: Scenario 1 (1 in 200 year event)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m – 0.50m – 1.00m – 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

Project:
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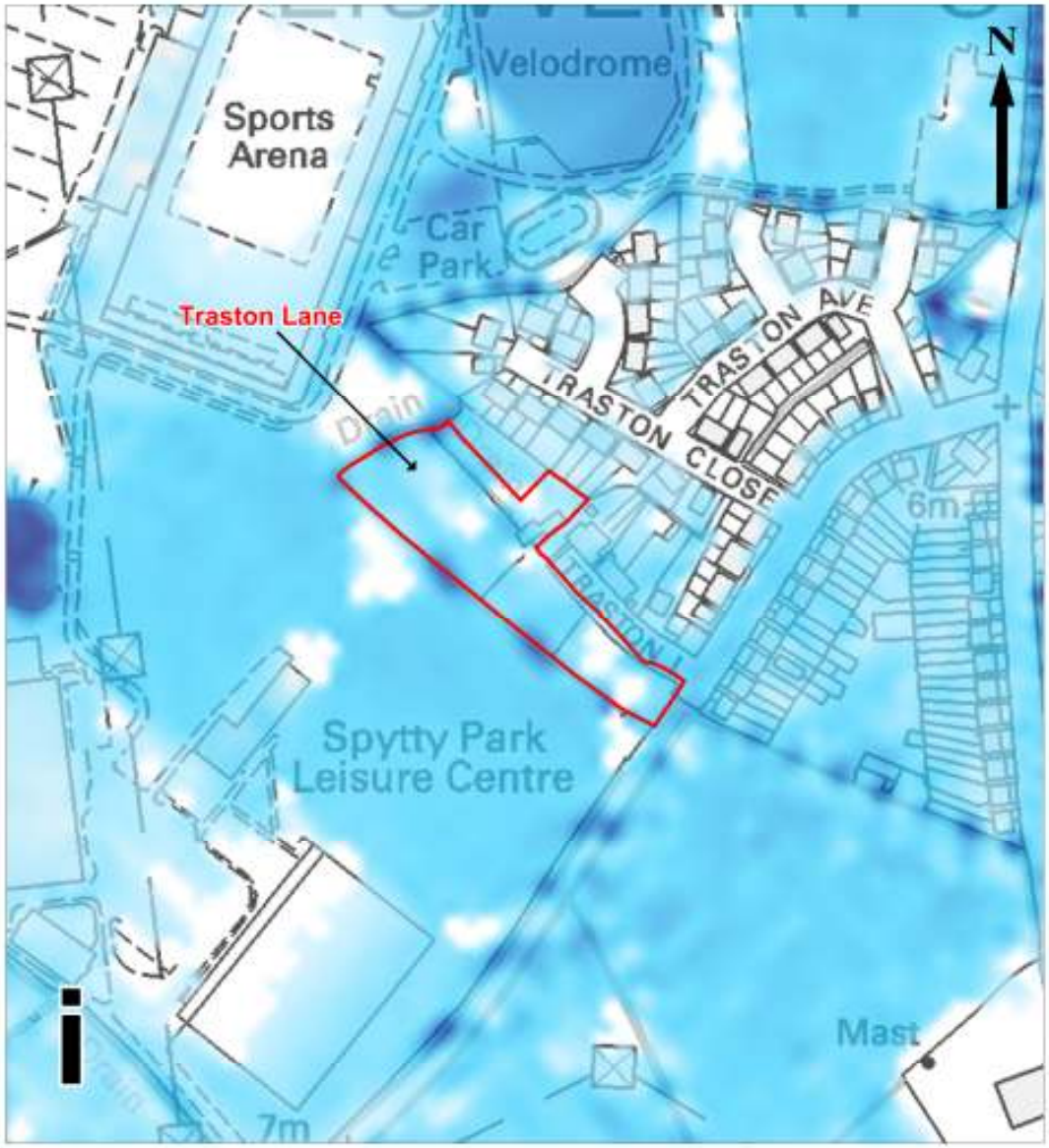
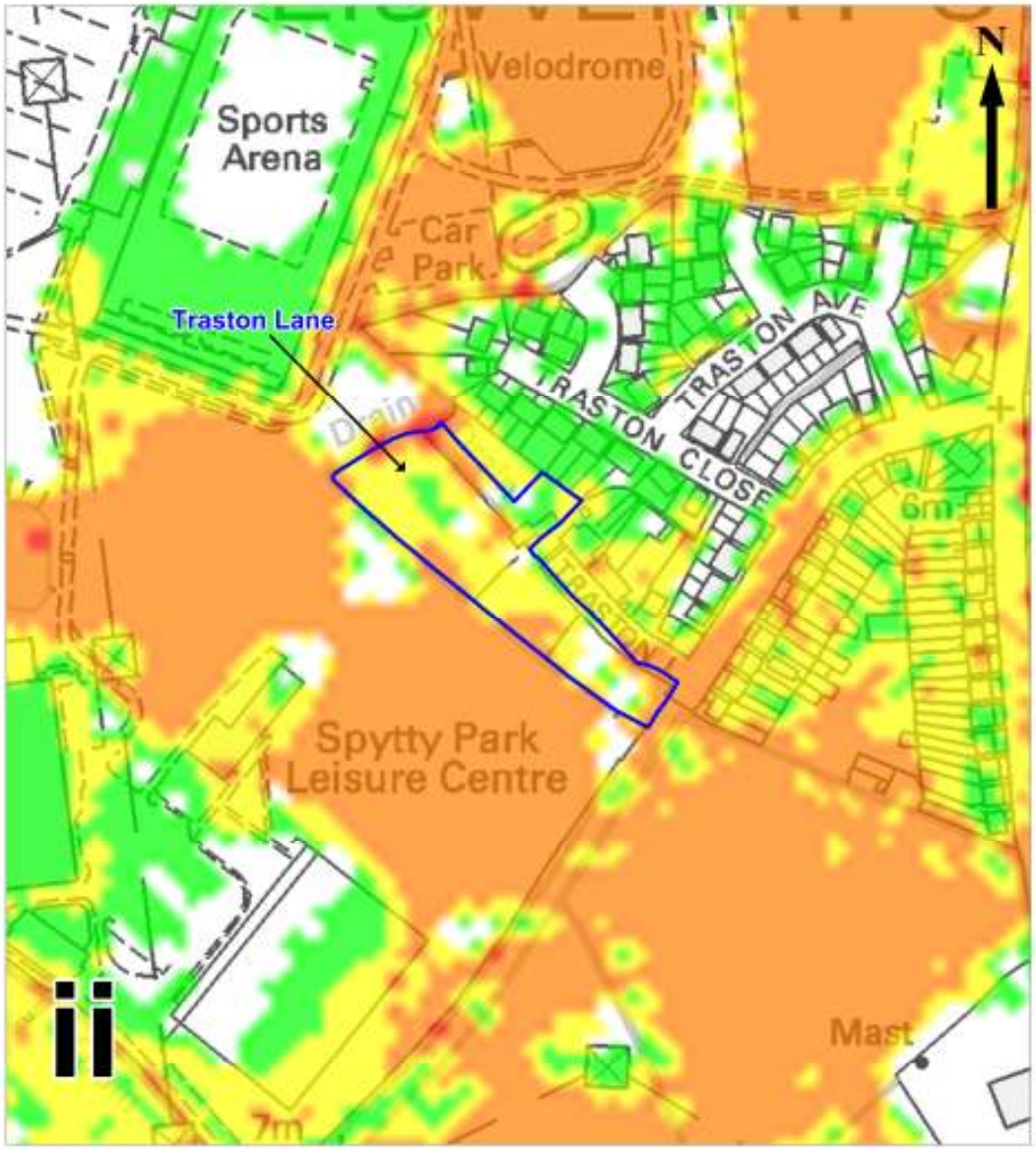
Figure F-2: Scenario 3 (1 in 200 year event - climate change to 2111)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

All data used is based on information provided by Newport City Council and the Environment Agency.

This drawing may only be used at a strategic level and only for the purpose intended.

Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

Project:
Stage 3 Strategic Flood Consequence Assessment

URS

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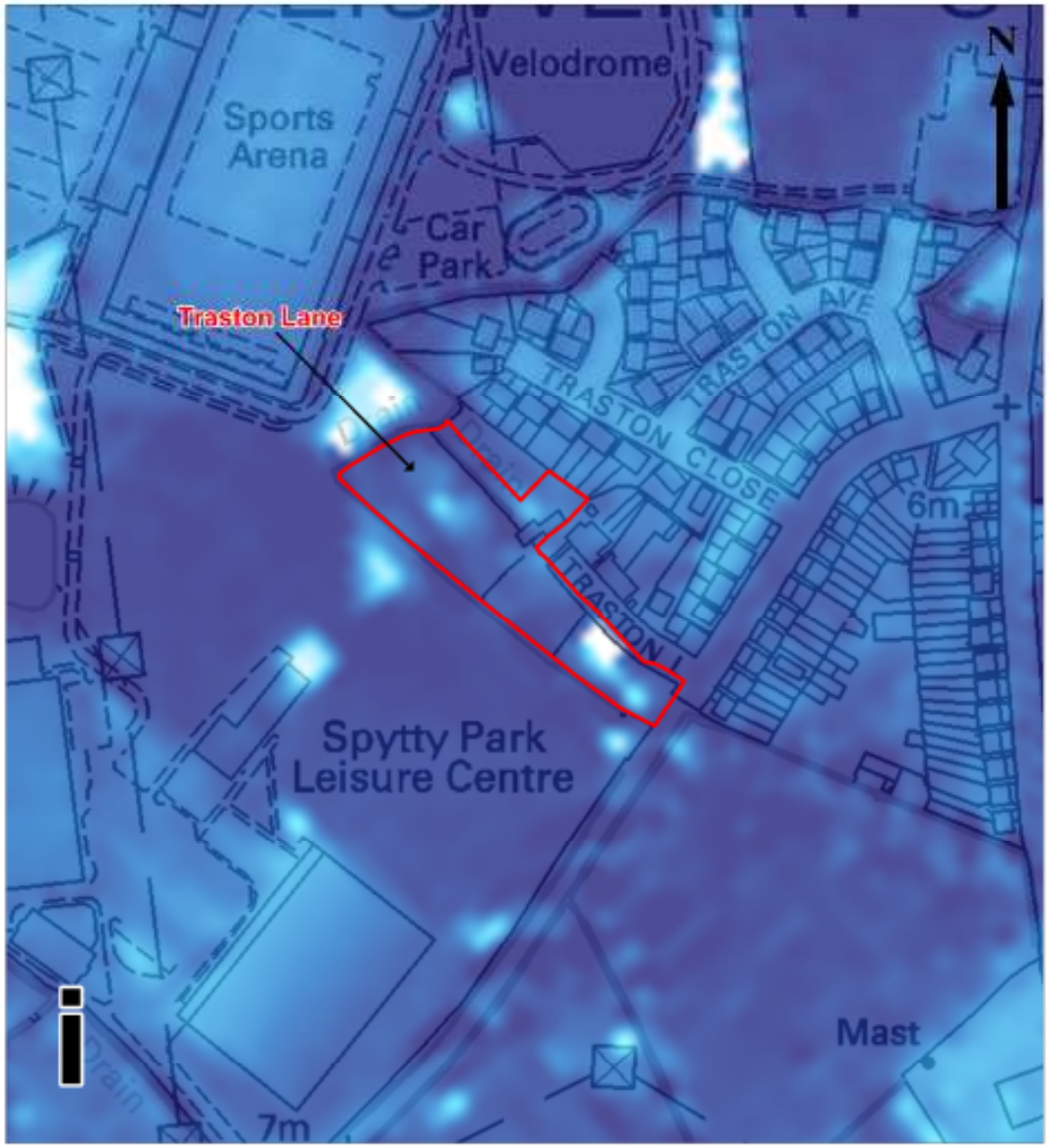
The Crescent Centre
Temple Back
Bristol
BS1 6EZ
www.ursglobal.com

Figure F-3: Scenario 4 (1 in 1000 year event)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard



Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
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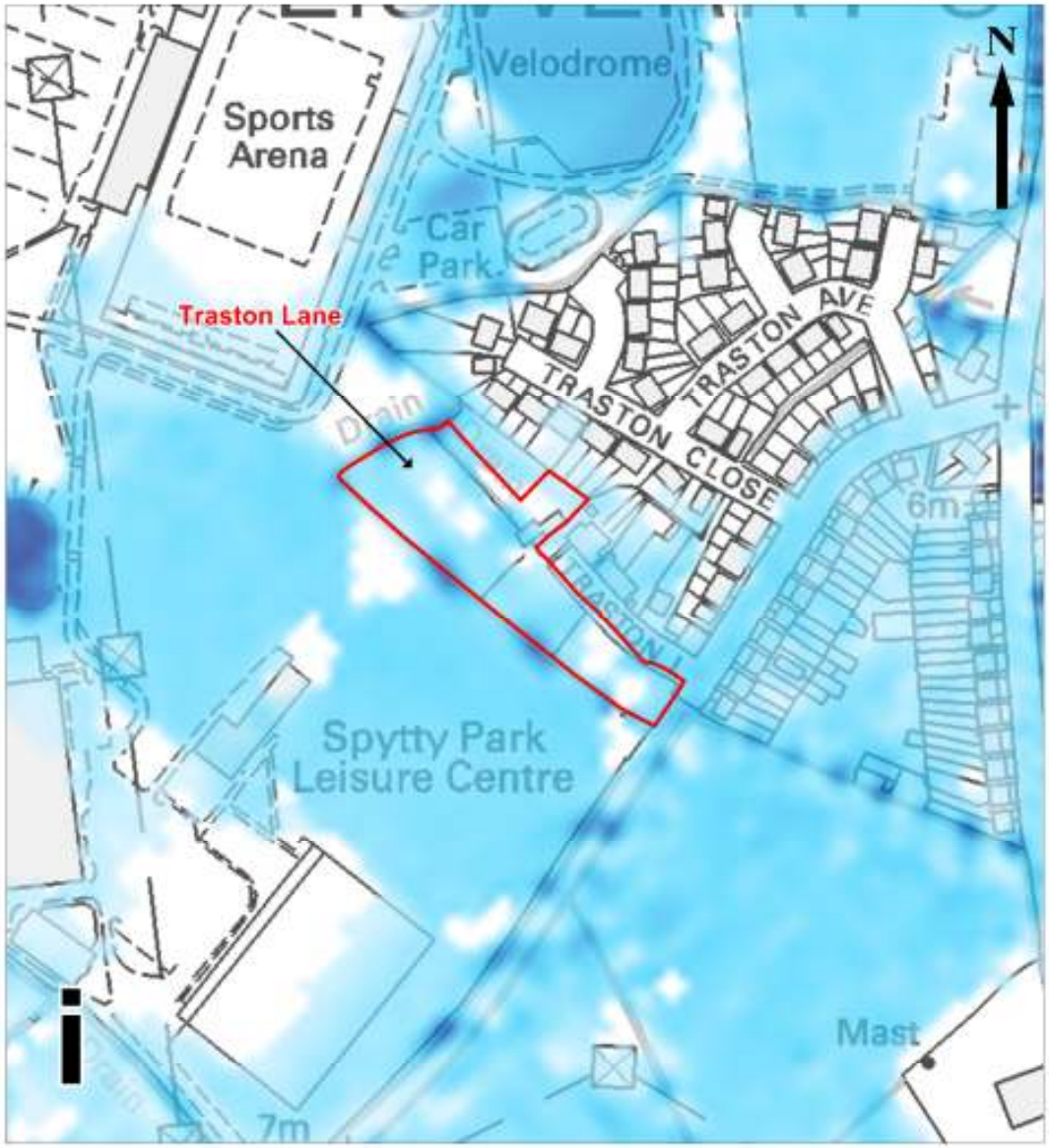
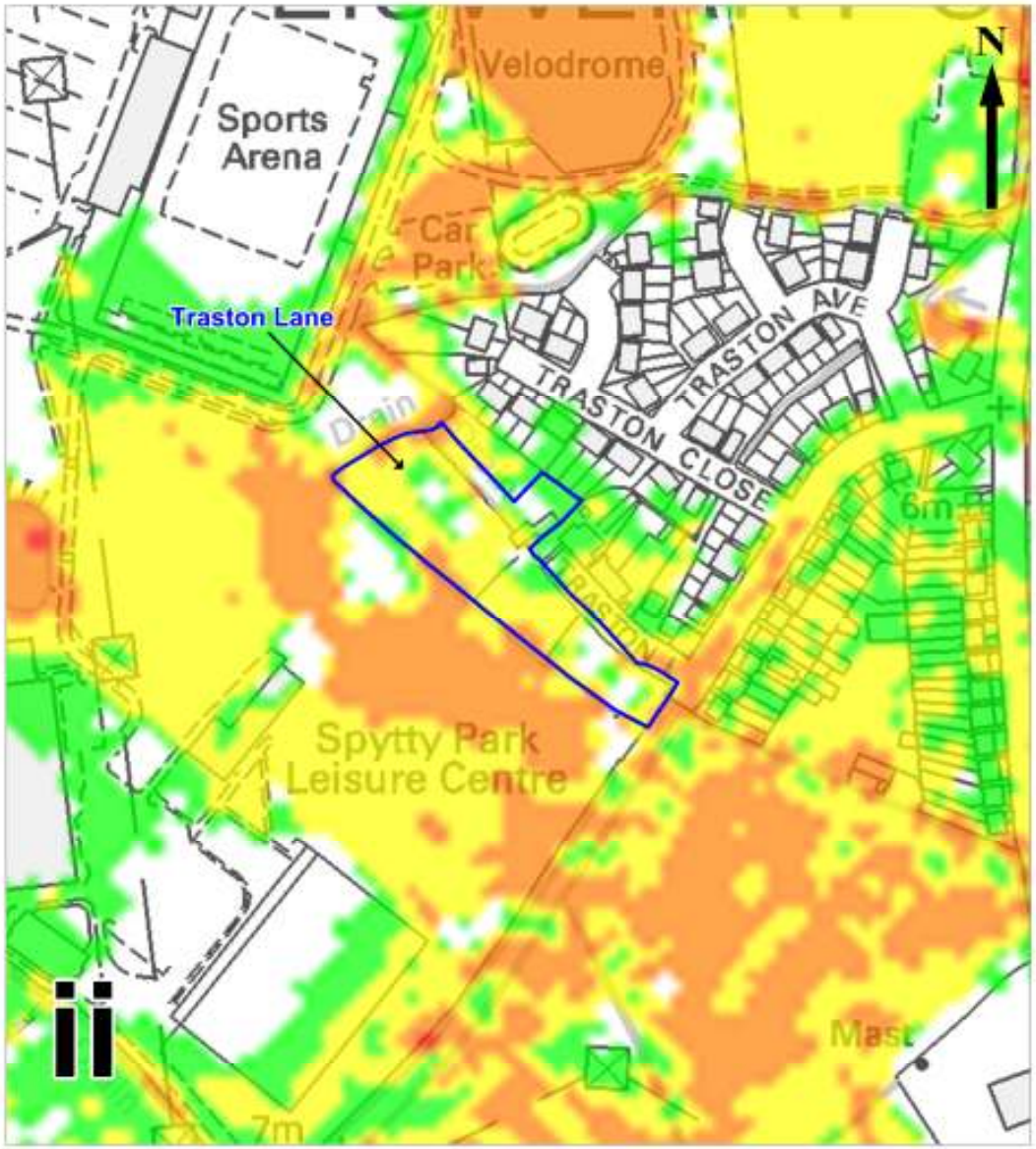
Figure F-4: Scenario 6 (1 in 1000 year event - climate change to 2111)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

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Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

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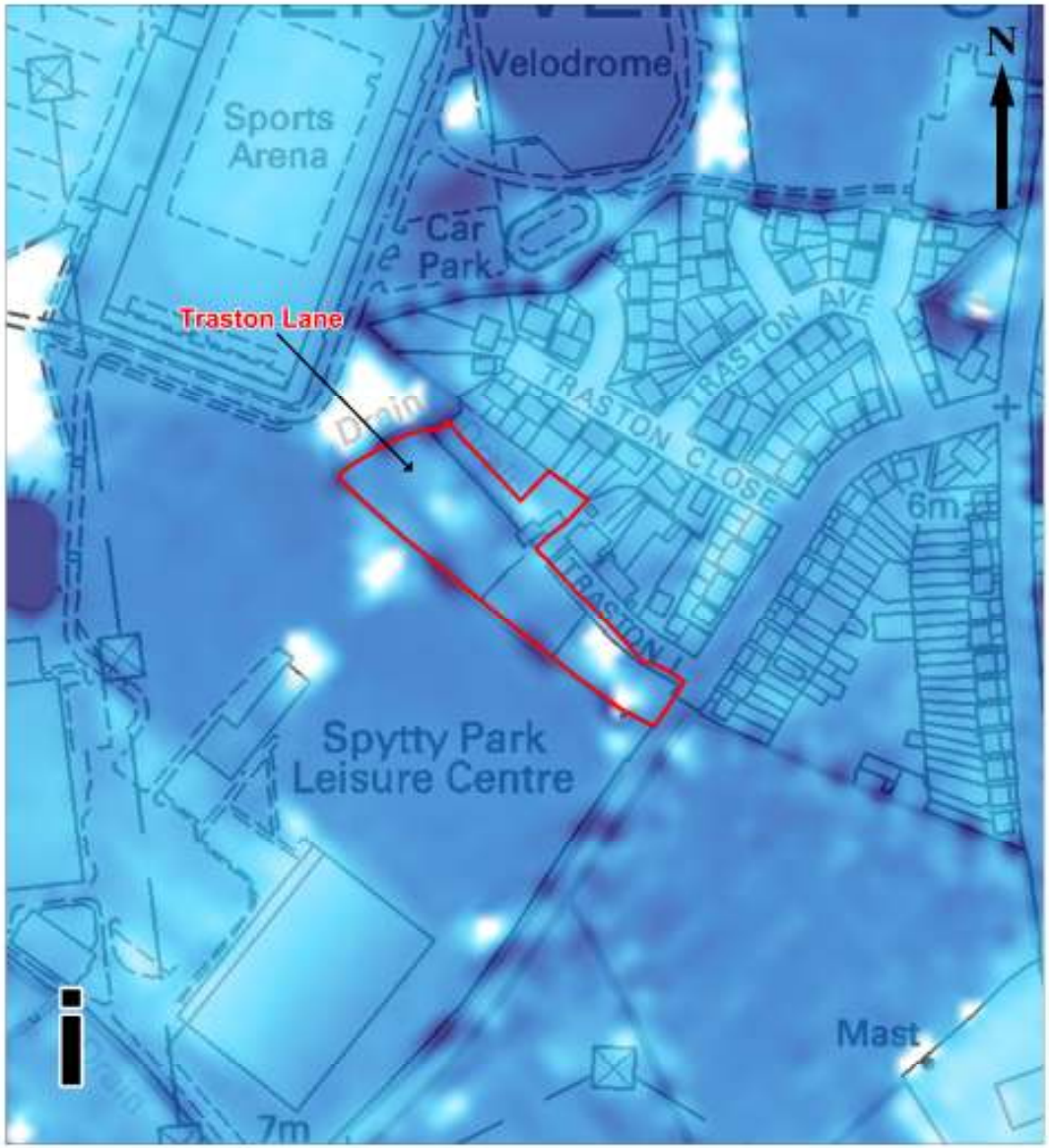
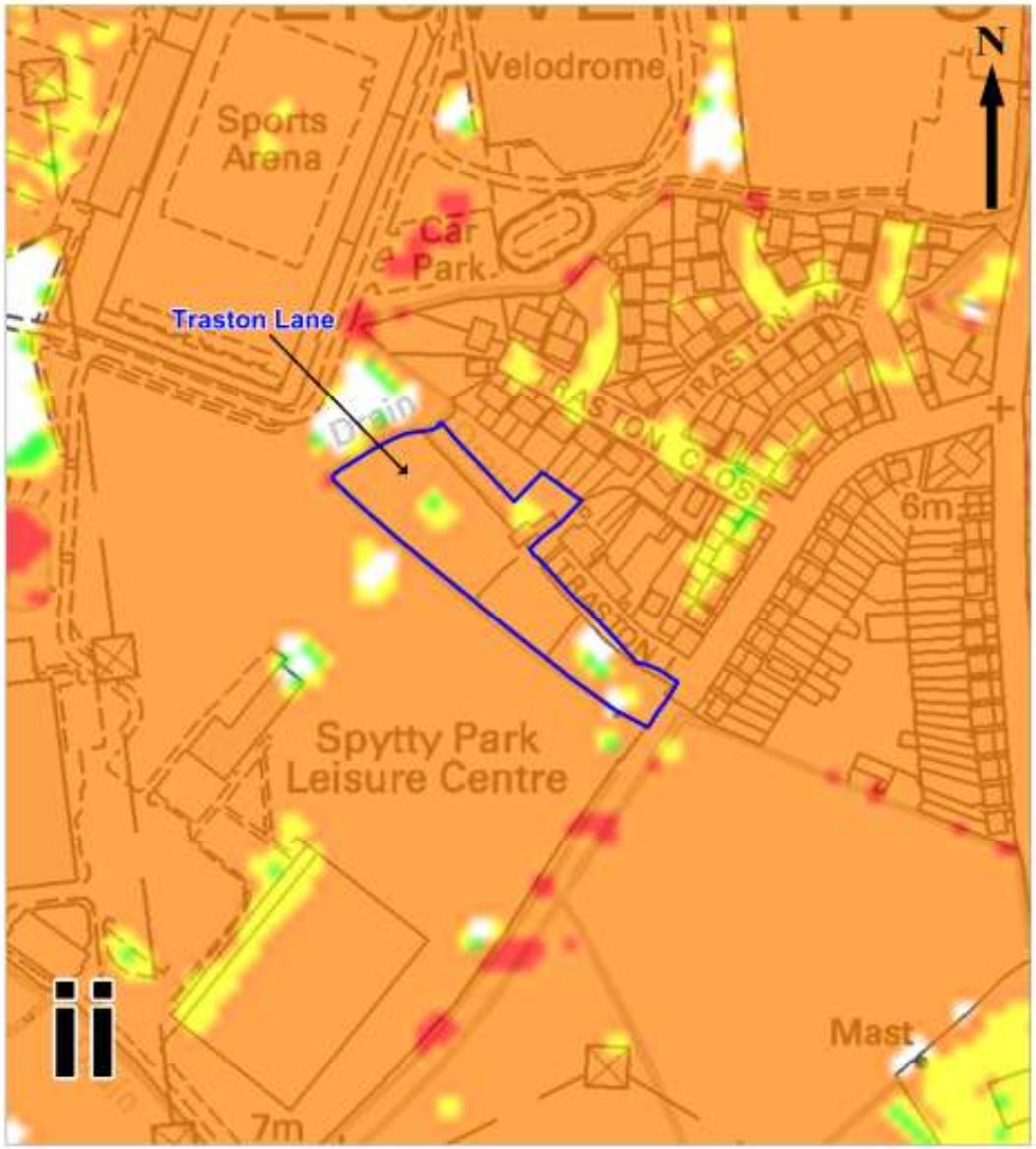
Figure F-5: Scenario 7 (1 in 200 year event with Breach Location)
(i) Maximum Flood Depth (ii) Maximum Flood Hazard





Depth Legend

Revised Deposit LDP Designations

Maximum Flood Depth (m)

0.00m 0.50m 1.00m 1.50m+

Hazard Legend

Revised Deposit LDP Designations

Maximum Flood Hazard

Low
Moderate
Significant
Extreme

Client:
Newport City Council

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Scale at A3:	Date:	Drawn by:	Approved By:
1: 2,500	Mar 2014	RM	RS

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Figure F-6: Scenario 9 (1 in 200 year event - climate change to 2111 with Breach Location). (i) Maximum Flood Depth (ii) Maximum Flood Hazard