Derby City Strategic Flood Risk Assessment

North Riverside, Castleward, and Derwent Triangle Level 2 SFRA

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North Riverside, Castleward, and Derwent Triangle

Level 2: Report

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Plan Design Enable

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Glossary of Terms

Term	Meaning / Definition
AAD	Average Annual Damages
AEP	Annual Exceedance Probability
CFMP	Catchment Flood Management Plan
CSRIP	Core Strategy & Rural Issues Plan
DG5	Water companies record of Sewer Flooding
EA	Environment Agency
PAR	Project Appraisal Report
LDDs	Local Development Documents
LDF	Local Development Framework
LPA	Local Planning Authority
FWD	Floodline Warnings Direct
FRA	Flood Risk Assessment
FSR	Flood Studies Report
GIS	Geographical Information System
Main River	This term is used for watercourses shown on statutory maps held by the Environment Agency and DEFRA. They can include any structure or appliance for controlling or regulating the flow of water into, in or out of the channel. The Environment Agency has permissive powers to carry out works of maintenance and improvement on these watercourses (Main Rivers).
NFCDD	National Flood and Coastal Defence Database
PPS1	Planning Policy Statement 1: Delivering Sustainable Development
PPS3	Planning Policy Statement 3: Housing
PPS25	Planning Policy Statement 25: Development and Flood Risk
RFRA	Regional Flood Risk Assessment
RPB	Regional Planning Body
RSS	Regional Spatial Strategy
SFRA	Strategic Flood Risk Assessment
SMD	Soil Moisture Deficit
SOP	Standard of Protection
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
WCS	Water Cycle Strategy
NFFS	National Flood Forecasting System
PAR	Project Appraisal Report

SFVI	Social Flood Vulnerability Index
STW	Severn Trent Water

Annual Exceedance Probability (AEP)

The severity of the events discussed in this document are defined as Annual Exceedance Probabilities (AEP), the table below provides a summary of AEP and corresponding Return Periods.

The AEP is the probability that there will be an event exceeding a particular severity in any one year. The Return Period is the average duration (in years) between events of a particular severity.

Annual Exceedance Probability	Return Period
50%	1 in 2yrs
10%	1 in 10yrs
4%	1 in 25yrs
3.3%	1 in 30yrs
2%	1 in 50yrs
1.33%	1 in 75yrs
1%	1 in 100yrs
0.5%	1 in 200yrs
0.4%	1 in 250yrs
0.1%	1 in 1000yrs

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Executive Summary

This Level 2 Strategic Flood Risk Assessment (SFRA) has been produced for Derby City Council. It complements the City of Derby Level 1 SFRA completed by Derby City Council in 2009, and should be read in conjunction with this document.

A SFRA is required under Planning Policy Statement 25: Development and Flood Risk, to facilitate sustainable planning and development on a regional scale. In producing this document, consultation with a number of parties has taken place. The key consultees utilised in the completion of this Level 2 SFRA have been the Environment Agency, Severn Trent Water & Derby City Council.

The data collected during this Level 2 SFRA has resulted in a high level of understanding of flood risk within the Derby City Area. Three individual areas North Riverside (Area A), Castleward (Area B) and Derwent Triangle (Area C) were considered for this assessment. It is understood that these areas are allocated within the local area development plan of Derby City Council. Detailed 1D-2D fluvial modelling study of the River Derwent and surrounding floodplains was undertaken as part of this assessment for all the three SFRA Level 2 areas. The existing 1D Environment Agency model for the River Derwent was utilised for this purpose. Also a 2D overland surface water model comprising the Severn Trent Water sewer model which was incorporated for the Castleward (Area B).

The hydraulic modelling shows there is a high fluvial risk to North Riverside (Area A) and falls within Flood Zones 2 and 3 with the 1% AEP event producing an extreme fluvial hazard. However, the area is not within the functional floodplain. There is no surface water flooding issues recorded at this location according to Derby City Council. However the Environment Agency map for areas susceptible to flooding shows that the area has potential surface water flood risk near south west boundary.

The modelling exercise has confirmed that the Castleward (Area B) is not at risk from fluvial flooding in the 1% AEP flood event including allowance for climate change. However the 0.1% AEP flood event causes significant flooding in this area. The 2D overland surface water modelling shows the site suffers from surface water flooding during the 1% AEP and 1% AEP plus climate change flood events near the south east corner of the site at London Road. The Castleward area is not within the functional floodplain.

The Derwent Triangle (Area C) does not flood in the 4% AEP fluvial flood event. However it does flood during the 1.33% AEP fluvial flood event. The modelling exercise has confirmed that the area is within the Flood Zone 3 (1% AEP flood event). This area is undeveloped and as such no risk from surface water flooding has been identified. This area is not within the functional floodplain.

There is no record of historical groundwater flooding for the three SFRA Level 2 areas according to the Environment Agency. A detailed groundwater assessment was undertaken which shows all three areas to have low risk of groundwater flooding.

The outcome of this Level 2 SFRA has enabled a series of recommendations to be considered, which upon approval of this Level 2 SFRA will form a detailed proposal and methodology for further assessments.

Further detailed assessment on North Riverside (Area A) and Castleward (Area B) is recommended to be undertaken as part of Surface Water Management Plans (SWMP) to have improved understanding of the combined surface water and fluvial flood risk and to assist in identifying appropriate development types within the areas.

1. Introduction

1.1 The need for a Strategic Flood Risk Assessment

Planning Policy Statement 25: Development and Flood Risk (PPS25) (Ref: 1) was published in December 2006 and updated in March 2010 as the overarching policy document that incorporates flood risk into the planning process. The aim of PPS25 is to ensure new development is not located where it is at an unacceptable risk of flooding, nor does it contribute to an increase in flood risk elsewhere within the catchment. PPS25 outlines that Local Planning Authorities (LPAs) should undertake a Strategic Flood Risk Assessment (SFRA) as part of the evidence base for the Local Development Framework (LDF) to ensure strategic land use planning. This facilitates catchment wide development by providing information to allow the Sequential Test to be performed to ensure development is proposed in sustainable locations.

An SFRA is completed in two stages; the Level 1 assessment forms the baseline for flood risk assessment within the catchment with reference to proposed development and the Level 2 assessment will provide a more detailed report of flooding issues and mitigation measures. The Level 1 Derby City SFRA (Ref: 2) was completed by Derby City Council in 2009 and will inform this Level 2 assessment (although at the time of writing this report the Environment Agency had yet to sign off the Level 1 SFRA). The results from this Level 2 report incorporate some of the findings from the Level 1 assessment specific to the sites assessed, but this document should be read in conjunction with the Level 1 SFRA.

As well as the Environment Agency guidance notes the SFRA will inform smaller scale Flood Risk Assessments (FRAs) that must be completed for development proposals located in Flood Zones 2 or 3, or those that have the potential to increase flood risk elsewhere i.e. are larger than 1 hectare in size. These small FRAs are site specific and have to be submitted along with the planning application for the new development to ensure flood risk have been taken into account at the planning stage of the development.

1.2 Level 1 SFRA

The Level 1 assessment provided an overview of flood risk in relation to development within Derby City in context with national, regional and local policy. In addition the Level 1 SFRA was completed as a requirement for the funding available for new residential development within the East Midlands.

The Level 1 SFRA outlined a number of recommendations for further work, these are as follows:

- Further investigation to be undertaken into the flood risk to Derby, however it should be carried out for particular areas or catchments rather than the City as a whole;
- Additional survey work is carried out for watercourses which are not covered by the existing surveys;
- Increase understanding of the drainage system within all areas of Derby, this includes pipe sizes, overflows and arrangements of intakes and outfalls;
- Additional modelling work to be carried out for flood flows from all sources including the failure of sewers, overland flows and watercourses;
- The production of documentation that highlights the risk to vulnerable assets, proposed emergency shelters, those at risk, guidance on flood protection and guidance for the LPA on the sites for new infrastructure, residential and commercial developments; and
- A provision of a ‘scope of works’ to describe the options and measures available to reduce flood risk and the production of a tool to assist with the cost/benefit analysis for flood defence or mitigation schemes.

1.3 Scope of this document

In line with the recommendations from the Level 1 SFRA this Level 2 SFRA does not cover the entire Derby City, but focuses on three key regeneration areas North Riverside (Area A), Castleward (Area B) and Derwent Triangle (Area C).

The aim of this document is to provide supplementary information to the Level 1 SFRA by providing details on flooding and recommendation on flood defence/mitigation in reference to future development.

Five objectives have been proposed for this Level 2 SFRA:

- Provision of a robust Derby City Level 2 SFRA (for the three areas of interest) that follows best practice and national guidance;
- An outline of recommendations for site specific FRAs;
- Building upon the Level 1 SFRA and data and information held by the Environment Agency on Flood Risk Zones and flood management strategies including Catchment Flood Management Plans (CFMPs) and Project Appraisal Reports (PARs);
- Integration with other strategies and research such as the Derby City Local Plan, Core Strategies and the Water Cycle Strategy and
- Informing site specific documents such as the Area Action Plan and Supplementary Planning Documents.

The purpose of an SFRA and thus this Level 2 SFRA is to facilitate the application of the Sequential and Exception Tests on site specific level using the detailed assessment on flood risk, as outlined in PPS25, and thereby informing the strategic planning of the Derby City through analysing the scale of flood risk to existing and proposed development. Further aims and purposes of the study are to:

- Allow partners involved in the investment and delivery planning of the City to gain a better understanding of the implications of flood risk management;
- Inform the site allocation process for the key growth areas by steering vulnerable development and/or redevelopment away from those areas that are at highest risk;
- Assess the implications of flood risk on existing and future infrastructure and land use development;
- Assess the impact of flood risk taking into account wider spatial considerations such as environmental health and safety issues;
- Identify opportunities for development of infrastructure that offers wider sustainability benefits;
- Identify weaknesses in flood defence infrastructure; and
- Support the process of emergency planning within the Derby City area.

It should be noted that all SFRAs, including this document, should be considered as ‘living documents’ and as such will be updated when necessary due to either changing policy or improved flood risk information. It is important that this document is read in conjunction with other reports that are relevant to flood risk within the Derby City such as the Level 1 SFRA (Ref:2), the FRA for the City Centre (Ref: 3) and the Derby Housing Market Area Water Cycle Study (Ref: 4), as well as national, regional and local planning documents.

2. Planning Policy relating to Flood Risk

The planning process is driven by policy at national, regional and local levels and flood risk is now a major component of this. The overarching policy for flood risk is Planning Policy Statement 25: Development and Flood Risk (PPS25) (Ref: 1). Regional and local policy in the form of development plans and other similar documents support this national guidance. This section outlines the various policies on development that relate to flood risk.

2.1 National Planning Policy

Planning Policy Statements set out the Governments policies on various aspects of land use planning in England. These national policies play a fundamental role in shaping Regional Spatial Strategies (RSS) and Local Development Frameworks (LDFs) which are produced by Regional Planning Bodies (RPBs) and Local Planning Authorities (LPAs). PPS25 sets out the requirements for an SFRA, however PPS1 and PPS3 have also been used for the preparation of this document.

2.1.1 Planning Policy Statement 1: Delivering Sustainable Development

The Governments objectives for sustainable development are set out in PPS1 (Ref 5). This means that the sustainability of the development must be considered over the life of the development, with reference to changes in the physical environment and climate.

An example of changes in the physical environment is the change in natural hazards, including flooding, that may pose a risk to the development. The consequence of this is that LPAs must recognise the potential hazards to allocated development sites in order to site development in areas that are at a limited risk. However in certain circumstances development would be proposed on sites that are potentially at risk from natural hazards when the development satisfies other sustainability issues. PPS1 supports such development if it can accommodate the natural hazard and associated potential changes so that the development is safe, sustainable, durable and adaptable without causing an increased risk elsewhere.

2.1.2 Planning Policy Statement 3: Housing

The Governments housing objectives are set out in PPS3 (Ref: 6) and as such should be used when LPAs and RPBs prepare their Local Development Documents (LDDs) and RSSs. Whilst identifying broad locations for potential development sites, LPAs must take into account the physical constraints that might be imposed at each location to comply with PPS3.

PPS3 sets the annual target that 60% of new housing development is constructed on brownfield sites in order to make effective use of land and as such LPAs should strive to allocate land on previously developed areas. However PPS3 recognises that this is not always possible as sites that have been previously developed are not always suitable for housing development. This can include when a previously developed site that has the potential for re development is located within a flood risk area and as such is not suitable for housing development.

2.1.3 Planning Policy Statement 25: Development and Flood Risk

Planning Policy Guidance Note 25 (PPG25) was produced in 2001 to set out the Governments policies on development relating to flood risk. This has now been made redundant following the publication of Planning Policy Statement 25 (PPS25) (Ref: 1) in December 2006 and updated in March 2010. PPS25 is the overarching document for development and flood risk and requires local authorities to produce an SFRA. In addition the PPS25 Guidance document (Ref: 7) which has been updated in 2009 is to aid LPAs and other parties with compliance to PPS25.

There several notable differences can be summarised between PPG25 and PPS25 as PPS25 promotes:

- A more strategic planning approach to managing flood risk;
- Stronger guidance on flood risk assessments at all stages in the planning process;

- A clarified Sequential Test;
- An Exception Test to be implemented when development is proposed in areas at risk of flooding, but where not developing these sites will cause social or economic problems; and
- Clearer guidance on how to assess the impacts of climate change.

The aim of PPS25 is to ensure that new development is not at an unacceptable risk of flooding by steering developed to areas of lowest risk. Where development is unavoidable in areas at risk from flooding PPS25 ensures that the development is safe and without increasing flood risk elsewhere and where possible reducing overall flood risk.

The completion of RSSs, Development Plan Documents and Supplementary Planning Documents must involve the undertaking of a Sustainability Appraisal as required by the Planning and Compulsory Purchase Act 2004. To contribute to the Sustainability Appraisal freestanding flood risk assessments must be completed; RPBs should prepare Regional Flood Risk Assessments (RFRAs) and LPAs should prepare SFRAs. Aspects of the SFRA will help inform the more detailed site specific FRAs. This will aid RPBs and LPAs in conforming to PPS25 by preparing and implementing planning strategies that promote sustainable development. The Environment Agency and other relevant bodies should be consulted when RPBs and LPAs develop their policies and strategies to appraise, manage and reduce flood risk.

PPS25 should be read in conjunction with other national policies for flood risk and water management such as Making Space for Water (Ref: 8) and the Water Framework Directive (Ref: 9).

2.1.4 Flood Zone Definition

Environment Agency Flood Map

The Environment Agency's Flood Map was first published on the internet in October 2004. The flood maps show the best estimate of flood extents for the undefended 1% AEP and 0.1% AEP fluvial floodplain and 0.5% AEP and 0.1% AEP tidal floodplain.

The Flood Map outlines have been derived using a combination of a generalised model derived as part of the Flood Zone Project (a high level national mapping programme), more detailed hydraulic modelling and historical flooding outlines. The Flood Map outlines therefore have a varying degree of accuracy, dependent on the quality of the inputs and in particular the availability of detailed hydraulic modelling. The Flood Map is updated on a quarterly basis as the Environment Agency's knowledge of flooding is improved through detailed modelling studies, recent flood events and data from river level and flow monitoring stations.

The Flood Map presents flood risk in accordance with the PPS25 Flood Zones 1, 2 and 3.

The Environment Agency Flood Zones 2 and 3 show flood risk which does not take into account the presence of flood defences However maps which indicate areas benefitting from defence have been published by the Environment Agency.

PPS 25 Flood Zones

PPS25 splits the Environment Agency's Flood Map into three separate Flood Zones. These Flood Zones should be used when determining the appropriateness of proposed development uses when considering flood risk through the application of the Sequential Test. They represent flooding without flood defences in place.

Derby City is not at risk from tidal flooding due to its inland location, thus tidal flooding is not discussed further.

Flood Zone 1 is defined as having a 'Low Probability' of flooding and incorporates areas where the annual probability of flooding is lower than 0.1%. PPS25 imposes no constraints upon the type of development within Flood Zone 1.

Flood Zone 2 is defined as 'Medium Probability' with an annual probability of flooding between 0.1 and 1.0% for fluvial flooding. PPS25 recommends that Flood Zone 2 is suitable for most types of development with the exception of 'Highly Vulnerable' (see Table 2.1) land uses as defined in table D2 of PPS25.

Flood Zone 3 is defined as 'High Probability' with an annual probability of flooding of 1.0% or greater for fluvial flooding. PPS25 recommends that appropriate development is based upon a further classification of Flood Zone 3 into 3a High Probability and 3b Functional Floodplain (where water has to flow or be stored in times of flood).

Table D2: Flood Risk Vulnerability Classification, within Annex D of PPS 25 outlines the vulnerability classification for different types of development and is included within this SFRA document as Table 2.1 below.

Land Use Vulnerability	Type of Development
Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk • Essential utility infrastructure, which has to be located in a flood risk area for operational reasons, including electricity generating power stxations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind turbines.
Highly Vulnerable	• Police Stations, Ambulance Stations and Fire stations, Command Centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent.
More Vulnerable	• Hospitals. • Residential institutions such as care homes, children's homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs and hotels. • Non-residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short let caravans and camping, subject to specific warning and evacuation plans.

Land Use Vulnerability	Type of Development
Less Vulnerable	• Police Stations, Ambulance Stations and Fire stations which are not required to be operational during flooding. • Buildings used for: shops, financial, professional and other services; restaurants and cafes, hot food takeaways; offices; general industry; storage and distribution; non-residential institutions not included in 'more vulnerable'; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except for landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment plants which do not need to remain operational during times of flood. • Sewage treatment plants (if adequate pollution control measures in place).
Water Compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and Gravel workings. • Docks, Marinas and Wharves. • Navigation facilities. • MOD installations. • Shipbuilding, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water based recreation (excluding sleeping accommodation). • Lifeguard and coastguard operations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to specific warning and evacuation plans.

Table 2.1 – Flood Risk Vulnerability Classification (based on Table D2 of PPS 25, Ref: 1)

Table 2.2 demonstrates when development, based on the vulnerability classification shown in Table 2.1 is suitable, unsuitable and when the Exception Test is required.

Flood Risk Vulnerability Classification (see Table D2 of PPS25)		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table D1 of PPS25)	Zone1 Low Probability	✓	✓	✓	✓	✓
	Zone2 Medium Probability	✓	✓	Exception Test required	✓	✓
	Zone 3a High Probability	Exception Test required	✓	*x*	Exception Test required	✓
	Zone 3b 'Functional Floodplain'	Exception Test required	✓	*x*	*x*	*x*

✓ Development is appropriate

x Development should not be permitted

Table 2.2 – Appropriate Development for each Flood Zone (based on Table D3 of PPS 25, Ref: 1)

Sequential Test

PPS25 states that the Sequential Test should be carried out by LPAs when allocating land in LDDs to demonstrate that there are no sites available for development in areas that are at a lower risk from flooding from all sources.

When an area is at risk from either fluvial or coastal flooding then development should be allocated outside Flood Zones 2 and 3. However if there are no reasonable sites for development within Flood Zone 1 then depending upon flood vulnerability, proposed development sites could be allocated in Flood Zones 2 or 3. The vulnerability classification of development to flood risk is outlined in table D.2 in PPS25 included in this SFRA as Table 2.1.

For the specific study areas (A-C) this SFRA will illustrate areas at risk from flooding and as such should be used within the Sequential Test process for the Derby City area to direct land allocations in Flood Zones 2 and 3 to areas at the lowest probability of flooding from all sources. This SFRA assesses land allocations and development control policies in terms of potential sources and probability of flooding with the impact of climate change.

Exception Test

Occasionally it is not possible to locate development in areas that are at the lowest risk of flooding through the Sequential Test. In certain circumstances the Exception Test could be carried out, which, if passed will allow development to go ahead. Table 2.2 in this SFRA is taken from table D.3 in PPS25 and outlines where development is appropriate, not appropriate and when an Exception Test must be carried out depending upon the vulnerability of the proposed development.

The purpose of an Exception Test is to demonstrate that there are wider sustainability reasons for development at a specific location based on issues other than flood risk. In order to pass the Exception Test, which allows development to go ahead, it must be demonstrated that the development satisfies all of the following;

- Provides wider sustainability benefits to the community that outweigh the risk of flooding;

- Is located on land that has been previously developed or there are no other previously developed sites that are suitable for the development; and
- A FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Regeneration Areas

According to Planning Policy Statement: PPS25 Practice Guide (para 4.38), where redevelopment is ongoing as part of an existing regeneration strategy in Flood Zones 2 or 3, it has to be accepted that the redevelopment cannot go anywhere else, as there are no other reasonably available sites. Nevertheless, the sequential approach should still be applied within the regeneration area, and it may even be appropriate in some cases for a formal sequential test to be applied within large areas.

The Masterplan for Derby is subject to alteration and the Environment Agency's Lower Derwent Strategy project is currently ongoing, therefore the Sequential Test should account for any impacts or recommendations from these studies to ensure that development within Derby is allocated in the most suitable locations. If these studies are completed following the application of the Sequential Test it may be appropriate (subject to the outcomes of the projects) to revisit the Test.

The developer still needs to satisfy the final part of the Exception Test, that the development will be safe and will not increase flood risk elsewhere. Evidence should be provided in the FRA that the sequential approach and all three parts of the Exception Test have been considered within the strategy area. Depending on how far the regeneration strategy has developed there may still be opportunities through design and layout to minimise flood risk and where possible reduce it. The FRA should show that opportunities to substitute lower vulnerability uses in higher risk areas and place housing development in lower risk areas have been taken wherever possible.

2.2 Regional Planning Policy

2.2.1 East Midlands Regional Spatial Strategy

The East Midlands Regional Spatial Strategy (RSS8) (Ref: 10) constitutes aims to contribute towards the achievement of sustainable development through a series of objectives, or policies. The document covers the period until 2021, but is considerate of the longer term. Within the RSS8 Derby is identified as one of the five Principle Urban Areas and a key area for growth and regeneration.

Specifically it is Policy 36 of RSS8 which relates to flood risk including the requirement for SFRAs, flood management schemes, sustainable drainage and development sensitive to the needs of floodplain preservation and management.

2.3 Local Planning Policy

2.3.1 Derby City Council – Policy Statement on Flood Defence and Land Drainage

The Policy relates to the reduction in flood risk for new development and the promotion of effective Sustainable Drainage Systems (SuDS). It is stated within the Policy that 'Derby City Council will work in partnership with the Environment Agency to reduce flooding through the Planning process and through the encouragement of SuDS in order to return water to the ground thereby contributing to available ground water and reducing the possible effects of shrinkage of plastic soils'.

2.3.2 Local Plan Review (GD3) Flood Protection Policy

The Local Plan Review (GD3) Policy has been adopted by Derby City Council to service the role of the Land Drainage and Flood Defence team and for the maintenance and management of the land drainage infrastructure. The Policy outlines where development should not be accepted unless it can be demonstrated that effective compensatory measures would be implemented to offset potential increases in flood risk as a result of new development.

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3. Data Collection and Review

3.1 Consultation

All information obtained during the SFRA consultation process has been detailed in Section 3.3 and will feed into the application of the Sequential Test.

3.1.1 Derby City Council

Derby City Council's drainage team have been consulted in order to determine if there is any flooding (fluvial or surface water) that other consultees were not aware of.

3.1.2 Environment Agency

Derby City Council's area spans only one Environment Agency area – Eastern Area in the Midlands Region. This area has been consulted to obtain information on sources of flood risk, hydraulic modelling, flood defences and flood warning.

3.1.3 Severn Trent Water

The sewerage infrastructure within the Derby City area is maintained by Severn Trent Water. Severn Trent Water has supplied information on known surface water flooding locations, historical flooding and information on the assets that they maintain to ensure that the 'critical drainage areas' are identified. The Severn Trent Water DAP (Drainage Area Planning) sewer model for the Derby area was obtained as part of the surface water flooding assessment for Castleward- Area B.

3.1.4 British Waterways

British Waterways have not been consulted as part of this Level 2 SFRA, as there are no British Waterway owned navigation stretches within or in close proximity to the sites of interest.

3.2 Catchment Characteristics

This Level 2 SFRA covers three separate areas within Derby, the North Riverside site, the Castleward site and the Derwent Triangle site referred to as Areas A, B and C respectively. These sites cover a total area of 0.7km^2 and can be seen on Appendix A. The catchment descriptions of these areas are as follows:

According to the Environment Agency information, all 3 sites are designated as Minor Aquifer and comprises fractured or potentially fractured rocks which do not have a highly primary permeability, or other formations of variable permeability unconsolidated deposits. Although these aquifers will seldom produce large quantities of water for abstraction they are important both for local supplies and in supplying base flow to rivers.

North Riverside (Area A): The Derby SFRA Level 2 North Riverside Area [grid reference 435499, 336542] is a highly urbanised area and is located south of A601 St Alkmund's way in the Derby city centre. The River Derwent is located adjacent to the southern boundary of the site. The site is bound by the St Mary's bridge in the north west and the Longbridge weir in the south.

Castleward (Area B): The Derby SFRA Level 2 Castleward area [grid reference 435870, 335770] a highly urbanised area and is located in Derby city centre and immediately to south of A6 Station Approach. The River Derwent is located in close proximity to the northern boundary of the site. Mill Fleam, an engineered open channel passes adjacent to the north western boundary before joining the confluence at River Derwent. The site comprises a drainage system including storm and foul water sewers.

Derwent Triangle (Area C): The Derby SFRA Level 2 Derwent Triangle, Area C is an undeveloped site [grid reference 437710, 335501] and is located south of Wyvern retail park. The

River Derwent is located to the western boundary of the site. The eastern bank of the River Derwent comprises a flood defence embankment.

3.3 Sources of Flood Risk Information

Information from the Level 1 SFRA has been used for this document and where required has been updated.

3.3.1 Historic Flood Events

Analysis of historic flood events is available for the three sites of interest. Information on historical flood events can supplement the understanding of flooding mechanisms and flood extents within a catchment.

Flooding from River Derwent occurred during 1947, 1960, 1965 and 1977. The River Derwent channel capacity was exceeded however no raised defences were present during these flood events. The flooding characteristics will have changed significantly due to construction of flood defences.

3.3.2 Hydrological Studies, Hydraulic Modelling and Flood Outlines

Three hydrological studies have been carried out by the Environment Agency who has been consulted for this Level 2 SFRA. These studies are for the River Derwent, Markeaton Brook and Cuttle Brook.

The Environment Agency hydraulic model for the Lower Derwent was made available for this study. This is an ISIS 1D hydraulic model with its upstream extent located near the railway bridge, approximately 2.2km upstream of the A38 (SK 3559 4151) and the downstream extent at the River Trent Confluence near Great Wilne (SK4590 3080). However in its original state it would not have been fit for the purposes of the Level 2 SFRA and thus modification of this model was required to ensure the model represents current conditions and a refined floodplain representation.

To ensure the model and the model outputs are fit for the purposes of the Level 2 SFRA such that the Sequential and Exception Tests can be carried out, the processes outlined in Table 3.1 have been carried out.

Processes	Description
Review Hydraulics	Review of model schematisation to identify modifications required to provide detailed and reliable information required for the individual locations (Area A, Area B and Area C).
Review Hydrology	Carry out review of the existing model hydrology to identify if updates are required.
Modify Model	Make necessary amendments to the model (including replacing 1D floodplains with 2D units as required).
Calibration/Verification	Simulate the models for the calibration events previously used to verify validity of the model.
Model Results	Model output processed to provide salient information for the Level 2 SFRA and enable the Sequential and Exception Tests.

Table 3.1 Processes involved in hydraulic modelling assessment

3.3.3 Environment Agency List of Potential Areas Susceptible to Flooding

The Environment Agency maps which shows potential areas susceptible to flooding was obtained and this shows the sites that have potential for surface water flood risk. The map has been produced using a simplified method that excludes underground sewerage and drainage systems, and smaller over ground drainage systems, buildings, and uses a single rainfall event – therefore it only provides a general indication of areas which may be more likely to suffer from surface water flooding. Because of the way they have been produced and the fact that they are indicative, the maps are not appropriate to act as the sole evidence for any specific planning decision at any scale without further supporting studies or evidence. Further detailed information and assessment on the surface water flood risk for the 3 sites are included in Section 4.2.

3.3.4 Flood Warning

All three SFRA Level 2 Areas are within the Environment Agency's flood warning system boundary.

The Environment Agency sends out warning to the specified flood warning areas with one of four messages;

- Flood Watch – Flooding of low-lying land and roads is expected. Be aware, be prepared, watch out.
- Flood Warning – Flooding of homes and businesses is expected. Act now.
- Severe Flood Warning – Severe flooding is expected. There is extreme danger to life and property. Act now.
- All clear – Flood Watches and Warnings are no longer in force in this area.

The following Flood Warning status was confirmed from the Environment Agency.

- The North Riverside Area A falls partly within the EA flood warning area called 'The River Derwent at Derby City' and the triggers set at 3.2 metres at the Derby St Mary's river gauge.
- The Castleward Area B falls partially within the EA flood warning area called 'The River Derwent at Pride Park and Derby Railway Station' and the triggers set at 3.8 metres at the Derby St Mary's river gauge.
- The Derwent Triangle Area C falls within the EA flood warning area called 'The River Derwent at Chaddesden' and the triggers set at 3.3 metres at the Derby St Mary's river gauge.

Further information on flood warnings can be obtained either by referring to the Environment Agency website or by contacting Floodline on 0845 988 1188.

3.3.5 Existing Flood Defences

Flood defences are present along both banks of the River Derwent through Derby. The Environment Agency has provided details of these defences including location and ownership. This information is reported in section 4.3.

3.3.6 Development Plans, Policy and Guidance

The following Development Plans, Policy and Guidance documents have been provided to aid with the SFRA:

- The Derby City Partnership FRA for the City Centre (Ref: 3)
- The Derby Housing Market Area Water Cycle Study (Ref: 4)
- The East Midlands Regional Spatial Strategy (Ref.7)

3.3.7 Existing Studies on Flood Risk

Environment Agency Lower Derwent Strategy

The Environment Agency is currently carrying out a project to define the flood risk management strategy for the Lower Derwent. This project will consider the potential for developing a 'Blue Corridor' through Derby. The concept of the 'Blue Corridor' is to make the river an integral part of the urban environment, by opening up the river corridor within the city so that it can be enjoyed by people, support wildlife and enhance its cultural heritage, as well as Making Space for Water.

The concept includes consideration of the existing flood defences and potential realignment of the defences to open up the 'Blue Corridor' and reduce flood risk to the City. The realignment option seeks to increase the standard of protection to an optimum standard on both the left and right bank of the river.

Derby City Partnership Flood Risk Assessment for the City Centre

The Derby City Growth Strategy, 2006 provides a balanced assessment of Derby's economy and outlines clear priorities to ensure the city continues to experience economic growth in the coming years. This report identified that there are opportunities for Derby to build on these assets, particularly around growing the strong sectors in the city. It also recommends that Derby also has a great natural asset at its core, the River Derwent and therefore there is considerable potential to utilise the river feature to support the economy of Derby.

Additional to the priorities under the vision statements City Growth has also identified a need for action to deliver projects that will transform Derby's physical assets. This includes:

- Enhance accessibility to all areas of the city and improve road safety by improving road, cycle and pedestrian routes and public transport.
- Work towards achieving 21st Century electronic communication in Derby by making the case for investment and supporting the development of appropriate infrastructure.
- Work with private landlords to improve housing conditions in the private sector.
- Protect and enhance Derby's valuable green spaces and the natural environment to ensure they can be used by all for sport, leisure and recreation.
- Develop a sustainable flood risk management strategy for the River Derwent that protects people and property and provides usable green and recreational spaces that encourage biodiversity.
- Ensure that people are fully engaged in preparing new plans to guide the physical development of Derby.

Derby Housing Market Area Water Cycle Study

The Derby Water Cycle Study, January 2010 was produced for the purpose of providing strategic level advice on water infrastructure and environmental capacity to the Council Local Development Frameworks and strategic site allocation. The study area has been defined as the three local authority boundaries of Amber Valley Borough, Derby City and South Derbyshire District to cover the growth area of the Derby Housing Market Area (HMA). The Water Cycle Study aims to take an integrated approach to management of the water environment and ensure sustainable flood risk management over the long term are delivered through policies to protect future development from flooding in addition to addressing several planning related objectives.

According to the water cycle study, the main sources of flood risk in the study area have been identified as fluvial, from the rivers Derwent and Trent and their tributaries, and from surface water run-off. Development in the highest flood risk zones should only be permitted if they are at the appropriate level of vulnerability in accordance with PPS25. It also recommends that the findings of the SFRAs undertaken for the areas are taken into account in spatial planning: developments should, where possible, be located in the lowest flood risk zone based on the SFRA.

The water cycle study report identifies that surface water flooding; as a result of heavy rainfall events, urbanisation and insufficient drainage capacity is a problem in the study area, with particular reference to Derby City and urban areas. This report recommends Sustainable Drainage Measures are recommended in the study area to provide multiple benefits such as providing amenity and environmental benefits, reducing pressures on the drainage system and providing more storage of rainwater.

3.4 Flood Mapping Data

Flood risk data for the sites of interest within Derby City have been made available for this Level 2 SFRA from a number of sources as outlined in the previous sections. This section provides details on the information which has been used to produce the mapping which is presented in Appendix A and will be used for the application of the Sequential Test.

The fluvial flood risk to Areas A, B & C has been assessed by developing a 1D/2D hydraulic model. The Environment Agency ISIS model of the Derwent was has been modified to include a 2D representation of the floodplain through Derby. The modifications to the existing model (used for this analysis) have been limited to improving the representation of the overland flow for the three specific Areas.

As a separate project commissioned by the Environment Agency, the model of the River Derwent is being updated. This updated model will supersede the model that has been used for this interim analysis. Early indications are that there is not a significant change in the predicted flooding, however this cannot be confirmed until the Environment Agency revised modelling is complete.

Further information regarding the fluvial modelling methodology is provided in Appendix B.

The classifications for the flood hazard are as defined in FD2320/TR2. The classifications are provided in Table 3.2.

Hazard Rating	Degree of Hazard	Description
<0.75	Low	**Caution**: Flood zone with shallow flowing water or deep standing water
0.75 – 1.25	Moderate	**Dangerous for some (i.e. children)**: Danger: Flood zone with deep or fast flowing water
1.25 – 2.0	Significant	**Dangerous for most people**: Danger: flood zone with deep fast flowing water
>2.0	Extreme	**Dangerous for all**: Extreme danger: flood zone with deep fast flowing water

Table 3.2 – Hazard to people definitions

In addition to fluvial flood risk mapping the Environment Agency has made available to Local Authorities which highlights areas that are susceptible to surface water flooding. This mapping is current at the time of writing but it is planned that the Environment Agency will update this mapping by summer 2010. There are a number of uncertainties associated with this mapping and as such the guidance (Ref: 12) states that the mapping should not be displayed at a more detailed scale the 1:50,000, thus the mapping within this SFRA provides an overview of areas susceptible to surface water flooding.

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4. Flood Risk

4.1 Flood Risk Sensitivity

The following section details the potential changes to flood risk due to climate change, increase in urban land use and changes in land management practices as well as an outline of how dealing with runoff from urban areas.

4.1.1 Climate Change

PPS25 and other Planning Policies, such as PPS1 'Delivering Sustainable Development', clearly recognise the need for future growth to consider the impacts of climate change to ensure development is undertaken in a sustainable manner.

Future climate change in England will impact upon both sea levels (which will rise), and rainfall intensities (which will intensify). Detailed figures on climate change allowances taken from Tables B.1 and B.2 of PPS25 respectively are given in Table 4.1.

The flood risk assessments accounting for climate change are included in the site specific data in the following sections.

Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Sea level (East of England, East Midlands, London, SE England	4.0mm rise	8.5mm rise	12.0 mm rise	15.0mm rise
Sea level (South West)	3.5mm rise	8.0mm rise	11.5mm rise	14.5mm rise
Sea level (NW England, NE England.	2.5mm rise	7.0mm rise	1.0mm rise	13.0mm rise
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

Table 4.1 – Climate change allowances taken from PPS25

The UK climate projections (UKCP09) provide information on how the UK's climate is likely to change in the 21st century, as it responds to rising levels of greenhouse gases in the atmosphere. Further information on climate change can be found in their website (http://ukclimateprojections.defra.gov.uk).

4.1.2 Increased Urban Development

The impact of increased urbanisation, if uncontrolled, is likely to create an increase in flood risk. Storm runoff from impervious surfaces, routed rapidly by artificial drainage networks can increase flood peaks in watercourses downstream of new urbanised areas. There is also an increased risk of localised 'flash flooding' during intense rainstorms. Urban growth will, therefore, increase surface water runoff rates and volumes if not properly controlled.

However, new developments are unlikely to increase surface water flood risk for the following reasons:

- Derby SFRA Level 2 sites (North Riverside-Area A and Castleward- Area B) are highly urbanised areas and therefore have connections to the drainage network. Therefore, unless the land use significantly increases the impermeable surface area, new development is unlikely to increase surface water flood risk. There is an exception to this, whereby low density residential areas of large houses, with extensive gardens, are replaced with high density developments of flats or smaller houses. However with the use of Sustainable Drainage Systems (SuDS) these potential adverse effects can be avoided.

- For any ‘greenfield’ allocations (Area A and Area B), surface water discharges from any new developments into watercourses would be controlled by the planning authority with technical leadership and guidance from the Environment Agency to ensure that the existing greenfield runoff rates are maintained post development. In addition to this, developers would have to approach Severn Trent Water to determine if they have the capacity to allow new development to connect to the drainage system. Severn Trent Water would either allow the connection if capacity allows, or they would inform the developer that an increase in capacity is required. The developer would then be required to cover the costs of increasing the capacity prior to development taking place and allowing connection to the Severn Trent Water system.
- The Derwent Triangle- Area C is an undeveloped site and as such any urban development will increase impact on surface water runoff from the site. Sustainable Drainage Systems (SuDS) should be considered as part of the mitigation measures.
- Any additional development carried out in the Functional Floodplain (as defined in PPS25) will lead to an increase in flood risk and require further mitigation.

Section 4.1.3 below identifies the various surface water mitigation options in the event that surface water flood risk is increased.

4.1.3 Potential Sustainable Mitigation

The form and function of SuDS to be used within a development, is heavily dependent on catchment characteristics. The topography and geology of the area will determine which form of SUDS would be most beneficial for the site; whether to assist the movement of water through infiltration, or to store excess flows. Table 4.2 details the types of SuDS options that could be developed within the sites of interest.

It is recommended that any site specific developments that may utilise SuDS infiltration techniques should be subject to thorough geological investigations to determine if infiltration techniques are suitable for the site.

SuDS Component	Utilisation on Development Site	Benefits
Filter Strips	These are wide, gently sloping areas of grass or other dense vegetation that treat runoff from adjacent impermeable areas. They should be between 5 and 15 m wide, however wide and more densely vegetated strips will provide better pollutant removal.	Filter Strips can be used effectively to remove excess solids and pollutants before discharging to an infiltration system. In addition Filter Strips may preserve the character of riparian zones and prevent erosion along stream banks by reducing flow velocities and spreading the flow across a wide area. They can also provide an excellent wildlife habitat when used in this way.
Swales	Swales are broad, shallow channels covered by grass or other suitable vegetation. They are designed to convey and/or store runoff, and can infiltrate the water into the ground (if ground conditions allow).	Swales can be used to form a network within a development, linking storage ponds and wetlands. The performance can be enhanced by placing check dams across the swale to reduce the flow rate which, in turn, reduces the risk of erosion in a swale. Swales can also be used to improve water quality. Swales avoid the need for expensive roadside kerbs, gullies and related maintenance.
Infiltration Basins	Infiltration basins are depressions in the surface that are designed to store runoff and infiltrate the water to the ground.	They can be used to serve large catchments (up to the 10 ha) in comparison to infiltration trenches because a larger volume of water can be stored on the surface. The design life of these facilities can be increased by providing runoff pre-treatment, in the form of filter strips, gullies or sump pits to remove excessive solids. They may also be landscaped to provide aesthetic and amenity value.
Wet ponds / Retention ponds	Wet ponds are basins that have a permanent pool of water for water quality treatment. They provide temporary storage for additional storm runoff above the permanent water level.	The storage of water at all times means that unsightly exposure of banks collected with sediment can be avoided. Wet ponds provide water quality benefits as they facilitate the removal of nutrients, trace metals, coliforms and organic matter. They also may provide amenity and wildlife benefits.
Extended Detention Basins	Extended detention basins are normally dry, though they may have small permanent pools at the inlet and outlet.	They are designed to retain flood events, reducing peak flows and limiting the risk of flooding. They can also provide water quality treatment.
Constructed Wetlands	Constructed wetlands are ponds with shallow areas and wetland vegetation.	The purpose of constructed wetlands is to improve pollutant removal and enhance wildlife habitat. Wetlands can provide a much greater degree of filtering and removal of nutrients by algae and, to a lesser extent, by plants in comparison to other methods.
Filter drains and perforated pipes	Filter drains are trenches that are filled with permeable material. Surface water from the edge of paved areas flows into the trenches, is filtered and conveyed to other parts of the site. A slotted or perforated pipe may be built into the base of the trench to collect and convey the water.	Filter drains can be used to trap sediment, organic matter and oil residues that can be broken down by bacterial action through time.

SuDS Component	Utilisation on Development Site	Benefits
Infiltration Devices/Trenches	Infiltration devices temporarily store runoff from a development and allow it to percolate into the ground. An infiltration trench is a shallow, excavated trench that has been lined with a geotextile and backfilled with stone to create an underground reservoir.	The operational life of the trench may be enhanced by providing pre-treatment for the inflow, such as filter strips, gullies or sump pits to remove excessive solids. Effective infiltration trenches can significantly reduce the level of solids, coliforms, trace metals and organic matter. Nutrient levels can also be reduced.
Green Roofs	Green roofs are systems which cover a building's roof with vegetation. They are laid over a drainage layer, with other layers providing protection, waterproofing and insulation.	The implementation of green roofs can reduce the volume and rate of runoff such that downstream SuDS and other drainage infrastructure can be reduced in size. In addition they have water quality and habitat benefits, can improve insulation and extend roof life.

Table 4.2 – SuDS Options (adapted from CIRIA c697 Table 1.1 and EA SUDS: An Introduction)

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4.1.4 Land Management

In addition to urban areas, management of agricultural land is also necessary to manage flood risk. It is necessary to manage agricultural land in relation to surface water runoff and sediment generation as agricultural practices, such as intensive livestock grazing which can lead to soil compaction, growing of crops that cover less of the soil surface which can promote soil erosion, the removal of hedgerows and woodland areas, reshaping the landform and the provision of positive land drainage can all result in an increase in flood risk downstream.

4.2 Sources of Flooding

4.2.1 Area A: Riverside

Fluvial

Baseline Overtopping Scenario

The Riverside Area is within Flood Zone 3. However, the modelling exercise has confirmed that the area is not within the Functional Floodplain. No flooding occurs during the 4% AEP flood event; flooding does occur during the 2% AEP flood event. Peak water levels at four locations within Area A (WL1–WL4) are presented in Appendix G.

The Area starts flooding from the north, with water spilling out of the Derwent further upstream and flowing overland along Phoenix Street and Derwent Street, under St Alkmund’s Way and into the Riverside Area. These are the predominant flow route into the Riverside Area; there is no significant flood flow directly from the Derwent into Area A.

The fluvial flood hazard data for Area A is shown in Figure 4.1. Additional maps showing the fluvial flood risk are provided in Appendix D.

Flood hazard for the 1% AEP fluvial flood event in Area A is generally classed as Extreme.

Once the Riverside Area starts to flood the majority of the site is flooded within 2 hours and the whole area is flooded within approximately 4 hours. A map showing the propagation of the flood across the site is provided in Appendix F.

The timing of the flooding in Area A has been compared to the time when the Environment Agency Flood Warning trigger thresholds are reached at St Mary’s Gauge. The 0.1% AEP event has been used for this assessment and it shows that the site would start flooding approximately 1 hour before the trigger level at St Mary’s gauge is reached.

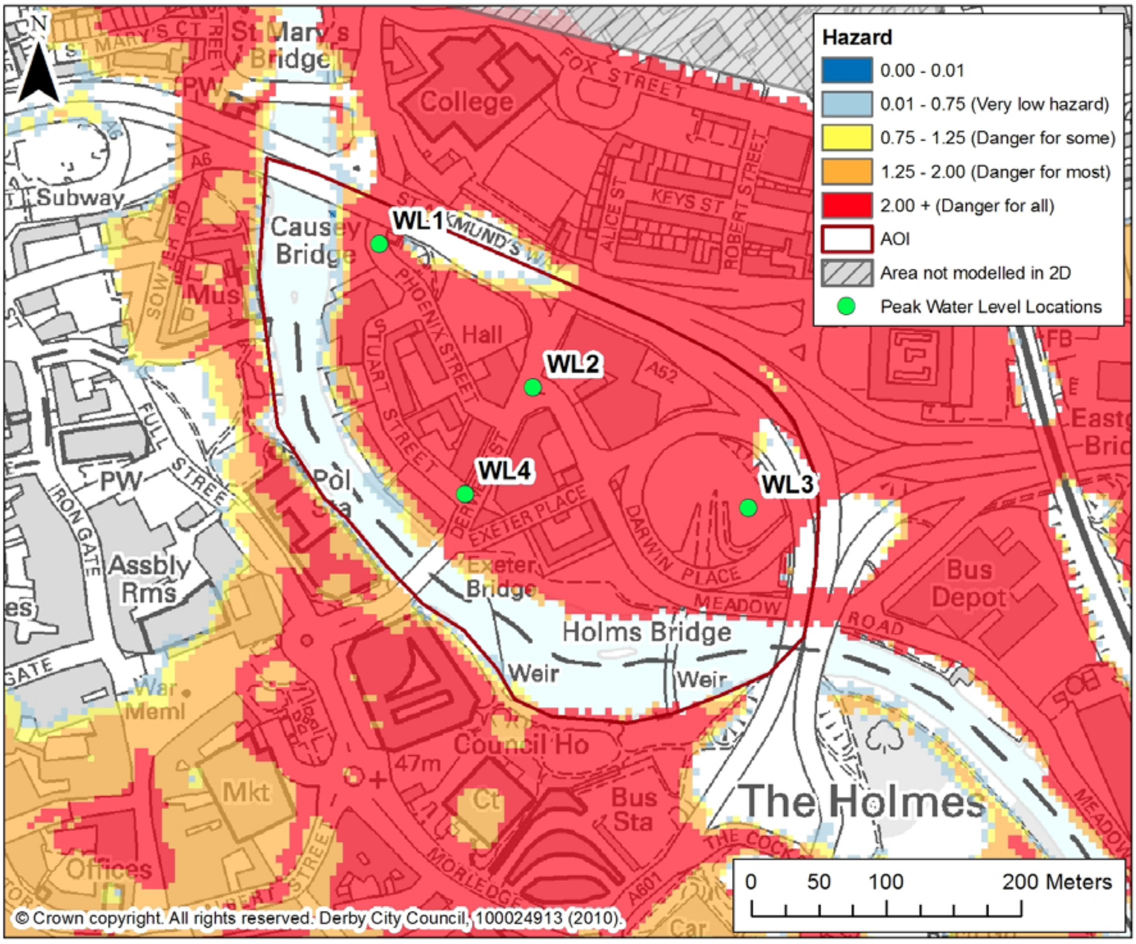

Figure 4.1 – 1% Fluvial Flood Hazard for Area A (Baseline Overtopping Scenario)

Post Development Overtopping Scenario

The model has simulated the fluvial flood hazard for the post development scenario. As no specific detail is available for potential future development scenarios, the whole of Area A has been raised up to a level so that it does not flood during the 1% AEP flood event. There is therefore no flooding in this or less extreme events. It is recognised that raising the whole area out of the floodplain is not a realistic post development scenario, however in the absence of detail development plans, this approach was taken to estimate the maximum potential impact on flood risk.

During more extreme events the whole Area is inundated as shown in Figure 4.2, but the flood hazard is generally Significant, and Extreme in small areas. Peak water levels at four locations within Area A (WL1–WL4) are presented in Appendix G.

Raising the ground levels in Area A increases the flood depths to the north of St Alkmund's Way by approximately 100mm. The flood depths to the east of the Area A and the railway line are affected, but only by a maximum of about a 10mm increase.

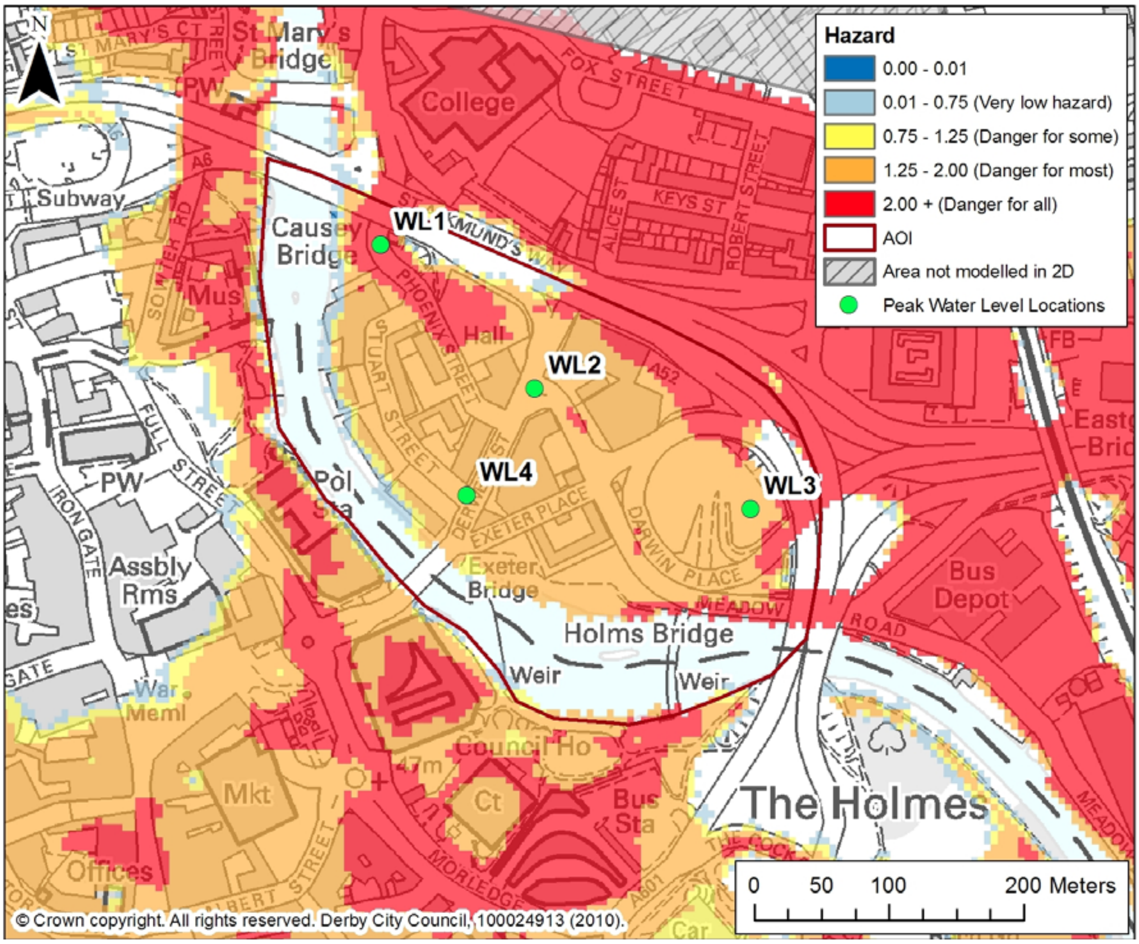

Figure 4.2 – 0.1% Fluvial Flood Hazard for Area A (Post Development Overtopping Scenario)

Baseline Breach Scenario

A flood defence breach scenario was simulated for area A. This involved a breach along the defence wall of the Derwent just upstream of the weir at Holms Bridge. To assess a breach scenario, a breach is assumed to occur 1 hour before the peak of the flood event; the width of the breach was set as 20m wide, and will remain open for 36 hours. These are the typical parameters for a hard fluvial flood defence.

The breach scenario results showed that the flood levels in Area A were lower than the baseline (non-breach) scenario. This is because the dominant flood flow route into Area A is from areas to the north. Introducing a breach effectively provides an additional flow path out of Area A.

As a consequence, the breach results have not been included in this report.

Surface Water

The North Riverside area is a fully urbanised catchment and assumed to comprise a drainage system including storm and foul water sewers. The Environment Agency map for areas susceptible to flooding was used to analyse this site. This shows that the site has potential surface water flood risk near Phoenix Street, Derwent Street and Darwin Place.

The Environment Agency map has been produced using a simplified method that excludes underground sewerage and drainage systems, and smaller over ground drainage systems, excludes buildings, and uses a single rainfall event – therefore it provides a general indication of areas which may be more likely to suffer from surface water flooding. Because of the way they have been produced and the fact that they are indicative, the maps are not appropriate to act as the sole evidence for any specific planning decision at any scale without further supporting studies or evidence.

Any increase in the urbanisation due to new or redevelopment will have an impact on the drainage system by an increased surface water runoff. This area is located within the fluvial flood zone 3a therefore a possible risk from sewer flooding due to interaction with fluvial flooding exists.

Figure 4.3 shows the Environment Agency surface water flooding area map for the three Derby SFRA Level 2 sites.

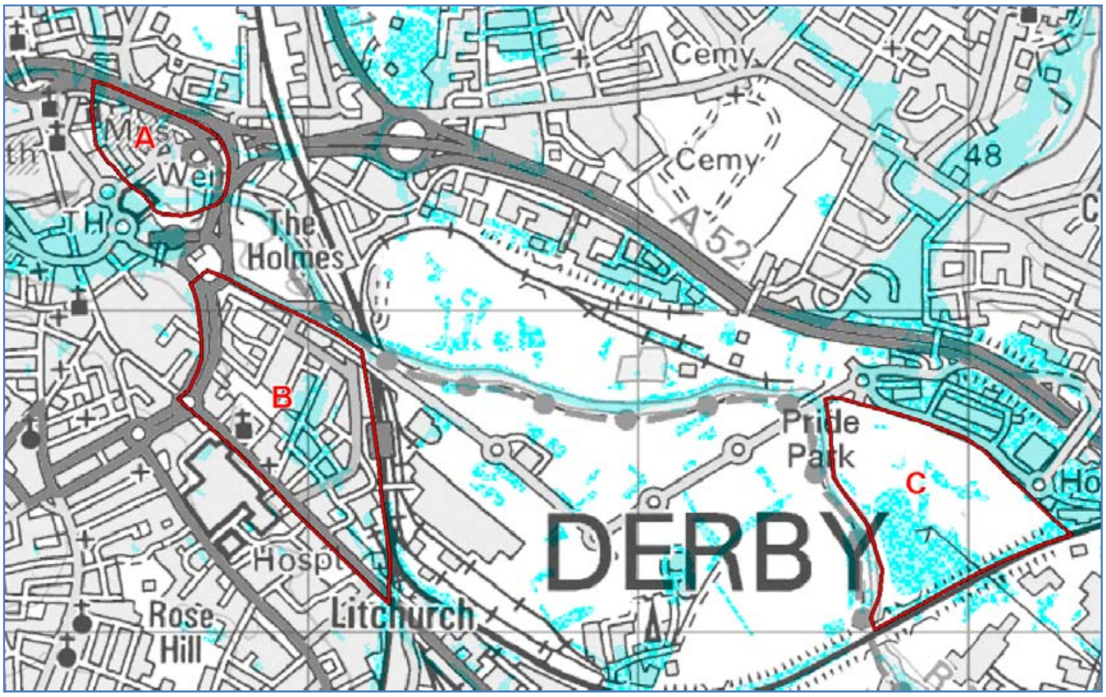

Figure 4.3 - Environment Agency plan showing areas susceptible to surface water flooding- Derby SFRA Level 2 Sites A, B and C

Groundwater

In terms of solid geology, all three sites (A, B and C) are underlain by the Triassic mudstones which are part of the Mercia Mudstone Group. The Mercia Mudstone Group is characterised by a sequence of brown, red-brown, calcareous clays and mudstones, with occasional beds of impersistent green siltstone and fine-grained sandstone. The Mercia Mudstone Group is classified by the Environment Agency as Non-Aquifer due to its relatively low overall permeability, although the sandstone bands within it can be locally important sources of groundwater.

The soil in North Riverside Area A has been classified as HU. H indicates that the soils are of High Leaching Potential, which have little ability to attenuate diffuse source pollutants and in which diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater. Soil category HU refers to urban areas, which are classified based on fewer observations than elsewhere, therefore a worst case vulnerability classification (H) is assumed until proved otherwise.

The superficial deposits of the valley bottom (predominantly alluvium) are likely to be in hydraulic connection with the river and it is considered that fluvial flooding would be the main issue in this setting.

The Environment Agency have no historical records of any groundwater flood risk and as such are unaware of any groundwater flooding events with regard to the proposed sites.

A detailed Groundwater assessment is included as Appendix H of this report.

Canal Infrastructure

There are no canals located in the vicinity of the site boundary.

Reservoirs

There are no reservoirs located in the vicinity of the site boundary.

4.2.2 Area B: Castleward

Fluvial

Baseline Overtopping Scenario

The Castleward area is not within Flood Zone 3. The modelling exercise has confirmed that the area is not at risk from fluvial flooding in the 1% AEP flood event. Nor does flooding occur during the 1% AEP plus climate change allowance flood event.

The 0.1% AEP flood event causes flooding in Area B. The Area starts flooding in the north west corner, spilling out of the Derwent upstream of Holmes Bridge. Flow passes along Station Approach and flows south, generally following the route of Canal Street and Park Street. Flood flows onto the railway near London Road Junction. Peak water levels at two locations within Area B (WL5 and WL6) are presented in Appendix G.

The fluvial flood hazard data for Area B is shown in Figure 4.4. Additional maps showing the fluvial flood risk are provided in Appendix D.

The West and South West sections of Area B are free from flooding in the 0.1% AEP flood event.

Flood hazard for the 0.1% AEP fluvial flood event along Station Approach in generally classed as Extreme, and large areas along Canal Street are Significant.

Once the Castleward area starts to flood, the flood water reaches the south east corner of the site within approximately 4 hours. A map showing the propagation of the flood across the site is provided in Appendix F.

The timing of the flooding in Area B has been compared to the time when the Environment Agency Flood Warning trigger thresholds are reached at St Mary's Gauge. The 0.1% AEP event has been used for this assessment and it shows that the site would start flooding approximately 4 hour after the trigger level at St Mary's gauge is reached.

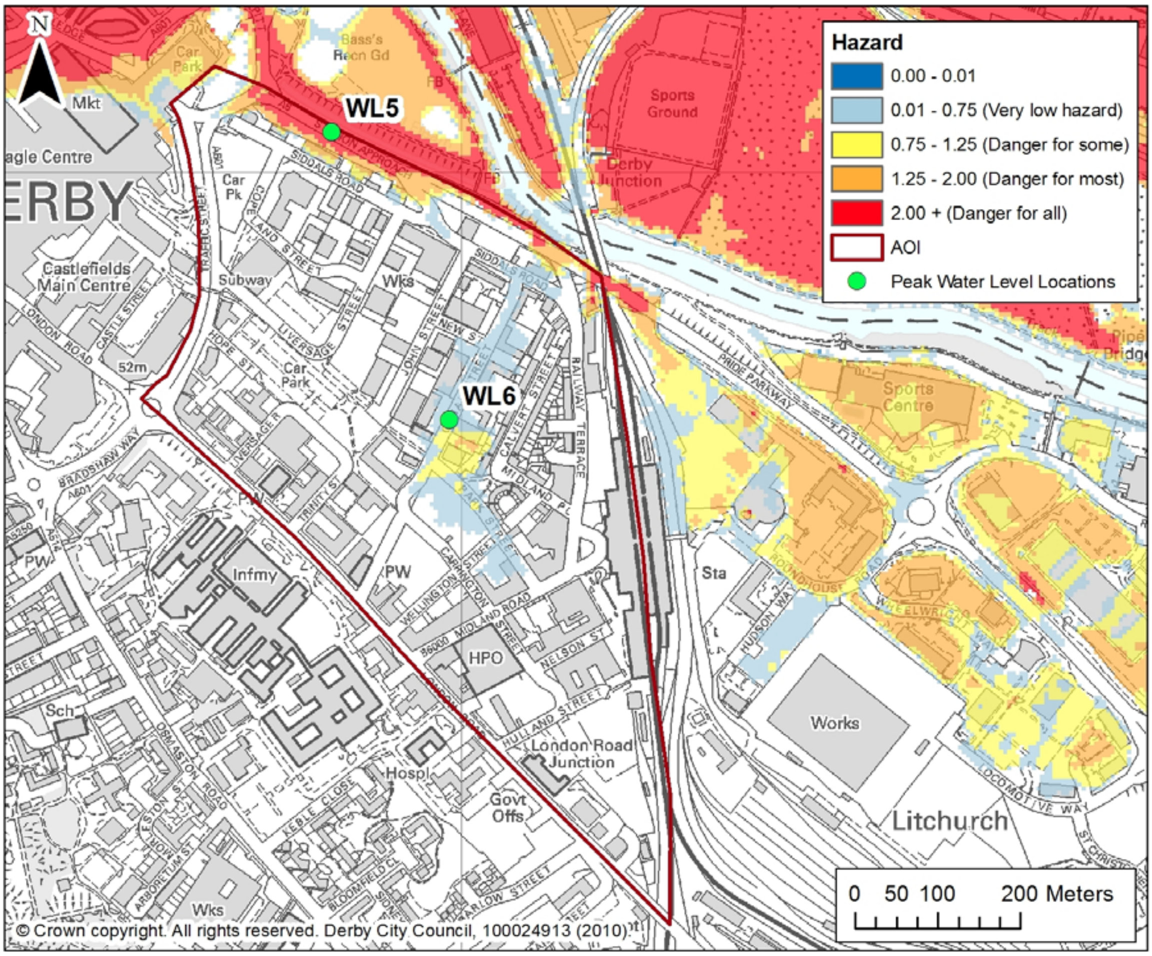

Figure 4.4 - 0.1% Fluvial Flood Hazard for Area B (Baseline Overtopping Scenario)

Post Development Overtopping Scenario

The model has simulated the fluvial flood hazard for the post development scenario. The footprint of the proposed development for Castleward as detailed in the City Centre Eastern Fringes Area Action Plan, has been included in the 2D model, and the flood events simulated.

The pattern of flooding is similar to the current development scenario as shown in Figure 4.5, however the flood extent and hazard is seen to be slightly lower. Conversely the flood hazard upstream of Area B has slightly increased. The method for assessing the impact of the new development is likely to overestimate the impact; however the model results indicate that the peak water levels in the river are not affected by the change in development within Area B.

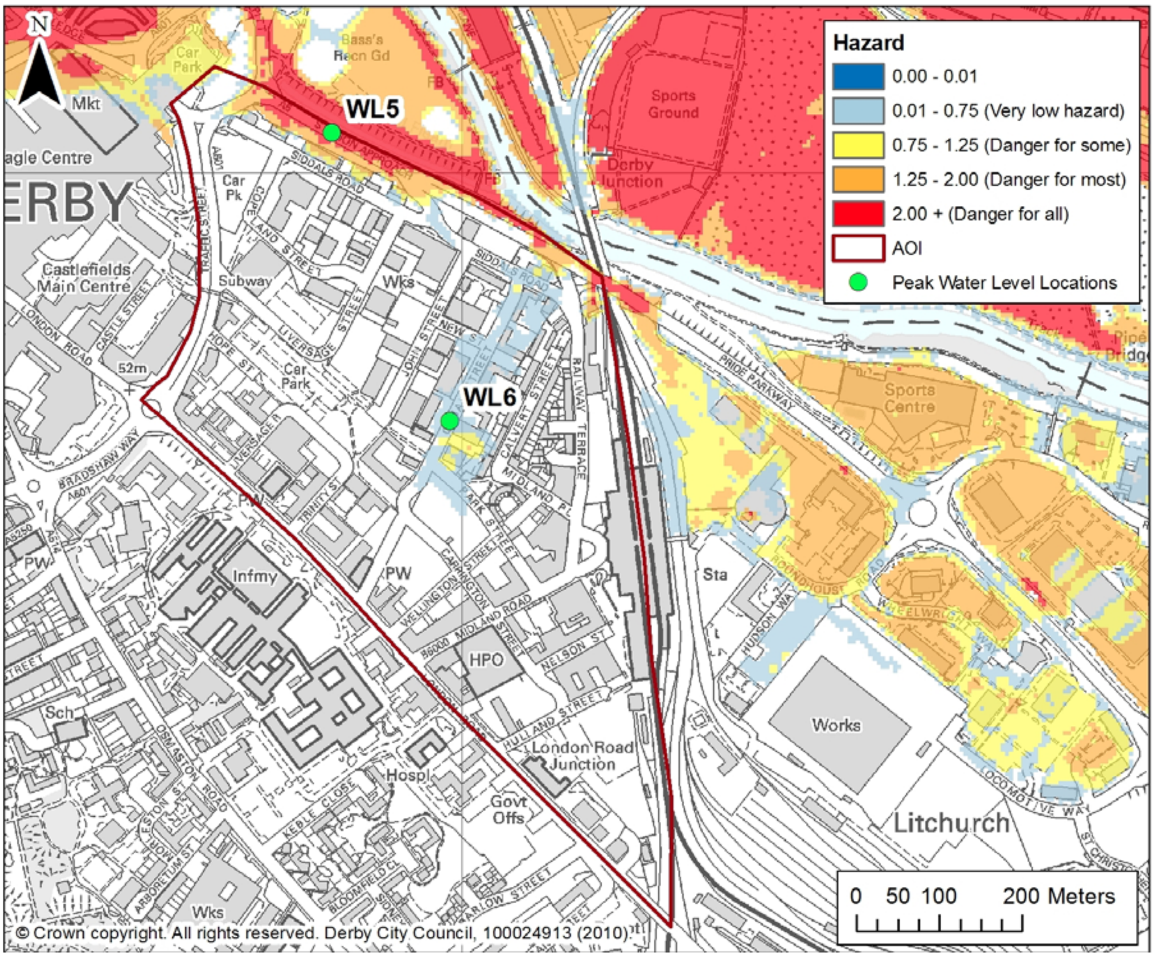

Figure 4.5 – 0.1% Fluvial Flood Hazard for Area B (Post Development Overtopping Scenario)

Baseline Breach Scenario

No suitable locations for a breach could be located along the Derwent at Area B and therefore no fluvial breach modelling was undertaken.

Surface Water

The Environment Agency map as shown in Figure 4.3 shows areas susceptible to surface water flooding- Derby SFRA Level 2 Sites A, B and C for areas susceptible to flooding was used to analyse this site. This shows that the site has potential surface water flood risk at Canal Street, Park Street and Carrington Place and some isolated flood risk near London Road Junction near south east corner of the site.

The map has been produced using a simplified method that excludes underground sewerage and drainage systems, and smaller over ground drainage systems, excludes buildings, and uses a single rainfall event – therefore it only provides a general indication of areas which may be more likely to suffer from surface water flooding. Because of the way they have been produced and the fact that they are indicative, the maps are not appropriate to act as the sole evidence for any specific planning decision at any scale without further supporting studies or evidence.

It is recommended by the Environment Agency that Local Authorities should use the maps in level 1 SFRAs only in conjunction with other evidence (for example historical data, other models, other organisations' data) to assess surface water flooding risks in different locations and to prioritise areas where further detailed assessment in level 2 SFRAs is necessary.

Therefore a detailed assessment was considered to better quantify risks from surface water flooding as described below in this section.

The surface water drainage model developed for this study has been undertaken using IWCS (InfoWorks-CS) and IWCS-2D. IWCS is the UK industry standard software for urban drainage analysis that is produced by Wallingford Software. Further information about this software platform can be found on the Wallingford Software website[1].

The Castleward area is a fully urbanised catchment and comprises a drainage system including storm and foul water sewers. The existing Severn Trent Water model for the Derby area comprises a complex sewer network including storm and foul water sewers and extents from upstream near A38 Road approximately 1km north of Darley Abbey and until downstream near the Spondon Weir sewer outfall in River Derwent. Therefore it was considered appropriate to use this model network to undertake surface water flooding assessment for this site.

There are sewer outfalls located at Mill Fleam and River Derwent near the Five Arches Railway Bridge crossing adjacent the site of interest. It is understood from investigation of the STW sewer model that the Mill Fleam outfall collects a large volume of the storm water sewer flows from upstream including the Markeaton Brook catchment located north west of the site. The majority of the sewers within the site were comprised of foul water sewers.

The surface water drainage modelling of the Castleward site includes 1D sewer model with 2D overland flow ground model incorporated dynamically. The modelling results demonstrates that the Castleward site does not flood during the 4% AEP and 3.3% AEP flood events with only insignificant overland flow occurring near the manhole located at the junction of the Midland Road and Railway Terrace including Park Street.

The site suffers from surface water flooding during the 1% AEP and 1% AEP plus climate change flood events near the south east corner of the site at London Road. This flooding is due to a combination of overland flows from sewer flooding occurring from Hulland Street and London Road. Also the junction of Midland Road and Railway Terrace was found to be flooding during large return period flood events.

There is some flooding that occurs near the east of the Cockpit roundabout on Station Approach. In addition, the A601 at Bradshaw roundabout located at the south west corner of the site is found to be flooding. This however does not encroach up to Hope Street in the north and Liversage Road in the east and stays within the roundabout location and as such considered to be insignificant risk to the Castleward site.

The locations near the sewer outfalls at Mill Fleam and River Derwent adjacent the site boundary is prone to backwater sewer outfall flooding due to fluctuations that might occur in the River Derwent water levels. A combination of flood return period levels at the River Derwent was therefore simulated within the IWCS-2D sewer model for outfall boundaries.

When compared with the fluvial flood risk impact as identified from the fluvial modelling results, the surface water flood risk on this site is considered to be insignificant.

Figure 4.6 and Figure 4.7 shows the impact of the surface water flooding on site and the flood hazard classified as defined in DEFRA guidance document FD2321/TR1 for 1% and 1% plus climate change return period flood events. Flood hazard for the 1% flood event for surface water drainage along Station Approach is generally classed as ‘Significant’, and areas along Park Street and south east corner of the site near Hulland Street is considered to be within the range of ‘Low’ and ‘Moderate’. The flood hazard rating information can be found as in Table 3.2.

Detailed flood hazard and flood depths output from surface water drianage modelling are included in Appendix C of this report.

[1] Wallingford Software – InfoWorks CS - http://www.wallingfordsoftware.com/

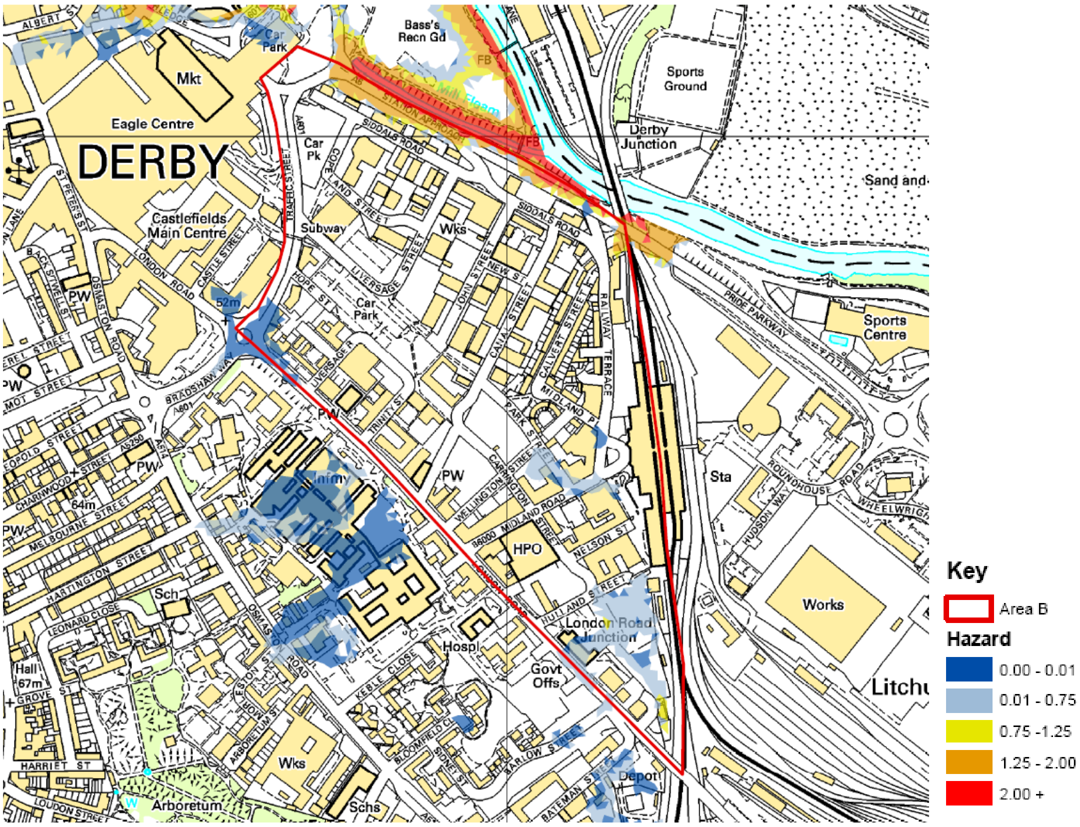

Figure 4.6 – 1% AEP Surface Water Drainage Flood Hazard for Area B

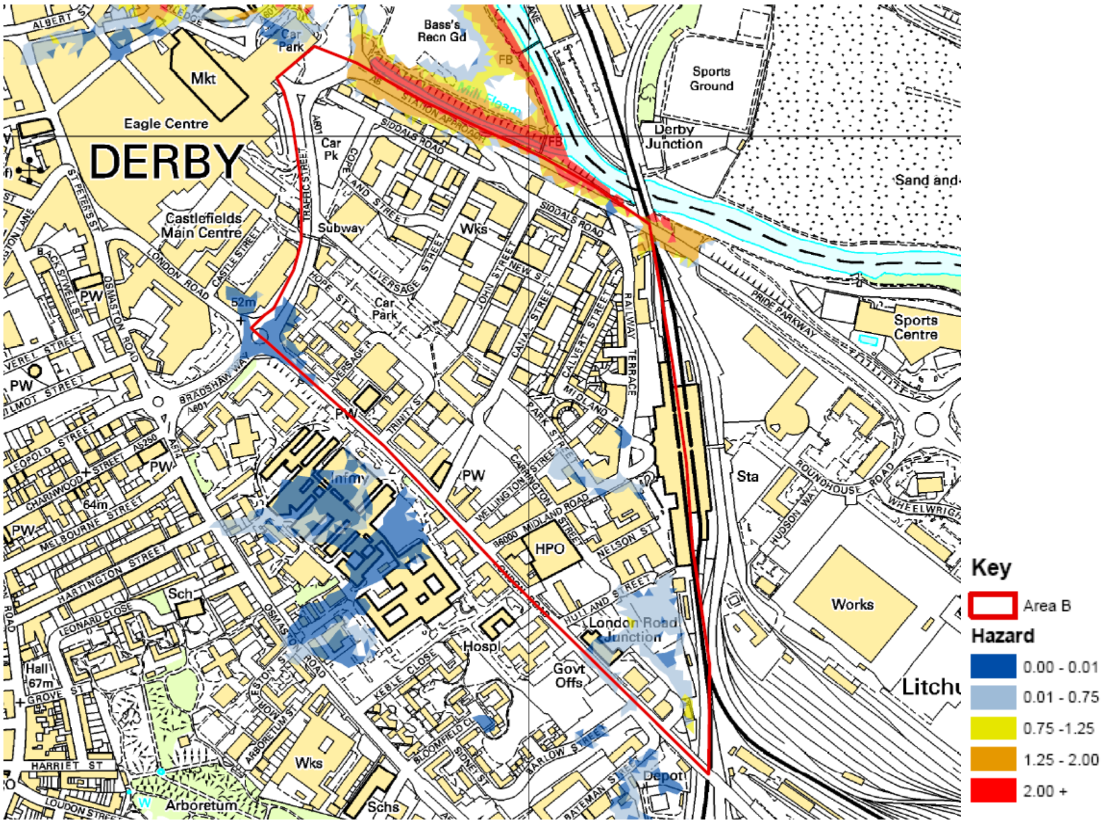

Figure 4.7 – 1% AEP plus climate change Surface Water Drainage Flood Hazard for Area B

Groundwater

According to the Environment Agency information, all three sites are designated as Minor Aquifer and comprise fractured or potentially fractured rocks which do not have a highly primary permeability, or other formations of variable permeability unconsolidated deposits. Although these aquifers will seldom produce large quantities of water for abstraction they are important both for local supplies and in supplying base flow to rivers.

The soil in Castleward Area B been classified as H1. H indicates that the soils are of High Leaching Potential, which have little ability to attenuate diffuse source pollutants and in which diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater. Subcategory H1 includes soils which readily transmit liquid discharges because they are either shallow or susceptible to rapid flow directly to rock, gravel or groundwater.

The superficial deposits of the valley bottom (predominantly alluvium) are likely to be in hydraulic connection with the river and it is considered that fluvial flooding would be the main issue in this setting.

The Environment Agency have no historical records of any groundwater flood risk and as such are unaware of any groundwater flooding events with regard to the proposed sites.

A detailed Groundwater assessment is included as Appendix H of this report.

Canal Infrastructure

There are no canals located in the vicinity of the site boundary.

Reservoirs

There are no reservoirs found in the vicinity of the site.

4.2.3 Area C: Derwent Triangle

Fluvial

Baseline Overtopping Scenario

The Derwent Triangle Area does not flood in the 4% AEP fluvial flood event – however it does flood during the 1.33% AEP fluvial flood event. The modelling exercise has confirmed that the area is within the Flood Zone 3 (at risk of flooding in the AEP 1% flood event).

Area C starts flooding from the north west corner from Wyvern area, via the road bridge underpass and access road. Flooding also occurs through the break in the embankment to the east of the site. There is no significant flood flow directly from the Derwent into Area C. Peak water levels at three locations within Area C (WL7–WL9) are presented in Appendix G.

The fluvial flood hazard data for Area C is shown in Figure 4.8. Additional maps showing the fluvial flood risk are provided in Appendix D.

Flood hazard for the 1% AEP fluvial flood event in Area C ranges from Low to Extreme depending on the topography of the site.

Once the Derwent Triangle Area starts to flood, the majority of the Area is flooded within approximately 4 hours. A map showing the propagation of the flood across the site is provided in Appendix F.

The timing of the flooding in Area C has been compared to the time when the Environment Agency Flood Warning trigger thresholds are reached at St Mary's Gauge. The 0.1% AEP event has been used for this assessment and it shows that the site would start flooding approximately 4 hour after the trigger level at St Mary's gauge is reached.

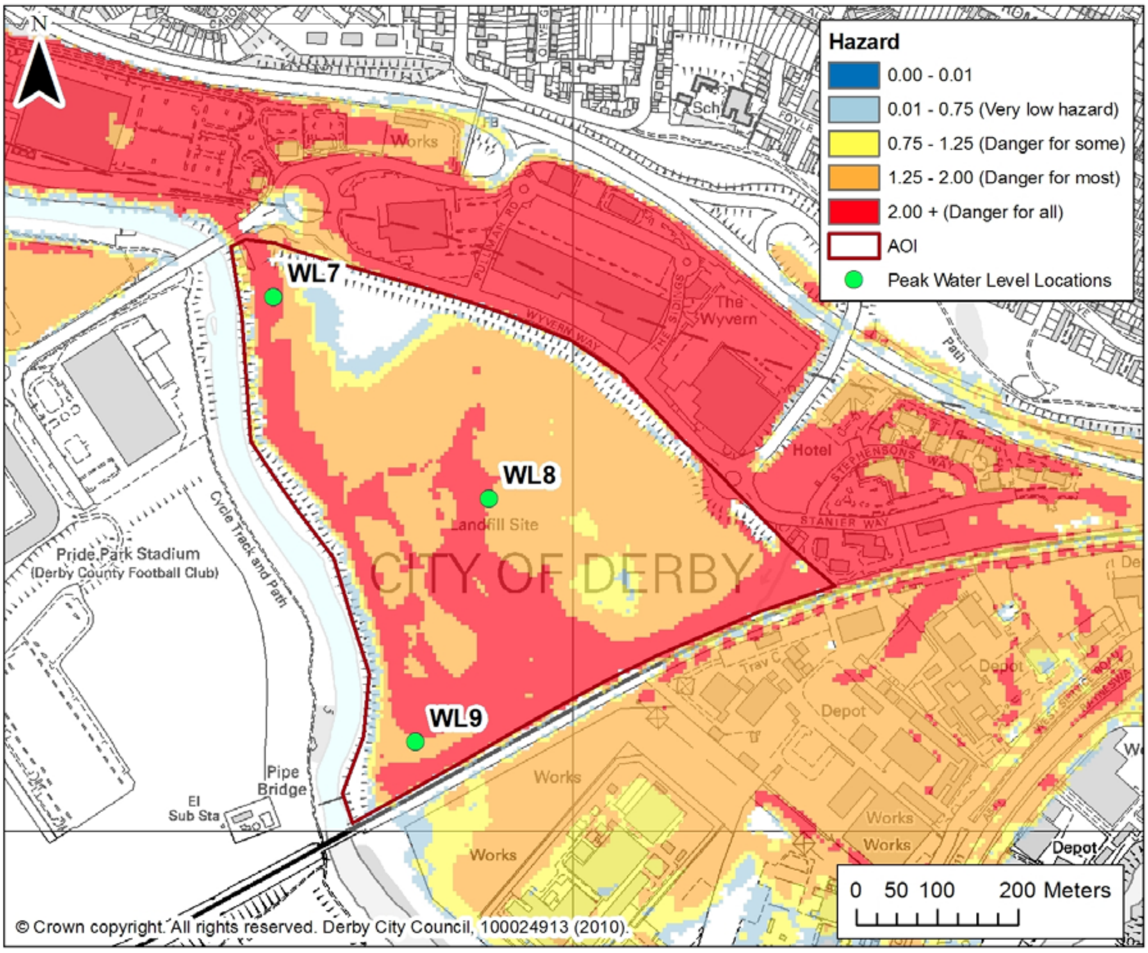

Figure 4.8 – 1% Fluvial Flood Hazard for Area C (Baseline Overtopping Scenario)

Post Development Overtopping Scenario

The model has simulated the fluvial flood hazard for the post development scenario. As no detail is available for potential future development scenarios, the whole of Area C has been raised up to a level so that it does not flood during the 1% AEP flood event. During the simulated post development scenario no flooding occurring in Area C during the 1% AEP event or any less extreme events. It is recognised that raising the whole area out of the floodplain is not a realistic post development scenario, however in the absence of detail development plans; this approach was taken to estimate the maximum potential impact on flood risk.

During more extreme events the whole Area is inundated, but the flood hazard is Moderate.

Raising the ground levels in Area C has an impact on the flood depths and hazard in the Wyvern area as shown in Figure 4.9. In the 1% AEP fluvial flood event the flood depths are predominantly within the 1.0m to 2.0m range; for the post development scenario the flood depths are predominantly >2.0m leading to an increased flow near Wyvern and Raynesway. This increase in risk is also reflected in the Flood Hazard classification; a greater proportion of the Wyvern area is now classified as Extreme Hazard.

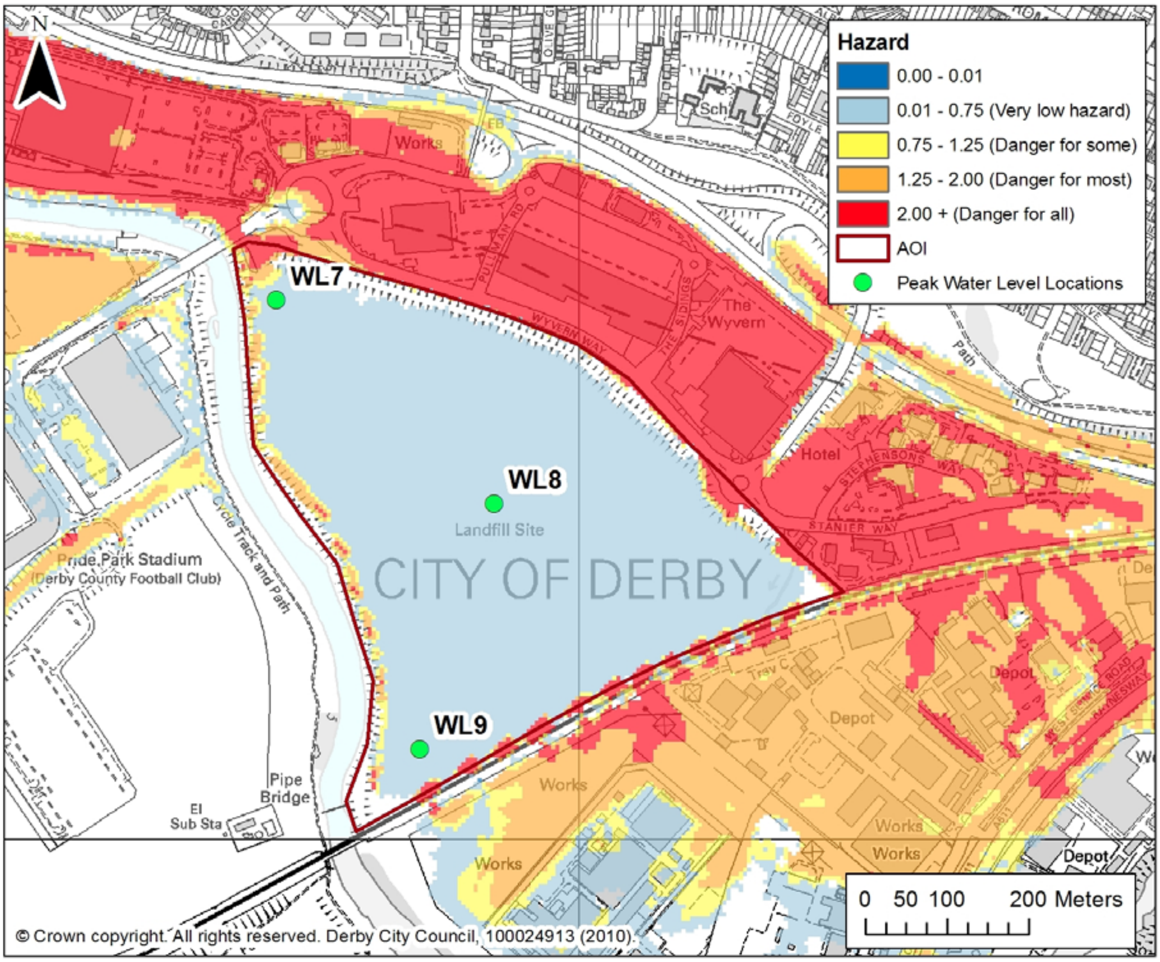

Figure 4.9 – 0.1% Fluvial Flood Hazard for Area C (Post Development Overtopping Scenario)

Baseline Breach Scenario

Flood defence breach scenarios were simulated for area C. This involved two separately modelled breaches along the flood defence embankments of the Derwent along the western edge of Area C, one in the northern area, one in the south. To assess a breach scenario, each breach is assumed to occur 1 hour before the peak of the flood event; the width of the breach will be 40m wide, and it will remain open for 36 hours. These are the typical parameters for a soft fluvial flood defence.

The breach scenario results showed that the flood levels in Area C were lower than the baseline (non-breach) scenario. This is because the dominant flood flow route into Area C is from the north rather than directly flooding form the River Derwent. Introducing either of the two breaches effectively provides an additional flow path out of Area C. As a consequence, the breach results have not been included in this report.

Surface Water

The Derwent Triangle, Area C catchment is of rural in nature and therefore assumed not to comprise drainage sewers located on site. The Environment Agency plan as shown in Figure 4.3 for areas susceptible to flooding was used to analyse this site. This shows that the site has potential surface water flood risk near the south eastern boundary.

The area is currently undeveloped and therefore it is envisaged there is no current risk of sewer flooding from within the area. Area C is bound by raised embankment south of Wyvern Way. The main flow path for overland flooding is through the underpass walkway located in Derwent Parade adjacent left bank of the River Derwent. Therefore the risk of flooding on this area is considered to be primarily from fluvial flooding.

Any new development on this site will increase surface water runoff due to reduced permeable areas thereby increasing flood risk from surface water. It is therefore recommended that a detailed development drainage assessment is undertaken as part of a Surface Water Management Plan and appropriate mitigation measures are included within the detailed drainage design. Sustainable Drainage Systems (SUDS) should be considered as part of the mitigation measures

Groundwater

The soil in Area C is classified as I1, these are soils of Intermediate Leaching Potential (I). These soils that have a moderate ability to attenuate diffuse source pollutants though it is possible that some non-adsorbed diffuse pollutants and liquid discharges could penetrate the soil layer. As a result, subcategory I1 includes soils which can transmit a wide range of pollutants.

The superficial deposits of the valley bottom (predominantly alluvium) are likely to be in hydraulic connection with the river and it is considered that fluvial flooding would be the main issue in this setting.

The Environment Agency have no historical records of any groundwater flood risk and as such are unaware of any groundwater flooding events with regard to the proposed sites.

A detailed Groundwater assessment is included as Appendix H of this report.

Canal Infrastructure

There are no canals located in the vicinity of the site boundary.

Reservoirs

There are no reservoirs found in the vicinity of the site.

4.3 Flood Defence and Structures

4.3.1 Environment Agency Maintained Structures and Flood Defences

The following information provides a summary of the existing structures and flood defences currently maintained by the EA. This information indicates where the presence of formal defences could influence flood risk. The residual flood risk behind a defence must be considered in site specific flood risk assessments.

Structures

The Environment Agency asset information was obtained for the sites A, B and C. This provided updated information on assets along the River Derwent that was undertaken as part of the NaFRA Pilot study in 2007. There are no Environment Agency maintained structures identified within the Derby SFRA Level 2 sites. There are a number of sewer outfalls that are located near the River Derwent and are maintained by Severn Trent Water.

Flood Defences

North Riverside- Area A: The Environment Agency maintains defences along the River Derwent near Derby City Centre. However combinations of stakeholders are involved in the maintenance of the east bank defence within the North Riverside-Area A boundary. The defence immediately downstream of the Causey Bridge and the reach between Exeter Bridge and Longbridge Weir is maintained by the local authority. The defence downstream of Longbridge Weir falls within the Environment Agency jurisdiction. The defences located downstream of Causey Bridge and upstream Exeter Bridge, falls within private riparian ownership.

Castleward- Area B: The natural raised defences on the west bank of the River Derwent near Castleward area is within private riparian ownership. The Environment Agency maintains the raised natural defences on the right bank side of the Mill Fleam and adjacent to the Castleward site boundary.

Derwent Triangle- Area C: The Environment Agency maintains the man made raised flood defence on the eastern bank of the River Derwent adjacent the Area C.

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5. Developer Guidance

5.1 Generic Developer Guidance

The developer should consult various documents when considering developing in an area. These documents are outlined in the following sections.

This section aims to guide the developer through the use of the SFRA and also explains the requirements and the level of detail required in the Site specific Flood Risk Assessment (FRA). It also provides guidance for the types of development appropriate within each of the Flood Zones, as well as additional guidance for developing in undefended and defended floodplains and information on how to raise floor levels and provide compensatory storage if required. Guidance on the Surface Water Drainage Assessment and Appropriate Mitigation Measures is also detailed in this section.

When developing a site it is important that developers have early discussions with the Environment Agency to ensure that any site specific requirements are highlighted at the earliest possible stage. This will lead to a more efficient application process.

Applications are reviewed by the Council Development Control Team and as such guidance will be incorporated to help them assess windfall applications.

5.1.1 How to Use the Strategic Flood Risk Assessment

The Strategic Flood Risk Assessment is the assessment and categorisation of flood risk on a district wide basis in accordance with PPS25. SFRAs refine information on the probability of flooding, taking other sources of flooding and the impacts of climate change into account. The SFRA provides the basis for applying the Sequential Test and the Exception Test where consideration needs to be given to the impact of the flood risk management infrastructure on the frequency, impact, speed of onset, depth and velocity of flooding within the Flood Zones considering a range of flood risk management maintenance scenarios.

A developer should consider flood risk issues at a site as early as possible. The SFRA can be used to provide an indication of the likely flood risk issues at a site from all sources of flooding. Developers should identify whether the development site has been allocated for that type of land use in the Local Development Documents or the Local Plan.

5.1.2 When is a Flood Risk Assessment Required?

A FRA will be required to accompany planning applications for:

- any development proposals of 1 hectare or greater in Flood Zone 1
- any development proposals in Medium Probability Flood Zone 2
- any development proposals in High Probability Flood Zone 3

The FRA should identify and assess the risks of all sources of flooding to and from the development, taking into account climate change and demonstrate how the risk will be managed.

A FRA will also be required where the proposed development is a change of use to a more vulnerable class or where the Environment Agency and/or other bodies have indicated that there may be drainage problems.

5.1.3 Standard Flood Risk Management Guidance for Developers

The broad aim of the PPS25 is to reduce the number of people and properties within the natural and built environment at risk of flooding. To achieve this aim, planning authorities are required to ensure that flood risk is properly assessed during the initial planning stages of any development.

Responsibility for this assessment lies with developers and they must demonstrate the following:

- Whether the proposed development is likely to be affected by current or future flooding from any source.
- Whether the proposed development will increase flood risk elsewhere.
- Whether the measures proposed to deal with any flood risk are sustainable.
- Whether the proposed development is safe and that residual flood risk is appropriately managed.

The developer must prove to the Local Planning Authority and the Environment Agency that the existing flood risk or flood risk associated with the proposed development can be satisfactorily managed.

The detail to be provided by a FRA will depend on where the proposed site fits within the development framework, particularly on its justification against the sequential test, described in the SFRA.

Development should follow the standard FRA approach provided by the Environment Agency and CIRIA, as follows:

- National Standing Advice to Local Planning Authorities for Planning Applications - Development and Flood Risk in England' (January 2007)
- CIRIA Report C624 "Development and Flood Risk – Guidance for the Construction Industry" (2004).

The general requirements of a FRA are listed in Appendix E of PPS25 and within the Practice Guide to PPS25. Further guidance on the level of detail required for a FRA can be found in the Environment Agency's Flood Risk Assessment guidance notes available at (http://www.environment-agency.gov.uk/research/planning/93498.aspx)

5.1.4 Guidance for Development within Each Flood Zone

A FRA should be commensurate with the risk of flooding to the proposed development. For example, where the risk of flooding of the site is negligible (Flood Zone 1 Low Probability) there is little benefit to be gained in assessing the potential risk to life and/or property as a result of flooding. The particular requirements for FRAs within each of the Flood Zones delineated within PPS25 are outlined below.

Flood Zone 1 Low Probability

There are generally no fluvial or coastal flood risk related constraints placed upon future development within Zone 1 Low Probability according to PPS25; however it is important to recognise that if development is not carefully managed within this zone it may adversely affect the existing flooding regime.

The risks of alternative sources of flooding (e.g. groundwater, surface water) need to be considered. The proposed development should also consider surface water runoff to ensure that there are no detrimental effects to existing development and where possible the runoff is reduced through sustainable drainage systems.

Flood Zone 2 Medium Probability

To satisfy the requirements of the Sequential Test, PPS25 recommends that development within Flood Zone 2 should be restricted to 'essential infrastructure', 'water compatible', 'more vulnerable' or 'less vulnerable' land uses (see Table 2.1 for a list of types of development appropriate for these land use classifications).

Where non-flood risk related planning matters dictate that highly vulnerable development should be considered further within Flood Zone 2 it will be necessary to carry out the Exception Test.

PPS25 states that for the Exception Test to be passed:

- it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared.

- the development should be on developable, previously-developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously-developed land; and
- a FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

The risks of alternative sources of flooding (e.g. groundwater, surface water) need to be considered. The proposed development should consider surface water runoff to ensure that there are no detrimental effects to existing development and where possible the runoff is reduced through sustainable drainage systems.

As part of the FRA, it will be necessary to demonstrate that the residual risk of flooding can be effectively managed and a planned evacuation route or safe haven can be provided.

Flood Zone 3a High Probability

To satisfy the requirements of the Sequential Test, PPS25 recommends that development within Flood Zone 3a should be restricted to ‘Less Vulnerable’ and ‘Water Compatible’ land uses (see Table 2.1 for a list of types of development appropriate for these land use classifications).

Where non-flood risk related planning matters dictate that ‘More Vulnerable’ development or ‘Essential Infrastructure’ should be considered further within Flood Zone 3a, it will be necessary to carry out the Exception Test (as discussed above).

An FRA should include the following:

- The vulnerability of the development to fluvial and/or tidal flooding as well as to flooding from other sources.
- The impact of climate change over the lifetime of the development on the flooding regime, i.e. maximum water levels, flood extents and flow paths.
- The effect of the new development on surface water runoff ensuring that there are no detrimental effects to existing development and where possible that runoff is reduced through the use of appropriate sustainable drainage systems.
- Demonstration that residual risks of flooding, after existing and proposed flood management and mitigation measures are taken into account, are acceptable.
- Demonstration that dry access can be provided to enable the safe evacuation in the event of flooding or where this is not achievable a safe haven an appropriate safe haven can be provided which meets the requirement of the authority’s Emergency Planner..

Highly vulnerable development is not suitable in this Flood Zone.

Flood Zone 3b Functional Floodplain

PPS25 recommends that development within Flood Zone 3b should be restricted to ‘water compatible’ land uses (see Table 2.1 for a list of types of development appropriate for these land use classifications).

Where non-flood risk related planning matters dictate that ‘Essential Infrastructure’ should be considered further within Flood Zone 3b it will be necessary to carry out the Exception Test (see above for details).

A FRA should include the following:

- The vulnerability of the development to fluvial and/or tidal flooding as well as other sources, e.g. groundwater, sewer, surface water, critical infrastructure failure.
- The impact of climate change over the lifetime of the development on the flooding regime, i.e. maximum water levels, flood extents and flow paths.

- The effect of the new development on surface water runoff ensuring that there are no detrimental effects to existing development and where possible that runoff is reduced through sustainable drainage systems.
- Demonstration that residual risks of flooding, after existing and proposed flood management and mitigation measures are taken into account, are acceptable.
- Demonstration that dry access can be provided to enable the safe evacuation in the event of flooding or where this is not achievable a safe haven can be provided.

Highly, more and less vulnerable development is not suitable for this Flood Zone.

5.1.5 Additional Guidance

This section provides additional information for developers wishing to develop in areas of undefended and defended floodplain, as well as how to raise floor levels and provide compensatory storage where required in areas such as these.

Undefended Floodplain

Areas at risk of flooding need to be assessed against the 1% AEP criteria for fluvial flooding and against the 0.5% AEP criteria for tidal flooding. The Environment Agency's hydraulic models may be made available for use by developers to determine the site's vulnerability to flooding. The developer will need to firstly ensure that the models are fit for purpose and sufficiently detailed to provide an accurate understanding of flood risk to the site. If existing models are not available, then a developer will need to assess the extent and requirements of any modelling work that is required. Detailed hydraulic modelling will involve the following:

- carrying out a hydrological assessment using Flood Estimation Handbook techniques and using gauging records where available;
- constructing an in-bank model using up to date survey data including structures, e.g. bridges, weirs, culverts and sluices;
- extending the in-bank model to include floodplains where necessary using appropriate hydraulic modelling approaches to replicate the extent, storage and conveyance of the floodplains, e.g. through extended cross sections, reservoir units or 2-D modelling.
- calibrating or verifying the hydraulic model where hydrometric monitoring data or flood records are available;
- carrying out sensitivity analysis to confirm modelling assumptions and assess climate change impacts; and
- mapping of flooding extents.

Defended Floodplain

Development sites within a defended tidal or fluvial floodplain are at particular risk due to the risk of the defences being overtopped or breached, resulting in the rapid onset of fast flowing and deep water flooding with little or no warning.

Residual risk from the breach or overtopping of defences needs to be considered as part of a FRA. DEFRAs Flood Risk Assessment Guidance for New Development provides guidance on the level of risk related to distance and flood depth for overtopping and breaching scenarios.

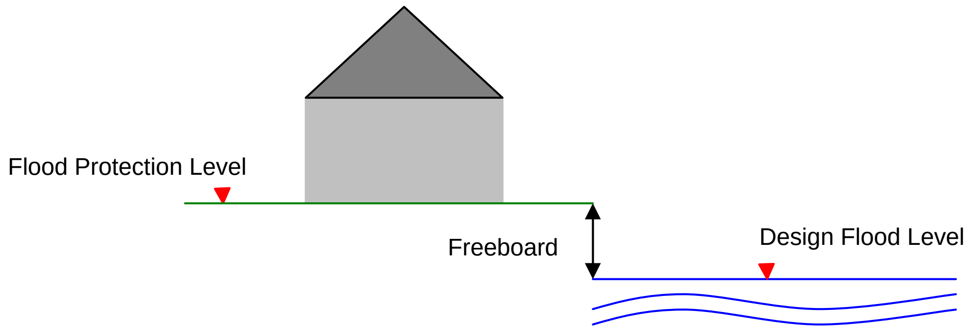
The objectives of a breach analysis are as follows:

- to determine the Rapid Inundation Zone where there is a potential risk to life (including production of hazard mapping);
- to investigate the impact of the proposed development on the flood risk to others; and
- to test the effectiveness of mitigation measures.

Consideration of flood risk behind defences should take into consideration the standard of protection and design freeboard of the flood defence along with its condition and potential mechanisms of failure. The parameters of a breach in terms of potential location and width as well as the duration of a flood event should be agreed with the Environment Agency prior to any analysis.

Raised Floor Levels

It may be feasible to reduce the risk to a development through raising the ground level above the design flood level, as shown below:



Floor levels should be raised above the 1% AEP fluvial flood level plus an allowance for climate change assuming a 20% increase in flow over the next 100 years. The typical minimum requirement for freeboard is 600mm. There is no need to allow for the 0.5% AEP coastal/tidal flood levels in the sites of interest as there is no risk of coastal/tidal flooding to Derby City.

Floor levels will be subject to the approval of Derby City Council and/or the Environment Agency.

Compensatory Storage

Where development is proposed in undefended areas of floodplain, which lie outside of the functional floodplain, the new building footprint and any ground raising will effectively reduce the flood storage capacity of the site. The potential impacts on flood risk elsewhere need to be considered. Raising existing ground levels may reduce the capacity of the floodplain to accommodate floodwater and increase the risk of flooding by either increasing the depth of flooding to existing properties at risk or by extending the floodplain to cover properties normally outside of the floodplain. Flood storage capacity can be maintained by lowering ground levels of areas outside the adjacent floodplain to provide at least the equivalent volume of storage lost to the development at a nearby location and at the same level. Further guidance on compensatory storage is available within 'Development and Flood Risk- Guidance for the Construction Industry', CIRIA 624 section A3.3.10.

For development in a defended area of floodplain, the potential impact on residual flood risk to other properties needs to be considered. New development behind flood defences can increase the residual risk of flooding if the flood defences are breached or overtopped by changing the conveyance of the flow paths or by displacing flood water elsewhere. If the potential impact on residual risk is unacceptable then mitigation should be provided.

5.1.6 Dry Islands

In some circumstances areas located within Flood Zone 1 can be surrounded by areas at a greater risk from flooding (i.e. Flood Zones 2 and 3). These areas located within Flood Zone1 are referred to as dry islands and even though the site may not be at risk from flooding, it can present a hazard to those located within these dry islands in times of flood as access routes may become impassable. If a development falls within a dry island or for more information on dry islands that it is recommended the interested party contacts their local Environment Agency Planning Liaison team on 08708 506 506.

5.1.7 Surface Water Drainage Assessment

Developers should demonstrate that the disposal of surface water from the site will not exacerbate existing flooding from all new development within Flood Zones 3 and 2 and from any development greater than 1ha in Flood Zone 1 or within areas that are known to suffer from surface water drainage or sewer flooding.

A surface water drainage assessment should be undertaken to demonstrate that surface water runoff from the proposed development can be effectively managed without increasing flood risk elsewhere. A surface water drainage assessment should include the following:

- Assessment of whether the development will increase the overall discharge from the site by calculating the change in area covered by roofs and hard-standing.
- Details of how overland flow from the new development can be intercepted to prevent flooding of adjacent land.
- Details to justify the method of surface water disposal, including demonstration that a sequential approach to consider varying types of SuDS.
- Demonstration that overland flows will not increase flood risk to both existing development and receiving watercourses.
- Calculations showing pre and post development impermeable areas, discharge rates and method of disposal including storage volumes and/or SuDS design, where required. Agreement of these details should be sought from the Environment Agency/IDB and sewerage authorities.

Further guidance on Surface Water Drainage methodology, design and implementation is contained within ‘The SUDS Manual’ CIRIA 697, 2007.

5.1.8 Groundwater Consideration

Due to the high degree of variability when considering groundwater flooding, it is important to ensure that the potential risk of groundwater flooding to a property is considered within a local context. This is most appropriate at the development application stage (i.e. as part of the detailed FRA).

Typically, groundwater flooding will not preclude development unless there is a demonstrated history of relatively frequent and problematic flooding on site. Where a potential risk of groundwater flooding is identified it may be necessary to, for example, incorporate flood-proofing measures and/or the raising of entry thresholds to mitigate possible damages. The adopted design of the proposed development will need to ensure that it does not result in worsening of the risk posed to adjoining properties through, for example, the displacement of available groundwater storage capacity as a result of basement construction. As groundwater flooding can last for extended periods (up to six months in some cases), access to at risk areas should be an important consideration, as should the maintenance of utility services, particularly foul water services.

Another consideration with respect to groundwater is the effectiveness (or otherwise) of SuDs. The design of proposed developments should carefully consider the impact that raised groundwater levels may have upon the operation of SuDs during periods of heavy rainfall. Infiltration techniques will be compromised in areas in which the water table is elevated or there is limited soil permeability. The feasibility can only clearly be determined by considering ground investigation works on site.

5.1.9 Selection of Appropriate Mitigation Measures

The sequential approach should be applied within development sites to locate the most vulnerable elements of a development in the lowest risk areas. Where vulnerable development cannot be allocated within low risk areas then measures need to be put in place to mitigate against the flood risk.

There are several sources of information on potential mitigation measures, as follows:

- Flood Risk Assessment Guidance for New Development, Environment Agency R&D (FD2320)

- Development and Flood Risk – Guidance for the Construction Industry, CIRIA 624

The Environment Agency R&D Guidance on Flood Risk Assessments for new development suggests that mitigation measures can be split into three types:

- Measures that reduce the physical hazard, e.g. through raised defences or flood storage
- Measures that reduce the exposure to the hazard, e.g. raise properties above flood levels
- Measures that reduce the vulnerability to the hazard e.g. Flood Warning or emergency planning.

The selection of appropriate mitigation measures depends on the requirements of the development and its sensitivity to flood risk. Any mitigation measure selected should be sustainable in the future by taking into consideration the impact of climate change on flood risk. The residual risk of developing an area vulnerable to flooding with mitigation measures in place should also be considered.

Flood defence walls or embankments

Flood defences, fully funded by the development can be constructed and maintained in perpetuity to protect a new development. However, the impact on the risk of flooding elsewhere with defences in place needs to be assessed and managed, for example, through the provision of compensatory storage as detailed in section 5.1.5. Residual risk of flooding with flood defences also needs to be assessed and managed. It should be noted that the construction of new defences to facilitate new development should only be undertaken in exceptional circumstances and alternative options should be considered in the first instance.

Flood Storage

Flood storage either offline or online can be used to manage water levels at or downstream of a development site.

Building Design

Flood management measures only manage the risk of flooding rather than remove it completely. Therefore, buildings should be designed to be flood resistant and flood resilient where they are built behind flood defence systems. Flood resistance is the prevention of flood water entering a building through, for example, flood barriers or raising floor levels. Flood resilience is ensuring the finish (e.g. type of flooring) and services (e.g. electrics) are such that following a flood the building can be returned quickly to its normal operation.

Guidance on flood resilience is contained within ‘Improving the Flood Performance of New Buildings- Flood Resilient Construction’ DGCL, May 2007 and a basic level of flood resistance and resilience can be achieved through good building practice and complying with Building Regulations (ODPM, 2000).

Flood Warning

The Environment Agency provides Flood Warnings to a number of existing properties at risk of flooding to enable owners to protect life and manage the effect of flooding of their property. Flood Warning should only be provided as a measure to manage residual risk and should not be used as the sole measure to offer protection to a development. Section 3.3.4 provides further details on flood warning within Derby City.

Access and Egress

PPS25 requires that safe access and escape is available to and from new developments in flood risk areas. Where possible, safe access routes should be located above design flood levels and an evacuation procedure should be in place for an extreme flood event. If safe access cannot be provided for all events then a safe haven of sufficient size to accommodate all occupiers of the development should be provided within the development. The safe haven must meet the requirements of the authority’s Emergency Planner.

Sustainable Drainage Systems

Suitable SUDS techniques will vary from site to site depending upon factors including characteristics of the site (e.g. geology, topography and hydro-geological); goals of the LPA and developer; requirements of the Environment Agency and IDB; and long term maintenance issues.

There are also a number of environmental aspects that need to be considered when proposing SUDS techniques which include: bio-diversity and the provision of environmental habitat; pollution control; groundwater recharge; amenity/recreational facilities; and maintaining or restoring the natural flow regimes of watercourses.

The WCS is a high level document which provides a broad picture of the possible SUDS that may be suitable for implementation in the development area and it provides a Developer Checklist of the requirement for developers.

Windfall sites

The suitability of windfall sites should be considered at a strategic level. This would be achieved through a policy which identifies broad locations and quantities where according to the Sequential Test, the development is acceptable or not. This Level 2 SFRA can be used to determine where windfall sites can be appropriately allocated, in terms of flood risk. If the windfall site falls within Flood Zone 2 or 3, this SFRA will determine the type of development that will be suitable for the windfall site and whether further site specific FRAs will be required for the windfall site. For further details refer to the Determining the Flood Risk (PPS25) Sequential Test for Planning Applications document (Ref: 8)

5.2 Flood Defence and Mitigation

The DEFRA ‘Making Space for Water’ (2004) (Ref:11) publication advisies that a long term adoption strategy would be crutial to the success of effective and efficient SUDS management given that there is at present there is no standard framework for the adoption and maintanence of SUDS infrastructure. As a result of Recommendation 20 in the Pitt Review it is proposed that County and Unitary Authorities should take formal responsibility to ensure that effective funding and maintenance measures are in place for adopted SUDS, as part of their overall resonsibility for local flood risk management,

Recommendation 18 in the Pitt Review of the summer 2007 floods which suggests ‘local surface water management plans as set out under PPS25 and co-ordinated by local authorities should provide the basis for managing all local flood risk’.

5.3 Surface Water Management Plans

The increasing pressure of development and the importance of flood risk consideration in the planning process, contained within PPS25 has promoted the completion of SWMPs. A SWMP outlines policies for the district in terms of surface water management which supports Government objectives relating to flood risk and the environment.

The Flood and Water Management Act outlines the increased responsibility the Local Authorities now have with regards to surface water management and the production of a Surface Water Management Plan (SWMP) which will become an increasingly important tool in delivering sustainable development. The use of SWMPs has also been promoted within PPS25.

Defra have produced a technical guidance document on the preparation of SWMPs that takes into account lessons learnt from the 15 Integrated Urban Drainage pilots. This guidance will aid in the delivery of SWMPs. It is proposed that this current guidance will be updated, with a revised option available autumn/winter 2009 and as such SWMPs commissioned after this time should make use of the update version.

The production of a SWMP would follow the outlined four stages, preparation, risk assessment, options and implementation and review as outlined in the Government Guidance (Ref: 5). This strategic approach can promote recreational facilities and other benefits as an additional product in comparison to dealing with surface water runoff on site specific basis for each development proposal.

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6. Conclusions & Recommendations

6.1 Conclusions

This Level 2 SFRA report provides an overview of the planning context in relation to flood risk and development within the three specific development areas in Derby City. Flood risk is considered within each of the tiers of planning policy; nationally within the Planning Policy Statements, regionally within the RSS and locally within the Local Plan. Data has been collected through consultation with Derby City Council, the Environment Agency, Severn Trent Water and Derby City Council. The data collected has provided information on all sources of flood risk, flood defences, Flood Warning, land allocation and the geology and topography of the SFRA areas.

The primary source of flood risk for the three SFRA Level 2 areas is fluvial flooding. The River Derwent runs from north west to south east through the middle of Derby City and is the greatest source of flood risk.

North Riverside (Area A) falls within fluvial Flood Zones 2 and 3 with an extreme fluvial hazard during the 1% AEP event. There is no surface water flooding issues recorded at this location according to Derby City Council. However the Environment Agency map for areas susceptible to flooding shows that the area has potential surface water flood risk near south west boundary.

Castleward (Area B) is not at risk from fluvial flooding in the 1% AEP flood event including allowance for climate change. However the 0.1% AEP flood event causes significant fluvial flooding in this area. The 2D overland surface water modelling shows the site suffers from surface water flooding during the 1% AEP and 1% AEP plus climate change flood events near the south east corner of the site at London Road.

The Derwent Triangle (Area C) does not flood in the 4% AEP fluvial flood event. However it does flood during the 1.33% AEP fluvial flood event. The modelling exercise has confirmed that the area is within the Flood Zone 3 (1% AEP flood event). This area is undeveloped and as such no risk from surface water flooding envisaged.

All three SFRA Level 2 Areas are within the Environment Agency's flood warning system boundary. Based on the 0.1% AEP event, it is understood that the North Riverside (Area A) would start flooding approximately 1 hour before the trigger level at St Mary's gauge is reached. The Castleward (Area B) and Derwent Triangle (Area C) would start flooding approximately 4 hours before the trigger level at St Mary's gauge is reached.

There is no record of historical groundwater flooding for the 3 SFRA Level 2 areas according to the Environment Agency. Detailed groundwater assessment undertaken shows all three areas to have low risk of groundwater flooding. The superficial deposits of the valley bottom (predominantly alluvium) are likely to be in hydraulic connection with the river and it is considered that fluvial flooding would be the main issue in this setting.

Climate change is expected to increase the flood risk to some properties within the SFRA Level 2 areas as evident in the hydraulic modelling undertaken for this study.

The Derby SFRA Level 2 areas have the potential to include SuDS for future developments and as such recommended these are explored as part of the master planning.

Any additional hydraulic modelling that is carried out as part of further detailed assessments, should utilise existing hydraulic models. The modelling carried out specifically for this study will be superseded during 2010 by the work currently being undertaken by the Environment Agency. Any additional assessment should utilise the most up to date model as appropriate. These models will need to be reviewed and updated to include more detail for the development being assessed. In places where there are no hydraulic models available, hydraulic models may need to be developed.

6.2 Recommendations

6.2.1 General

The Masterplan for Derby is subject to alteration therefore following changes to the plan, the sequential test should be revisited in conjunction with the regeneration strategy to confirm the areas suitable for development. Similarly following the conclusions of the Environment Agency's Lower Derwent Strategy project the suitability of the Areas considered within this SFRA should be reconsidered.

6.2.2 North Riverside (Area A):

The area is heavily urbanised and comprises an integral drainage system extending beyond the boundary of the area assessed. A coarse post development assessment using 2D fluvial modelling shows increased flood risk impact north of the area, therefore if further development is proposed within this built up area, then it is recommended that detailed post scheme modelling utilising the latest master plan for the development is carried out to determine the flood risk in accurately and assess any mitigation options. As this Area is currently heavily urbanised and at risk predominantly from fluvial flooding, it is recommended that a detailed Surface Water Management Plan is carried out to determine the combined flood risk including surface water flooding. Future plans for the Area should take into consideration the SWMP (if available) or include a Drainage Strategy Plan to ensure that drainage is developed in a strategic and sustainable manner rather than a piecemeal approach.

6.2.3 Castleward (Area B):

The area is heavily urbanised and comprise an integral drainage system extending beyond the boundary of the area assessed and therefore if further development is proposed within this built up area, then it is recommended that a detailed Integrated Urban Drainage assessment is carried out to determine the combined flood risk in detail.

6.2.4 Derwent Triangle (Area C):

The area is currently undeveloped. A coarse post development assessment using 2D fluvial modelling shows increased flood risk impact north of the area near Wyvern Park. Therefore if further development is proposed within this built up area, then it is recommended that detailed post scheme modelling is carried out to determine the flood risk in detail and assess any mitigation options. A Drainage Strategy Plan for Area C should be developed for future drainage on the site to ensure that drainage is developed in a strategic and sustainable manner rather than a piecemeal approach.

7. References

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Appendix A Area Location Plans

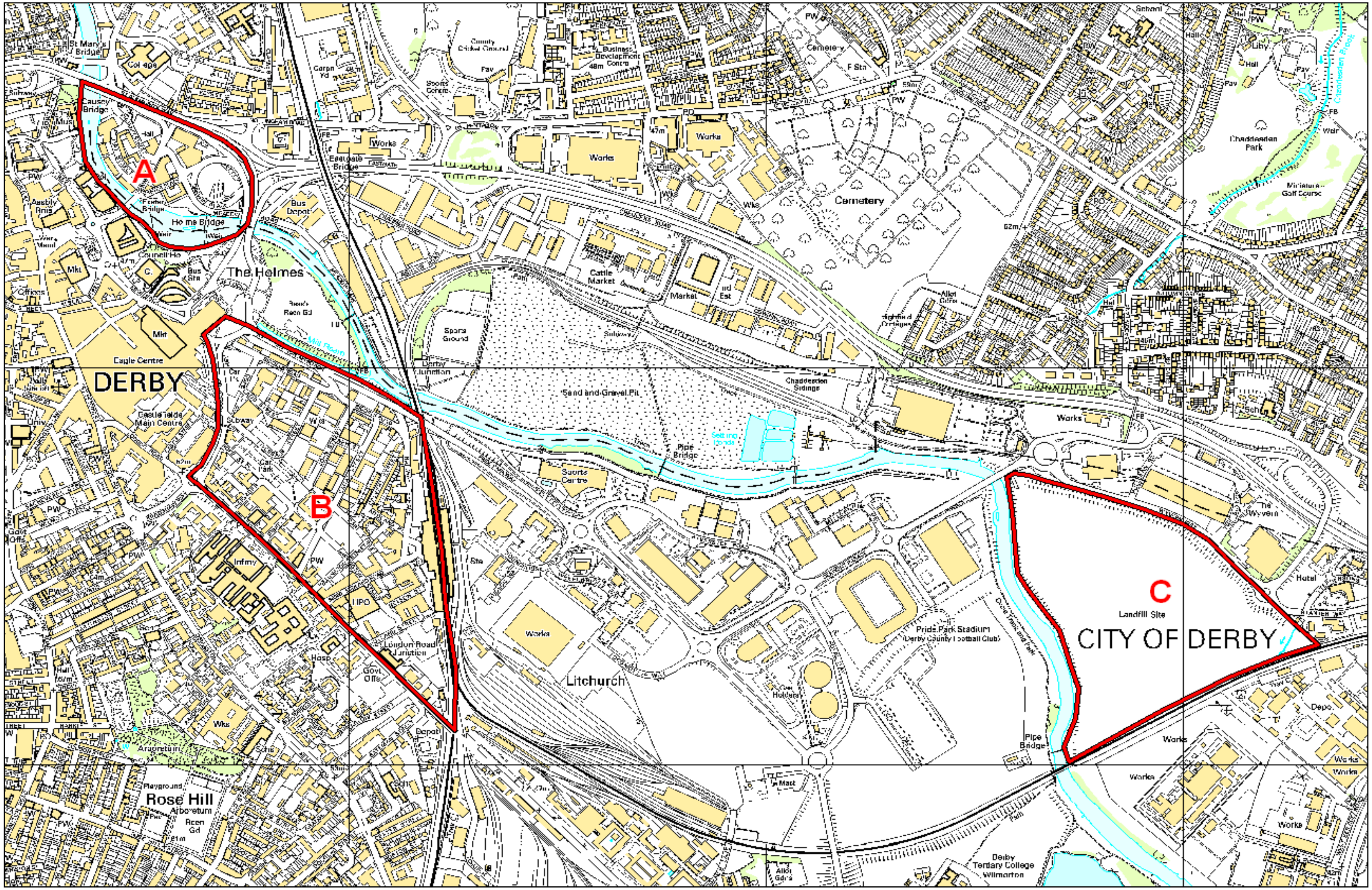

Figure A.1 – Area Location Plan

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Appendix B Fluvial Flood Risk Modelling Report

ATKINS

B.1 Introduction

A 1D/2D hydraulic ISIS-Tuflow model was developed to assess the fluvial flood risk for this study. ISIS is an industry standard software package for undertaking 1D hydraulic flood analysis developed by Halcrow. Tuflow is an industry standard software package for undertaking 2D hydraulic flood inundation software developed by Australian company, WMB.

ISIS version 3.0.2 and Tuflow version 2008-08-AI-iSP were used for this study.

A pre-existing model from the Environment Agency for the Lower Derwent was made available for this study. In its original state, the Environment Agency's model was deemed not fit for the purposes of the Level 2 SFRA and thus modification of this model was required to ensure the model represents current conditions and a refined floodplain representation. The model was converted into a 1D/2D ISIS-Tuflow model, where, the 2D Tuflow model domain was developed to model the overland flow within the three areas of interest (Areas A, B and C) once the water has spilled out of the Derwent river channel. This provides detailed information on the potential flow paths, flood depths, velocities and hazard, for each individual cell of the 2D model.

This appendix provides detailed information on the fluvial model build undertaken for this study.

B.2 Site Details

The fluvial model was developed with a focus on providing results for the three areas (Areas A, B and C) as described in section 3.2 in this report and illustrated in Appendix A.

B.3 Data Sources

This section describes the key data sources used in the used in the fluvial modelling. Detailed information on each is provided below:

- **Environment Agency's Lower Derwent ISIS model** – Derby model v158 last developed by Black & Vetch in March 2007 was adopted for this study. This is an ISIS 1D hydraulic model with its upstream extent located near the railway bridge, approximately 2.2km upstream of the A38 (SK 3559 4151) and the downstream extent at the River Trent Confluence near Great Wilne (SK4590 3080).

- **Environment Agency LiDAR** – The latest filtered and unfiltered LiDAR was acquired from the Environment Agency's Geomatics department. LiDAR provides highly accurate height data at 2m spacing using a laser based airborne mapping system. No level of accuracy was provided for the dataset, however it is widely accepted that the LiDAR has a global error of +/- 140mm. The LiDAR used in this study was surveyed in April 2005.

  LiDAR was used as the predominant height data source in the 2D Tuflow model.

- **Ordnance Survey Mastermap Topographic Layer** – The OS Mastermap topographic layer is detailed topographic mapping product depicting topographic features at a 1:1250 or 1:2500 scale.

  Mastermap was used to represent topographic features such as roads and railways and define the land use, used to set the roughness values in the 2D Tuflow model.

- **Site Visit information** – A site walkover was undertaken in February 2010. Photos and anecdotal evidence was collected and used to supplement the other data sources.

B.4 Model build

B.4.1 Model build introduction

The 1D/2D ISIS Tuflow model is used to simulate a series of fluvial flood events on the Lower Derwent through Derby. The majority of the catchment was represented using the existing Environment Agency ISIS model. In areas of the floodplain at or linked to the three areas (areas A, B and C), the representation of the floodplain in the ISIS model was replaced with a 2D Tuflow model. The map in Figure B.1 illustrates the areas of the model within the study area represented by either the 1D ISIS or 2D Tuflow models.

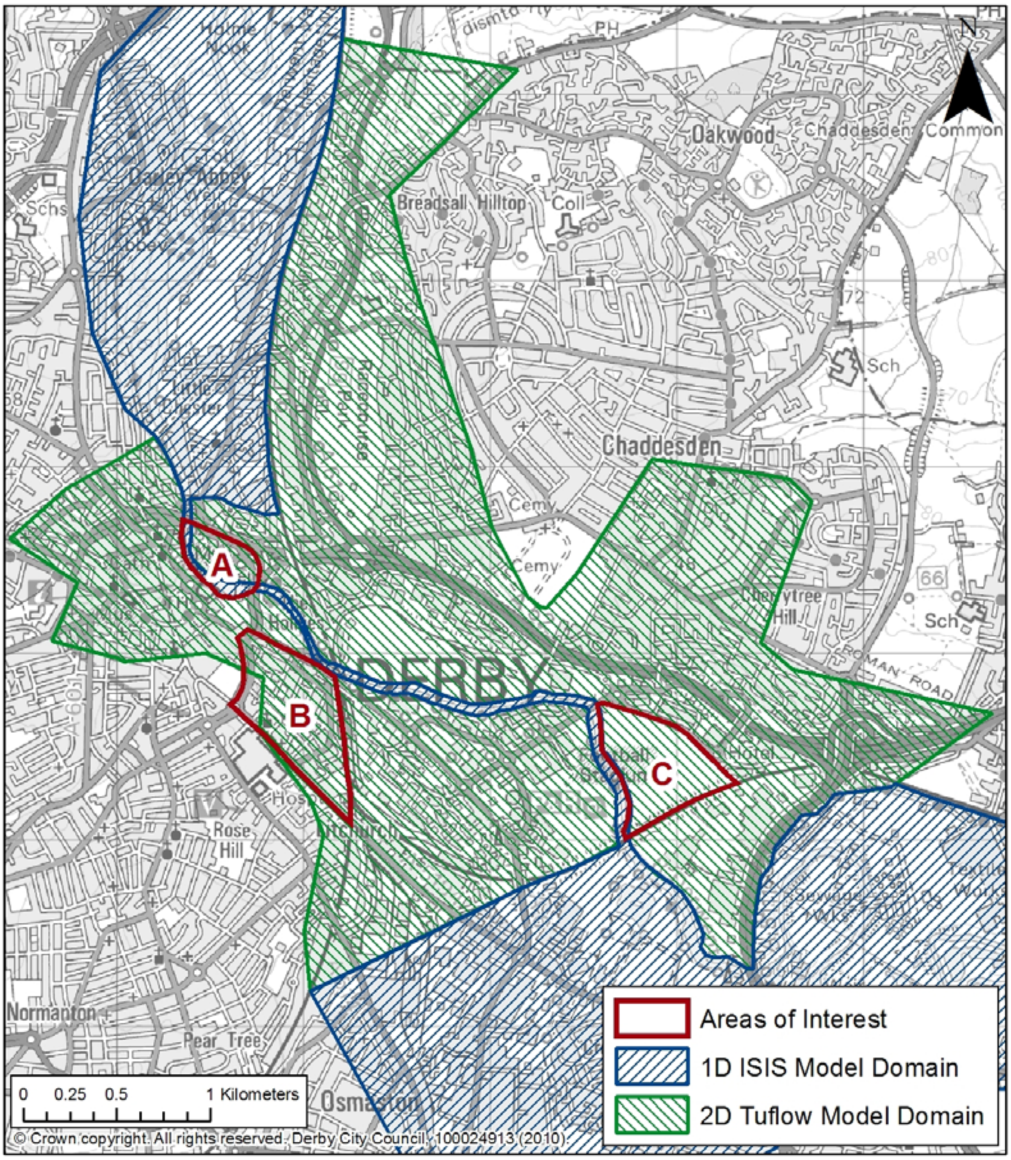

Figure B.1 - 1D/2D model domain map

B.4.2 1D ISIS Model

Version 158 of the Environment Agency Lower Derwent model was adopted and used for this study. No changes were made to the study with the **exception** of those listed below. All other aspects of the hydraulic and hydrological model were assumed to be appropriate.

A new version of the Derby ISIS model (DerbyModel-158_SFRA_002.DAT) was created with the following changes:

- All spills and reservoir on the right bank between nodes DE053D – DE045-1 were removed;
- All Spills and reservoir units on the left-bank between DE052U – DE043 were removed;
- All Spills and reservoir units connected downstream of floodplain unit LitlChestr-4 and Orifice Unit Cul-1 (to provide connectivity with the Tuflow model);
- Structures Eastgate6 and Eastgate7 were removed;
- HT boundary dummy units were added to floodplain unit LitlChestr-4 and Orifice Unit Cul-1 (renamed Chester-pk7 in the model) to allow floodplain connectivity to the 2D domain.

B.4.3 2D Tuflow Model

2D Model Description

A single 2D domain was used to represent the floodplain for Areas A, B and C and adjacent floodplain. This extends on the right-bank of the Derwent from Little Chester Footbridge to Wilmorton rail crossing. On the left-bank, the domain extents south of Fox Street, east of the railway and south of Wheatcroft Way west of the railway extending to Raynesway. Figure B.2 illustrations the 2D model domain extent.

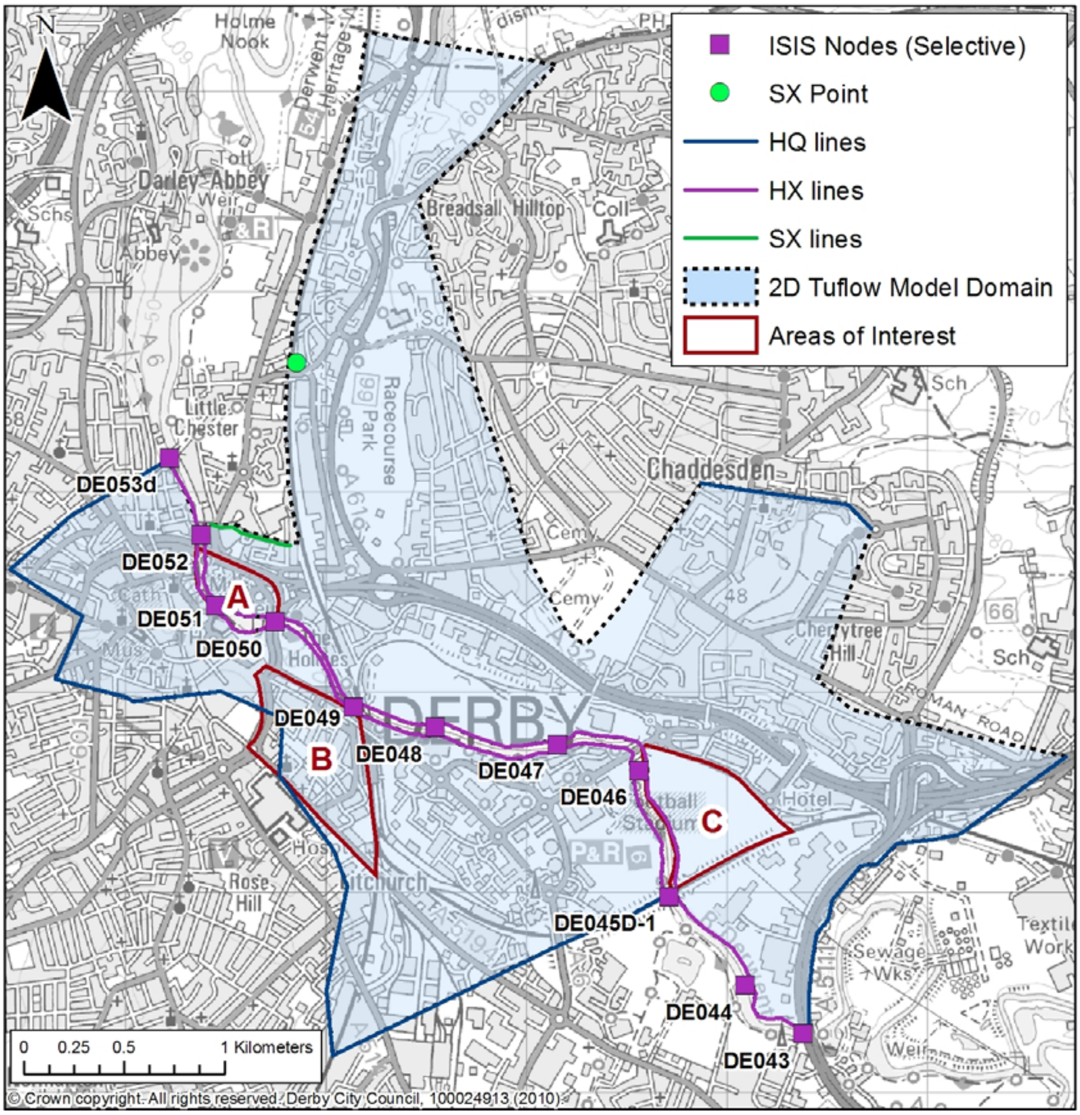

Figure B.2 – 2D model features

DTM Construction

A *Zpoint* DTM for the 2D model was generated to represent the ground elevations in the 2D model. The following was carried out:

- The 5m grid was initially derived using the filtered LiDAR;
- All areas of railway including bridges and embankment were replaced using unfiltered LiDAR;
- Underpass at the railway on the eastern end of Area B was added using *zPoly*. A 20m gap to represent the underpass in railway bridge was inserted into model and the level reduced to 45.5mAOD;
- A *zline gully* was inserted to represent Mill Fleam, lowering the DTM levels along the channel to the water level recorded in the LiDAR (41.6mAOD);

- A *zline ridge* was inserted to represent the wall along the right-bank edge of the Derwent adjacent to Longbridge Weir, raising the ground level to 47.1mAOD;
- Ground lowered using *zPoly* under the railway to the existing road level at Eastgate Bridge and Nottingham Road to represent the two underpasses formally represented in the ISIS model as structures Eastgate6 and Eastgate7. These were lowered to 46.0mAOD and 46.4mAOD respectively;
- Ground raised using *zPoly* out of the floodplain to represent the solid foundations of the Pride Parkway near Station Approach based on unfiltered LiDAR elevations;
- Ground lowered using *zPoly* to surrounding levels to represent the subway connecting the cattle market and gravel pit off Chequers Road;
- Ground lowered using *zPoly* to surrounding levels in the north-west corner of Area C to lower the mounts of spoil present in the LIDAR.
- Ground raised using *zPoly* to surrounding levels in Area B between Canal Street and Calvert Street to remove artefacts caused by poorly removed buildings in the filtered LiDAR; and
- Ground raised using *zPoly* to surrounding levels to developed land adjacent to the junction between the Pride Parkway and Roundhouse Road to remove artefacts caused by poorly removed buildings in the filtered LiDAR.

Material (roughness)

OS Mastermap was used to define the roughness values for the 2D model DTM. These were defined by assigning a particular value, based on the land type 'featurecode' of OS Mastermap topography polygons. Table B.1 confirms which roughness values were adopted for the different land types:

Land Use	Manning's n
Grass	0.05
Paths, roads and other man-made hard surfaces	0.02
Pavement	0.05
Rail	0.05
Gardens/Fences	0.5
Trees	0.1
River/Open Water	.035
Buildings/Structures	0.8

Table B.1 – Tuflow model roughness values

Buildings have been represented in the model by increasing the roughness value to **0.8**, this is a very high value but recognises that flow will still pass into buildings and provide some storage capacity.

B.4.4 1D/2D link

A 1D/2D ISIS-Tuflow link was created to dynamically link the ISIS and Tuflow models. This consists of a 1D/2D boundary polyline inserted along both edges of the river channel (shown as a purple line in Figure B.2) which is linked to the ISIS river unit nodes (shown as purple squares in Figure B.2). To ensure that a smooth transfer of flow across the link, elevations in the 2D model domain along the length of the 1D/2D boundary are adjusted to the bank heights in the 1D ISIS models at each node. Elevations along the 1D/2D boundary between ISIS 1D nodes are automatically linearly interpolated by Tuflow.

The ISIS model was linked to the Tuflow model at the following locations (note, each boundary is shown in Figure B.2):

- A *HX line* representing the right bank between nodes DE053D – DE045-1;
- A *HX line* representing the left-bank between DE052U – DE043;
- *A SX line* along Fox Street linking to the dummy HT unit connected to LitlChestr-4 floodplain unit
- A *SX point* at the railway culvert near St Mary's Junction linking to the HT boundary dummy units connected to Orifice Unit Cul-1 (renamed Chester-pk7 in the model).
- In addition, *HQ lines* with a slope of 0.01 were inserted along the landward edges of the model where glass walling of the 2D domain might occur.

B.4.5 Hydrology

The Hydrology provided by the Environment Agency with the ISIS model was used unchanged in the ISIS/Tuflow model. The hydrographs based on the 1965 event were used as these were considered the worse case.

Hydrographs for the 25yr, 75yr, 100yr, 100cc (100+20%) and 1000yr scenarios were used.

B.5 Design Runs

B.5.1 Model Scenarios

Three model scenarios were simulated, these were:

- Baseline Overtopping Scenario
- Post Development Overtopping Scenario
- Baseline Breach Scenario

A complete list of fluvial design runs modelled for this study is presented in Table B.2. Further information on each scenario and how they were represented in each of the three areas is presented in the remainder of section of B.5.

Return Period	Scenario		
	Baseline Overtopping	Post Development Overtopping	Baseline Breach
4% AEP (25yr)	n/a	n/a	n/a
2% AEP (50yr)	✓	✓	n/a
1.33% AEP (75yr)	✓	✓	n/a
1% AEP (100yr)	✓	✓	n/a
1% AEP + cc (100yr+cc)	✓	✓	✓ (areas A 7 C only)
0.5% AEP (200yr)	✓	✓	n/a
0.1% AEP (1000yr)	✓	✓	n/a

Table B.2 – Fluvial flood model design run

B.5.2 Baseline Overtopping Scenario

Baseline overtopping scenario based on the existing topography based on OS Mastermap Topography layer. Topography was modelled using variations in ground roughness values.

Further information on the different roughness values adopted in the model is presented in section B.4.3.

B.5.3 Post Development Overtopping Scenario

Same as baseline scenario except for the following changes

- **Area A** – Ground elevations across area A were raised to 47.85mAOD (deemed the highest water level occurrence in area A in the baseline 1% AEP scenario)
- **Area B** – Roughness values were altered based on the land use allocations in the City Centre Eastern Fringes Area Action Plan.
- **Area C** – Ground elevations across area C were raised to 45.80mAOD (deemed the highest water level occurrence in area C in the baseline 1% AEP scenario).

For Areas A and C, it is recognised that raising the whole area out of the floodplain is not a realistic post development scenario, however in the absence of detail development plans, this approach was taken to estimate the maximum potential impact on flood risk. If land is raised, compensatory storage will be required where floodplain storage or conveyance is lost.

B.5.4 Baseline Breach Scenarios

Same as baseline scenario except for the inclusion of a breach to the fluvial flood defences occurs during the flood event. The breach locations were selected as location in the three areas that due to the nature of the existing defences were considered potential breach locations that could impact the severity of flooding in the three areas.

The breaches were modelled individually for the 1% + climate change scenario.

The breaches were modelled using Tuflow's breach module. This simulates the lowering of an area of the defences in the 2D domain based in a set of predetermined parameters. The location and breach parameters for the three areas are listed below and illustrated in Figure B.3:

- **Area A** – A single breach location (A1) in the wall on the left-bank of the Derwent just upstream of Longbridge Weir. The breach occurred 2 hours before the peak flow of the flood event at that location, the breach was 20m wide, deemed appropriate for a hard defence;
- **Area B** – no suitable locations for a breach were located; and
- **Area C** – Two locations for a breach were selected, the first (C1) located along the earth bank defences on the left-bank of the Derwent to the north west of Area C, the second (C2) located to the south west of Area C. The breaches occurred 2 hours before the peak flow of the flood event at that location, the breaches were each 40m wide, deemed appropriate for a soft defence.

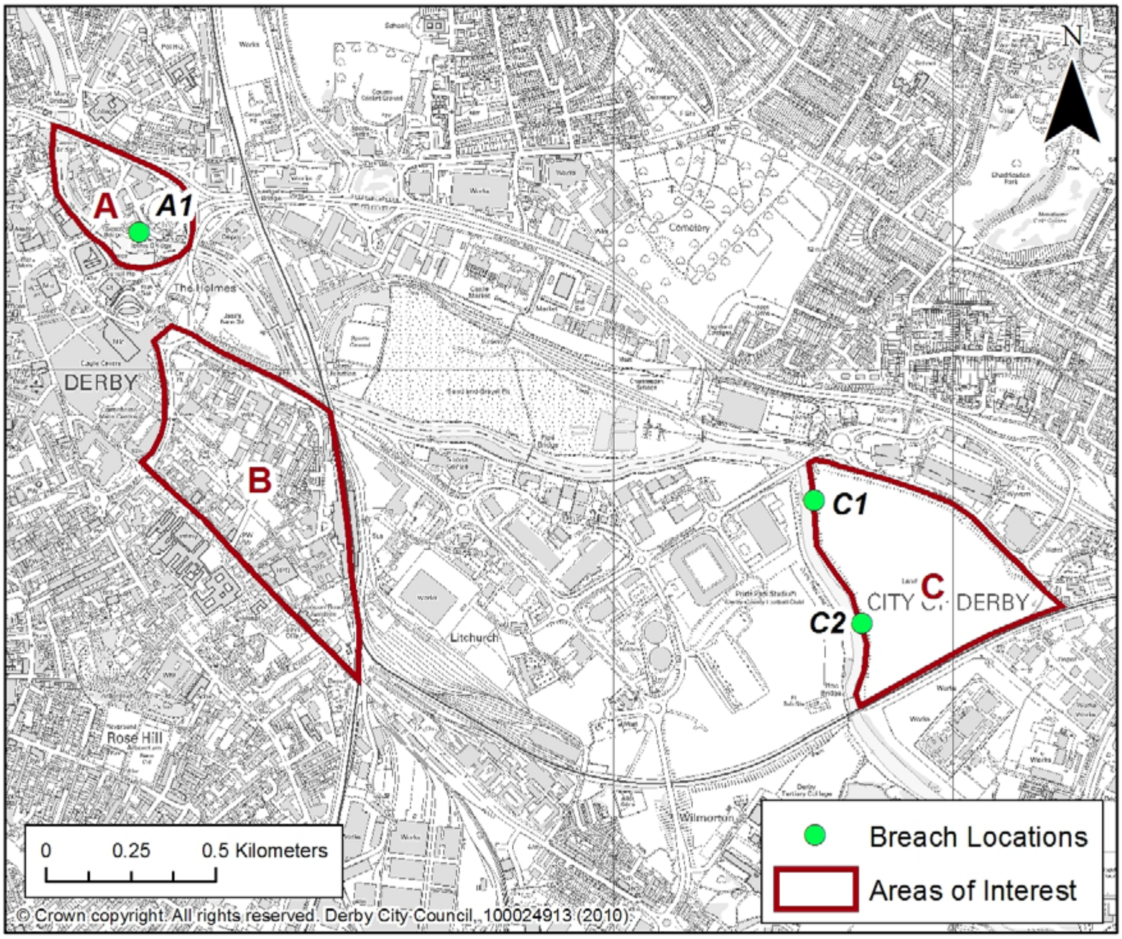

Figure B.3 – Modelled breach locations

B.6 Results

Results are represented in the main body of the report in section 4.2.

Appendix C Surface Water Modelling Report

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C.1 Introduction

The surface water drainage model developed for this study has been undertaken using IWCS (InfoWorks CS) and IWCS-2D. IWCS is the UK industry standard software for urban drainage analysis that is produced by Wallingford Software. Further information about this software platform can be found on the Wallingford Software website[2].

C.2 Site Details

The Derby SFRA Level 2 Castleward area [grid reference 435870, 335770] is located in Derby city centre and immediately to south of A6 Station Approach road. River Derwent is located in close proximity to the northern boundary of the site. Mill Fleam, an engineered open channel passes adjacent to the north western boundary before joining the confluence at River Derwent. A location plan is shown below as Figure C.1.

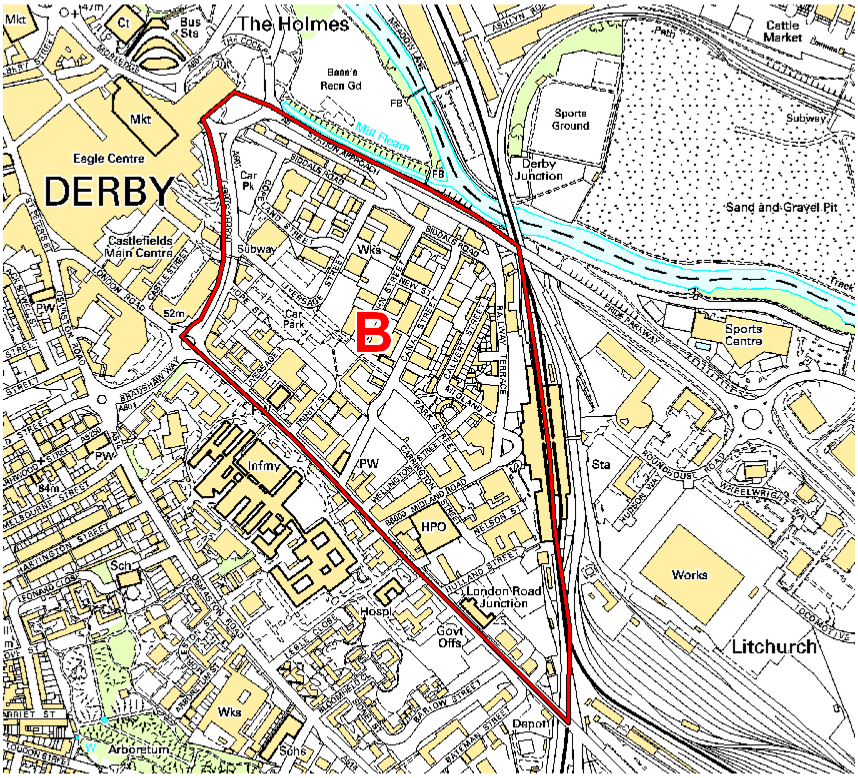

Figure C.1 - Location plan showing Derby SFRA Level 2 site Castleward (Area B)

C.3 Model Build

The Castleward area is a fully urbanised catchment and comprises a drainage system including storm and foul water sewers. The existing Severn Trent Water model for the Derby area comprises a complex sewer network including storm and foul water sewers and extents from upstream near A38 Road approximately 1km north of Darley Abbey and until downstream near the Spondon Weir in River Derwent. Therefore it was considered appropriate to use this model network to undertake surface water flooding assessment for this site.

C.3.1 Survey and Data Used

The different elements of the surface water drainage model for Castleward site have been developed with the sources of data listed in the Table C.1 below.

[2] Wallingford Software – InfoWorks CS - http://www.wallingfordsoftware.com/

Element	Data
Combined drainage	STW Drainage Area Plan models – Derby Final Design model
Overland flows (ground surface)	LiDAR (1m and 2m resolution) Digital Terrain Model –(DTM)
Sewer Outfall Levels/River Outfalls	EA's 1D ISIS model data for the River Derwent.
Site survey	Walkover site visit and photographs for flow paths and restrictions

Table C.1 - Data used in the development of the Surface water drainage model for Castleward site (Area B)

C.3.2 Ground Model:

The overland flow representation is the important component of the surface water drainage assessment that not only links the below ground assets together at the surface, but also allows these to interact with the fluvial components of the model by allowing floodwaters to flow into and out of the respective systems. Hence, to ensure that above ground flows are appropriately represented within the site if interest, the representation of the ground surface is crucial.

LiDAR data for the study catchment was obtained from the Environment Agency and is similar to the data used for the fluvial modelling assessment undertaken for this site. The LiDAR comprise a 2m resolution as DTM 'bare-earth' data and has been passed through new supervised classification and filtering routines to improve the accuracy of the representation of the ground. No separate site surveyed elevations were undertaken although a spot check was conducted using the latest OS master map that was available at the time to verify the ground elevations within the site.

A 2D ground data in the form a TIN (Triangular Irregular Network) comprising ground elevations was generated for the site using the recent available LiDAR data. A filtered LiDAR data was utilised for this purpose. The 2D domain was integrated dynamically to the existing 1D sewer model network using IWCS-2D tool.

C.3.3 Manning's n co-efficient of roughness

Channel roughness has been represented in the model by use of an appropriate Manning's *n* value. The values were assessed from site inspection together with recommendations given in the "Open Channel Hydraulics"[3] guidance published by Chow (Equation 5-12). The calculation of the different Manning's *n* values, together with representative photographs, is presented in Appendix B8.

The ground model that represents the overland flows of the IUD model has used IWCS default Manning's *n* co-efficient of roughness of 0.0125.

C.3.4 Fluvial Interaction:

There are approximately 13 nos. of sewer outfalls located at Mill Fleam and River Derwent. It is understood that the Mill Fleam outfall collects a large volume of the storm water sewer flows from upstream including the Markeaton Brook Catchment located North West of the site. The majority of the sewers within the site are comprised of foul water sewers.

A schematic of the modelling extent and detail of 2D model domain covering the Castleward area and the existing sewer system as 1D element is shown below as

Figure C.2.

[3] Chow, V.T. (1959) *Open Channel Hydraulics*. McGraw-Hill Companies

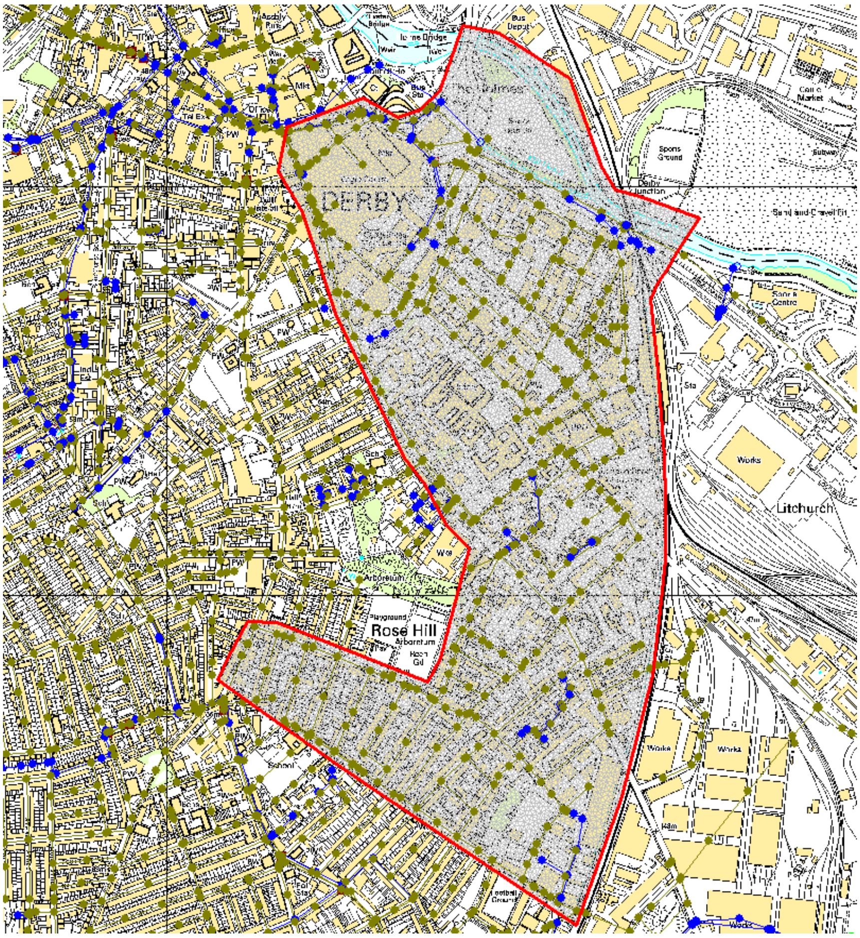

Figure C.2 - Model Schematic showing 1D sewer network and 2D model domain

C.3.5 Boundary Conditions:

The 2D domain boundary was considered based on the ground level information obtained from the LiDAR data with the periphery of the domain leading to high ground levels in relation to the site of interest. The underpass near the eastern bank of the River Derwent was included within the model geometry as to allow overland flows either side of the railway embankment. The average ground levels at this location are 45.5m AOD.

The 2D model domain includes normal condition boundary to allow flows to freely interact with the 1D elements of the sewer model that lies immediately outside the 2D boundary. A non-porous wall was created using IWCS-2D to represent the restriction to flows created by the Railway embankment located in the eastern boundary of the site.

The 1D IWCS sewer model network represents out of sewer flooding in the form of available individual storage elements at the manhole units. In order to allow a realistic overland flooding on the site, these storage elements were converted to free overflow units within the IWCS 2D for the manhole locations.

The STW sewer model comprises approximately 13 sewer outfalls located at the east bank side of the River Derwent. It was understood that the water levels at these outfalls were set to an approximately 1-year return period flood levels at the River Derwent for design purposes. In order to understand the impact of the flooding at Castleward site during 5%, 3.3%, 2%, 1% and 1% plus climate change AEP events, it was considered appropriate to assess the impact of the variable water levels at the outfall locations. This was because of the close proximity of the site to the River Derwent. However no separate joint probability study was undertaken as it was outside scope of this study.

The sewer outfall locations from the existing Severn Trent Water IWCS sewer model were extracted for geo coordinates. The Environment Agency 1D ISIS River Derwent model for the

Derby City that is used for undertaking fluvial flood risk modelling was run for all available return period flood events. The peak water levels from the River Derwent near the sewer outfall locations were extracted and a separate sewer outfall water levels file was created for each of the flood return periods.

C.3.6 Hydrology

Critical Duration

The Severn Trent Water sewer model included rainfall, design inflows, trade wastes and waste water generators data for different events such as 100%, 20%, 10%, 5%, 3.3% and 2.5% AEP. The inflows comprised data for various storm durations and as such it was considered important to assess the most critical storm duration for the Castleward site with respect to flood risk. In order to identify the most appropriate critical storm duration for the site, the 1D STW sewer model was run for the 2.5% AEP design flood with all storm durations including 15, 30, 90, 120, 240, 360, 480 and 960 minutes. The results were compared with flood flows and levels near and at site. The storm with 120 minutes duration was found to produce maximum impact on flood risk to site with high flood levels and volumes. Therefore the surface water drainage modelling considers the 120 minutes as critical duration for all design flood events model runs.

Inflows

In order to understand flood risk on a new development perspective, it was considered appropriate to undertake flood risk modelling for 100 year and 100 year plus climate change return period flood events. It was originally envisaged that the current STW sewer model will already possess model inflows required for this assessment and as such detailed assessment of the inflows for the sewer model catchment using the latest methods was outside the scope of this assessment. Therefore a coarse only assessment was undertaken by deriving inflows growth curve factor using the industry standard WINFAP-FEH method for the sewer model catchment. This was then compared with the growth curve obtained from the existing lower return period design flood flows from the 1D sewer model. Accordingly, a factor of 1.25 was applied to the existing 40 year inflows to obtain the 1% AEP inflows for the sewer model. An increase of 20% was applied over the 1% AEP inflows to obtain the 1% AEP plus climate change inflows. The Figure C.3 below shows the inflows growth factor for the existing and the larger flood events such as 1% AEP and 1% AEP plus climate change floods.

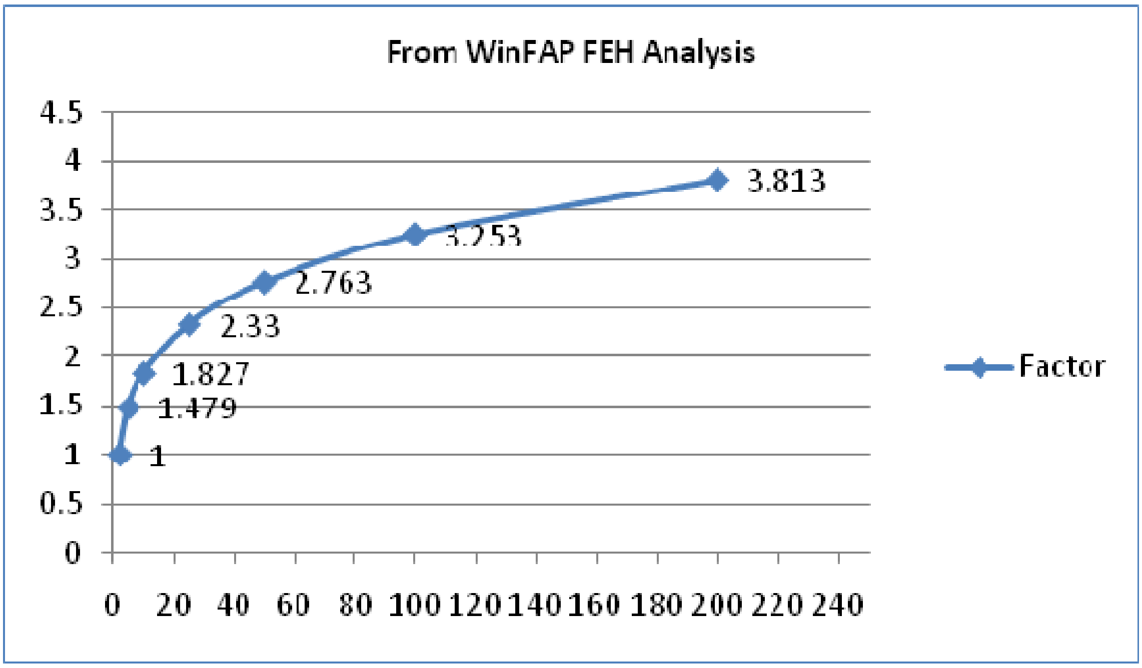

Figure C.3 – Inflows Growth Curve Analysis

C.3.7 Rainfall and return period

Design rainfall was created for the following AEP events and used to run the model: 5%, 3.3%, 2%, 1% and 1% with climate change (20% multiplier on all time steps, i.e. both peak and total rainfall). A typical setup is shown below in Figure C.4, illustrating the use of UK rain event parameters utilised. The catchment parameters were utilised based on the existing STW sewer model rainfall data from the 1-Year rainfall.

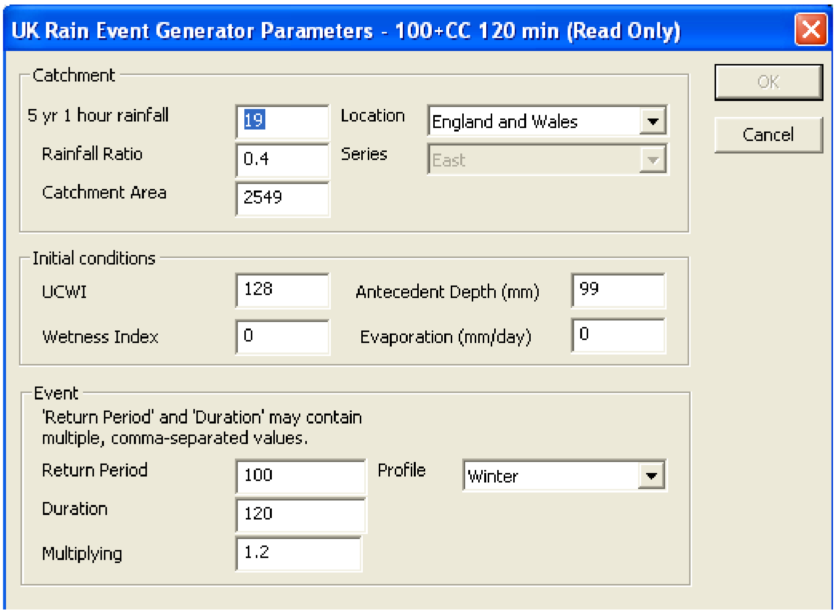

Figure C.4 - Design rainfall set up

C.4 Design Runs

The model run involves opening all the required components into a "schedule hydraulic run" dialog, as shown below in Figure C.5. The network is the drainage system (sewers, conduits etc.). The wastewater and trade waste components relate to the foul system, and apply to all runs. Inflows are as described in section C.3.6, and are specific to each return period, as is the rainfall. The field "Level" represents the design sewer outfall levels and allows a time varying level to be applied as a downstream boundary condition. A combination of joint probability exercise was undertaken as part of this modelling. IWCS has the capability of modelling transport of sediment and pollutants, both dissolved and attached to the sediment. This facility is not relevant to this project. The 2D initial conditions were not used, as the ground is taken as dry at the start of each run.

The 'Run parameters' include the Duration of the model run and this was applied to be twice as the critical duration of the model run identified as appropriate for the catchment.

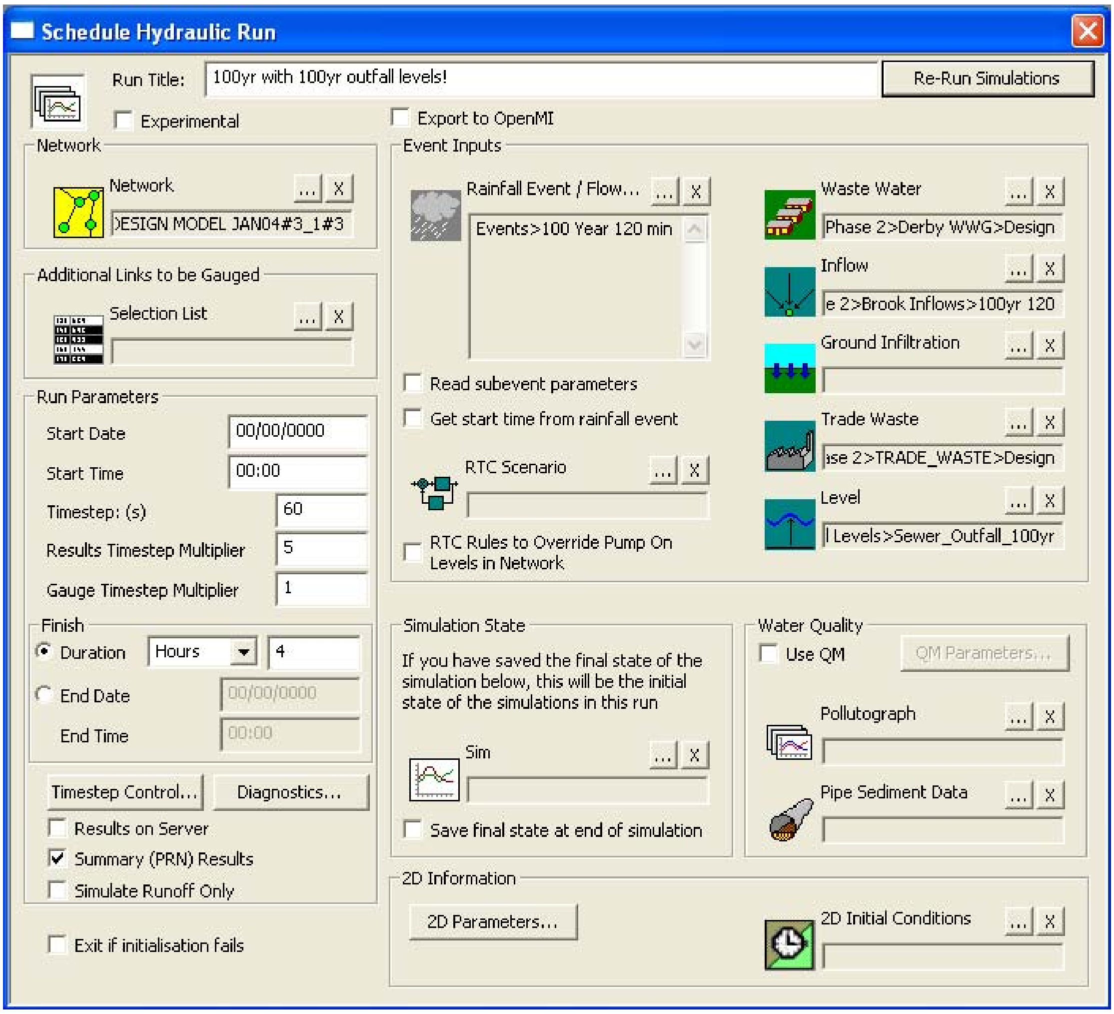

Figure C.5 - Model runs

In order to understand the impact of flooding of the site due to the variable water levels at the sewer outfalls at the River Derwent, a combination of model runs were undertaken as shown below in the Table C.2. The following model run combinations were based on the assumption that a large catchment such as the River Derwent will generally exhibit only up to an equivalent or lower return flood event when compared at the same period with the smaller tributary catchments. In this case, the River Derwent comprises a large catchment in relation to the sewer model network catchment which includes the smaller tributaries such as the Markeaton Brook and Bramble Brook.

Design Runs (years)	Sewer Outfall Levels- using EA 1D ISIS model (years)					
	Design	10	25	50	100	100+CC
20	✓	✓	n/a	n/a	n/a	n/a
30	✓	✓	✓	n/a	n/a	n/a
50	✓	✓	✓	✓	n/a	n/a
100	✓	✓	✓	✓	✓	n/a
100+CC	✓	✓	✓	✓	✓	✓

Table C.2 – Model runs for joint probability impact

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C.5 Model results

IWCS produces results in a variety of numerical and graphical formats. For the purposes of this assessment, the extent of flooding showing flood depths and the hazard rating were derived and analysed. It was identified from the fluvial modelling assessment undertaken using 1D/2D ISIS-TUFLOW that the Castleward site (Area B) lies outside the 1% flood outline. However it can be seen from the IWCS model which predicts flooding from manholes from some locations on site that is not represented by the river only models.

Separate detailed layouts showing flooding outline and hazard rating for 3.3% AEP, 1% AEP and 1% AEP plus climate change flood events are included with this report as Appendix D.

The Castleward (Area B) is outside the 1% flood outline according to fluvial river modelling undertaken for this site. With respect to sewer flooding the majority of the Area does not flood other than a small overland flow that is identified near east of Midland road during the 3.3% AEP flood event.

As discussed earlier, the Castleward (Area B) lies in close proximity to large river systems such as River Derwent and Mill Fleam and therefore the impact of the variability of water levels at the sewer outfalls will play an important role to the flooding risk for the site. Therefore a combination of outfall design levels was considered and this shows the change in flood outline due to change in outfall levels and included as detailed layouts in Appendix D of this report. The proposed development master plan was superimposed over the surface water flood maps produced from the sewer modelling. This identifies that the proposed buildings near south of Hulland Street and the residential units adjacent Wellington Street and Park Street junction will be prone to flooding by approximately up to 300mm depth during the 1% AEP period flood with 1% AEP design outfall levels at River Derwent.

C.6 Conclusions and recommendations

C.6.1 Conclusions

The principal conclusions of the surface water modelling study for the Castleward (Area B) are set out below:

1. The current Severn Trent Water DAP model for the Derby City was considered appropriate for this surface water drainage and flood risk modelling purpose.
2. 2D overland flow modelling for the Castleward (Area B) using IWCS-2D demonstrates accurately the surface water flood risk on the site.
3. The site is outside the 1% AEP fluvial flood outline according to river modelling undertaken for this site. The surface water drainage modelling undertaken shows that the majority of the site does not flood during the 3.3% AEP flood other than a small overland flow that is identified near east of Midland road.
4. The Castleward (Area B) suffers from surface water flooding during the 1% AEP and 1% AEP plus climate change return period flood events near south east corner of the site at London Road. This flooding is due to overland flows from sewer flooding occurring at London Road sewers. Also the north east corner of Midland Road was found to be flooding during these flood events.
5. There is some flooding that occur near east of the Cockpit roundabout at A6-Station Approach. In addition, the A601-Bradshaw roundabout located near south west corner of the site is found to be flooding. This however does not encroach up to Hope Street in the north and Liversage road in the east and stays within the roundabout location and as such considered to be insignificant risk to the Castleward site as a whole.
6. Based on the current master plan that was superimposed to identify potential flooding risk, the proposed buildings near south of Hulland Street and the residential units adjacent Wellington Street and Park Street junction will be prone to flooding by approximately up to

300mm depth during the 1% AEP flood with 1% AEP design outfall levels at River Derwent.

7. The locations near the sewer outfalls at Mill Fleam and River Derwent adjacent the site boundary is prone to backwater sewer outfall flooding due to fluctuations that might occur in the River Derwent Water Levels. A combination of flood return period levels at the River Derwent was therefore simulated within the IWCS-2D sewer model for outfall boundaries.

8. Flood hazard was assessed in accordance with DEFRA guidance document FD2321/TR1 and it was identified that the flood hazard along Station Approach near north western boundary of the site is generally classed as ‘Significant’, and areas along Park Street and south east corner of the site near Hulland Street is considered to be within the range of ‘Low’ and ‘Moderate’. Separate layouts showing detailed flood hazard and flood depths from surface water drianage modelling are included with this modelling report.

C.6.2 Recommendations

1. Further detailed hydrological assessment for sewer model catchment using latest methodologies will improve confidence in the inflows utilised within the sewer model. This is also because any recent changes in land use will lead to a change in inflows and rainfall parameters applied for individual catchments in the model network.

2. Other flooding locations have been identified elsewhere in the catchment and outside the Castleward (Area B) boundary, but were not assessed as it is outside the remit of the scope of this assessment. Therefore increasing the 2D model domain boundary including any minor open water courses modelled as linked channels will improve the results obtained. An integrated urban drainage modelling approach should be adopted for this purpose.

3. Long term flow monitoring survey will enable the model to be calibrated accurately. Also carry out detailed modelling of upstream structures to improve the accuracy of the results obtained and should be undertaken in conjunction with the calibration work.

4. Consult with Severn Trent Water concerning sewer improvements.

5. Use the model to undertake a Surface Water Management Plan for the Derby City area and include other flooding locations identified by the study. This plan would provide a mechanism to implement holistic flood alleviation scheme where required.

Appendix D Fluvial Flood Risk Maps

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Appendix E Surface Water Flood Risk Maps

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Appendix F Flood Propagation

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Appendix G Fluvial Peak Water Levels

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G.1 Peak Water Levels

This appendix presents the peak water levels extracted from the fluvial modelling results at a number of locations within Areas A, B and C . The location of each of the points is illustrated in Table G.1, the peak water levels for each baseline and post development overtopping scenario are presented in Table G.2.

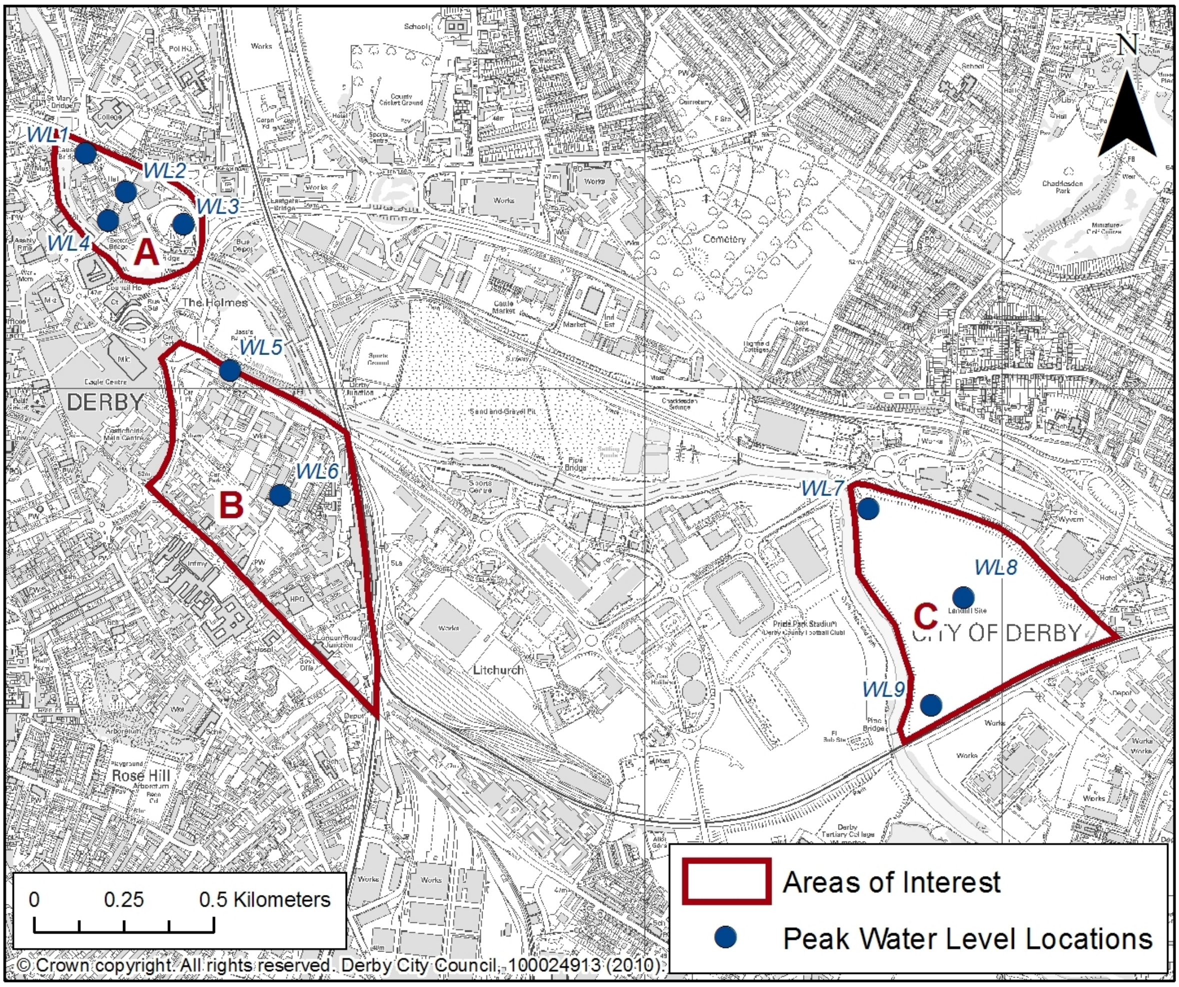

Table G.1 – Peak water level location map

Area ID	Water Level ID	Easting	Northing	Baseline Overtopping Scenario						Post Development Overtopping Scenarios					
				2%	1.33%	1%	1% + CC	0.5%	0.1%	2%	1.33%	1%	1% + CC	0.5%	0.1%
A	WL1	435437	336655	46.33	47.19	47.52	47.97	48.18	48.96	N/A	N/A	N/A	48.32	48.49	49.02
	WL2	435552	336548	46.57	47.04	47.32	47.74	47.96	48.85	N/A	N/A	N/A	48.02	48.10	48.68
	WL3	435712	336459	46.56	47.00	47.28	47.74	48.00	48.98	N/A	N/A	N/A	47.90	47.92	48.56
	WL4	435501	336469	N/A	N/A	47.33	47.75	47.96	48.80	N/A	N/A	N/A	48.06	48.14	48.63
B	WL5	435842	336048	N/A	N/A	N/A	N/A	N/A	48.38	N/A	N/A	N/A	N/A	N/A	48.39
	WL6	435984	335700	N/A	N/A	N/A	N/A	N/A	47.69	N/A	N/A	N/A	N/A	N/A	47.59
C	WL7	437629	335661	N/A	45.16	45.33	45.46	45.50	45.62	N/A	N/A	N/A	45.88	45.91	45.98
	WL8	437896	335411	N/A	44.29	44.53	44.73	44.77	44.87	N/A	N/A	N/A	45.82	45.83	45.85
	WL9	437805	335110	N/A	44.29	44.53	44.72	44.77	44.86	N/A	N/A	N/A	N/A	45.80	45.81

Table G.2 – Peak water levels (mAOD) extracted from the 2D fluvial model for baseline and post development overtopping scenarios

Appendix H Groundwater Flood Risk

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H.1 Groundwater flooding mechanisms

Groundwater flooding is the emergence of groundwater at the ground surface or into subsurface voids arising as a result of:

- abnormally high groundwater heads or flows;
- the introduction of an obstruction to groundwater flow; or
- the rebound of previously depressed groundwater levels.

It most commonly occurs in unconfined aquifers; either major aquifers from which considerable amounts of water can be discharged or in shallow permeable sediments. Flooding locations are typically near areas of natural groundwater discharge such as river valleys and spring lines. However, it can also arise from artesian flow from confined or semi-confined aquifers and in any location where a pathway from the aquifer to the ground surface exists and the hydraulic head in the aquifer is higher than the ground elevation.

Groundwater flooding usually occurs following a prolonged period of low intensity rainfall. Because groundwater flow is much slower than surface flow the flooding may not recede for long periods of time, typically weeks or even months.

H.2 Specific flood risk to the site

H.2.1 Geological Setting & Hydrogeology

A 1:625,000 scale BGS 1:625,000 solid and drift geology map for Derby area was used for the assessment.

In terms of solid geology, all three sites (A, B and C) are underlain by the Triassic mudstones which are part of the Mercia Mudstone Group. The Mercia Mudstone Group is characterised by a sequence of brown, red-brown, calcareous clays and mudstones, with occasional beds of inconsistent green siltstone and fine-grained sandstone. The Mercia Mudstone Group is classified by the Environment Agency as Non-Aquifer due to its relatively low overall permeability, although the sandstone bands within it can be locally important sources of groundwater.

British Geological Survey Sheet 125 (Derby) indicates that the Triassic mudstones are overlain by recent alluvium. The composition of the alluvium is not described but this is likely to be predominantly silty or clayey. The extent to which the alluvium in the immediate vicinity is underlain by coarser river terrace sands and gravels is unclear. The superficial deposits of the River Derwent valley will contain groundwater which is likely to be in hydraulic connection with the river, but groundwater movement within the alluvium will be relatively slow, reflecting its low permeability. Higher groundwater storage coefficients and permeability would be expected in any sands and gravels.

Under the Environment Agency's Policy and Practise for the Protection of Groundwater the three sites are in an area designated as Minor Aquifer (Environment Agency reference: CS29591/EI/JR). These can be fractured rocks which do not have a high primary permeability, or other formations of variable permeability or unconsolidated deposits – the latter in this instance.

Although Minor Aquifers will seldom produce large quantities of water for abstraction they are important both for local supplies and in supplying baseflow to rivers. The sites are not located within any current Source Protection Zones according to the Environment Agency information.

H.2.2 North Riverside (Grid Reference: SK 35526 36434) – Site A

The soil has been classified as HU. H indicates that the soils are of High Leaching Potential, which have little ability to attenuate diffuse source pollutants and in which diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater. Soil category HU refers to urban areas, which are classified based on fewer observations than elsewhere, therefore a worst case vulnerability classification (H) is assumed until proved otherwise.

H.2.3 Castleward (Grid Reference: SK 36988 35688) – Site B

The soil has been classified as H1. H indicates that the soils are of High Leaching Potential, which have little ability to attenuate diffuse source pollutants and in which diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater. Subcategory H1 includes soils which readily transmit liquid discharges because they are either shallow or susceptible to rapid flow directly to rock, gravel or groundwater.

H.2.4 Derwent Triangle (Grid Reference: SK37844 35429) – Site C

The soil has been classified I1, these are soils of Intermediate Leaching Potential (I). These soils that have a moderate ability to attenuate diffuse source pollutants though it is possible that some non-adsorbed diffuse pollutants and liquid discharges could penetrate the soil layer. As a result, subcategory I1 includes soils which can transmit a wide range of pollutants.

H.3 Groundwater Flood Risk

It is important to recognise the risk of groundwater flooding is typically highly variable and heavily dependent upon local geology, topography and weather conditions, as well as local abstraction regimes. Groundwater flooding is hard to predict and challenging to mitigate. Even with a carefully monitored network of boreholes, it can be difficult to tell when and where groundwater flooding will occur.

The Environment Agency does not have any groundwater observation wells in the vicinity of the proposed sites and as such there are no data available to this study to indicate any details of depth to groundwater or groundwater flow directions or to provide any relevant borehole logs.

The Environment Agency have no historical records of any groundwater flood risk and as such are unaware of any groundwater flooding events with regard to the proposed sites.

Groundwater Emergence Maps were produced as part of a Defra research project (Jacobs, 2004) and set out to provide information on the potential scale, distribution and nature of groundwater flooding in England. The maps were produced at a scale suitable for national assessment and, as such, do not pinpoint sites where groundwater flooding will occur. Instead, they define broad areas of risk based on geology and topography. The Groundwater Emergence Maps do not imply flooding per se, only that groundwater could emerge at the surface first within the indicated areas. Where no flooding has been reported, or no information is available, the maps indicate estimated areas based on anticipated groundwater levels using relevant aquifer properties. Where no groundwater contours are available or the aquifer is of local significance only, the Base Flow Index (BFI) derived from the Hydrology of Soil Types (BFIHOST) classification colour coded network gives some indication as to the proportion of flow derived from baseflow.

On these indicative maps the areas of interest is not marked as a groundwater emergence area. This is partly because there was no specific groundwater data available as this area is not underlain by a major aquifer. However, the area was classified on the BFIHOST classification, and was given the lowest indicative groundwater flood risk category mapped (BFIHOST<0.7).

There are limited data available to assess the flood risk to these three sites from groundwater. The Mercia Mudstone Group beneath them, which is not a major aquifer, lacks the potential to store and transmit large quantities of water. Consequently the risk of groundwater flooding is considered to be low, despite the thin water-bearing sandstone bands within it.

The superficial deposits of the valley bottom (predominantly alluvium) are likely to be in hydraulic connection with the river and it is considered that fluvial flooding would be the main issue in this setting.

H.4 Climate Change

The potential effects of climate change on groundwater levels are uncertain. Greater seasonality in groundwater level fluctuation is a potential outcome under a pattern of higher winter rainfall and less summer rainfall. The former is more likely to lead to a greater risk of groundwater flooding. In the UK groundwater flooding was experienced following the wet winters of 2000-01 and 2007-08, but also as a result of the prolonged rainfall of summer 2007. Broad predictions of the impacts of climate change on groundwater levels are difficult to make at the present time.

References:

- Jacobs (2004), Strategy for Flood and Coastal Erosion Risk Management: Groundwater Flooding Scoping Study (LDS 23), Final Report. Report for Defra.
- Letter from Steven Tupper, Environment Agency titled Request for Information – Level 2 flood risk assessment for sites in Derby, dated 12 February 2010, Atkins Ref: 5090410/072/DI/012
- British Geological Survey, 1972. Derby. England and Wales Sheet 125. Solid and Drift Edition. 1:50,000 series.

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Appendix I
Fact Sheet- Flood Risk Overview

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Flood Risk Overview
North Riverside- Area A

0.1% AEP fluvial flood (Baseline Scenario)

Catchment Overview

The North Riverside Area A [grid reference 435499, 336542] is a highly urbanised area and is located south of A601 St Alkmund's way in the Derby city centre. The River Derwent flows adjacent to the southern boundary of the site.

Historical Events

Flooding from River Derwent occurred during 1947, 1960, 1965 and 1977. The River Derwent channel capacity was exceeded and no raised defences were present during the flooding.

Fluvial Flood Risk

The area is not within the functional floodplain. There is a relatively high fluvial risk to North Riverside Area and falls within Flood Zones 2 and 3. The main fluvial flood risk is from the River Derwent. There are several properties along this river corridor which are located in both Flood Zones 2 and 3. As a result of fluvial flood risk for the North Riverside is served by the Environment Agency Flood Warning System called 'The River Derwent at Derby City'.

According to the 2D modelling undertaken for the area, the 1% AEP event produces an extreme fluvial hazard. This hazard classification was based on table 4 in the Environment Agency guidance for assessing and managing flood risk.

Surface Water Flood Risk

The North Riverside area is a fully urbanised catchment and comprises a drainage system including storm and foul water sewers. The Environment Agency map for areas susceptible to flooding shows that the North Riverside (Area A) has potential surface water flood risk near Phoenix Street, Derwent Street and Darwin Place.

Groundwater Flood Risk

The risk of groundwater flooding for the North Riverside is considered to be low.

Flood Risk Mitigation

At present no potential flood risk mitigation options have been outlined for North Riverside.

Climate Change Impact

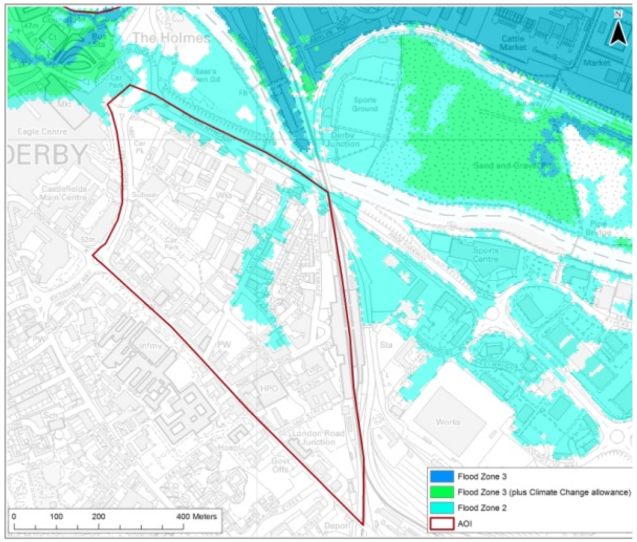
The 2D modelling of the area shows impact of climate change through increased flood risk in the area.

Recommendations for a site specific FRA

A FRA will need to be completed for any proposed development located within either Flood Zones 2 or 3 and for any development which covers an area greater the 1ha. The FRA must be completed to demonstrate;

- that through the Sequential Test and LDF process for Derby the site has been identified as suitable for development.
- the development does not increase flood risk elsewhere within the catchment;
- the mitigation measures proposed are suitable to deal with flood risks and the residual risk is appropriate;
- the Sequential Approach can be applied within the Area boundary to guide vulnerable uses to the lower flood hazard areas, using the results from the 2D modelling.
- It is recommended that the developer consults the Development and Flood Risk Guidance for the Construction Industry C624 (CIRIA, 2004) to ensure the correct level of detail is given within the FRA.
- The area is heavily urbanised and comprise an integral drainage system extending beyond the boundary of the area assessed and therefore if further development is proposed within this built up area, then it is recommended that a detailed Integrated Urban Drainage assessment is carried out to determine the combined flood risk in detail.
- The Area A is at significant risk of flooding from fluvial /River Derwent and therefore any assessment of surface water flooding will require an integrated approach including fluvial and surface water modelling and can form part of the SWMP.
- Further detailed breaching analysis is undertaken to identify the hazard and mitigation for residual flooding to any future development.

Flood Risk Overview
Castleward- Area B



0.1% AEP fluvial flood (Baseline Scenario)

Catchment Overview

The Derby SFRA Level 2 Castleward area [grid reference: 435870, 335770] is a highly urbanised area and is located in Derby city centre and immediately to the south of A6 Station Approach. The River Derwent is located in close proximity to the northern boundary of the site. Mill Fleam, an engineered open channel passes adjacent to the north western boundary before joining the confluence at River Derwent. The site comprises a drainage system including storm and foul water sewers.

Historical Events

No major flooding from River Derwent was recorded for the Castleward area.

Fluvial Flood Risk

The area is not within the functional floodplain. There is no fluvial risk to Castleward Area during 1% and 1%+climate change AEP events and falls outside fluvial Flood Zone 3. According to the 2D modelling undertaken for the area, the 0.1% AEP event produces a low to medium fluvial flood hazard. This hazard classification was based on table 4 in the Environment Agency guidance for assessing and managing flood risk.

The fluvial flood risk for the Castleward is served by the Environment Agency Flood Warning System called 'The River Derwent at Pride Park and Derby Railway Station' set at the Derby St Mary's river gauge.

Surface Water Flood Risk

The Castleward area is a fully urbanised catchment and comprises a drainage system including storm and foul water sewers. A 2D overland sewer modelling shows the area suffers from surface water flooding during the 1% AEP and 1% AEP plus climate change flood events near London Road and south of Railway Terrace.

Groundwater Flood Risk

The risk of groundwater flooding for the Castleward Area is considered to be low.

Flood Risk Mitigation

At present no potential flood risk mitigation options have been outlined for Castleward area.

Climate Change Impact

The 2D modelling of the area shows no impact of climate change on flood risk for the area.

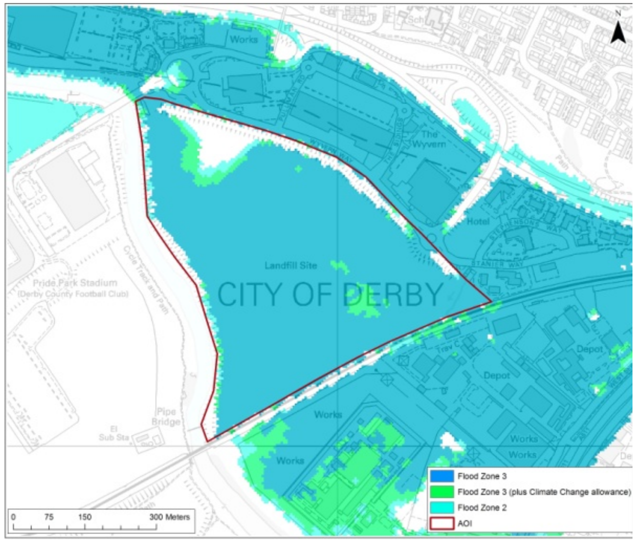
Recommendations for a site specific FRA

A FRA will need to be completed for any proposed development located within either Flood Zones 2 or 3 and for any development which covers an area greater the 1ha. The FRA must be completed to demonstrate;

- that through the Sequential Test and LDF process for Derby the site has been identified as suitable for development.
- the development does not increase flood risk elsewhere within the catchment;
- the mitigation measures proposed are suitable to deal with flood risks and the residual risk is appropriate;
- the Sequential Approach can be applied within the Area boundary and the development passes part c of the Exception Test (if appropriate).
- It is recommended that the developer consults the Development and Flood Risk Guidance for the Construction Industry C624 (CIRIA, 2004) to ensure the correct level of detail is given within the FRA.
- The area is heavily urbanised and comprise an integral drainage system extending beyond the boundary of the area assessed and therefore if further development is proposed within this built up area, then it is recommended that a detailed Integrated Urban Drainage assessment is carried out to determine the combined flood risk in detail.

Flood Risk Overview

Derwent Triangle- Area C



0.1% AEP fluvial flood (Baseline Scenario)

Catchment Overview

The Derby SFRA Level 2 Derwent Triangle area is an undeveloped site [grid reference: 437710, 335501] and is located south of Wyvern retail park. The River Derwent is located to the western boundary of the site. The eastern bank of the River Derwent comprises the Environment Agency maintained flood defence embankment.

Historical Events

Flooding from River Derwent occurred during 1947 in the Derwent Triangle area. The River Derwent channel capacity was exceeded and no raised defences were present during this flooding.

Fluvial Flood Risk

The area is not within the functional floodplain. There is a relatively high fluvial risk to Derwent Triangle area and falls within Flood Zones 2 and 3.

The fluvial flood risk for the Derwent Triangle area falls within the EA flood warning area called 'The River Derwent at Chaddesden'.

According to the 2D modelling undertaken for the area, the 1% AEP event produces an extreme fluvial hazard. This hazard classification was based on table 4 in the Environment Agency guidance for assessing and managing flood risk.

Surface Water Flood Risk

The Derwent Triangle area is currently undeveloped and does not currently comprise complex drainage system located on site. The main flow path for overland flooding is through the underpass walkway located in Derwent Parade adjacent left bank of the River Derwent. Therefore the risk of flooding on this area is considered to be primarily from fluvial flooding.

Groundwater Flood Risk

The risk of groundwater flooding for the Derwent Triangle is considered to be low.

Flood Risk Mitigation

Any new development on the Derwent Triangle area will impact flood risk north of the area near Wyvern Park. This is also evident from the 2D fluvial modelling for the area.

At present no potential flood risk mitigation options have been outlined for Derwent Triangle area.

Climate Change Impact

The 2D modelling of the area shows impact of climate change through increased flood risk in the area.

Recommendations for a site specific FRA

A FRA will need to be completed for any proposed development located within either Flood Zones 2 or 3 and for any development which covers an area greater the 1ha. The FRA must be completed to demonstrate;

- that through the Sequential Test and LDF process for Derby the site has been identified as suitable for development.
- the development does not increase flood risk elsewhere within the catchment;
- the mitigation measures proposed are suitable to deal with flood risks and the residual risk is appropriate;
- the Sequential Approach can be applied within the Area boundary and the development passes part c of the Exception Test (if appropriate).
- It is recommended that the developer consults the Development and Flood Risk Guidance for the Construction Industry C624 (CIRIA, 2004) to ensure the correct level of detail is given within the FRA.
- The area is currently undeveloped. A coarse post development assessment using 2D fluvial modelling shows increased flood risk impact north of the area near Wyvern Park. Therefore if further development is proposed within this built up area, then it is recommended that detailed post scheme modelling is carried out to determine the flood risk in detail and assess any mitigation options.