Redcar and Cleveland Borough Council Level 2 Strategic Flood Risk Assessment

Final Report

August 2010

Roger Tait
Senior Planning Officer
Planning Policy and Design
Redcar and Cleveland Borough Council
Belmont House
Guisborough
TS14 7FD

JBA Office

JBA Consulting
The Brew House
Wilderspool Park
Greenall's Avenue
Warrington
WA4 6HL

JBA Project Manager

Sam Wingfield

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Draft version 1.0. May 2010		Roger Tait and Cameron Sked
Final version 2.0 August 2010	Updated following EA and RCBC comments	Roger Tait and Cameron Sked

Contract

This report describes work commissioned by Roger Tait, on behalf of Redcar and Cleveland Borough Council, by an email dated 05/02/10. Redcar and Cleveland Borough Council's representative for the contract was Roger Tait. Sam Wingfield of JBA Consulting carried out this work.

Prepared by ....Sam Wingfield BSc MRes

Analyst

Reviewed by ....Chris Isherwood BSc MSc DipWEM

Analyst

Reviewed by ....Jonathan Cooper BEng MSc CEng MICE MCIWEM MIoD DipCD

Divisional Manager

Purpose

This document has been prepared as a final Report for Redcar and Cleveland Borough Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Redcar and Cleveland Borough Council.

Acknowledgments

JBA would like to thank Alan Smuk and Roger Tait who assisted in the production of this report.

Carbon Footprint

A printed copy of the main text in this document will result in a carbon footprint of 181g if 100% post-consumer recycled paper is used and 231g if primary-source paper is used. These figures assume the report is printed in black and white on A4 paper and in duplex.

JBA is a carbon neutral company and the carbon emissions from our activities are offset.

Executive Summary

Purpose

This Level 2 SFRA follows on from RCBC's Level 1 SFRA (Volumes I, II and III).

This study has two main purposes. The first is to provide a more detailed assessment of flood hazards for the area at risk of tidal flooding (between Coatham Sands and the Tees Estuary) and how this impacts on the proposed development sites. The second is to provide further detail on and confirm the candidate Critical Drainage Areas (cCDAs), identified in the Level 1 SFRA.

Land use in the tidal flood risk area is dominated by the steel and chemical industry. Parts of this area require development and regeneration for economic purposes and RCBC has identified a number of proposed employment development sites (and one residential site).

Method

The current Environment Agency Flood Map in the area between the Tees Estuary and Coatham Sands is defined on broad scale modelling techniques based on extreme tide levels (which have now been superseded) and a broad scale digital elevation model. This Level 2 SFRA has carried out new tidal modelling for this area, in order to provide a more accurate and realistic reflection of flood risk.

The new modelling takes into account natural and man made restrictions to tidal flooding; including the sand dune system at Coatham Sands and the disused railway embankment at Warrenby.

Conclusions

When these natural and man made barriers to flooding are modelled, this 'existing risk' scenario shows that only a small number of the proposed development sites are at risk. Flood depth and hazard results show that these sites could be developed safely with straightforward mitigation measures. A conservative estimate of undefended flood risk (all barriers to tidal flooding removed) showed that all of the proposed development sites in the study area are at risk of flooding to some degree. The results of which illustrate the important role natural and manmade defences play in effecting flood risk within the area. Flood risk to these sites can therefore be seen as more a 'residual risk' which can be managed through mitigation measures such as selected land raising and flood resilience techniques. In conclusion, all of the sites assessed in the Level 2 SFRA should be suitable for development subject to a detailed flood risk assessment (FRA).

Recommendations

The three strategic locations that were identified in the Level 1 SFRA as cCDAs have been studied in more detail. These cCDAs are in Guisborough, Eston and Redcar and have been confirmed as CDAs following the Level 2 assessment.

A number of individual studies have been proposed for the CDAs, based on the work completed in this Level 2 SFRA. These include investigating the viability of 'green' attenuation schemes and improvements to the sewer infrastructure in order to reduce surface water flooding in the CDAs. These studies could form part of a full SWMP or as individual studies if 'quick wins' funding is available.

Contents

1. Introduction 1

1.1 Background 1
1.2 Scope and objectives 1
1.3 Study area 2

2. Tidal Flood Risk and Flood Defence Review 5

2.1 Estuary and Coastal Environment 5
2.2 Extreme flood levels 8

3. Level 2 Assessment of the Sites at Tidal Flood Risk 13

3.1 Tidal Modelling 13
3.2 Main Barriers to Tidal Flooding 13
3.3 Existing Risk Modelling Scenario 15
3.4 Undefended Tidal Modelling Scenario 21
3.5 Summary 25

4. Critical Drainage Areas 28

4.1 Introduction 28
4.2 Detailed Surface Water Mapping 28
4.3 Critical Drainage Areas 29
4.4 Future Studies 46

Appendices I

A. Figures I

B. Glossary II

List of Figures

Figure 1 - The Level 2 SFRA tidal flood risk sites 3
Figure 2 - Tees Estuary and the steel works 6
Figure 3 - Golf course and industrial land behind the Coatham dunes 7
Figure 4 - 1 in 200 year level elevation and Flood Zone 3 comparison 10
Figure 5 - 1 in 200 year flood level and the climate change level elevations 11
Figure 6 - Modelled breach locations 14
Figure 7 - Flood extents for the existing risk scenario at the Level 2 SFRA sites 17
Figure 8 - 1 in 200 year+cc flood depth for the existing risk scenario at the Level 2 SFRA sites 19
Figure 9 - 1 in 200 year+cc flood hazard for the existing risk scenario 21
Figure 10 - Flood extents for the undefended scenario 23
Figure 11 - Flood extents for the undefended scenario 24
Figure 12 - Looking u/s at a field drain as it enters Guisborough 30
Figure 13 - Tributary to Chapel Beck 31
Figure 14 - Surface water sewer entering Chapel Beck 32
Figure 15– Detailed surface water mapping in Guisborough 33
Figure 16 - Redcar location map 35
Figure 17 - The Fleet looking downstream at Limerick Road 36
Figure 18– Detailed surface water mapping in Redcar 37
Figure 19– Detail of the area at greatest risk in Redcar 38
Figure 20 - Eston Moor from the A174 39
Figure 21 - main flood sources in Eston 40
Figure 22 - Fence across a watercourse in Eston 41
Figure 23 - Ochre rich watercourse near Eston by the A174 42
Figure 24– Detailed surface water mapping in Eston 43
Figure 25– Detail of the area at greatest risk in Eston 44
Figure 26– Proposed development, surface water maps and historic flooding locations 46

List of Tables

Table 1 - Still water tide levels at Tees Mouth 8
Table 2 - Suggested Screening Criteria for Mitigation Measures 18
Table 3 - Flood Hazard Thresholds 20
Table 4 - Site specific flood risk summary 27
Table 5 - Suitability of SUDS Techniques 49
Table 6 - Strategic SUDS Applicability 50

1. Introduction

1.1 Background

JBA Consulting was commissioned in February 2010 by Redcar Borough Council (RCBC) to undertake a Level 2 Strategic Flood Risk Assessment (SFRA). The Level 1 SFRA was submitted in November 2009 and has now been finalised. This Level 2 SFRA follows on from the findings and recommendations of the Level 1 SFRA, providing a greater depth of detail for the sites shown to be at high risk of tidal flooding, between the Tees Estuary and Coatham Sands. A more detailed assessment of candidate Critical Drainage Areas (cCDAs) proposed in the Level 1 SFRA has also been carried out.

Both Level 1 and 2 SFRAs for RCBC have been prepared in accordance with current best practice, Planning Policy Statement 25 Development and Flood Risk (PPS25 - March 2010) and the PPS25 Practice Guide (December 2009). This document comprises the Level 2 SFRA.

1.2 Scope and objectives

The purpose of this investigation is to provide an assessment of tidal flood risk for the proposed residential and employment allocations between the Tees Estuary and Coatham Sands. This flood risk information will inform the Local Development Framework (LDF) and the policies and proposals produced for the developments. This study will also assess the candidate Critical Drainage Areas (cCDAs) in more detail, confirming them as CDAs.

The RCBC Level 1 SFRA (Volume II) has provided sufficient data and information to inform the application of the Sequential Test. This information was based on current available information, including:

- Flood Zone maps
- Modelled flood outlines
- Flood risk management measures maps
- Surface water flooding maps
- Climate change maps

A number of the proposed development sites in the area between the Tees Estuary and Coatham Sands are shown to be within Flood Zone 2 and 3. However, an initial assessment within the Level 1 SFRA showed that the tidal flood extent currently within the Environment Agency's Flood Map may be over estimating risk. This is because these extents are based on tidal flood level predictions that have now been superseded. These extents were also produced using a broad scale digital elevation model and more detailed LIDAR data is now available for this area.

By constructing a 2D tidal model, a more accurate representation of tidal flood risk could be produced. The results of which, reveal the extent of flood risk has been reduced. For the sites still at risk the new modelling would allow a consideration of flood depth and hazard to assess whether the sites will be safe for development (following the Sequential Test). This information can also be used to identify the flood risk management mitigation measures required in order to bring the sites forward for development.

One of the proposed development sites is residential and within Flood Zone 3, the Exception Test will therefore need to be passed if this site is brought forward for development. The requirements of the Exception Test are displayed below:

a. 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. If the LDD has reached the 'submission' stage (see Figure 4.1 of PPS12:

Local Development Frameworks) the benefits of the development should contribute to the Core Strategy's Sustainability Appraisal (SA);

b. The development must 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

c. A site-specific Flood Risk Assessment must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Whilst the Exception Test process makes it possible to assess the need for development in high flood risk areas and whether or not it can be sustainable, it must not been seen as an opportunity to place inappropriate development in flood risk areas.

In order to establish whether applying the Exception Test is justified or can then be satisfied, namely part c), the Level 2 SFRA considers the detailed nature of flood hazard, taking account of the presence of flood risk management measures such as flood defences. The detail nature of the flood hazard within a flood zones includes:

- Flood probability;
- Flood depth;
- Flood Velocity; and
- Rate of onset of flooding.

These factors can be significantly affected by the presence of flood defences or any other infrastructure which acts as a flood defences. Flooding behind such infrastructure can occur either as a result of:

- Constructional or operation failure of the defence, either in whole or in part (breach); or
- Water levels rising to exceed the level of the defence (overtopping); or
- Overloading of the surface water drainage system, either due to its own limited capacity, or being unable to discharge due to high water levels outside the defended area.

By facilitating the application of the Exception Test, the Level 2 SFRA technical work will also provide supporting evidence towards possible mitigation measures that would enable the development to proceed in a sustainable manor.

1.3 Study area

The study area is based around a heavy industrial area and is dominated by the steel works and the chemical works at Wilton International. The allocations of interest are predominantly to the east of the main steel works although the Corus allocations border with the steel works.

Wilton International (chemical industry), the steel industry and Teesport, are seen as a vitally important part of the local, regional and national economy.

RCBC are looking to promote employment land use for chemical industry and other skilled employment use area in this area. This includes the development of the renewable energy and recycling sectors and other knowledge-based industries and businesses based in areas around Wilton International.

The North and South Tees Industrial Development Framework identifies future development opportunities in the South Tees area, in particular the expansion and diversification of the environmental technology and petrochemical sectors (and the associated expansion of the port and logistics function), which have the potential to become the key drivers of the Tees Valley economy[1].

[1] Tees Valley Joint Strategy Unit, North and South Tees, Industrial Development Framework, Level 1 - Flood Risk Assessment, Draft, Parsons Brinckerhoff Ltd, May 2009

Similar industrial use is proposed for Warrenby Industrial Estate but housing is proposed for Warrenby Caravan Park.

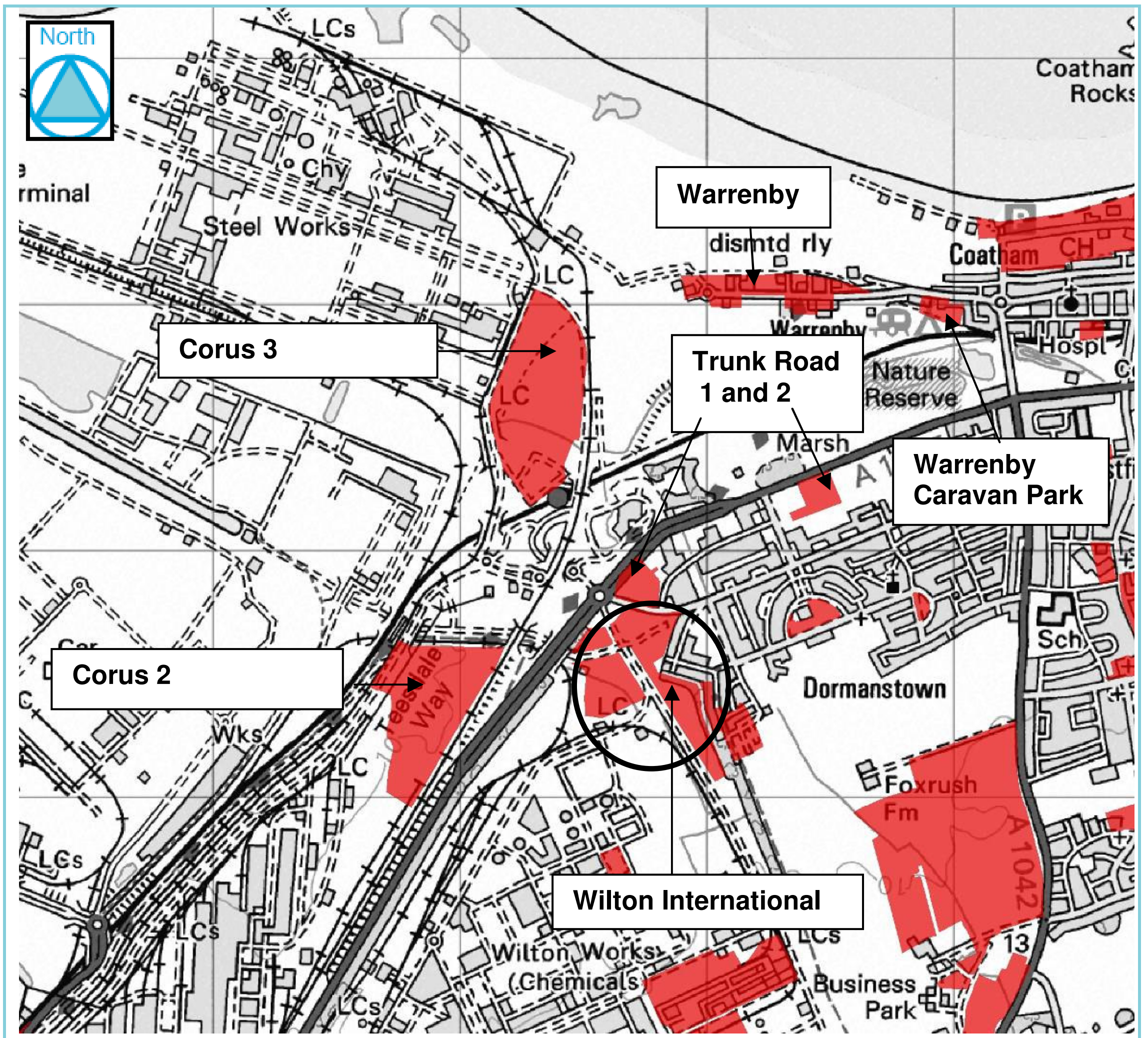
The Level 2 SFRA will focus on the proposed development sites that are shown to be at tidal flood risk according to the Environment Agency's Flood Zones are predominantly for employment use. These sites have come from the Available Employment Land study and are listed below.

Employment sites

- Trunk Road 1 (Dormanstown Industrial Estate)
- Trunk Road 2 (Dormanstown Industrial Estate)
- Wilton International
- Corus 2
- Corus 3
- Warrenby

There is one, smaller, proposed residential site that is also shown to be at risk of tidal flooding called Warrenby Caravan Park. This site is allocated in the Communities DPD Preferred Options Report. The proposed employment and residential sites are also shown in Figure 1.

Figure 1 - The Level 2 SFRA tidal flood risk sites



The Level 2 SFRA will also look at three separate locations that have been identified as candidate Critical drainage Areas (cCDAs) in the Level 1 SFRA in more detail and confirm them as Critical Drainage Areas (CDAs) if necessary. The three cCDAs to be looked at in more detail are:

- Guisborough
- Redcar
- Eston

The study area will cover these areas in addition to any green infrastructure opportunities and surface water flooding areas identified by the more detailed surface water mapping.

2. Tidal Flood Risk and Flood Defence Review

2.1 Estuary and Coastal Environment

This section describes the existing environment around the south Tees Estuary within RCBC and the coastline leading from the estuary to Redcar. Much of the information on the Coatham Sands coastline has been obtained from the Shoreline Management Plan 2[2] (SMP2). This review will assist in developing flood modelling scenarios and understanding tidal flood risk in this area. Chapter 3 describes the modelling scenarios and tidal flood risk.

2.1.1 Tees Estuary

The study area starts from the RCBC boundary within the Tees Estuary at Normanby Wharf and extends round the coastline to Redcar (but not including Redcar).

The Tees Estuary within RCBC is not covered by either the Tees Tidal Strategy[3] or the SMP2 until Bran Sands. The SMP2 covers the coastline from Bran Sands along the full length of RCBC's open coastline.

The Tees Tidal Strategy study area indicates that the Tees Estuary in RCBC is included, but there is no flood cell or policy for it within the report.

The area to the south of the Tees Estuary is generally composed of industrial land; the majority is dominated by the Corus steel works and Wilton chemical works. Figure 2 shows the Tees Estuary and the heavy industrial use (including the steel works) to the east. Much of the RCBC Tees Estuary frontage is elevated above 5mAOD putting it above the 1 in 200 and 1 in 1000 year flood events, but not when the effects of climate change area added (see Section 2.2). An exception is the Tees Dock area which is generally lower than the surrounding ground.

The southern mouth of the Tees Estuary is the South Gare breakwater which runs parallel to the main channel of the Tees and is built out over areas of deposited slag. Within the mouth of the Tees, to the south of the South Gare, is the Bran Sands bay, backed by dunes behind which are part of the Tees Valley industrial area.

[2] Shoreline Management Plan 2, River Tyne to Flamborough Head, North East Coastal Authorities Group, February 2007, Final Report
[3] Draft Tees Tidal Flood Risk Management Strategy, Environment Agency, February 2008

Figure 2 - Tees Estuary and the steel works

2.1.2 Coatham Sands coastline

To the east of the South Gare breakwater is the wide expanse of the Coatham dunes. This area is protected at their western end by the slag banks, known as the German Charlies. Between this point and the Coatham Rocks, at Redcar, a shallower dune backed bay has been formed. The dunes and open low-lying ground extend back some 400m, providing protection to the northern flank of steel works and to eastern edge of Redcar.

The dunes themselves act as a flood defence system to the open ground and golf course behind (see Figure 3). From here, a good width of upper, generally dry sand beach continues in front of the Coatham car park, only reducing in width at the corner at the start of the Redcar sea front. There are coastal defences in front of the car park and these become heavier and more prominent approaching the corner at Redcar.

Figure 3 - Golf course and industrial land behind the Coatham dunes

Future Coastline

The SMP2 states that over the next 100 years, it is expected that the South Gare, together with the slag deposits, would maintain a general influence on the coast. It would be subsequent years during which more major erosion would take place, with the coastline cutting back through to the Tees Estuary, infilling Bran Sands.

It is expected that Coatham Sands would setback, but there would be some resistance to this at the mouth of the Tees due to the slag banks and also due to the more resistant nature of slag tipped into the dune area. The area further to the south, over the more natural dune line, would also be setback by erosion. This general rolling back of the dunes may expose access to the larger flood area through to Warrenby and Coatham.

Future Management

The future management policy for the South Gare is to maintain this structure. The policy for the Coatham Sands is for no active intervention. This will allow a natural coastline to develop around Coatham Sands. The SMP2 states that it will be important to monitor this and to ensure no weak points develop which might result in the potential for breach through to the potential tidal floodplain behind. Although not an official flood defence, the SMP policy aims to ensure that the natural function of the dunes as a front line flood defence as well as an area of important ecological interest is maintained. It is, however, accepted that this natural defence may not continue to provide adequate protection to the housing behind Coatham Sands.

It is proposed in the SMP2 that there should be further detailed examination of the actual flood risk to Warrenby and Coatham in order that there is confidence in long term flood risk management. This is the area where some of the proposed development sites are situated. The intent within the SMP2 is that any need for improving flood defences here is undertaken to the rear of the dunes, without the need to disrupt the open coast system. The Environment Agency has advised that floor levels to this development should be above 5m AOD and that the flood risk assessment for the whole area should assume that Coatham Sands will roll back.

As the coast to the west retreats, the caravan park at the Redcar end of Coatham Sands will come under considerably greater pressure as would the corner of Majuba Road and the proposed development in this area (Coatham Enclosure). The SMP2 concludes that it would be unlikely that defence of the area of the caravan park would be justified. Management of this section needs to be seen as a transition between the desires to hold the main frontage of Redcar while equally allowing the natural development of the Coatham Dunes.

There is still much uncertainty as to the extent to which the dune line will retreat, this being strongly dependent on rates of sea level rise. The baseline erosion rate used in the SMP2 for Coatham Sands is 0.2m/year. Projected shoreline mapping in the SMP2 shows that by 2100, the shoreline would retreat by a small degree by the golf course but by a greater degree in front of the Steel works and Bran Sands. This shoreline retreat does not get anywhere near to any existing or proposed development but could open up some parts of the dune so that a tidal flood event could reach the lower land behind.

2.2 Extreme flood levels

Extreme tide levels for the Tees Estuary, shown in Table 1, have been taken from the Draft Tees Tidal Flood Risk Management Strategy (Environment Agency, February 2008). These levels (and climate change levels) are the current Environment Agency recommended levels for assessing tidal flood risk in the area.

Within the estuary, mean high water springs are 2.7m AOD and the highest astronomical tide is 3.3m AOD, the highest recorded water level of 4.0m on the Tees Estuary was a result of a large surge tide (1953 event).

Sea levels on the Tees are forecast to rise by 255mm over the next fifty years and 885mm over the next 100 years as a result of sea level rise[4]. Although stormier conditions can be expected in the future, any impact in terms of increased wave heights within the estuary adjacent to the Borough will probably be of little consequence compared with the impact of sea level rise.

Table 1 - Still water tide levels at Tees Mouth

Return Period (years)	Probability (%)	Level by Year (m AOD)				
		2007	2025	2055	2085	2107
1	100.0	3.353	3.398	3.608	3.908	4.238
2.5	40.0	3.488	3.533	3.743	4.043	4.373
5	20.0	3.590	3.635	3.845	4.145	4.475
10	10.0	3.693	3.738	3.948	4.248	4.578
25	4.0	3.843	3.888	4.098	4.398	4.728
50	2.0	3.933	3.978	4.188	4.488	4.818
100	1.0	4.073	4.118	4.328	4.628	4.958
200	0.5	4.186	4.231	4.441	4.741	5.071
300	0.33	4.244	4.289	4.499	4.799	5.129
500	0.2	4.303	4.348	4.558	4.858	5.188
1000	0.1	4.403	4.448	4.658	4.958	5.288
	Shading demonstrates the reduction in return period with time					

[4] Annex B, Table B1of Planning Policy Statement 25, Communities and Local Government, March 2010.

2.2.1 Flood Zone and Projected Levels Comparison

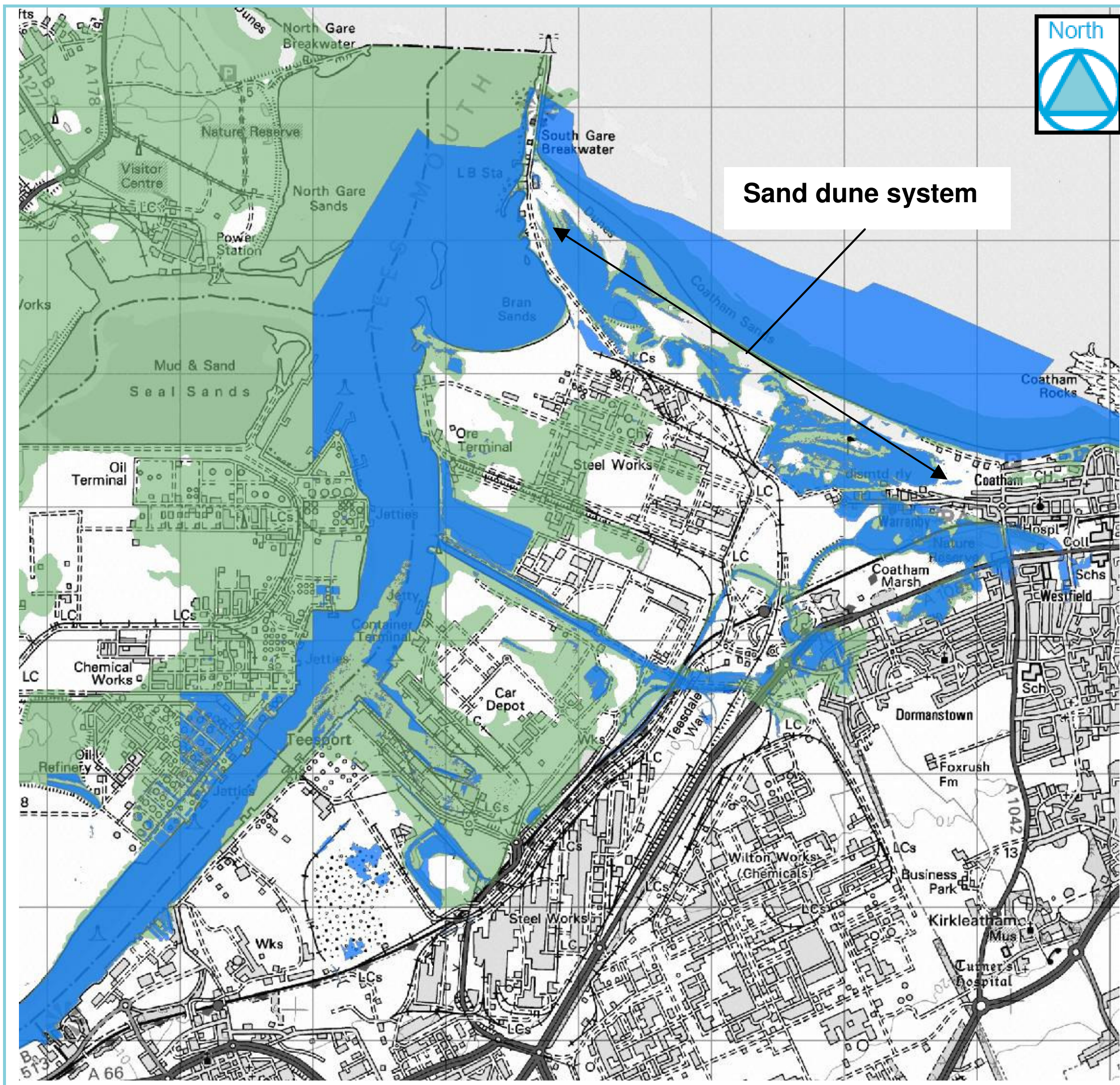
A Level 2 assessment is being undertaken for the tidal flood risk area primarily to asses the risk of flooding to the proposed development sites in this area. Strategic modelling undertaken in the Level 1 SFRA identified that the Environment Agency Flood Zone maps currently overestimate the tidal flood extents in this area. The reason for this was assumed to be the broad scale topographic model used to create the extents which used peak tidal flood levels which have now been superseded when compared to data provided in Table 2.

Even before detailed modelling took place in this SFRA, the difference in the current Flood Zones and the flood levels can be seen. Figure 4 shows a comparison of the current Flood Zone 3 and the 1in 200 year flood level (equivalent of Flood Zone 3) projected onto the LIDAR data. Although the area landwards of Coatham Sands shows a similar extent, the steel works and car depot area to the east of the Tees Estuary are very different. This is due to a combination of the more accurate elevation data and the latest flood levels being lower than the ones previously used.

It should be noted that the 1 in 200 year flood level has been projected over the topography data to create the blue extent, however it does not take into account any natural or manmade barriers to tidal flooding. For the current Environment Agency Flood Zone 3 extent, several breaches in the Coatham Sands dunes have been assumed.

Whilst the tidal floodplain behind the dunes have been identified as flooding during this event, in reality these dunes are high enough to prevent flooding from the 1 in 200 and 1 in 1000 year events.

Figure 4 - 1 in 200 year level elevation and Flood Zone 3 comparison



OS Licence: © Crown Copyright 100019983 (2010).

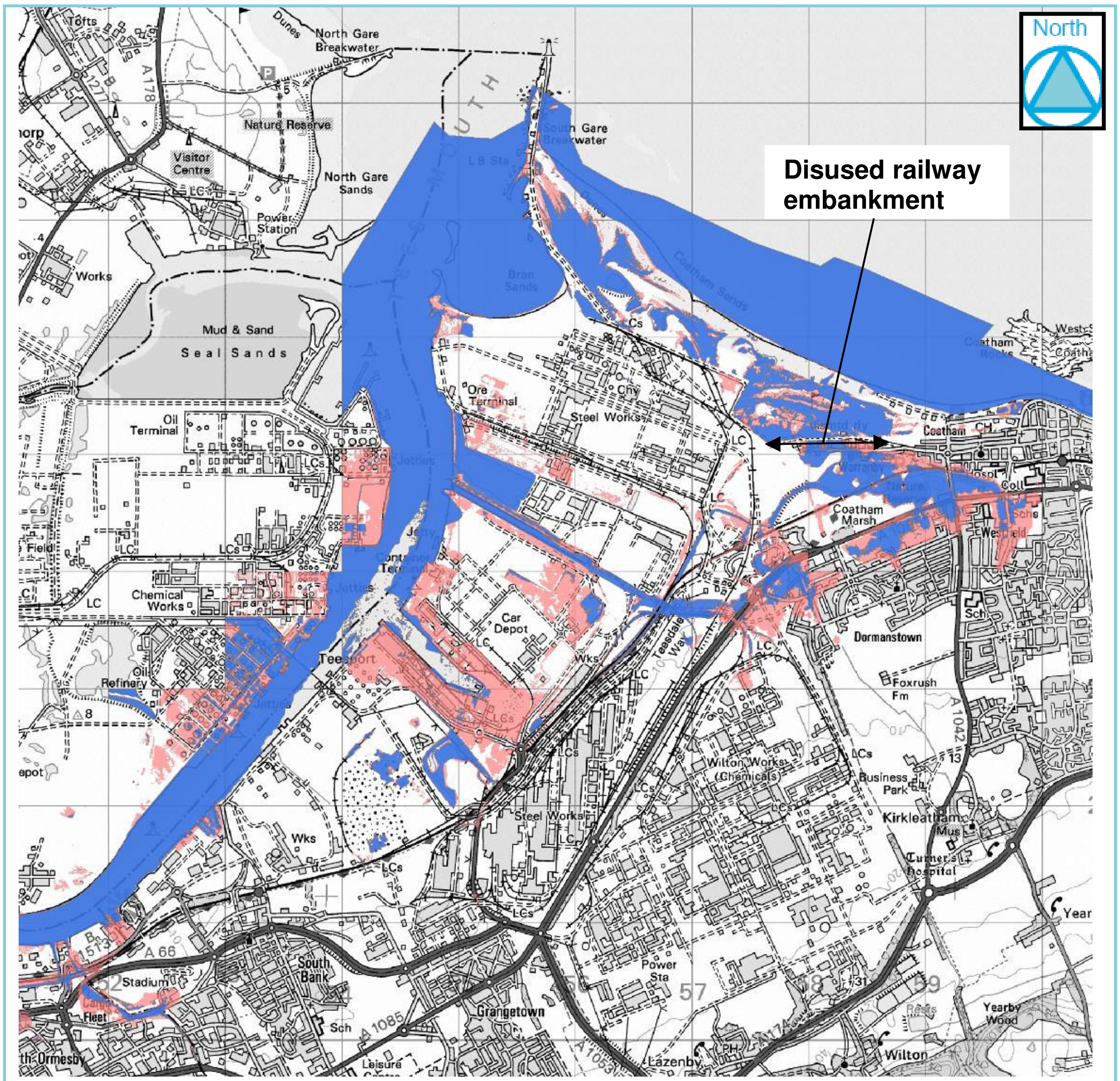
Legend

(blue)	4.19m contour 1 in 200 yr level
(green)	Floodzone 3a

Figure 5 shows a comparison of the 1 in 200 year flood level and the 1 in 200 year flood level with the effects of climate change added (up to 2110). This indicates that the steel works and car depot area will be at risk with climate change. A greater area around Dormanstown will also be at risk. However, this will be dependant on whether the dunes have gaps in or are breached. A disused railway embankment at Warrenby also prevents flow to this area.

The tidal modelling will run a scenario based on the most likely situation during these extreme flood events (existing risk). Chapter 3 provides more information on this and describes the scenarios that have been modelled.

Figure 5 - 1 in 200 year flood level and the climate change level elevations



Legend

4.19m contour 1 in 200 yr level

5.07m contour 1 in 200+cc yr level

2.2.2 Flood Defences

The Environment Agency's NCFDD dataset (see glossary) shows that the only formal flood defences are along the Coatham Sands coastline. The sand dunes here are classed as coastal protection and maintained by RCBC but there is no other information on their condition or standard of protection.

By analysing the LIDAR data it can be seen that the dunes are generally elevated at 6m AOD or more (greater than all of the extreme flood events). The width of the dunes varies. The section of dunes in front of the golf course and towards the South Gare breakwater is around 150m wide. The dunes directly in front of the steel works are more in the region of 250m wide. However, in several locations, due to erosion, the dunes can be more in the region of 30m wide. These sections are relatively narrow (around 30m) but shows that a storm could easily erode this thin section of dune and enter the low lying land behind (which is at around 3 to 4m AOD).

Due to the size of the dune system, they have been classed as a natural topographic feature which will generally prevent flood water entering the lower hinterland. However, due to the areas of reduced width, it is judged more likely than not that the dunes will be breached during an extreme tidal flood event (e.g. the 1 in 200 year event).

The other feature identified within NFCDD is the South Gare breakwater. This is classed as man made coastal protection. This offers no immediate flood defence benefit to development but forms the south part of the Tees Mouth.

Another feature has been identified that, although not a coastal defence, acts a barrier to flood water entering Warrenby (where there is a proposed development). This feature is a disused railway embankment and is approximately 20m wide and 2m high (from ground level to the top) at around 5.7m AOD (above the extreme tide levels - see Table 2). The width of this feature and its height means that a breach is very unlikely (as overtopping would not occur and wave action would not reach the landward side of the embankment). It has therefore been assumed that this embankment is a topographic feature that would prevent the natural flow of tidal flood water. However, it is not know whether there are any holes in the embankment e.g. watercourse culverts.

3. Level 2 Assessment of the Sites at Tidal Flood Risk

3.1 Tidal Modelling

A 2D tidal TUFLOW model (see glossary) has been constructed for part the Redcar coast and the Tees Estuary within RCBC. The model stretches from Coatham round to Normanby Wharf. A 2D model represents flood flow pathways driven by a tidal curve as opposed to projecting a level over a topographic surface. This is more realistic and takes into account barriers to flooding and the volume of flood water available to fill the areas at risk.

This modelling has been undertaken in order to estimate flood extents, depths and flood hazard to proposed future developments in RCBC.

3.2 Main Barriers to Tidal Flooding

As mentioned in Chapter 2, there are a number of official flood defences and unofficial barriers to flooding. These are described in more detail here, before the modelling scenarios are described.

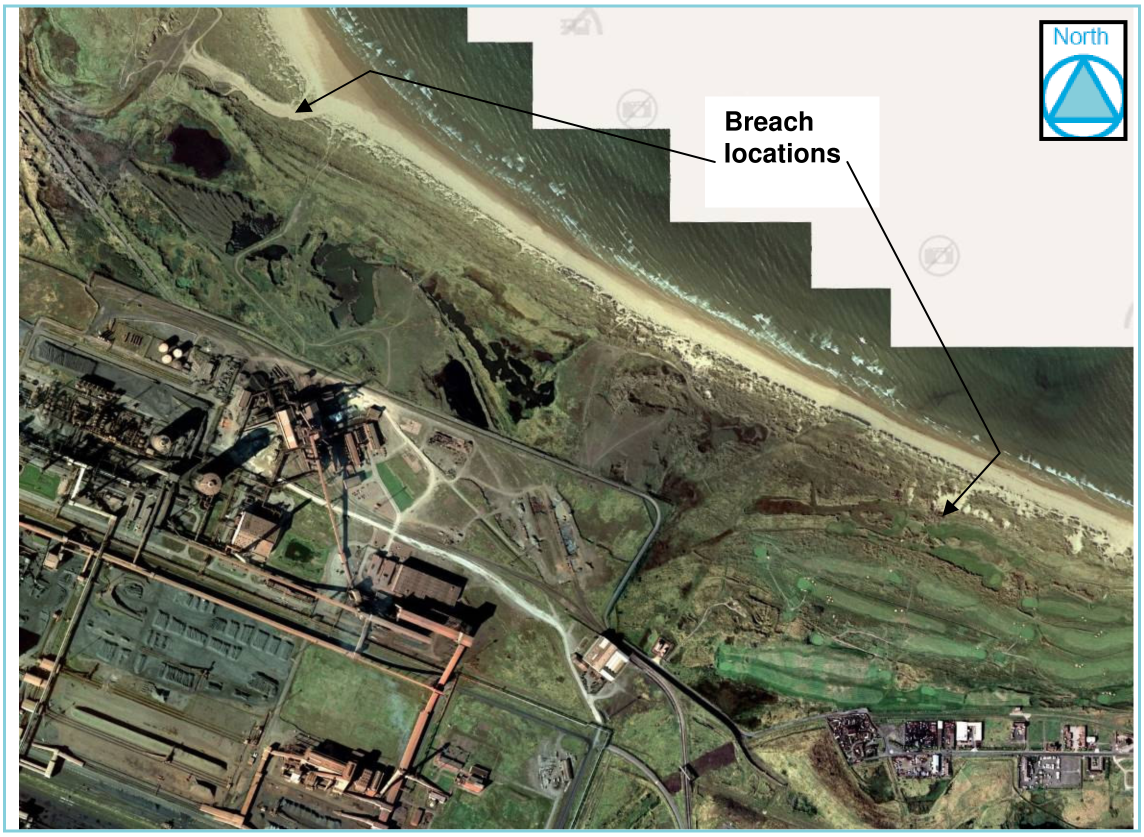
3.2.1 Coatham Dunes

Between the beach at Coatham Sands and the lower ground at the golf course is a line of sand dunes (these are described in Section 2.1.2). The dunes range in height between 6 and 7mAOD. This height prevents flooding from the entire extreme tidal flood events modelled. The SMP2 states that the dunes act as a flood defence system to the open lower ground and golf course behind dunes. As a result, this open low-lying ground behind the dunes provides protection to the northern flank of the steel works and to the towns of Warrenby and Coatham.

In general, the dune width is between 100 and 150 metres but there are some locations where this protection is only 30m wide. It is therefore expected that during an extreme 1 in 200 year event, these locations are likely to open up, due to overtopping, allowing the tidal flood water to enter the lower lying areas. As this is more likely than the dunes not opening during the 1 in 200 year flood event, these locations will therefore be modelled as open during the 'existing risk' scenario. The modelled breach locations can be seen in Figure 6 below.

As a conservative undefended estimate of flood risk, the flood extents produced from projecting the flood levels across the topography will be used. This will assume that all barriers to flooding (included the sand dunes) have been removed.

Figure 6 - Modelled breach locations



3.2.2 Disused Railway Embankment

If breaches/openings occurred in the Coatham Sand dunes, a disused railway embankment would block tidal flood flow to Warrenby Industrial Estate, Warrenby Caravan Park, Corus 3 and Trunk Road proposed development sites. This embankment is approximately 20m wide and 2m high (from approximately 3.5mAOD at the base to 5.7mAOD at the crest). This forms a wide flat embankment.

As this is not an official flood defence in NFCDD, there is no guarantee that it will remain there in the future especially as it is currently disused. It would therefore be prudent to understand what the flood risk would be if this embankment were removed, as this feature could be removed or altered in the future. This can be seen in the figures that show the extreme tidal flood levels projected across the topographical model.

If an extreme tidal event reached this embankment, flood depths at the embankment would range between 0.7m and 1.6m. This would create a load on the defence, but it is unlikely that this force alone on a 20m wide embankment would be enough to breach it.

Wave overtopping causing erosion of the leeward side of the embankment is the most likely breach mechanism. However, none of the extreme tidal flood levels reach the crest of the embankment (compare the crest level of 5.7mAOD to Table 2). In addition, for the embankment to be subject to wave action, the buffering effect of the dunes would need to be removed. It is unlikely that the dunes will completely disappear (according to the SMP2). It has therefore been judged over conservative (and unrealistic) to model a breach in the disused railway embankment. Residual flood risk in this area should therefore be based on the scenario if the embankment were removed (not breached).

3.2.3 Raised Ground at the Steel Works and Tidal Gates

Immediately behind the dunes is Redcar steel works, which is built on land that has been reclaimed (in Victorian times) and raised above the natural ground level. This raises the steel works itself above the 1 in 200 year plus climate change event. Some of the associated steel works land (used for storage of material etc) is on slightly lower ground.

Industrial areas by estuaries often have modified watercourses running through them. This is the case around the Redcar steel works. Dabholm Gut is an example of a watercourse that has been excavated in order to direct fluvial flow away from the built industry. In its lower reach Dabholm Gut is predominantly tidal. Just before a sewage treatment works, there is an outfall (possible from the treatment works) and possibly a tidal gate structure. A tidal gate may have been installed at this point to stop tidal water spreading further upstream putting low lying areas at tidal flood risk (although this can not be confirmed). From this point upstream, the watercourse is predominantly fluvial and is called Dabholm Cut.

Tidal gates can malfunction and remain open (or they could be removed in the future). As it can not be confirmed that the tidal gate is there, the existing risk modelled scenario will assume that this part of the channel is open and the tidal flood water will propagate as far upstream as the topography and tidal flood volume allows.

3.3 Existing Risk Modelling Scenario

In order to asses flood risk to the proposed development sites, an 'existing risk' scenario has been modelled. This scenario takes into account all existing infrastructure and represents what is most likely to occur during a major flood event. This is different to the Environment Agency Flood Zones which do not take into account the benefit of flood defences. An 'existing risk' scenario is required to look at whether a site will be safe once developed and whether it will increase flood risk elsewhere.

As described in 3.2.1, the dunes are a major barrier to tidal flooding in the study area (Figure 1). However, there are two locations where the dune width is around 30m wide (as opposed to 100-150m across the majority of the dunes). It has been assumed that during a 1 in 200 year flood event (or greater) that gaps would open up in these locations allowing a flow pathway through the dunes and to the lower land. This has been included in the existing risk scenario (rather then the undefended scenario) because the width of sand dune here is so narrow that fully breached gaps (as a result of en extreme tidal flood event) would be more likely than not.

The disused railway embankment has been left in the model for the existing risk scenario without a breach assessment. This is because the embankment is approximately 2m high (above all the extreme tidal flood levels, with the effects of climate change added) and 20m wide and is well inland from the main coastline, behind an existing dunes system. Due to the embankment size and location, the risks of it breaching are very low. The only way tidal water could get through this barrier is if there are any culverts that pass through it. The risk of flooding with the embankment removed is considered in the undefended scenario.

Dabholm Gut is potentially a main tidal flood pathway to some of the development sites from then west. This watercourse appears to change from being predominantly tidal to fluvial at a point where there is a bridge, near to the sewage works. It is assumed that there is a tidal gate here, which allows fluvial flow down the watercourse but prevents tidal flows propagating further upstream. It is common for tidal gates to malfunction and remain open. Due to this and because it can not be confirmed that there is a tidal gate there, the existing risk scenario allows a tidal flood flow through Dabholm Gut.

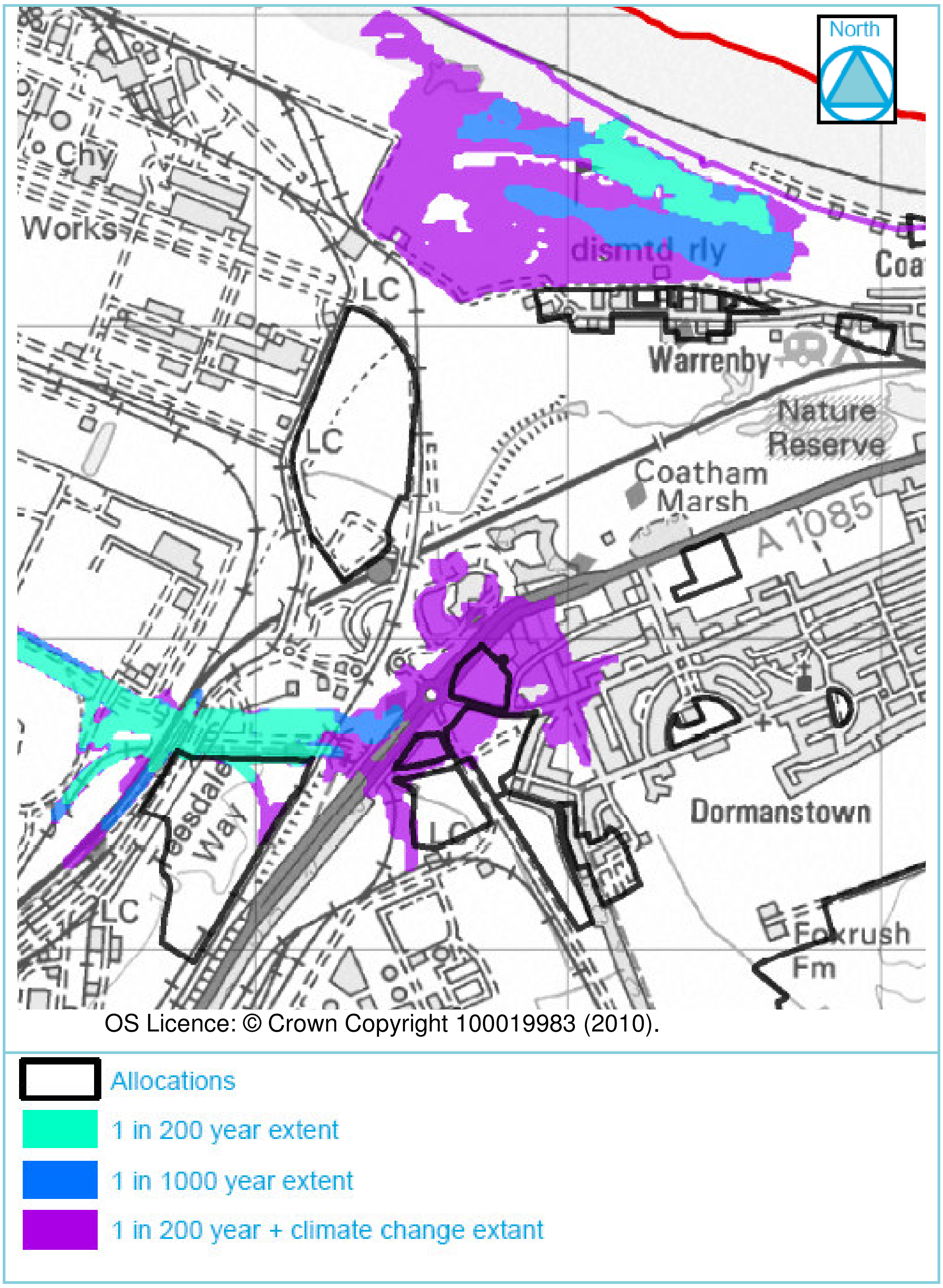
Figures showing the flood extents, depths and hazard for the 1 in 200, 1 in 1000 and 1 in 200 year plus climate change can be seen in Appendix A, figures A1 to A7. Figures focused around the Level 2 SFRA sites are also included within the report.

3.3.1 Flood Extents and Pathways

For the 1 in 200 year flood, the tidal event passes through the two gaps in the dunes and spreads through the lower lying ground, but does not reach the disused railway embankment. This event also propagates up Dabholm Gut through to the north boundary of Corus 2 but does not enter this proposed development site. The 1 in 1000 year event extends slightly further than the areas described for the 1 in 200 year event. A significant difference can be seen when it comes to the 1 in 200 year plus climate change event. The low-lying area behind the dunes fills up to the disused railway embankment. The Warrenby sites are not affected due to the higher ground and embankment blocking the flow. The area either side of Teesport and the car depot is inundated during this event though.

The other significant increase in extent comes from the Dabholm Gut flow pathway. This extends through this watercourse and then spreads over the area at the A1085 including the top of the Wilton International allocations and Trunk Road (1). A small section of Corus 2 is also put at risk from this event.

Figure 7 - Flood extents for the existing risk scenario at the Level 2 SFRA sites



3.3.2 Flood Depth and Emergency Access

New development should be flood free during the 1 in 200 year event, flood risk mitigation measures should also take into account climate change (i.e. should be added to freeboard). New development should be able to manage the risk from the 1 in 1000 year event (or the 1 in 200 plus climate change event, whichever is higher). This does not necessarily mean that the development should be flood free for the 1 in 1000 year event, but measures such as flood resilience (see glossary) should be in place up to this event.

Table 2 below (taken from Volume I of RCBC's Level 1 SFRA) shows the typical depths where certain mitigation measures would be applicable.

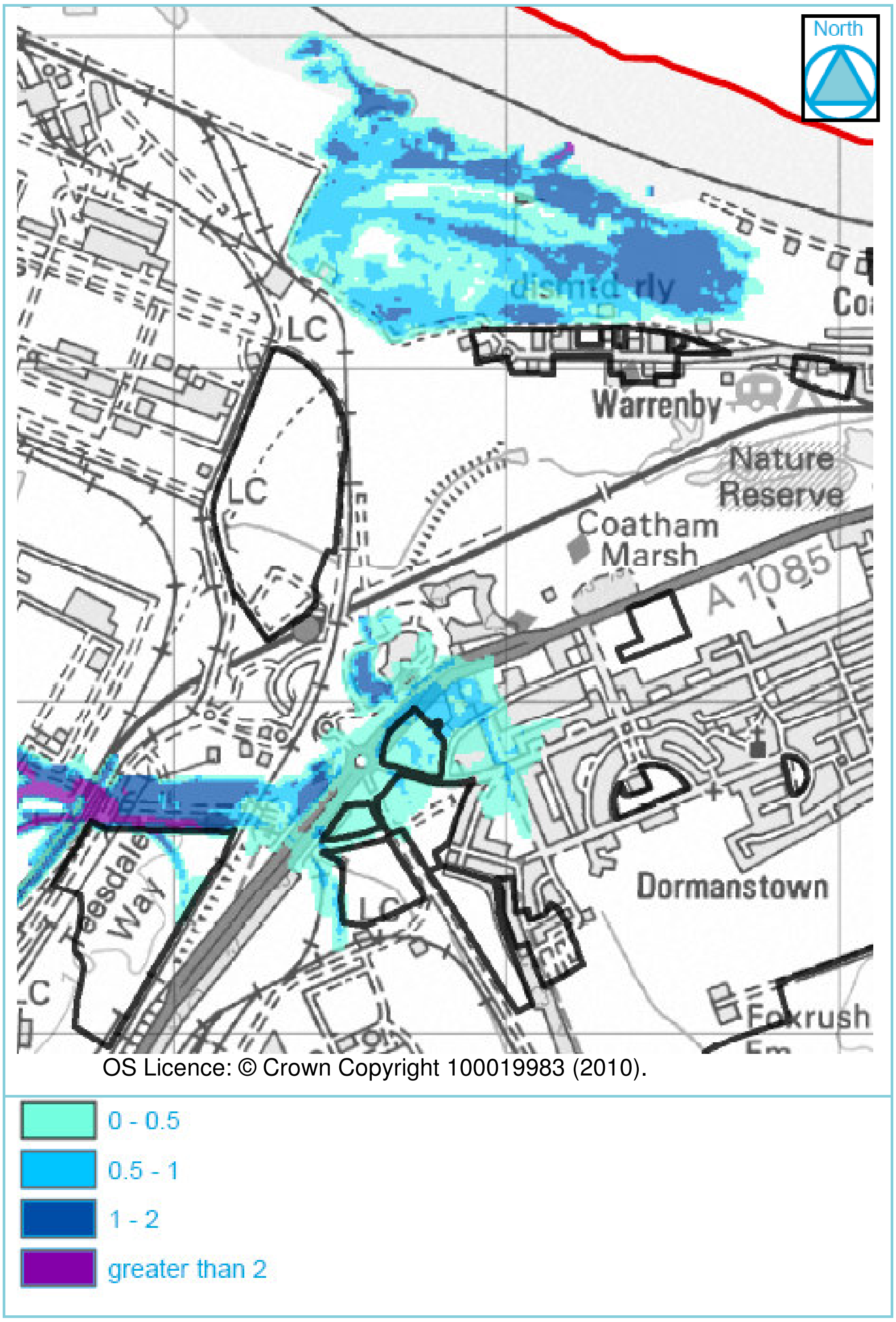
Table 2 - Suggested Screening Criteria for Mitigation Measures	
Depth of Inundation*	Comments
0 to 1.0 m	Sustainable mitigation and flood risk management may be feasible for both housing and employment purposes. There is a greater likelihood that the Exception Test can be passed.
1.0 to 1.5 m	Mitigation is likely to be costly and may not be economically justifiable for low value land uses. Housing allocations are considered appropriate, provided flood risk can be managed or mitigated (e.g. by using lower levels for car parks or public areas). Floor level raising for employment purposes is unlikely to be economically viable and employment allocations should be reconsidered in favour of alternative lower risk sites. The likelihood of passing the Exception Test is lower.
Above 1.5 m	Flood risk mitigation measures are unlikely to be economically justifiable and both housing and employment allocations should be reconsidered in favour of alternative lower risk sites. Development is unlikely to be sustainable and the likelihood of passing the Exception Test is low.
Notes: * Based on predicted depth of inundation for the 1% (Fluvial) event + 20% additional flow for Climate Change as per PPS25. Environment Agency flood zone data.	

The 1 in 200 and 1 in 1000 year flood events do not impact any of the development sites. However, flood depths on the north side of Corus 2 where it borders Dabholm Cut are around 1 to 2 meters for these events. Corus 2 is on higher ground and so even though flood depths are up to 2m during the 1 in 200 plus climate change event near to the site, only a small gully is flooded (see Figure 7). However, it would be prudent to ensure that there should be an emergency access and egress road away from this flood risk area to the north of the site.

The 1 in 200 year plus climate change (2010) event floods the north part of Wilton International to depths of between 0.5m and 1m and Trunk Road (1) to depths of around 1m (see Figure 8). These depths are not significant and can be managed through mitigation measures (see Table 3) such as flood resilience or land raising. In addition, as these sites are at risk of tidal flooding (as opposed to fluvial), there are no major constraints as compensatory flood storage will not be required for ground raising.

The Warrenby sites are not affected by the 1 in 200 plus climate change (2010) event due to the disused railway embankment. On the seaward side of this embankment are depths of between 1m and 1.5m. To take account of this, it should be ensured that there is an emergency access and egress route available to the east.

Figure 8 - 1 in 200 year+cc flood depth for the existing risk scenario at the Level 2 SFRA sites



Flood hazard

Table 3 below (taken from Volume I of RCBC's Level 1 SFRA) shows the flood hazard thresholds and aligns with the colours in Figure 9 and Figures A5 to A7 in Appendix A. The hazard ratings come from Defra / EA guidance on assessing acceptable levels of hazard to people[5].

Table 3 - Flood Hazard Thresholds		
Flood Hazard d(v+0.5)+DF	Description	Alternative Name / Hazard Class
0	Safe (dry)	None
0 to 0.75	Caution	Low
0.75 to 1.5	Dangerous for some	Moderate
1.5 to 2.5	Dangerous for most	Significant
Over 2.5	Dangerous for all	Extreme

As development needs to be dry for the 1 in 200 year event (taking into account climate change), flood hazard is normally used as an indicator for the level of residual risk (the 1 in 1000 or 1 in 200 year plus climate change event). The development does not have to be dry during this event, but should be safe.

For the existing risk scenario, none of the sites are flooded during the 1 in 200 or 1 in 1000 year events. The north part of Wilton International and Trunk Road (1 - Dormanstown Industrial Estate) are flooded during the 1 in 200 plus climate change event though. The risk to these sites from this event can be mitigated by either land raising or flood resilience measures. If flood resilience measures are chosen, then the people working at these sites would be at risk of flood hazards rated between low and moderate. This means that flood depths and velocities will be relatively low for these sites and would not put people at an unacceptable level of risk.

[5] Flood Risk Assessment Guidance for New Development. Phase 2, Framework and Guidance for Assessing and Managing Flood Risk for New Development – An Overview R&D Technical Report FD2320/TR1 and TR2, Defra / Environment Agency, October 2005

Figure 9 - 1 in 200 year+cc flood hazard for the existing risk scenario

OS Licence: © Crown Copyright 100019983 (2010).

3.4 Undefended Tidal Modelling Scenario

An undefended flooding scenario is required in order to understand what the risk would be to the proposed development allocations if none of the natural and manmade barriers to flooding were in place. The Environment Agency's Flood Zones are also produced with the natural and manmade barriers to flooding removed.

These outputs will be used as a comparison to the 'existing risk' scenario and will be a good indication of residual flood risk (see glossary). Flood risk assessments should take into account residual risk. This may mean additional mitigation measures or, if the residual risk is great, considering avoiding or a different land use for the allocation.

The undefended flood risk results are based on a conservative approach to an undefended scenario. The flood extents and flood depths have been produced by projecting the 1 in 200, 1 in 1000 and 1 in 200+cc flood levels across the LIDAR data (digital elevation model). The flood extents therefore ignore all topographical barriers to flood flow (compared to the existing risk results which models flow pathways and barriers to flow).

The two main barriers to flow that have been ignored in this scenario are the sand dune system and the disused railway embankment. As described earlier, the SMP2 states that the sand dunes are likely to remain in place for at least the next 100 years. An erosion rate of 0.2m/year has been estimated for the sand dunes (within the SMP2). Over the next 100 years, this would result in 20m of dune erosion, the dunes are between 100 and 150m wide in most places which means they would still provide a barrier to tidal flooding. However, it is possible that the dunes will roll back by a greater degree or that larger breaches may open up. This is especially important as the SMP2 policy for this area is ‘no active intervention’.

These results also show the flood extent if the disused railway embankment was not there. This is conservative as (due to its size) it should be viewed as a permanent topographical feature. However, it would not be totally unreasonable to see this feature being removed some time in the future by a developer (for example) as this feature is not designated/protected as a flood defence asset.

Figures showing the flood extents and depth for the 1 in 200, 1 in 1000 and 1 in 200 year + climate change and be seen in Appendix A, Figures B1 to B4. Figures enlarged around the Level 2 SFRA allocations are also included within the report.

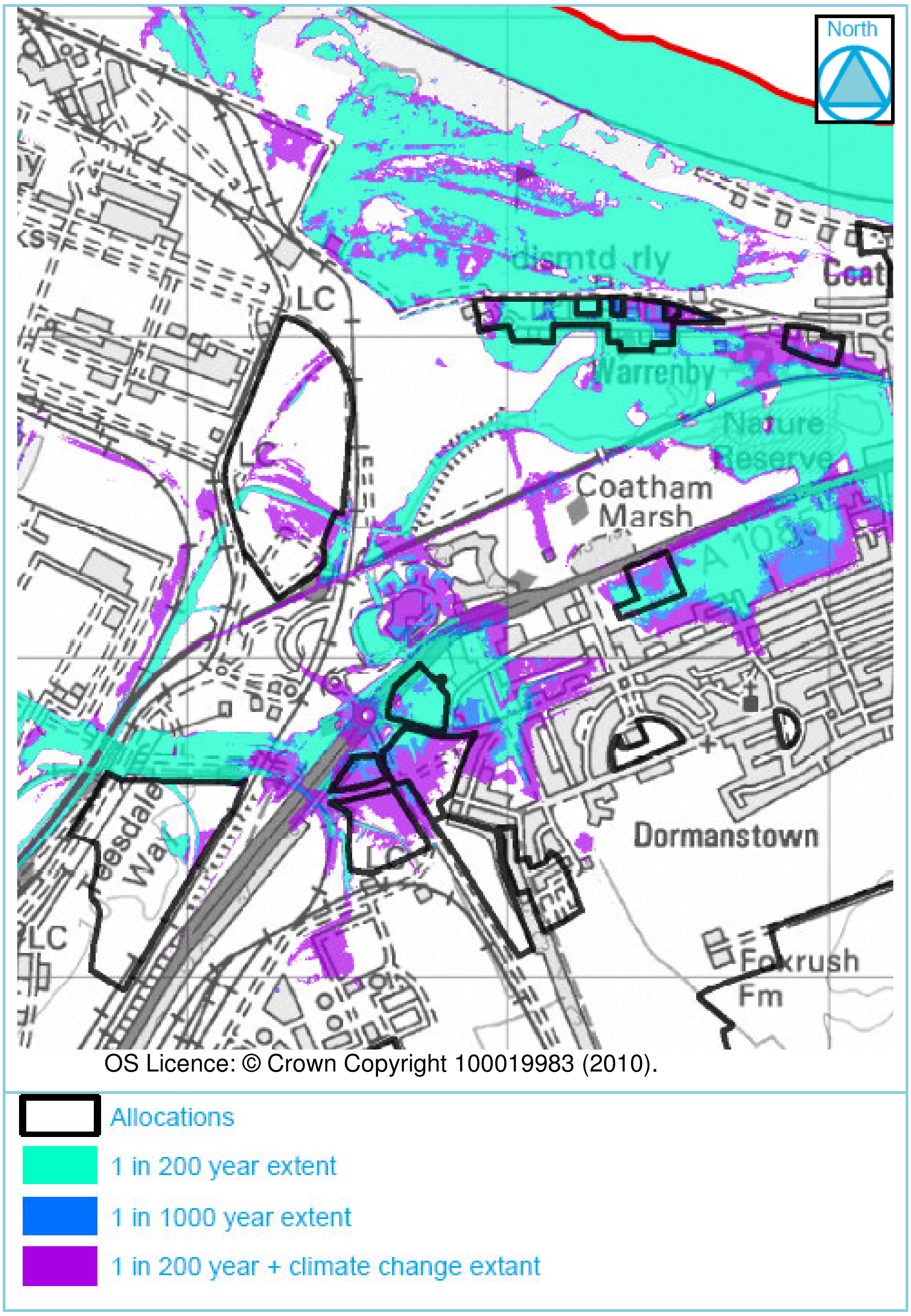
3.4.1 Flood extents and pathways

Figure 10 shows that if all natural and man made barriers to tidal flooding were removed, the Warrenby site and Trunk Road 1 and 2 would be at risk from the 1 in 200 year flood. The remaining sites would only be at risk from the 1 in 200 year+cc event (although some discreet areas would be at risk from the lower return period events).

Flooding to Warrenby, Warrenby Caravan Park and Trunk Road 1 sites are flooded primarily from the coastline at Coatham Sands (with the dunes removed or heavily breached). However, there is also a flood pathway from the Tees Estuary which gets to the sites via Dabholm Gut, the Wilton International/Steel House area and then Coatham Marsh. In the existing risk scenario, the A1085 is a barrier to this flow pathway. These flow pathways also put the north part of Wilton International and Trunk Road 1 at risk but for these sites, the predominant contribution is from Dabholm Gut.

A small flood extent is shown for Corus 3 during this scenario. This would come from Coatham sands, via Warrenby and is therefore dependant on the disused railway embankment as a blockage to flood flow.

Figure 10 - Flood extents for the undefended scenario

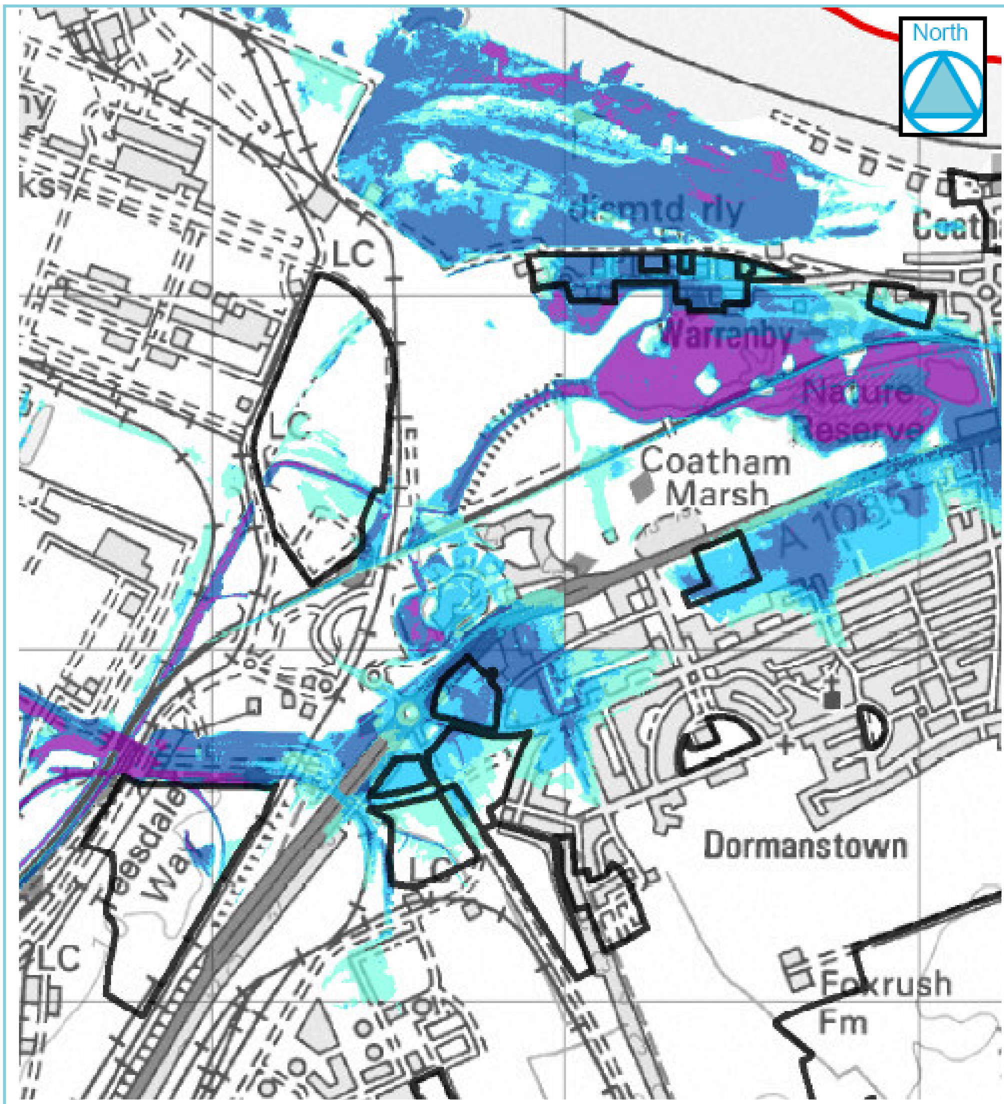


3.4.2 Flood depth

At Warrenby, the proposed employment site floods to depths of between 1m and 1.5m during the 1 in 200 year plus climate change undefended event (depths are nearer 0 to 0.5 for the 1 in 200 year event). This should be seen as a residual risk as the disused railway embankment, prevents tidal flooding reaching this site. Table 4 states that the cost of mitigation this flood risk may be a constraint. However, the mitigation measures required for this site are relatively straight forward (land raising or flood resilience measures above the 1 in 200 plus climate change flood level) and not excessively expensive. Alternatively, if it could be guaranteed that the disused railway embankment will not be removed, no mitigation measures would be required. The same issues apply to Warrenby Caravan Park and Trunk Road (1) but flood depths are more in the region of 0.5m to 1m. Emergency access and egress could be guaranteed if the disused railway embankment is maintained. If there are concerns over the longevity of this embankment, then Tod Point Road could be raised to tie in with the higher York Road to the east.

The north part of Wilton International and Trunk Road (1) are at risk from the existing risk and undefended scenarios. When considering mitigation measures, the flood depths from the existing risk scenario should be used this provides a more detailed summary of predicted flood depth, rather than projecting flood levels across the LIDAR topography.

Figure 11 - Flood extents for the undefended scenario



- 0 - 0.5
- 0.5 - 1
- 1 - 2
- greater than 2

3.5 Summary

The Level 1 SFRA identified a number of proposed employment (and one residential) sites within the Environment Agency's Flood Zone map in the area between the Tees Estuary and Coatham Sands (see Figure 1).

The planning process ensures only appropriate development takes place in areas vulnerable to flooding. This includes adopting a precautionary approach to decisions based on estimates of the present and future impact of flood risks. Although the sites assessed in this Level 2 SFRA are at some risk of flooding, there are strong economic and planning reasons why development should still go ahead in this area. These reasons should form part of the Exception Test (part a).

In addition, Chapter 2 described that the current Environment Agency Flood Zones in this area are in need of revision. New, more accurate flood levels have been made available along with a more accurate digital elevation model. By projecting these levels over the elevation model, significant differences can be seen between this and the current Flood Zones.

2D tidal modelling takes these improvements a step further by modelling a more realistic tidal flooding scenario. This 2D (TUFLOW) model includes the tide curves, flow pathways and barriers to flooding.

An 'existing risk' scenario was modelled that included the natural and man made barriers to flood flow and the limited volume of tidal flood water during the tidal cycle. This scenario included two gaps in the Coatham Sands dunes system and did not model a restriction to flow in Dabholm Gut to allow flood flow through these locations. This scenario showed that only the north part of Wilton International and Trunk Road (1) were at risk of flooding during the 1 in 200 year plus climate change event (the most extreme event modelled). Flood depth and hazard during this event could be managed relatively easily through simple mitigation measures.

A worse case, undefended scenario was developed by assuming all natural and man made barriers to flooding (including the sand dunes and disused railway embankment at Warrenby) were removed, with an unlimited volume of tidal flood water. This is a very conservative estimate of undefended flood risk, but ensures that any potential long term man made and natural changes are taken into account for example, the removal of the sand dunes. These extents showed that the Warrenby and Trunk Road (2) sites are at risk of flooding from the 1 in 200 year flood. Flooding occurs at a lower probability for Trunk Road (1), but in general, flooding in this area is similar to the 'existing risk' scenario. This means that flood risk to the Warrenby area is dependant on the disused railway embankment. If the flood defence function of the railway embankment can be formalised, then no mitigation measures will be required. If there are major doubts over this, then ground raising or flood resilience measures above the 1 in 200 plus climate change flood level should be a requirement of development to mitigate against this residual risk.

3.5.1 Flood Risk Assessment requirements for the Level 2 sites

Whilst the Level 1 SFRA focuses on delivering a strategic assessment of flood risk within RCBC, this Level 2 SFRA has gone one step further in investigating flood risk in more detail at specific sites. This Level 2 SFRA has outlined which sites could be developed safely and what mitigation measures will be required to do this if they pass the Sequential Test. However, there is still a need for a site specific flood risk assessment (FRA) to resolve detail.

General FRA guidance for developers has been supplied within the Redcar and Cleveland BC Level 1 SFRA, which must be referred to (see Chapter 3 of Volume III). Elements of the FRA guidance are listed below:

- Appropriate land use in flood risk areas
- Undefended areas – flood risk mitigation

- Defended areas
- Overtopping
- Breaching
- Public Safety and rapid inundation
- Feasibility of flood risk mitigation

Table 4 provides a summary of the tidal flood risks and the requirements for each site in order for development to go ahead safely. This table should be referred to when completing FRAs for the individual sites.

3.5.2 Emergency Planning

Appropriate emergency planning must be incorporated in any FRAs. Emergency planning can be a crucial tool in reducing the residual risk to both people and to lesser degree property. Current flood response plans must be considered if development is going to place a greater number of people in areas of high risk whether the actual risk can be managed or not.

Table 4 also identifies where emergency access routes should be identified for the Level 2 SFRA sites as part of emergency planning measures.

Table 4 - Site specific flood risk summary			
Site	**Existing Flood risk**	**Residual (undefended) risk**	**Development requirements**
Warrenby	Not at risk, protected by the disused railway embankment.	At risk from the 1 in 200 year flood, if the disused embankment were removed. Flood depths would be between 1 and 1.5m during the 1 in 200 year+cc event.	If the disused embankment can be maintained long-term, no mitigation measures will be required. If not, ground raising or flood resilience (the cheaper option) up to the 1 in 200 year+cc event would be required (1 to 1.5m from ground level). Tod Point Road would also need to be raised to tie in with the higher York Road to the east for emergency access.
Warrenby Caravan Park	Not at risk, protected by the disused railway embankment.	Only at risk from the 1 in 200 year+cc flood, if the embankment were removed. Flood depths would be between 0 and 1m during the 1 in 200 year+cc event.	If the disused embankment can be maintained long-term, no mitigation measures will be required. If not, ground raising or flood resilience up to the 1 in 200 year+cc event would be required (0 to 1m from ground level). Emergency access and egress can be made to the sites at higher ground to the north, tying in to York Road.
Trunk Road 1	Only at risk from the 1 in 200 year+cc event via Dabholm Gut. Flood depths are between 0 and 0.5m. Flood hazard is moderate.	Only at risk from the 1 in 200 year flood if the main active railway line embankment were removed. Flood depths would be between 0.5 and 1m for the 1 in 200+cc event.	Due to the presence of the active railway line embankment, this site is only at risk from the 1 in 200 year+cc event (this event overtops the embankment). An FRA should consider the ability of the railway line to prevent flooding from the 1 in 200 year flood event. The residual risk of flooding up to the 1 in 200+cc event should be mitigated through flood resilience or ground raising.
Trunk Road 2	Not at risk, protected by the disused railway embankment.	At risk from the 1 in 200 year flood, if the disused embankment were removed. Flood depths would be between 0.5 and 1m during the 1 in 200 year+cc event.	If the disused embankment can be maintained long-term, no mitigation measures will be required. If not, ground raising or flood resilience (the cheaper option) up to the 1 in 200 year+cc event would be required (0.5 to 1m from ground level). An emergency access and egress should be made available to the south (if the presence of the disused railway embankment can not be guaranteed).
Corus 2	A small section is at risk from the 1 in 200 year event, from the Dabholm Gut flood pathway. This comes from a ditch that runs through the site.	The same as existing risk. The majority of the site is on higher ground and there are no barriers to flooding here.	This site is situated on ground above all of the tidal flood events modelled. Any low areas could be raised. The Mill Race watercourse, may need to be kept open to reduce the risk of fluvial flooding though. This should be considered in an FRA.
Corus 3	Not at risk, protected against minor flood risk by the active railway line embankment.	Small scale flooding could occur on this site through backing up of The Fleet from the west and potentially via Coatham Sands if the disused embankment is removed for the 1 in 200+cc event. Flood depths would be minor (0 to 0.5m).	The majority of this site is above the 1 in 200 year+cc flood level. Some low areas would be at risk through tidal water backing up The Fleet from the west during the 1 in 200 year+cc event. The Fleet could also back up from the east if the disused railway embankment were removed. The viability of tidal gates on this watercourses should be considered in an FRA. Otherwise, The Fleet should be kept open and lower sections of land raised to the same levels as the rest of the site.
Wilton International	The north part is at risk from the 1 in 200+cc event via the Dabholm Gut flood pathway. Flood depth is 0 to 1m, flood hazard low to moderate.	The same as existing risk. There are no barriers to flooding here. Low flood depths and hazard are expected for the 1 in 200+cc event.	Only the north part of the site is at risk from the 1 in 200+cc event. The flood depths here are low. Ground raising or flood resilience measures up to the 1 in 200+cc flood would provide adequate protection.

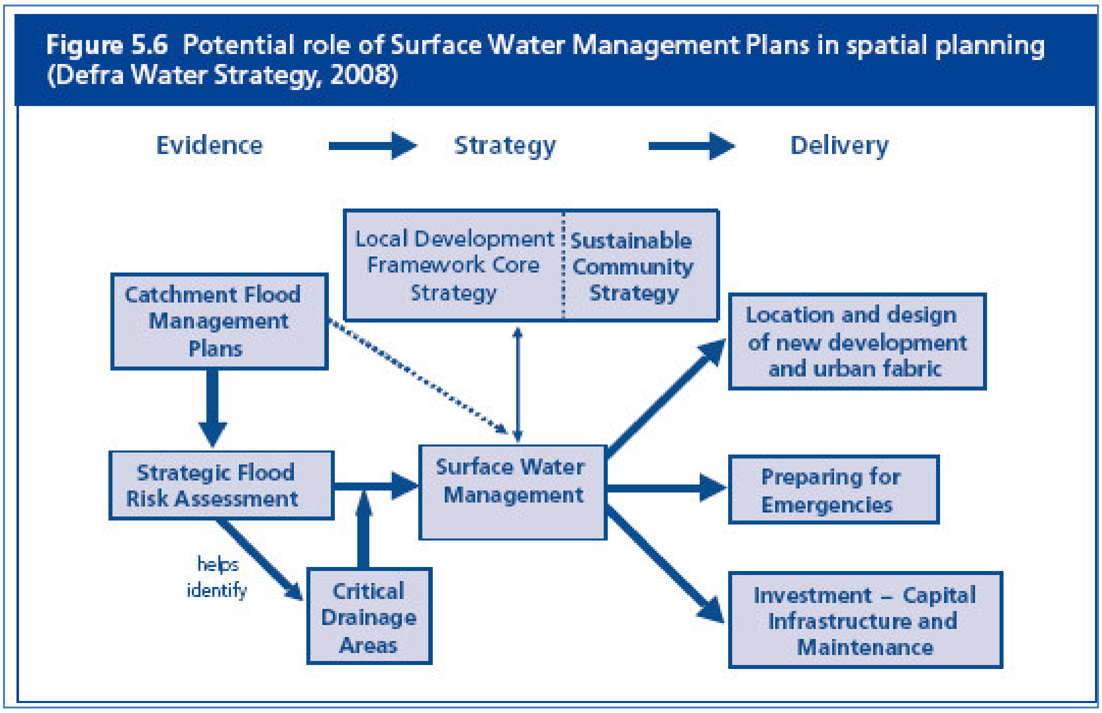
4. Critical Drainage Areas

4.1 Introduction

During the Level 1 SFRA, historical surface water flooding data was collected from a number of stakeholders. This included RCBC, the Environment Agency, Cleveland Emergency Planning Unit and Cleveland Fire Brigade. This data was combined with the Areas Susceptible to Surface Water Flooding maps collected from the Environment Agency.

Using the above data, 'candidate' Critical Drainage Areas (CDAs) were identified. CDAs are those areas identified from historical flood events and/or modelled data as having a significant risk from surface water flooding or subject to potential large changes in runoff due to development. PPS25 Practice Guide states that SFRAs should provide the evidence and recommendations for LPAs to understand the need for a Surface Water Management Plan (SWMP) by identifying Critical Drainage Areas (CDAs) within their borough.

The figure below, taken from PPS25 Practice Guide, shows how SFRAs link to SWMPs and then to overall spatial planning.



The candidate CDAs identified in the Level 1 SFRA includes the areas of Eston, Guisborough and Redcar.

These areas have been investigated further within this Level 2 SFRA through:

- Detailed surface water modelling;
- Consultation with Northumbrian Water; and
- Site visits and consultation with RCBC.

This has enabled the Level 2 SFRA to confirm the candidate CDAs as CDAs. When a SWMP is undertaken, these are the areas that should be focussed on.

4.2 Detailed Surface Water Mapping

As part of the confirmation of CDAs and to gain a better understanding of surface water flooding in RCBC, detailed surface water modelling has been completed.

The 2D modelling software developed by JBA called JFLOW was used to route rainfall over an elevation model. This is the same base tool used to produce the Environment Agency's Areas Susceptible to Surface Water Flooding maps (see Section 3.6 of Volume II Level 1 SFRA), however the following improvements were made:

- LIDAR data was used for the elevation model for the entire area;
- The elevation model was modified via MasterMap data to include roads and buildings to help define flow paths;
- The run-off from the surface was varied depending on whether an area was developed or green space, to take into account the variation in infiltration (water being absorbed by the ground);
- An extreme 1 in 200 year rainfall event with a storm duration of 1 hour was chosen; and
- Three flood outlines were produced 1) less, 2) intermediate and 3) more susceptible to surface water flooding.

Most new sewers are designed to a 1:30 year standard and hence sewer flooding problems will often be associated with more frequent storm events when a sewer becomes blocked or fails. In the larger events that are less frequent but have a higher consequence, surface water will exceed the sewer system and flow across the surface of the land. The capacity of the sewer network was therefore not taken into account.

Hence the surface water modelling and mapping, which is based on an extreme scenario, picks up overland flow paths that would be expected should the sewers surcharge (back up) or gulleys block.

Considering both sewer and surface water flooding together is considered to be appropriate when taking a strategic view of flood risk in an extreme event from both these sources.

This detailed surface water mapping has been used to verify the cCDAs and larger surface water flooding locations. Plans showing the detailed surface water mapping can be seen in Appendix A Figures C1 to C12.

4.3 Critical Drainage Areas

Section 2.4.1 in Volume II of the Level 1 SFRA provides an assessment of surface water flood risk. This includes flood historic and flooding locations in the candidate CDAs of Guisbrough, Redcar and Eston. The Level 2 SFRA builds on this with the findings from the detailed surface water modelling, site visit and further consultation.

4.3.1 Guisborough Critical Drainage Area

Description Of The Issue

The surface water flooding problems in Guisborough are strongly linked to the fluvial system of Chapel Beck (including, Hutton Beck, a tributary). The area of greatest concern mainly covers the part of Guisborough to the south of Chapel Beck. All of the surface water flow thorugh Guisborough eventually end us in chapel Beck.

During heavy rainfall events, runoff from the Guisborough Hills to the south rapidly reaches the south part of Guisborough. This runoff reaches Guisborough via a number of ditches passing through farm fields. As these drains and ditches reach the urban area, they enter low capacity culverts or ditches which are prone to blockage. Figure 12 shows one of these drains entering Guisborough to the south of the RCBC offices on Rectory Lane. This drain has been known to surcharge and flood a number of houses before entering Chapel Beck. Figure 13 shows another tributary entering Guisborough round the back of Sainsbury's.

Figure 12 - Looking u/s at a field drain as it enters Guisborough

Figure 13 - Tributary to Chapel Beck

The surface water flooding problem revolves around a number of these tributaries, which often enter small pipes, blocking and surcharging during heavy rainfall events. The surcharging results in surface water flooding, affecting houses, before the flow enters Chapel Beck.

Surface water from new development enters the Chapel Beck system as NWL do not allow new surface water discharge to enter combined sewers. This strain on the Chapel Beck system could increase as new development (some on greenfield land) takes place. Opportunities to reduce overall runoff rates should be sought, but this will be difficult with new development on greenfield land.

In addition to this, high flows on Chapel Beck can cause the surface water sewers (and small culverted ordinary watercourses) that enter the beck, to back up. The system can then surcharge and spread over land causing surface water flooding (see Figure 14).

This part of Guisborough is not a key surface water flooding priority according to Northumbrian Water (NWL). This appears to be because many of the problems are associated with ditches and culverts for which RCBC are responsible for (and not because the problem is insignificant). Flood events in this area are not one off events, they occur regularly, with a recent flood history (see section 2.4.1)

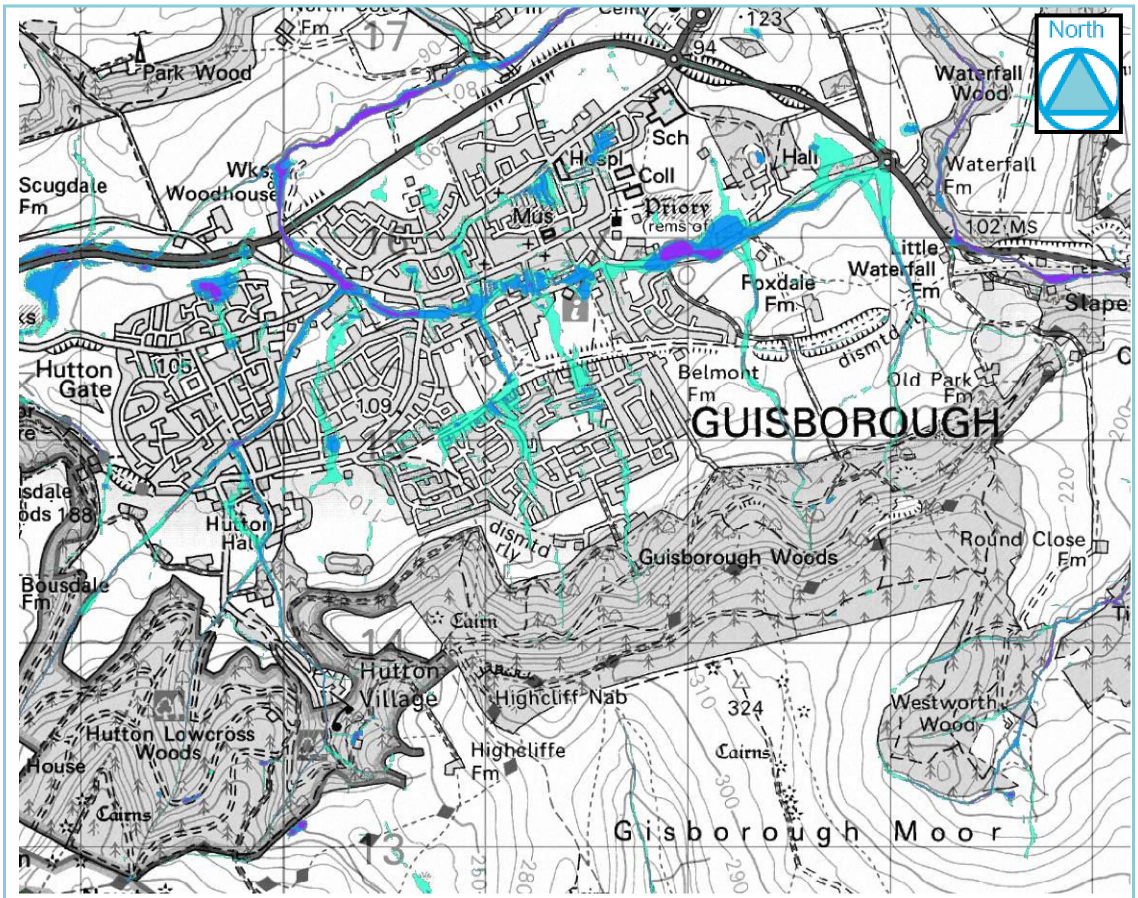
Figure 14 - Surface water sewer entering Chapel Beck

In summary, the CDA for Guisborough relates to the surface water drainage system (composed of pipes, culverts, ditches and small watercourses) to the south of Chapel Beck. During heavy rainfall events, runoff rapidly reaches the urban area from the Guisborough Hills. The sewer system is under capacity and prone to blockages, as a result, the heavy rainfall overwhelms the system.

Surface Water Modelling

As described in section 4.2, detailed surface water modelling has been undertaken for this area. An extract of the output for Guisborough is shown in Figure 15 below. As can be seen from this figure, the main surface water flow routes are south to north from Gisborough Moor and into Chapel Beck. This aligns with the information gathered for this study, i.e. runoff coming from the hills to the south and surcharging the system during storm events. The main urban flow pathways are between Hutton Beck and Belmangate, in the south part of Guisborough. This is where the main historic flooding locations are, surface water flooding extents represent the most likely places that surface water will go, following surcharging of the surface water sewer system.

Figure 15– Detailed surface water mapping in Guisborough



High Susceptibility to Surface Water Flooding

Medium Susceptibility to Surface Water Flooding

Low Susceptibility to Surface Water Flooding

Conclusion and Potential Strategic Solutions

The surface water flooding problems that exist in Guisborough is due to one main source and one flood mechanism via a number of flood pathways. The problems are predominantly confined to the south part of Guisborough (south of Chapel Beck). The surface water sewer system and a number of small, culverted ordinary watercourses take runoff from Gisborough Moor, via the Guisborough urban area and into Chapel Beck. The surface water sewer system and culverts lacks capacity and can back up during high flows on Chapel Beck.

There are three main flood sources in the urban area (see Figure 16) coming from the Moors to the south. It may be possible to attenuate the storm flows in one place, before it reaches the urban area.

- One option could be to investigate the potential for peat bog restoration on Gisborough Moor through grip blocking. This would allow runoff to stay stored in the moors for longer durations rather than allowing it to flow quickly through manmade or eroded drainage cuttings. A Natural England example can be found at: **http://www.naturalengland.org.uk/about_us/news/2009/210409.aspx**. Alternatively, woodland planting in the upland catchment could help to reduce peak runoff.
- Similarly, opportunities could be sought to attenuate surface water runoff within the fields directly to the south of the village, by allowing the main feeder streams to come

out of bank during heavy rainfall events (through a stewardship schemes for example).

These two solutions would also have environmental benefits as well as reducing peak flows on Chapel Beck (a flood risk watercourse).

Modification to the sewer system is another option by increasing the pipe size. However, this would increase flow conveyance to Chapel Beck (which already has flood risk problems). A hard engineering solution should therefore consider attenuation, for example storage tanks near the top of the system.

Ultimately, the location should be taken forward to a SWMP where all parties (including RCBC, NWL and the Environment Agency) would come together to find a solution to reduce peak runoff and/or increase the drainage capacity (see section 4.4).

4.3.2 Redcar Critical Drainage Area

Description Of The Issue

The Level 1 SFRA described the type of surface water flooding in Redcar that arises in urbanised areas. Modified watercourses, culverts and surface water sewers that pass through areas like Redcar can block and surcharge. As there is no space for this flood water to go, roads become pathways, flooding surrounding properties. In addition, Redcar has a relatively flat topography, meaning that there may be a lack of gradient in parts of the surface water sewer system resulting in low discharges through the system. This also means that large areas may be affected by surface water flooding as any surcharging would spread further on a flat topography.

The drift of the lower parts of Redcar is sand. When this is saturated during high tide events, the water table can remain high; adding to surface water flood risk as this high water table restricts the infiltration of surface water runoff.

There is a recent, regular surface water flood history in these locations with the most recent being the summer of 2009 (see section 2.4.1 in Volume II of the Level 1 SFRA). These events have caused flooding to properties.

There are three main watercourses/culverts/surface water sewers that pass through Redcar which are the main source of surface water flooding (see Figure 16). These include:

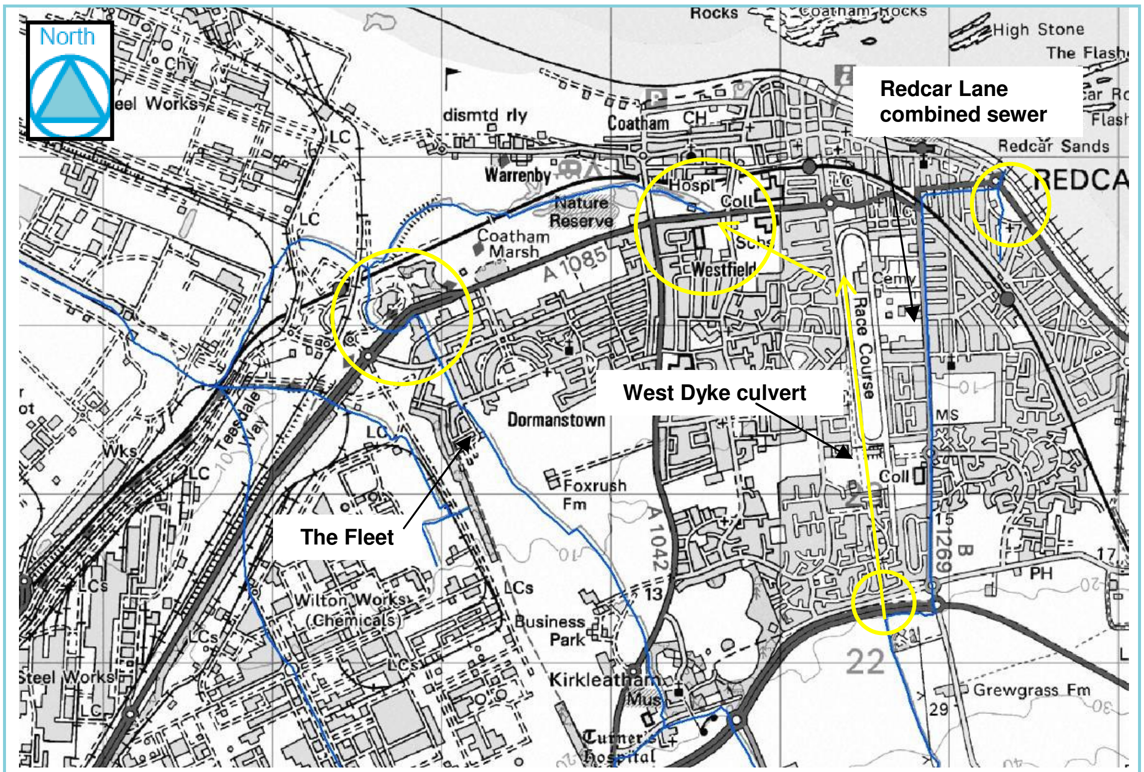
- The Fleet watercourse;
- West Dyke culvert; and
- Redcar Lane surface water sewer.

Flooding from these sources is concentrated in four main locations; these are circled in yellow on Figure 16.

Figure 16 shows a main river centre line following Redcar Lane and originating from Roger Dyke. This is in fact a surface water sewer. Roger Dyke flows into West Dyke and roughly follows the yellow line before converging with The Fleet near Dormanstown.

In contrast to Guisborough, the main flooding issues in Redcar are due to combined sewers not being able to cope with the runoff coming from the hills to the south and urban area during heavy rainfall events. In Guisborough the problem is predominantly related to surface water sewers and small, culverted ordinary watercourses.

Figure 16 - Redcar location map



OS Licence: © Crown Copyright 100019983 (2010).

- The blue line is the Environment Agency's main river network.
- The yellow line is a correction made after a site visit and consultation with RCBC.

There is a combined NWL sewer system and a surface water sewer running along **Redcar Lane** (neither of these sewers receives flow from Roger Dyke as shown on the Environment Agency's main river map). The surface water sewer eventually flows into the combined sewer before discharging into the North Sea. This combined sewer system is unable to cope with the amount of flow it receives during heavy rainfall events and there are several sewer flooding incidents along the sewer line. Surface water flooding occurs in nearby Zetland Park as this area is lower than the outfall to the north. NWL have recently completed schemes to improve the capacity of combined sewers in this area. This may have reduced the flooding issues in this area. Any new development will not be allowed to discharge surface water runoff into Redcar Lane combined sewer and efforts should be made to reduce surface water discharge from new developments here.

The **West Dyke** culvert starts on the edge of Redcar at Oxgang Bridge (A174) as it takes the flow from Roger Dyke which originates in the uplands near Eston Moor. This is where flooding issues start. West Dyke used to be open here, but since it has been culverted, it has caused flooding to nearby bungalows which are located in a dip.

Significant redevelopment and development on greenfield land is proposed in this area (e.g. Redcar racecourse). NWL will resist permitting any surface water runoff from new developments to enter their combined sewers. The temptation will then be to direct the runoff into West Dyke culvert (this has already happened with some new developments). If this happens, the greenfield development in particular has the potential to increase surface water runoff which would increase peak flows in West Dyke culvert during heavy rainfall events.

The West Dyke culvert can just about cope with the flood flows it currently receives (although there has been flooding events associated with it in the past). A strategic solution will be required for the new developments here in order to reduce the strain on West Dyke culvert.

The greatest risk of flooding from this system is around Mersey Road down to the A1085. In the area around Thames Road and Mersey Road, there is a combined sewer system that has caused flooding to properties. NWL have completed a scheme in this area, so the risk should have been significantly reduced for this specific area. However, this is a low lying area and there are remaining issues. Storage options may need to be considered here.

The Fleet watercourse passes through open farmland before entering Dormanstown as a modified (straightened and culverted) Watercourse. This watercourse takes the majority of the runoff from the east side of Eston Moor. The Fleet then enters the Corus steel works land. RCBC do not have access to this land for maintenance and inspection purposes. It is thought that siltation due to a lack of maintenance on this watercourse (and a pond) within Corus land causes backing up of The Fleet and contributes to surface water flooding in this low lying area. Limerick Road in particular floods on a regular basis (Figure 17 shows the Fleet at Limerick Road)

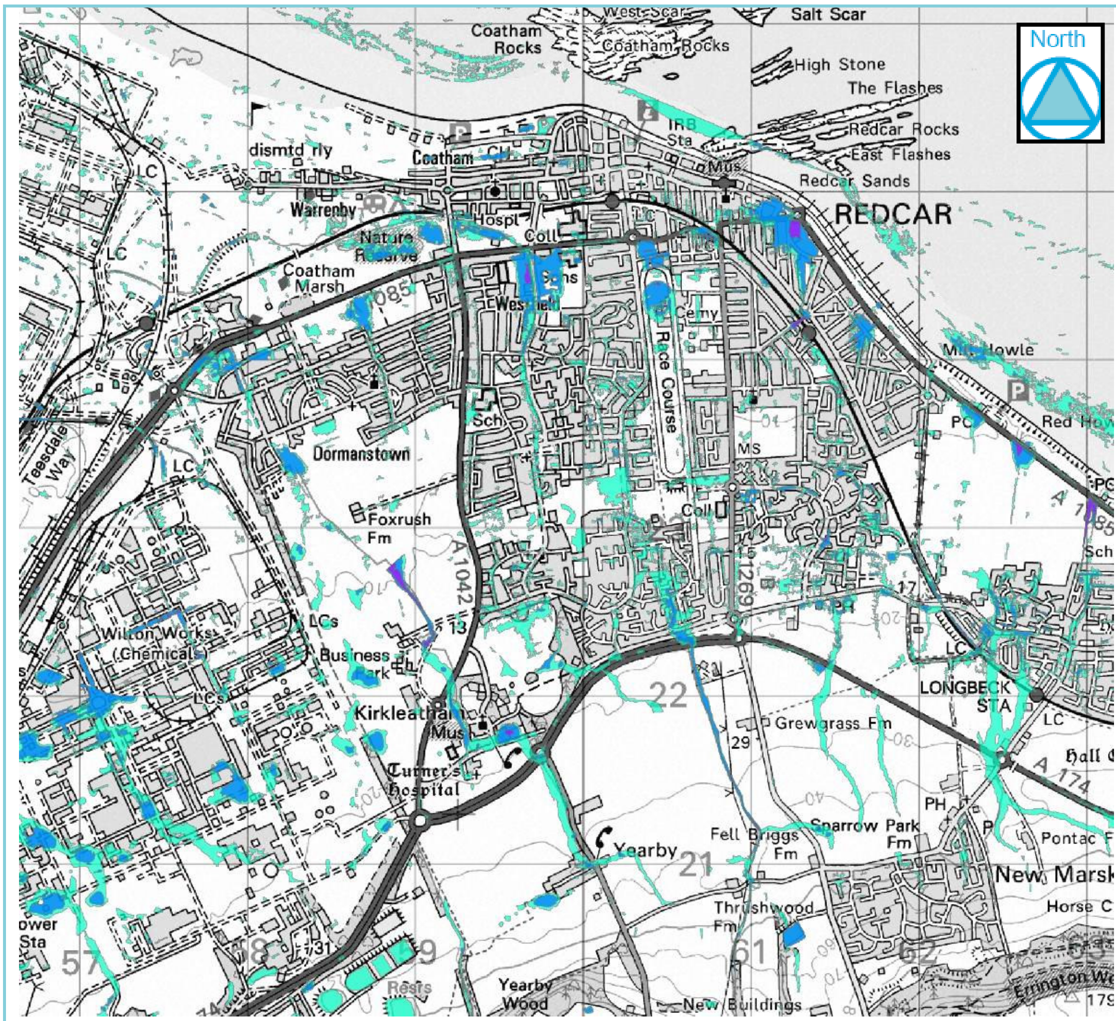
Figure 17 - The Fleet looking downstream at Limerick Road

Surface water mapping

Outputs from the surface water flooding maps can be seen in Figure 18 below (also see Figures C2, C3, C5 and C6 in Appendix A). The Figure shows the potential for surface water flooding in the three main locations in Redcar as described above. The surface water flow pathway can be seen if West Dyke culvert surcharged at the A174. But in general, the flood extents are confined to the roads until they reach the A1085 and railway line. Here, on this lower lying, flat land, flood water has the potential to extend further and with greater depths.

The source of the surface water can also be seen in Figure 18. There are around five main surface water flow paths flowing from the hills to the south and through agricultural land before entering the culverted watercourses (West Dyke culvert and The Fleet) and sewer system in Redcar.

Figure 18– Detailed surface water mapping in Redcar

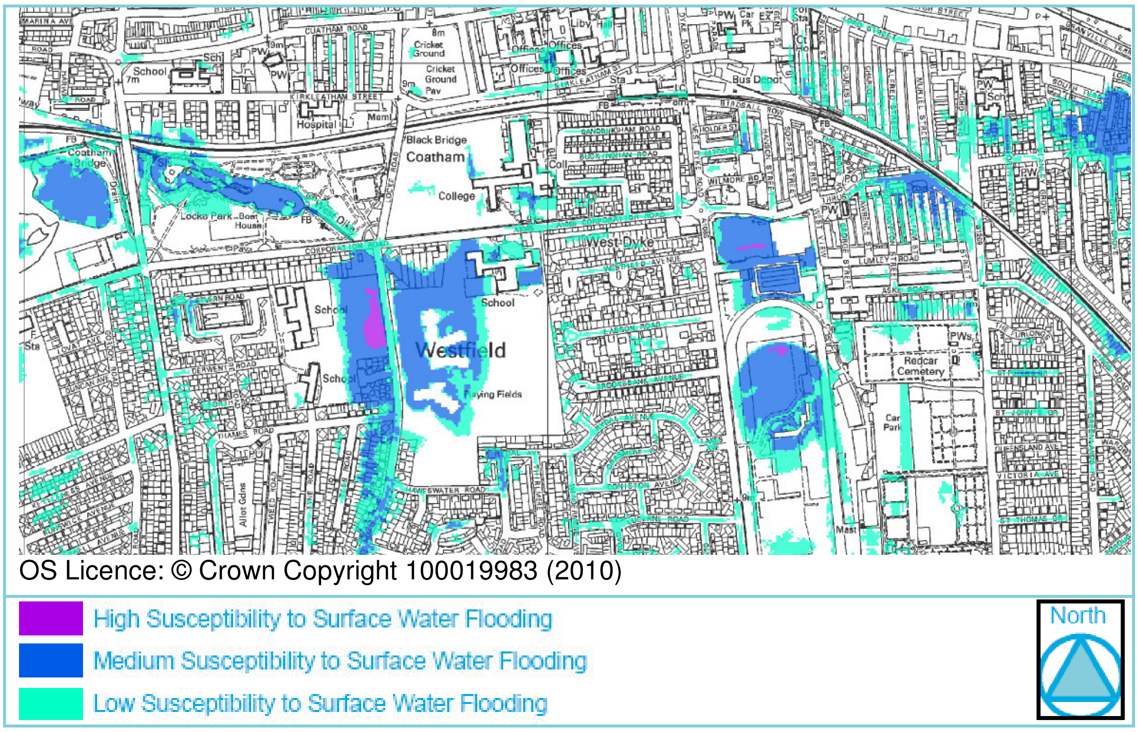


© Crown Copyright 100019983 (2010).

High Susceptibility to Surface Water Flooding
Medium Susceptibility to Surface Water Flooding
Low Susceptibility to Surface Water Flooding

The detailed mapping extract in Figure 19 shows where the areas of greatest risk (greatest probability, extent and depths) are. These areas are actually green open spaces within Redcar. It is likely that these areas could be enhanced to have a flood attenuation function. This means that developing in these areas (e.g. the racecourse) could significantly increase surface water flood risk in Redcar, if this is not taken into account.

Figure 19– Detail of the area at greatest risk in Redcar



Conclusion and Potential Strategic Solutions

Similarly to Guisborough, the main source of flooding in Redcar is heavy rainfall in the local hills rapidly reaching the urban sewer network and culverted watercourses. The contributing catchment is moorland which has been converted to farmland, so opportunities for peat bog restoration may also be applicable. In addition, the ditches that carry the runoff pass through a relatively large section of agricultural land before entering Redcar (see Figure 20). Opportunities to increase flooding in this area to reduce flows within Redcar may be an option (through an environmental stewardship scheme for example).

Significant future redevelopment is proposed for parts of Redcar, adjacent to the main surface water flood risk locations (e.g. The Closes and Redcar Racecourse). Opportunities exist to significantly improve the situation through strategic surface water drainage solutions (rather than unconnected piecemeal works).

Within Redcar itself, there is a large connected green area, composed of the racecourse and a number of public and school playing fields. Parts of this area are already shown to be at risk of surface water flooding. These areas may naturally attenuate surface water flows and should therefore be maintained. As some of these areas are earmarked for development, this should be a key consideration. Any development here should seek to improve the existing situation and not increase runoff into the already under strain system.

One way to reduce surface water flood risk could be redesigning the topography to allow more of this area to flood. Alternatively, if some of the urban area is to be redeveloped, the culverts (which carry the main flow) could be opened up and a green pathway developed as part of the green infrastructure network, allowing for an active floodplain and improving biodiversity and amenity space.

If a hard engineering solution is sought, then any increase in conveyance (through increasing culvert/sewer capacity) may increase flood risk to the downstream locations. Taking this into account, storage tanks at the top of Redcar or downstream of a larger culvert/sewer, could be an option.

Similar to Guisborough, this location should be taken forward to a SWMP where all parties (including RCBC, NWL and the Environment Agency) would come together to form a solution (see section 4.4).

4.3.3 Eston Critical Drainage Area

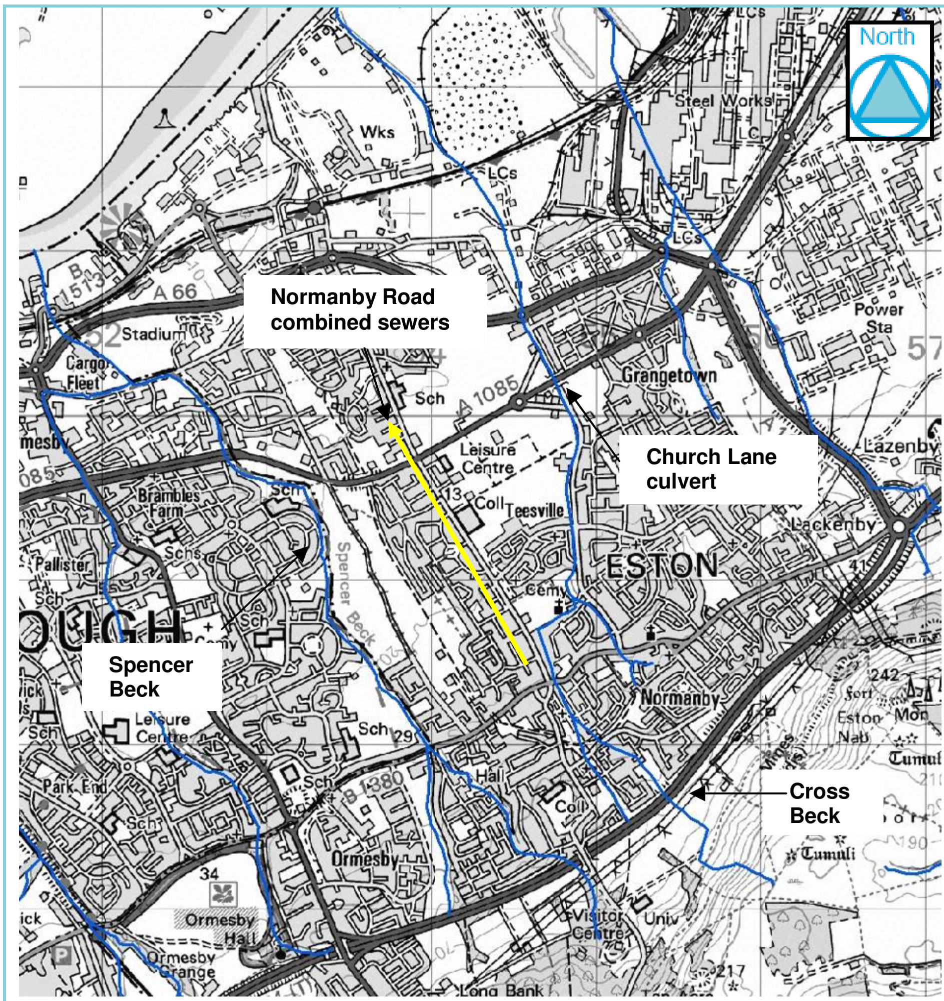
Description Of The Issue

Runoff from heavy rainfall rapidly reaches the urban area from the nearby, steep Eston Moor. Figure 20 shows Eston Moor at the A174, just before the Eston urban area. Flood risk in Eston is predominantly associated with two main flood pathways:

- **The Church Lane culvert.** This culvert originates from a several tributaries that come from Eston Moor, the main tributary being Cross Beck. These tributaries combine within Eston and convey the majority of the flow from Eston Moor and the majority of the surface water drainage from Eston. Figure 21 shows the location of the main watercourses and culverts.
- **Normanby Road combined sewers.** Two combined sewers run parallel to Normanby Road and a combined sewer overflow (CSO) takes storm flows into the downstream end of Spencer Beck. Two small open and culverted drains also link into this system. All of the surface water from this part of Eston ends up in Spencer Beck (see Figure 21).

Figure 20 - Eston Moor from the A174

Figure 21 - main flood sources in Eston



OS Licence: © Crown Copyright 100019983 (2010).

The majority of Eston's surface water drainage eventually ends up in the Church Lane culvert with the remainder being conveyed through the Normanby Road CSOs and then Spencer Beck.

This culvert and the associated surface water sewers that run perpendicular to the Church Lane culvert are unable to cope with the flows during heavy rainfall events.

Similarly, the CSOs that run parallel to Normanby Road and the perpendicular connecting sewers are also prone to surcharging due to capacity issues. There have been many flooding incidents in the Teesville area, but a scheme is planned by NWL which may reduce the risk here. Linked to Normanby Road CSO surface water flood risk are two part open and culverted drains that pass through relatively open ground near the school and sports centre at Lowfields. These drains/surface water sewers eventually lead to Spencer Beck and present a surface water flood risk along this route.

Flooding occurs in Eston regularly (once or twice a year), including the flooding of properties. The flooding dates and description of individual incidents can be seen in section 2.4.1 in Volume II of the Level 1 SFRA.

Some of the small culverted ordinary watercourses and drains in Eston pass through private land, complicating the flooding issues. This means that the residents are responsible for maintenance in some cases. RCBC have made efforts maintain some of these private areas but development has taken place immediately up to the watercourses in some cases making it difficult to gain access. Figure 22 shows where a developer has erected a fence across a small urban watercourse in Eston, creating a potential blockage and flood risk.

Figure 22 - Fence across a watercourse in Eston

Another complication with surface water flooding in Eston is the high concentration of dissolved ochre (iron oxide) originating from the old iron mines above Eston. The ochre precipitates out in the pipes creating an iron crust, reducing the pipe capacity. Figure 23 shows one of the ochre rich watercourses before it enters Eston. This has resulted in some pipes being blocked completely and having to divert flow into a relief drain (which is also crusting up).

Figure 23 - Ochre rich watercourse near Eston by the A174

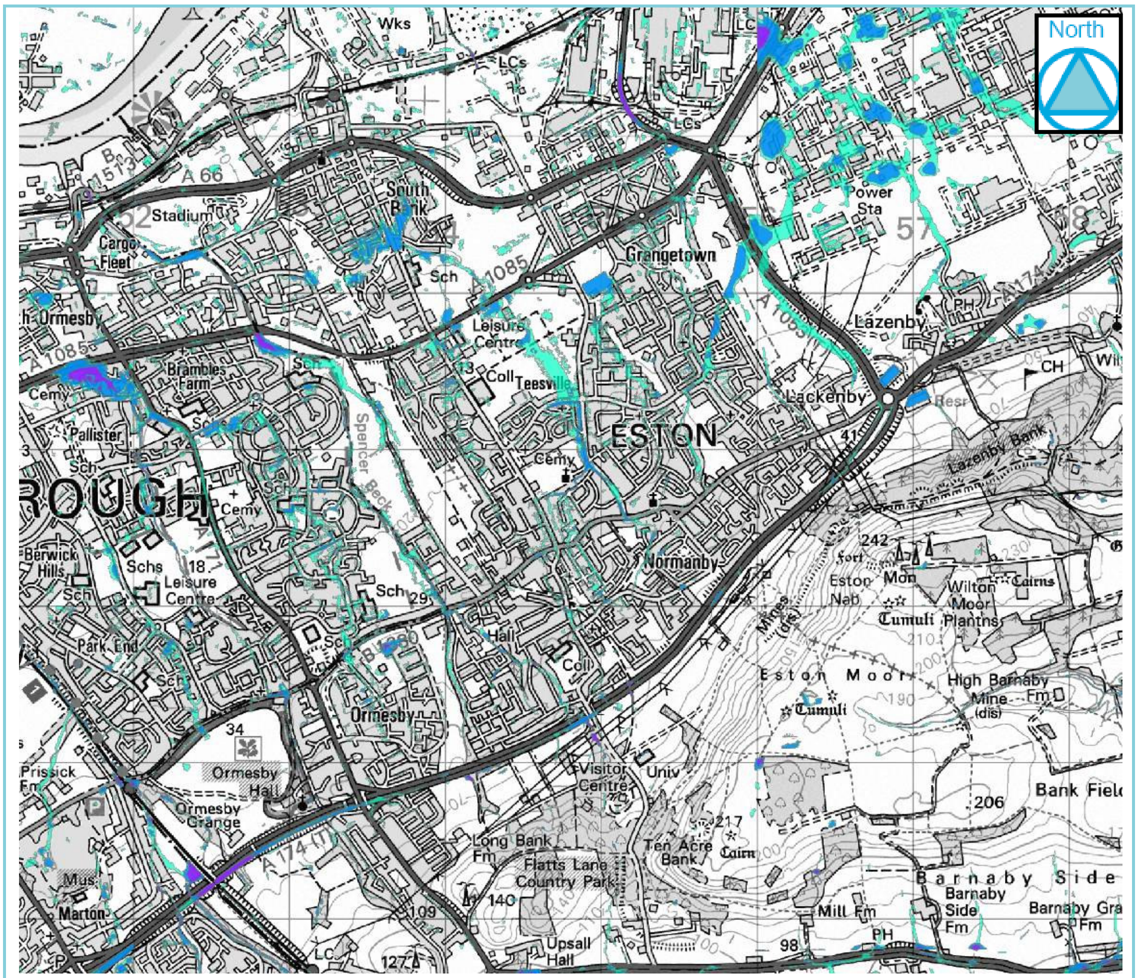
Redevelopment is proposed for much of the north part of Eston. This may present opportunities to reduce the overall strain on Church Lane culvert and Normanby Road system, but the redevelopment may also want to discharge more surface water runoff into these two systems. It may be difficult to reduce the net surface water runoff in this area as a significant amount of greenfield development is also proposed. Although SUDS can easily be integrated into greenfield sites, the ground conditions mean that on site surface water attenuation options will be limited.

Surface water mapping

The detailed surface water mapping shown in Figures 24 and 25 illustrate a strong surface water flow pathway between the Normanby Road combined sewers and the Church Lane culvert. The source of this flow is Cross Beck. The detailed extract in Figure 25 shows strong flow pathways down St Helens Close (following on from Cross Beck) and down Church Lane. The main flood extent from this pathway is in Lowfields (green open space) and around Hampden Street and Normanby Road.

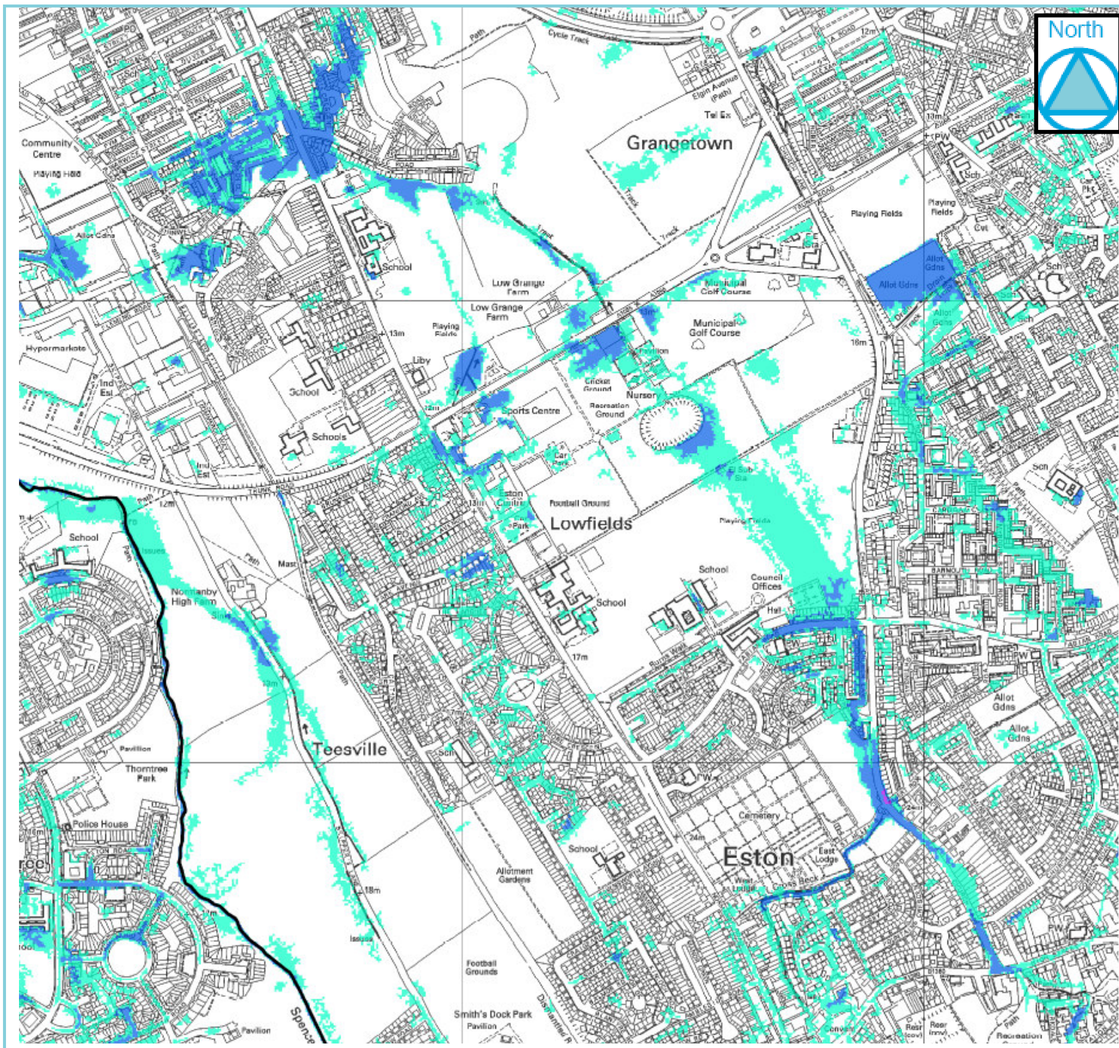
The source of the surface water can be seen as coming from Eston Moor via many small tributaries that would probably only be in flow during heavy rainfall events. Cross Beck is a major collection point for taking the flow into Eston. There is also another significant collection point at Flatts Lane. This flow will either end up in Spenser Beck, the combined sewers on Normanby Road or Cross Beck.

Figure 24– Detailed surface water mapping in Eston



OS Licence: © Crown Copyright 100019983 (2010).

Figure 25– Detail of the area at greatest risk in Eston



OS Licence: © Crown Copyright 100019983 (2010).

High Susceptibility to Surface Water Flooding
Medium Susceptibility to Surface Water Flooding
Low Susceptibility to Surface Water Flooding

Conclusion and Potential Strategic Solutions

Similar to Redcar, there is a significant amount of green open space in Eston. This provides opportunities to use this space as green infrastructure for reducing surface water flood risk and enhancing biodiversity and amenity. However, there is also major development planned is Eston, on previously developed sites but also within some of the greenfield areas.

For the already developed areas, this provides opportunities to improve the existing situation through a strategic surface water drainage scheme. The greenfield development is more likely to increase net runoff rather than an opportunity for improvement, especially the greenfield areas that are at risk of surface water flooding.

The combined sewers on Normanby Road are at capacity and should not take any more surface water flow from new development (NWL are likely to insist on this). The only other location for the surface water runoff to go will be either Spence Beck or Cross Beck (Church Lane culvert). Both of these watercourses have existing flood risk issues.

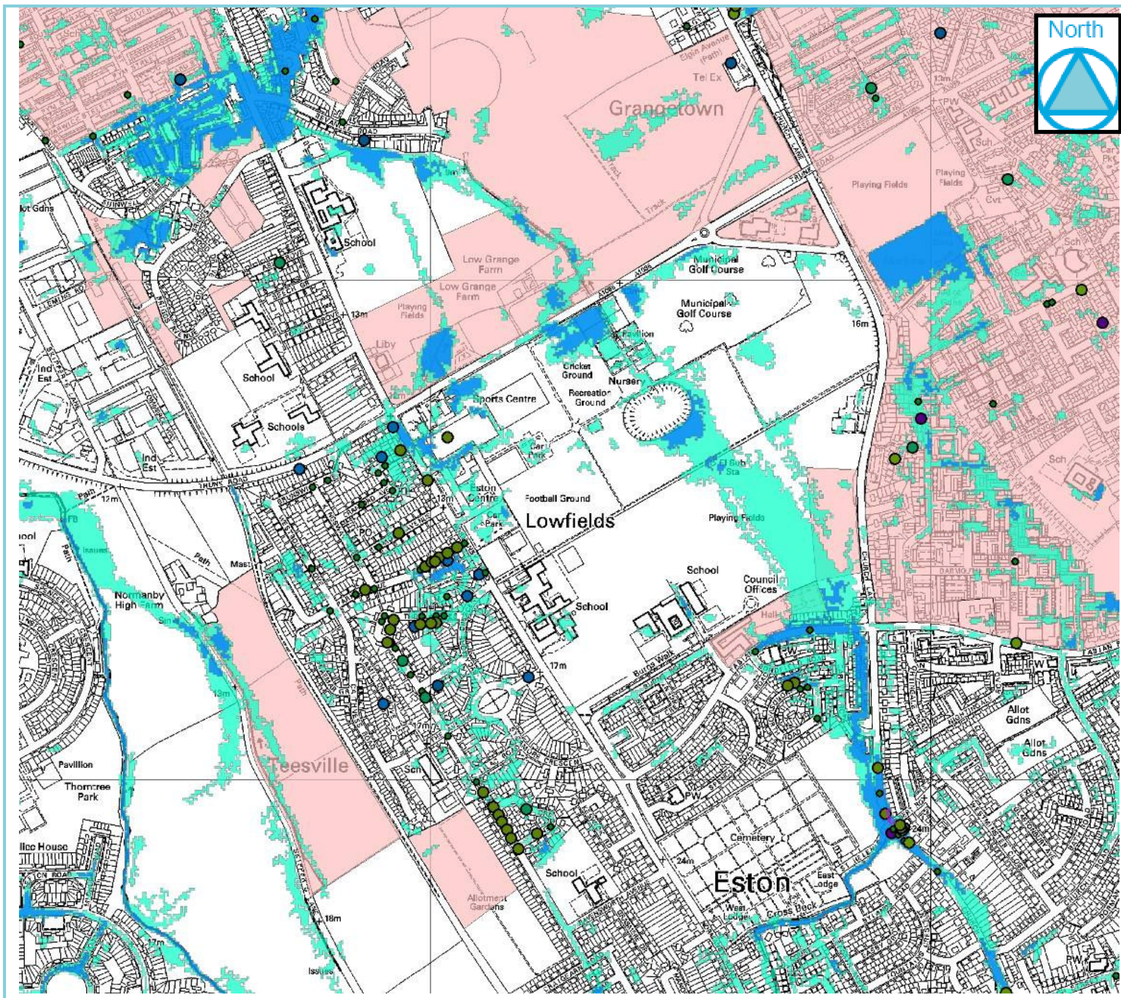
In summary, a solution needs to be able to deal with the existing and potential increase in surface water flow without increasing flow to the combined sewers and watercourses. In addition, a solution should try and reduce the amount of ochre that enters the culverts and surface water sewer pipes, causing them to block, potentially through treating the runoff closer to the source.

The flow from some of the tributaries that contribute to the Church Lane culvert could be attenuated. An example is at the recreation ground parallel to Ripon Way. The original surface water sewer here has become encrusted by the ochre and a relief drain is now used (although this is slowly reducing in capacity). This drain can surcharge and flood the adjacent houses. If this drain was opened up and allowed to flood the recreation area (during high flows), then the risk to the houses would be reduced as well as reducing the strain on the Church Lane culvert. This could be done in a number of ways, one part of the culvert could be opened up to allow the field to flood and then direct the flow back into a downstream section of the culvert at a slower rate than the original situation. Alternatively, all of the culvert could be opened up and an open watercourse restored. This could provide biodiversity and amenity benefits, and could contribute to a green infrastructure network in Eston.

Similar opportunities should be sought where major redevelopment is proposed in Eston. This should be a key consideration for the proposed development at Grangetown, Low Grange Farm and South Bank, as the Church Lane culvert, combined sewers and surface water flow paths. Figure 26 shows the proposed development areas (pink), the detailed surface water mapping and the historic flooding locations.

The Eston catchment (which provides the runoff contributing the surface water to Eston's drainage system and watercourses) is small originating from one location (Eston Moor). It therefore may not be too difficult to attenuate the peak flows closer to the source. This could be done by designing a storage area at the foot of Eston Moor, just before Eston (see Figure 24). In addition, a solution is needed to tackle the iron ochre which is precipitating out and blocking the sewer and culvert pipes in Eston. In the short to medium term, a number of sewers will become defunct and will need to be replaced or bypassed. A long term solution should therefore be considered. As a long term solution, the viability of using a surface water storage area (as described above) to filter out the iron ochre could be assessed. This could be achieved through a reed bed system. This would have the added benefits of treating the surface water before it passes through Eston which would make any existing watercourses and others that are opened up within Eston more attractive.

Figure 26– Proposed development, surface water maps and historic flooding locations



High Susceptibility to Surface Water Flooding

Medium Susceptibility to Surface Water Flooding

Low Susceptibility to Surface Water Flooding

4.4 Future Studies

4.4.1 SWMP Related Studies

As described earlier, SFRAs should identify Critical Drainage Areas (CDAs). Surface Water Management Plans (SWMPs) should then prioritise these CDAs and develop a greater understanding and solutions for the surface water flooding issues. Section 6.2.2 in Volume III of the Level 1 SFRA provides more details on SWMP requirements.

In general, a SWMP will be required if there are complex flood mechanisms with a number of different stakeholders involved and for areas where significant new development and regeneration is proposed.

The timing for the completion of the SWMP is dependant on available funding. However, within RCBC, surface water flooding is an issue that occurs regularly so early action is encouraged.

A number of individual studies have been proposed below, based on the work completed in the Level 1 and 2 SFRA. These studies could form part of a full SWMP or as individual studies if 'quick wins' funding is available. Alternatively, when a major development comes forward, part of the developer requirement could be to undertake a Drainage Management Strategy to establish a strategic surface water drainage solution before construction (see 4.4.2 for further information).

Guisborough

- A study to investigate the effectiveness of land management change in reducing peak runoff and therefore flood risk in Guisborough. For example, the potential for peat bog restoration on Gisborough Moor through grip blocking or upland tree planting. The potential for land management to reduce peak flows within the south part of Guisborough's sewer system should be the focus. The potential environmental benefits should also be highlighted.
- Included in the above study or as a separate study, the viability of attenuating surface water runoff within the fields directly to the south of Guisborough, by allowing the main feeder streams to come out of bank during heavy rainfall events. The potential environmental benefits should also be highlighted
- A hard engineering solution to the surface water flooding problems e.g. storage in the system.

If any of the above studies developed into a scheme, it would have the added benefit of reducing flood risk from Chapel Beck (a main rover with a history of flooding problems). The first two approaches could provide significant environmental benefits.

Redcar

- The contributing catchment is moorland which has been converted to farmland, so opportunities for peat bog restoration and tree planting similar to Guisborough may also be applicable.
- The ditches that carry the majority of Redcar's urban runoff pass through a relatively large section of agricultural land before entering Redcar (see Figure 24). Opportunities to increase natural flooding in this area to reduce flows within Redcar may be an option (through an environmental stewardship scheme for example).
- Significant future redevelopment is proposed for parts of Redcar, adjacent to the main surface water flood risk locations (e.g. The Closes and Redcar Racecourse). Opportunities exist to significantly improve the situation through strategic surface water drainage solutions (rather than unconnected piecemeal works). The works here could form part of a Drainage Management Strategy or SWMP where runoff rates etc can be set. A Drainage Management Strategy will be able to propose a strategic surface water management solution for the new development, promote the use of SUDS and set runoff rates.
- Where possible, green/open areas within Redcar should be protected and opportunities to reduce surface water flood risk by further utilising these green areas could be investigated.
- A hard engineering solution for example storage ponds at the top of Redcar's drainage system or downstream of a larger culvert/sewer (so as not to increase risk downstream), could be investigated.

Eston

- The potential for a storage area at the foot of Eston Moor, just before Eston and the viability of using a surface water storage area to filter out the iron ochre could be assessed. This could be achieved by designing a reed bed system.
- There is a significant amount of green open space and proposed redevelopment in Eston. Opportunities to use the green space as green infrastructure to reduce

surface water flooding and a strategic drainage solution within the redevelopment should be investigated, potentially as part of a Drainage Strategy or SWMP.

- Significant future redevelopment is proposed for parts of Eston, adjacent to the main surface water flood risk locations. Opportunities exist to significantly improve the situation through strategic surface water drainage solutions (rather than unconnected piecemeal works).
- The flow from some of the tributaries that contribute to the Church Lane culvert could be attenuated. An example is at the recreation ground parallel to Ripon Way.

4.4.2 Surface Water Drainage and Development

When major proposed developments come forward, opportunities for developing a Drainage Management Strategy across development site boundaries should be explored, and a catchment led approach should be adopted. This approach has been recognised in the consultation paper by Defra, Making Space for Water. An integrated approach to controlling surface water drainage can lead to a more efficient and reliable surface water management system as it enables a wider variety of potential flood mitigation options to be used. In addition to controlling flood risk, integrated management of surface water has potential benefits, including improved water quality and a reduction of water demand through grey water recycling.

Surface water drainage assessments are required where proposed development may be susceptible to flooding from surface water drainage systems. The potential impact upon areas downstream of the development, including the impact on a receiving watercourse, also needs careful consideration.

The specific requirements for surface water drainage systems will need to be discussed with the Council's Land Drainage Engineers, Environment Agency and Northumbrian Water. Consideration should be given to whether a "greenfield runoff approach" to the assessment of source control is appropriate. This method is generally satisfactory in the cases where the development is relatively small, isolated from other planned sites and the runoff processes are fully understood.

The FRA should then conclude with an assessment of the scale of the impact, and the recommended approach to controlling surface water discharge from a proposed development.

4.4.3 SUDS

This section provides a strategic summary of the applicability of SUDS techniques in RCBC. This is a broad scale assessment and should therefore not be used for assessing individual sites but it should be used for strategic planning. For more detailed assessments such as individual planning applications or site investigations, a comprehensive reporting service for specific locations and can be found here: **http://www.landis.org.uk/services/sitereporter.cfm**

Table 2 shows the soil types, the expected ground conditions from this soil type and the SUDS techniques that will be possible with these ground conditions.

The SUDS techniques are categorised as storage (i.e. water stored on site and then slowly released) or infiltration (i.e. where surface water is allowed to infiltrate into the ground). Infiltration SUDS require ground conditions that allow the infiltration of surface water through the ground. Clay rich soils and areas with a high water table will not be suitable for infiltration SUDS. Table 1 shows the infiltration and storage SUDS techniques.

For this broad assessment of soils a simplified 1:250,000 soils dataset, derived from the more detailed National Soil Map. This is Cranfield University data and is available online. The drift geology data was obtained in GIS format from the British Geological Survey.

Table 5 - Suitability of SUDS Techniques

SUDS Technique	Infiltration	Storage
Green Roofs	×	✓
Permeable Paving	✓	×
Rainwater Harvesting	×	✓
Swales	✓	✓
Detention Basins	✓	✓
Ponds	×	✓
Wetlands	×	✓
Source: PPS25 Practice Guide		

Table 6 - Strategic SUDS Applicability

Area	Soils and drif	Ground conditions	SUDS Implications
Eston, Redcar, Guisborough	Drift - till. Soil - Seasonally wet, loamy clayed soils.	These soils have impeded drainage which means that they are generally wet and winter waterlogging can result in very wet ground conditions.	SUDS infiltration techniques may not be possible, only SUDS storage techniques or underground storage basins.
Eston Moor	Drift - rock. Soil - slightly acid loamy soils	Freely draining soils which means this area should absorb rainfall readily and allow it to drain through to underlying layers.	The soil type indicates that it could be suited to surface water storage in the upper catchment. Lower down the drainage is impeded.
Gisborough Moor	Drift - rock. Soil Mixture of wet upland soils, peat with a wet surface and clayey soils with impeded drainage.	Generally impeded drainage and pools of surface water	The soil type already stores surface water storage in the upper catchment and could possibly be enhanced through grip blocking.
Steel works, Teesport and north part of Eston	Drift - raised marine deposits of sand and gravel. Soil - loamy and clayey soils of coastal flats.	These soils are naturally wet and have naturally high groundwater levels.	SUDS infiltration techniques will not be possible, only SUDS storage techniques or underground storage basins.
New Marske, Sketon, Skinningrove, Loftus	Drift - till. Soils - loamy clayey soils.	This soil/drift type leads to slightly impeded drainage. These soils form a tight, compact, deep subsoil that impedes downward water movement. After heavy rainfall, particularly during the winter, the subsoil becomes waterlogged.	Infiltration systems should be possible, they could be impeded after prolonged heavy rainfall though.

Appendices

A. Figures

(Provided separately)

B. Glossary

Attenuation

Reduction of peak flow and increased duration of a flow event.

Catchment Flood Management Plans (CFMP)

A strategic planning tool through which the Environment Agency will seek to work with other key decision-makers within a river catchment to identify and agree policies for sustainable flood risk management.

Climate change

Long-term variations in global temperatures and weather patterns, both natural and as a result of human activity.

Compensation storage

A floodplain area introduced to compensate for the loss of storage as a result of land raising for development purposes.

Design event

A historic or notional flood event of a given annual flood probability, against which the suitability of a proposed development is assessed and mitigation measures, if any, are designed.

Design flood level

The maximum estimated water level during the design event.

DG5 register

Register held by water companies on the location of properties at risk of sewage related flooding problems

Digital Elevation Model (DEM)

A digital representation of ground surface topography or terrain. It is also widely known as a digital terrain model (DTM).

Extreme Flood Outline

Flood 'zone' maps released by the Environment Agency to depict anticipated 0.1% (1 in 1000 year) flood extents in a consistent manner throughout the UK

Flood defence

Flood defence infrastructure, such as flood walls and embankments, intended to protect an area against flooding to a specified standard of protection.

Flood Map

A map produced by the Environment Agency providing an indication of the likelihood of flooding within all areas of England and Wales, assuming there are no flood defences. Only covers river and sea flooding.

Floodplain

Area of land that borders a watercourse, an estuary or the sea, over which water flows in time of flood, or would flow but for the presence of flood defences where they exist.

Flood Risk Management (FRM)

The introduction of mitigation measures (or options) to reduce the risk posed to property and life as a result of flooding. It is not just the application of physical flood defence measures.

Flood risk management strategy

A long-term approach setting out the objectives and options for managing flood risk, taking into account a broad range of technical, social, environmental and economic issues.

Flood Risk Assessment (FRA)

A study to assess the risk to an area or site from flooding, now and in the future, and to assess the impact that any changes or development on the site or area will have on flood risk to the site and elsewhere. It may also identify, particularly at more local levels, how to manage those changes to ensure that flood risk is not increased. PPS25 differentiates between regional, sub-regional/strategic and site- specific flood risk assessments.

Flood risk management measure

Any measure which reduces flood risk such as flood defences.

Flood Zone

A geographic area within which the flood risk is in a particular range, as defined within PPS25.

Fluvial

Flooding caused by overtopping of rivers or stream banks.

Freeboard

The difference between the flood defence level and the design flood level, which includes a safety margin for residual uncertainties.

Greenfield land

Land that has not been previously developed.

ISIS

ISIS is a software package used for 1-Dimensional river modelling. It is used as an analysis tool for flood risk mapping, flood forecasting and other aspects of flood risk management analysis.

LIDAR

Light Detection And Ranging. Airborne laser mapping technique producing precise elevation data (see DEM).

Local Development Framework (LDF)

A non-statutory term used to describe a folder of documents which includes all the local planning authority's Local Development Documents (LDDs). The local development framework will also comprise the statement of community involvement, the local development scheme and the annual monitoring report.

Local Development Documents (LDD)

All development plan documents which will form part of the statutory (LDDs) development plan, as well as supplementary planning documents which do not form part of the statutory development plan.

Main River

A watercourse designated on a statutory map of Main Rivers, maintained by Defra, on which the Environment Agency has permissive powers to construct and maintain flood defences.

Major development

A major development is:

a) where the number of dwellings to be provided is ten or more, or the site area is 0.5 Ha or more or

b) non-residential development, where the floorspace to be provided is 1,000 m^2 or more, or the site area is 1 ha or more.

NFCDD

The Environment Agency's National Flood and Coastal Defence Database (NFCDD).

Ordinary watercourse

All rivers, streams, ditches, drains, cuts, dykes, sluices, sewers (other than public sewer) and passages through which water flows which do not form part of a Main River. Local authorities and, where relevant, Internal Drainage Boards have similar permissive powers on ordinary watercourses, as the Environment Agency has on Main Rivers.

Permitted development rights

Qualified rights to carry out certain limited forms of development without the need to make an application for planning permission, as granted under the terms of the Town and Country Planning (General Permitted Development) Order 1995.

Planning Policy Statement (PPS)

A statement of policy issued by central Government to replace Planning Policy Guidance notes.

Previously-developed land

Land which is or was occupied by a permanent structure, including the (often referred to brownfield land) curtilage of the developed land and any associated fixed surface infrastructure (PPS3 annex B)

Ramsar Site

Sites identified or meeting criteria set out in The RAMSAR Convention on Wetlands of International Importance. This definition has no legal status, but such sites are designated as SSSIs under the Wildlife and Countryside Act 1981 (as amended).

Regional Spatial Strategy (RSS)

A broad development strategy for a region for a 15 to 20 year period prepared by the Regional Planning Body.

Reservoir (large raised)

A reservoir that holds at least 25,000 cubic metres of water above natural ground level, as defined by the Reservoirs Act, 1975.

Residual risk

The risk which remains after all risk avoidance, reduction and mitigation measures have been implemented.

Resilience

Constructing the building in such a way that although flood water may enter the building, its impact is minimised, structural integrity is maintained and repair, drying & cleaning are facilitated.

Resistance

Constructing a building in such a way as to prevent flood water entering the building or damaging its fabric. This has the same meaning as flood proof.

Return period

The long-term average period between events of a given magnitude which have the same annual exceedence probability of occurring.

Risk

The threat to property and life as a result of flooding, expressed as a function of probability (that an event will occur) and consequence (as a result of the event occurring).

Run-off

The flow of water from an area caused by rainfall.

Shoreline Management Plan (SMP)

A plan providing a large-scale assessment of the risk to people and to the developed, historic and natural environment associated with coastal processes. It presents a policy framework to manage these risks in a sustainable manner.

Standard of Protection (SOP)

The design event or standard to which a building, asset or area is protected against flooding, generally expressed as an annual exceedence probability.

Strategic Flood Risk Assessment (SFRA)

The assessment of flood risk on a catchment-wide basis for proposed development in a District.

Sustainable Drainage Systems (SUDS)

A sequence of management practices and control structures, often referred to as SUDS, designed to drain water in a more sustainable manner than some conventional techniques. Typically these are used to attenuate run-off from development sites.

Sustainability Appraisal (SA)

An integral part of the plan-making process which seeks to appraise the economic, social and environmental effects of a plan in order to inform decision-making that aligns with sustainable development principles.

TUFLOW

TUFLOW is a software package used for 2-Dimensional river modelling. It is used as an analysis tool for flood risk management analysis.

Vulnerability Classes

PPS25 provides a vulnerability classification to assess which uses of land maybe appropriate in each flood risk zone.

Washland

An area of the floodplain that is allowed to flood or is deliberately flooded by a river or stream for flood management purposes.

Water Framework Directive (WFD)

A European Community Directive (2000/60/EC) of the European Parliament and Council designed to integrate the way water bodies are managed across Europe. It requires all inland and coastal waters to reach “good status” by 2015 through a catchment-based system of River Basin Management Plans, incorporating a programme of measures to improve the status of all natural water bodies.

Offices at

Atherstone
Doncaster
Edinburgh
Haywards Heath
Limerick
Newcastle upon Tyne
Newport
Northallerton
Northampton
Saltaire
Skipton
Tadcaster
Wallingford
Warrington

Registered Office
South Barn
Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE

t:+44(0)1756 799919
e:info@jbaconsulting.co.uk

Jeremy Benn Associates Ltd
Registered in England 3246693