Ipswich Borough Council
Level 2 Strategic Flood Risk Assessment
Revised
May 2011

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Limitations.

The SFRA is limited to the area within Ipswich Borough Councils administrative boundary. It is intended for the use of Ipswich Borough Council. Information contained or used has been gathered from a range of different sources, the providers of such information should be contacted before making any irreversible decisions based upon it.

Ipswich Borough Council provides no warranty as to the accuracy, completeness, or suitability for any purpose of the information contained herein.

Issue & Version List

Date	Version	To
26 March 2010	14	Strategic Planning, Planning Inspectorate
31 March 2010	15 – typing errors, page numbers	Strategic Planning, Planning Inspectorate, IBC web site
25 March 2011	24	EA
13 May 2011	25	EA
23 May2011	26 - Safety framework, now includes frequency of overtopping. Frequency maps in 5.16 and 5.18 corrected. Tables in 16.4	EA 23/5/2011
26 May 2011	27 - Recommendations, policies	Exec summary and section 16 to Russell Williams
26 May 2011 27 May 2011 31 May 2011	28 – Added recommendation re Climate change & Minor revisions	Andy Osman – Suffolk Resilience Forum Will Todd – EA Strategic Planning, Planning Inspectorate

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LIST OF APPENDICES

1 EXECUTIVE SUMMARY

1.1 Introduction

This assessment follows Planning Policy Statement 25 (PPS25 Dec 2006) and the "PPS25: Development and Flood Risk Practice Guide" (Dec 2009) and relates to potential development sites listed in the Strategic Housing Land Availability Assessment (SHLAA), which identifies land available for possible allocation in the site-specific plans stage of the Ipswich Local Development Framework (LDF). It supersedes the draft level 1 SFRA dated November 2007 which was intended to inform the sequential test at the preferred options stage.

It is apparent, from the SHLAA, that in order to achieve Regional Spatial Strategy (RSS) growth targets between now and 2021, it would be necessary to develop brown field sites within the flood plain in Ipswich.

This level 2 SFRA is therefore required to enable the exception test to be carried out for certain types of potential land use allocations for possible development sites in the flood plain. It should also enable Ipswich Borough Council to undertake a sequential test approach to flood risk, based on the consequences of flooding on existing and proposed development in high-risk flood areas as part of the preparation of the LDF.

The original level 1 SFRA assumed no tidal flood defences and was based on tide levels that have since been revised as part of the design process for the Ipswich Flood Defence Management Strategy. Final details of the strategy, received in January 2010, have now enabled this level 2 SFRA to be produced accounting for the presence of recently improved defences, as well as for the planned flood defence barrier expected to be operational in 2014.

The SFRA also considers the potential effects of development on local flooding and minor watercourses and identifies mitigation measures including sustainable urban drainage systems (SUDS) and suggests a framework for safe development in flood zones 2 & 3.

This level 2 SFRA is a living document In the future, updates will be provided when the Surface Water Management Plan is completed, on completion of the Ipswich Flood Defence Barrier and as relevant parts of the Floods and Water Management Bill come into force.

1.1.1 Ipswich Flood Defences

The older parts of the existing tidal flood defences are deteriorating and long lengths are expected to reach the end of their life between 2012 and 2017.

Improvements are planned and *"The Environment Agency has received approval, in principle, for the Ipswich Flood Defence Strategy, which provides for a major flood defence investment in the form of a barrier in the area of the New Cut, together with some improvements and repairs to the existing flood defences."*

Flood walls either side of the barrier were completed in March 2011.

The barrier element of the strategy is dependant on allocation of national funding, however the programme has been approved with completion expected in 2014. Funds for design have been allocated for 2011/12

The SRFA therefore considers two circumstances:

- With existing defences (this includes new defences along East and West banks and a new flood gate in the Wet Dock Lock.
- As above but with proposed barrier across the New Cut. This barrier will be a gate that is raised in advance of predicted surge tides likely to cause flooding. It is not intended to raise upstream water levels.

1.2 Key planning objectives

PPS25 sets out government policy on development and flood risk. Extracts from page 2 of PPS25 follow:

The aims of planning policy on development and flood risk are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at highest risk. Where new development is, exceptionally, necessary in such areas, policy aims to make it safe without increasing flood risk elsewhere and where possible, reducing flood risk overall.

Regional planning bodies (RPBs) and local planning authorities (LPAs) should prepare and implement planning strategies that help to deliver sustainable development by:

- *Identifying land at risk and the degree of risk of flooding from river, sea and other sources.*
- *Preparing Regional Flood Risk Appraisals or Strategic Flood Risk Assessments as appropriate, as freestanding assessments that contribute to the Sustainability Appraisal of their plans;*

- *Framing policies for the location of development, which avoid flood risk to people and property where possible, and manage any residual risk, taking account of the impacts of climate change.*
- *Only permit development in areas of flood risk when there are no suitable alternative sites in areas of lower flood risk and the benefits of the development outweigh the risks from flooding.*
- *Safeguard land from development that is required for current and future flood management e.g. conveyance and storage of floodwater, and flood defences.*
- *Reduce flood risk to and from new development through location, layout and design, incorporating sustainable drainage systems (SUDS).*
- *Use opportunities offered by new development to reduce the causes and impacts of flooding.*
- *Enable decisions on planning applications to be delivered expeditiously.*
- *Ensure spatial planning supports flood risk management and emergency planning.*

Annex D of PPS25 describes what land uses may be permissible in various flood risk zones. Some developments are only permissible if they satisfy the "exception" test.

1.3 Conclusions

1.3.1 Storm surge tidal flooding is the predominant, but not the sole, flooding factor in determining land use allocation in Ipswich; other drainage/flooding related factors would also affect development density, layout and form.

1.3.2 For thousands of years sea levels have been rising. During the last few hundred years, waterside towns such as Ipswich adapted to the increasing flood risk. Over the years waterside commercial buildings were built on filled raised land. Street levels were gradually raised as they were surfaced and resurfaced. New buildings were built on top of more ancient foundations. Residential areas were established uphill in safer areas. Buildings were not sited in the lowest areas of Ipswich such as the town marsh (Ipswich Village).

1.3.3 Only in the last 100 years have residential properties been built in the lowest areas and following the floods of 1953 many of these were replaced with commercial developments. By 2007 active port areas had moved to higher safer ground created further down the river leaving the now vacant lower lying (brown field) areas at the Ipswich Waterfront.

1.3.4 The rate of sea level rise is predicted to increase from 4mm/year now to 15mm/year by 2085. PPS25 requires LPAs to take account of these predictions. By 2110 sea levels are predicted to rise by 1.02m.

1.3.5 By 2110, if there were no flood defences, tidal flooding could occur many times per year in parts of the Waterfront and Ipswich Village areas. There would be many consequences such as foul sewage flooding, loss of electricity supplies and damage to vegetation and infrastructure. Salt floodwater could reach a depth of 2 to 3 metres, sufficient to cause deaths and injuries

1.3.6 Flood risk is a product of 'probability' and 'consequence'. It takes into account the consequences, e.g. death and injury, damage to property and businesses.

Probability, frequency or return period are ways of describing how often flooding will occur. Very frequent flooding that causes slight damage would be low risk.

Probability is expressed as the annual exceedance probability (AEP) i.e.: the chance of an event being exceeded in any year.

For example a 1% AEP = 100 year return period. (not necessarily every 100 years –but would be on average every 100 years)

1.3.7 Across much of the floodplain (not including the Belstead Brook valley) the annual probability of tidal flooding due to overtopping of existing defences is 0.5% - 2 % (return period 200 to 50 years). Computer modelling indicates in some parts the frequency is less.

1.3.8 Over the next 100 years if sea level rises as predicted and defences were not improved, the probability of flooding would increase to between 100% and 20% AEP

1.3.9 The proposed barrier will reduce the frequency of flooding upstream to less than 0.1%AEP, however sea level rise and climate change is predicted to increase the frequency of flooding to 0.33% AEP by 2110

1.3.10 With the barrier in place and the Wherstead Rd defences improved in step with sea level rise, the risk to people and therefore demand for emergency services is likely to reduce, even with the anticipated sea level rise and proposed population.

1.3.11 With no barrier, if a 0.5% AEP event occurred during 2010, flooding is likely to result in an estimated 127 injuries and 3 deaths.

With the proposed defence barrier, and if defences at Wherstead Rd are raised in step with rising sea levels, with planned increased population, the same event in 100 years time is likely to result in no injuries or deaths

1.3.12 The Belstead valley is functional floodplain and here the frequency of flooding is predicted to be 20-100% AEP now and 100%+ AEP (several times per year) by 2110.

1.3.13 Whilst new defences would normally prevent flooding, there is a small chance one of the four gates in the proposed defences could fail to close, or defence walls could collapse. Detailed 2D modelling indicates this could result in rapid, deep, flooding in certain areas with a hazard rating "danger to all" people. (Extreme danger, deep fast flowing water)

1.3.14 The chance of failure of most of the scenarios is reduced by including, for example, back up systems such as standby generators and extra hydraulic rams to close gates. The SFRA identifies additional measures could help reduce the chance of failure further.

1.3.15 In all sixty 2D computer simulations have been carried out to assess such residual risks.

1.3.16 Safety of developments is a prime consideration when undertaking the exception test and allocating land uses, indeed PPS25 requires all development in flood zones 2 and 3 to be safe. However there are many factors that need to be considered.

1.3.17 Guidance on factors affecting safety is provided in the PPS25 Practice Guide however "*Ultimately, it is the responsibility of the planning authorities to decide what level of risk is acceptable*."

1.3.18 To assist planners and developers, clear guidance is now included in this SFRA in the form of a framework (section 16.2) which includes requirements for…

- Structural Safety of buildings.
- Emergency plans for actions by emergency responders.
- Emergency plans for evacuation and flood warning arrangements for users of buildings
- Temporary Refuges
- Safe emergency access for Fire & rescue Service
- Safe access/escape routes for building users
- Raised floor levels
- Flood resilience measures.

The prime factors governing allocations are flood hazard rating, flood frequency and depth of floodwater on access routes to and from development sites.

Hazard ratings and appropriate water depths are shown on a pair of maps –

- Appendix 5.34 without the planned flood defence barrier
- Appendix 5.35 with the planned barrier.

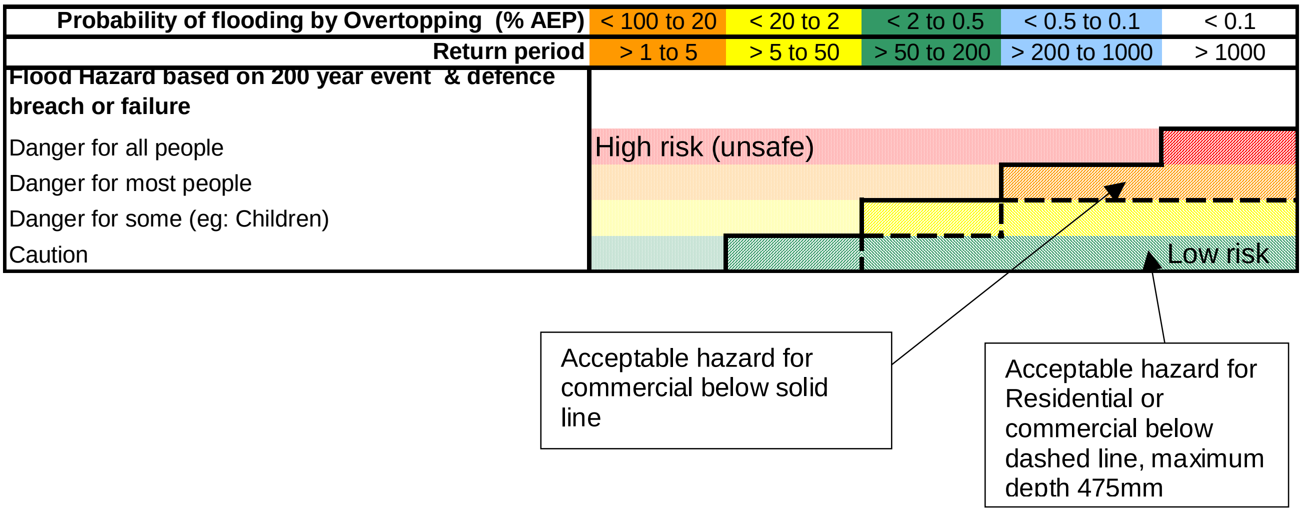
These maps combine hazards associated with the most likely defence failure scenarios. Hazard rating combined with flood frequency describes the risks to people in floodwater.

Flood frequencies are shown on maps:

- Appendix 5.16 or section 8.7, without the planned flood defence barrier.
- Appendix 5.18 or section 8.9 with the planned barrier.

The following table suggests acceptable combinations of frequency and hazard. This is described in detail in section16.2.6

Acceptability of Hazards on Access or Escape Routes - In areas protected by defences.



Probability of flooding by Overtopping (% AEP)	< 100 to 20	< 20 to 2	< 2 to 0.5	< 0.5 to 0.1	< 0.1
Return period	> 1 to 5	> 5 to 50	> 50 to 200	> 200 to 1000	> 1000
Flood Hazard based on 200 year event & defence breach or failure					
Danger for all people	High risk (unsafe)				
Danger for most people					
Danger for some (eg: Children)					
Caution					Low risk

Acceptable hazard for commercial below solid line

Acceptable hazard for Residential or commercial below dashed line, maximum depth 475mm

The exception would be water compatible development –see 16.3.

1.3.19 The SFRA (section 16.4) has assessed sites against the acceptable hazards and frequencies shown on the above table.

1.3.20 Even with defences, and the proposed safety framework, flood risk management measures might be required to make some vulnerable forms of development or higher risk sites safe for people. Such measures may include land raising, raised floor levels and raised safe access. Some are identified in section 16.4. In general it is not known how practicable or affordable these may be. However land raising has been used recently at several sites.

1.3.21 Flood risk management (FRM) measures may affect the form and appearance of the Waterfront and Village areas as well as development costs. These issues should be considered over a much longer time frame than the LDF.

1.3.22 Results of assessment of Sites in Flood Zones 2 and 3

Summary

	Proposed Residential / mixed use sites			Sites considered for Commercial only		
	Safe	Likely to be made safe by FRM measures	Unlikely to be Safe	Safe	Likely to be e made safe by FRM measures	Unlikely to be Safe
No Barrier	0	11	23	1	6	25
With barrier	11	20	3	24	5	3

Commercial only sites, includes sites proposed for residential that were found to be unsafe for residential use.

Of the 3 sites that appear unlikely to be safe - even for commercial uses with the flood barrier, 2 might be suitable for water compatible development leaving 1 site, which may be suitable for commercial development with a short design life.

Some sites listed as requiring FRM measures may be regarded as safe without them if the sites are developed early in the LDF period and/ or it is agreed they have limited design life.

As time goes on and as sea levels rise more sites will become unsafe or require more FRM measures.

For details for individual sites see section 16.4

1.3.23 If the Council wishes and allow more development, and reduce flood risk management (FRM) costs, then higher hazard ratings would need to be accepted on safe access / escape routes. This would place more people at risk. Equally lower hazard ratings could be set to reduce risks further but fewer sites would be developable.

1.3.24 The LDF Core Strategy Policy DC4 is acceptable. It states - *"Development will only be approved where it can be demonstrated that the proposal satisfies all the following criteria:*

a. it reduces does not increase the overall risk of all forms of flooding in the area through the layout and form of the development and appropriate application of Sustainable Urban Drainage Systems (SUDS);

b. it will be adequately protected from flooding in accordance with adopted standards wherever practicable;

c. it is and will remain safe for people for the life time of the development; and

d. *it includes water efficiency measures such as rainwater harvesting, or use of local land drainage water where practicable*."

1.4 Recommendations

1.4.1 The following recommendations presume that PPS25 is followed as stated in the Core Strategy DC4.

1.4.2 The Council's Executive Committee needs to decide what level of risk is acceptable.

1.4.3 Assuming the committee approves the framework for safety suggested in section 16.2 and 16.3 of this SFRA, the supporting text to the LDF DC4 policies should link to the SFRA safety framework as follows:-

1.4.4 Add the following supporting text to DC4 " *More vulnerable and less vulnerable development sited in flood zones 2/3a, as defined in PPS25 may be acceptable. However FRA's will be required to demonstrate that such developments will be "safe" in accordance with the Safety Framework described in sections 16.2 and 16.3 of the SFRA (To be detailed in a future SPD) and consider flood risk from other sources. The assessment will follow PPS25 and Annex E of PPS25.*

Planning permission will not be granted if submitted details do not comply with the Safety Framework.

In addition permissions should not be granted if emergency responders are concerned about their capabilities/ plans."

1.4.5 Add the following supporting text to DC4 "FRAs for proposals in flood zones 2 and 3 need to clearly state the frequency of flooding in and around the site and, until the EA's flood defence barrier is implemented, will need to assume existing defences are in place. Alternatively a FRA could be presented assuming the barrier is defences are in place, however any planning permission should be conditioned to prevent construction until the final stages of the barrier are assured."

1.4.6 Add the following supporting text to DC4 "Highly vulnerable development will not be permitted in flood zone 3a"

1.4.7 Add the following supporting text to DC4: " Basements or lowered ground levels around buildings will increase flood risk to people contrary to the aims of PPS25. Basements are particularly vulnerable to all types of flooding. Basement dwellings should therefore not be permitted where the floor level is below the 0.1% AEP tide level in 100 years time. Basements dwellings should not be permitted in Areas Susceptible to SW flooding. Basements in zone 1 should only be permitted subject to adequate FRAs, which must address ground water, sewer and overland flood sources. "

1.4.8 Add the following supporting text to DC4**:** *"FRA's will be required for any land raising including impacts on Surface water flood risk. No raising of ground levels should be permitted around the Wet Dock that would impede surface water flood paths from Bridge Street, Key Street, Fore Street and Coprolite Street to the Wet Dock."*

1.4.9 Add the following supporting text to DC4: *"SUDS are an important method of reducing flood risk associated with development and are an essential element of any development in the Borough wherever practicable."*

1.4.10 Add the following supporting text to DC4: "*The SFRA also identifies key surface water flood paths and watercourses (flow routes) and areas at risk of flooding. These are to be safeguarded for the future by protecting them from development and other obstruction. Development proposals should design for key flow routes. Surface water management plans will be able to facilitate this."*

1.4.11 Add the following supporting text to DC4: *"SUDS standards and policies are currently set out in the Councils Drainage and Flood Defence Policy (although these standards may be rewritten and incorporated as a supplementary planning document). In the future it is expected that National Standards will be followed"*

1.4.12 The Council's Drainage and Flood Defence policy should be updated to allow for increases in rainfall intensity due to climate change.

1.4.13 Add the following supporting text to DC4" *Layout and form of buildings and roads must be designed around SUDS bearing in mind SUDS should be sited in lower areas, but preferably close to source, making use of topography."*

1.4.14 For Ipswich the floodplain of Belstead Brook upstream of Bourne sluice and the Gipping upstream of the Norwich railway line should be regarded as functional flood plain – Flood zone 3b.

1.4.15 Where appropriate the LDF should allocate green corridors along the lines of watercourses. See plan in appendix.

1.4.16 Space for water / storage for pluvial floodwater needs to be provided in lowest areas of each of the zone 3 flood compartments. See plan in Appendix..

1.4.17 Alderman Recreation ground provides an area for storage of floodwater should the canal embankment fail. The Alderman canal contains about 8,500 cubic metres of water. Recommended management measures include:

- Ensuring the embankment is not damaged by trees blown over by strong winds - when roots are liable to be lifted with embankment material.
- Ensuring the coloured area shown in section 9 is not filled.

1.4.18 In accordance with PPS25 the Council should seek opportunities for relocation of existing highly vulnerable development to land in zones with a lower probability of flooding. (Or redevelop with raised ground levels and safe access).

The suggested order of priority is as follows - top priority first:

1. Some highly vulnerable single storey residential buildings used by vulnerable people within high-risk areas - Great Gipping Street Area.

2. Essential infrastructure such as the fire station in Princes Street and electricity sub stations.

1.4.19 Planning tariffs should be used to fund the cost of reducing residual risk. If possible this should also cover checking of floor levels under construction and ensuring residents in high risk areas have adequate flood awareness and are registered with the Environment Agency's Flood Warning Direct system (0845 988 1188). Other measures could include fire fighting equipment that can operate in >475mm of floodwater or strategic land raising, flood sirens and perhaps other equipment to assist emergency services.

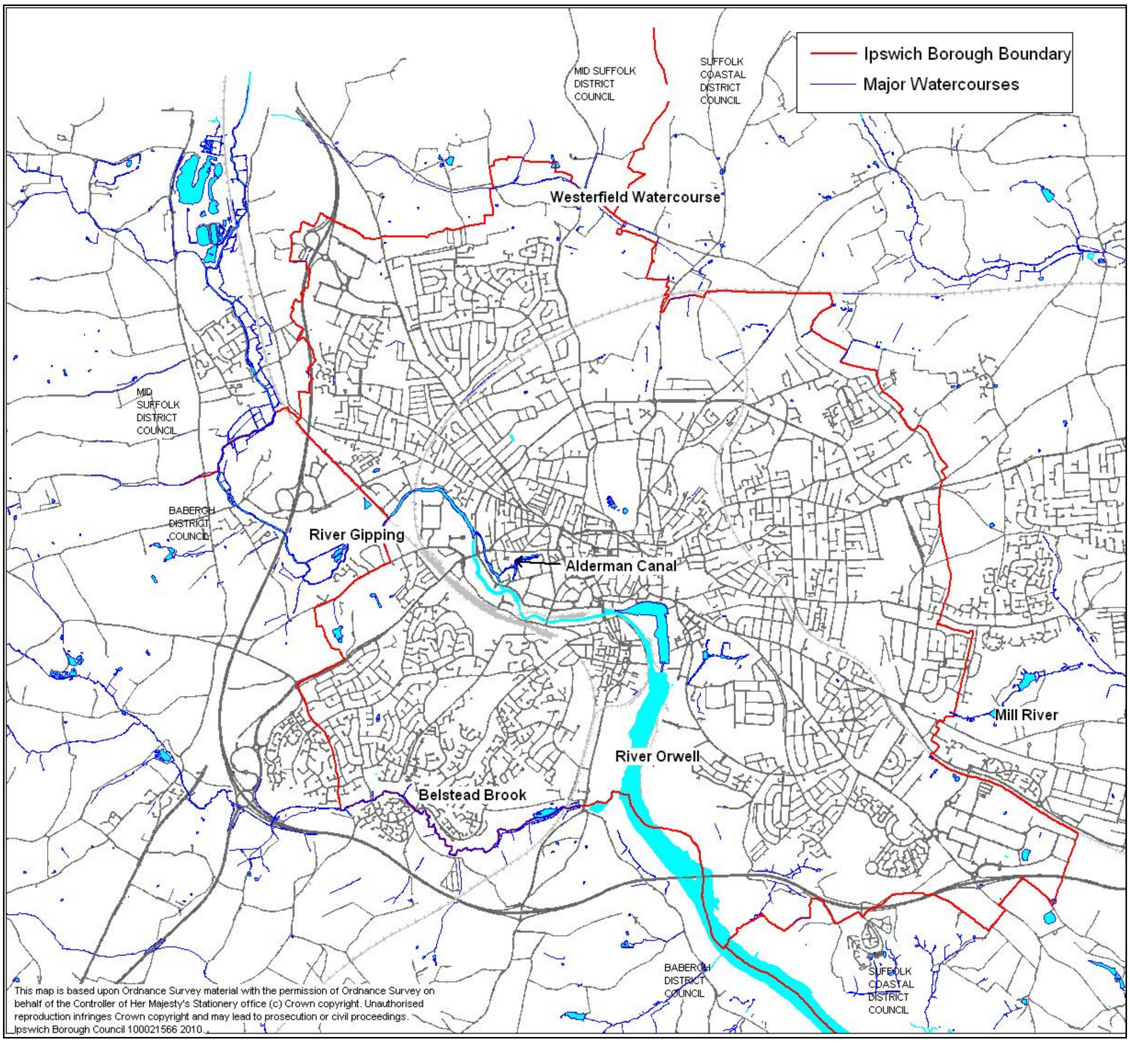
1.4.20 This report and background data should be made available to emergency responders. Maps, the main body of the report and GIS mapping used to produce the SFRA include much information that can be used for emergency planning purposes, this should also assist emergency services in commenting on planning applications for development in flood risk areas.

The Council's Drainage Engineering team has produced this Level 2 Strategic Flood risk Assessment. The Halcrow Group carried out 2D modelling and hazard mapping for this SFRA using the Environment Agency's hydraulic model.

The Council published this report in June 2011.

2 LOCATION

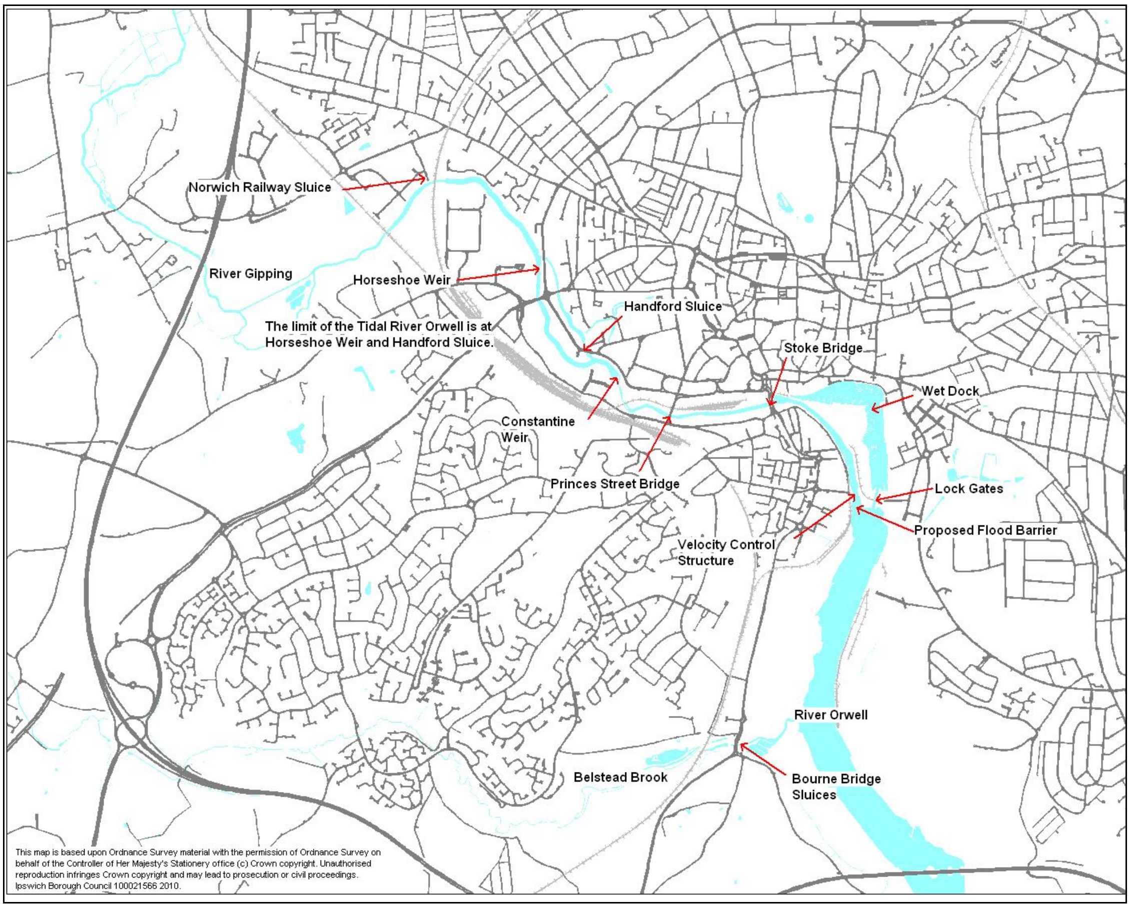
The map shows the area administered by Ipswich Borough Council, the subject of this report. (Repeated at large scale in the appendices.)



3 DRAINAGE & FLOOD DEFENCES - DESCRIPTION

3.1 Main River Gipping and Orwell Estuary

Ipswich is sited where the freshwater River Gipping becomes the tidal River Orwell. The Orwell Estuary downstream from Ipswich is a wildlife site of international importance designated SSSI, RAMSAR, SPA and an AONB.



The estuary funnels tidal surges with the result that tidal levels in Ipswich can be slightly higher than at Harwich.

The catchment of the River Gipping includes the towns of Stowmarket, Needham Market, Bramford, Claydon and Western parts of Ipswich but is predominantly rural.

At Horseshoe sluice (Yarmouth Rd) the river divides, with the tidal Orwell on the West side and the freshwater Gipping on the East side of an island. The island is defended against tidal flooding but not fluvial flooding. The Gipping spills over Handford sluice (off West End Road) to join the Orwell.

The active port and docklands area and parts of the urban area adjacent to the Orwell are low lying and at risk of tidal flooding. Ground levels in the flood risk zone are typically as low as 2.0m above Ordnance datum (AOD) and high water spring tide level is about 2.2m AOD. Annually tide levels reach about 3m AOD. The 1953 flood level was 4.2m AOD. Some areas upstream of Stoke Bridge are also at risk of fluvial flooding.

3.2 Wet Dock

The Wet Dock, completed in 1840, is connected to the Orwell by a lock. Water levels are normally maintained at about 1.5m AOD. The Orwell Navigation Service closes a movable floodgate sited between the lock gates, when the tide level reaches 2.6m AOD.

The Dock sewer, owned by the Port Authority and skirting the North and East of the Wet Dock, originally intercepted the polluted water from old culverts and streets thus keeping the enclosed dock clear of pollution. The Dock sewer has two outfalls into the Orwell. The Port authority has resisted the connection of piped drainage systems into the dock and as a consequence the enclosed salt water in the Dock is of good quality.

However approximately every year or two, surface water flooding (resulting from overloading of piped drainage systems) affects Duke Street, Fore Street, College Street and Key Street - the lowest roads surrounding the Dock. The floodwater overflows into the dock, this helps reduce flood levels and consequences.

3.3 River Gipping and Orwell & Belstead valley Flood Defences

The River Gipping and Orwell flood defences were upgraded in a comprehensive scheme between 1970 and 1983 following the tidal surge that resulted from a vigorous depression and associated strong winds in 1953. The river channel was improved and 15 km of flood defence walls and 5 control structures were constructed.

These are: -

- A gate at the Norwich Railway Bridge, which can be dropped to temporarily prevent fluvial flows in the Gipping from entering Ipswich.
- Horseshoe Weir and Handford sluice at the normal tidal limits – these are adjustable and control upstream river levels (& Alderman Canal water level if the penstock is open).
- The velocity control structure across the Orwell at Bath Street – This can be raised to control the risk of scour caused by coincident high fluvial flows and low tidal conditions.

- Tidal flap valves and an embankment normally prevent tidal waters back flowing into the Belstead Brook valley.
- The floodgate at the Wet Dock lock gates – a vital part of the defences.

The Wet Dock Lock gates normally retain water in the Wet Dock, however each leaf gate includes 2 sluices, each 1.1m X 0.4m located close to the base of the gate. These might be opened to assist drain down should flooding occur when the lock gates are closed. The level of the top of the lock gates is 3.1mAOD.

The first stages of the Ipswich Flood Defence Management Strategy were constructed between 2008 and 2010 – these replaced and raised the level of the defences on the East and West banks of the Orwell downstream of the Wet Dock, the Wet Dock flood gate was also replaced –all with a with a crest level of 5.71 m AOD.

The final major part of the strategy is to install the Barrier across the New Cut, again at a level of 5.71m AOD. The EA plan to start building the barrier during the winter of 2011/12. This is expected to take 2 years to complete. These timings of the EA delivering the scheme are correct at time of publishing.

Other future parts of the strategy include repairs to the defences upstream of the barrier. These will need to be kept at their original design levels.

The Strategy is designed to provide a standard of protection against tidal and fluvial flooding, including combinations of 0.33 % annual exceedance probability (1 in 300 years return period) allowing for increased sea levels expected in 100 years time.

The Wherstead Road area is protected, mainly by the high ground of the West Bank Terminal and some local raising of the main road. A Flood Defence Committee Levy funded scheme is expected to raise the level of this defence to 4.4m AOD during 2012. A future scheme may be needed to reduce the risk of overflow from the Wherstead Rd flood compartment B to the Bath Street Compartment C at the point where the road dips under the railway bridge.

Ipswich is included in the Essex and South Suffolk Shoreline Management Plan (SMP). The consultation draft dated 12 February 2010 confirms the policy of “Hold the Line” upstream of the Orwell bridge (West bank) and the Cliff Quay Sewage treatment works (East Bank).

The Appendices include a plan showing the main structures.

3.4 Condition of EA's Flood Defences

The EA's Flood Defence Management Study Report (June 2005) concluded:

- The floodwalls provided varying levels of protection to flooding from surge tides along the estuary.

- Some of the defence walls are in urgent need of repair and in recent years 3 short lengths of wall have failed. Some temporary repairs (earth banks) were carried out at New Cut East in1996 and 2 more sections of sheet piled walls just downstream of Horseshoe sluice were repaired in 2003. The report states works to repair the lock flood defence gate mechanism were completed in 2003.

- 882 residential properties and 261 commercial properties were in the tidal/fluvial flood risk zones adjacent to the Orwell and Gipping. (See section 13 for most recent figures)

The Appendices include a plan showing the crest levels of the defences. These were taken from the original design and from National Flood & Coastal Defence Database.

The EA's report lists expected failure dates for various sections of defence.

As a result of the study the EA developed the Ipswich Flood Defence Strategy, which provides for a major flood defence investment in the form of a barrier in the New Cut, together with some improvements and repairs to the existing flood defences, which would safeguard defences for the next 100 years.

During March 2007 the section of wall at New Cut East suddenly subsided following a surge tide of circa 3.2m AOD. For the SFRA it is assumed the temporary earth bank has a crest level of 3.8m AOD, however on the 13 June 2007 an inspection of defences revealed a short length of temporary earth bank was removed as work was undertaken behind the wall. By September 2007 it had been reinstated.

This section of wall is founded on timber piles.

Additionally movement of the defence wall (quoted failure date 2012-2017) further upstream opposite the Steam Boat Tavern was noted.

A further section of the concrete defence wall on the West bank just downstream of the Velocity Control Structure, which was not replaced in 1977, is also in poor condition and likely to fail soon. Life expectancy for this section is shown as 2007-2012.

The long-term strategy includes the repairs to these walls that will raise subsided sections to the original design level of 4.25m AOD.

3.5 Belstead Brook

Belstead Brook (main river) joins the Orwell Estuary at Bourne Bridge to the South of the town. The catchment is mainly rural but includes Copdock and the extreme South West of Ipswich. The brook has a mainly undeveloped flood plain, with three properties known to be at risk of flooding.

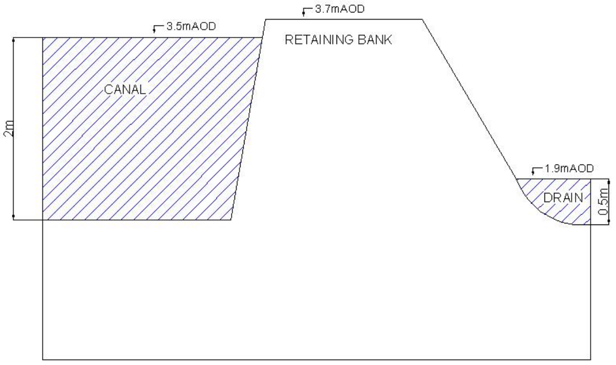
3.6 Alderman Canal

The Alderman Canal (ordinary watercourse & Local Nature Reserve) originally fed water mills at Alderman Rd and Stoke Bridge with flows from the River Gipping. Circa 1880 the channel downstream of Alderman road was filled in and replaced with part of the “Low Level trunk sewer”. Apart from a 762mm rectangular penstock, river flows are now prevented from entering the canal by an embankment across the old channel. There is no known formal outlet.

Water is retained at a high level by another earth embankment crest level 3.7m AOD along the south side of the canal. Any leakage is intercepted by a counter ditch, which drains the low-lying meadows and playing fields back into the Tidal Orwell at via a culvert and surface water sewer at Constantine Road. The water level in the canal is normally the same as the River Gipping, however during periods of flood risk the EA close the penstock to prevent overtopping of the embankment, which has only 200mm, freeboard in normal conditions.

There are a number of trees along the embankment of the canal, which could increase the likelihood of a breach if they were to fall due to high winds.

A survey was carried out in February 2010 as follows:



3.7 Mill River – East of Ipswich

Mill River flows eastwards from the extreme East of Ipswich towards the Deben Estuary. The upstream part in the urban area has been replaced with a surface water sewer, which outfalls into a SSSI wet land area known as Bixley Heath.

Upstream of the wetland area large sections of the original valley have been filled, however the original valley remains in two areas – upstream of Bixley Rd and just off Bucklesham Rd. Drainage of these areas is reliant on the surface water sewer. In extreme events the remaining low areas are liable to flood.

Water leaves the wetland area just upstream of the entrance to Bixley Heath and flows through several ponds at Purdis Heath. The enmained part of Mill River starts downstream of the ponds and flows through a rural area.

3.8 Westerfield Watercourse

This flows westwards from Westerfield village towards the River Gipping at Claydon. Areas of undeveloped land including the Council's Millennium Cemetery in the North of Ipswich fall within its catchment. An ISIS model was built by a developer in 2009.

3.9 Other Watercourses, Springs and Land Drainage.

Due to geological conditions many other smaller watercourses exist. As the town has been urbanised some have become fragmented, piped or only flow in exceptional conditions.

During heavy rainfall, runoff and overflow from overloaded or blocked drainage systems inevitably makes its way towards the minor watercourses and then the low areas adjacent to the Orwell and Gipping, including the Wet Dock.

During 2009 The EA undertook a national exercise to map areas that may be susceptible to surface water flooding (ASTSWF). These maps ignore the presence of underground drainage and relate to a single storm event. Effectively these highlight valley bottoms or hollows where flooding may occur. Some parts of the ASTSWF map may be refined as part of the process to produce a Surface Water Management Plan (SWMP). A plan in the Appendix shows the ASTSWF, overlaid on areas where historic local flooding, major floodpaths and watercourses have been recorded by Ipswich Borough Council. No detailed base mapping has been used in conjunction with the ASTSWF due to the potential inaccuracies.

Away from the main valley of the Orwell and Gipping the ground rises steeply to a flattish, predominantly residential, area at about 30-40m AOD. Boulder clay (diamicton) caps the very highest areas to the north of Ipswich. Below this sands and gravels overlay London Clay. Many of the minor watercourses are fed by springs issuing from the base of the sands and gravels. Over time some watercourses have eroded steep sided tributary valleys cutting into the higher areas. (A map showing geology, minor watercourses and general topography is included in appendices with paper copies of this report.)

As Ipswich developed many of these watercourses were used for water supplies, or culverted where they flowed through streets – towards the Orwell. Examples are Northgate Street, Lower Brook Street, Spring Road and Upper Orwell Street.

Some watercourses were used to create the ponds in Christchurch Park, Holywells Park and Chantry Park. Along the eastern boundary of Holywells Park, a canal, with water retained by an earth embankment up to 3m high, originally fed the Cliff Brewery. This is now drained via an old Anglian Water storm overflow Sewer to the Orwell. Problems have recently arisen with high water levels or falling trees threatening to breach the embankment, with leaks flooding across parking areas in adjacent premises.

Land drainage systems (intended to drain ground water using porous pipes) have been installed in valley bottoms in several areas to help drain gardens. Examples can be found at Tuddenham Avenue, Cavendish Street, Ancaster Road, Gippeswyck Park and Cliff Lane.

Land drains were also incorporated in the main river flood defences – these drain ground on the land ward side and at intervals these outfall through the sheet piled walls with flaps intended to prevent reverse flow.

3.10 Sewerage System

In about 1880 the Low Level Trunk sewer was installed and tributary sewers were added as the town grew rapidly. The original system is still in use and carries foul and surface water runoff from NW and central Ipswich around the Wet Dock and to the Cliff Quay Waste Water Treatment Works.

A plan in the appendix shows trunk sewers.

In the lowest parts of the town, the Low-level sewer is extremely shallow and pumping stations were installed to lift foul/combined flows into the sewer, often with separate surface water systems draining to the estuary by gravity. Flap valves were intended to prevent reverse flow when tide levels exceed ground level. In some areas, such as Bath Street and Wherstead Road, oversized pipes or storage tanks are included to store runoff when rainfall coincides with high tidal conditions.

By 1939 the system had to be reinforced by the addition of the High Level trunk sewer constructed on a roughly parallel route to the North of the Low Level

Sewer. This permitted development of the Crofts residential area to the NW of Ipswich.

Later flows from villages outside Ipswich at Blakenham, Bramford & Claydon were pumped into the system. Storm-water overflow sewers, from the trunk sewers to the rivers, were added to relieve flooding. Even so both trunk sewers flood during severe weather, especially where they cross the tributary valleys. Flows then route overland along the valleys and watercourses towards the lowest parts of the town.

Many other sewerage improvements and additions were made as the town expanded, the most recent being "Project Orwell" a £33M 2.4m diameter tunnel and a series of pumped tanks which provided further relief and reduced emissions from the overflow sewers to the river/estuary.

Foul and combined flows from North West and central Ipswich are pumped into the Cliff Quay wastewater treatment works.

Much of the East of Ipswich drains via combined sewers to either the "Eastern Area trunk sewer", built in 1960, or the "South East Area Sewer" built in 1983. As they enter the Cliff Quay treatment works, large storm overflow structures allow surplus flows to spill via screens to the Orwell.

There are now some 40 major outfalls through the flood defence walls into the Orwell or Gipping. Most have flap valves intended to prevent reverse flow and tidal flooding. Some of these are very large: - twin 2.7 m square flap valves at Stoke Bridge and two pairs of 2.4m diameter flaps at Toller Rd.

The Anglian Water system in Ipswich now includes 15 pumping stations, a further 4 pumped tanks, at least 6 attenuation tanks and an open attenuation pond at Ransomes Europark. The sewerage system serving NW and central Ipswich is therefore complex.

Anglian Water (AW) has "Infoworks" computer models to enable them to understand the operation of the sewer network and model possible improvement schemes in detail.

Much of the Chantry area, south of the river, is served by separate foul and surface water sewerage systems. Surface water systems drain to Belstead Brook. Foul sewage is drained by gravity to Chantry wastewater treatment works. AW is currently developing a model for parts of this area.

3.11 Highway or Railway Drains

In a few areas of Ipswich, highway or railway drains discharge to watercourses; in other areas private systems serve large areas. In the Dales Road area the railway, in cutting, is thought to drain rural runoff from fields East of Henley Road towards Norwich Road.

Highway or railway drains are unlikely to be shown on AW's sewer maps. Some have been mapped – see plan in appendices.

3.12 SUDS and Soakaways

As a result of policy changes during the last few years (PPG25, the Ipswich Drainage and Flood Defence Policy & Building regulations), SUDS, soakaways or attenuation systems have been increasingly used to reduce adverse impacts on watercourses and the sewerage network. Examples of this are at the Park and Ride and Anglia Parkway sites North of Bury Rd and St Mary's Convent. Areas of the town served by such systems are recorded by IBC.

In parts of Ipswich, soakaways are used for surface water drainage; these are normally the property owners' responsibility. However some 82 soakaways, adopted by the Highway Authority, are known to exist and have been mapped, (see plan in appendices) others probably exist. During the past few years many of the older ones, installed circa 1950-1970, have been found to be totally inadequate and several have been replaced/enlarged.

Ravenswood, a 1200 home development currently under construction, uses landscaped infiltration basins and soakaways for surface water drainage - all designed to protect homes from a 1 in 100 year rainfall event. These features do not affect the springs and watercourses in Braziers Wood.

Some recent developments, located in low areas, where attenuation storage has been installed, have suffered from flooding because surcharging of the sewerage system prevents discharge at the designed rates. AW typically specifies an allowable discharge and designers erroneously assume the sewer has capacity, for that discharge rate, without surcharging.

Other recent developments have included low-level basement car parking or buildings below water levels (surcharge levels) that commonly occur in adjacent sewers. Some of these are situated in flood risk zones. Private pumping systems are increasingly being used in an effort to avoid flooding of such low areas.

3.13 SFRA Compartments

The compartments in the report comprise shallow basins, which could fill with floodwater to a threshold level before overflowing into adjacent compartments. Ground levels, roads or bridge embankments govern the threshold levels. These compartments were defined in the Environment Agency's "Ipswich Flood Defence Management Strategy – Hydraulic Modelling – Draft Model Report (Nov, 2003)".

4 HISTORIC FLOODS

4.1 Surge Tides

Tidal flooding (or storm surge) is caused by weather patterns and will be worst when combined with a spring tide. Water levels in the North Sea are raised when atmospheric pressure is low over the North Sea and high over the Atlantic. Previous severe tidal flooding has been accompanied/caused by hurricane force winds.

Storm surges have caused tidal flooding in East Anglia on many occasions. A quick search (reference 7) indicated major surge tides occurred in 1236, 1287, 1613, 1619, 1762, 1894,1904,1905, 1927/8, & 1938. These would not have caused great damage because the town's marshes were not built on.

The most recent serious flood was in 1953. A plan in the appendix, copied from IBC's contemporary paper record, shows the extent mapped against 1950's background Ordnance Survey plans.

2,500 people died in Northern Europe and the East coast of England. Thousands were made homeless.

40 people died at Felixstowe where homes where destroyed. No deaths occurred in Ipswich but the flood affected residential properties in the Bath Street area (these were subsequently demolished) and power and gas supplies failed.

Flood defences built between 1971 and 1983 saved the town from serious surge tide flooding on 2/3 January 1976, 11/12 January 1978 and 1 February 1983.
(Reference dated 1987).

More recently on 9th November 2007, a surge tide peaked at 2.2m above normal. Luckily this coincided with low water and the tide level reached 3.2m AOD.

Only minor flooding at Wherstead Strand (outside Ipswich) occurred. If the peak surge had coincided with high water then the level would have reached about 3.8m AOD. Advance warnings were provided and emergency plans were activated along the East coast. The progress of the surge along the coast was closely monitored. At Great Yarmouth the surge peaked at high water and some minor overtopping of defence occurred. It was some 4 hours before it reached Ipswich.

A slightly higher tide level was recorded on 24 November of 3.48m AOD, again this cause no serious problems.

4.2 Fluvial Flooding

The most recent severe fluvial events were in 1947 and 1939. These were partly caused by flood debris that obstructed the old “Seven Arches Bridge” at London Road. The current replacement bridge is single span and no longer obstructs the flow.

It appears that during these events, floodwater followed the original path of the River Gipping before it was filled in 1882, through the “Ipswich Village” area, and spilled across Bridge Street into the Wet Dock at Albion Wharf. Floodwater was reported to be five feet deep in Princes Street and cars were swept away.

Contemporary paper record plans showing the 1939 and 1947 floods on relevant OS survey background are reproduced in the Appendices.

1939 Floodwater from river Gipping spilling into wet dock at Albion Wharf

1939 Floodwater in Princes Street

4.3 Pluvial or Local “flash” flooding

This currently occurs much more frequently than tidal or fluvial floods, generally with relatively low consequences, however repeated flooding can cause much distress and expense, especially where floodwater (often with sewage) enters or comes close to entering homes

Ipswich is unusual in having about 30 years of detailed records of local flooding resulting from heavy rainfall, not attributed to overtopping of river or tidal defences. Such flooding results from surface runoff, overloading of soakaways, SUDS, piped systems, ordinary watercourses (ditches, streams or valley bottoms) or ground water.

As the town grew and more surfaces were paved, runoff increased. Flooding resulted and was often subsequently alleviated by drainage improvements. Thus the oldest records are unlikely to be of much significance. However, stubborn problems remain as shown on a map included in the appendices. (Plan shows Local Flooding, Watercourses, ASTWF & ground water flooding.).

Currently the most serious problems are at: Lovetofts Drive, Daimler Close, Swinburne Rd, Norwich Rd, Coltsfoot Road, Monton Rise, Bridgewater Rd, Ellenbrook Rd, Bixley Rd, Hadleigh Rd, Holywells Rd, Duke Street, Maidenhall.

IBC have many photos of such flooding, such as the following, included to illustrate some relevant problems.

Holywells Road – floods several times per year.

Duke Street – water level just below floor level of shop, water is overflowing into Wet Dock – this restricts flood depth.

Major newsworthy flooding events occurred on 22 occasions between 1976 and 2007.

4.4 Ground Water

The Council has recorded locations where complaints have been received mapped on the "Local Flooding, Watercourses, ASTSWF & Ground Water Flooding" map in the appendix 5.5

5 EMERGENCY PLAN – EXISTING

Ipswich Borough Council has, for many years, had a Flood Response Plan, which forms part of the Council's Major Emergency Response Plan. These plans are closely aligned with the strategic Suffolk Flood Plan produced by the Suffolk Resilience Forum and the Town Centre and Waterfront Evacuation Plan.

The plans have been developed further in response to:

- The Civil Contingencies Act,
- The Pitt Review,
- Changes with the EA's flood warning service
- The new EA/Met Office Flood Forecasting service
- Ongoing regeneration of Waterfront areas.

The findings of the Level 1 SFRA were presented to the various emergency responders and resulted in further evolution of the plans.

The recent ASWTF mapping has also been considered and rest centre locations have been chosen to avoid areas that may be at risk of various forms of flooding.

Further updates to the plans are planned in 2011.

Emergency plans are viewable on the Suffolk Resilience Forum's web site – http://www.suffolkresilience.com/ Or Ipswich Borough Council's Web site.

6 ASSESSMENT OF RISKS - INTRODUCTION

6.1 Introduction

Flood risk is a product of ‘probability’ and ‘consequence’. It takes into account the consequences, i.e. death and injury, damage to property and businesses.

Probability, frequency or return period are ways of describing how often flooding will occur. Very frequent flooding that causes slight damage would be low risk.

Probability is expressed as the annual exceedance probability (AEP) i.e.: the chance of an event being exceeded in any year.

For example a 1% AEP = 100 year return period.

Ongoing sea level rises and predicted increasing rainfall will gradually increase risks unless these are mitigated by defences, improved drainage or emergency plans.

6.2 Risk matrix

The matrix illustrates how risks depend on the combination of frequency and consequences.

H =High, M=Medium, L=Low, N=Negligible risk

	Flood Probability			
Consequence	Likely >4% annual probability or every 1-25 years on average	Infrequent 4% - 1% Once a lifetime –on average	Possible 1 - 0.1% High/Med in PPS25	Remote <0.1% Every 1000 years Low in PPS25
High (high damage to property or loss of life.)	H (Highest)	H	H	H
Medium (moderate damage to property)	H	H	M	M
Low (minor damage to property)	M	M	L	L
Negligible (no damage to property)	L	N	N	N (lowest)

6.3 Residual Risk

In situations where a relatively high standard of flood protection is enjoyed, such as London, the probability of flooding due to overtopping or failure of defences is relatively low, but the consequences, if flooding did occur, are very high.

Since 1977 defences have protected Ipswich from many surge tides and very few people can remember when flooding last occurred. However the risk of flooding would dramatically increase if defences were allowed to deteriorate and fail or if floodgates or barriers fail to operate.

The idea that there is a significant “residual risk” even though defences are in place is difficult to explain to non-specialists, especially in situations when wide scale flooding has not been experienced in recent times. In such situations it is easy to become complacent and ignore the certainty that flooding will occur. When it does consequences will be more severe than for communities with awareness of flood risk.

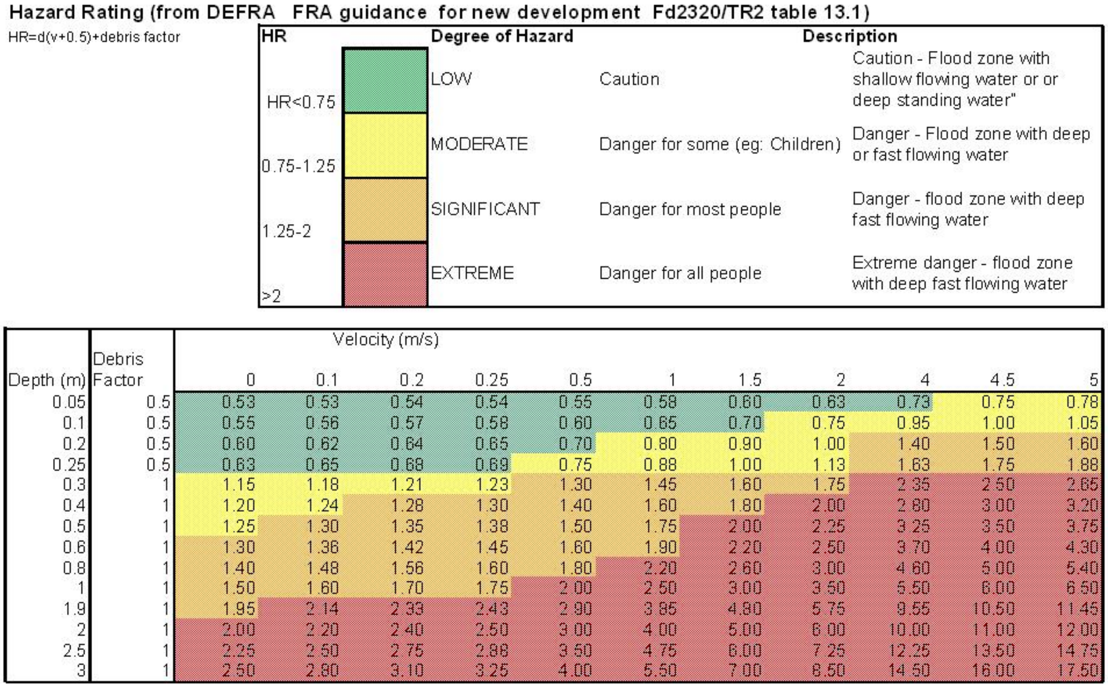
The proposed new or repaired defences will dramatically reduce risks but there will be “residual risks” which arise from the possibility of overtopping or collapse of defences, failure of sluices/gates etc. These risks will be highest where fast moving or deep floodwater could rapidly inundate and damage areas posing a high risk of death / injury.

6.3.1 Flood Hazard

“Flood hazard” describes the conditions in which people are likely to be swept over or drown based on depth and velocity of floodwater – (not the rate of rise of floodwater) in a particular event.

DEFRA ‘s Flood Risk To People draft Guidance provides ways of assessing risks to people in flood risk areas.

The formula below is used in the assessment to calculate hazard ratings across flooded areas. The variation in hazard rating is mapped and used later in considering the safety of developments. It is standard practice to assess risk using the above hazard ratings from 0.5% and 0.1% AEP events



Hazard Rating (from DEFRA FRA guidance for new development Fd2320/TR2 table 13.1)

HR=d(v+0.5)+debris factor

HR		**Degree of Hazard**		**Description**
HR<0.75	🟩	LOW	Caution	Caution - Flood zone with shallow flowing water or or deep standing water"
0.75-1.25	🟨	MODERATE	Danger for some (eg: Children)	Danger - Flood zone with deep or fast flowing water
1.25-2	🟧	SIGNIFICANT	Danger for most people	Danger - flood zone with deep fast flowing water
>2	🟥	EXTREME	Danger for all people	Extreme danger - flood zone with deep fast flowing water

		Velocity (m/s)										
Depth (m)	Debris Factor	0	0.1	0.2	0.25	0.5	1	1.5	2	4	4.5	5
0.05	0.5	0.53	0.53	0.54	0.54	0.55	0.58	0.60	0.63	0.73	0.75	0.78
0.1	0.5	0.55	0.56	0.57	0.58	0.60	0.65	0.70	0.75	0.95	1.00	1.05
0.2	0.5	0.60	0.62	0.64	0.65	0.70	0.80	0.90	1.00	1.40	1.50	1.60
0.25	0.5	0.63	0.65	0.68	0.69	0.75	0.88	1.00	1.13	1.63	1.75	1.88
0.3	1	1.15	1.18	1.21	1.23	1.30	1.45	1.60	1.75	2.35	2.50	2.65
0.4	1	1.20	1.24	1.28	1.30	1.40	1.60	1.80	2.00	2.80	3.00	3.20
0.5	1	1.25	1.30	1.35	1.38	1.50	1.75	2.00	2.25	3.25	3.50	3.75
0.6	1	1.30	1.36	1.42	1.45	1.60	1.90	2.20	2.50	3.70	4.00	4.30
0.8	1	1.40	1.48	1.56	1.60	1.80	2.20	2.60	3.00	4.60	5.00	5.40
1	1	1.50	1.60	1.70	1.75	2.00	2.50	3.00	3.50	5.50	6.00	6.50
1.9	1	1.95	2.14	2.33	2.43	2.90	3.85	4.80	5.75	9.55	10.50	11.45
2	1	2.00	2.20	2.40	2.50	3.00	4.00	5.00	6.00	10.00	11.00	12.00
2.5	1	2.25	2.50	2.75	2.88	3.50	4.75	6.00	7.25	12.25	13.50	14.75
3	1	2.50	2.80	3.10	3.25	4.00	5.50	7.00	8.50	14.50	16.00	17.50

The danger classifications of 'danger to all', 'danger to most' and 'danger to some' references are from HR Wallingford (2005) *Flood Risks to People Phase 2, The Flood Risk to People Methodology*, Environment Agency\Defra R&D Technical Report FD2321/TR1, March 2005.

6.3.2 Consequences of flooding

Consequences depend on many factors including flood hazard, vulnerability of people or buildings, emergency planning, public awareness.

Vulnerability of various types of development is defined in PPS 25 table D.2

The greatest consequences are likely to result from tidal flooding, as it is likely to be fast flowing and deep.

At present tidal flooding will most likely occur during the winter, coincident with strong winds – probably from a Northerly direction.

Before severe flooding occurs, it is likely that advanced warnings would be received, however emergency responders may be attending incidents involving power outages, flying debris, damaged buildings, traffic disruption or even snow fall etc. The Orwell Bridge may be closed with traffic diverted through Ipswich,. Effects of the storm would be regional or national.

Increased storminess is likely to increase the frequency or severity of storm surges and wind damage potential.

In general consequences of severe tidal flooding are likely to be:

- Death and injury of public, especially children, the infirm or elderly,
- Death or injury of emergency service staff,
- Destruction and damage to vehicles, buildings, possessions, essential infrastructure –such as power supplies, or fire stations,
- Destruction of vegetation including trees and the ITFC football pitch by saltwater – long lasting or permanent once salt enters the ground.
- Sewage would escape and mix and spread with the floodwater – health hazards.
- Uninsurable buildings and contents
- Reduced Property values
- Long term damage to regeneration plans
- Damage to Economy
- Long term damage to health caused by anxiety and stress

The chance of people being exposed to floodwater depends on whether they are outdoors, on foot or in vehicles. People in multi-storied buildings may stay above flood level. If they are in the open or in single storey buildings they will be exposed. If they are in basements they will be at greater risk.

The degree to which people are exposed depends on whether flood warnings are received and acted on.

Whilst a flood-warning scheme is available, not everyone will receive it or act on it. Many people passing through flood risk areas in cars may not to receive a warning, (especially those diverted into Ipswich if the Orwell Bridge is closed).

Even those who receive warnings and live in multi storey buildings will not all react in an appropriate way, children or others may be attracted to floods and car owners may attempt to move their cars from basements.

The speed of onset will have a major impact on whether people are exposed to floodwater. Where onset is slow they will have time to leave the area. If a defence suddenly overtops or collapses people will be at high risk.

Vulnerable people are less able to cope than others in a flood situation and will be more prone to death or injury.

The assessment of tidal risk considers frequency, hazard rating and speed and duration of inundation.

6.4 Climate Change

For the assessment of impacts of climate change on flooding from land and rivers the increases listed in table B.2 of PPS25 are used, see below.

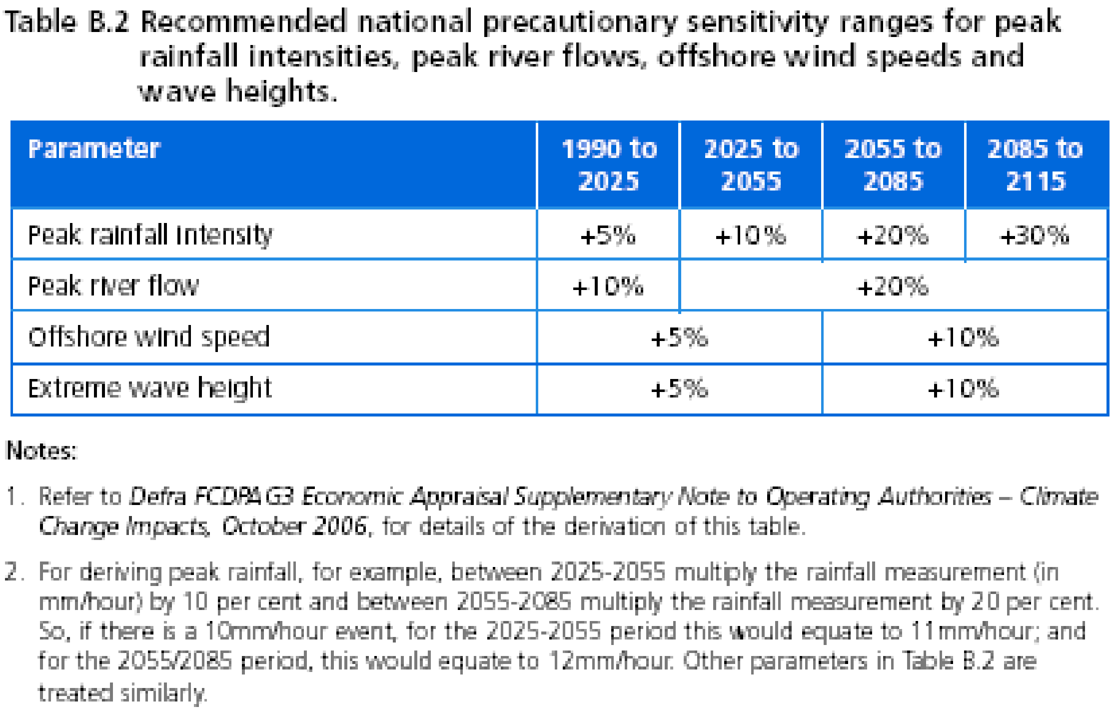


Table B.2 Recommended national precautionary sensitivity ranges for peak rainfall intensities, peak river flows, offshore wind speeds and wave heights.

Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

Notes:

1. Refer to *Defra FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts, October 2006*, for details of the derivation of this table.
2. For deriving peak rainfall, for example, between 2025-2055 multiply the rainfall measurement (in mm/hour) by 10 per cent and between 2055-2085 multiply the rainfall measurement by 20 per cent. So, if there is a 10mm/hour event, for the 2025-2055 period this would equate to 11mm/hour; and for the 2055/2085 period, this would equate to 12mm/hour. Other parameters in Table B.2 are treated similarly.

PPS25 Annex E2 sates *"…The future users of the development must not be placed in danger from flood hazards and should remain safe throughout the lifetime of the plan or proposed development and land use."*

The PPS25: Development and Flood Risk Practice Guide states in section 3.100 "For individual developments, an appropriate allowance should be included over the lifetime of each development in question. Developers should therefore *carefully consider, and advise those undertaking the Flood Risk Assessment, on what the design life of the development is. The assessor can consider the implications of climate change for this period using the precautionary allowances and indicative sensitivity ranges in PPS25 Annex B.*"

Environment Agency internal policy defines design life of residential and commercial development as100 and 75 years respectively.

The PPS25 Practice Guide paragraphs 3.102 and 3.103 provide further advice, suggesting a lower design life may be acceptable for development other than residential. A shorter life would need to be justified by the developer and would need to be agreed following discussion between developers, the LPA and the EA.

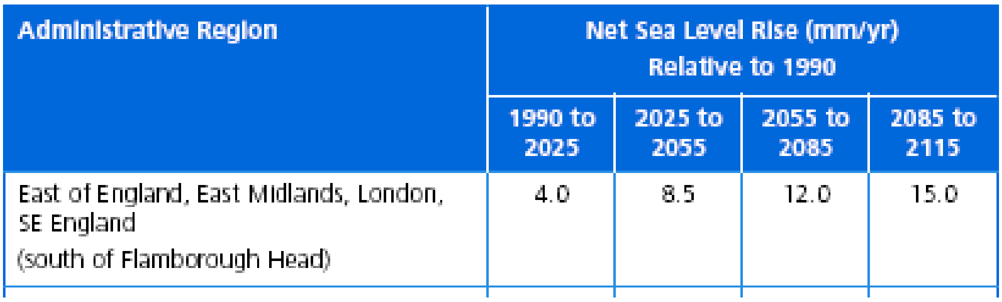
6.5 Sea Levels

Since the level1 SFRA was produced, the EA have adopted new tide levels for use in FRAs, these are typically 200mm higher. These are based on statistical analysis reported in Royal Haskoning's report "Extreme Tide Levels for Ipswich, Suffolk," (2008).

The report currently provides the best available estimate of the annual exceedance probability of a given level for Ipswich. This is based on a reference year of 2006. For later years additions are required to allow for sea level rise as described below:

For the assessment of impacts of sea level rise on flooding from the estuary the increases listed in table B.1 of PPS25 are used, see below.

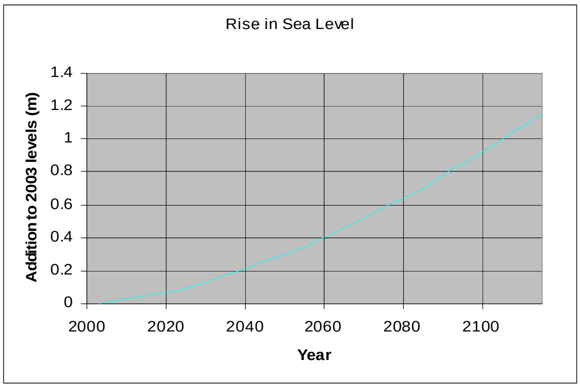
Table B.1 Recommended contingency allowances for net sea level rise



Administrative Region	Net Sea Level Rise (mm/yr) Relative to 1990			
	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
East of England, East Midlands, London, SE England (south of Flamborough Head)	4.0	8.5	12.0	15.0

The allowance includes for the effect of land sinking. Note sea levels have been rising for the last few thousand years.

The PPS25 allowance for sea level rise amounts to just over 1m over the next 100 years as shown on the following graph.



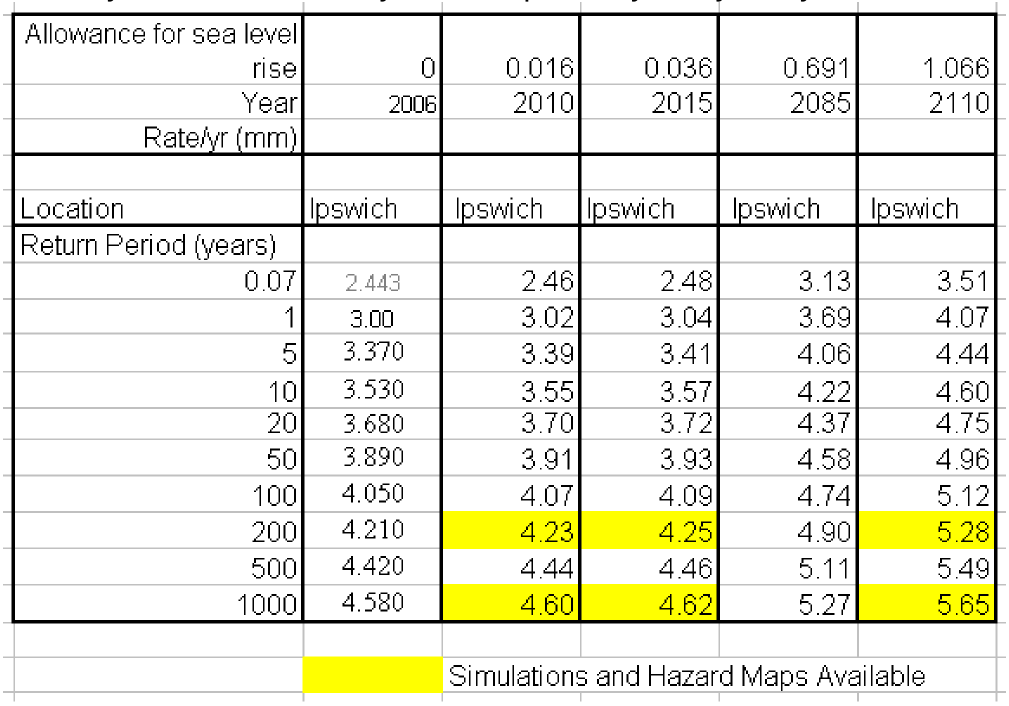
The Environment Agency's internal policy defines design life of residential and commercial development as100 and 75 years respectively.

The base level (m AOD) used in this assessment was at 2006.

Predictions for extreme levels at 2010, 2015, 2085 and 2110 for various return periods are shown in the table below:

Return periods are a way of describing average frequency of occurrence. The annual exceedance probability (AEP) or chance of a 2-year return period sea level is 50%.
The AEP of a 100-year return-period event is 1%.

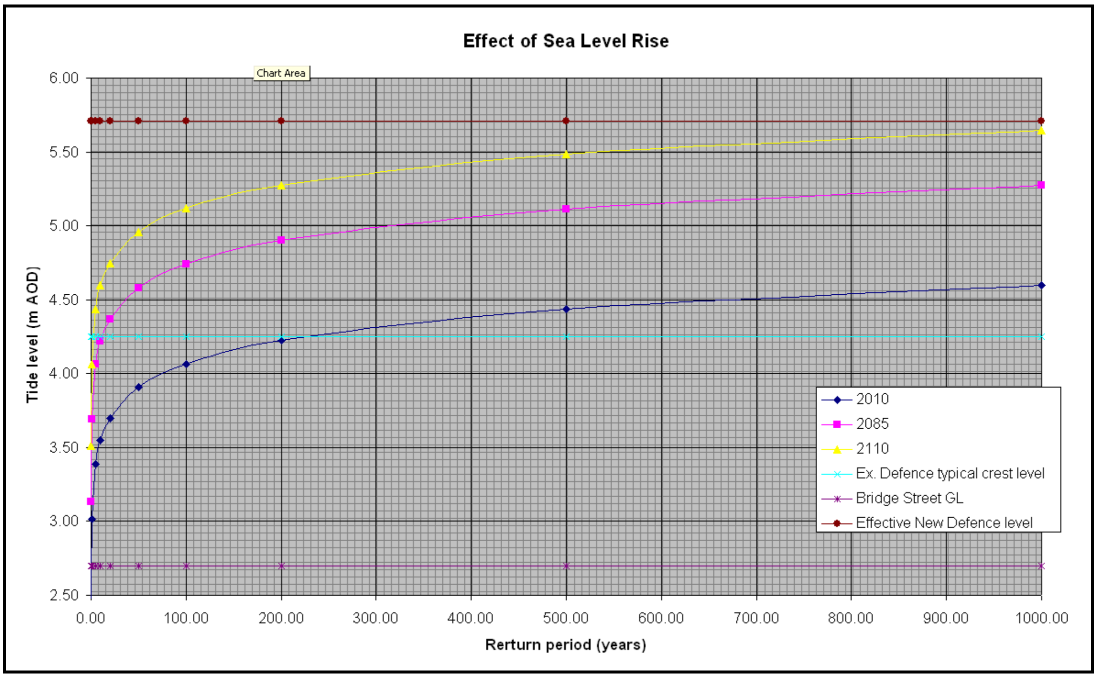
Note a 100-year event is unlikely to occur precisely every 100 years.



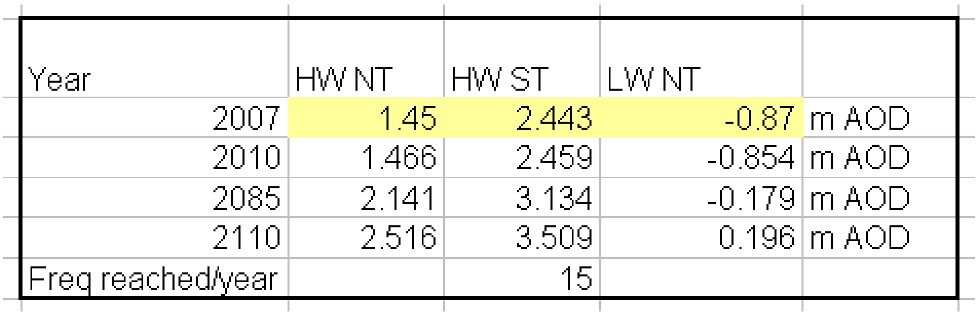
Allowance for sea level rise	0	0.016	0.036	0.691	1.066
Year	2006	2010	2015	2085	2110
Rate/yr (mm)					
Location	Ipswich	Ipswich	Ipswich	Ipswich	Ipswich
Return Period (years)					
0.07	2.443	2.46	2.48	3.13	3.51
1	3.00	3.02	3.04	3.69	4.07
5	3.370	3.39	3.41	4.06	4.44
10	3.530	3.55	3.57	4.22	4.60
20	3.680	3.70	3.72	4.37	4.75
50	3.890	3.91	3.93	4.58	4.96
100	4.050	4.07	4.09	4.74	5.12
200	4.210	4.23	4.25	4.90	5.28
500	4.420	4.44	4.46	5.11	5.49
1000	4.580	4.60	4.62	5.27	5.65
	🟨	Simulations and Hazard Maps Available			

These extreme levels will change in the future as sea levels rise, and the results of further research become available. These levels will be reviewed by the EA and could increase. If critical these should be checked with the EA.

The following graph illustrates how the rising sea levels will dramatically increase frequency of flooding.



Rising sea levels will affect normal daily tide levels without the effect of surges:



Year	HW NT	HW ST	LW NT	
2007	1.45	2.443	-0.87	m AOD
2010	1.466	2.459	-0.854	m AOD
2085	2.141	3.134	-0.179	m AOD
2110	2.516	3.509	0.196	m AOD
Freq reached/year		15		

HWNT – High Water Neap Tide
HWST – High Water Spring Tide
LWNT – Low Water Neap Tide

6.6 Source Pathway Receptor Model

Based on historical flooding and first hand local experience, the following table summarises flooding, sources and how it is assessed later in this report.

Source	Pathway	Receptor	Scale of Consequences	Comment	Assessment in SFRA
Tidal/Fluvial Flooding from the Gipping or Tidal Orwell	Breach or overtopping of flood defences	Many Properties in Flood compartments	Very High,	Potentially very large number of properties involved and significant risk to people. Information available to undertake analyses.	Informed by: • The EA's Ipswich Flood Defence Management Strategy FRA and Modelling report - Jan 2010 • Breach and Overtopping simulations and Hazard mapping undertaken by Halcrow Group Ltd during March 2010 for Ipswich Borough Council using ISIS/TUFLOW model Presented as a series of maps showing flood hazards and frequencies. Plans show condition and crest levels for defences. Duration and speed of onset from simple spreadsheet flood compartment models and ISIS/TUFLOW
Tidal/Fluvial Flooding from the Gipping or Tidal Orwell	Failure to operate moveable defences: Proposed barrier across New Cut or Lock gates at Wet Dock,	Flood compartments - Wet Dock, Island site and Ipswich Village	High	Large number of properties at risk. Risk to people.	Modelled along with breaches of upstream defences as above
Tidal/Fluvial Flooding from the Gipping or Tidal Orwell	Failure to operate moveable defences: West bank railway gate or Future gate under Wherstead Rd railway bridge	Bath Street Flood compartment	High	Very deep water in Riverside Industrial park	Modelled as above

Source	Pathway	Receptor	Scale of Consequences	Comment	Assessment in SFRA
Tidal/Fluvial Flooding from the Gipping or Tidal Orwell	Leaking flap valves on drainage outfalls – some are 2.7m square	Low spots in Flood compartments	Low but salt water has potential to damage football pitch trees and green spaces.	Backflow normally limited to short periods.	Informed by records of flooding. Penstocks fitted at largest sites may be used if flaps fail. Ground level contour map shows lowest areas that are most at risk.
River Gipping or Fluvial Flooding	Breach, overtopping of fluvial defences Over bank flooding	Many Properties situated in the Fluvial Floodplain	Medium to High	Large number of properties at low risk. Risk to people. Large consequences where standard of protection is low.	Informed by the EA's Ipswich Flood Defence Management strategy FRA and Modelling report - Jan 2010
Tidal or fluvial flooding from Belstead Brook	Overtopping of tidal defences at Bourne Bridge. Or overloading of channel.	3 properties, meadows, parkland	Low	Very low tidal defence at Bourne Sluice.	Tidal flooding informed by simple spreadsheet model. Fluvial flooding by HECRAS model (2003). Limited assessment –no LDF sites. Tidal flooding predominant.
Green open spaces	Watercourses, valley floors	Properties & highways in local flood risk areas and Flood compartments	Generally Low but Med-high for basements		Informed by records of flooding. Flood-paths & watercourses shown on map.
Ordinary Watercourses	Failure of embankments – Alderman Canal or Holywells park	Properties & highways in local flood risk areas and Flood compartments	Medium	Small no of properties, earth embankments 2-3m high with trees.	For Alderman Canal a breach is considered, inundated area estimated based on volume of water in canal. No assessment for Holywells canal.
Ordinary Watercourses	Blockage, or flows exceeding channel pipe/culvert capacity	Properties and highways.	Low		Watercourses including major flood paths are recorded by IBC and are shown in Appendices. ASTWF maps now included

Source	Pathway	Receptor	Scale of Consequences	Comment	Assessment in SFRA
Sewerage system, private drainage systems, watercourses	Drains: blockage, flows exceeding pipe/culvert capacity. Failure of pumps or blocked outfall grilles, flap valves etc & penstocks (Toller Rd Tunnel)	Properties & highways in local flood risk areas and Flood compartments. Wet Dock	Low High for basements	Surface water flooding is a complex and variable issue. Detailed assessment is required at a local level to quantify the risk. Mapped by IBC Limited available information to assess risk in more detail.	Informed by records - IBC have Databases and maps showing “local flood risk areas” Anglian Water have Info Works sewerage models
Groundwater Flooding	High groundwater levels, springs and blocked land drainage	Parkland & properties in low lying areas, civil infrastructure	Low	Limited number of properties involved at present.	Informed by records. Spring lines inferred from BGS map, and ASTWF now shown in Appendices

7 TIDAL & FLUVIAL FLOODING – APPROACH TO ASSESSMENT

7.1 Freeboard

No allowance is included for freeboard during the assessment of risks. This approach has been agreed with the EA and Halcrow. This is because:

- The upper Orwell estuary is sheltered from the NW winds and so wave heights during surges will be small.
- The precautionary nature of the new flood defence design.
- In addition the defences are designed to a high standard.

Freeboard allowance is however required for floor levels in vulnerable buildings

7.2 Ground Levels

Ground levels used in the assessment are from LIDAR data supplied by the EA. The data had been processed to remove buildings.

Hazard mapping is based on 2008 LIDAR data supplied in February 2010.
Other assessments were based on data supplied during January 2007 from surveys in 1999 and 2001. In three areas, recent raising of ground levels has occurred. Flood mapping takes account of the new levels based on proposals submitted with planning applications. The areas were Rapier Street, Bath Street and Ranelagh Road

Plans in the appendices show when areas were surveyed.

A ground level contour plan based on the LIDAR data is also included.

7.3 Frequency And Sequence Of Existing Flooding

The extent of flooding is mapped for a range of tide levels, each corresponding to a particular compartment defence (natural or manmade) level, assuming the flood compartments fill immediately when overtopping of the defences commences. The extent of flooding may be overestimated however no allowance is made for freeboard.

Frequencies associated with each tide level/flood level are from the graph in section 6.5.

Further more detailed modelling has been carried out for 0.5% and 0.1% AEP events – reported later.

7.4 Design Of The New And Proposed Tidal /Fluvial Defenses

The report " Ipswich Flood Defence Management Strategy, East Bank, West Bank and Barrier Works Flood Risk Assessment (January 2010)" describes in detail the modelling work undertaken by the Halcrow Group to design the proposed defences, including the barrier-operating regime.

The coupled ISIS TUFLOW model extends from Bramford gauging station to the Orwell Bridge but did not include Belstead Brook.

Much of the Halcrow's work looked at the interaction between tidal and fluvial flows and how the proposed barrier would be operated. Extreme tides can affect river levels upstream of the Horseshoe Weir and Handford Sluice.

Halcrow re examined fluvial flow records and tidal water levels and used the extreme sea levels described in section 6.5

The correlation between coincident tidal surges and fluvial events, has been considered using DEFRA report "Use of Joint Probability Methods in Flood Management: A Guide to Best Practice, R & D Technical Report FD2308/TR2, Defra/Environment Agency Flood and Coastal Defence R&D Programme, March 2005."

A very low (precautionary) correlation was considered appropriate and a precautionary allowance was made to account for inaccuracies in fluvial flow records.

"The model was run for 50%, 20%, 10%, 4%, 2%, 1%, 0.33% and 0.1% AEP tidal events using the Haskoning surge profile with a 36 hour duration. The model used a constant fluvial inflow at Bramford, to give either a 1 in 300 year combined probability event over a 9 hour duration, assuming χ=0.01, or 9 m$_3$/s which is exceeded 1 % of the time if this was higher. The 100, 300 and 1000 year events were also run with a 20 % increase in flow and a 1.01 m increase in the downstream boundary to test the sensitivity to climate change."

It is proposed that the barrier would be raised in advance of a surge tide, normally at low water. Fluvial flows would be stored upstream of the barrier.

If upstream water levels in the river exceed downstream tide levels the barrier would be lowered.

The nearest tidal forecast location to Ipswich is Felixstowe. Based on analysis of the error in forecasts at Felixstowe, preparations should be made to close the barrier if the tidal forecast is 3.61 m AOD or higher if the upstream defences at New Cut East are repaired, and 3.13 m AOD if they are not.

Use of these thresholds gives a 1 % probability of a tidal event being over the upstream defence height when it is forecast to be lower than the upstream defence height. Using the current DEFRA guidance on sea level rise this means that the barrier will be closed once every 14 years in 2006 and 5 times a year in 2106 if the upstream defences are repaired, and once every 2 years in 2006 and 50 times a year in 2106 if the upstream defences are not repaired.

If sea level rise and fluvial flows increase as predicted, the report finds, by about 2035 to 2053 a fluvial pumping station (capacity 22 to 39 cubic metres per second) may be required to maintain the standard of protection at >0.33% AEP.

There is high degree of uncertainty in these predictions, which are sensitive to the frequency of barrier operation, fluvial flows, and the level of the defences along the island site.

The report recommended further monitoring of fluvial flows since there was evidence that the flow gauging station at Bramford was under measuring. The report also recommended tidal predictions at Felixstowe and actual levels in Ipswich should be recorded and analysed.

It is expected the results of the monitoring would enable the barrier closure frequency to be reduced. This would effectively reduce the probability of high fluvial flows occurring during a barrier closure.

The report confirms that if the barrier is not raised there is capacity in the river channel for at least a 0.1% fluvial event including for 20% increase in flow due to climate change. This was with a tide level tide level of 3.14m – HWST @2106.

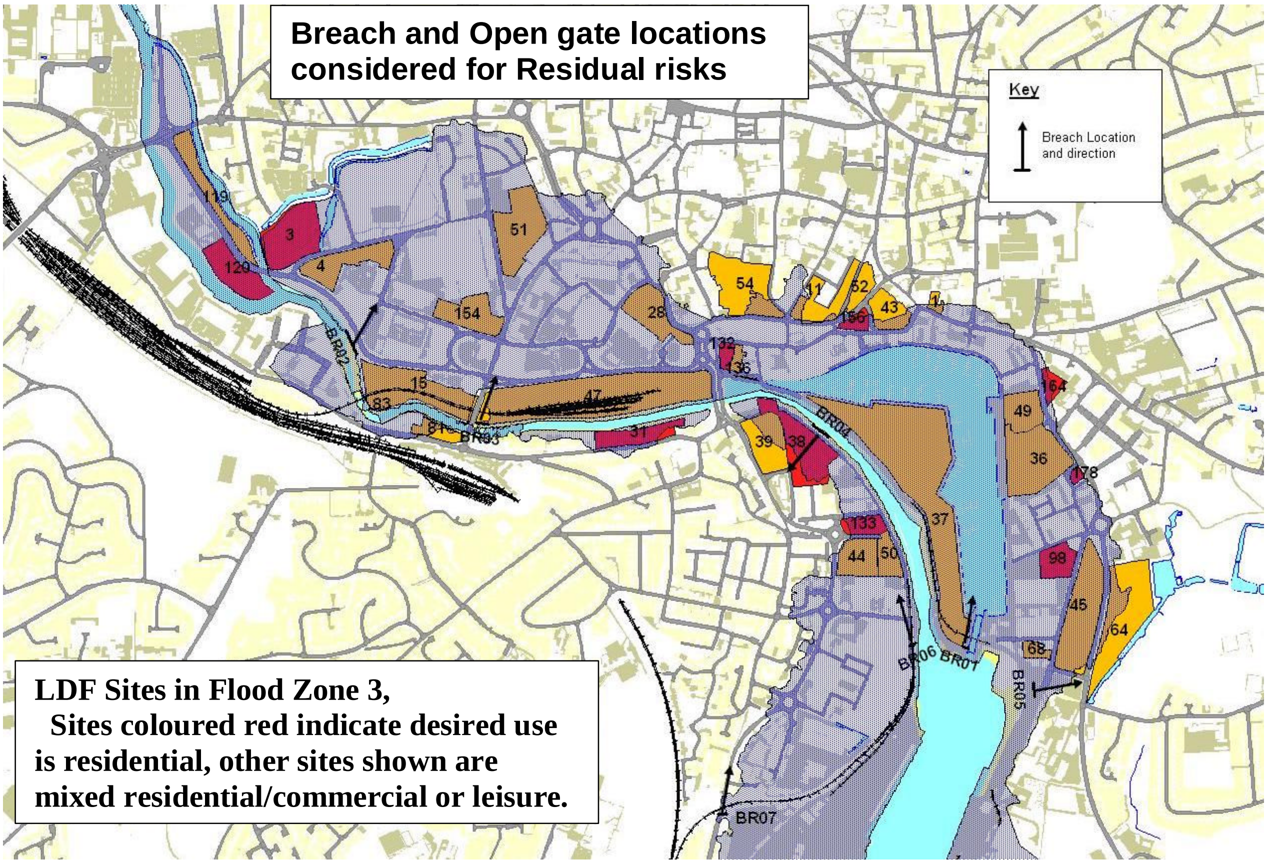
7.5 Detailed Modelling - Rivers Orwell and Gipping

Ipswich Borough Council commissioned the Halcrow Group to slightly modify the EA's TUFLOW ISIS model and use this to simulate overtopping and breaching for existing and future scenarios used to assess residual risk.

The2D TUFLOW model generally has a 10 m minimum grid size built using 2008 LIDAR data supplemented where necessary e.g.: under the railway bridge at Wherstead Rd or where ground raising has recently taken place at Bath Street and Ranelagh Road by data produced by IBC.

Breach and open gate locations have been chosen based on the proximity of potential development sites and where the head of water retained by the sheet piled defences is highest relative to the ground level on the landward side.

These were agreed with EA and are shown below:



Breach and Open gate locations considered for Residual risks

LDF Sites in Flood Zone 3, Sites coloured red indicate desired use is residential, other sites shown are mixed residential/commercial or leisure.

Breaches may not occur at the locations chosen for the analysis; other locations may need to be considered for specific sites.

Breach parameters were agreed with the EA and follow paragraph 7.14 of the PPS25 Practice Guide, which refers to "At risk? - Planning for Flood Risk in Yorkshire & Humber" (2004).

A width of 20 m was therefore assumed for the breaches in hard defences.

Breaches are assumed to develop (i.e. defence collapses to ground level) either when overtopping commences or when the maximum tide/fluvial water level is reached.

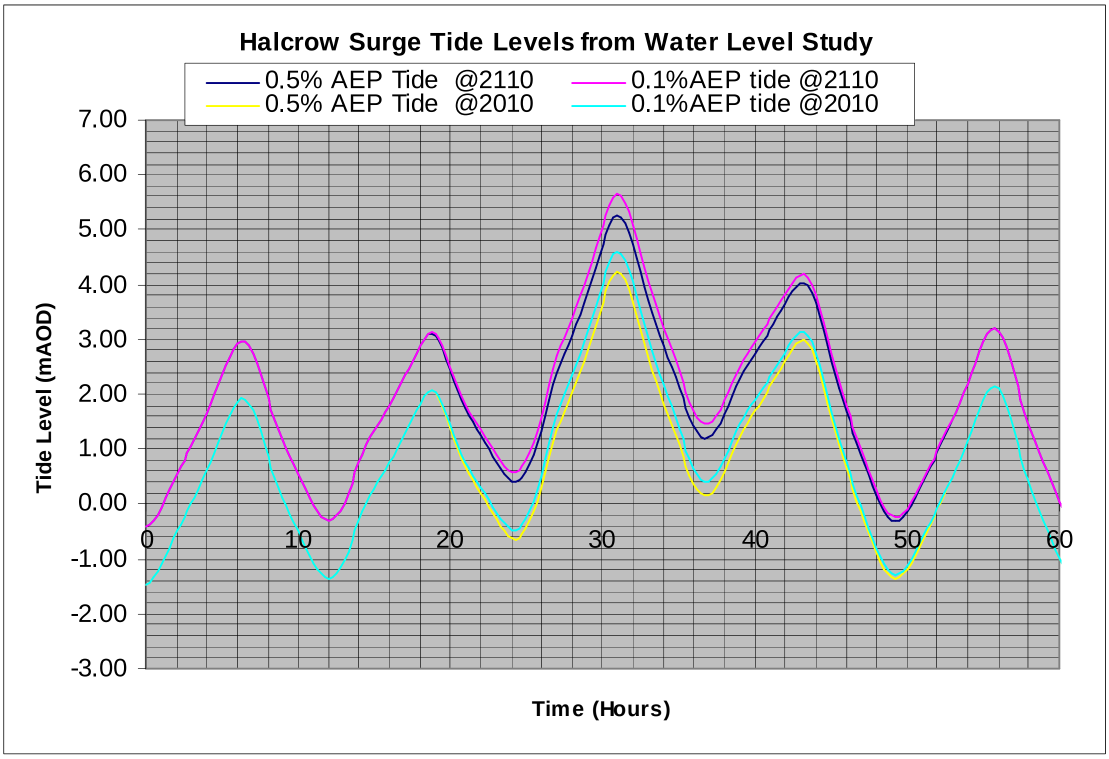
It is assumed that breaches are repaired after 36 hrs.

Where gates have been represented in the open position they are assumed to be open throughout the simulation.

Large buildings close to breach locations identified from OS Mastermaps are included where these are likely to influence flood flows. These are represented as “stubby buildings” which are only 300mm high. This represents both the obstruction to fast flows and storage within the buildings. Manning's "n" for buildings is set at 0.1

The initial water level in the Wet Dock is assumed to be 2.6m AOD.

Tidal profiles used for Hazard mapping by Halcrow.



7.6 Residual Risk Scenarios Considered

The model representing the existing situation (IP01) includes the recently completed East and West bank defences, large buildings in close proximity to breach sites, and raised ground levels. This model was used to simulate fully operational, overtopping and breach scenarios for sea levels and fluvial flows at 2010 and 2110. Multiple breaches were not considered. The subsided section of floodwall at New Cut East is assumed to be at 3.8m

A similar base model (IP02) was developed which included full implementation of the Flood Defence Management Strategy (FDMS), this time including the constriction in the New Cut East at the barrier site, a fluvial pumping station, raised and repaired defences at New Cut East, a flood gate at Wherstead Rd railway bridge and a major development planned at SHLAA site 47 (N Bank US of Stoke Bridge which raises the existing defence to 6m AOD – Planning permission was granted in March 2010).

This model was used to simulate scenarios at 2015 and 2110 all assuming the barrier is left open. (The probability of the barrier being left open is low as several back up systems are planned)

A third base model (IP03) was also developed and this again represented the full implementation of the FDMS, but this time the New Cut barrier is raised.

For each of the above base scenarios a range of breaches or gate failures was modelled.

A fourth base model (IP04) represented full implementation of the strategy with the gate raised but this time assumed the fluvial pumping station was not operative.

For each scenario the models were used to generate flood hazard mapping for 0.1% and 0.5% AEP events.

The exercise was repeated taking into account climate change and sea level rise for year 2110.

The table below summarises the simulations undertaken. Hazard maps produced for each simulation are in section 8.11.

Hazard Mapping Scenarios Modelled -

		Fully Operational	Wet Dock Lock Gates left open	Breach into West End Rd (left bank)	Breach d/s Princes St bridge (left bank)	Breach into Bath Street area (right bank)	Breach in new East Bank defence or Red 7 gate left open	Railway gate in West Bank defence left open.	Gate in Wherstead Rd defences left open.
	Breach Reference:	**Br00**	**Br01**	**Br02**	**Br03**	**Br04**	**Br05**	**Br06**	**Br07**
Model	**Base Scenario**								
IP01	Existing defences including the new East and West bank defences.	2010 0.5% 2010 0.1% 2110 0.5% 2110 0.1%	2010 0.5% 2010 0.1% 2110 0.5% 2110 0.1%	2010 0.5% 2010 0.1% 2110 0.5% 2110 0.1%	2010 0.5% 2010 0.1% 2110 0.5% 2110 0.1%	2010 0.5% 2010 0.1% 2110 0.5% 2110 0.1%	2010 0.5% 2010 0.1% 2110 0.5% 2110 0.1%	2010 0.5% 2010 0.1% 2110 0.5% 2110 0.1%	
IP02	Proposed defences including the barrier, pumping station for fluvial flow, repairs to New Cut u/s defences, Wherstead Rd floodgate, and Tesco development with enhanced defence. Barrier open.			2015 0.5% 2015 0.1% 2110 0.5% 2110 0.1%	2015 0.5% 2015 0.1% 2110 0.5% 2110 0.1%	2015 0.5% 2015 0.1% 2110 0.5% 2110 0.1%			
IP03	Proposed defences including the barrier, pumping station for fluvial flow, repairs to New Cut u/s defences, Wherstead Rd floodgate, and Tesco development with enhanced defence. Barrier closed.	2010 0.5% 2110 0.1%	2015 0.5% 2015 0.1% 2110 0.5% 2110 0.1%				2015 0.5% 2015 0.1% 2110 0.5% 2110 0.1%	2015 0.5% 2015 0.1% 2110 0.5% 2110 0.1%	2015 0.5% 2015 0.1% 2110 0.5% 2110 0.1%
IP04	Proposed defences including the barrier, pumping station for fluvial flow, repairs to New Cut u/s defences, Wherstead Rd floodgate, and Tesco development with enhanced defence. Barrier closed and pumping station not built.	2110 0.5% 2110 0.1% Year	Annual Exceedance Probability (AEP)						

7.7 Belstead Brook

Tide levels limit the discharge of flows to the estuary and the tidal flood plain acts as a storage reservoir.

A HEC-RAS model of a 4Km length of the Belstead Brook floodplain upstream of Bourne Sluice was developed by Babtie (now Jacobs) Group for Ipswich Borough Council during 2003.

The modelling included a 20% addition to peak flows and assumed varying tidal levels - It concluded that tidal flooding was predominant at Bobbits Lane, where the 1% annual probability fluvial flood level was approximately 2m AOD - much lower than the 0.5% annual probability tidal flood level.

7.8 Speed Of Onset And Duration Of Tidal Flooding

The speed of onset will have a major impact on whether people are exposed to floodwater. Where onset is slow they will have time to leave the area.

Speed of onset and duration of flooding has been estimated for each compartment using an “in house” model that accounts for draining down of floodwater through a simplified representation of the sewerage system or piped watercourses. The model has also been used to estimate tidal flood levels in the Belstead valley where tide levels can be substantially higher than flood levels.

In reality it is possible that drain down times could be longer if drainage gully grates etc block with debris, or shorter if defences collapse as the tide level in the Orwell drops below flood water levels retained behind defences.

Bearing in mind the inherent inaccuracies only one scenario is considered:
- The 0.5 % annual probability level at 2110 with existing flood defences.

This is the worst case for the speed of onset and duration in the majority of flood risk areas.

Compartments H&J are linked as the Low Level Trunk Sewer runs through both compartments and also because the threshold between the two compartments is low. These two compartments are therefore combined. The initial water level in the wet dock is assumed to be 2.6m. It is assumed that the floodgate is open and the sluice gates in the Lock gates are open.

The results are shown graphically in the appendix together with a compartment plan. The graphs can be used to determine the likely speed of onset and duration of flooding for specific development sites.

8 TIDAL & FLUVIAL FLOODING - RESULTS OF ASSESSMENT

8.1 Frequency Of Recent Tidal Events.

By comparing defence levels shown in appendix 5.3 with the tide levels from section 6.5, it is clear that defences would not overtop until the tide reached about:

- 3.3m at Bourne bridge Sluice (Belstead Brook (5% AEP)
- 3.8m – 4.25m where the New Cut east defences have subsided and the earth bank should provide protection to about 4.25m i.e. (2% to 0.5% AEP)
- 4.07m where raised ground at the West bank terminal protects Wherstead Road (1%AEP)

The highest tide recorded in recent years was 3.48m. This caused no major problems.

8.2 Flood Zones

The EA provide maps of areas (zones) with medium and high probability of flooding from the main rivers – i.e. the River Gipping and Belstead Brook, and tidal waters – i.e. the Orwell Estuary. These zones ignore the presence of any flood defences.

Zone 2 is regarded as MEDIUM and Zone 3 As HIGH probability.

Zone 1, outside Zone 2, has a less than 1 in 1000 chance of main-river or sea flooding in any year (<0.1% or LOW probability).

For areas likely to suffer tidal flooding Zone 2 has a 0.5% -0.1% probability of flooding in any year and Zone 3 >0.5% probability.

For areas likely to suffer fluvial flooding, zone 2 has a 1% - 0.1% probability of flooding in any year and Zone 3 >1% probability in any year.

PPS25 subdivides zone 3 into zone 3a and zone 3b – “functional floodplain” where raising ground levels or obstructions would worsen flooding.

The EA maps are “indicative” and do not show “islands” within these zones that may not flood. They do not show how risks vary within the zones.

At the lowest points in zone 3 the probability of flooding is much higher than 0.5%.

In the past FRAs have erroneously (or ambiguously) indicated that sites are at risk of flooding in a 0.5% probability event simply because it is within Zone 3, whereas the probability is really much higher.

This SFRA therefore provides mapping which will readily enable the probability and risk of flooding to be estimated at a particular point.

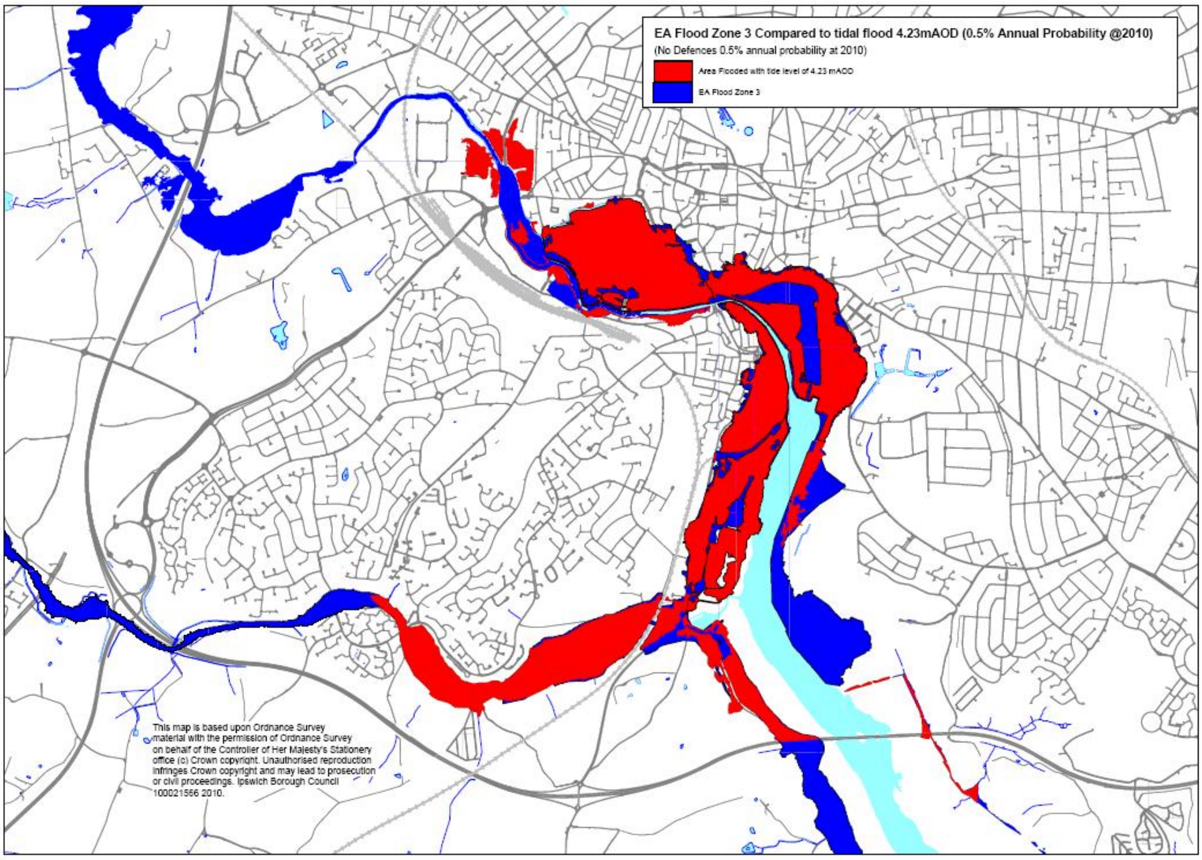
For Ipswich there appears to be no zone2 – this is because ground levels rise steeply from the flood plain and zone 2 is very narrow.

8.3 Flood Zone 3, Current 0.5% Tidal and 1% fluvial flood areas

The following plan assumes no defences and highlights areas where differences between the two maps occurs – primarily the Wherstead Rd area and Port.

The extent of the 0.5% AEP tidal flood is effectively the 4.23m ground level contour.

The 1% AEP fluvial level is predicted to reach 3.85m AOD just upstream of Yarmouth Rd and there are isolated lower areas beyond the banks of the river. These are not shown below since the tidal level predominates. Upstream of the Norwich railway sluice the blue area relates to the fluvial floodplain.

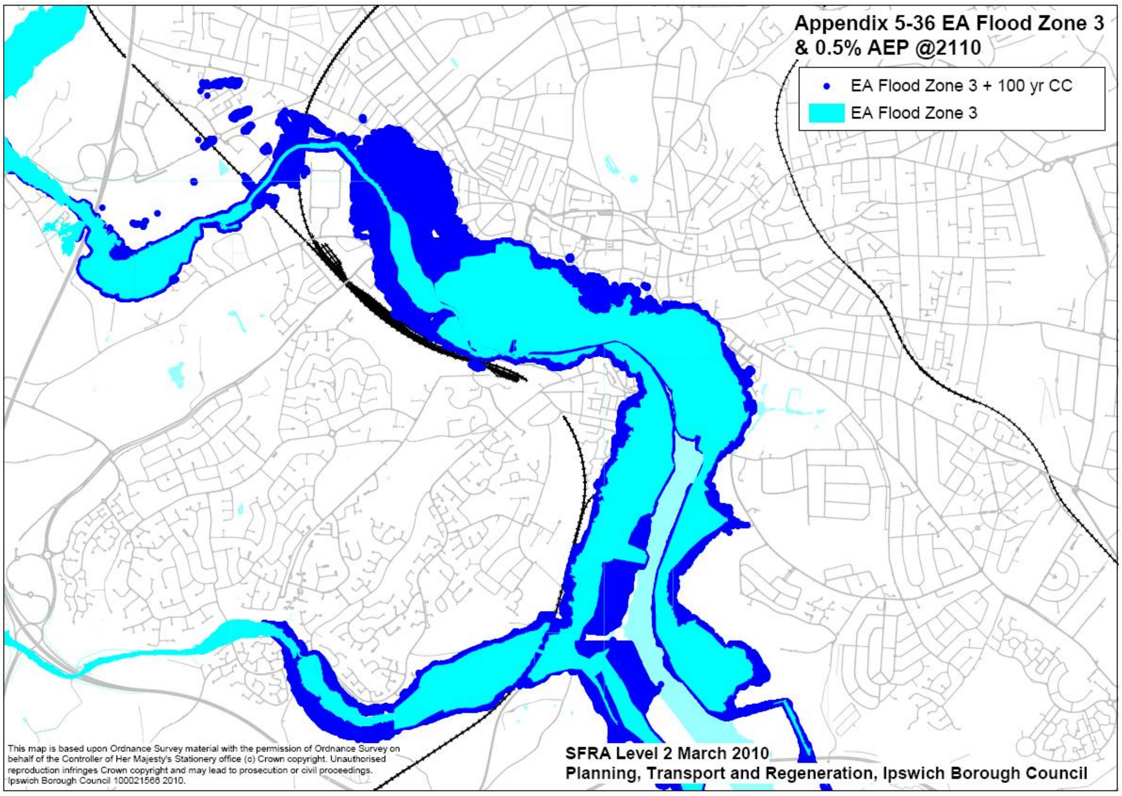


8.4 Flood Zone 3, Future 0.5% Tidal And 1% Fluvial Flood Areas

The plan below accounts for sea level rise up to the year 2110, assumes no defences and highlights areas where differences between the two maps occurs.

The extent of the 0.5% AEP tidal flood is effectively the 5.28 m ground level contour.

The 1% AEP fluvial level including climate change to 2107 was predicted to reach 3.95 m AOD just upstream of Yarmouth Rd; this is only 100mm higher than the current level.



8.5 Functional Flood Plain

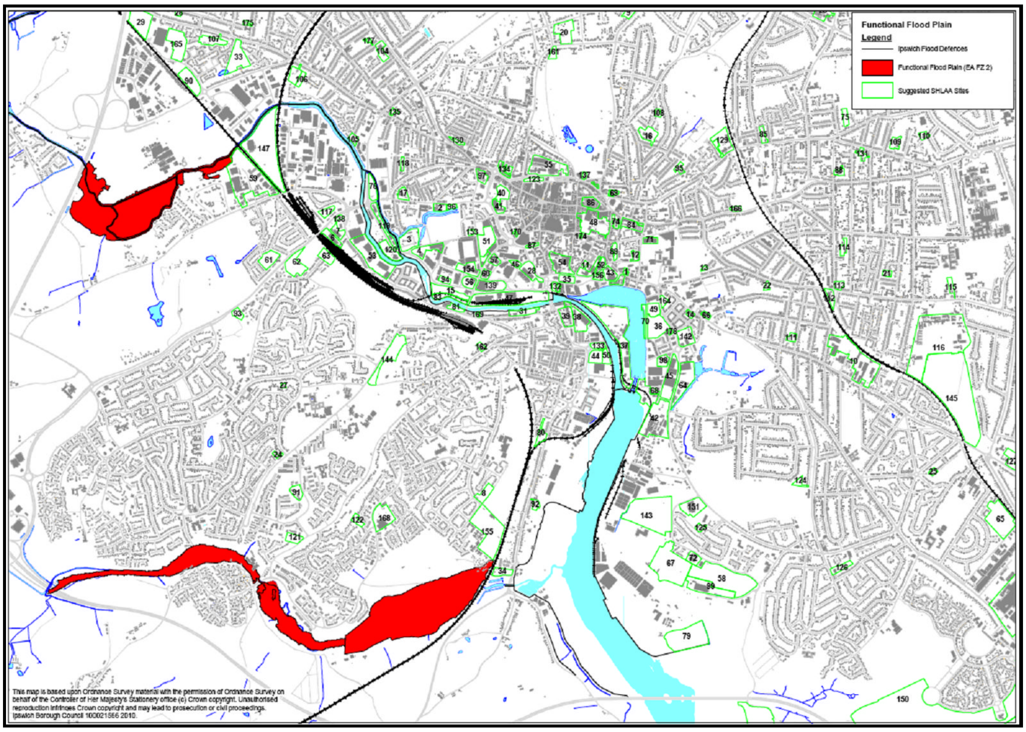
In PPS25 functional floodplain is defined as:

Land where water has to flow or be stored in times of flood.

These are areas that if infilling or development were allowed to occur, flood storage would be reduced causing flood levels and severity of flooding to increase. PPS25 further describes functional floodplain as land which:

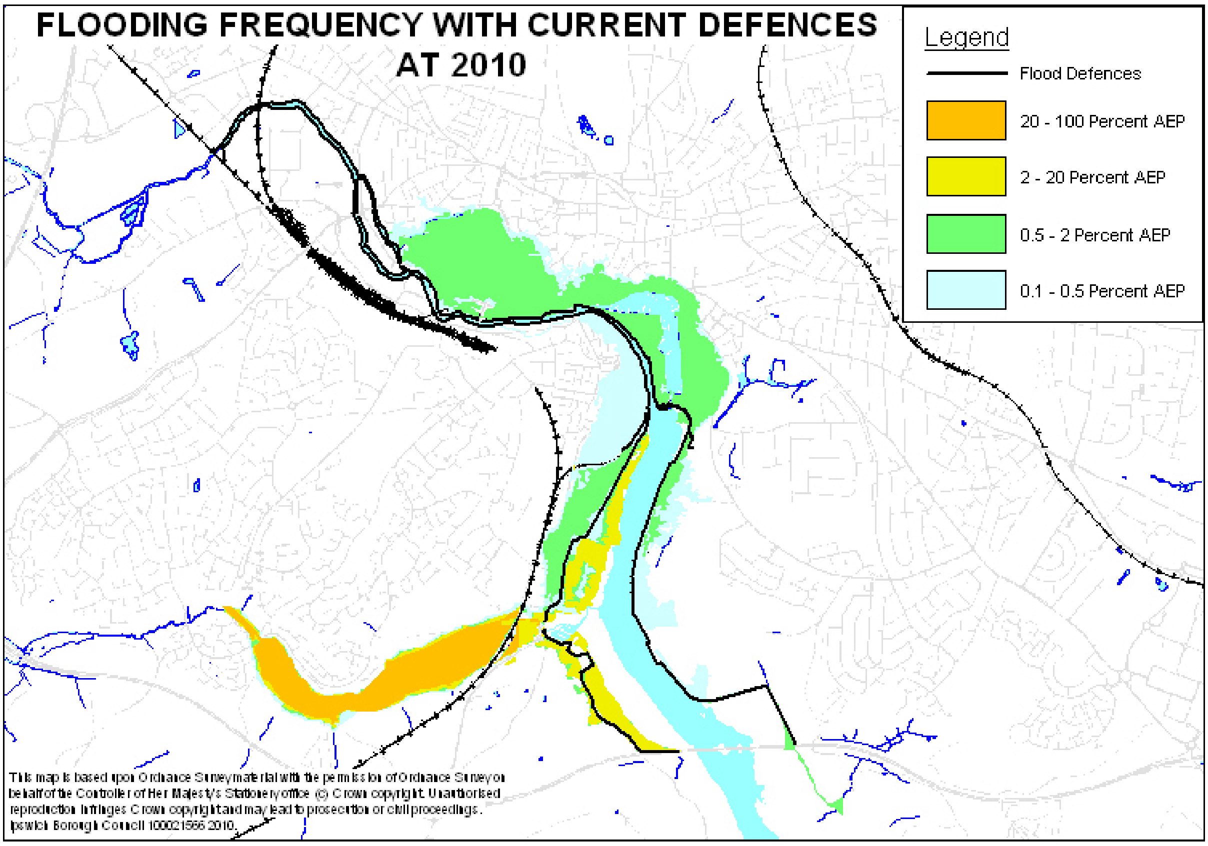
- **Would flood with an annual probability of 1 in 20 (5% AEP) or greater in any year**
- **Is designed to flood in an extreme (0.1% AEP) flood.**

For Ipswich the floodplain of Belstead Brook upstream of Bourne sluice and the Gipping upstream of the Norwich railway line should be regarded as functional. .



8.6 Frequency @2010 - Existing Defences

Maps showing existing defences and flood compartments are included in Appendices. The plans showing variability of flood frequency included below are included at a larger scale, in the appendices.



The frequency of flooding within compartments H and J (Wet Dock and Village area) is shown to vary between 2% and 0.5% AEP - due to variations in crest level along the New Cut East defences. (3.8m to 4.25m AOD.)

However the TUFLOW modelling shows a 4.23m (0.5% AEP) tide would flood across new Cut East and the island to fill the Wet Dock to the 3.1 m AOD with a small amount of overflow into compartment J (Village area). The plan could therefore be refined.

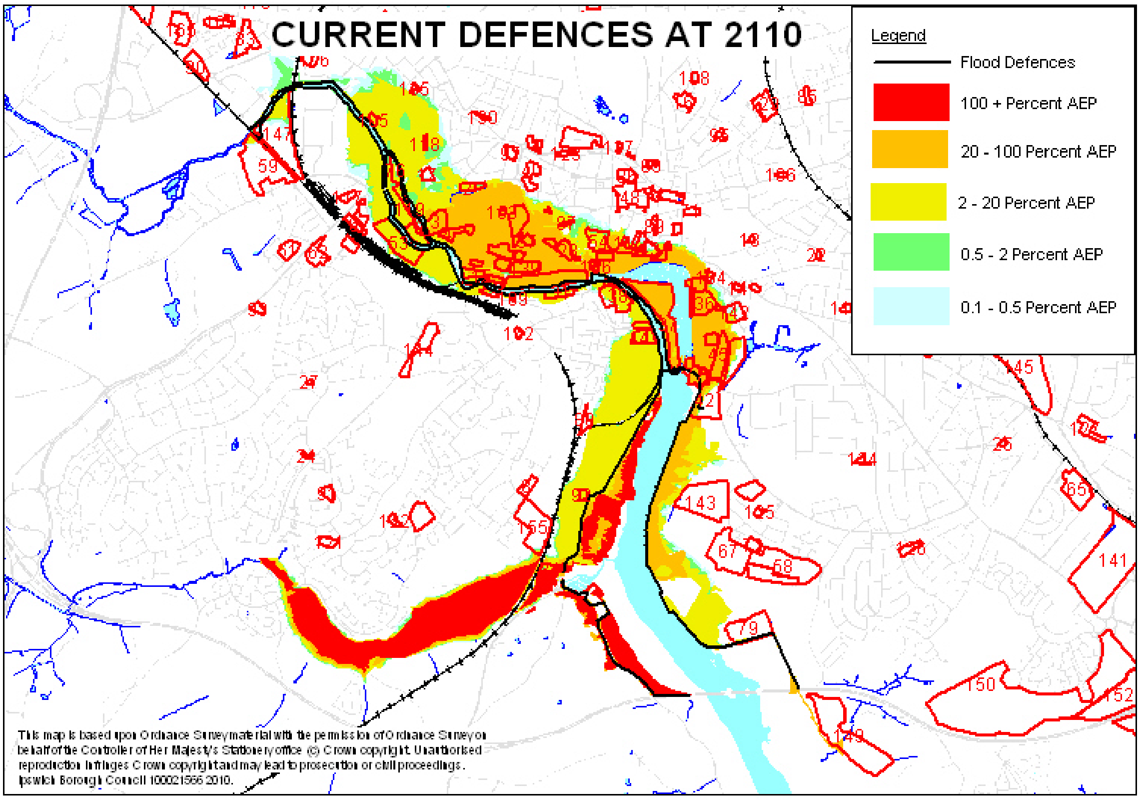
It can be seen that there is wide variation in frequency and the existing topography provides a degree of protection in some areas such as the Wherstead Rd –compartment B Here the Wherstead Road area is shown to flood only when the tide exceeds 4.07m AOD and overtops the raised West bank Terminal land. However the depth suddenly reached in Wherstead Road would be 1.2m - sufficient to represent a danger to most people and cause major damage.

The “defence” crest level of 4.07m was taken from the EA’s Project Viability Report - IFDMS –Wherstead Rd Flood Risk Management Scheme (Sept 2009). This is a locally low section and is slightly lower than shown on the LIDAR data used in most of this assessment. NFCDD shows no information. Defence levels here are reducing due to subsidence. Again the frequency of flooding is therefore precautionary but may be reached in a few years if defence levels are not raised.

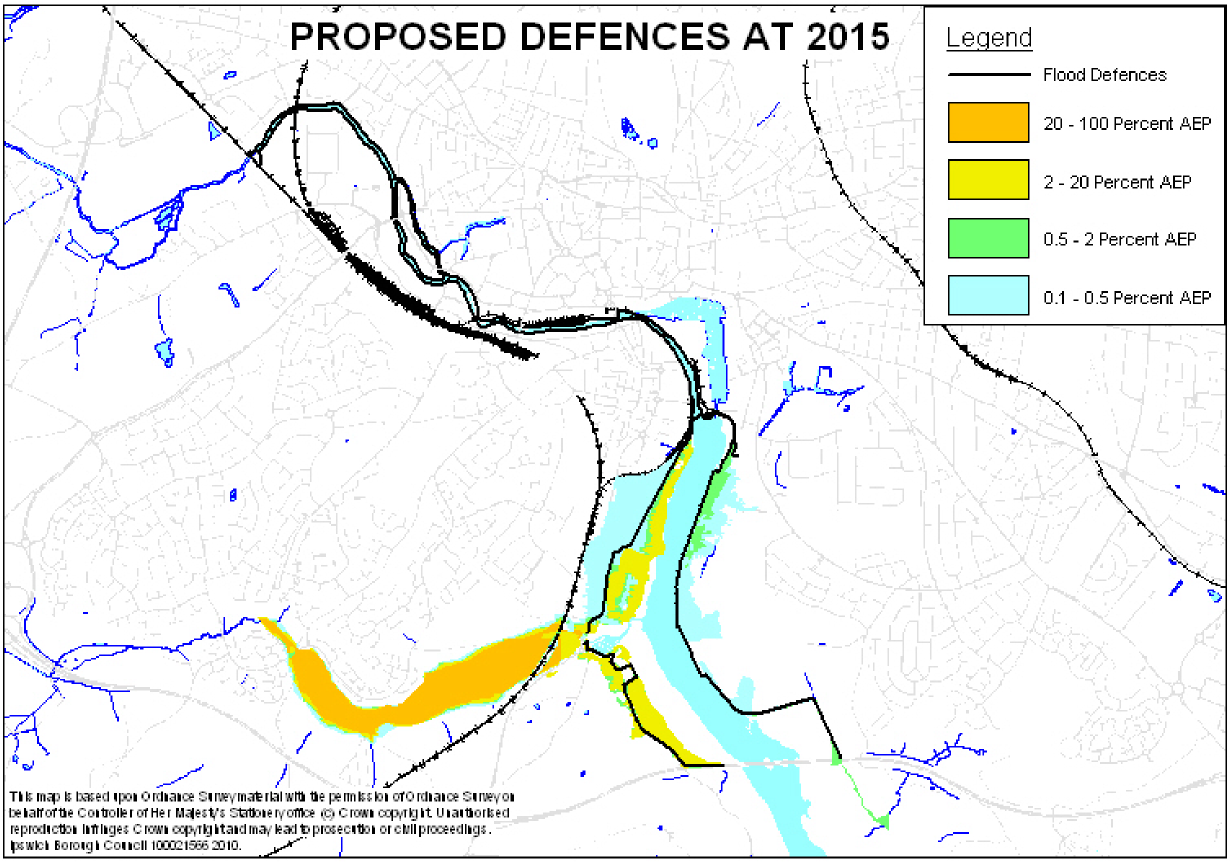
The plan could be used to inform current emergency plans as it shows areas at risk for a range of tide levels and indicates the likely sequence of flooding. As the tide level rises flooding would start to affect red areas first and blue areas last.

8.7 Frequency At 2110 – Existing (2010) Defences

With no changes to the existing defences the frequency of flooding increases dramatically in response to rising sea levels. By 2110 the Village and Wet Dock areas would flood in events with an AEP 20% - 100% (return period 5 years to 1 year). Sea level /frequency data is in section 6.5



8.8 Frequency @2015 With Barrier



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There is a small degree of uncertainty regarding frequency of flooding in Compartments H and J shown above to be <0.1 %AEP.

The crest of the new defences is at 5.71m. This is much higher than the 0.1 % AEP tidal level (4.62m).

At 2015, the annual probability of tidal/fluvial flooding upstream of the barrier will certainly be less than 0.33% because Halcrow's work indicates by 2035 to 2053 a fluvial pumping station is likely to be needed to maintain the 0.33% AEP standard of defence

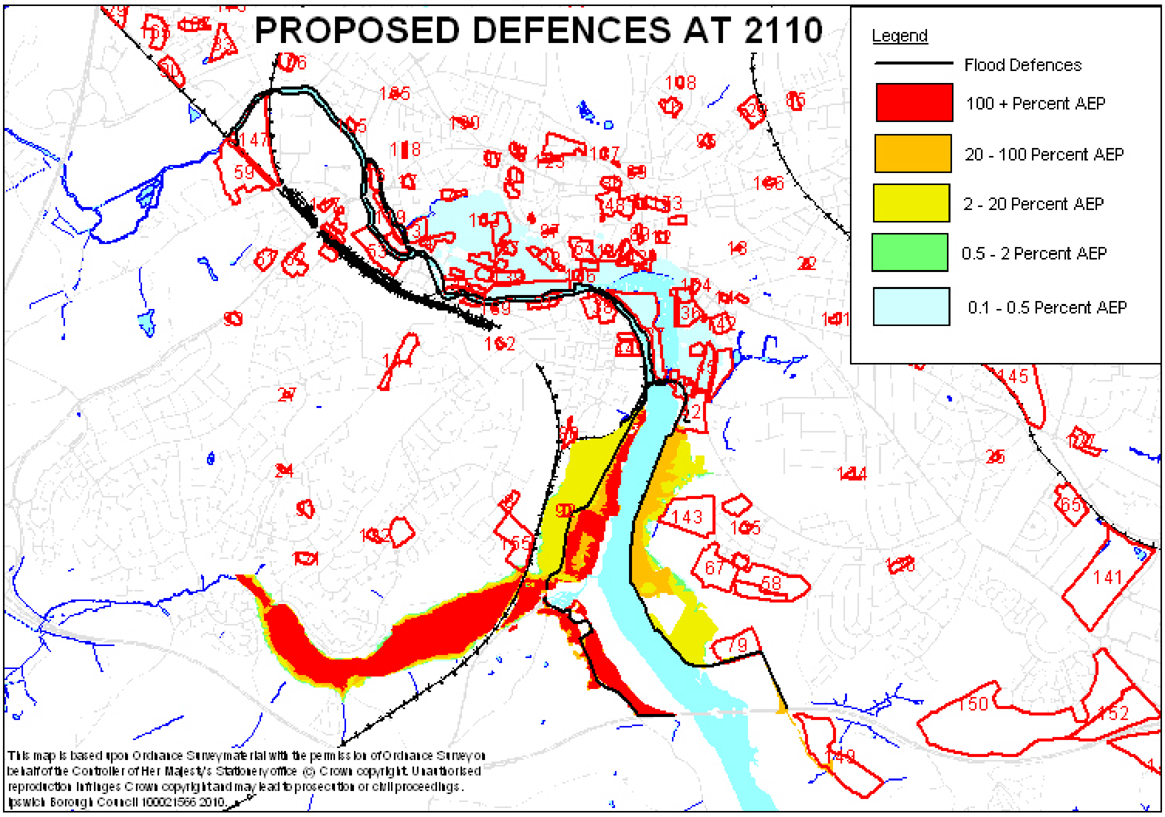
The Halcrow modelling report does not consider in detail combined tidal/fluvial 0.1 %AEP events at 2015 so there is a possibility that there could be some fluvial flooding in compartments J and H in a 0.1 %AEP combined tidal/fluvial event in 2015. However Halcrow have taken a conservative approach due to uncertainties as described in 7.4.

In addition improved fluvial flow recording, and monitoring of the accuracy of tidal predictions should result in reduced barrier closure frequency and therefore probability of coincident high tides and fluvial flows.

The above plan shows the frequency to be <0.1% AEP, partly to help illustrate the effect of climate change when compared to the next plan and partly due to the conservative approach taken.

Wherstead Road compartment B is assumed to flood when the tide reaches 4.4m AOD – the proposed defence level for work planned in 2012.

8.9 Frequency @2110 With Barrier



By this date the fluvial pumping station is predicted to be required during barrier closure periods, to keep water levels upstream of the barrier below the New Cut East Defence level (4.25m). The pumps would be designed to maintain the standard of protection in compartments H and J at 0.33% AEP.

One of the residual risk scenarios modelled and described in section 7.6 assumes failure of the pumps and predicts flooding in Compartments H and J to reach the levels of 3.6 to 3.8m AOD in the 0.1% AEP event. These contours are used on the above map to define the boundary of the blue area. This is a conservative assessment subject to many factors and future refinement.

Wherstead Road compartment B is assumed to flood when the tide reaches 4.4m AOD – the planned defence level in 2012. In practice if sea levels rise as much as predicted, the defences would probably be raised again when the frequency of flooding increased to 1% AEP.

8.10 Sequence Of Tidal Flooding - @2010 – No Barrier

Tide level in New Cut	Compartment	Effect	Comments
3.30	B1. Belstead Valley	Tide overtops Bourne sluice, clay embankment washed away, Very fast flowing water along Bourne Park access road under railway bridge.	
4.0	A. The Strand B. Wherstead Road	Road flooded West Bank terminal flooded. Water starts to overtop natural defences at West bank terminal and could flood Wherstead Rd to a depth of up to 1.8m.	Timber mobilised in this location.
4.25	H. Wet Dock J. Ipswich Village	New Cut East defences overtopped, flooding across Island into Wet Dock. If level is exceeded or is maintained buildings and roads along the Wet Dock Waterfront flood including College St Duke St. Power failures as water enters lighting columns and illuminated street furniture Rising water around Wet Dock suddenly floods Holywells Rd to 1.6m deep. Foul sewers start to overflow at Pooley’s Yard, Ancaster Rd/Ranelagh Rd (downstream sewer in flooded area)	Saltwater enters Low Level trunk sewer via gullies, sewage from perhaps 30,000 people floods into low lying areas in Portman Rd.

4.65	B. Wherstead Road D. Burrell Road	Wherstead Rd floods under railway bridge via highway drainage and railway drain. Fast flowing water across Wherstead Rd adjacent to Bourne Sluices. Foul sewers overflowing at Pooley's Yard, Ancaster Rd/Ranelagh Rd.	Ip-City centre and Felaw Street Malting buildings flooded. Foul pumping stations in Bath St and Dock Street flooded.
	E. Ranelagh Road	Ancaster Rd/ Ranelagh Rd flooded to 1.45m deep. Burrell Rd flooded. London Rd flooded	
	G. ABP Land	East Bank terminals flooded.	Fertiliser and timber floats off and away.
	C. Bath Street area J Ipswich Village	Tide overtops New Cut West & fast flowing water flows around Persimmon's new development, rapidly flooding surrounding roads to 2.25m deep. Riverside Industrial Estate floods rapidly to 2.45m deep. Floodwater reaches and rapidly fills pedestrian subway at Princes Street. Tide overtops bank upstream of Stoke Bridge and flows across Bridge Street, (1.85m deep & impassable to most vehicles) into wet dock. Fast flowing salt water across roads & car parks at Cardinal park, Princes Street and along Portman Rd.	

As the tide level in the Orwell drops, potential for sudden failure of any standing defences will be high. Fast flowing water laden with floating debris would flow back into the Orwell.

8.11 Hazard Mapping Results – Introduction

The following maps show flood hazards associated with fully operational defences (for actual risks) as well as for less likely scenarios such as breaches and or open floodgates, which are used to assess residual risk. The scenarios and breach locations considered are listed in 7.6

Different breach / open gate scenarios will have different probabilities and may affect a particular site in different ways.

A breach into one compartment may affect others

Hazard maps are not included for the Belstead Brook.

Hazard maps at a small scale are included below to enable comparisons to be made. Full sized hazard maps for fully operational defences are included in Appendices 5.15 to 5.26.

Summary tables in 8.13 and 8.15 compare flood levels reached in the Village and Wet Dock areas for each scenario. These provide an indicative comparison of risks associated with each scenario.

A further table considers the relative risk associated with the scenarios and outlines suggestions for controlling the residual risks

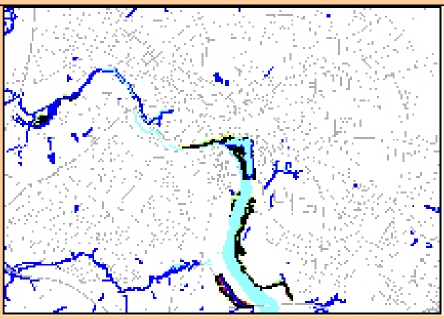
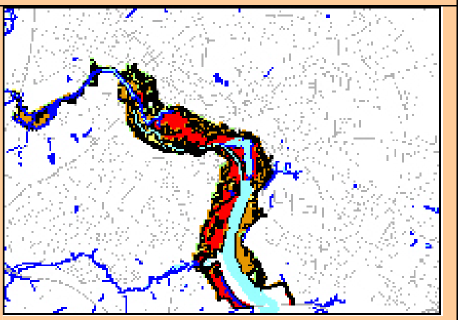
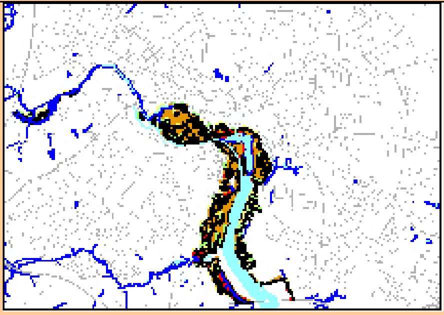
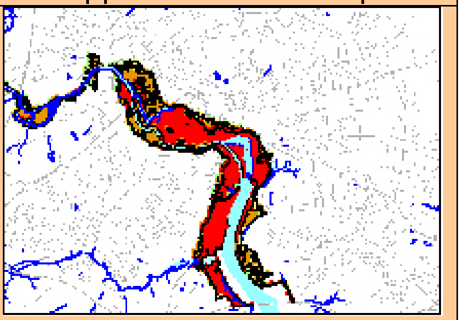
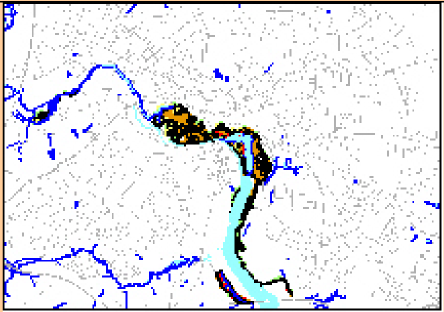
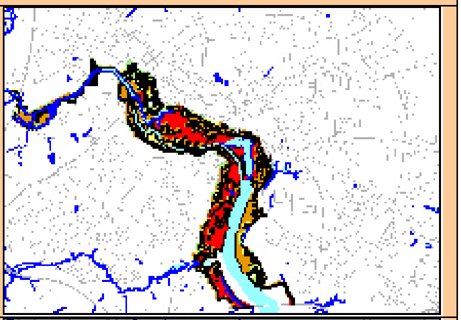
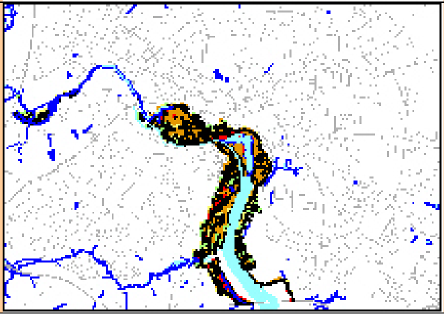
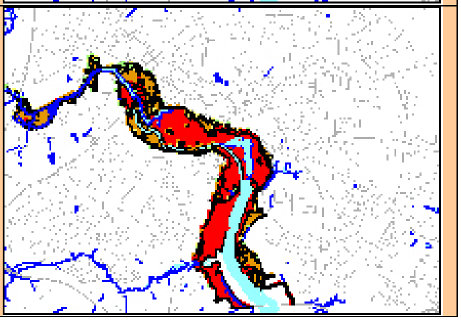
Some scenarios are unlikely and control measures appear to be practical.

For the remaining scenarios detailed Hazard maps are combined and included in the appendix. These are intended to inform land use allocation and development control decisions – Subject to the control measures been implemented.

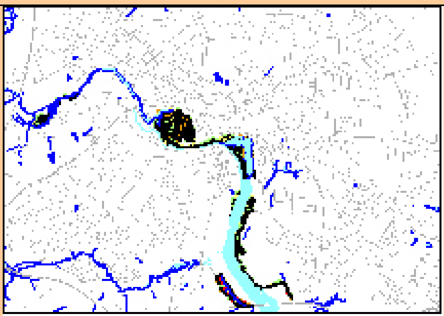
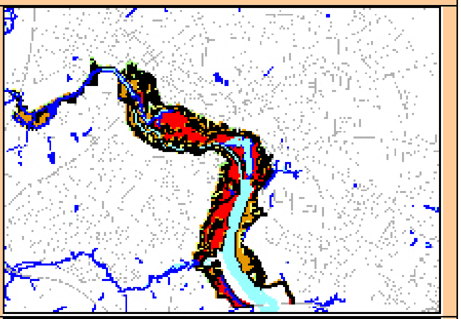
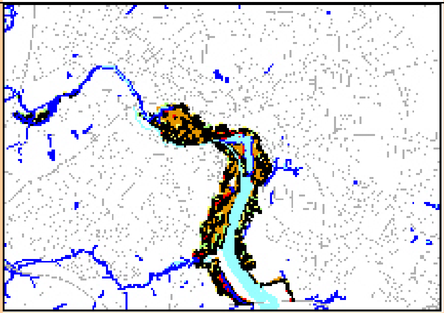
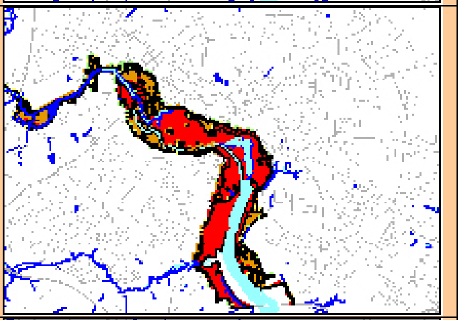
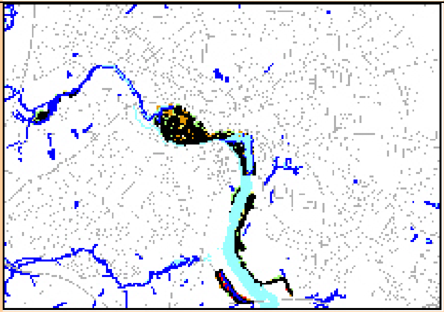
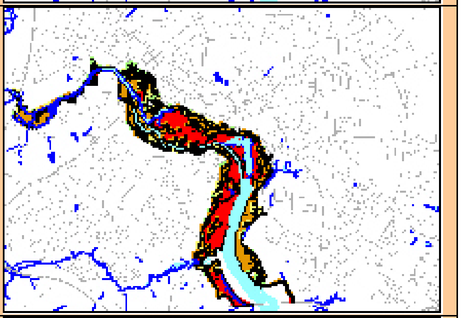
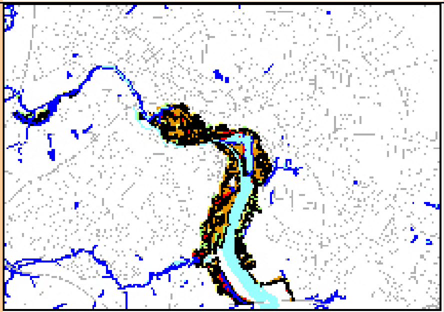
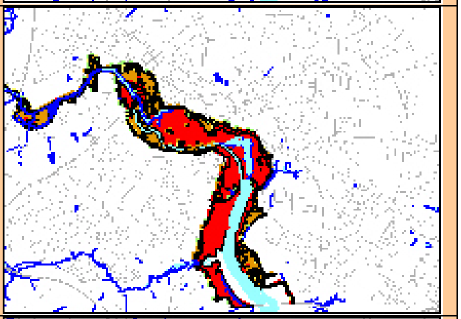
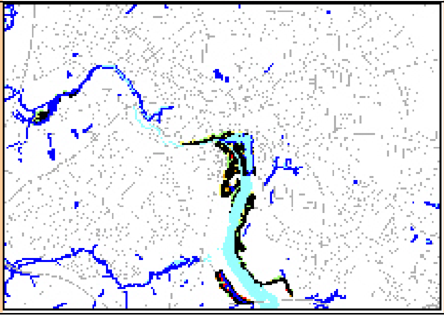
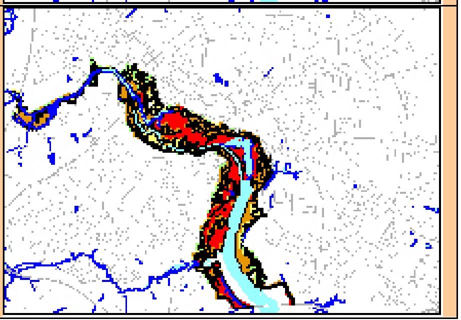
Key to coloured hazard maps:

HR		Degree of Hazard	Description	
HR<0.75	🟩	LOW	Caution	Caution - Flood zone with shallow flowing water or or deep standing water"
0.75-1.25	🟨	MODERATE	Danger for some (eg: Children)	Danger - Flood zone with deep or fast flowing water
1.25-2	🟫	SIGNIFICANT	Danger for most people	Danger - flood zone with deep fast flowing water
>2	🟥	EXTREME	Danger for all people	Extreme danger - flood zone with deep fast flowing water

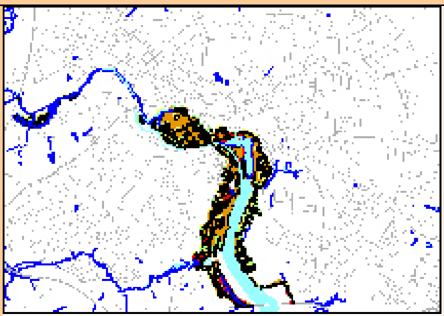
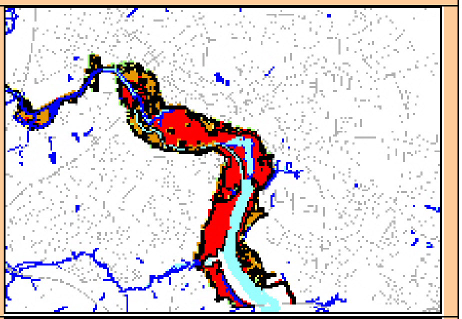
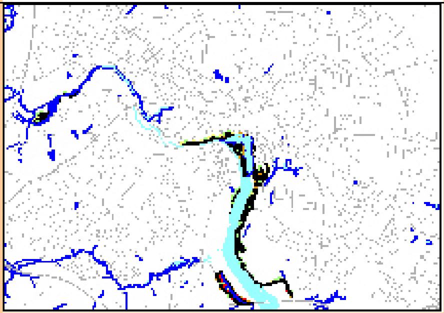
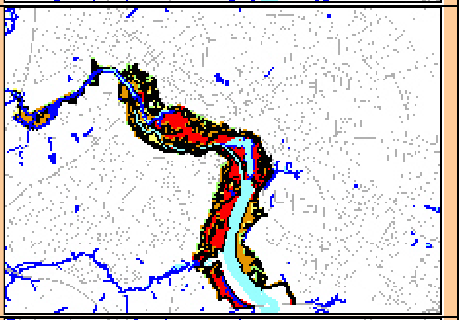
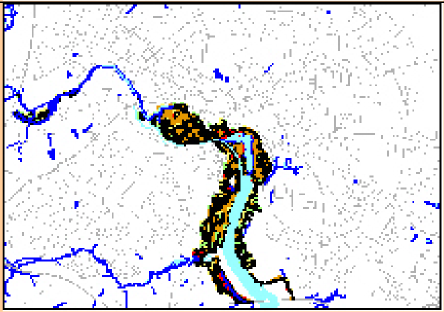
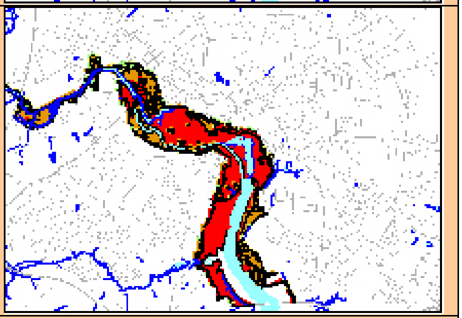
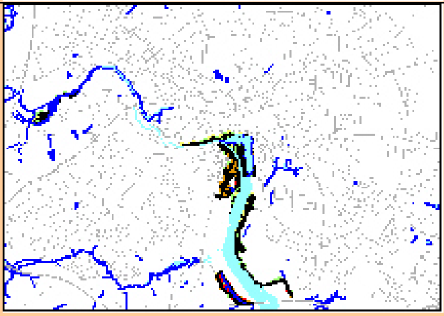
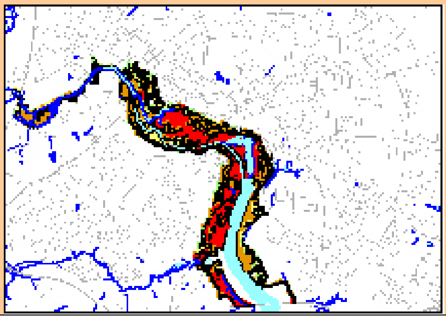
8.12 Hazard Maps – Existing defences

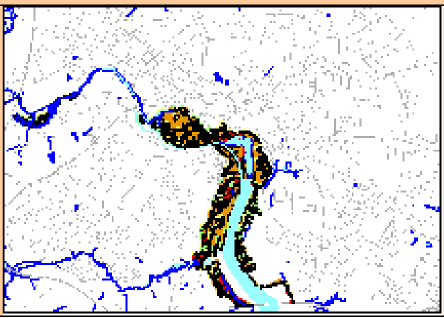
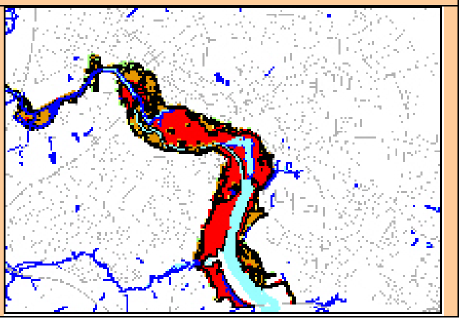
<table>
<tr><th colspan="4">Existing Defences including the new East and West bank defences (model IP01)</th></tr>
<tr><td>Scenario</td><td>AEP</td><td>At 2010</td><td>At 2110</td></tr>
<tr><td rowspan="2">BR00
No breaches or open gates – fully operational</td><td>0.5%
(200yr return period)</td><td>
See appendix for full size plan</td><td>
See appendix for full size plan</td></tr>
<tr><td>0.1%
(1000 yr return period)</td><td>
See appendix for full size plan with existing vulnerable development</td><td>
See appendix for full size plan</td></tr>
<tr><td rowspan="2">BR01
Wet Dock Flood gates left open</td><td>0.5%</td><td></td><td></td></tr>
<tr><td>0.1%</td><td></td><td></td></tr>
</table>

Existing Defences including the new East and West bank defences (model IP01)

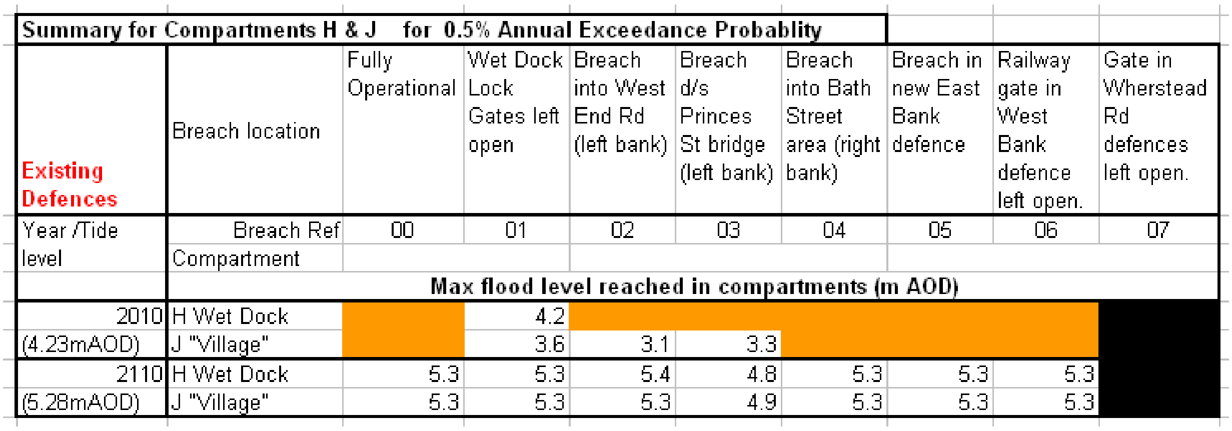
Scenario	AEP	At 2010	At 2110
BR02 Breach into West End Road	0.5%		
	0.1%		
BR03 Breach adj. Princes Street bridge	0.5%		
	0.1%		
BR04 Breach into Bath Street area	0.5%		

Existing Defences including the new East and West bank defences (model IP01)

Scenario	AEP	At 2010	At 2110
	0.1%		
BR05 Breach at new East Bank defence	0.5%		
	0.1%		
BR06 Railway gate in West bank defence left open.	0.5%		

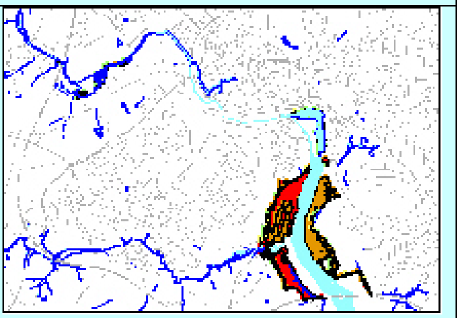
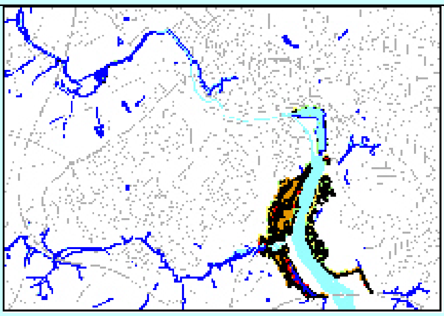
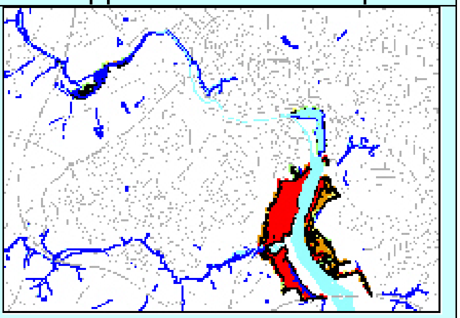
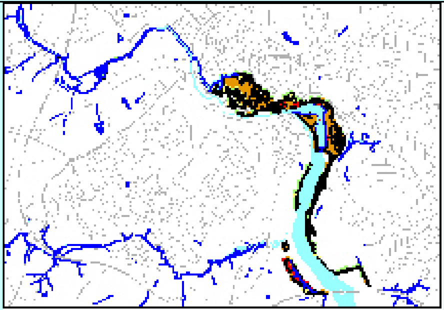
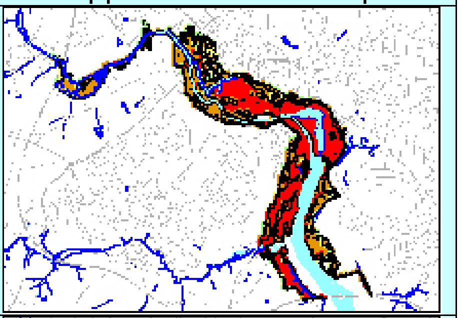
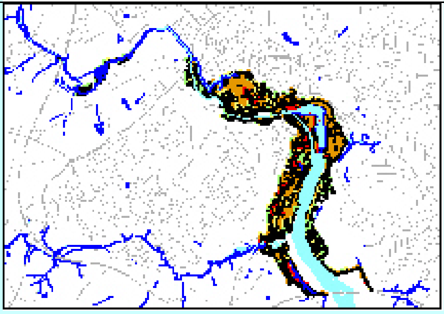
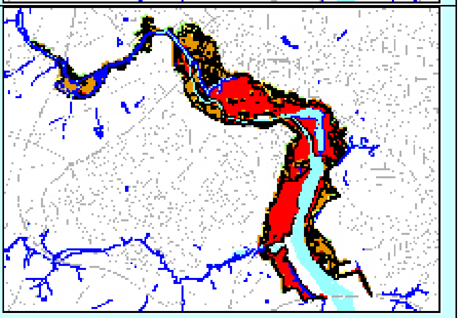
Existing Defences including the new East and West bank defences (model IP01)			
Scenario	AEP	At 2010	At 2110
	0.1%		

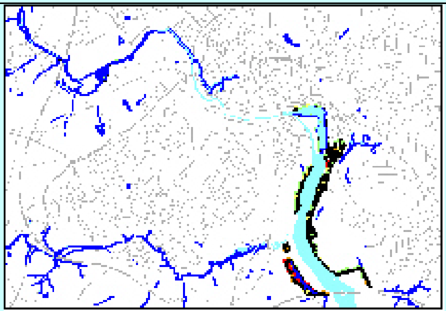
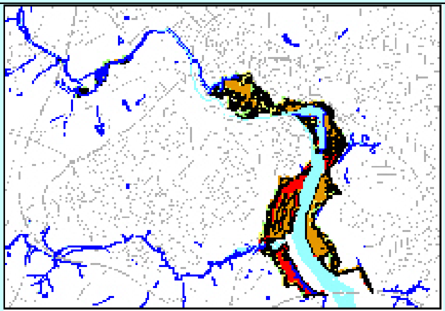
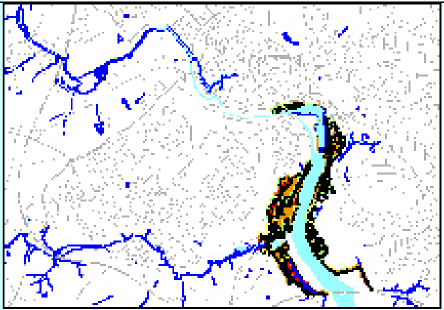
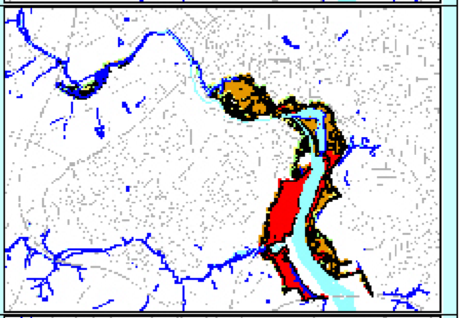
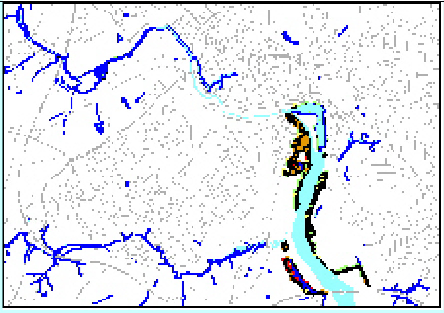
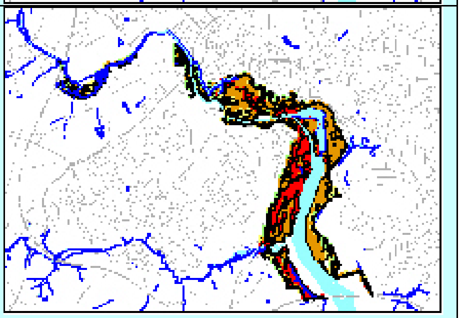
8.13 Flood levels predicted In Compartments J And H. – Existing

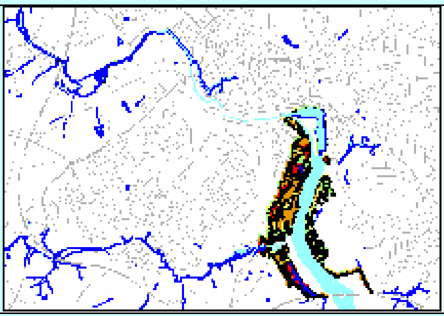
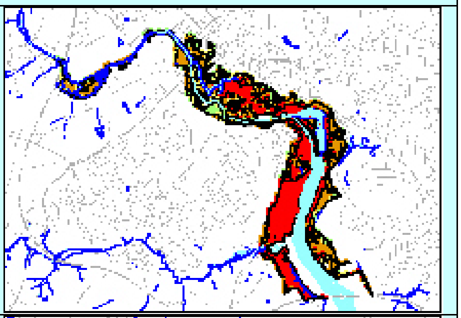
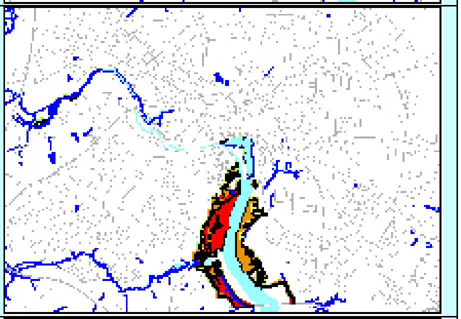
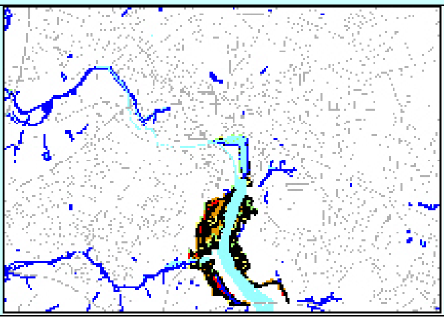
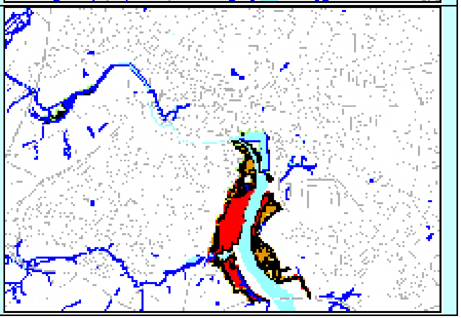


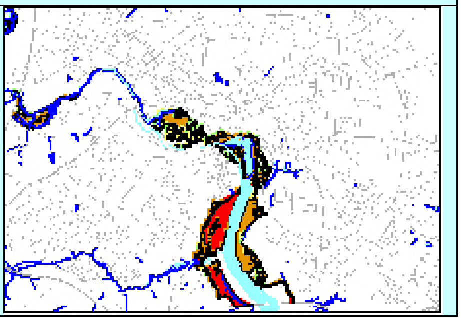
Summary for Compartments H & J for 0.5% Annual Exceedance Probablity									
Existing Defences	Breach location	Fully Operational	Wet Dock Lock Gates left open	Breach into West End Rd (left bank)	Breach d/s Princes St bridge (left bank)	Breach into Bath Street area (right bank)	Breach in new East Bank defence	Railway gate in West Bank defence left open.	Gate in Wherstead Rd defences left open.
Year /Tide level	Breach Ref	00	01	02	03	04	05	06	07
	Compartment								
	Max flood level reached in compartments (m AOD)								
2010	H Wet Dock		4.2						
(4.23mAOD)	J "Village"		3.6	3.1	3.3				
2110	H Wet Dock	5.3	5.3	5.4	4.8	5.3	5.3	5.3	
(5.28mAOD)	J "Village"	5.3	5.3	5.3	4.9	5.3	5.3	5.3	

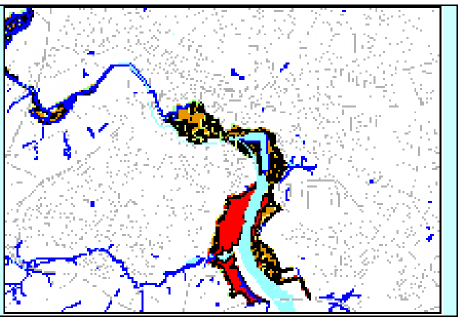
8.14 Hazard Maps – Proposed Defences

Proposed Defences with barrier raised (model IP03)			
Scenario	AEP	At 2015	At 2110
BR00 No breaches or open gates – fully operational	0.5%	No flooding upstream of barrier. For downstream of barrier see BR01 below:	 See Appendix for full size plan
	0.1%	 See Appendix for full size plan	 See Appendix for full size plan
BR01 Wet Dock Flood gates left open	0.5%		
	0.1%		

<table>
<tr><th colspan="4">Proposed Defences with barrier raised (model IP03)</th></tr>
<tr><td>Scenario</td><td>AEP</td><td>At 2015</td><td>At 2110</td></tr>
<tr><td rowspan="2">BR02
Breach into West End Road</td><td>0.5%</td><td colspan="2" rowspan="2">Considered below in barrier open scenario.
Unlikely to occur with barrier closed since water levels in the river channel upstream of the barrier are limited - due to the low level (4.25mAOD of the New Cut East Defence</td></tr>
<tr><td>0.1%</td></tr>
<tr><td rowspan="2">BR03
Breach adj. Princes Street bridge</td><td>0.5%</td><td>Considered below with barrier open</td><td></td></tr>
<tr><td>0.1%</td><td></td><td></td></tr>
<tr><td rowspan="2">BR04
Breach into Bath Street area</td><td>0.5%</td><td>Considered below with barrier open</td><td></td></tr>
<tr><td>0.1%</td><td></td><td></td></tr>
<tr><td rowspan="2">BR05
Breach at new East Bank defence</td><td>0.5%</td><td></td><td></td></tr>
<tr><td>0.1%</td><td></td><td></td></tr>
<tr><td>BR06
Railway gate in West bank defence left open.</td><td>0.5%</td><td></td><td></td></tr>
</table>

Proposed Defences with barrier raised (model IP03)			
Scenario	AEP	At 2015	At 2110
	0.1%		
BR07 Gate @ Wherstead Rd Bridge left open	0.5%	Tide level too low to breach.	
	0.1%		

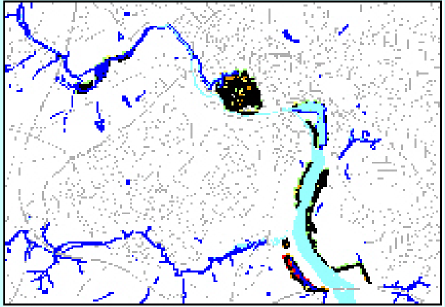
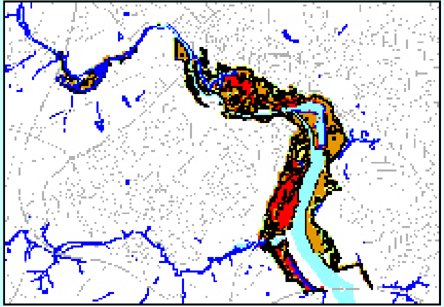
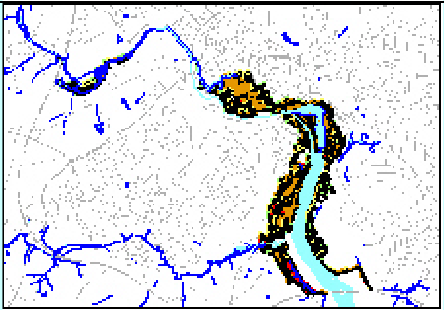
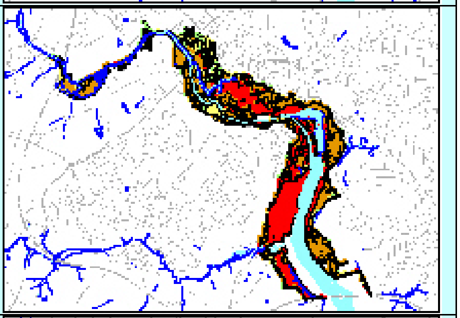
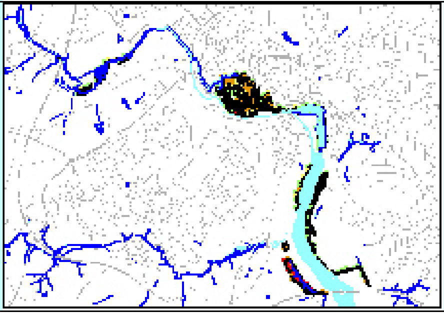
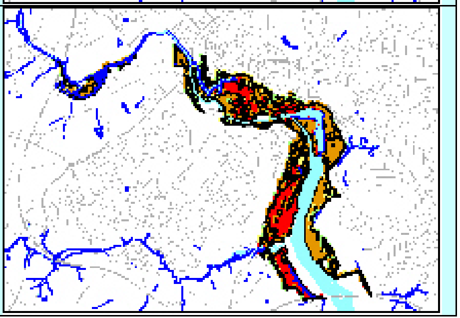
Proposed Defences but with barrier raised (model IP04)			
Scenario	**AEP**	**At 2015**	**At 2110**
BR00 Future fluvial pumping station inoperative	0.5%	Pumping station probably not required until 2035 to 2053.	

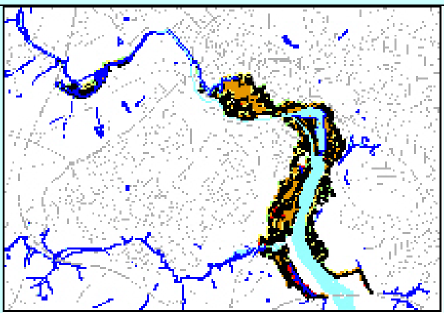
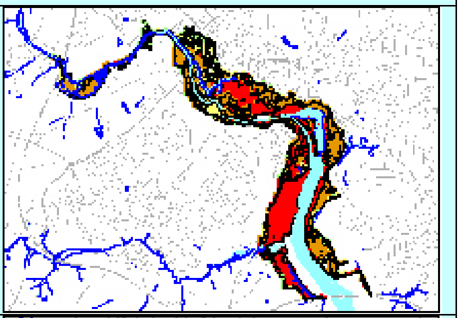
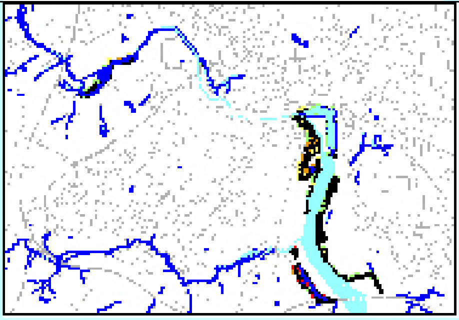
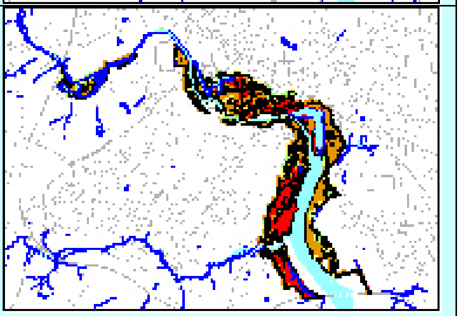
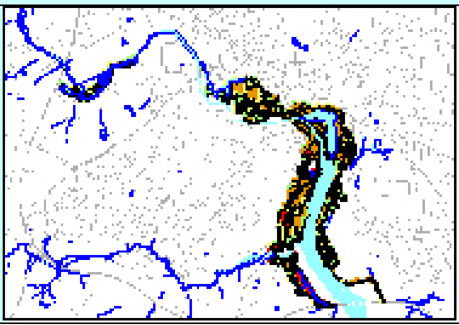
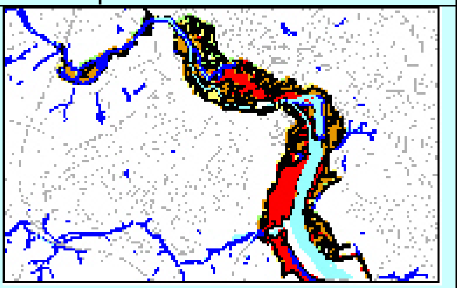
	0.1%		

Fluvial flows overtop New Cut East and flow across island into Wet Dock. This then overflows across Bridge Street into the “village” area.

The following three scenarios assumed existing defence walls upstream of the barrier breached AND the barrier failed to operate.

Proposed Defences but with barrier open (IP02)

Scenario	**AEP**	**At 2015**	**At 2110**
No breaches		See Existing Defence Scenarios above	
BR02 breach into West End Rd	0.5%		
	0.1%		
BR03 Breach adj. Princes Street bridge into Compartment J	0.5%		

Proposed Defences but with barrier open (IP02)			
Scenario	**AEP**	**At 2015**	**At 2110**
	0.1%		
BR04 Breach into Bath Street Compartment	0.5%		 Overtops
	0.1%		 Overtops

8.15 Flood levels predicted In Compartments J And H. – Proposed

Summary for Compartments H & J for 0.5% Annual Exceedance Probablity

Proposed Defences	Breach location	Fully Operational	Wet Dock Lock Gates left open	Breach into West End Rd (left bank)	Breach d/s Princes St bridge (left bank)	Breach into Bath Street area (right bank)	Breach in new East Bank defence	Railway gate in West Bank defence left open.	Gate in Wherstead Rd defences left open.	Fluvial Pumping station inoperative
Year /Tide level	Breach Ref Compartment	00 barrier raised	01	02	03 barrier open	04	05	06	07 barrier raised	00
						Max flood level reached in compartments (m AOD)				
2015 (4.25mAOD)	H Wet Dock J "Village"		4.2 3.5	 3.1	 3.3					
2110 (5.28mAOD)	H Wet Dock J "Village"		5.2 5.2	4.9 4.9	4.8 4.9	4.9 4.7	4.1 3.6	4.5 4.0	3.9	3.9 3.6

The table shows that at 2015 the highest flood levels result if the Wet Dock floodgates were left open.

If the proposed barrier is open AND breaches develop at West End Road or, adjacent to Princes Street Bridge there will be localised flooding in compartment J but none in the Wet Dock - compartment H.

If sea levels rise as predicted, by 2110 compartments J & H appear to be affected by more scenarios, some involving breaches into other compartments – i.e. BR04 (Bath Street) and BR06 (Railway Gate West Bank defence).

For BR04 this is because the New Cut barrier is also assumed to be open and floodwater overtops the New Cut East defences and floods into the Wet Dock.

For BR06 the New Cut barrier is closed but floodwater rapidly fills the Bath Street compartment and then overflows over the defences into the river channel upstream of the Barrier. Floodwater in the channel eventually overtops the New Cut East defences and floods into the Wet Dock.

8.16 Assessment of residual risks and Controls

A brief assessment of the likelihood of breaches or gate failure that affect compartments H and J follows.

Existing or planned controls	Con-sequence (High med or Low)	Chance		Suggested additional controls for consideration by Ipswich BC or EA
Wet Dock Lock Gates left open BR01				
Gate is operated by the Orwell Navigation Service, adjacent control building is manned 24 Hrs. 7 days per week Mechanism and gate recently replaced by the EA. In event of failure, flood gate could be pulled into position by hawser/ vehicle. Emergency planning Gate will be operated frequently so failure in a major rare event is less likely.	H	M		Operate at lower tide levels giving more warning/time to force gates shut. Further improvements to emergency plan. Flood sirens. All subject to discussion with the EA and ONS.

Existing or planned controls	Con-sequence (High med or Low)	Chance		Suggested additional controls for consideration by Ipswich BC or EA
Proposed New Cut Barrier open				
EA's Flood Defence Management Strategy includes for future maintenance/ replacement and includes back up systems for power and hydraulic rams, and allows for possible risk in flood warning predictions.	H	L		Flood sirens
Breach into West End Rd (BR02) - localised area where sheet piles are about 1.2 m above landward ground level				
New Cut Barrier as above EA's Flood Defence Management Strategy includes for future maintenance/ replacement. Structural design.	L	L		Raise landward ground levels to further reduce unlikely failure of piles. (Possibly funded by Planning tariff.)
Breach downstream of Princes Street bridge (BR03) where sheet piles protrude about 1.5m above landward ground level				
New Cut Barrier, EA's Flood Defence Management Strategy includes for future maintenance/ replacement	L	L		Proposed new development on SHLAA site 48 was approved by the planning committee March2010. It includes raising and replacing much of the defence in this location. Short lengths of exposed sheet piling will remain adjacent to Stoke Bridge and Princes Street bridge. - Raise land ward ground level to further reduce unlikely failure of piles. (Possibly

Existing or planned controls	Con-sequence (High med or Low)	Chance		Suggested additional controls for consideration by Ipswich BC or EA
				funded by Planning tariff.)–
Breach through defence wall into Bath Street compartment (BR04)				
New Cut Barrier, EA's Flood Defence Management Strategy includes for future maintenance/ replacement	M	L		Construction of high-level Riverside walkway or safe access. Consider similar on Island site
Breach Through new East Bank Defence wall (or Red 7 Shiplaunch gate left open) (BR05)				
EA's Flood Defence Management Strategy includes for future maintenance/ replacement. Modern structural design, safety factors, and earth bank on landward side	M	L		Red 7 gate – warning system/ emergency plan. Ensure ships are secure, including any on slipway.
Railway gate left open –new west bank defence (BR06)				
EA's Flood Defence Management Strategy includes for future maintenance/ replacement. Modern structural design, safety factors, and earth bank on landward side	M	L		Warning system /Emergency plan
Future gate in Wherstead Rd defences left open (BR07))				
EA's Flood Defence Management Strategy includes for future maintenance/ replacement. Modern structural design, safety factors,	M	L		Warning system /Emergency plan
Fluvial Pumping Station Inoperative				
EA's Flood Defence Management Strategy includes for future maintenance/ replacement. Modern design, safety factors,	M	L		Warning system/ Emergency plan

Thus there are existing or possible measures that reduce residual risk.

A framework of further measures to manage residual risks (for safe development) is described in section 16. This includes safe access requirements based on hazard maps for breach and overtopping scenarios as follows.

8.17 Hazard Maps for Land Use allocation and Development Control

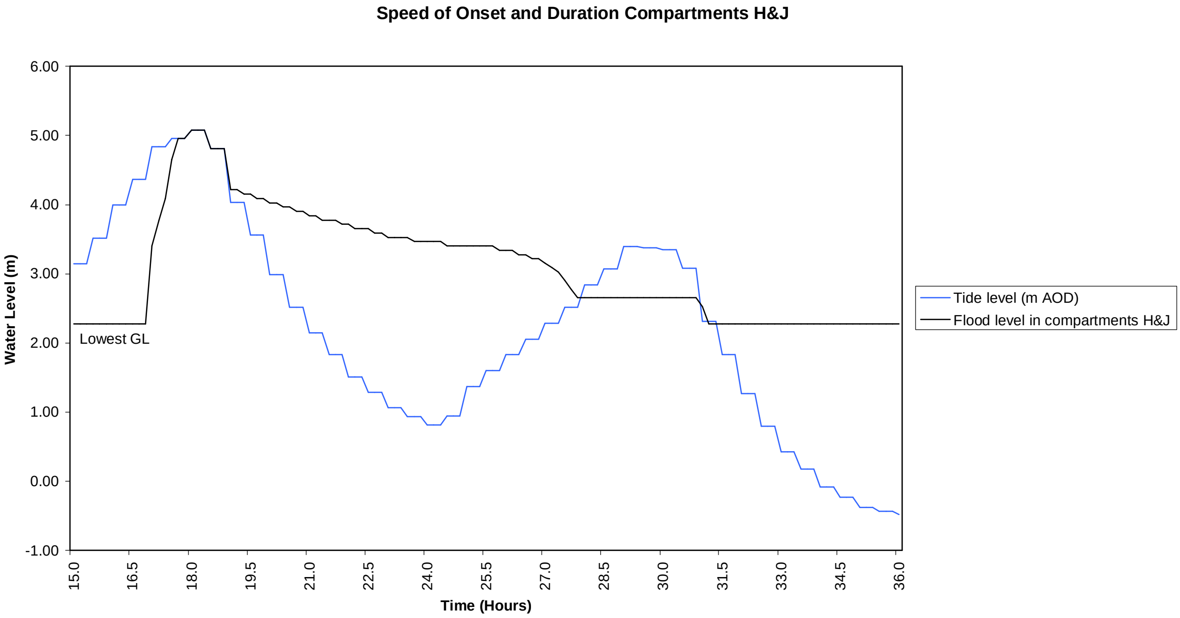
Combining hazard maps for the relevant scenarios on a single map makes it much easier to understand how flood risk varies behind defences and where appropriate land uses should be.
For existing defences, overtopping predominates and the combined hazard map in Appendix 5.34 includes hazards relating to all scenarios.

For the future defences, the combined hazard map in Appendix 5.35 does not include hazards relating to failure of the Proposed New Cut Barrier, Lock Flood Gate or West Bank Railway gates. These risks would be managed largely by evacuation in advance.

The combined hazard maps show the worst remaining hazard at any particular location. These maps should be used for deciding whether sites may be served by a “safe” access (as defined in section 16). Effectively this is the deciding factor for site allocations.

8.18 Speed of Onset and Duration

In general the speed of onset from the commencement of overtopping to peak flood level is an hour or so. Duration of flooding varies up to 26 Hours.



Speed of Onset and Duration Compartments H&J

Details of assumptions made are in 7.8

The graph above is shown as an example. If the level of a site is known the speed of onset and duration can be deduced from the graph.

Floodwater levels will rapidly reduce as floodwater flows back to the estuary over defences. When the flood level reaches the defence level, the trapped water behind the defences will fall at a reduced rate which is likely to depend largely on whether gulley grates, and highway drains block with flood debris.

In the Village area the counter drain is the lowest drain and may be least susceptible to blockage. An analysis has been undertaken using an Infoworks ground model assuming all drain down was via the 300 mm pipes from the counter drain.

8.19 Fluvial Flooding – River Gipping

The report "Ipswich Flood Defence Management Strategy, East Bank, West Bank and Barrier Works Flood Risk Assessment January 2010" states:

- *"The flow is in bank for a 0.1% probability (1 in 1000 year) fluvial event between, the Norwich railway line and the Orwell Bridge. Allowing for a potential 20% increase in flow due to climate change does not result in any flooding downstream of the Norwich Railway line.*

- *The flow is out of bank for a 1 in 2 year event between Chantry (TM13264446) and Sugarbeet (TM13644468) weirs, upstream of the Norwich Railway line. Flooding is confined to an area of natural flood plain"*

The above analyses assume a tide level of 3.17m

Areas around Yarmouth Road and West End Road appear to be most at risk.
Where the 1% AEP fluvial level is about 3.86m AOD and the 0.1% AEP level 3.95m AOD and most of the island at West End Road has ground levels between 5.5 and 4m AOD.

Thus the island should not be regarded as at risk of fluvial flooding in the 1% annual probability event and therefore should not be regarded as Functional Flood plain.

As future sea levels rise, tide levels will regularly exceed normal river levels – e.g. HWST at 2110 is expected to be 3.59m. Operation of the Tidal barrier should be able to counteract such effects.

The residual risks due to a failure of the proposed future fluvial pumping station are included on the combined hazard maps described above.

8.20 Fluvial Flooding – Belstead Brook

A HEC-RAS model of a 4Km length of the Belstead Brook floodplain upstream of Bourne Sluice was developed by Babtie Group for Ipswich Borough Council during 2003.

The modelling included a 20% addition to peak flows and assumed varying tidal levels - It concluded that tidal flooding was predominant at Bobbits Lane, where the 1% annual probability fluvial flood level was approximately 2m AOD - much lower than the 0.5% annual probability tidal flood level.

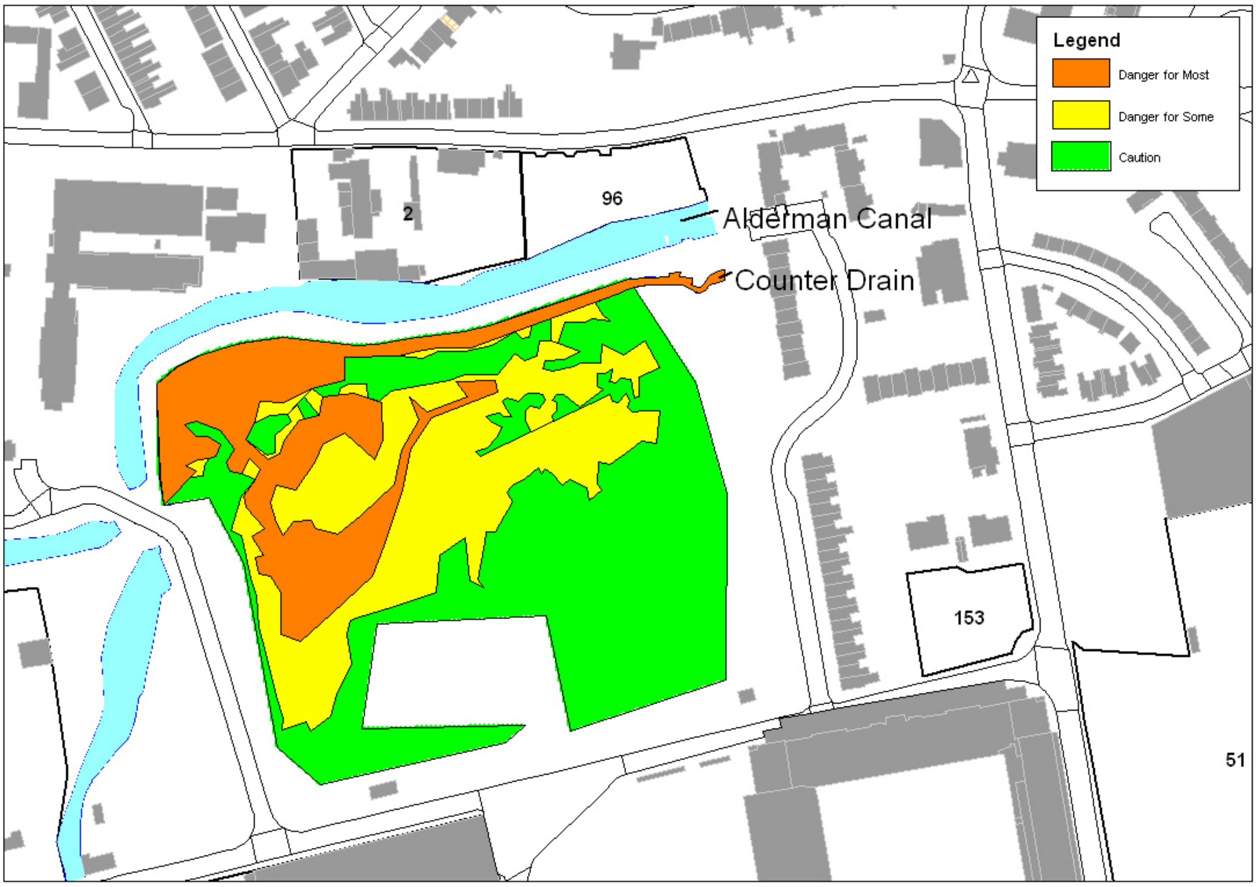
Fluvial flooding will be more significant upstream where flooding of properties has occurred. The full report or model should provide more information should it be required – No sites are proposed here in the LDF.

The discharge of flows to the estuary is limited by tide levels and the tidal flood plain acts as a storage reservoir and should be regarded as Functional.

9 ALDERMAN CANAL – ASSESSMENT

A simple assessment of risks due to failure of the embankment has been carried out assuming the whole contents of the canal spill into counter drain and flood the recreation area. A cross section is shown in section 3.6

The volume of water in the canal is about 8,500 cubic metres. This would flood across the recreation area as shown below, flooding this area to a level of about 2.7 m AOD.



Suggested management measures include

- Ensuring the embankment is not damaged by trees blown over by strong winds - when roots are liable to be lifted with embankment material.
- Ensuring the coloured area is not filled.

10 MILL RIVER – ASSESSMENT

A recent planning application relating to SHLAA site 127 in the original valley bottom off Bucklesham Road was supported by a FRA undertaken essentially by Anglian Water. At this location normal flows are conveyed through Anglian Water's surface water sewer. The FRA shows this area floods to a level of 26.25m AOD in a 1% AEP event. Floor levels for new developments in site 127 need to be at least 300mm higher. If this area were filled increased flooding would be expected in adjacent areas.

11 LOCAL FLOODING FROM OTHER DRAINAGE SYSTEMS AND WATERCOURSES.

Many factors can influence this flooding – such as whether manhole covers are stuck, blocking of grilles or gullies etc. The extent of known local flooding is mapped, and included in the appendix.

Flooding is only shown where repeated complaints are received by IBC that do not appear to be due to blocked road gullies. The map shows 88 locations, the extent of flooded areas are based on contours, photographs and reports (not generally LIDAR). Reported incidents are monitored. Between 2001 and 2009 annual numbers ranged from 68 to 200 with no apparent trend.

Such flooding is certain to increase due to climate change and increasing paving of gardens and may decrease where/when/if major sewerage improvements are made.

No indication of frequency is provided on the map, however since the flooding has occurred and by inspection of the records and news paper cuttings it is regarded as “likely” - typically occurring with return periods between less than 1 year to 25 years.

During heavy rainfall, manhole covers are blown off, sometimes along with road surfacing, and foul debris is deposited on streets in several areas. The open manholes represent a serious hazard to people. Councillors and MPs are involved and petitions have been received. Repeated flooding (even if it only comes close to entering buildings) causes a great deal of stress and anxiety and recent changes in property conveyance practices are believed to have lead to under reporting of flooding. Some roads become impassable.

Flooding particularly affects buildings lower than adjacent roads, especially basements and subways, these are not shown on the map. Some have been fitted with flood boards, non-return valves or pumps in an effort to alleviate the problem but these techniques are not reliable. The local flood map should be amended to show and quantify buildings at risk.

Non-main rivers, streams and ditches along with some roads and valley bottoms where floodwater is known to flow are also shown on the map. There are also smaller un-mapped valleys/roads, which occasionally carry floodwater towards the Orwell or Gipping.

The most frequently flooded areas are the roads around the Wet Dock - Bridge Street, Key Street, College Street and Duke Street. However the depth of floodwater is currently limited since it can easily overflow overland into the wet dock. Paving levels around the Wet dock should therefore not be raised

Recently constructed developments at the wet dock include a building with shallow undercroft parking that has suffered repeated flooding that damages car-stacking equipment. This flooding is due to surcharging of the sewerage system back through a pumped sump.

Deeper basements will be at risk of rapid, deep and potentially dangerous flooding from sewers or overland flows.

The Low Level sewer is routed through these areas and so the overland “escape route” also benefits low areas upstream.

Anglian Water (AW) most recently completed sewerage flood relief schemes in Hadleigh Road and Larchcroft Road (2007). Further improvements are being considered at Meredith Rd, Lovetofts Drive and Bridgwater Road and Ellenbrook Green. Such projects are normally triggered by internal flooding, inside buildings, which occurs more often than twice in 10 years – however project costs will affect AW’s priorities.

Formal consultations were undertaken with Anglian Water in 2007 and again in November 2009. A summary of their comments relating to specific sites is included in the appendix.

In the future increasing sea levels will particularly increase flooding from sewerage systems that drain surface water from the lowest parts of the town into the tidal Orwell. When tide levels are above the soffit of outfall pipes the hydraulic gradient and hence capacity of drainage systems serving the lowest areas is reduced. If the tide exceeds upstream ground levels then discharge to the Orwell is not possible.

Raising of the proposed tidal barrier at the New Cut at Low tide in advance of expected pluvial events predicted by the new EA/Met office flood warning service should help mitigate this affect.

However the performance of sewers draining into estuary downstream of the barrier will reduce unless future improvements such as the addition of storage capacity are implemented. Wherstead Rd is likely to be vulnerable to increasing SW flooding in the future.

Saltwater will be able to enter the foul sewerage system via road gullies when tides exceed the defence levels.

Where floodwater fills adjacent flood compartments at different rates sewage may overflow from manholes and road gullies.

This appears most likely in the Alderman Rd, Portman Rd area and parts of Princes Street and Cardinal Park where ground levels are as low as 2.7m AOD before this area suffers tidal inundation.   A similar effect is likely in the Riverside Industrial estate at Rapier Street.

The new East bank tidal defences cross over Anglian Water ‘s 1.5 m X1.5m Low level sewer, which feeds into the Cliff Quay Treatment works.

If the tide level exceeds about 5.7m AOD then salt water may enter the main lift pumping station at Cliff Quay STW. This would “back up” the Low Level trunk sewer and overflow into the Project Orwell Tunnel, which has a storage capacity of 25,000 cu m.

Simple calculations indicate that the 0.1% tidal event would not fill the tunnel, however tidal floodwater may be able to enter via drains connecting into the Low Level and High Level sewers at Cliff Quay.

Once the tunnel is filled it would overflow along Shiplaunch Street into the Wet Dock.

A similar flood occurred a few years ago during heavy rain following failure of a penstock gate on the outfall from the tunnel.

12 GROUND WATER

Ground water flooding has affected gardens in many areas including: Tuddenham Avenue, Spring Road, Springfield Close, Cavendish Street / Back Hamlet Allotments, Birkfield Drive, Heatherhayes, Pembroke Close, Lavender Hill, Coltsfoot Road, Lavenham Road, Worsely Close, Manchester Rd and Ritabrook Rd.

These locations are shown on a plan in the appendices

These are mostly at the crag/clay interface (see geological map) and associated with minor watercourses.

Basement and subway flooding has occurred.

Retro fitting of infiltration type drainage for existing development may increase risk.

Increasing sea levels will increase risk in lower areas. Some isolated low areas have been identified that close to the Gipping at Yarmouth Road and Gatacre Road and where ground levels are below between 3.8m and 3.4m AOD

Ponds are known to have existed in several areas, which have been filled in. In some cases these drained the highway.

13 EXISTING DEVELOPMENT

Approximately 3,000 properties (including 43 Electricity sub stations) have been identified in buildings within zone 3 of the floodplain by overlaying “Address Point” mapping on the flood hazard map – see Appendix.

This compares to “*882 residential properties and 261 commercial properties”* quoted in the EA’s 2005 project appraisal report described in section 3.4.

PPS25 table D.1 states for **existing** development within flood zone3, “ *LPA’s should seek opportunities to relocate existing development to land in zones with a lower probability of flooding*.”

The suggested order of priority is as follows - top priority first:

1. Some highly vulnerable single storey residential buildings used by vulnerable people are within high-risk areas - Great Gipping Street Area.

2. Essential infrastructure such as the fire station in Princes Street and electricity sub stations.

14 PLANNED DEVELOPMENT

The Ipswich Strategic Housing Land Availability Assessment (SHLAA) report suggests possible allocations in the Site Allocations and IP-One Plans which form part of the LDF.

For each site the report lists a possible range of uses as set out in the Town and Country Planning (use classes) Order 2005. The categories of possible uses are shown below along with their vulnerability to damage, and risks to people caused by flooding. Some categories have been subdivided in the table below because they are not permitted in high flood risk areas under any circumstance. These are marked *.

Land Use proposed in LDF	**Land use referred to in SFRA & PPS25**	**Flood risk Vulnerability from PPS 25 table D.2**	**Safety Design Life**
Education	Non-residential health services, nurseries & educational establishments.	More Vulnerable	Commercial (usually 75 years)
	Student halls of residence.	More Vulnerable	Commercial
Employment*	Installations requiring hazardous substances consent.	Highly vulnerable*	Commercial
	Landfill and sites used for waste management facilities for hazardous waste.	More vulnerable	Commercial
	Buildings used for financial, professional, & other services: offices, general industry, storage & distribution.	Less vulnerable	Commercial
	Docks, marinas, wharves.	Water Compatible	Commercial
Housing*	Basement dwellings, caravans, mobile homes & park homes intended for permanent residential use.	Highly vulnerable*	Residential (usually 100 years)

	Buildings used for dwelling houses, student halls of residence. Residential institutions such as residential care homes, social services homes, prisons and hostels.	More vulnerable	Residential
Leisure	Buildings used for drinking establishments, nightclubs & hotels.	More Vulnerable	Commercial
	Buildings used for assembly and leisure.	Less Vulnerable	Commercial
	Water based recreation (excluding sleeping accommodation). Essential ancillary sleeping or residential accommodation for staff (subject to a specific warning and evacuation plan)	Water Compatible	Water Compatible
Retail	Buildings used for shops restaurants, cafes and hot food takeaways.	Less Vulnerable	Commercial
Open Space	Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms.	Water compatible	Water Compatible
Not specifically shown but infrastructure will be needed to service new development.	Essential transport infrastructure, including mass evacuation routes, which has to cross the area at risk, and strategic utility infrastructure, including electricity generating power stations and grid and primary sub stations.	Essential Infrastructure-	Commercial / Water Compatible if passes the Exception Test.

15 THE SEQUENTIAL AND EXCEPTION TESTS

The sequential and exception tests should be used to inform site allocations, and development control policies as described in Annex D of PPS25. The following text explains the process that should be carried out when making allocations but is not intended to be the test(s).

The aim is to:-

a) wherever possible; avoid allocating developments in flood risk areas

Or, if impracticable:
b) site land uses with lower vulnerability to flooding in higher risk areas and
site land uses with a higher vulnerability to flooding in lower risk areas and move existing vulnerable uses in higher risk flood areas to lower flood risk areas.

In exceptional circumstances such as where regeneration and sustainability pressures exist and developments will be safe for people, some types of vulnerable development may be permitted in high flood risk areas.

Table D.1in PPS25 shows how development from different classifications of flood risk vulnerability may be appropriate in flood risk zones, but only if:

- The requirements relating to flood risk assessments are met;
- The residual risks of flooding are assessed and managed;
- And where appropriate, the ‘Exception Test’ is passed.

15.1 The Sequential test

The Environment Agency’s Flood Zones are the starting point for applying the Sequential Test.

Annex D of PPS25 and paragraph 4.13 of the Practice Guide describe the Sequential Test process in detail. The overall aim is to steer all new development to areas at lowest probability of flooding – zone 1.

Table D.3 of PPS25, reproduced below, summarises how development from different classifications of vulnerability may be appropriate in flood risk zones.

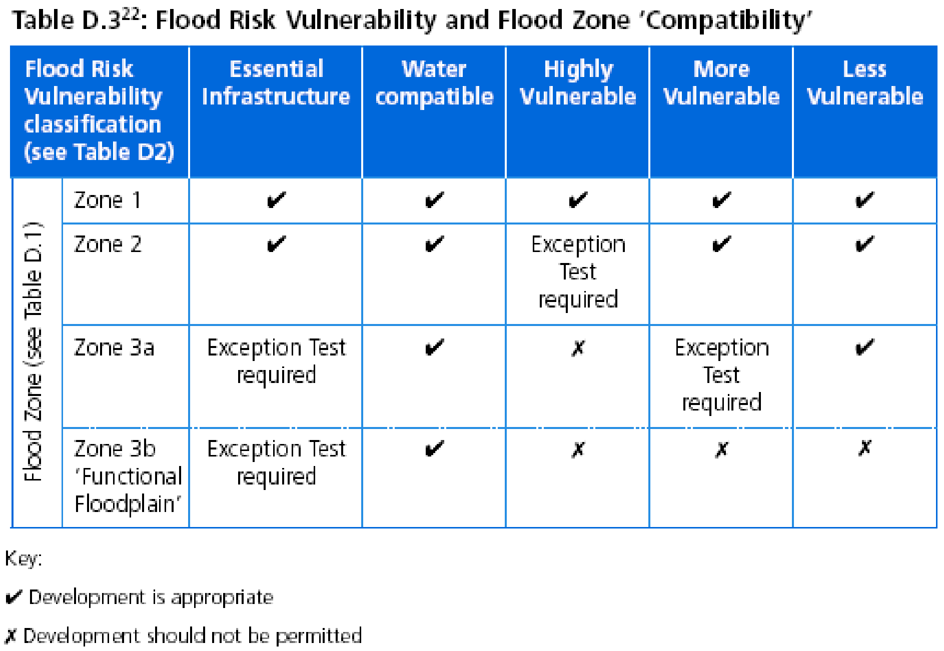


Table D.3[22]: Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Risk Vulnerability classification (see Table D2)		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table D.1)	Zone 1	✔	✔	✔	✔	✔
	Zone 2	✔	✔	Exception Test required	✔	✔
	Zone 3a	Exception Test required	✔	✗	Exception Test required	✔
	Zone 3b 'Functional Floodplain'	Exception Test required	✔	✗	✗	✗

Key:

✔ Development is appropriate

✗ Development should not be permitted

Maps in the appendix show the flood risk zones and LDF sites. Note For Ipswich zones 2 and 3 are very similar in extent.

The sequential test also effectively requires sustainable urban drainage systems (SUDS) to be considered for all sites. See section 17.4

The table shows water compatible and less vulnerable development is appropriate in Flood Zone 3a, **however there is still the need for these developments to be safe as per PPS25 Annex E2 and as follows in section 16.**

Sites Considered to Pass the Sequential test

The Council has, through its Strategic Housing Land Availability Assessment (SHLAA, March, 2010), identified sites, which are capable of delivering residential development either wholly or as part of mixed-use development during the plan period to 2026. The SHLAA assesses the suitability, availability and achievability of sites indicating a likely delivery timescale. One of the constraints identified in the site analysis is whether a site is in Flood Zone 2 or 3. The SHLAA informed the Council's housing trajectory, which was published in its Annual Monitoring Report 6, 2009/10 (December, 2010) and identifies a housing land supply for 15 years (2011 to 2026) including the current monitoring period of 2010/11.

The housing trajectory identifies 1,733 dwellings in Flood Zone 1 that do not have planning permission and a further 2,500 dwellings on a large Greenfield urban extension in Flood Zone 1. In Flood Zone 2 and 3, the housing trajectory identifies 1,504 dwellings without planning permission, all of which are on previously developed land.

Therefore, although the Council identifies sites in Flood Zone 1 for residential development through the Sequential Test, there is not enough land in this Flood Zone to meet the housing land requirement and a large proportion of it, 69%, is Greenfield development. Furthermore the Core Strategy is an urban regeneration led plan, which focuses development in the centre of Ipswich. In doing so it follows on from the existing adopted strategy in the Local Plan. Therefore sites in Flood Zone 2 and 3 are required to meet the objectives of urban regeneration and sustainable development as well as meeting the previously developed land targets set of at least 60% of new housing in Planning Policy Statement 3 (June, 2010) and at least 70% of all development in the Council's Core Strategy policy CS9.

Sites passing sequential test
IP003
IP004
IP011b
IP015
IP028a
IP028b
IP031
IP036b
IP037
IP039
IP044
IP049
IP050
IP054
IP080
IP081
IP083
IP096
IP098
IP105
IP120
IP136
IP188

These sites are from the March 2010 Strategic Housing availability assessment. They do not include sites which had received planning permission as at 1 April 2009.

15.2 The Exception test

This is only carried out after the sequential test.

For the Exception Test to be passed:

a) It must be demonstrated that the development makes wider sustainability benefits to the community that outweigh flood risk, informed by the SFRA. If the Development Plan Document (DPD) has reached the submission stage – see Figure 4 of PPS12: Local Development Frameworks - the benefits should contribute to the Core Strategy's Sustainability Appraisal;
b) The development should be on developable previously developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on previously developed land; and
c) A FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere and, where possible will reduce flood risk overall.

16 SAFETY OF DEVELOPMENTS IN FLOOD ZONE 2/3

Guidance on what is "safe" is provided in the PPS25 Practice Guide (paragraphs 4.54 to 4.69). This was updated in December 2009.
Paragraph 4.74 states:
"Defra and the Environment Agency R & D Document 'Flood Risk Assessment Guidance for New Development' FD2320 provides guidance on this topic area. Ultimately, it is the responsibility of the planning authorities to decide what level of risk is acceptable."

Important considerations, as set out in paragraph 4.57 of the PPS25 Practice Guide, include:

- The characteristics of a possible flood event e.g. flood depths and velocities (hazard ratings), frequency, speed of onset and duration of flooding.
- The safety of people connected with the development - people within the building and those around or in adjacent areas. This includes the ability to safely access and exit the building during a design flood (0.5% AEP) and ability of residents and users to evacuate before an extreme flood (0.1%AEP)
- The structural safety of the building
- The impact of floods on water, electricity or fuel supplies for example.
- Flood warning and evacuation and likelihood of buildings being occupied at the time of a flood

Where a development is protected by defences, they can be taken into account provided their continued presence and maintenance is reasonably certain. This will be the case in flood compartments upstream of the proposed barrier, once it is built.

The flood defence barrier planned for 2014 will provide a large reduction in flood frequency. It reduces the annual probability of flooding from circa 1% to about 0.01%.

Even with climate change and sea level rise, the standard of protection is expected to remain better than 0.1%AEP until 2110. The frequency plans in section 8 shows areas that benefit.

However even with the proposed defences, residual risks due to overtopping, or failure of the defences or barriers will remain. There are many measures that can be implemented, all adding together to reduce residual risks, including for example: building design, safe access and escape, flood warning and evacuation plans.

The following suggested local guidance and policy on what is "safe" has been developed following discussions with the Suffolk Resilience Forum, IBC's Emergency Plans officer, and Environment Agency.

It is important to realise that "safe" has no clear definition and risk needs to be judged against the benefits that regenerating the brown field sites and providing homes and places to work in the flood plain bring.

The public happily take risks that are regarded as acceptable in their everyday lives for example flying or driving.

One of the key planning objectives in PPS25 is to ensure that, where new development is exceptionally necessary in high flood risk areas, policy aims to make it safe without increasing flood risk elsewhere and where possible, reduce flood risk overall. **The safety of all developments, not just those that are required to pass the Exception Test, needs to be considered**.

The PPS25 Practice Guide also suggests (para 4.62) that the LDF proposals should not increase the scale of rescue that might be needed.

If there are more people in floodplain then the risk may increase. Conversely more severe flooding may be tolerable where the probability of it happening is lower i.e. with new defences.

Safety needs to be considered as a development nears the end of its lifetime taking into account predicted sea level rise over that time. Appropriate lifetimes for design would normally be 75 years for commercial development and 100 years for residential. Paragraphs 3.102 and 3.103 of the PPS25 Practice Guide allow some flexibility in specific cases where this can be justified.

The general safety of people in the flood plain is firstly considered below, taking into account the presence of existing and proposed defences and sea level rise, ignoring the possibility of breaches/failures.

16.1 General Safety of Development in the Flood Plain.

The DEFRA report "*Flood risks to People Phase 2" FD2321/TR2 (March 2006) page 57-64 - Guidance Note 6 Flood Defence Regulation and Development Contro*l" provides a method which combines frequencies of flooding with "hazard ratings", "area vulnerability" and "people vulnerability" to estimate the likely average annual risk of an individual being killed or harmed during flooding.

This has been used to estimate, in a broad manner, the likely number of injuries with and without the proposed defence barrier at 2010, 2015 and at 2110 allowing for anticipated sea level and population increases.
The number of injuries is seen as an indicator for the likely demand for emergency services (scale of rescue).

Calculations are included in Appendix 5.37

The results have been summarised in the table below:

Indicative effect of Development and Flood Defence proposals on Demand for Emergency services

	Year			
	2010		**2110**	
Population	**4,000**	**6,424**	**4,000**	**6,424**
No Barrier Scenario - predicted average number of injuries per year	1.75	2.78	78.63	133.67
With Barrier Scenario - predicted average number of injuries per year	0.36	0.40	0.21	0.33

The table assumes the Wherstead flood defences (downstream of the barrier) are at 4.01m in 2010 and raised to 5.65m AOD by 2110. The Environment Agency plans to raise these to 4.4m AOD during 2011/12.

The table shows:

- Without the proposed barrier: risks and demand for emergency services will increase dramatically. However some residential or commercial development may be permissible around the edges of the flood zones – where hazards / risks are lower.

- **With the barrier in place and the Wherstead Rd defences improved in step with sea level rise, the risk to people and therefore demand for emergency services is likely to reduce, even with the anticipated sea level rise.**

Estimates of likely numbers of injuries or deaths in specific events (0.1% AEP and 0.5% AEP) are included for emergency planning purposes in Appendix 5.37

16.2 Safety of Individual Developments – framework.

For a particular development, residual risks and further issues need to be considered:

A framework of requirements for a development to be safe is proposed:

- Structural Safety of buildings.
- Emergency plans for actions by emergency responders.
- Emergency plans for evacuation and flood warning arrangements for users of buildings.

Because not everyone will take notice of flood warnings and none would be received for an unexpected sudden breach (collapse) with predicted tide level lower than the flood warning threshold level, the following measures should also be required:

- Temporary Refuges

Because not everyone will stay in safe refuges and some may need rescuing the following further measures based on the appropriate combined hazard maps in Appendix 5.34 or 5.35 and Flood frequency maps in section 8.6 or 8.9 (either with or without barrier as described in section 8.17) should also be required:

- Safe emergency access for Fire & rescue Service
- Safe access/escape routes for building users

To aid recovery after floods and minimise damage costs:

- Raised floor levels
- Flood resilience measures.

It should be noted the hazard maps relate to breaches at specific locations (shown in section 7.5) Where development is proposed close to defences where breaches have not been considered then the site specific FRA will need to infer hazard ratings or include new 2d Modelling.

Detailed requirements under each of the above headings is included below:

16.2.1 Structural Safety of buildings

This requirement will not affect site allocations but will affect the design of most buildings.

Because the consequences of collapse would be severe, all buildings should be designed to remain standing and resist moving floodwater.

The PPS 25 Practice Guide (6.27 – 6.35) explains how structural design to resist floodwater may be related to flood resistance or resilience measures. For example structural damage might be avoided by allowing water to enter and pass through buildings.

Water velocities and depths for design, should be those resulting from the worst-case breach/open gate scenario for an event of 0.1% AEP @ 2110. (Or more severe.)

Flood depth and velocity information for various breach and open gate scenarios is provided in Appendices 5.31 & 5.32. An additional 300mm allowance for freeboard should be added to depths.

On some sites it may be appropriate for developers to undertake specific breach modelling or include additional detail such as constrictions between buildings in order to ensure buildings remain structurally safe.

16.2.2 Emergency plans for evacuation and flood warning arrangements for users of buildings

Developers and building owners/operators should be required to develop and implement these as described in Appendix 4. Appropriate signage will also be required within developments.

The aim will be to self evacuate on receipt of appropriate warnings received via the EA's national system (Flood Warning Direct). Severe flood warnings are normally issued at least 2 hours before flooding. For major tidal flooding events more warning time would normally be provided.

The Pitt review, following the summer 2007 floods found 80% of fluvial flood warnings were issued on target (>2 Hrs before flooding) measures to improve flood warning and public awareness have been instigated since then.

This time is considered to probably be sufficient for self-evacuation in advance of predicted overtopping.

Measures to provide warning time to allow self-evacuation in the unlikely event of failure to close a floodgate, are proposed below.

However no warnings would be received for breaches (collapse of defences) when tide levels are significantly below defence levels. In such an unlikely event there may be little or no warning and so evacuation is unlikely to be achievable, in fact it might be more hazardous.

This issue is managed by the requirements for safe refuge and access below.

16.2.3 Temporary refuges

A temporary "safe refuge" - is any place or structure where individuals trapped by floodwater (those who did not receive or ignored flood warnings) can remain for a short period in relative safety whilst awaiting rescue.

Provision of refuges within buildings makes developments safer. PPS 25, para 4.66 states - safe refuges play a role in reducing the overall risk of flooding, they do not in themselves make a development safe, as they relate more to a rescue situation than to effective evacuation in advance of a flood occurring.

“Normally” about 10% of the population are likely to stay put in temporary refuges or attempt to escape through floodwater. More may stay put in the event of an unexpected breach (Reference 19).

During the 2009 surge at Great Yarmouth approximately 7,500 residents were advised to evacuate out of whom about 800 evacuees were accommodated in Rest Centres. Some residents self-evacuated and stayed outside the area with friends and relatives. A few went to hotels. Many residents did not evacuate but it is not clear how many stayed at home.

It is therefore suggested temporary refuges are needed for most developments within the floodplain. In many cases this would only entail slight raising of floor levels which need to be raised as described per paragraph 16.2.7 .

The quality of refuge (provision of facilities, communications, warmth power supply etc) required would depend on the duration that people are trapped for.

An exception might be commercial developments which are much less likely to be occupied during a flood event - they are occupied for limited durations, and because users would be most likely to have responded to flood warnings.. However the risk remains in the event of unexpected flooding.

Safe refuges should be above the 0.1%AEP event tide level at the end of the development’s life.

Effectively this means most buildings in the flood plain need to be greater than 1 storey high.

16.2.4 Emergency Plans for Actions by Emergency Responders

Normally public authorities / responders will receive at least 12 Hours warning of potential tidal flooding. Several days warning time is likely with more extreme events.

Existing flood plans which are normally initiated in response to flood warnings are described in section 5. Plans constantly evolve. Road closure and traffic diversion plans are included.

The Ipswich Flood Plain evacuation plan is to be published by the emergency services in the future. Police are responsible for evacuation but cannot force people to evacuate. The Evacuation Plan will be police led but will be a multi-agency plan.

To reduce residual risk, the emergency plans could address potential flooding that might arise from open floodgates. This issue is examined in detail in section 18 which concludes that:

- The time taken to implement evacuation plans ideally needs to be less than about 4 Hours to allow for any potential problem with the proposed New Cut barrier. The plans need to include warning / communications between the barrier operator and the Emergency services.

- Because flooding would start within an hour of failing to close the wet Dock floodgate and this is unlikely to provide adequate time for implementing emergency plans, the Wet Dock floodgate-operating regime should be changed now and reviewed in the future as sea levels rise.

It appears to be reasonably practicable to alter the regime so that closures are initiated earlier, in response to tidal predictions rather than actual levels reached.

The proposed railway gate and Ship launch gates will also need to be operated at the same time as the Wet Dock floodgate so as to provide adequate warning time.

Guidance on these issues is provided for emergency planners in section 18

16.2.5 Safe emergency access for Fire Service

Access by fire and rescue services needs to be possible. In an emergency, especially if power supplies fail, as there will be an increased risk of fire, especially in residential buildings. The fire service has confirmed they can operate in water up to a depth of 0.475m.

This is based on the following response from the Suffolk Fire and Rescue Resilience Manager:

> *"If the appliance is standing in the water, pumping for example, it would need to be below the exhaust outlet height approx 300mm (12 inches) whilst driving through water is governed by the following*
>
> *Driving through floodwater <u>should be avoided as far as possible</u>, AND NEVER WHERE THE WATER DEPTH WOULD EXTEND BEYOND THE CENTRE OF THE WHEEL as water could be drawn into the engine and cause irreparable damage. Where it is deemed unavoidable, a wader should walk ahead of the vehicle using an appropriate item to check the way ahead; this person will be an appropriately dressed Swift Water Rescue Technician with a wading/bank stick to determine depth. This action is limited purely to finding out water depth and not identification of submerged hazards.*

> *The centre of the wheel would be 475mm (19inches).*
> *These figures relate to standing water. If the body of water was moving there would need to be a dynamic risk assessment completed resulting in the unlikelihood of committing resources into flood areas"*

The maximum flood depth on access /rescue routes for residential developments should therefore not exceed 0.475m.

The combined hazard maps also show areas where flood depths exceed 0.475m.

In then future it may be worth exploring the possibility of obtaining a specialist vehicle capable of operating in deeper water – possibly funded by planning tariffs.

The exception would be "water compatible" or commercial developments which are less likely to be occupied and are therefore at less risk of fire during flooding.

16.2.6 Safe access/escape routes for building users

To help reduce risks to people who do not evacuate or stay in the safe refuges, hazard ratings on access and escape routes to higher ground (where local facilities including shops, schools, doctors' surgeries and buildings likely to be used as places of assembly during flooding are available) should be limited.

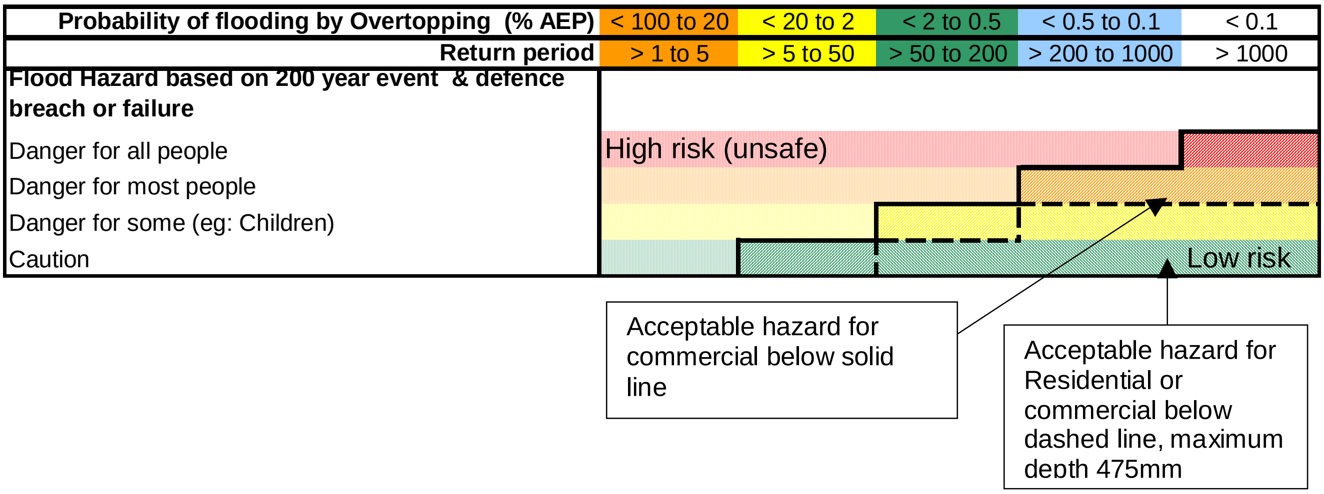
High risk relates to high flood hazard rating combined with a high probability of flooding. Low risk relates to low hazard and probability.

This is illustrated in Table 12.3 of the DEFRA / Environment Agency's "Flood Risk Assessment Guidance for New Development Phase 2 R&D Technical Report FD2320/TR2" (Reference 23).

It is suggested low risk cells in the table would be acceptable for safe access to residential developments, and medium risk for commercial developments.

The following table adopts this approach.

Acceptability of Hazards on Access or Escape Routes - In areas protected by defences.



Probability of flooding by Overtopping (% AEP)	< 100 to 20	< 20 to 2	< 2 to 0.5	< 0.5 to 0.1	< 0.1
Return period	> 1 to 5	> 5 to 50	> 50 to 200	> 200 to 1000	> 1000
Flood Hazard based on 200 year event & defence breach or failure					
Danger for all people	High risk (unsafe)				
Danger for most people					
Danger for some (eg: Children)					
Caution					Low risk

Acceptable hazard for commercial below solid line

Acceptable hazard for Residential or commercial below dashed line, maximum depth 475mm

The exception would be water compatible development –see 16.3.

Flood hazards are those shown the appropriate combined hazard map – Appendix 5.34 for existing defences, or 5.35 for with the proposed barrier. These are hazards due to overtopping, breaches or open gates allowing for sea level rise to 2110. These are described in section 8.17

Flood frequencies for existing defences at 2110 are shown on a map in section 8.7. Flood frequencies for proposed defences at 2110 are in section 8.9. Full size plans are available in the appendices.

Reduced hazards or frequencies may be possible if design life of the development is less than 100 years.

Note the table generally allows for the 475mm fire access requirement for residential developments. If floodwater is static “Danger for some” (yellow cells) represent a 500 mm water depth.

It should be noted:

- The hazard map relates to breaches at the locations shown on the map. If development is proposed close to defences where breaches have not been considered in this SFRA then a development level FRA will need to infer hazard ratings or undertake new 2d Modelling.

- The combined hazard maps relate to the 0.5%AEP event at 2110 and during the course of the LDF time period, allowable access levels will gradually increase.

- With no flood barrier, a minimum floor level may also be required for commercial developments to help businesses obtain insurance. Based on guidance (@2010) from the Association of British Insurers (ABI), flood cover would appear to be available in areas defended against a 1.3% AEP event. Floor levels would therefore need to be above the 1.3%AEP flood level as follows;

Year	Approximate 1.3%AEP tide level
2010	4m
2085	4.6
2110	5.1

Care will need to be taken when planning floor and access levels,

16.2.7 Habitable Floor Levels

Should be above the 0.5 %AEP flood level in 100 years time. – From Tables 8.13 or 8.15 as appropriate. An additional 300mm allowance for freeboard should be added.

16.2.8 Flood resilience measures

Resilient designs minimise damage caused by floodwater by for example: the use of water resistant building materials, decorative finishes, the location of electricity meters and sockets, and readily repairable designs.
In flood zones 2/3 all new buildings should be "flood resilient " below the 0.5% AEP tide level in 100 years time (or to higher levels.)

More information is provided in 17.2.1

16.3 Safety of Water Compatible Development

Ideally the above approach should be followed, however it is recognised that providing safe access, raised floor levels and temporary refuges is likely to be impracticable. The operators of docks, marinas and wharves will be familiar with flood risk and so flood warnings are very likely to be followed. It is therefore suggested that the only requirements should be:

- Structural Safety of buildings (16.2.1)
- Emergency plans for evacuation and flood warning arrangements for users of buildings (16.2.6)
- Emergency plans for actions by Emergency responders (16.2.4)
- Flood resilience measures

16.4 Summary / Implications / Conclusions for site allocations

The requirements for safe access/escape routes set out in section 16.2.6 effectively guide site allocations.

For both the “with” and “without Barrier” scenarios the guidance is the same based on the appropriate combined hazard map in appendices 5.34 or 5.35, the frequency maps in section 8.7 or 8.9. and the table in 16.2.6. This assumes emergency plans for responders are upgraded to provide adequate warning time for evacuation – in event of gate failure.

The table in 16.2.6.is the best way of understanding the guidance…effectively it means:

- No residential allocations in areas where the annual exceedance probability (AEP) of flooding is >=2% (i.e. floods more often than every 50 years)
- No commercial allocations in areas where the AEP of flooding is>=20% (floods more often than every 5 years)

- Water compatible development could be acceptable in all areas.

Residential development would be accepted where:

- AEP of flooding is < 2% (less often than every 50 years) AND hazard ratings are “caution (green cells))
- AEP <0.5% AND hazard ratings are “Danger for Some (yellow cells)

Commercial development would be accepted where:

- AEP <20% (less often than every 5 years) AND hazard ratings are “caution)
- AEP < 2% AND hazard ratings are “Danger for some” (yellow cells)
- AEP < 0.5% (less often than every 200 years) AND hazard ratings are “Danger for most” (orange cells)
- AEP< 0.1% (less often than every 1000 years) AND hazard ratings are “Danger for all” (Red cells).

Water compatible development could be acceptable in all areas.

The frequencies and hazards above are those at the end of the design life of the development. Appendix 1 provides data for 2110 for each site.

The affect on potential site allocations in or immediately adjacent to current flood zones 2 and 3 is summarised below;

Residential Sites (Table includes mixed residential and commercial sites and does not include sites with planning permission as at April 2009. Site reference numbers are from 2010 SHLAA)

	Residential Sites			
	Without Flood Defence barrier		**With Barrier**	
Sites passing sequential test (table in 15.2)	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe$^+$**	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe$^+$**
IP003 Waste tip north of Sir Alf Ramsey Way	No		Yes	
IP004 Bus depot, Sir Alf Ramsey Way	No		Yes with On & Offsite works	Raise site and raise part of existing highway to provide high level safe access to West End Rd
IP011b Smart St., Foundation St.	Yes with On & Offsite works	Raise low part of site provide safe access from higher ground	Yes	
IP015 West End Road Surface Car Park	Yes with On & Offsite works	Raise site and provide safe high level access off Princes Street	Yes with onsite works	Raise parts of site and provide safe high level access off Princes Street
IP028a Land West of Greyfriars Road	No		Yes	
IP028b Land West of Greyfriars Road (Jewsons)	No		Yes with onsite works	Raise parts of site and provide safe high level access to North east
IP031 Burrell Road	Yes with onsite works	Raise site and access from higher part of Burrell Rd.	Yes	
IP036b Shed 7	Yes with On & Offsite works	May be possible with high level safe access through site 36a across highest part of Duke Street	Yes with On & Offsite works	May be possible with high level safe access through site 36a to Duke Street
IP037 Island Site	No		Yes with On & Offsite works	Raise site and provide bridge to Mather Street
IP039 Land between Vernon St. & Stoke Quay	Yes with onsite works	Raise site, provide high-level safe access to higher ground.	Yes with onsite works	Raise site, provide high-level safe access.
IP044 Land South of Mather Way	No		Yes with onsite works	Raise small part of site. Safe access to N.W.

	Residential Sites			
	Without Flood Defence barrier		**With Barrier**	
Sites passing sequential test (table in 15.2)	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe$^+$**	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe$^+$**
IP045 Holywells Road West / Toller Road	Yes with On & Offsite works	Raise all of site and provide a safe access across Toller Rd / Landseer Rd Junction	Yes with Onsite works	Raise all of site and provide a high level safe access through site to the Toller Rd / Landseer Rd Junction *
IP046 Wolsey St.	No		Yes with on and off site works.	Raise part of site. Wolsey Street, safe access to East.
IP047 Land at Commercial Road	Yes with Onsite works.	Raise site, provide high level safe access to Stoke Bridge and or Princes Street	Yes with Onsite works.	Raise parts of site and provide high level safe access to Stoke Bridge and or Princes Street
IP049 No 8 Shed, Orwell Quay	No		Yes with Onsite works	Raise lowest parts of site and provide high-level safe access to Duke Street to South East of site.
IP050 Land West of New Cut	No		Yes	
IP051 Old Cattle Market, Portman Road – South	No		Yes with On & Offsite works	A strategic land and road-raising scheme might be feasible - Raise whole site and provide offsite high level safe access from Civic Drive, & include re- development of vulnerable housing at Canham Street and Great Gipping Street & perhaps site 153.
IP054 Land between Old Cattle Market & Star Lane	Yes with Onsite works	Raise site provide safe access to higher ground to North	Yes	Safe access to higher ground to North
IP064 Holywells Road East	No		Yes with On & Offsite works	Raise lowest parts of site and provide high level access to junction of Toller rd and Landseer Rd (or raise Holywells Rd with dev of site 45) *
IP068 Truck & Car Co, Cliff Road	No		No	Strategic land / road raising?
IP076 Land at Yarmouth Road	No		Yes	
IP077a Drunken Docker area (north)	No		No	Strategic land / road raising?

	Residential Sites			
	Without Flood Defence barrier		**With Barrier**	
Sites passing sequential test (table in 15.2)	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe+**	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe+**
IP080 240 Wherstead Road	Yes with On & Offsite works	No safe access from Wherstead Rd but may be possible via private parking area to West?	Yes with On & Offsite works	No safe access from Wherstead Rd but may be possible via private parking area to West?
IP081 Land North of Ranelagh Road	Yes with onsite work	Raise site, provide high level safe access to higher part of Burrell Rd	Yes	
IP083 Banks of river, upriver from Princes St.	Yes with On & Offsite works	Raise site, provide high level safe access to Princes Street through site 15	Yes with on and offsite work.	Raise parts of site, provide high level safe access to Princes Street through site 15
IP092 427 Wherstead Road	No		No	
IP096 Car Park Handford Road East	No		Yes	
IP098 Transco, south of Patteson Road	No		Yes with on and offsite work.	Raise low parts of site, and adjacent road, to create safe access to Myrtle Road roundabout perhaps as part of strategic scheme with site 45.
IP105 Depot, Beaconsfield Road	No		Yes	But site is in ASTWF
IP120 Land West of West End Road	No		Yes	
IP136 Silo, College St.	No		Yes with on and offsite work	Raise College St, or access to South with site 132.
IP154 2-6 Russell Road	No		Yes with on and off site & works	Raise adjacent road probably in conjunction with development of site 56 (commercial)
IP188 Websters Saleyard site, Dock Street	No		Yes with On & Offsite works	Small amount of road raising needed at Dock Street / Gower Street junction. Probably needs to be developed in conjunction with site 38

	Residential Sites			
	Without Flood Defence barrier		**With Barrier**	
Sites passing sequential test (table in 15.2)	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe**+	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe**+
IP132 Bridge St., Northern Quays (west)	No		Yes with On & Offsite works	Strategic land and road raising scheme might be possible including site 136 and perhaps 37. SW flooding issues. Raise all of site and Dock access road to South providing a high level safe access to Stoke Bridge (note 1 way traffic)

+ The feasibility of off site works are required to create safe access routes, typically by providing new roads or raising existing roads, is generally unknown. Land raising has been used recently at several sites.

* For Sites 45,98 and 64 (Holywells Rd / Cliff Road area) strategic land raising, including raising routes to higher ground, might enable development and alleviate severe local highway flooding..

Sites 38 and 188 should be developed together to allow for safe access.

Such flood risk management measures are described in section 17

Sites 68, 77 and 92 are therefore unlikely to be safe for residential uses.

These are considered below for commercial uses.

Commercial
Sites listed above and shown likely to be safe for residential developments will also be safe for commercial.

Sites not allocated for any residential development, together with those listed above as being unlikely to be safe for residential developments are considered below for commercial uses.

Since commercial uses have a 75-year design life and the assessment is based on sea levels at 2110, it is possible some additional commercial sites may be regarded as safe without on or offsite FRM works. I.e. those constructed early on in the LDF period and / or if a lower design life is agreed.

	Commercial Sites			
	Without Flood Defence barrier		With Barrier	
Sites passing sequential test	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe$^+$**	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe$^+$**
IP028a Land West of Greyfriars Road. IP28b Land West of Greyfriars Road (Jewsons)	No		Yes	
IP034 578 Wherstead Road	No		No	
IP035 Key St./ Star Lane/ Burtons Site	No		Yes	
IP036a & b Shed 7	Yes with On & Offsite works	Raise lowest parts of site provide high-level safe access to higher part of site.	Yes	
IP037 Island Site	No		Yes	
IP188 Websters Saleyard site, Dock St.	No		Yes	
IP042 Land between Cliff Quay and Landseer Road	Yes with onsite works	Develop only highest parts or raise lowest parts of site and provide high level safe access to Landseer Rd	Yes with onsite works.	Develop only highest parts or raise lowest parts of site and provide high level safe access to Landseer Rd
IP044 Land South of Mather Way	Yes with On & Offsite works	Raise site and part of roundabout provide high level access to bridge serving island site 37	Yes	
IP045 Holywells Road West / Toller Road	Yes with On & Offsite works	Raise all of site and provide a safe access across Toller Rd / Landseer Rd Junction - Very unlikely to be feasible. *	Yes with On site works	Raise or avoid lowest part of site and provide a high level safe access through site to the Toller Rd / Landseer Rd Junction * possible strategic FRM measures?
IP046 Wolsey St.	No		Yes	
IP049 No.8 Shed, Orwell Quay	Yes with on and offsite work	Raise site and existing road or provide safe access through site 36. and / or short design life. (or allow water compatible development	Yes	

	Commercial Sites			
	Without Flood Defence barrier		**With Barrier**	
Sites passing sequential test	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe+**	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe+**
IP050 Land West of New Cut	No		Yes	
IP051 Old Cattle Market, Portman Road - South	No		Yes	
IP056 Russell Road / Princes St. / Chancery Road	No		Yes	
IP060 Fison House, Princes St.	No		Yes	
IP064 Holywells Road East	Yes with On & Offsite works	Raise lowest parts of site and provide high level access to junction of Toller Rd and Landseer Rd (or raise Holywells Rd with dev of site 45	Yes with On & Offsite works Yes	Raise lowest parts of site and provide high level access to junction of Toller rd and Landseer Rd (or raise Holywells Rd with dev of site 45)
IP068 Truck and Car Co	No	(probably OK for Water compatible development)	Yes with on and off site works.	Major strategic road and land raising or use for water compatible
IP070 Orwell Quay	No	(probably OK for Water compatible development)	Yes with on and off site works	Use for Water compatible dev or raise levels & provide safe access to East
IP076 Land at Yarmouth Road	No		Yes	
IP077a & b Drunken Docker area (north) & (south)	No	(probably OK for Water compatible development)	No	(probably OK for Water compatible development)
IP079 Land South of Sewage Works	Yes		Yes	
IP092 427 Wherstead Road	No	(Probably OK for Water compatible development)	No	(probably OK for Water compatible development)
IP094 Rear of Grafton House, Russell Road	No		Yes	

	Commercial Sites			
	Without Flood Defence barrier		**With Barrier**	
Sites passing sequential test	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe**$^{+}$	**Likely to be safe?**	**Potential Flood Risk Management measures to make site safe**$^{+}$
IP096 Car Park Handford Road East	No		Yes	
IP098 Transco, south of Patteson Road	No	Strategic land and road raising scheme might be possible including sites 45 and	Yes	
IP105 Depot, Beaconsfield Road	No		Yes	
IP119 Land East of West End Road	No		Yes	
IP120 Land West of West End Road	No		Yes	
IP136 Silo, College St.	No		Yes	
IP139 Royal Mail Sorting Office, Commercial Road	No		Yes	
IP153 Car Park, Sir Alf Ramsey Way / Portman Road	No	A strategic land and road-raising scheme might be feasible. Raise whole site and provide offsite high-level safe access from Civic Drive, e- development of vulnerable housing at Canham Street and Great Gipping Street and site 51.	Yes	
IP154 2-6 Russell Road	No	Most of site needs to be raised with safe access to adjacent roads at Grafton Way / Princes Street - junction here may be problematic.	Yes	

+ The feasibility of off site works are required to create safe access routes, typically by providing new roads or raising existing roads, is generally unknown. Land raising has been used recently at several sites.

Sites 34 (Bourne Bridge – 578 Wherstead Rd)), 77 (Drunken Docker) and 92 (427 Wherstead Road) are may therefore not be safe for commercial uses. However sites 77 and 92 might be suitable for water compatible use and site 34 might be suitable for commercial use with a short design life.

16.5 Summary /conclusions for Development control policies for safe development

The LDF Core Strategy Policy DC4 (c) States *"Development will only be approved where it can be demonstrated that it is and will remain safe for people for the life time of the development."* The following supporting text is suggested to ensure the safety framework is followed:

"More vulnerable and less vulnerable development sited in flood zones 2/3a, as defined in PPS25 may be acceptable. However FRA's will be required to demonstrate that such developments will be "safe" in accordance with the Safety Framework described in section 16.2 of the SFRA (and detailed in a future SPD) and consider flood risk from other sources. The assessment will follow PPS25 and Annex E of PPS25.

Planning permission will not be granted until submitted details comply with the safety framework.

In addition permissions should not be granted if emergency responders are concerned about their capabilities/ plans."

Additional text relating to basements is also suggested as section 17.2.2

17 FLOOD RISK MANAGEMENT

This section relates to site specific as well as strategic measures

17.1 Flood risk Management -Tidal & Fluvial

It is clear the flood defence management strategy, which includes the proposed Barrier, is essential and the most important single FRM measure.

Secondly flood warning and emergency plans for public bodies could be improved to help manage the residual risks related to the possibility of floodgate failure. Guidance is provided below in section 18

The combined hazard map for the with barrier scenario assumes satisfactory emergency plans are in place for potential failures of the Wet Dock Flood Gate, the New Cut Barrier or the West Bank railway gate.

Where the map shows local hazard ratings are too great to satisfy specific requirements for safe access, then other strategic measures may sufficiently reduce the hazard ratings and design water levels. – Examples include:

- Land raising,
- Providing raised safe access routes –such as a bridge across the New Cut East.
- Reducing the chance of failure of the East Bank defence or Ship Launch gate (Red 7) (br05) or the future gate at Wherstead Rd (br07)

17.2 Flood Risk Management – Measures For All Zones

17.2.1 Flood Resilient and Resistant Design

Time to reoccupy properties is a principal consequence of flooding which can have a profound impact on the health and livelihoods of those affected. The Pitt Report (June 2008) highlighted the lessons learned from the summer 2007 floods and included a recommendation that building regulations be developed for new and existing buildings relevant to flood resilience.

"Flood Resilient Construction", DCLG, London. (2007) provides guidance.

Resilient designs minimise damage caused by floodwater by for example: the use of water resistant building materials, decorative finishes, the location of electricity meters and sockets, and readily repairable designs.

In flood zones 2/3 all new buildings should be "flood resilient " below the 0.5% AEP tide level in 100 years time (or to higher levels) - one of the framework of measures required for safe development described in section 16.2 which includes raised floor levels in many circumstances and structural design to resist loading due to moving floodwater.

Flood resistance, or dry proofing measures intended to stop water entering a building are unlikely to be fully successful and cannot be used in isolation as a mitigation measure but can play a part as described in the following table extracted from the PPS25 Practice guide.

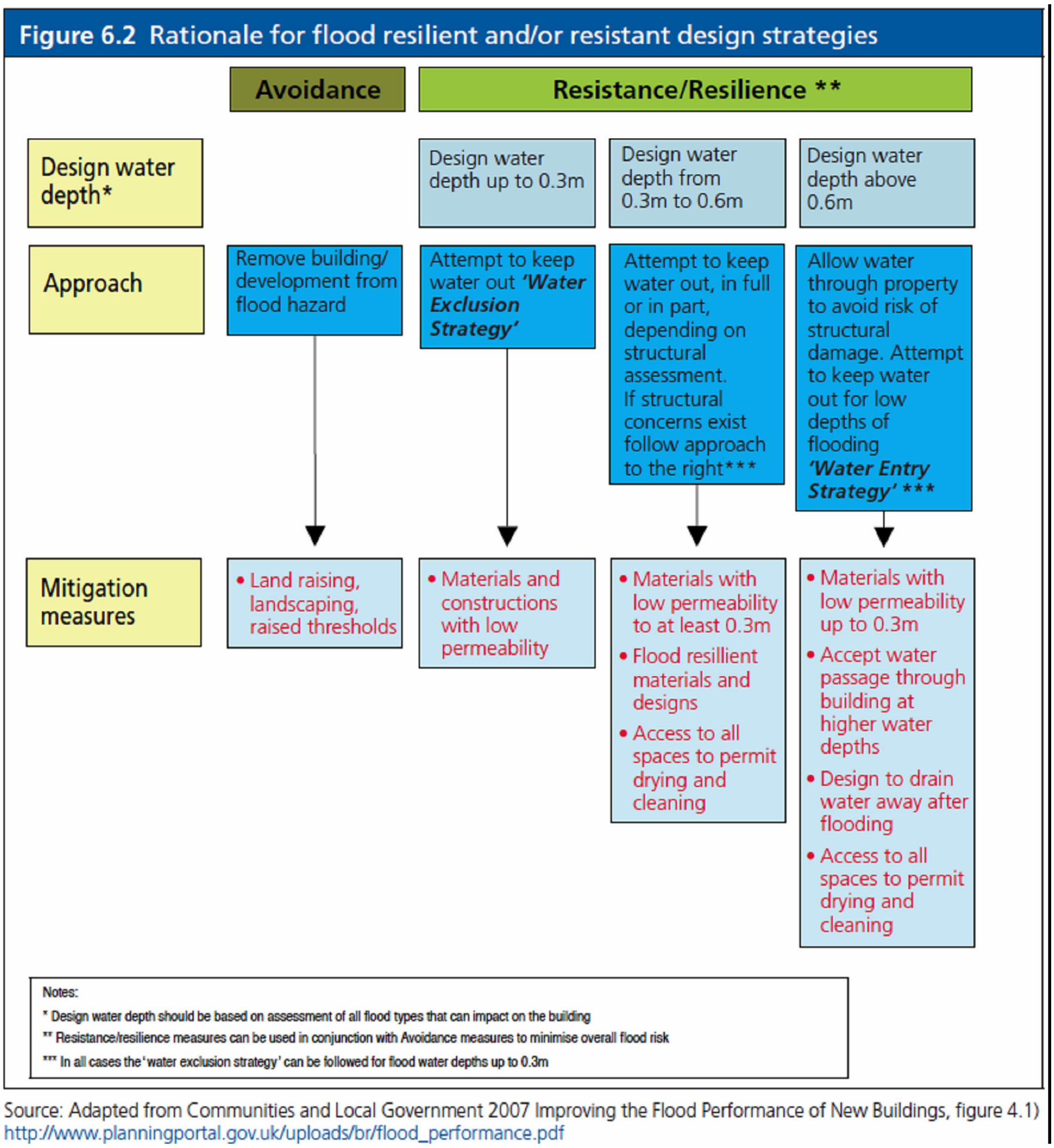


Figure 6.2 Rationale for flood resilient and/or resistant design strategies

	Avoidance	Resistance/Resilience **		
Design water depth*		Design water depth up to 0.3m	Design water depth from 0.3m to 0.6m	Design water depth above 0.6m
Approach	Remove building/ development from flood hazard	Attempt to keep water out ***'Water Exclusion Strategy'***	Attempt to keep water out, in full or in part, depending on structural assessment. If structural concerns exist follow approach to the right***	Allow water through property to avoid risk of structural damage. Attempt to keep water out for low depths of flooding ***'Water Entry Strategy'*** ***
Mitigation measures	• Land raising, landscaping, raised thresholds	• Materials and constructions with low permeability	• Materials with low permeability to at least 0.3m • Flood resillient materials and designs • Access to all spaces to permit drying and cleaning	• Materials with low permeability up to 0.3m • Accept water passage through building at higher water depths • Design to drain water away after flooding • Access to all spaces to permit drying and cleaning

Notes:
* Design water depth should be based on assessment of all flood types that can impact on the building
** Resistance/resilience measures can be used in conjunction with Avoidance measures to minimise overall flood risk
*** In all cases the 'water exclusion strategy' can be followed for flood water depths up to 0.3m

Source: Adapted from Communities and Local Government 2007 Improving the Flood Performance of New Buildings, figure 4.1)
http://www.planningportal.gov.uk/uploads/br/flood_performance.pdf

In "Areas Susceptible to SW flooding" all new buildings need to be flood resilient " below the 1% flood level in 100 years time.

Flood resilient/ resistant designs would also be required in "Areas Susceptible to SW flooding" where the use of an existing building is to be changed and it can be demonstrated that no other measure is practicable.

In both the above circumstances a simple site specific FRA would be needed to identify the flood level.

17.2.2 Basements.

The PPS25 Practice Guide states:

"Basements are defined as self-contained, with no free internal access upstairs in an event of flood water coming down outside access routes.

Basement dwellings are defined as 'highly vulnerable' in table D.2 of PPS25 because they are particularly vulnerable to all forms of flooding. The summer 2007 floods showed that surface water flooding can pose a serious risk to users of basements, but other forms of flooding, such as groundwater flooding, can be equally dangerous. Basements are at high risk because they are likely to flood first, inundate rapidly, and escape may be difficult, particularly for people with mobility impairments. If basements flood there is not only the risk of damage to the property but also a risk to life. Resilient design may also be difficult to implement, for example, locating a useable electricity supply above predicted flood levels."

PPS25 does not permit habitable basements in zone 3 and the suggested framework for safe development in flood zones 2 and 3 (described in 16.2 would prevent basement dwellings from being built in both zones 2 and 3).

However, in some locations basements outside zone 2 could be flooded by tidal or fluvial flooding via the sewerage system.

Basement dwellings should therefore not be permitted where the floor level is below the 0.1% AEP tide level in 100 years time.

Basements dwellings should not be permitted in "Areas Susceptible to SW flooding.

Basements in zone 1 should only be permitted subject to adequate FRAs, which must address ground water, sewer and overland flood sources.

The above recommendations should also apply to changes of use of existing basements.

Basement car parking

The PPS25 Practice Guide states:

"Long-term and residential car parking is unlikely to be acceptable in areas which regularly flood to a significant depth, due to the risk of car owners being away from the area and being unable to move their cars when a flood occurs. Like other forms of development, flood risk should be avoided if possible. If this is not feasible, the FRA should detail how the design makes the car park safe."

17.2.3 Temporary Barriers

The Council has a limited stock of barriers and unfilled sand bags that can be used to help reduce the risk of shallow depths of floodwater from entering buildings. In some circumstances these have been issued to residents. Advice is on both the Council's and the EA's web site and in EA literature that is supplied to those who are flooded, sees refs 11 and 12

These cannot be relied on as mitigation measure.

17.3 Flood Risk Management – Local flooding - Minor Watercourses and drainage systems

Risk associated with minor watercourses is managed at present through various policies:

- IBC's Drainage and Flood Defence policy (ref 6) – provides SUDS standards and describes IBC curent flood risk management strategy which includes guidance for public, investigating and recording flooding and drainage systems.

- Known ordinary watercourses and major floodpaths have been mapped by IBC (no assessment of flows has been undertaken).

- It is the Council's intention (ref 6) to inspect open watercourses from time to time and if necessary use its powers to ensure they are kept clear by their owners.

- IBC's Drainage and Flood Defence policy will "*not permit drainage of surface water into land drains or piped watercourses unless they have been constructed to an acceptable standard and have adequate capacity*."

- The Environment Agency's consent is required to pipe in watercourses. Their policy is that this is not normally permitted. Ideally watercourses should be retained in open space, encouraging wildlife.

- New national planning requirements (2009) regarding paving of front gardens aim to reduce runoff from these areas into the sewerage system.

The Ipswich Drainage and Flood Defence Policy is likely to be updated or replaced in the next year or so in line with the requirements of the Floods and Water Management Act, as the Surface Water Management Plan (SWMP) is developed and as National Standards for SUDS are implemented and a new SUDS adoption body (SAB) commences (expected April 2012).

The SWMP will refine the EA's Areas Susceptible to Surface Water flooding (ASTWF) maps and Surface Water Flood map in at least 4 of the 34 catchment areas in Ipswich.

Further mitigation measures are suggested as risks associated with watercourses are expected to increase:

- In the LDF, Green Coridoors should weherever possible correspond with watercourses in open spaces.

- The existing embankment which retains Holywells Canal adjacent to LDF sites 64 and 45 is in poor condition and is not owned by the Council. People and property downwhill, including users of Holywells Road, will be at risk should a breach occur. It should be strengthened to adequate standards before other works on either site commences.

- Where spring fed watercourses discharge into the sewerage system, the abstraction and use of the water for irrigation could reduce sewer flows and so provide several benefits – saving mains water as well.

- To ensure developments within ASTWF areas do not worsen flooding, or are flooded by the overland flows the developer should be required to undertake a FRA to consider overland flows through and from off site. This may affect site layout, floor levels and need for resilient design.

The likely effect of ASTWF and SUDS on development site capacity has been included in IBC's Strategic Housing land Availability Assessment –(SHLAA)

17.4 FLOOD RISK MANAGEMENT USING SUDS

17.4.1 Introduction

PPS25 states "*In all zones developers and LPAs should seek opportunities to reduce the overall level of risk in the area, and beyond, though the layout and form of the development, and the appropriate application of sustainable drainage techniques.*"

SUDS (Sustainable Urban Drainage Systems) are used to dispose of surface water runoff from developments in a manner that mimics natural processes and mitigates impacts on the environment. In particular properly designed and installed SUDS reduce peak flows and consequently flooding and pollution. Other benefits relate to amenity and biodiversity.

SUDS have been promoted by IBC since 2002 via the Council's Drainage and Flood Defence Policy document (ref 6). Section 13 of the document provides design standards for SUDs including requirements for relative levels of gardens, roads and building floors.

Overall the document is in need of updating and recommendations for some updates are included in this SFRA.

New building Regulations and the "National SUDS working group's Framework for SUDS in England and Wales" (reference 20) complement the Councils policy.

The Floods and Water Management Act will introduce national SUDS Standards and a SUDS adoption Body (SAB) probably in April 2012.

The following is intended to be a strategic overview, broadly identifying areas where SUDS should be viable, areas where a single SUDS might serve several sites, or where retro fitting may be possible in order to reduce risk elsewhere.

17.4.2 Forms of SUDS

SUDS may be "infiltration" type, which soak water into the ground or attenuation systems, which drain controlled flows into sewerage systems or watercourses.

Ground conditions primarily dictate the type of system used:

	Infiltration type SUDS	Attenuation type SUDS
Soil permeability >10mm/hrR	OK	Use Infiltration in preference
Soil permeability <10mm/Hr	No	OK
High water table	Not below water table	May be OK, permanent water possible
Filled land	No	
Contaminated land	Probably Not	OK
Ground water source protection Outer Zone	Subject to Pollution control measures… not directly to aquifer strata	OK
Groundwater protection Inner Zone	OK for Roof water	Ok

The British Geological Society's map showing superficial deposits is included in paper copies of this report. It shows a range of soils with wide variations in permeability.

Experience shows that even in the Kesgrave sands and gravels, soakage rates may not be high enough for infiltration systems. Rates measured in accordance with BRE365 (ref 14) can vary from less than 1mm/Hr to about 100 mm/Hr depending on the depth and location of the test pit.

Soakage tests carried out in bore holes or small pits are often inappropriate, very inaccurate and not normally acceptable for planning purposes. Larger scale tests in accordance with BRE 365 are normally required.

A second map included in the appendices shows areas where infiltration systems are most likely to be possible (subject to soakage tests). These are areas expected to have sands and gravels that are outside the flood plain, above spring lines and outside known filled areas (which may possibly be contaminated). Inner groundwater protection zones are also shown.

Soils outside the area might be found to be suitable for infiltration systems and in such cases infiltration systems should be used.

Pollution prevention measures may be needed for infiltration systems in source protection zones.

The map shows infiltration systems are likely to be appropriate across about 50% of Ipswich.

17.4.3 Opportunities for Strategic SUDS or Flood risk reduction.

Highway drainage/flood relief schemes have in the last few years used infiltration type SUDS to avoid increased downstream flood risk often associated with traditional piped schemes.

Highway drainage schemes that provide limited capacity or have yet to be installed due to lack of funding include:

Humber Doucy Lane adjacent to site 30 where joint SUDS solutions for drainage of highway and development would have wider benefits.

Such schemes would be particularly beneficial where surface water could be separated from the existing combined sewerage system.

For brown field sites with existing direct, uncontrolled discharges to the sewerage system, SUDS incorporated in new development, should reduce peak flows discharged to the sewerage system and thus provide a more strategic benefit to local flooding.

Retrofitting SUDS as development becomes denser and “Space for water” is lost is a growing problem. Where space could be identified it should be possible to connect Highway drainage into SUDS in adjacent open spaces.

IBC should identify sites such as wide verges or other open land that could be used for SUDS to provide strategic relief. Some such locations have been identified at Heath Rd (scheme installed 2009/10) and Bixley Rd.

In appropriate locations, to reduce flood risk generally and locally developers should be required to drain highways adjacent to their sites into SUDS within their sites.

The Council is considering how to reduce the impact of paving of gardens and loss of grass verges, some measures relating to new footway crossings are in place. The maps with this report should assist in development of policies.

17.4.4 Flood storage in Flood Zone 3

The capacity of drainage systems serving the low-lying areas is reduced when tide levels are above the soffit of outfall pipes. Discharge to the Orwell will not be possible whilst the tide is above upstream ground levels.

Rising sea levels, paving of gardens and increased development will increase the risk of flooding whilst the above mitigation measures will offset the effect to a certain extent.

Anglian Water’s existing underground storage tanks at Alderman Recreation Ground, east of Yarmouth Rd, and adjacent to Stoke Bridge were designed primarily to reduce pollution from some of the outfalls and can be expected to fill several times per year and so do not provide sufficient flood storage at present.

Flooding of the lowest areas should be expected at present, and indeed the local flooding maps do show such flooding in several areas. It is thought that flooding in other low open space areas is simply not reported.

Detailed sewerage modelling by Anglian Water could determine how much additional storage is needed to provide adequate future standards of protection but would need to make assumptions regarding future paving and development.

Spaces for additional storage need to be identified and reserved before they are developed.

Such storage (attenuation type SUDS) would most likely be a combination of facilities provided at ground level (landscaped basins, ponds etc) and underground, sited in the lowest parts of the tidal flood compartments and/or adjacent to AW’s existing tanks.

Flood storage areas could drain by gravity until low water neap tide levels come close to the level of bottom of the flood storage area. LWNT by 2107 is predicted at 0.15 m A.O.D.

The appendices include a plan showing the location of current storage facilities and low lying areas likely to be needed for flood storage and local flooding.

Detailed FRAs for developments in or adjacent to the areas identified for possible flood storage need to fully determine the surface water/combined sewage flood storage requirements in the lowest areas. Anglian Water should be consulted.

17.4.5 Guidance on SUDS

Some other factors that affect whether SUDs can be used or are needed are:

- Attenuation systems are normally inappropriate for draining small areas where small throttles (<100mm) would be prone to blockage.
- Attenuation systems may be inappropriate in very low-lying areas where sewers are likely to overflow into the storage system.
- Attenuation systems need a suitable outfall with adequate capacity - not a piped watercourse or land drain.
- Maintenance/adoption.
- SUDS would not be required to limit flows discharged from developments alongside the Orwell, however the EA has required them to limit flows discharged to the Gipping.
- Infiltration systems should not be used where they could threaten stability of steep slopes.

Layout and form of buildings and roads must be designed around SUDS bearing in mind SUDS should be sited in lower areas, but preferably close to source, making use of topography. In addition infiltration systems must be sited at least 5m from buildings, 4 m from adopted highway kerblines and 10m from railway boundary fences

SUDS should be sited as close to the source as possible. Source control techniques include the use of permeable paving. IBC have a guidance note.

CIRIA’s Publications C532 and C697 C582, (refs 14, 15 &16) provide guidance on various forms of SUDS.

18 INFORMATION FOR UPDATING EMERGENCY FLOOD PLAN

18.1 Frequency of evacuation

Frequent flooding and evacuation would lead to much disruption, stress and anxiety and high demands on emergency services. However it would also offer practice and it is likely more people would be aware of and follow emergency plans as they become more familiar with them..

Assuming evacuation is instigated when the tide level is predicted to reach within 300 mm of the defence levels then the likely frequency of evacuation is estimated as follows:

Average interval (years) between evacuations

	Waterfront/ Village	**Bath Street & other areas where defences are @4.65m AOD**	**Wherstead Rd**
No Barrier			
Predicted tide to trigger evacuation (m AOD)	3.95 (after defences repaired)	4.35	3.8
Average Interval @2010	50 years	300 years	30 years
@2085	5 *	20	3
@2110	1 (annually)	5	<1 (several times per year)
With Barrier +4.4 m Levy Funded defence at Wherstead Rd			
Predicted tide to trigger evacuation	5.4	5.4	4.1
Average Interval @2015	>10,000 years	>10,000 years	100 years
@2085	1,000+	1,000+	5
@2110	300	300	1 (annually)

* It appears that, **<u>with no barrier</u>**, by 2085, properties would need to be evacuated on average every 5 years in the Village and Waterfront areas. However the proposed safety framework would not allow new commercial development in these areas.

18.2 Likely numbers of deaths and injuries

Estimates of approximate likely numbers of injuries or deaths in specific events (0.1% AEP and 0.5% AEP) are included for emergency planning purposes in Appendix 5.37.

18.3 Rest centre capacity

Appendix 5.37 also estimates the current resident population in the floodplain is about 4,000 and 69% of homes are assumed to receive automated flood warnings (Anglian Region figures). However not everyone who receives warnings will need rest centres, and some who do not receive warnings from the EA may require them.

During the 2007 surge at Great Yarmouth approximately 7,500 residents were advised to evacuate, of which about 800 evacuees were accommodated in Rest Centres (Source: Great Yarmouth Borough Council) Some residents self-evacuated and stayed outside the area with friends and relatives. A few went to hotels. Many residents did not evacuate but it is not clear how many stayed at home.

Based on Great Yarmouth, about 10% of residents i. e. 400 would need rest centres. However in the recent exercise “Watermark” rest centres were planned for 2,000 residents.

18.4 Residual Risks

Flood warning and emergency plans for public bodies need to be updated to manage the residual risks related to the possibility of floodgate failure at the Wet Dock Lock, The West Bank railway gate as well as the New Cut Barrier. The combined hazard maps. (Appendices 5.34 and 5.35) will then be valid for use in considering safety of development – for development control and planning purposes These should not be used for emergency planning purposes, other than to indicate areas most at risk.

Hazard Maps for Emergency planning though may need to include hazards relating to floodgate failure - The available maps are shown in 8.12 – for existing defences and 8.14 for with the proposed barrier. These are not included with this report as appendices but can be supplied.

The analysis in 8.15 shows the greatest flood depths of flooding by far, result from failure to close the proposed barrier or the wet dock floodgates. Hazards resulting would widely reach “Danger to Most” and locally ”Danger to all. These hazards are likely to be too great to permit “safe” residential development .

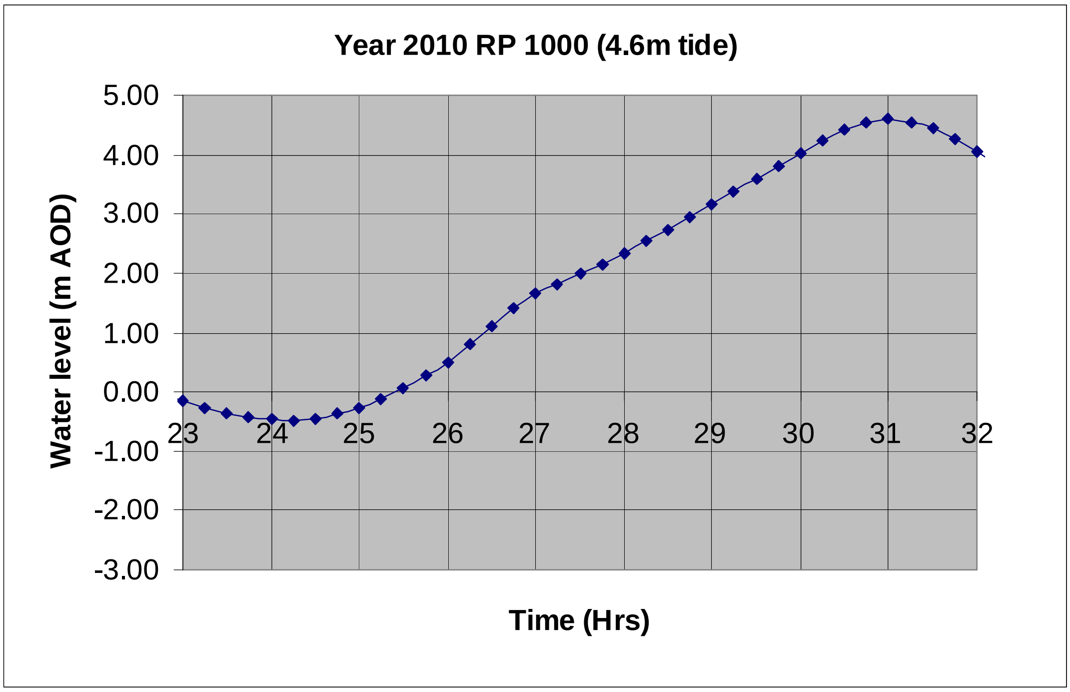
Even though the risk of failure is considered to be very low it is considered to be worth managing the residual risk due to the high consequences (hazards), even if further residential development is not planned.

18.4.1 Failure to Close the proposed New Cut Barrier

Since the barrier needs to be closed at low tide, it would be operated at least 6 Hours before the peak flood.

There are back systems to reduce the probability of failure e.g.: standby power generators and duplicate hydraulic systems.

If the gate did fail to close, the first point to flood upstream by overtopping would be the New Cut East /Island where defences will be at 4.25m AOD - flooding would initially affect the Island 5 hours after the gates should have been closed – as illustrated by the following graph..



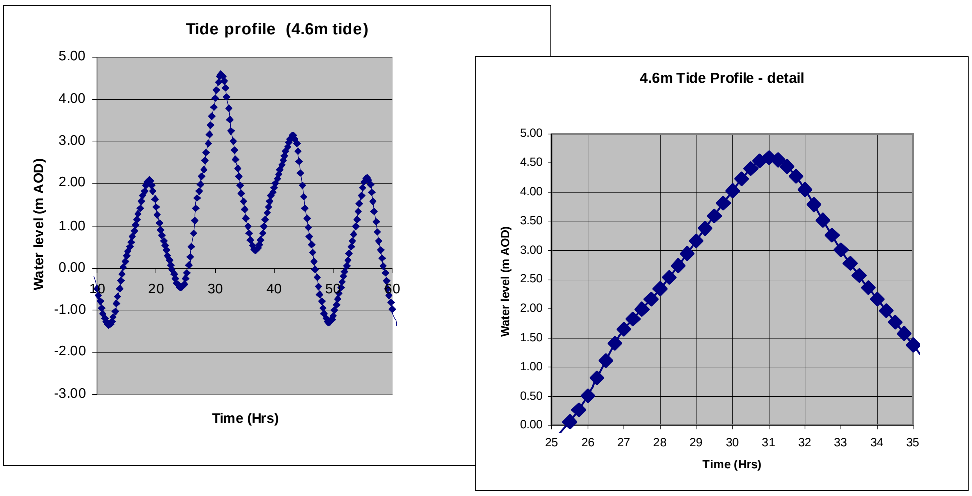
Flood warning and Evacuation plans must therefore allow for a maximum of 5 hours - say 4 to evacuate.

18.5 Failure to Close Existing Wet Dock Flood Gate

The gates are currently closed when the water level in the Wet dock reaches 2.6m AOD.

If the gates are not closed, then flooding of the quayside areas will start when the water level in the dock reaches about 3.2m AOD.

The 4.6 m tide profile used by Halcrow (shown below) indicates flooding around the wet dock would commence about an hour after the gate should have been closed. Thereafter rapid flooding of Bridge Street to a depth of 0.5m would occur. The peak flood level would be reached after 2 hours, when fast flowing water across Bridge Street would be 1.9m deep (Danger to all).



The graphs assume sea levels are at year 2010. Rising sea levels will increase the frequency and duration of gate closures. The current activation level 2.6mAOD is currently about HWST – occurring about 16 times per year. By 2110 HWNT would be about 2.5m AOD and the gate would therefore be closed almost twice every day of the year and HWST would be 3.5 m AOD (with no surge addition)

If more warning time is needed the gates would need to be closed earlier whenever the tide is **predicted** to reach say 2.9m AOD… about annually now, 15 times per year by 2085 and almost daily by 2110. ….i;e. Fewer closures.

To provide 4 hours warning the gate would need to be operated 4 Hours before the tide is predicted to reach 2.9m AOD and the duration of closure would be about 7 Hours.

To provide 3 Hours warning the gate would be operated 3 Hours before the tide reaches 2.9m AOD and the duration of the closure would be 6 Hours.

There is a need to determine:

- The minimum time needed to provide adequate warnings and implement subsequent evacuation, road closures and traffic diversions.

- Whether the operating regime be altered?

Flood sirens operated by the gate operator would speed up flood warning.

19 GUIDANCE FOR FRAS IN SPECIFIC AREAS

A particular site may fall within several parts of the table below. For example site 45 falls within several categories – Holywells Rd area, lowest parts of Zone 3 and brown field site and ASTSWF.

FRAs will be required for sites falling into these categories even if they are <1Ha

Area	Special requirements/issues for FRA	Purpose
Areas susceptible to SW flooding (ASTSWF)	FRAs required considering overland flows through and from off site. Will affect site layout, floor levels and need for resilient design. SWMP being prepared.	To ensure development does not worsen flooding, or is flooded by the overland flows.
Adjoining flood defence walls.	Breach of defences… SFRA provides hazard maps for certain breach locations… For other locations it may be possible to infer hazard ratings from the SFRA.	
Holywells Road area	Holywells canal embankment stability & risk of overtopping. Canal outlet/highway drainage. - flood-paths. Severe local flooding -. Highway drainage investigation. Surface runoff from frontage development. Combined sewer flooding from Cliff Lane. Tidal flooding. Sewerage system surcharging. AW tunnel overflow via Ship Launch Rd if overloaded or if outfall	Highway drainage system not recorded.

	penstock malfunctions.	
Wet Dock frontages- Sites S of Key St, Fore St	There should be no increase in ground level (paving). Ground floor levels to be set above likely 1%AEP local surface water flood levels. ABP Dock sewer.	To avoid worsening flooding of low-lying properties by overland flows.
Lowest parts of Zone 3	SW Flood storage, Ground water. Foul & SW drainage.	
Green field sites with permeable soils	Foul drainage availability / capacity. BRE365 Soakaway tests, ground water levels, ground water protection. Layout and levels of proposed dev to have space to retain 100 year event runoff on site allowing for adequate clearance from infiltration systems to buildings. Maintenance arrangements.	To ensure combined sewer flooding and pollution of watercourses is not worsened. To ensure layouts allow sufficient space for adequate SUDS and ensure SUDS are maintained in the future
Green field sites with impermeable soils	Foul drainage, Soakage tests or ground investigations required to prove ground unsuitable for infiltration type SUDS. If not suitable - Green field runoff rates, outfall capacity, suitability or route. **Layout and levels of proposed dev to have space to retain 100-year event runoff on site in lower parts of site.** Land drainage – pipes and or ditches	To ensure combined sewer flooding and pollution of watercourses is not worsened.

Brown field Sites	SUDS to reduce off site discharges. Soakage tests in permeable areas, Contamination /remediation may affect drainage.	
Sites adjacent to roads with no drainage e.g. Humber Doucy Lane site 30, Whitton Church lane, Norwich Rd North of Ipswich	Drainage or flooding of highway to be resolved as part of the development.	
Isolated sites North of Ipswich with no readily available FW or SW drainage.	FW – consider draining wider area – some existing properties served by unsatisfactory septic tanks etc. SW drainage, greenfield runoff, land drainage.	No readily available foul sewer- probable capacity issues.
Sites SE boundary of Ipswich	FW SW	No readily available foul sewer.

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