Suffolk Flood Risk Management Partnership

JUNE 2012

Ipswich Surface Water Management Plan

Phase 3 Report – May 2012

Produced for Suffolk County Council by Ipswich Borough Council

water management alliance · Environment Agency · IPSWICH Borough Council · Suffolk County Council · anglianwater

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Phase 1 report	4	Sharepoint
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Phase 3 report	6 blanked out modelling/AW costs and red text indicating recent changes	Jane Burch 27 April 2012
Phase 3 report	7 revised modelling/AW costs	

Limitations

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.

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1 List of Appendices

2 Abbreviations

AEP	Annual Exceedance Probability. The probability associated with a return period. Thus an event of return period 50 years has an AEP of 0.02 or 2%
AOD	Above Ordnance Datum
AONB	Area of Outstanding Natural Beauty
ASTSWF	Environment Agency map showing areas susceptible to surface water flooding (ignoring underground drainage)
AW	Anglian Water
CFMP	Catchment Management Flood Plan (for East Suffolk)
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
FDGiA	Flood Defence Grant in Aid
FDMS	Flood Defence Management Strategy (for Ipswich – tidal and fluvial)
FMfSW	Environment Agency flood map for surface water (takes account of drainage)
FRM	Flood risk management
FRMP	Flood risk management plan
GIS	Geographic Information System. A software framework that captures, stores, analyses, manages, and presents data that is linked to location
IBC	Ipswich Borough Council
IDB	Internal Drainage Board
LDF	Local Development Framework. Ipswich Borough Council's planning framework
LiDAR	Light Detection and Ranging. Method for collecting high-resolution topographic data
LLFA	Lead Local Flood Authority
PFRA	Preliminary Flood Risk Assessment. Requirement under the Flood Risk Regulations (2009)
PH	IBC Portfolio Holder
PM	Project manager
RAMSAR	Wetlands of International Importance
RBMP	River Basin Management Plan. Environment Agency plan for delivery of the Water Framework Directive within the Anglian Region
RMS	Root Mean Square error of LiDAR data. Difference between values predicted and observed

RP	Return Period – average time between reoccurrences
PV	Present Value. The PV of the scheme is the notional sum of money that needs to be put aside (invested) now to fund the scheme. PV is affected by inflation and investment interest rates and may include capital and ongoing maintenance costs
SCC	Suffolk County Council
SFRA	Strategic Flood Risk Assessment
SFRMP	Suffolk Flood Risk Management Partnership
SPA	Special Protection Area. Area protected under the EU Birds Directive
SSSI	Site of Special Scientific Interest
SW	Surface Water
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
WFD	Water Framework Directive

3 Policy context

Defra's intention is to use Surface Water Management Plans (SWMPs) as the primary vehicle to manage surface water flood risk in England. This intention was published in the Future Water Strategy (2008). The SWMP concept was recognised and promoted within Planning Policy Statement 25 (PPS25) and is implicit in the new National Planning Policy Framework.

A SWMP will fit within the existing policy framework and can provide the evidence base to inform Preliminary Flood Risk Assessments and fulfil the requirement for Flood Risk Management Plans under the Flood Risk Regulations (2009).

The Floods and Water Management Act 2010 requires lead local flood authorities to develop a strategy for local flood risk management for their area. SWMPs make an important contribution to informing the development of this strategy and identifying ways to implement it.

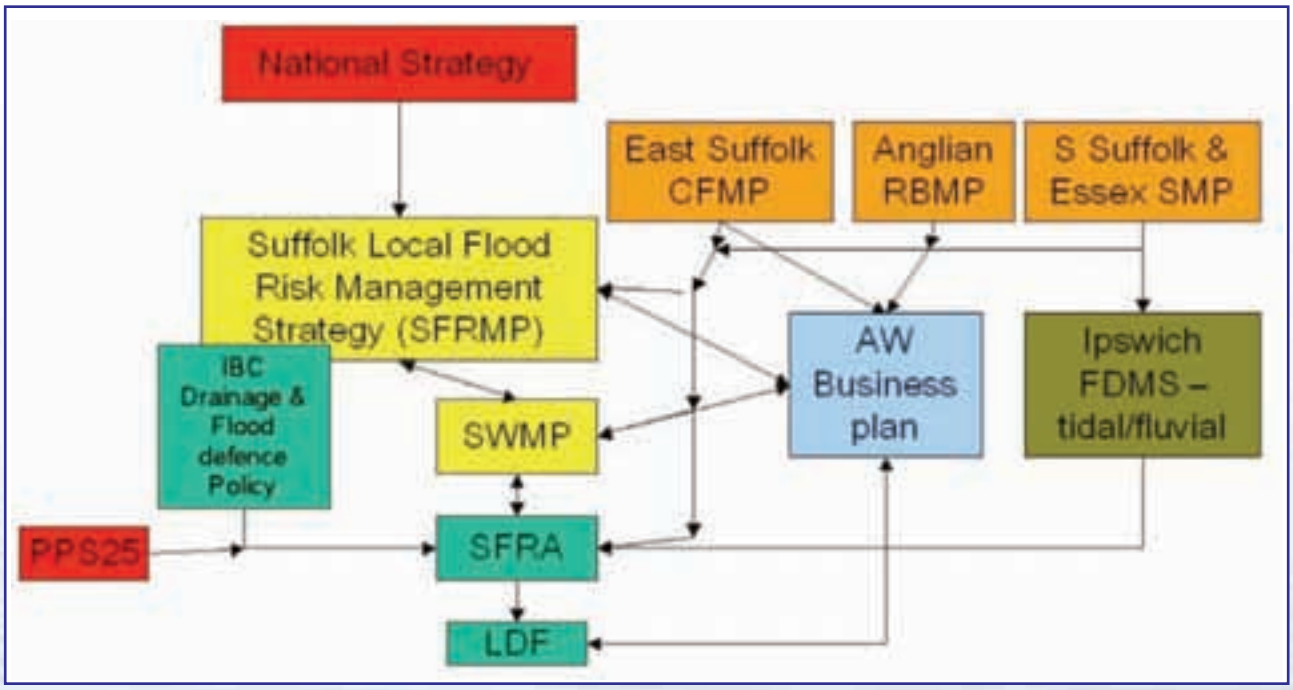


Figure 3.1 Flood and coastal erosion management policy framework

4 Executive Summary, Conclusions & Recommendations

1. The Surface Water Management Plan process has been found to be cost beneficial; the costs of the study and likely costs of flood relief measures put together should easily exceed the expected reduction in flood damage costs.

2. 34 sub catchments in Ipswich have been identified and prioritised. The top four catchment areas:

a) London Road to Lavenham Road and Hadleigh Road
b) Ancaster Road/Burrell Road
c) Lovetofts Drive to Lagonda Drive
d) Worsley Close/ Ellenbrook Green

These areas have been studied in detail.
The resulting action plan (see section 10) proposes measures for alleviating flooding in these four areas and suggests ways to reduce the effects of urban creep (paving of gardens, small extensions, etc) which should also have Suffolk wide benefits.

3. Actions include: further modelling by Anglian Water, subsequent updating of option evaluation, design and implementation of retrofit SuDS systems and maintenance work.

4. The plan suggests four further sub-catchment areas are studied in detail following the processes described later in this report. These are: Swinburne Road, Coltsfoot Road, Portman Road and Maidenhall Approach. If this second stage SWMP is also found to be cost effective, then the SWMP should be extended again to include lower priority areas and so on, until the costs of SWMP development plus the cost of flood management measures exceed the benefits.

5. The cost of the second stage SWMP is estimated to be £77,000.

6. A methodology for prioritising detailed SWMP studies across Suffolk is described and an Excel workbook provided for future use. This made use of the Environment Agency's Areas Susceptible to Surface Water Flooding (ASTWF) maps.
The spreadsheet should be updated to use the more recent Flood Map for Surface water (FMfSW) which was used for the Suffolk Preliminary Flood Risk Assessment.

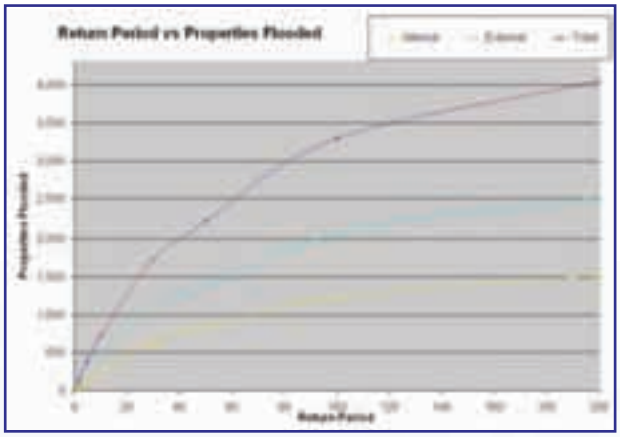
7. Another workbook has been developed for estimating damage costs and benefits in each detailed study area. A similar methodology could be used for future SWMP studies.

8. The following numbers (below) of properties are predicted to flood internally in each of the four priority areas:

Return period (yrs)	1	2	5	10	30	50	100	200
Ancaster Internal	1	1	1	2	2	10	15	19
Chantry Park Internal	0	0	0	0	0	0	3	6
Ellenbrook Internal	0	2	7	11	21	25	34	42
Lovetofts Internal	0	0	0	2	13	13	18	21

9. The SWMP predicts fewer properties at risk than the PFRA and the EA's Flood Map for Surface Water (FMfSW). Based on SWMP figures above, as explained in section 7.5, the total number of properties likely to suffer internal flooding in Ipswich is estimated to be 1,525, whereas the estimate quoted in the PFRA was 5,628 (external + internal). These figures are for an extremely intense and rare rainfall, with a 0.5% annual probability in any year (occurs on average once every 200 years)

10. Smaller numbers of properties will flood in more common events as shown on the following graph:



11. Across Ipswich an average of about 360 properties are predicted to suffer some flooding per year, of which 130 would suffer internal flooding. In a 1-year return period event 48 properties are predicted to flood of which 18 would suffer internal flooding.

The above Ipswich-wide estimates are likely to be high because they were extrapolated from the highest priority areas. The average number of properties recorded to flood per year is 124. Flooding, especially external, often goes unreported, so the results give credence to the SWMP predictions.

12. There are inherent inaccuracies in predicting whether homes will flood. For example, no account is taken of individual property protection, wash from vehicles, fences, etc. Blockages affecting pipes, grilles or grates and deposits of flood debris will have varying affects. Ground level data used for modelling has an accuracy of + or -150mm, whereas thresholds are often only 50mm above ground levels.

The methodology used therefore provides catchment-wide figures and should not be relied on for predictions of flooding at individual properties.

13. New flood maps are included for the four study areas. Flood hazards to people are generally low apart from in a few parts of the Ellenbrook area – notably at Gusford Community School. It is recommended the school management are made aware of these hazards and encouraged to put appropriate measures in place.

14. It will be for Suffolk County Council to decide whether the newly mapped areas are significant flood risk areas (Flood Risk Regulations 2009).

15. The new flood maps should be incorporated or cross referenced in the Strategic Flood Risk Assessment (SFRA) and made available to planners and developers.

16. The Ipswich Local Development Framework (LDF) already includes requirements for controlling development in local flood risk areas. The new maps should be used to assist in associated Flood Risk Assessments (FRAs).

17. Lessons for future SWMPs are listed in section 10.10. The following are considered to be especially important at this time:

- Representation of highway gullies in models in flood risk areas is important and will provide an understanding of flood mechanisms and aid decisions on flood management and design of solutions involving SuDS.
- Simulation results from a wide range of return periods are needed to properly assess options. Interpolation from a limited range of results is sometimes possible but time consuming.

18. The measures proposed in the SWMP are expected to have a very small but beneficial affect on water quality in local watercourses.

19 .The following information and advice should be provided to the public.

Initially this will be at the exhibition/drop in session used for consulting the public on the action plan:

- Flood maps – with limitations explained.

- Information on the developing Suffolk Local Flood Risk Management Strategy.
- Responsibilities – changes in regard to private drainage made in October 2011.
- Responsibilities – who and how to report flooding or blockages.
- Advice on flood risk management and water quality improvement measures that residents and businesses can take:
  - Not to obstruct flood paths, ditches or watercourses.
  - Not to wash cement, fat, oil, or pesticides down drains.
  - Paving of gardens e.g. – minimise paved areas, use permeable construction or rain gardens.
  - Flood resilience barriers, etc.
  - Flood warnings and awareness / preparedness.

20. No formal environmental or equality assessments have been undertaken. These will be applied to individual flood management schemes that result from the plan.

21. Under the Floods and Water Management Act, Suffolk County Council will be responsible for monitoring and reporting implementation of the action plan. This will be done through the Suffolk Flood Risk Management Partnership in line with the annual review proposed in the Suffolk Local Flood Risk Management Strategy.

It is recommended the Suffolk Flood Risk Management Partnership continues to work together to discuss and monitor progress. According to Defra's guidance, the action plan should be reviewed and updated once every 6 years as a minimum but there are circumstances which might trigger an earlier review such as:

- Occurrence of flooding.
- Additional data or modelling becoming available which may alter the understanding of risk.
- Outcome of investment decisions by partners requiring revisions to the action plan.
- Additional development or other changes which affect surface water flooding.

Long term recording, monitoring and review of flood records will be undertaken, as planned in the draft Local Flood Risk Management Strategy. This should make use of Ipswich Borough Council's historic records to set the base line data.

5 Introduction

5.1 Purpose, history and guidance on use of this report

The main purpose of this report was to inform the project board members and enable them to endorse both the work undertaken so far and the proposed action plan prior to public consultation. It will also inform the development of future SWMPs and future investment decisions.

Consultation responses will be considered and appropriate amendments may need to be incorporated. Following formal approval and adoption by partners, the report will be made available to the public, developers and planners alongside the Ipswich Strategic Flood Risk Assessment (SFRA).

The report is expected to be a living document, updated in line with changing circumstances such as when further detailed studies or flood risk management measures are planned or implemented or if major flooding problems occur.

This report documents the SWMP process in chronological order and has evolved from and replaces the phase 1 report.

Sections 5.2 to 6.13 are essentially unchanged.

Section 6.9 was written to inform the Suffolk PFRA in 2010 - this has not been updated following the detailed modelling and option evaluation described in later parts of the report.

5.2 SWMP process

Development of the SWMP followed Defra's guidance, issued March 2010 **www.defra.gov.uk/publications/files/pb13546-swmp-guidance-100319.pdf**

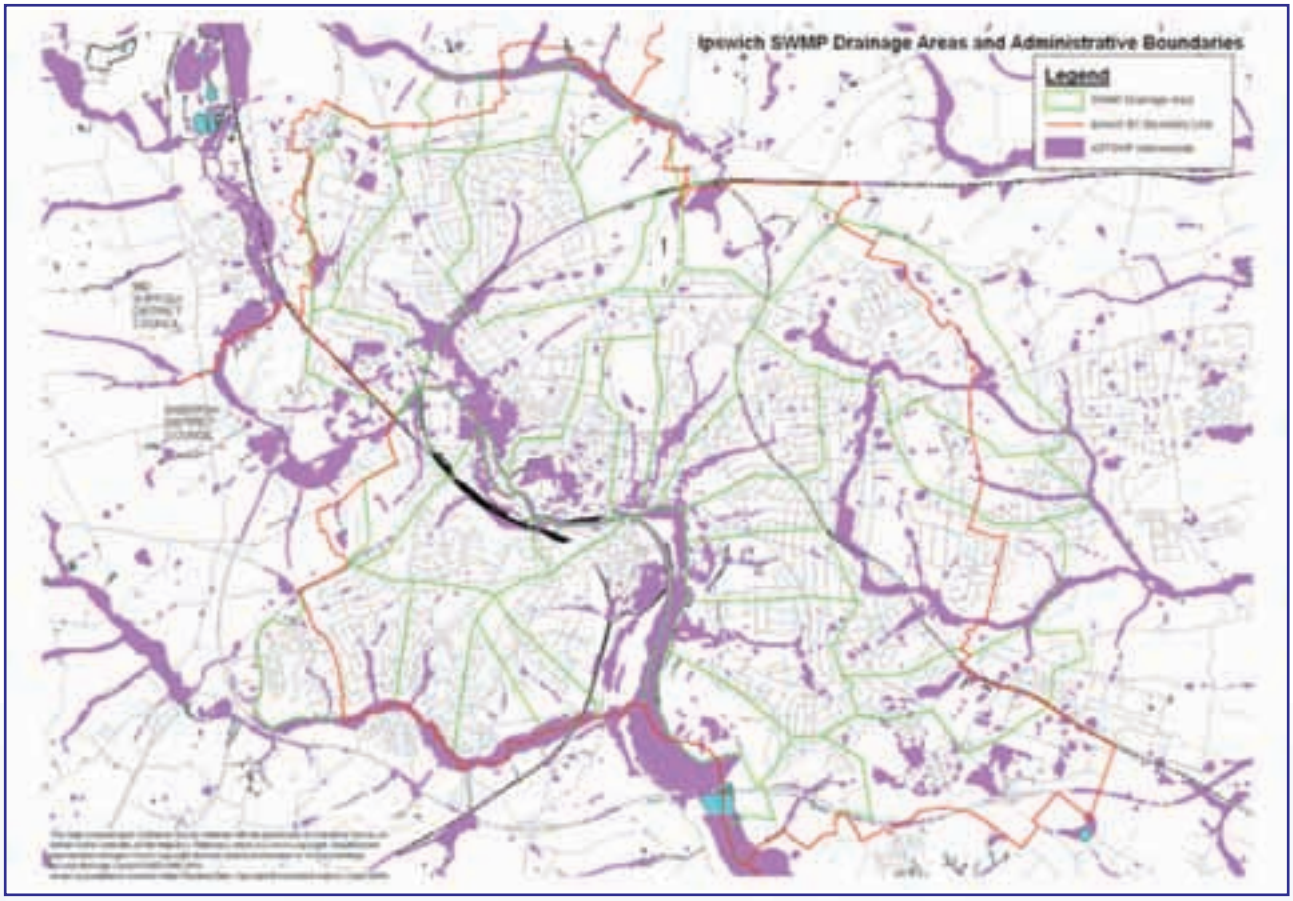
This describes the general process for developing an action plan for Surface Water Management.

The action plan includes cost effective measures which reduce flooding, manage the consequences of flooding, or prevent increased flooding – e.g. by preventing obstruction of flood-paths. Other benefits should include water quality improvements and more joined up working with people or partners, influencing planning and development control and emergency plans.

The production of the plan was funded by Defra with additional input from Anglian Water, Ipswich Borough Council and Suffolk County Council. The budget was limited and detailed study had to focus on priority areas - only 4 of the 34 sub-catchment areas forming the study area.

The prioritisation process concentrated on flooding issues with greatest emphasis put on historic flooding rather than areas identified as susceptible to surface water flooding (ASTWF) on the Environment Agency's map.

The following diagram from Defra's guidance illustrates the process of developing a SWMP.



5.3 Geographic extent of the report

The areas covered by the SWMP report are outlined in green. These denote catchment boundaries or water sheds.

The purple areas indicate valleys or low spots where flooding is most likely.

Pinewood within the Babergh District Council area to the South East of Ipswich has been included in the SWMP study at the request of the Project Board.

Babergh District Council and the Environment Agency had no records of flooding in Pinewood. However Ipswich Borough Council do have some records of flooding here as the Borough are highway agents for this area

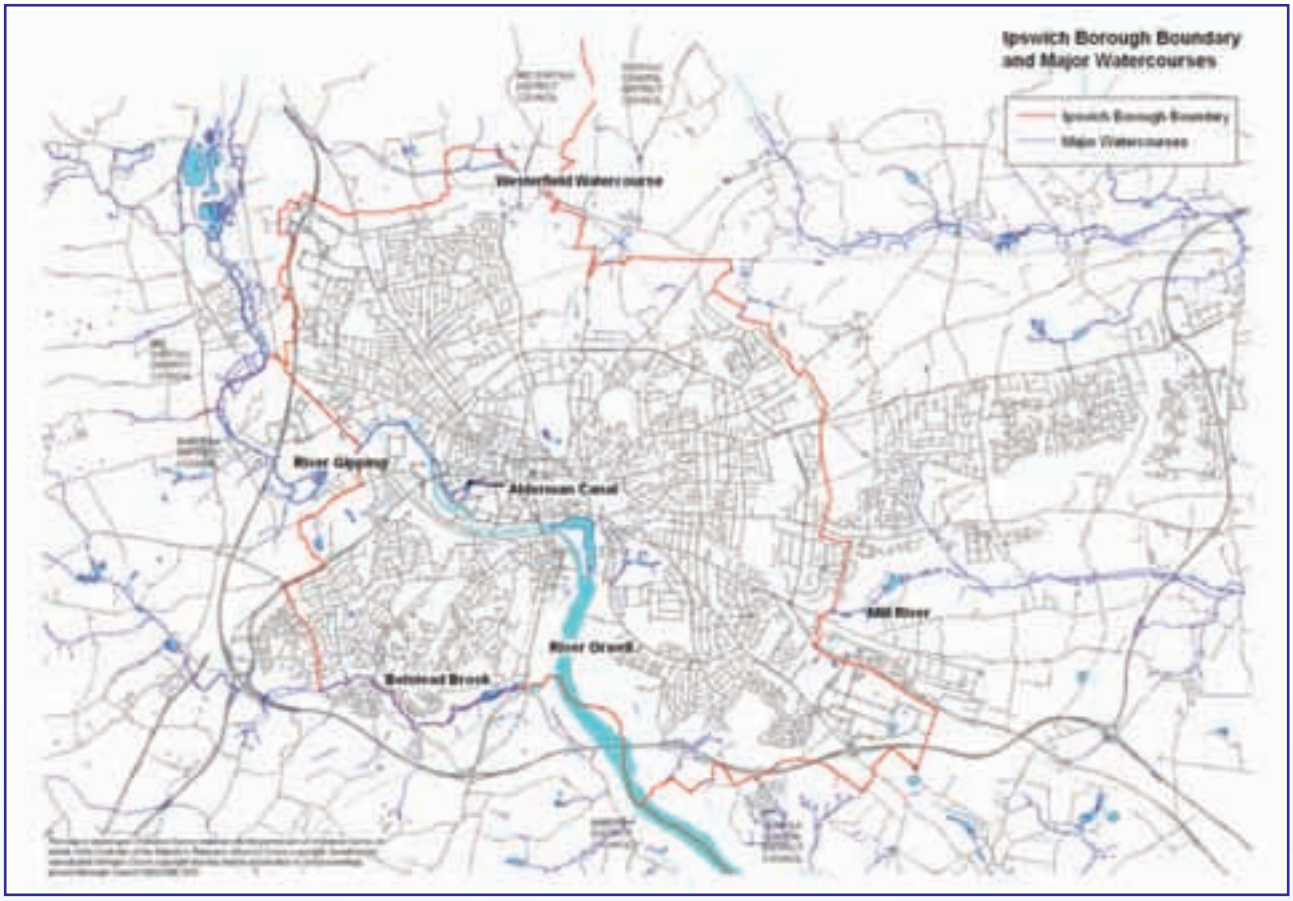
5.4 Overview of Ipswich drainage

Ipswich Borough Council has always had a drainage engineering team who have developed and operate the Council's drainage and flood defence policy – effectively a quality system aiming to manage flooding problems with record keeping and monitoring of flooding a core activity. As a result Ipswich has an array of records, GIS and software used to develop the SWMP.

The overview includes descriptions of tidal flood defences. Whilst tidal flooding is outside the scope of the SWMP, tidal defences will have some effect. In some areas the defences may act as barrier to surface water flows, in others defences will aid surface water drainage.

5.4.1 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 within an Area of Outstanding Natural Beauty.



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 Road) 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 area and parts of the urban area adjacent to the Orwell are low lying and at risk of tidal flooding (see map on next page).

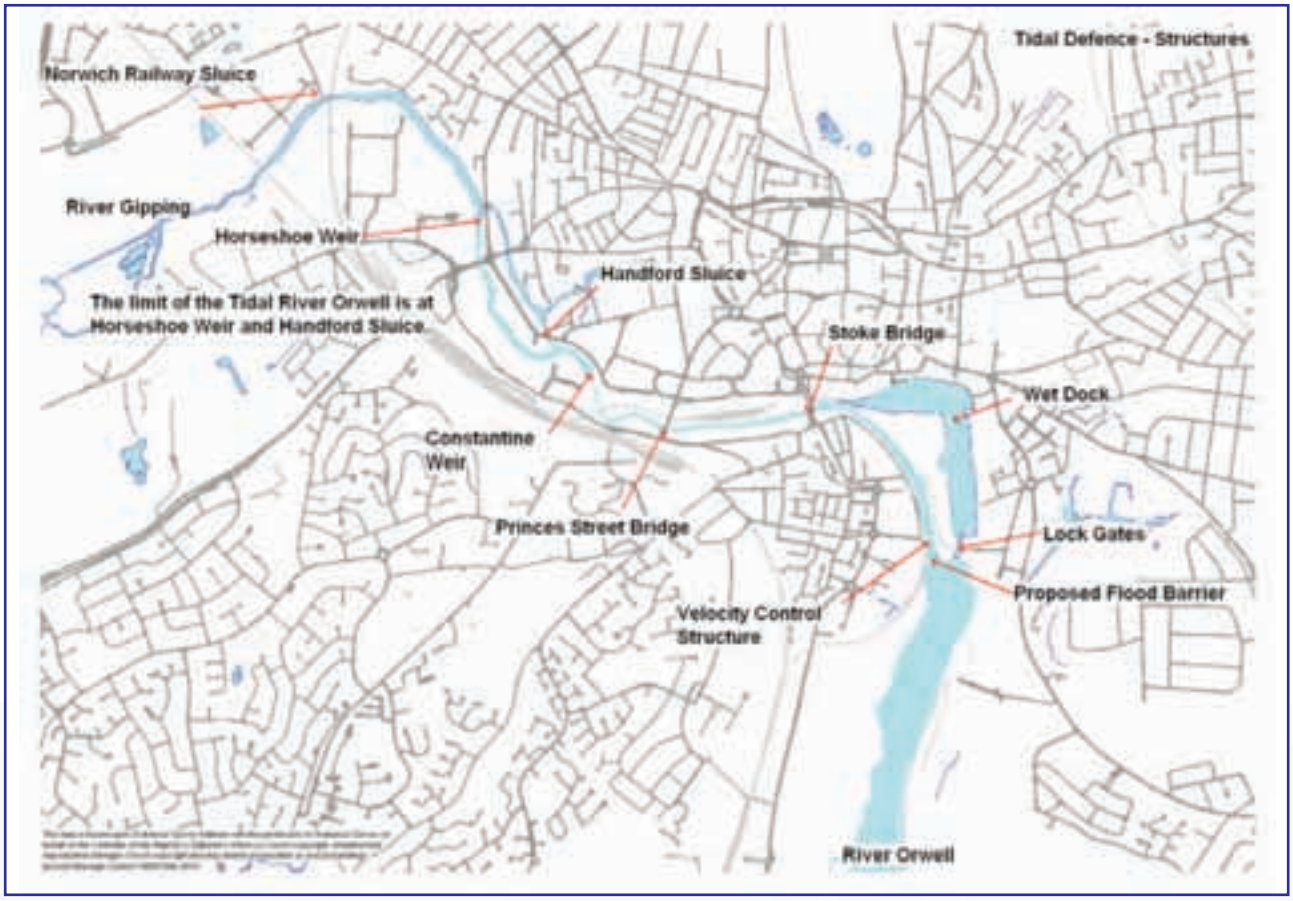
Following the 1953 tidal surge the River Gipping and Orwell flood defence walls were upgraded in a comprehensive scheme between 1970 and 1983. The river channel was improved and 15 km of flood defence walls and 5 control structures were constructed. These walls are generally at least 2m above inland ground levels.

By 2006 these defences had deteriorated and were in need of improvement. In response the Ipswich Flood Defence Management Strategy was adopted.

The first stages of the 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 by about 1.5m.

The final major part of the strategy is to install the Barrier across the New Cut. The Environment Agency plan to start building the barrier in 2014, with the work expected to take two years to complete.

The barrier is a gate, which will normally not affect river levels. The gate would be raised at low tide, in advance of predicted surge tides >3.6m AOD.



It will be operated in a way to avoid increasing upstream river flood levels.

The strategy also proposes future repairs to the defences upstream of the barrier to keep them 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 the 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 local flood levy-funded scheme has recently been completed to raise the level of this defence to 4.4m AOD.

5.4.2 Wet Dock and Dock Sewer

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 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 drainage should flooding occur when the lock gates are closed. The level of the top of the lock gates is 3.1m 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, 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 helping to reduce flood levels and consequences.

5.4.3 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 largely undeveloped flood plain, with three properties known to be at risk of flooding.

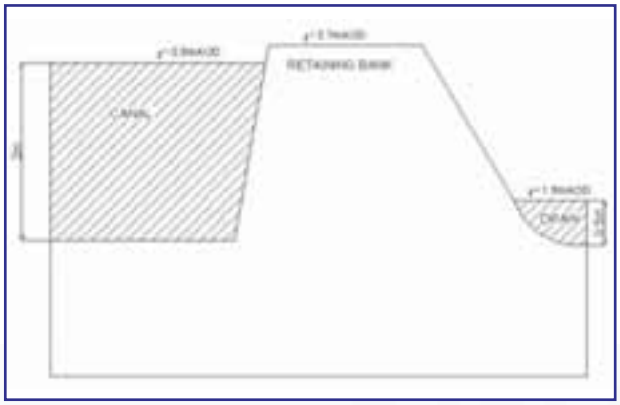
5.4.4 Alderman Canal

The Alderman Canal (ordinary watercourse & Local Nature Reserve) originally fed water mills at Alderman Road and Stoke Bridge, with flows from the River Gipping. In about 1880 the channel downstream of Alderman Road was filled in and replaced with part of the "Low Level Trunk Sewer". Apart from a small diameter penstock, river flows are now prevented from entering the canal by an embankment across the old channel. There is no known formal outlet.

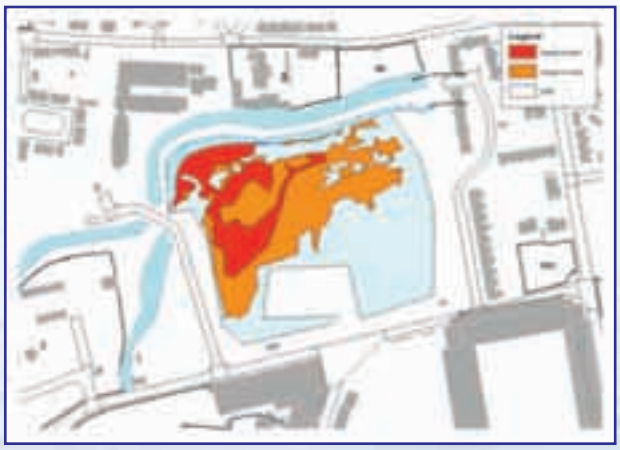
Water is retained at a high level by another earth embankment, with crest level 3.7m AOD, along the south side of the canal. Any leakage is intercepted by a counter ditch, which drains the low-lying meadows and playing fields back into the tidal Orwell via a culvert and surface water sewer at Constantine Road. The water level in the canal is normally the same as the River Gipping. However, during periods of flood risk the Environment Agency 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:



The extent of flooding that would result from a breach of the embankment was determined in the SFRA.



5.4.5 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 Road and just off Bucklesham Road. 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 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.

5.4.6 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.

5.4.7 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 Environment Agency 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 only one storm event. Effectively these highlight valley bottoms or hollows where flooding may occur.

A plan in Appendix 12.1 shows the areas susceptible to surface water flooding, overlaid on areas where historic local flooding, major flood paths and watercourses have been recorded by Ipswich Borough Council.

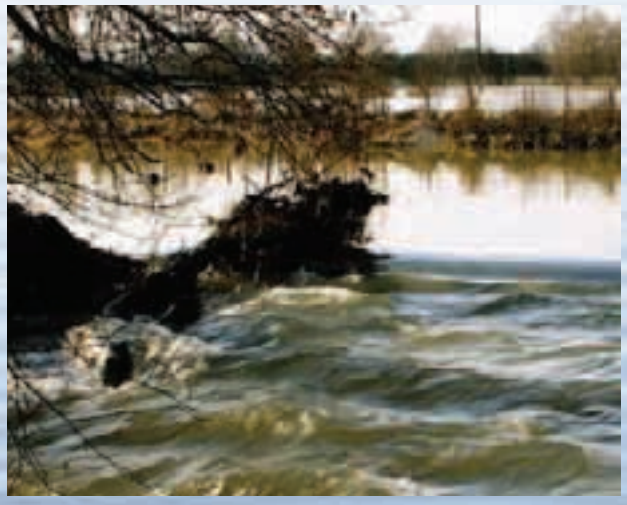
Away from the main valley of the Orwell and Gipping the ground rises steeply to a flattish, predominantly residential, area at about 30-40m AOD. Boulder clay (diamicton) caps the very highest areas to the north of Ipswich. Below this, sands and gravels overlay London Clay. Many of the minor watercourses 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 Appendix 12.2).

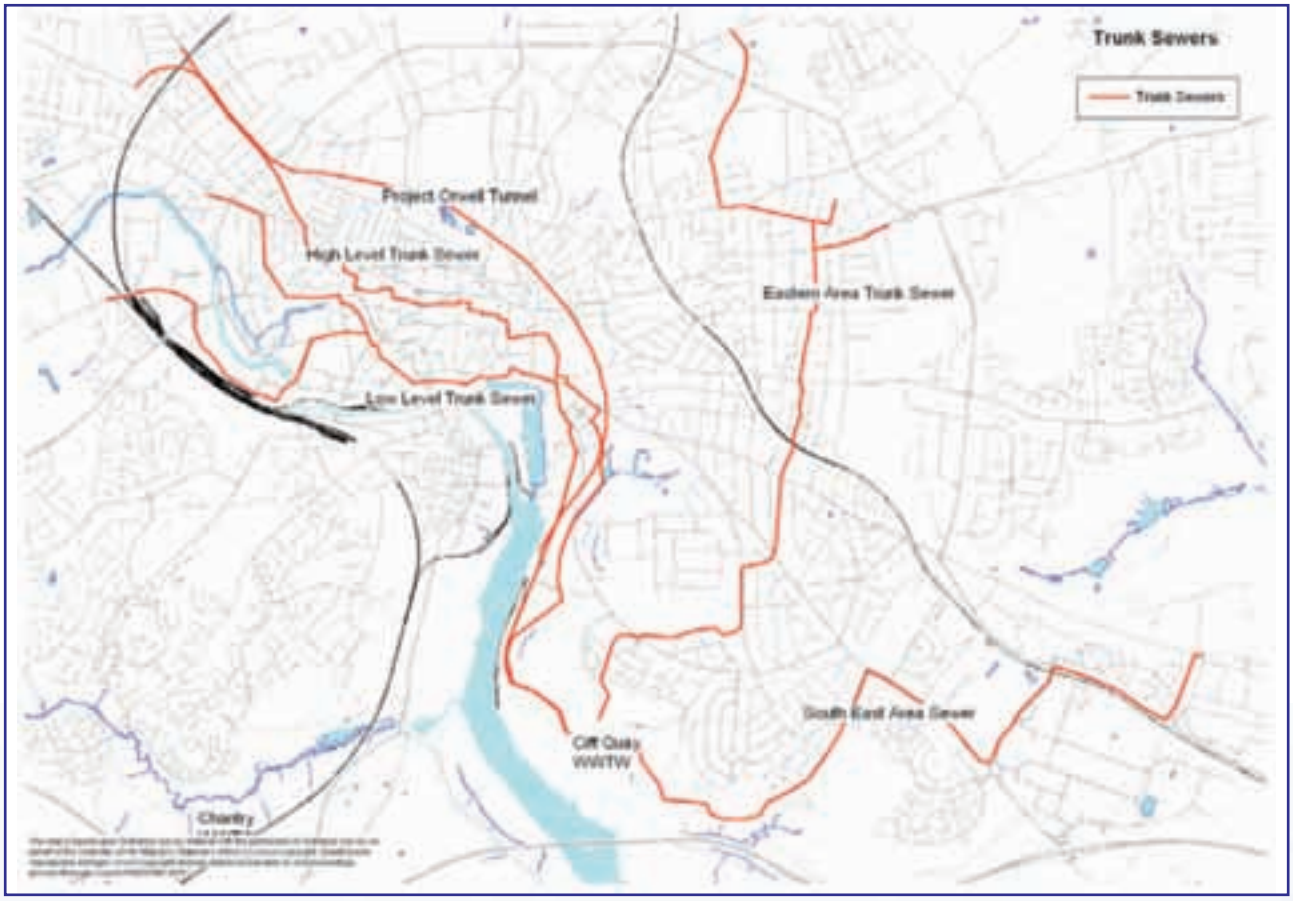
As Ipswich developed many of these watercourses were used for water supply or culverted where they flowed through streets towards the Orwell. Examples are in Northgate Street, Lower Brook Street, Spring Road and Upper Orwell Street.

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 Anglian Water storm overflow sewer into 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.

In several locations land drainage systems (intended to drain ground water using porous pipes) have been installed in valley bottoms 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 landward side and at intervals these outfall through the sheet piled walls with flaps intended to prevent reverse flow.





5.4.8 Sewerage system

Circa 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 North West and central Ipswich around the Wet Dock and to the Cliff Quay Waste Water Treatment Works.

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. Some of these areas also have 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 (600–1500mm diameter) constructed on a roughly parallel route to the north of the Low Level Sewer. This permitted development of the Crofts residential area to the northwest of Ipswich.

Later, flows from villages outside Ipswich at Blakenham, Bramford and Claydon were pumped into the system. Storm water overflow sewers, (from the trunk sewers to the river), were added to relieve flooding. Even so, both trunk sewers flood during severe weather, especially where they cross the tributary valleys. The water then flows over land 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 £33million 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 northwest and central Ipswich are finally 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 2.7m square flap valves at Stoke Bridge and two pairs of 2.4m diameter flaps at Toller Road.

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 northwest and central Ipswich is therefore complex.

Anglian Water (AW) uses "InfoWorks" computer models to enable them to understand the operation of the sewer network, and model possible improvement schemes in detail. Coverage of Anglian Water's models is shown on a map in section 7.1

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 has an unverified model of the surface water system.

5.5 Highway or railway drains

In a few areas of Ipswich, highway or railway drains discharge to watercourses. In the Dales Road area the railway, in cutting, drains rural runoff from fields east of Henley Road towards Norwich Road.

Highway or railway drains are unlikely to be shown on Anglian Water's sewer maps. Some have been mapped – see plan in Appendix 12.3.

5.6 Sustainable Drainage Systems (SuDS) and soakaways

As a result of policy changes during the last few years (PPG25, PPS25, the Ipswich Drainage and Flood Defence Policy and Building Regulations), SuDS, soakaways or attenuation systems have been increasingly used to reduce adverse impacts on watercourses and the sewerage network. Examples are at the Park and Ride and Anglia Parkway sites north of Bury Road and St Mary's Convent. Areas of the town served by such systems are recorded by Ipswich Borough Council. See plan in Appendix 12.3.

In parts of Ipswich, soakaways are used for surface water drainage. These are usually the property owners' responsibility. However some 82 soakaways, adopted by the Highway Authority, are known to exist and have been mapped, (see plan in Appendix 12.3) and others probably exist. During the past few years many of the older ones, installed 1950–1970, have been found to be totally inadequate and several have been replaced or enlarged.

Ravenswood, a 1200 home development currently under construction, uses landscaped infiltration basins (SuDS), flood paths 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. Anglian Water 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.

5.7 Overview of local sources of flood risk[1]

Ipswich Borough Council 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.

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.

Such flooding results mostly from surface runoff, overloading of piped systems, soakaways and ordinary watercourses (ditches, streams or valley bottoms) or ground water.

Local flooding occurs much more frequently than tidal or fluvial flooding, 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.

Records show homes have suffered internal flooding in 88 locations.

Basement and subway flooding has occurred.

Highways flood most often but the extent is difficult to define. Some roads become impassable regularly, for example Holywells Road and Ancaster Road.

In a few locations, manhole covers are blown off following heavy rainfall, sometimes along with road surfacing, and foul debris is deposited on streets. The open manholes represent a serious hazard to people, resulting in Councillors and MPs becoming involved and petitions being received.

Recent changes in property conveyance practises and insurance are believed to have resulted in under reporting of flooding.

Many factors can influence this type of flooding, such as whether manhole covers are stuck and blocking of grilles on outfalls or gully grates.

Ground water and springs affect 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, Worsley Close, Manchester Road and Rita Brook Road. These are mostly at the crag/clay interface (see geological map, Appendix 12.2) and associated with minor watercourses.

1. Note, this section was written in 2010 at the start of the SWMP process

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

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.

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

Traditionally pipes were typically designed to run full in a rainfall event with a return period of 1 to 2 years. Modern designs are generally for no flooding in a 30 year return period. Local flooding is inevitable in extreme events which exceed these design standards.

5.8 Overview of recent activities or projects

Anglian Water (AW) most recently completed sewerage flood relief schemes in Hadleigh Road and Larchcroft Road (2007). Further improvements are being considered at Meredith Road, Lovetofts Drive and Bridgwater Road and Ellenbrook Green. Such projects are normally triggered by flooding inside buildings, which occurs more often than twice in 10 years. However, in any circumstance projects need to be cost beneficial.

Highway drainage schemes were recently completed at Hadleigh Road, Bixley Road, Campbell Road, Birkfield Drive, Hawke Road and Whitton Church Lane.

A prioritised programme of outstanding highway drainage works is included in Appendix 12.5.

A highway maintenance operational plan specifies maintenance programmes. These include cleaning road gully pots and soakaways. Pots are routinely cleaned every nine months and soakaways annually, at present. Gully connection pipes and footway drains are maintained as and when complaints are received.

Grates are cleaned when Ipswich Borough Council Road Space sweeps roads. The frequency varies with location and time of year. More cleaning is required in areas with trees during the autumn. The drainage team has provided maps indicating high-risk areas where such road sweeping should be focussed (see Appendix 12.4). Recently advanced warnings from the new National Flood Forecasting Centre enabled pre-emptive cleaning of grates in certain areas.

Highway projects such as speed humps or raised 'tables' can divert surface water flows into properties. Resurfacing can raise carriageway levels causing similar but more widespread affects. On the other hand small changes in design may enable improvements to flood risk management. These could involve extra gullies, raised kerbs or lowered carriageway levels.

A map showing current highway and borough council community improvements programmed for implementation in 2010/2011 is included in Appendix 12.5.

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 £70 million Ipswich Flood Risk Management Strategy (FDMS) is the Environment Agency's 100-year plan for tidal and fluvial flood defences. This will benefit surface water drainage in the flood plain once the tidal barrier is installed – expected by 2016.

Ipswich Borough Council operates a Drainage and Flood defence Policy (13) that explains the borough's current flood risk management activities. These include development control in accordance with PPS25 and promotion of SuDS, following standards set in the policy. The Borough Council's policy was developed following widespread consultation and approved by the Council's Executive Committee in 2001.

Ipswich Borough Council's Strategic Flood Risk Assessment (SFRA) recommended risk associated

with minor watercourses is managed through various Local Development Framework policies:

- Known ordinary watercourses and major floodpaths have been mapped (no assessment of flows has been undertaken).
- It is the Council's intention (6) to inspect open watercourses from time to time and if necessary use its powers to ensure they are kept clear by their owners.
- Ipswich Borough Council's Drainage and Flood Defence policy (6) 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[2]. Their policy is that this is not normally permitted. Ideally they should be retained as open space, encouraging wildlife.

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

- *In the LDF Green Corridors should include watercourses sited in gardens or open spaces.*
- *The existing embankment which retains Holywells Canal adjacent to LDF sites 70 and 44 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.*

IBC's drainage engineering team currently resists any plans to raise paving levels around the Wet Dock.

Recently the Planning Inspectorate (Nov 2011) approved the Borough's Local Development Framework (LDF) (13). The Core Strategy and Policies Development Plan Document include policy DM4 which confirms the council will apply the PPS25 hierarchy[3]:

- Assess flood risk
- Avoid flooding
- Substitute
- Control – using SuDS and implement SWMP to manage flood risk.

Paragraphs 9.32 to 9.42 of DCM4 refer to the Strategic Flood Risk Assessment (SFRA), SWMP, the Ipswich drainage and flood defence policy, the future national SuDS standards and safety of developments in flood risk areas.

Where developments are affected by mapped flooding shown in the SFRA (the Environment Agency's areas susceptible to surface water flooding is currently included in the SFRA), a flood risk assessment is required even if the development is less than 1 hectare.

Other relevant controls relate to basements and raising of ground levels around the wet dock. Specific relevant extracts are provided in section 10.1 of this report.

5.9 Overview of future flooding

Factors likely to increase flooding include climate change and ongoing increases in impermeable areas which are typically due to house extensions and paving of gardens. Some of this increase may be controlled by the implementation of controls on paving of front gardens. Conversely flooding may locally decrease when major sewerage or drainage improvements are made.

There has been a growing trend to pave verges where they become damaged by parking vehicles. This can have a major effect on local

2. Since April 2012 the County Council has taken over responsibility for consents in ordinary watercourses. The Environment Agency retains responsibility for consents in main rivers

3. Now incorporated into the technical guidance associated with the National Planning Policy Framework

flooding, especially where large areas of front gardens have also been paved and soils are permeable.

The Borough Council's drainage and flood defence policy has set standards for SuDS since 2001 which generally mean new developments will not increase flood risk (for events with an AEP >1%). Thus there could be an increase in the severity of flooding for rarer, more severe events.

However, where soakaways are used for brown field sites, which previously drained surface water to the sewerage system, there should be a reduction in flood risk.

When the relevant section of the Flood and Water Management Act has come into force, the resulting National SuDS Standards (determining peak discharge rates and preferential use of use of infiltration type SuDS) are expected to be similar to those currently applied by Ipswich Borough Council. These National Standards are therefore likely to have a similar effect on local flood risk.

Increasing sea levels (resulting from both climate change and isostatic change) may 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 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.

The operation of the proposed tidal barrier at the New Cut will help mitigate this effect for sewers that out fall upstream of the barrier.

A further improvement would result if the barrier was raised at low tide in advance of expected pluvial events when predicted by the new Environment Agency/Met Office flood warning service.

However, the performance of sewers draining into estuary downstream of the barrier at Wherstead Road will reduce unless future improvements such as the addition of storage capacity are implemented.

Growth in population would increase foul flows and hence flood risk for combined systems but water efficiency measures and polices such as metering could reduce the trend for increasing water consumption and sewage production. With the growth in population forecast for Ipswich, the overall affect on flooding and pollution is likely to be neutral.

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

Retro-fitting of infiltration type drainage for existing development may increase the risk of ground water or minor watercourse flooding in some areas.

6 Preparation

6.1 Establishment of the partnership

The Suffolk Flood Risk Management Partnership (SFRMP) was set up in 2009. It comprises: Suffolk County Council, all district/borough councils, Internal Drainage Boards, Anglian Water, the Environment Agency, Suffolk Resilience Forum, Highways Agency and the Broads Authority. There is also a joint flood scrutiny panel comprising district and county councillors and supporting officers in the county.

A sub-group of the SFRMP comprising representatives from Suffolk County Council, Ipswich Borough Council, the Environment Agency, the East Suffolk IDB and Anglian Water was set up as a Project Board in December 2009 to oversee the management of the Ipswich SWMP.

The Board was managed by Jane Burch (Suffolk County Council's Flood and Coastal Policy Manager). Board members report to and represent their organisations. The Board oversees the SWMP work and reports to the full SFRMP and Scrutiny Panel. The SFRMP will continue to manage and monitor the plan once in place.

In September 2009, at Suffolk County Council's request, Ipswich Borough Council agreed to manage the production of the SWMP. Funds were provided by Defra.

6.2 Ipswich SWMP aims as agreed by the Project Board

1. To provide an improved understanding of the surface water flood risk in Ipswich.
2. To produce a detailed plan of action to manage surface water flood risk for high-risk areas, and a less detailed plan for remaining areas.
3. To develop practical experience and guidelines for undertaking SWMPs, for the benefit of other partners in Suffolk.
4. To implement some practical flood alleviation within existing budgets or using funding from external sources.
5. To provide information for use in spatial and emergency planning.
6. To replace/update Ipswich Borough Council's Drainage and Flood Defence Policy (in conjunction with National SuDS Standards).
7. To provide public information and advice on flood protection to improve customer service.
8. To seek solutions that help deliver the objectives of the Water Framework Directive.

Flooded garden in Ipswich

6.3 Information held by Ipswich Borough Council

	Format	Notes
Flood database pre 2000	Vp Info/ CSV	Carefully designed database
Flood database post 2000	Excel	
Indicative local flood map	MapInfo GIS tab	Polygons outline max recorded extent of floods, no indication of return period
Internal and external flooding points	MapInfo GIS tab	Produced for SWMP
Paper Files – flooding	Paper	6 lever arch files
Flood pictures	JPG	
Flood files	Word, excel, outlook files in folders	
Various Drainage plans	Tif	Scanned in 2007/8
Public sewer maps 1882, 1950's, 1992	Tif	Scanned in 2007/8
Locational Sewer survey data (sewer manhole cards)	Tif	Scanned in 2007/8
Sustainable Drainage Systems catchments	MapInfo GIS tab	
Sustainable Drainage Systems designs	Excel spreadsheets, paper files/plans/planning application drawings and calculations	
Soakage Test results	MapInfo GIS tab	IBC's tests and extracted from planning applications
Highway carrier drains	MapInfo GIS tab	Does not include gully connection pipes
Highway Gullies	MapInfo GIS tab (+ now visible using Google Earth)	Some critical gullies mapped
Planning application documents	Anite Database, and paper files	Will include drainage designs for larger developments
Highway Drainage schemes	Paper and electronic files	
AW's sewer map 2009	MapInfo GIS tab	IBC internal Intranet/GIS
AW water mains 2009		

	Format	Notes
Gas, electricity		
Priority Area Assessment and collated historic flood data	Excel work book	
Guidance on SWMPs		

6.4 Data and information available from other partner organisations

Anglian Water supplied public sewer records and outputs from their hydraulic models.

6.5 National data

LiDAR and ASTWF from the Environment Agency.

During the process of developing the SWMP the Environment Agency published its Flood Map for Surface Water (FMfSW). This was only used for comparison purposes. It is recommended that this data is the starting point for future SWMPs.

6.6 Public information

Anglian Water public sewer map.

Ipswich Borough Council indicative watercourse flood map.

Ipswich Borough Council Strategic Flood Risk Assessment, level 2.

Suffolk County Council's Preliminary Flood Risk Assessment was prepared during the course of developing the SWMP – informed by the Phase 1 SWMP report.

The Suffolk Local Flood Risk Management Strategy was in production during the later part of the SWMP process.

6.7 Systems for storing and sharing flood risk data, maps and information

Collated flood record extracts and data relating to priority assessment is contained in an Excel workbook.

During the course of the study a web based SharePoint was set up on the Borough Council's server to aid data transfer between partners.

6.8 Quality assurance, security and licensing

Ipswich Borough Council's engineering team has achieved accreditation to ISO 9001:2008 and passed the surveillance audit for ISO 14001:2004.

Data provided by Anglian Water is subject to a Licence Agreement.

Spot checks using audit trails have been undertaken on collated flood data – see the workbook.

6.9 Preliminary assessment of flooding across Ipswich[4]

6.9.1 Historic tidal and fluvial flooding

Tidal and fluvial flooding is relevant since high river levels can aggravate operation of surface water systems. Minor flooding may occur from the drainage systems when tidal flaps leak in dry weather when the tide exceeds ground level.

4. This section was written in 2012 to inform the Suffolk Preliminary Flood Risk Assessment.

Rarely will flash flooding occur at the same time as tidal/fluvial flooding. Research has shown there is little or no correlation between fluvial flows and surge tides for East Anglia. The Ipswich Tidal Barrier Report April 2009 addresses this issue.

The most recent serious tidal flood was in 1953. A plan in Appendix 12.7, copied from Ipswich Borough Council's contemporary paper record, shows the extent mapped against 1950's background Ordnance Survey plans.

The level 2 Strategic Flood Risk Assessment describes and maps the extent of tidal flooding for various tide levels and defence failure scenarios.

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.

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

1939 Floodwater in Princes Street

It appears that during these events, floodwater followed the original path of the River Gipping (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 Appendices 12.8 and 12.9.

6.9.2 Historic pluvial or local 'flash' flooding

The extent of known local flooding has been mapped by Ipswich Borough Council – see Appendix 12.12.

Flooding is only shown where repeated complaints are received that does not appear to be due to blocked road gullies. The map shows 88 locations, the extents 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.

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

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.

Ipswich Borough Council has 3,150 detailed records of flooding incidents, including one from the 1950s. Older records include paper plans. 692 photographs and some videos also provide valuable evidence. All relevant records are now in Excel and GIS format. Records are kept whenever flooding is reported (small puddles due to blocked highway gullies are not included).

Some records have been added following onsite, post-flooding investigations. These often include door knocking or fire service records of attendance

at flooding incidents as well as media coverage and questionnaires. These show flooding is often not reported and people seem to move house more often in flood risk areas.

The database structure was carefully planned and developed back in 1988. An incident is defined as one property flooding in one event. Thus two properties flooding in one event would count as two incidents. Similarly one property flooding in two events would be two incidents.

A distinction is made between internal and external flooding. Internal flooding is likely to cause damage, external flooding is usually a temporary inconvenience but it can lead to anxiety and, especially if foul sewage is present, health risk. Past work provides some evidence of a spatial link between deprivation and flooding.

As part of the SWMP process these records have been extracted and copied to an Excel workbook – see Appendix 12.11. Incidents due to foul drainage blockages have been removed and records sorted by drainage area.

The workbook shows where recent flood relief projects are believed to have reduced flood risk and denote which records were removed to account for this. It is important to note that past flood relief will not stop flooding, just reduce the frequency. Typically newer projects are designed to reduce flooding to 1–10% annual exceedance probability (AEP).

Anglian Water supplied records of flooding that do not include full addresses (due to confidentiality). A few records have been included as shown on the worksheet.

A GIS map showing the location of the final historic internal and external incidents is included in the appendices. The plan also shows locations where manhole covers are known to blow during heavy rain.

The final workbook shows relevant historic flooding at about 500 different addresses.

No attempt has been made to allocate return periods (frequency) to the flooding data.

The most severe events tend to be localised. That is heavy rain most often affects only small areas, and the intensity of moving storm cells does not remain constant as these build and collapse.

Rainfall records needed to assign return periods would have to be based on a network of gauges that record intensity every minute or so. Weather radar makes such analysis a possibility but is not realistic at present.

Sewer model verification typically involves the use of perhaps 10 rain gauges being set up for a period of several months. These are very unlikely to catch a severe event.

6.9.3 Historic flooding of critical infrastructure

There are no records of flooding affecting critical infrastructure.

6.9.4 Historic groundwater flooding

The council has recorded locations where complaints have been received about local flooding, watercourses, areas susceptible to surface water flooding and groundwater flooding map in Appendix 12.12.

6.9.5 Future flood risk

Areas susceptible to surface water flooding maps are a useful guide to where extreme or future flooding might occur and highlight natural drainage paths.

These maps ignore the presence of underground drainage altogether. Secondly, it relates to only one rainfall event – a 0.5% AEP (annual exceedance probability) of 6.5 hour duration. Shorter or longer duration storms may cause more or less flooding at different locations.

During the course of the development of the SWMP the EA published its Flood Map for Surface Water. This takes account of the effect of buildings and makes an allowance for underground drainage systems. These were not used for the SWMP development but are compared with SWMP flood maps.

Ipswich Borough Council's indicative local flood maps show a much smaller extent of flooding than the areas susceptible to surface water flooding

mapping. This is to be expected due to the severity of the event modelled – an event unlikely during the past 30 years, and also because of some of the assumptions the current (2009) mapping makes.

In an urban situation such as Ipswich, where there is a well developed, large capacity underground system, it is likely there will generally be much less flooding than shown on the areas susceptible to surface water flooding maps.

To assess extreme flooding, GIS was used to highlight Ordnance Survey address points within 'intermediate risk' areas susceptible to surface water flooding. These are mapped and shown on the plan along side historic flooding.

4,429 address point where found to be within the intermediate mapping.

8,857 address points lie within 'less susceptible risk' areas on the areas susceptible to surface water flooding map. Most of these would be protected by thresholds /floor levels being above ground level (depth of water for less is >100mm).

Bearing in mind the above factors and the belief that flooding is under reported, the conclusion is that the actual number of addresses likely to be "at risk" in severe events was estimated at between 500 and 5,000.

Note: these figures are superseded by estimates in section 7.5

Future flooding of critical infrstructure

At present Ipswich Borough Council has no records of flooding affecting the operation of electricity sub stations, hospitals, fire stations or emergency rest-centres however 29 were found to be within the ASTSWF.

Future developement

Locations and areas for planned future development are from the March 2010 Local Development Framework (LDF) submissions stage. Surface water from these is likely to be drained SuDS and so development is unlikely to affect downstream flooding.

However, where new developments are within ASTWF, there is a risk that new buildings could be flooded by floodwater originating off the site.

Based on LDF proposals there could be 35 Ha of development site within intermediate ASTWF areas. Assuming a density of 30 Units/Ha this would mean that there could be up to an additional 1050 addresses at risk.

At present Ipswich Borough Council plans to manage this flood risk issue following the principles in PPS25: where a development site is within an ASTSWF, the developer should be required to produce a flood risk assessment (FRA), which may involve using SWMP output if it exists. Alternatively the developer might be required to undertake detailed modelling which could be used to update the SWMP.

Climate change is expected to increase risks. PPS25 provides guidance (summarised in the Strategic Flood Risk Assessment) on allowances to be made when planning developments in flood risk areas. Sea levels are predicted to rise about 1m over the next 100 years and peak rainfall intensities increase by 30%.

6.9.6 Results of preliminary Ipswich-wide assessment

Historic records indicate circa 500 properties are at risk. ASTWF show 4429 at intermediate risk.

Between 500 and 4,400 properties may be at risk of surface water flooding in severe events.

Note: these estimates are superseded by figures in section 7.5

Unless controls are maintained circa say 1,000 additional properties in 35 Ha of planned development may become at risk.

Flooding from blown manholes is known at 12 locations.

More detailed flood risk assessment was proposed as follows:

6.10 Identification of level of assessment

To ensure major elements of the SWMP action plan are cost effective it is necessary to firstly estimate the costs of damage caused by flooding in a 'do nothing' scenario. Damage costs are defined by a graph, gradually increasing as the severity of rainfall and flooding increases.

The effectiveness of a particular flood risk management option or group of options is then assessed by determining the frequency and depths of flooding with flood risk management measures and re-calculating damage costs. The benefit – cost ratio is the ratio of the damage cost prevented by the option divided by the cost of implementing that option.

Revenue (maintenance) options can be included if the approach considers expenditure and damage over a long time period, by using NPVs (Net Present Values).

For a flood risk management measure to be included in the action plan it will need to have a benefit-cost ratio great than 1. Flood risk management measures may be refined improving the benefit-cost ratio by considering different standards of protection (varying the design frequency of flooding). There are currently no fixed flooding standards for SWMPs.

Historic records of flooding cannot be used for damage costs estimation, as there is insufficient data to establish storm frequency and they will not take into account climate change or other factors, and the effectiveness of flood risk management options will not be known.

It is therefore necessary to use appropriate modelling techniques to establish flood depths, frequencies and extents and then damage costs.

Because modelling and associated survey work is resource intensive and resources limited, it was necessary to focus detailed assessments in certain priority areas.

In some other SWMPs, priority areas for further assessment have been decided simply by inspection of maps showing where flooding has been recorded. However for Ipswich, the large number of records makes it difficult to decide on that basis.

6.11 Prioritisation of areas for detailed assessment

An Excel workbook was developed which also provides a framework for future use. The workbook should be seen as an aid to make the final decisions on priorities for further assessments. The results of the subsequent detailed assessments enable a more accurate prioritisation of drainage areas based on flood risk.

The process aims to:

- Focus detailed assessment in areas where it is most cost effective – i.e. where flood risks are greatest, costs of the study are lowest and potential benefits are highest.
- Start detailed work on a relatively simple and small area not requiring sewer model data.
- Develop a methodology which may be used across Suffolk

The Ipswich area was divided into 34 catchments (drainage areas) based on topography / watercourses. Flood risks, assessment methodology and hence study costs are different in each area.

Criteria, which broadly and simply describe flood risk, have been identified and are described below. These are effectively the drivers for more detailed future assessment.

Within each drainage area, each driver is scored and assessment costs estimated. Scores allocated to each driver are adjusted by the use of weightings applied consistently across all areas to allow for the varying significance of the crtieria/driver. A high degree of judgement was necessary and reached after discussion amongst Board members. Some of the reasoning behind the weightings used is discussed below.

The variation in costs of detailed assessment is likely to broadly reflect the variation in costs of flood risk management. This is because both are expected to depend to a large extent on the size of the area

within which most of the flooding occurs and which needs to be modelled to determine the flood risk management measures and damage costs.

Final scores and priorities are based on the ratio of drivers to cost of the detailed assessment.

6.11.1 Criteria for describing flood risk – drivers

A wide range of criteria has been carefully chosen to cover the range of risks and consequences experienced in Ipswich. A simpler approach was considered at first however this resulted in some inconsistent priorities. The method suits the data readily available for Ipswich.

Data availability will influence how priorities can be assessed in the future across Suffolk, however the workbook can be easily adapted by changing the weightings. For example if long-term historic flood records do not exist in all drainage areas then weightings for historic data would need to be reduced and weightings for the number of addresses in areas suceptible to surface water flooding increased.

As SWMP work progresses and data sharing is established, priorities might be reconsidered, perhaps using predicted flood volumes from the sewerage model or using the Environment Agency's more recent flood map for surface water rather than the areas suceptible to surface water flooding map.

The workbook includes:

- Number of addresses within areas suceptible to surface water flooding.
- Future development site area.
- Number of critical infrastructure installations within areas suceptible to surface water flooding.
- Historic highway flooding (not blocked gullies).
- Historic property flooding incidents – internal.
- Historic property flooding incidents – external (gardens).
- Whether foul sewage debris is deposited in gardens or in streets.
- Consequences (varies from inconvenience to building/contents damaged/cars damaged/ road traffic accidents).

Cost of assessment depends on:

- Area to be surveyed or modelled.
- Degree of interaction between tidal, fluvial, sewerage, highway drainage, SuDS.
- Assessment method.

6.11.2 Data details and weightings

Number of addresses within areas susceptible to surface water flooding areas – The number of addresses within the areas suceptible to surface water flooding map was the basis of Defra funding allocation and is useful where there are no historic records or where there has been no recent major rainfall.

There is more certainty attached to historic records than to addresses in areas suceptible to surface water flooding. Taking the above issues into account a much higher weighting is applied to historic flooding as described below (about 10 times higher).

The scoring/weighting applied means this driver accounts for 3% of the total driver score. Including this criterion may allow, to some extent, for climate change.

In areas outside Ipswich, where there is no underground drainage, the weighting for addresses in areas suceptible to surface water flooding could be increased, as this becomes a more accurate indicator.

Areas of future development sites – Locations and areas are from the March 2010 Local Development Framework (LDF) submissions stage. These will be served by SuDS and are unlikely to affect downstream flooding. However, where new developments are within areas susceptible to surface water flooding there is a risk that new buildings could be flooded by floodwater originating off the site. For this reason only sites within areas susceptible to surface water flooding are viewed as drivers.

The weighting used means this driver accounts for 3% of the total driver score.

Number of critical infrastructure installations – At present the council has no records of flooding affecting operation of these sites so a low weighting has been applied. The weighting used means this driver accounts for 3%.

If historic records had indicated large numbers of properties were affected by flood induced failure of critical infrastructure then the weighting would have been increased.

Historic highway flooding – the Borough Council's GIS maps show areas commonly affected but do not show flood depths. For the last few years at least £100,000 per annum has been spent alleviating highway flooding to varying standards. A simple approach is used based on local knowledge, supported by records where a score of 1-3 is applied depending on whether any roads suffer minor flooding (score 1) or are impassable or damaged (score 3). The weighting used means this driver accounts for 6% of the total driver score.

Historic property flooding incidents – Data processing is described in 6.9.2

Data from the first sheet of the workbook (see appendix 12.13) automatically fills the appropriate cells of the second sheet – the priority scoring sheet.

Scores for external flooding account for 22% of the total driver score and scores for internal flooding account for 43%.

In areas outside Ipswich, where there is no underground drainage, the weighting for addresses in areas susceptible to surface water flooding could be increased, as this becomes a more accurate indicator.

Foul sewage debris deposited – Much of the Ipswich sewerage system is combined i.e. it carries both foul sewage and surface water. In some locations floodwater deposits sewage debris in gardens, on verges, and on roads. This causes much distress and complaint and a potential health hazard. Flood records indicate whether foul sewage is involved. However the scores express our experience of complaints and how much debris is left. Score 0 for no sewage, 1 for little visible sign and 3 for large amounts of sludge or obvious sewage items.

Scores for foul sewage debris deposited account for 8% of the total driver score.

Consequences – This was added to take account of any potentially very damaging floods – i.e. deep water and areas where high damage costs are possible. An example is Coltsfoot Road where furniture and carpets are ruined every few years, or Portman Road where the football pitch is thought to be at risk. Score 1 for low consequences and 3 for high.

Scores for this criterion account for 9% of the total driver score.

The following factors affect the cost of undertaking detailed assessments.

Area to be surveyed and/or modelled – This is assumed to be the major influence on cost of the study. A GIS map has been developed which assumes the area to be surveyed and modelled is the intermediate ASTWF and ignores areas remote from known flooding locations. The area to be modelled in each drainage area was multiplied by £2,000 to give a comparative cost of surveying and building models.

In one location (Lovetofts Drive) a 2-dimensional model was thought to exist and the costs of building this has been manually overridden. In another, (Chantry park) a simple ISIS or Infoworks model could be used, and again costs have been reduced manually.

No account has been made here for running the models, as a similar set of simulations is required for each drainage area.

Across the 34 drainage areas the estimated modelling and surveying costs range from £2,000 to £128,000. These figures were subsequently adjusted as described below:

Degree of interaction between tidal, fluvial, sewerage, highway drainage, SuDS and ease of assessment of potential flood risk management measures – High water levels in rivers or ordinary water courses coincident with heavy rainfall may cause temporary backing up

along drainage systems increasing flooding. Sewers may surcharge with similar affects on highway drainage. SuDS may overflow and add flows to downstream drainage systems. Conversely some flooding may relate to inadequate highway drainage.

Where such interactions occur there will be additional modelling work required and costs are increased by a varying percentage up to 30%.

At the initial stage there was a high degree of uncertainty in modelling costs and sewerage system model availability. Models can sometimes be sensitive to small changes in input data resulting in instabilities and errors that can be time consuming to resolve.

Across the 34 drainage areas the final estimated modelling and surveying costs ranged from £2,066 to £150,000. These costs are for comparison only and should not be used for budget purposes.

Costs and benefits of flood risk management measures – Cost benefit ratios guide the final priorities of flood risk management measures. However, these require information that can only be gained by modelling. Even so, the idea of incorporating cost benefit ratios at this stage of the priority assessment has been considered:

Back in 2003 Ipswich Borough Council produced some "heroic" cost estimates for alleviating or providing temporary emergency flood protection for the known historic flooding locations shown on the indicative local flood map. These flood areas are much smaller than the areas susceptible to surface water flooding. The estimates were based on judgement alone and did not account for additional properties that may be at risk in the future or a pre set standard of performance.

Typically the cost for alleviating flooding in one area was £1 million, whereas the cost of providing temporary flood barriers was only a few £1,000s. Each option would provide a very different standard of protection.

The exercise illustrated the magnitude of total cost needed to substantially reduce flooding by traditional methods, circa £24 million, and explained that some of the long standing problems remained because only a few properties had been positively identified to benefit from a traditional flood relief solution. This is typical of a risk-based approach to flood risk management.

Anglian Water's flood relief projects are typically justified if it costs less than £100,000 to alleviate internal flooding that has occurred at least twice in 10 years.

No further attempt at cost benefit analysis was made.

Thus there are a very wide range of flood risk management costs and standards of performance and insufficient data on flood frequency and damage costs.

The idea of assuming damage costs of say £30,000 per historic internal flooding incident was considered, however without flood frequency information before and after flood relief, the benefits could not be estimated.

The final worksheet is included in appendix 12.13.

6.11.3 Use for other SWMPS

The table below shows the final priorities and how this varies depending on availability of historic data and weightings applied.

The workbook has been tested for use where there is little or no historic flood data by setting appropriate weightings to zero to simulate the following scenarios:

1. no records for internal or external historic flooding.
2. no records for any historic flooding
3. no records for any historic flooding but the weightings for number of addresses in areas suceptible to surface water flooding set at 50%; critical infrastructure in areas suceptible to surface water flooding set at 33% and future development in areas suceptible to surface water flooding set at 17%

The scoring system and resulting prioities were agreed by the Board members in July 2010.

6.12 Priority areas for detailed assessment

The table below shows the resulting priorities from the workbook. The top 10 have been reconsidered and adjusted to bring forward priority areas where:

- modelling is largely independent of data from Anglian Water.
- a simple approach could be taken.
- a large amount of appraisal work has already been undertaken.
- it was considered likely that real improvements could be implemented.

The scoring system and resulting prioities were agreed by the board members in July 2010.

6.13 Brief description of top 10 drainage areas for detailed assessment

1. **London Road to Lavenham Road and Hadleigh Road:** Runoff from the dual carriageway drains to SuDS in Chantry Park, which can overflow across the park into a pond and watercourse which drains into the sewerage system. The likely solution here is cheap and probably achievable within 12 months, and will reduce peak flows into the sewerage system. The risk of the sewer backing up will need to be considered. The watercourse, in a strip of land of unknown ownership, needs maintenance. Records indicate flooding has been reported twice.

	Priority				
Flood path or Drainage Area	Based on driver score only	Based on driver score /assessment cost ratio	Final suggested priorities	Indicative assessment costs	Cumulative
London Rd to Lavenham Rd & Hadleigh Rd	19	4	1	£ 2,067	£ 2,067
Ancaster Rd / Burrel Rd	9	1	2	£ 3,547	£ 5,613
Lovetofts Dr / Lagonda Way	12	2	3	£ 2,333	£ 7,947
Worsely Close / Ellenbrook Green	5	8	4	£ 16,333	£ 24,280
Swinburne Rd to Bramford Lane	1	3	5	£ 10,320	£ 34,600
Coltsfoot / London Rd / Campion Rd	7	5	6	£ 10,360	£ 44,960
Portman Rd	3	6	7	£ 13,000	£ 57,960
Maidenhall Approach / Rapier Str / Belstead Avenue / Wherstead Rd	2	7	8	£ 14,868	£ 72,828
Chesterton Close / St Catherines Court	15	9	9	£ 7,200	£ 80,028
Belstead Rd / Lanercost Way	16	10	10	£ 10,080	£ 90,108
Fircroft & Henley Road to Dales Road	10	11	11	£ 26,400	
Christchurch Park to Lower Brook Street	11	12	12	£ 27,200	
Westerfield Rd / Tuddenham Av & Old Cemeteries	6	13	13	£ 42,000	
Heath Rd	24	14	14	£ 5,667	
Ramsay Close	25	15	15	£ 6,240	
Burnham Close via Spring Rd to Fore Street	13	16	16	£ 33,600	
Alan Rd / Duke Str	14	17	17	£ 31,200	
Valley Rd / Bramford Ln / Beconsfield Rd / Gatacre Rd	4	18	18	£ 105,000	
Yarmouth Road West End Rd island	27	19	19	£ 3,500	
Pinewood	22	20	20	£ 17,733	
Woodbridge Road to Bixley Rd and Mill river	8	21	21	£ 98,000	
Clapgate lane to Landseer Road	23	22	22	£ 21,485	
Campbell Rd Ransomes Way	21	23	23	£ 38,400	
Nacton Rd / Holywells Park / Holywells Rd / Cliff Ln / Oulton Rd	18	24	24	£ 55,733	
Sproughton Road	20	25	25	£ 56,000	
Whitton Church Lane / Thurleston Lane	28	26	26	£ 11,660	
Henley Rd North / Thurleston Lane East	30	27	27	£ 6,160	
Humber Doucy Lane / Rushmere Rd / Woodbridge Rd	17	28	28	£ 149,333	
Humber Doucy Lane / Westerfield Rd	26	29	29	£ 57,600	
Westerfield Rd	31	30	30	£ 7,700	
Henley Rd to Westerfield	29	31	31	£ 17,600	
Thurleston Lane West	32	32	32	£ 5,280	
Braziers Wood	33	33	33	£ 14,000	
Sandy Hill lane	34	34	34	£ 41,800	

2. **Ancaster Road/Burrell Road:** The most recent events affected a small, very low area of highway which floods from surface water and combined sewerage systems and runoff from an unadopted road. Floodwater overflows into a low-level car park under a new residential block. The likely solution is a new surface water sewer to adjacent river. The SWMP could influence planning of new buildings or the surfacing of unadopted road. There is an interaction between surface and tidal waters. Anglian Water has a model of underground systems but not the surface water drainage serving Burrell Road. There are many flood records for Burrell Road, but none since 1988. The reasons for this is unknown and residents/owners may need to be contacted to verify if any solution has been implemented.
3. **Lovetofts Drive to Lagonda Drive:** Flooding from the combined sewerage system since at least 1977. Anglian Water had a premlimary 2-d model. Recent development close by is nominally designed to allow floodwater through. A range of partial relief measures are possible. However, since at least 1987 an Anglian Water project has not been cost beneficial. A petition from residents to the MP was received in respect of flooding here.
4. **Worsley Close/Ellenbrook Green:** Surface water flooding. Anglian Water has a model of the local underground surface water sewerage system and has supplied some flood predictions and undertaken a recent appraisal. Ipswich Borough Council has conducted a door-to-door survey. The local residents' group submitted a petition about the flooding issue. There are several possible flood alleviation measures.
5. **Swinburne Road to Bramford Lane:** Combined sewer flooding since at least 1956. It requires water company investment but has lacked priority. Both the Borough Council and Anglian Water have attended residents' group meetings
6. **Coltsfoot / London Road / Campion Road:** Surface water sewer flooding since 1960s. Anglian Water has a model of the system there.
7. **Portman Road area:** Recent shallow flooding with combined sewage has affected the highway, part of the Ipswich Football club and two garages. This area is very low lying and is crossed by the low level trunk sewer. The area is served by surface water sewers, which drain via non-return valves into the tidal River Orwell. The lowest parts are parkland and these drain to a minor watercourse. A simple LiDAR-based 'InfoWorks' ground model has been built by Ipswich Borough Council to look at drain-down times for tidal or fluvial floodwater as part of the Strategic Flood Risk Assessment.
8. **Maidenhall Approach / Rapier Street / Belstead Avenue / Wherstead Road:** Combined sewer flooding since at least the 1960s. Lacked priority for Anglian Water investment.
9. **Chesterton Close / St Catherine's Court:** Surface water flooding. Anglian Water believes this is not due to sewer flooding. Availability of models unknown. Some simple flood risk management measures have been identified.
10. **Belstead Road / Lanercost Way:** Flooding here seems to relate to surcharging of the surface water sewer resulting in occasional internal flooding. More usually affects the roads and gardens. Sporadic reports indicate flooding of highway has occurred 3 times since 2000. Blockage of outfall grille or flap may be a contributory factor. Unlikely that Anglian Water has a model of this system which drains to Belstead Brook.

6.14 Planning the detailed assessment

Planning carried out between July and October 2010 included a series of technical meetings between Ipswich Borough Council's drainage team, Anglian Water and their consultant, Clear Environmental.

The general methodology was approved by the Project Board on 1 October 2010.

Estimates indicated there was likely to be sufficient resource available to undertake detailed assessments for the top 4 priority areas:

1. London Road to Lavenham Road and Hadleigh Road
2. Ancaster Road / Burrell Road
3. Lovetofts Drive to Lagonda Drive
4. Worsley Close / Ellenbrook Green

Anglian Water confirmed that they agreed with the top ten drainage areas prioritised for detailed assessment. These are mainly areas where the water company is already aware of flooding and their existing hydraulic models are largely suitable for looking at local flood relief.

However, Anglian Water did not have a model of the London Road to Lavenham Road and Hadleigh Road system. It was agreed Ipswich Borough Council would develop a model for this area.

Anglian Water agreed to fund and undertake work for areas 2, 3 and 4 above. Model development would include the addition of 2-d meshes and the inclusion of features that did not belong to Anglian Water (e.g. major SuDS, watercourses, ponds and highway drainage networks) where these influence flooding.

Consideration was given to the management of data. Data for modelling features such as SuDS was available from a variety of records held by Ipswich Borough Council. These could either have been supplied directly to Anglian Water or supplied as 'mini models', which might also double as working records.

The Floods and Water Management Act requires significant assets to be recorded. There will be an increasing amount of non-water company drainage assets such as SuDS which need to be recorded and included in models.

In addition, the SWMP aims included delivering Suffolk wide benefits and learning.

The decision was therefore made to obtain InfoWorks ICM (integrated catchment management) to model and record the assets for the London Road to Lavenham Road and Hadleigh Road system. Both the hardware and software sit within Ipswich Borough Council but are the property of Suffolk County Council and will also be available for future use across the Suffolk Flood Risk Management Partnership.

Resulting model data could be included in Anglian Water's models simply by 'copying/pasting'. Similarly Anglian Water's assets could be included in the InfoWorks model if necessary.

Anglian Water's consultant, Clear Environmental developed the models used. Clear Environmental were thus involved in the subsequent development of the SWMP methodology.

Clear Environmental were expected to obtain much of the detailed information needed for the 2-d mesh generation from Google maps and visual studies to establish locations of dropped kerbs, garden walls or fences.

Site surveys were planned to determine floor levels of buildings and road gulley locations. Ipswich Borough Council was to arrange surveys and supply data direct to Clear Environmental.

Site surveys to determine precise floor levels above Ordnance Datum were subsequently found to be unnecessary. See 8.7.1

Once models had been completed and verified against historic records the consultants would undertake flood mapping for a range of storm return periods and durations either side of the critical duration.

The output mapping would include flood levels/depths to enable flood damage costs to be estimated for each property affected.

It was decided to follow the Defra guidance and undertake simulations for the 100, 50, 30, 10, 5, 2 and 1 year rainfall return periods.

Damage costs would be estimated using the flood mapping results including ground levels, depths and water levels in the form of GIS tab files.

Initially, modelling results were needed for existing and future 'do nothing' scenarios, where future scenarios include allowances for growth, climate change and urban creep expected over the next 30 years.

Flood mapping and damage costs would be presented to project partners to decide on which possible flood risk management measures would be modelled in detail.

Chosen options would be modelled and benefit cost options assessed for all priority areas.

For each option there was no pre-set design standard in terms of acceptable flood frequency. Standards would inevitably vary from property to property. Modelling would test how well each option performed. For some options further refinement of designs would be needed (post SWMP) in order to optimise the benefit to cost ratio.

As there would be a lot of data sharing/transfer a SharePoint site was proposed and set up. This would help members of SWMP team to share controlled information and large files.

6.15 Communication and engagement plan

Engagement of stakeholders and partners was planned. A formal engagement plan was approved by the Board on 21 July 2010. The plan, included in Appendix 12.14, is closely linked to the approach proposed above.

It is a self-contained document summarising the SWMP process, key messages and details planned stakeholder engagement including a project programme and planned meeting schedule.

The plan proposed:

- 5 board meetings.
- 3 less formal Ipswich Borough Council, stakeholder and Anglian Water team meetings.
- Letter drop and door knocking.
- A public exhibition/drop in session. This would be similar in format to those organised for the Environment Agency's Ipswich Flood Defence Project and Anglian Water's 'Project Orwell'.
- County and Borough Councillor involvement would initially be by email and briefings to the Portfolio Holders.

Correspondence with the stakeholders was added to this document as the SWMP progressed along with general updates.

7 Risk Assessment

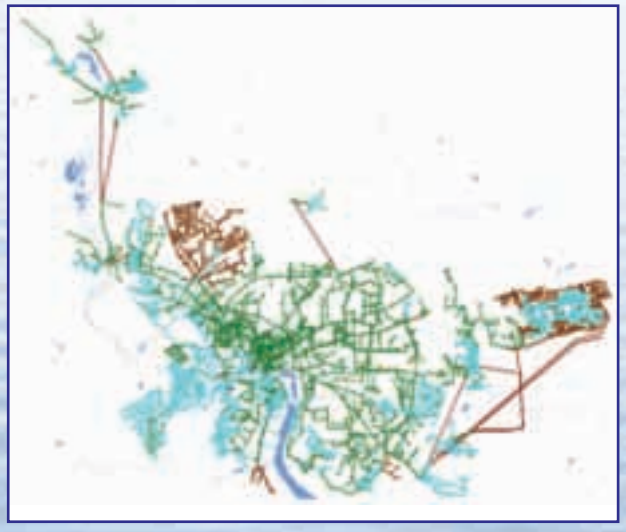
Anglian Water's consultant, Clear Environmental, undertook detailed 2-d modelling using InfoWorks CS for priority areas at Ancaster Road / Burrell Road, Lovetofts Drive to Lagonda Drive and Worsley Close / Ellenbrook Green.

Ipswich Borough Council used InfoWorks ICM to create a 2-d model for the London Road to Lavenham Road and Hadleigh Road catchment.

7.1 Detailed assessment by Anglian Water

Anglian Water's existing verified model of the combined sewage system draining to Cliff Quay Sewage Treatment Works was used for the Ancaster Road / Burrell Road and Lovetofts sub-catchments. This model is large, extending as far as Great Blakenham and Martlesham and inlcudes many advanced features such as real time control. It can make allowances for tidal and fluvial interactions. (The model was originally developed between 1986 and 2000).

A second much smaller un-verified model of the undergound surface water sewerage systems in the Bridgewater Road and Coltsfoot Road areas was used for the Worsley Close / Ellenbrook Green priority area. This model had been previously developed by Anglian Water to look at flooding issues but had no 2-d mesh.



Anglian Water's Sewerage models

Between September and October 2010 Clear Environmental were engaged on updating and improving the models, and adding the 2-d mesh. The updates and improvements were in part for the water company's own purposes. That is an assessment of development plans and general model updating. Addition of the 2-d mesh was solely for the purposes of the SWMP.

Ipswich Borough Council supplied the following information to Anglian Water and their consultant:

- Plans showing the probable extent of 2-d mesh required – i.e. the area where overland flows had been observed or was expected based on local knowledge and experience.
- Various historic plans showing SuDS and highway drains.
- Flood records / prioritisation spreadsheet.
- Rainfall records for a flood event in 1998.
- Estimated land drainage flows.

The resulting models included much larger mesh zones than originally intended. This probably increased computer run times and the risk of model instabilties.

Initial flood mapping for the 1998 rainfall event but using existing (2010) models was presented in October 2010. These seemed to be reasonably realistic bearing in mind the limitations / assumptions made in the use of rainfall data from a single rain gauge.

This mapping confirmed the area where 2-d mesh was required and where modelling of highway gullies may be needed to confirm causes of flooding, responsibilities possible evaluation of options or to improve accuracy.

In reality gullies (grates, gully pots and pipes) are the interface between surface flows and underground sewer flows. However, they are not normally included in sewer models. Gullies are not simple to model accurately and can be represented in various ways. In reality, as the flow along road channels increases, the flow by-passing gullies increases. Debris may completely or partly obscure grates. Road cross falls and longitudinal gradients are also important factors affecting flow into gullies.

Ipswich Borough Council undertook a survey to record the location of 384 highway gullies considered to be critical to flooding issues and with Clear Environmental researched available modelling techniques.

The following was extracted from Clear Environmental's modelling report.

> *"The gullies were modelled as nodes using the grate size as the shaft plan area; no account of the grate itself has been made. The depth of the gullies has been set at 150mm adding 0.075m^3.*
>
> *The cover level for all the gullies has been based on the modified ground model. Whilst much simplification of the gully opening has been undertaken for inclusion in the model, it is documented that in many instances the connection link between the gully pot and the sewer network is a greater restriction.*
>
> *The available guidance suggests the maximum flow rate that can be accepted by a gully pot without surcharge is about 10 l/s if the outlet pipe has a diameter of 100mm.*
>
> *The nature of the connection links is unknown across the model, consequently the connections have been assumed to be 100mm diameter pipes. The gradient of each conduit has been set to ensure a pipe full capacity of 10 l/s through the link.*
>
> *To avoid adding model instabilities all gully pipe lengths have been set to 5m. For the purposes of the model the gullies have been connected to the nearest available modelled node. If a suitable node was considered to be too far away a dummy manhole has been created to permit the connection of the gully to the network. Again, this has further increased the storage volume of the network, although the overall impact is considered negligible."*

It should be noted that Ipswich Borough Council believe gully connection pipes are 150mm diameter – as required by current highway design standards. The consultant's lack of inclusion of the head loss at grates may counter this error. Whatever method is used there will remain uncertainties about the degree of blockage of grates which could have a considerable affect on flooding.

There remains the problem that this representation does not enable the effect of blockages to be considered.

In extreme events, when most of the sewerage system surcharges to ground level, flows into gullies may cease or even reverse. In the case of reverse flow from the sewerage system, the connection pipe size will make a difference to flood depths. Ipswich Borough Council's method of modelling avoids this issue. Either way care needs to be taken, if drawing on model predictions, to make conclusions on responsibilities for highway flooding.

Flood maps for 2011 were shown to the project board and SFRMP in April 2011.

The Board agreed allowances for future growth, climate change and creep to be incorporated in future models:

- **Horizon** 30 years – i.e. 2040
- **Growth** (planned development) included only where it reduces flooding at Lovetofts Drive area. Here a brownfield site currently drains surface water runoff to the combined sewerage system. This will be redeveloped and drained via SuDS to the surface water system. For other

sites SuDS would be required to avoid increased flows for all events up to a 100-year return period.

- **Climate change** – a 10% increase in peak rainfall intensity is expected up to 2055. So a 7.5% increase is assumed to 2040.
- **Sea level rise** – 203mm by 2040.
- **Creep** (Paving of gardens or house extensions not requiring planning permission) two main sources of information are:
  - The UKWIR 2003 report: Allowance varies from 0.4 to 1.1 sq m per house per year for development <40 years old and
  - R Allitt's WAPUG paper (2009); research based on 4 cities. Average creep was about 0.75 sq m per house per year; more for detached and less for terraced homes.
  - For the SWMP, creep was based on housing density, regardless of age with a ceiling of 5% added impermeable area. Typical range from 0.86 to 0.1 sq m per year. The total addition for 82,176 properties was 73 Ha. (8.9 sq m/property or 0.3 sq m per year per property)

Options for flood alleviation, which had been put forward, were agreed by the Board and simplistic representations of the various flood risk measures modelled. Further details of options and their evaluation follow in Section 8.

Clear Environmental's Hydraulic Modelling Report CL491/005/002 dated May 2011 describes the work undertaken and assesses the results. This was received on 24 June 2011.

Results data which included flood maps and GIS files, showing pipe surcharge status, peak flow and hazard ratings, was supplied on a disc due to file size.

The report highlighted areas of potential inaccuracies, some of which related to instabilities in the models in some, but not all, simulations. These result in volume imbalances or peculiar flood predictions such as floods on the sloping embankment of the A14.

Subsequently the report was reviewed and a spreadsheet detailing and prioritising missing or unstable simulations was produced and used as a basis for discussions held on 12 Sept 2011. Anglian Water decided to curtail modelling work at this point as costs were rising.

Ipswich Borough Council subsequently found it was possible to interpolate water levels from good simulation results for some missing or unstable results as described in Section 8.7.

7.2 Detailed assessment: London Road to Lavenham Road and Hadleigh Road priority area.

Project Board decisions were taken as described for the previous section. This section deliberately describes the modelling process in some detail as it is not documented elsewhere.

The InfoWorks model, developed by Ipswich Borough Council, includes the highway drainage system serving part of London Road, the associated SuDS system, the Milden Road pond and ditch, headwall, gullies, highway drains and sewers in part of Lavenham Road. Overland flow from London Road across Chantry Park and downhill through back gardens as far as a steep drop at Norris House, Hadleigh Road is included using 2-d mesh. The modelling process is summarised below:

2-d mesh zones were generated by ICM from LiDAR data. Gullies were surveyed in Dec 2010 and the ditch in 2011 (following clearance of some vegetation).

At the upstream end of the catchment a mesh zone represents the London Road highway with a maximum triangle area of 7.5m^2 and a minimum element of 5m^2. Here 100% runoff and a Manning's roughness "n" value of 0.015 are assumed.

Gullies are represented as nodes with the "flood type" set to "2d gully". Head discharge curves for gullies were derived by IBC, assuming no blockages of the grates but including for head losses due to grates. "Rainfall" is applied directly to the mesh. Resultant flood mapping shows how runoff is routed along the road channels to the gullies and then into the piped network and the SuDS system.

A "dummy" overflow weir is included to simulate any flow from the road, which bypasses the gullies; the crest is set at the lowest kerb height.

The SuDS system is in fact a series of underground soakaways. These were readily modelled using standard ICM features.

For historic verification three ring soakaways with zero infiltration were included in the 2006 model. For 'do nothing' scenarios new soakaways including 2 trench soakaways, which were installed in 2006, are represented with an infiltration rate of 20mm/Hr. Data representing the soakaways was obtained from Ipswich Borough Council's drawing LONHW/05.

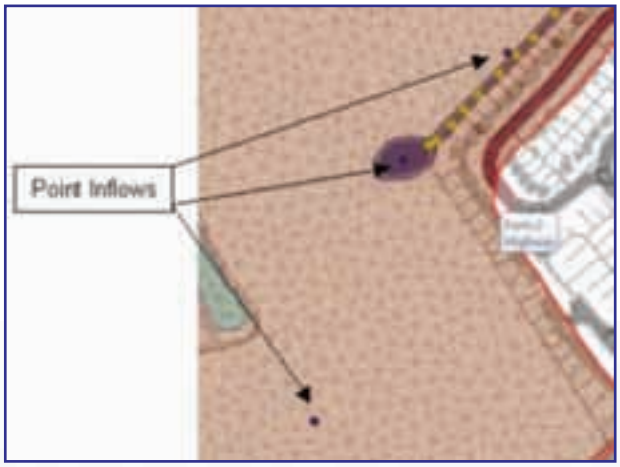
Flood predictions were found to be relatively insensitive to changing soakage rates. This is because the SuDS are relatively small and they overflow regardless of the soakage rate, even in common events.

Flows from the SuDS system and the overflow weir discharge onto a second 2-d mesh zone, which routes overland flows across the park. The mesh representing the park has a triangle size of 25–100 sq m and Manning's roughness n = 0.035 (shallow depths of flow through long grass)

Various ways of modelling runoff from the park were tested, including applying a percentage of rainfall directly to the mesh (this usefully helped confirm the catchment area that needs to be meshed as well as the flood path).

A wide range of flows results from different methods of rural flow estimation.

The final method used was to divide the park catchment area into three polygons and use the Re FH method to derive flow hydrographs resulting from each polygon for a range of storm durations and frequencies. Appropriate sets of these hydrographs were then applied to the mesh in the valley floor as point inflows.



To represent the pond and ditch various methods were tested. Initially reliance was placed on the mesh however it was soon apparent that the mesh generated from LiDAR did not represent either correctly. This was due to LiDAR data being unreliable in areas with dense trees/undergrowth and because the ditch was very narrow compared to the LiDAR resolution.

Attempts were made to lower the mesh but results were not visibly different. The model software company was contacted and eventually an upgrade was issued which should have solved the problem. However, to maintain progress, before the upgrade was issued, the ditch was represented as a trapezoidal channel with cross sections based on a site survey and the longitudinal section based on LiDAR. The ditch bed was found to fall 3m in 160m; however the section near the pond was relatively flat. Obstructions held back flow at several locations – as shown on the picture above. These were finally represented by assuming the ditch was only 100mm deep.

"Dummy" (imaginary) nodes were included in the model along the channel at changes in gradient. The flood type for the nodes was set to 2-d, which allows floodwater to escape from the channel onto the mesh and water on the mesh to enter the channel. The ground level at each node is set to mesh ground level – If the model is re-meshed these ground levels may need amending.

Innovyze advise these dummy nodes can be replaced with a linear connection between the channel and 2-d mesh. This should prove more realistic.

The upstream dummy node for the ditch is sited at the lowest mesh element within the pond.

Representation of the pond followed careful consideration of LiDAR and ditch levels and assumed the standing water in the pond was at the ditch outlet invert level when the surface area of water was 450 sq m (from OS mapping). Some of the storage capacity of the pond is represented in the node and part on the 2-d mesh.

The resultant model was easily edited to replicate the effects of a larger pond or ditch.

From the headwall at the downstream end of the ditch a 300mm diameter pipe drains to the

Anglian Water surface water sewer in Lavenham Road. The headwall includes a grille, which is frequently partially blocked with debris.

The effect of the blockage is represented in the 'do nothing' scenarios as an orifice with a diameter of 100mm.

The pipe from the headwall and a 110m length of the downstream sewer at Lavenham Road is included in the model together with highway gullies and connecting pipes. However connecting sewers and flows from the urban area are not included in the model.

The model predicts flows can overtop the ditch head wall and flow onto Lavenham Road. The predictions were confirmed following discussions with residents. The 2-d mesh zone therefore extends further downstream, including part of Lavenham Road, where modelled gullies utilise the same head discharge curve as those at London Road.

A roughness zone (n = 0.016) represents the smoother highway surface at Lavenham Road. A small part of the mesh here was dropped by 34mm to represent a low kerb line.

It was found that the gullies at Lavenham Road could only intercept a small flow before the water level overtopped the low kerb and overflowed into gardens, along the valley floor and on towards Hadleigh Road. Records confirm occasional flooding in gardens and more frequent flooding at Hadleigh Road.

The 2-d mesh extends from Lavenham Road further down along the valley to Hadleigh Road where there is a natural break point in the form of a 2m drop at Norris House.

The ReFH was used to estimate runoff from gardens assuming the sewerage system carried runoff from all paved and roof areas within 10m of buildings and pavement (as per WAPUG paper 21 – March 2009). Runoff was applied as a single point source to the mesh in the bottom of the valley about a quarter of the way down hill from Lavenham Road towards Hadleigh Road.

For the 'do nothing' scenario pre-2006 and, a 100 year return period, simulations were undertaken for 7 storm durations between 15 and 1440 minutes. The critical duration for flooding of properties was found to be 360 to 720 minutes.

For highway flooding at London Road the critical duration is 15 minutes.

7.2.1 Ipswich Borough Council model – historic verification

Flooding of properties in Milden Road (built 1982) has only been reported once in the past 29 years – during 1998.

Rainfall data recorded at Cliff Quay Sewage Treatment Works (3 km to SE) was available for this event but could not be directly used in a simulation, because the ReFH method calculates hydrographs based on rainfall return periods and durations. Processing revealed the 1998 event approximated to a 2-year return period 720 min duration event albeit with substantial rainfall over several days before the main event. However, no flooding was predicted for the main event.

Flooding of properties in Milden Road was predicted in a 30-year return period, 720 minute duration event.

Research into old correspondence revealed the 1998 flooding was blamed by residents on obstructions. It is considered that over time these obstructions may have been cleared or reformed, so for historic modelling there is a difficulty in deciding what ditch section is appropriate.

The apparent discrepancy may also be explained because the return period of the rain is not necessarily the return period of the flood.

In 1998 the catchment must have been very wet before the main event however ReFH estimations do not take into account specific antecedent conditions. It is also likely that prolonged overflow from the London Road highway soakaways during the preceding days would have waterlogged the valley down hill.

Another possibility considered was that surcharging of the sewerage system increased water levels in the ditch. The sewerage system serving Lavenham

Road flows eastwards and under London Road as it cuts into higher ground. This means it is possible for sewer flooding to occur in Lavenham Road.

The surface water sewer here is included in Anglian Water's sewer model of the Bridgwater Road and Coltsfoot catchments, but is considered to be un-verified.

Anglian Water's modelling indicates surcharge levels reach 16.9m AOD in a 100 year return period of 60 minute duration in 2040 (considered to be the critical duration for flooding at Bridgwater Road). A transient reverse flow of 37 l/sec is predicted towards the upstream sewer manhole in the garage area at Lavenham Road, which has the lowest cover level of 16.6m.

Ipswich Borough Council's model was tested to see what effect surcharging of Anglian Water's system might have on the ditch system, by applying a constant 16.9m AOD level hydrograph to the modelled section of the Anglian Water sewer. The test showed sewer surcharging would not affect flooding further up the ditch at Milden Road but will have some affects downhill of Lavenham Road.

7.2.2 Other model findings

Overflow from the London Road highway soakaways onto park: The pre-2006 base model predicts overflow more often than annually, which was as expected.

The post-2006 'do nothing' model (with extended SuDS serving London Road) with 2011 rainfall also overflows at least annually. Site inspection reveals overflow has occurred recently.

Flood depth across park <50mm even in a 200 year return period event.

London Road dual carriageway flooding: Flood depth is limited by kerb and verge height. Floodwater which overtops the kerb bypasses the SuDS system. Critical duration here is 15 minutes.

Milden Road: Some shallow garden flooding 10–50mm deep in rear gardens of Milden Road is predicted in a 5–10 year return period event and internal flooding at three properties is predicted in a 100 year event.

Flood depth did not exceed 50mm, even in a 200 year return period event.

Lavenham Road: Gardens flood 10-50mm deep at a 2–5 year return period. Water <10mm deep overflows into the garage area and then into rear gardens along the valley floor.

Gardens between Lavenham Road and Pickwick Road and Hadleigh Road: Floodwater flows towards Hadleigh Road with depths up to 560mm predicted in a localised hollow at rear garden of number 85, in a 200 year return period event. Flood depths <10mm in a 50-year return period. In a 100 year return period, depths exceed this.

85 to 89 Hadleigh Road: 'Do nothing' and 'base' models predict gardens adjacent to three homes to flood 50–100mm deep in a 200 year return period event. Internal flooding is predicted at a 50–100 year event. A land drain is shown on records plans here. However, it is not readily accessible and is not represented in the model. If the land drain is functional the flooding would be less frequent.

There are many records of historic flooding here attributed to sewer overloading and / or inadequate highway drainage. Since a flood relief project was installed by Anglian Water in 2007 no reports have been received.

Norris House: Water overflowing from the road over or through the retaining wall was last recorded in 2006.

7.2.3 Conclusion for Chantry Park

Bearing in mind various factors (including the low cost of potential solutions) the model with a 100mm deep channel, which predicts flooding in a 30 year return period is considered to be acceptable even though no verification involving a flow and rainfall survey, in accordance with the Code of Practise for the hydraulic modelling of sewer systems (WAPAG Nov 2002), has been undertaken.

7.2.4 Growth and creep

No planned developments were considered likely to affect surface water flows. Additional roof or paved areas were assumed to drain to the sewerage system. Allowances for climate change but not growth or creep were therefore included in the 2040 'do nothing' model.

7.3 Flood maps for 2011 and 2040

The results for 2011 'do nothing' scenarios are mapped and included in appendices 12.22 and 12.23 and at a smaller scale on the following pages. 2040 results are available but are very similar.

The maps show where water depths are greater than 0.01m. This depth was chosen because there will inevitably be some depth of water on impervious surfaces.

Flows of runoff along properly designed road channels will exceed 0.017m deep once a year. However most roads will have surface irregularities and gully spacing is often more than ideal, so depths may often be greater. Some shallow flooding will be shown on many roads whereas, in reality, this is not a problem.

Normally house floor levels are about 50–100mm above the lowest surrounding ground and so floodwater is most likely to enter homes in areas where flooding is greater than 50mm deep. Even then floodwater may not enter if the duration of flooding flood is short; if doors are sealed or airbricks/door thresholds are above the floor level or the floor levels raised.

Flood mapping assumes gullies are not blocked, ignores the effects of wash caused by vehicles and may not take into account all garden fences, walls, etc.

Another issue is the accuracy of ground levels used in the modelling. The average error of LiDAR is + or – 150mm. Model results are also simplifications, in particular the predicted depths of water assume an average ground level at each mesh element.

Flood maps are therefore indicative.

The maps are held in electronic MapInfo format, associated data fields for each 2-d element include maximum flood depth, water level, average ground level and peak hazard rating.

7.3.1 Flood map for Lovetofts 100 year return period, 'Do Nothing'

7.3.2 Flood map for Worsley Close / Ellenbrook 100 year return period 'Do Nothing'

7.3.3 Flood map for Ancaster Road / Burrell Road 100 year return period 'Do Nothing'

Flood map for London Road to Lavenham Road and Hadleigh Road. 100 year return period. 'Do Nothing'

7.4 Comparison with the Environment Agency's flood map for surface water (FMfSW)

SWMP flood maps have been compared to the Environment Agency's flood map for surface water for a 30 year return period. These maps show only predicted flooding of greater than 100mm deep.

The SWMP maps generally show much smaller areas of flooding and some differences in the location of the flooding. This is mainly because the SWMP models more accurately represent sub-surface flows and include interfaces between surface and underground systems. SWMP models realistically predict locations not shown on the FMfSW maps (e.g. Bridgwater Road), where water escapes from the underground systems to flow overland and vice versa.

7.5 Predicted numbers of properties at risk at 2011

Numbers of properties predicted to flood in a 200 year return period event in each study area were estimated using both the areas susceptible to surface water flooding (ASTSWF) and the flood map for surface water (FMfSW) maps and compared to those predicted to flood using the SWMP modelling. Section 8.7 describes the methodology used.

The FMfSW is judged to be the most accurate basis for projecting Ipswich totals from SWMP predictions. 9,025 properties are within areas shown to have more than 100mm of floodwater in a 200 year return period event.

In the four study areas the SWMP predicts 231 properties would flood whereas the FMfSW predicts 515.

Assuming the four study areas are representative of the whole town, the total for Ipswich should be about 4048. i.e. (231/515 = 0.45) times the total predicted by the FMfSW (9025).

Similarly 1,525 properties are likely to suffer internal flooding.

Conclusions	
Estimated number of properties flooded in Ipswich study area in a 200 year return period	
Internal flooding	1,525
External	2,523
Total	4,048
PFRA total was	*5,626*

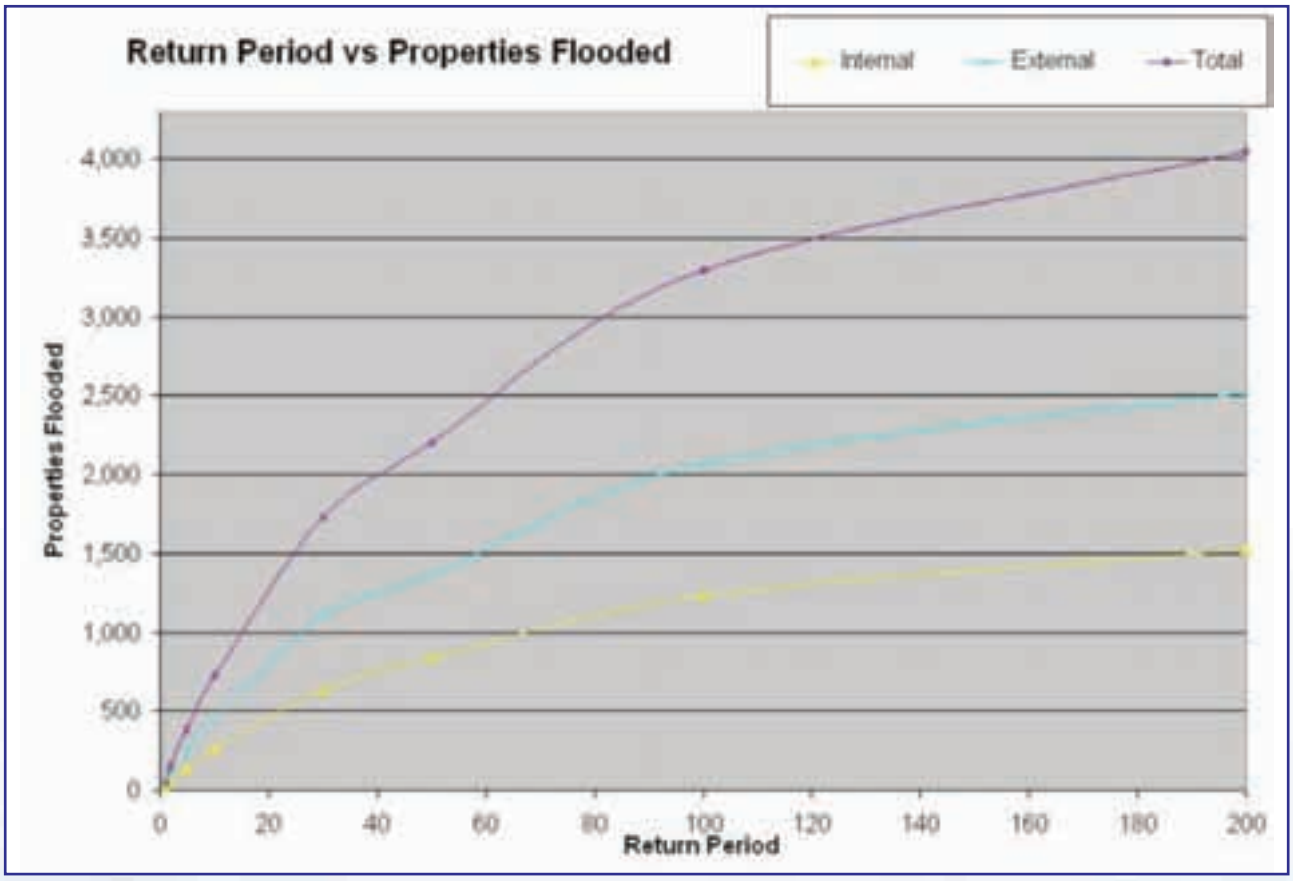
Estimates of numbers of properties flooded in a 200 year return period event (at 2011)

		Address points (Properties) counted within areas with >100mm of water		Properties Flooded predicted by SWMP, (projected for 200 year event)		
Study Area	Area Size (Ha)	Using ASTSWF	Using 200 yr FMfSW	Internal - mostly >50 mm of water	External >50mm somewhere in garden	Total
Ancaster Rd	106	42	88	19	18	37
Chantry Park	65	57	66	5	38	43
Ellenbrook	25	148	217	42	28	70
Lovetofts	111	160	145	21	60	81
Total	307	407	515	87	144	231
Whole of Ipswich	4,037	11,506	9,025			
	From PFRA (based on FMfSW)		5,626			

Predictions for whole of Ipswich Based on SWMP results from above			
	Internal	External	Total
Based on Area	1,145	1,894	3,039
Based on ASTWF	2,460	4,071	6,530
Based on FMfSW	1,525	2,523	4,048

Using the same principles the numbers of properties predicted to flood at various return periods are shown in the graph below:

Numbers of properties predicted to flood in Ipswich based on SWMP study at 2011



Some idea of the likely accuracy can be concluded by comparison with records:

The predicted annual average number of properties flooded was internal flooding 131 + external flooding 226 = 357 per year (estimated from the area below a graph of number of properties flooded against annual probability.)

Ipswich Borough Council records

(An incident is a property flooding on one occasion, 10 incidents could be 10 properties in one event or 1 property in 10 events)

It is known that flooding, especially external, often goes unreported, so the results of the comparison are not surprising and give credence to the SWMP predictions.

Year	No. of Incidents
2001	68
2002	200
2003	119
2004	121
2005	138
2006	110
2007	109
Average	**124**

8 Options

8.1 Short-listing of options and planning for option evaluation

The project team short-listed flood alleviation options which were subsequently agreed by the Board in April 2011. This meeting included a presentation of early flood maps together with details of the methodology planned for evaluating options and reviewing likely outputs against the agreed SWMP objectives. e.g. all options put forward should reduce pollution.

Decisions on which options to investigate in more detail were taken at this early stage to ensure the 'do nothing' models could easily be edited to represent the options chosen, and any differences in predictions resulted only from inclusion of remedial measures rather than other differences between models.

A rigorous approach (described in detail in section 8.7) to identifying flood receptors, flood damages, and cost benefit analysis was agreed to ensure consistent approach was applied. To facilitate this, Excel workbooks were developed, suitable for use in future SWMPs.

8.2 Options for Lovetofts Drive / Lagonda Drive

The following flood alleviation measures were considered:

1. Offline tank.
2. Divert gullies from combined system to new SuDS along verges of Lovetofts Drive. SuDS to drain to the surface water system.
3. Removal of surface water from combined system.
4. Possible extension of rising main.
5. Strategic SuDS including attenuation of Bury Road highway drainage to the north of Bury Road.

8.3 Options for Worsley Close / Ellenbrook

1. Grille cleared more frequently on outfall – assume 10% blocked.
2. SuDS system constructed in Stonelodge Park behind the bund wall.
3. Underground storage in Stonelodge Park.

8.4 Options for Ancaster Road / Burrell Road

1. High-level reinforcement of surface water sewer draining to river. This would operate infrequently and be unlikely to affect water quality.
2. More frequent maintenance: clearing highway gullies in Ancaster Road.
3. Bolting down of private drain cover in footway of Pooleys Yard.

8.5 Options for London Road to Lavenham Road and Hadleigh Road

1. Maintain SuDS, outfall grille and ditch.
2. Larger pond, including maintenance as above option 1.
3. Larger SuDS plus option 1.

8.6 Flood maps for options

For The Chantry Park – Hadleigh Road priority area a full range of flood maps are available.

For the other three locations only results for a 30 year return period were available.

Process for evaluating options

Defra's SWMP technical guidance (March 2010) has been followed. The prime measure for evaluation being the cost / benefit ratio. This is in line with the emerging national partnership funding

(FDGiA) funding for flood risk management schemes.

Other issues also affect option choice. For example environmental benefits such as creation of water dependant habitat.

The steps used for evaluation are:

1. Define receptors (those things that will be affected by flooding)
2. Estimate flood depths at receptors
3. Estimate average annual damage costs in 2011 based on flood depth in each receptor
4. Estimate average annual future damage costs (for 'do nothing' scenario)
5. Design and model options
6. Estimate average annual damage costs for each option for both the future and 2011 scenarios
7. Calculate the financial benefit for each option = reduction in damage cost
8. Calculate benefit / cost ratio

Receptors include buildings and, at Ancaster Road, the highway as flooding closes the road. At Lovetofts Drive damage to the highway, caused when a manhole cover blows, along with road surfacing, is also taken into account, assuming damage occurs when the pressure head at the manhole exceeds ground level.

Flood damage costs for various forms of development and assessment techniques are laid out in the Multi Coloured Handbook (MCH)[5]

Damage cost data is available for:

- Residential sector average – basis for SWMP
- Detached houses (split into ages and social classes)
- Semi-detached houses
- Terraced houses
- Bungalows
- Flats
- Closed roads, non residential buildings – e.g. shops, schools

The MCH relates flood damage cost to flood depth based on historic floods. The damage cost for the average residential property is shown as a constant £948 for flood levels from 300mm below ground floor level up to floor level.

For floods exceeding the floor level, damage costs increase rapidly. A depth of 300mm is shown to cause on average £22,944 of damage. The figures include for damage to gardens/fences/sheds.

Estimated damage costs cannot be used for specific properties but, over a wide area, will provide the best estimate of total damage costs.

Most floor levels are 0 to 100mm above ground and flood mapping does not show areas where floodwater is below ground. The decision was therefore taken to ignore damages resulting from flooding below ground floor level and assume flood receptors would be buildings where adjacent flood depths were >50mm in the 100 year event in 2040.

To simplify the approach the damage costs relating to the residential sector average was assumed for all residential properties.

Gardens, sheds, summerhouses and remote receptors unaffected by options were not regarded as receptors as damage costs for these were already included. Buildings with a past history of flooding were included.

Enhancements were added:

5.6% uplift for emergency services costs

£200 per flood per property for injuries

£99 per flood for investigation/record by the local authority (IBC costs)

5. "The Benefits of Flood and Coastal Risk Management Handbook of Assessment Techniques – (Flood Hazard Research Centre 2010.)"

At Ancaster Road the cost of traffic delays are estimated in accordance with the MCH. It was assumed:

- The diversion route is 2.5km

  The peak traffic flow is 1416 vehicles per hour (2004 data)

The road becomes impassable with >150mm of floodwater (as suggested in the MCH).

Flooding occurs at peak traffic time when the average speed of traffic is 20 km/hr.

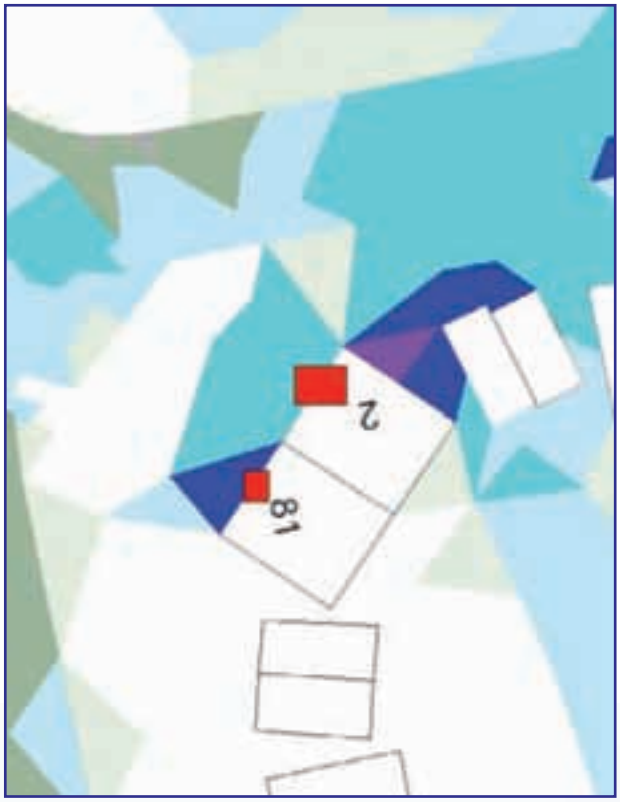
At Ancaster Road, flooding affects highway and can overflow over a very low kerb (10mm) into a basement car park sited beneath a building, which comprises 85 flats. There is no flooding inside homes. In reality a mixture of foul and surface water overflows onto the highway then into the car park. The car park was designed to be flood resistant and includes an extensive drainage system. The storage capacity and drainage system within the basement are not represented in the model. The threshold polygons used to extract data from GIS flood maps were positioned on the highway under the bridge and also alongside the entrance to the car park.

Damage costs for flooding of the car park were assumed to apply when the depth of adjacent floodwater reached 10mm or when combined sewer surcharge levels exceed ground level (apart from the sealed cover option). The MCH has no appropriate examples, so damage costs were assumed to be the same for each event and included cleaning up foul matter, intangibles (anxiety, health, etc) and local authority costs.

At Lovetofts Drive a £50,000 damage cost was agreed with Anglian Water for repairing the road surface and manhole when the sewer surcharge level exceeded ground level at manhole 5601 (at the Kerry Road junction).

8.6.1 Estimation of flood depths in receptors

2-d models represent the ground surface as thousands of triangular mesh elements. The output GIS flood maps include average ground level and peak flood level at each element.



In some locations (as illustrated) topography is relatively steep and flood depths vary around the perimeter of buildings.

The location of doors or other openings where water can enter will therefore be critical. These thresholds were mapped (shown red on above plan) following a site inspection or by using Google 'Streetview'.

Threshold tab files include fields for predicted water level and average ground level for each event. One threshold file was produced for each modelled scenario.

GIS tools were used to rapidly import flood levels and average ground levels from the appropriate cells of the flood maps into the threshold file.

An Excel workbook was developed to calculate the flood depths in each receptor, calculate damage costs and count the properties flooded. This required the height of each floor above ground level.

Consideration was given to surveying properties to determine floor levels relative to ordnance datum.

However since the 2-d mapping uses average ground levels, and produces average water levels at each element, and because the error for LiDAR data was +/-150mm, it was decided to estimate floor heights above ground level. This was done, in most cases, by inspection either on site, or using Google (using brickwork courses as a measure).

50mm appeared to be a realistic average height of threshold above ground and was generally added to the workbook apart from where the inspections showed a lower height.

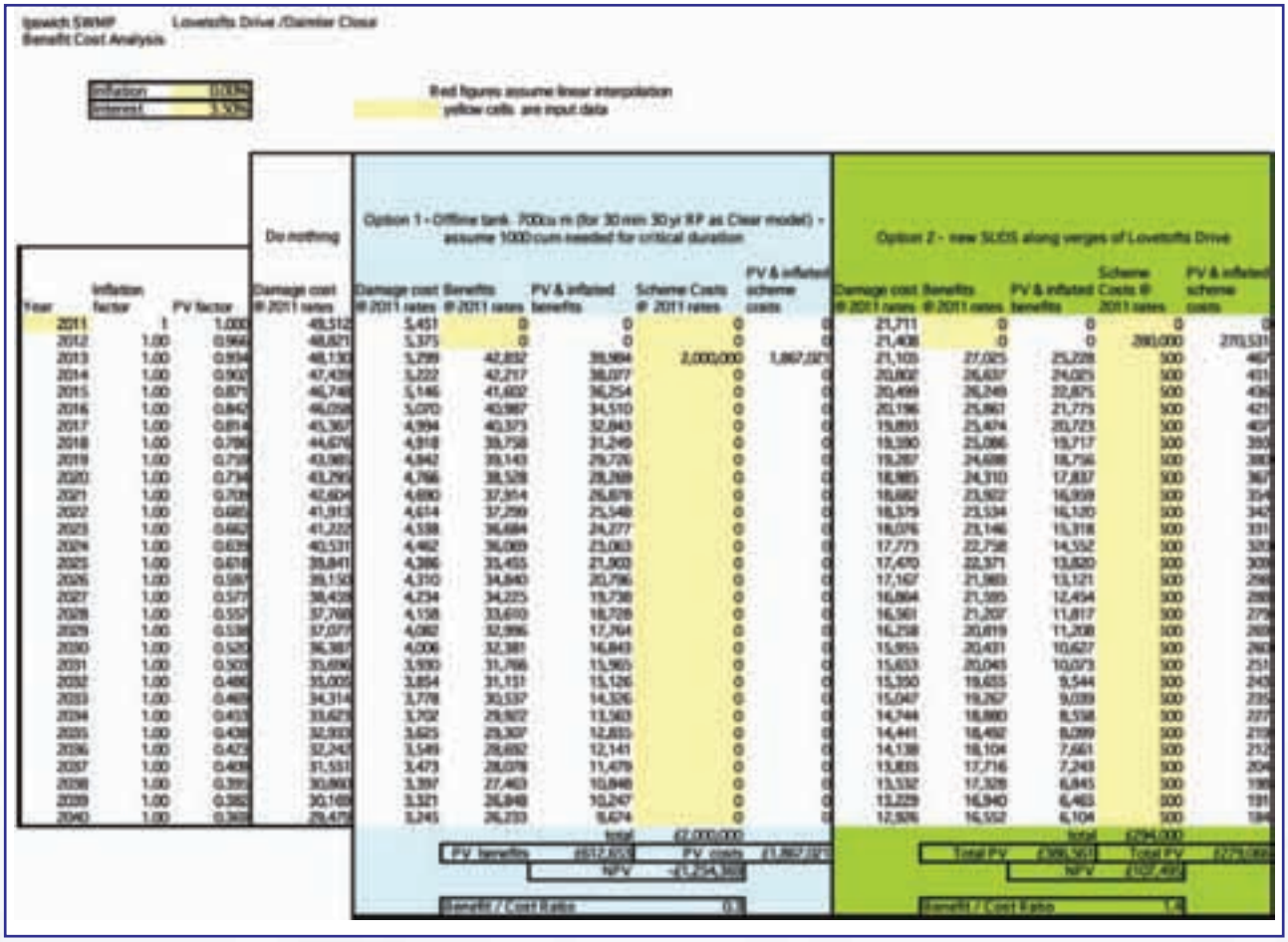
Four workbooks were used to evaluate options, one for each priority area. Each workbook contains worksheets for each modelled scenario. These calculate damage costs for each modelled event. The workbook can be readily reused for future SWMPs.

The workbooks ensure the same floor heights are used for all scenarios and events. Sensitivity to floor heights can also be investigated easily.

The average annual damage cost (AAD) for each scenario is calculated from the damage costs for each event (normally 8 events). However, Clear Environmental had only modelled a single event (30 Year Return Period) for each option. An additional sheet was therefore used to interpolate flood levels at receptors for the missing events.

The method used for interpolation was based on a full set of results for the 2011 or 2040 scenarios which enabled flood levels at each receptor to be related (by a factor) to the flood level at a key gauge point for each return period. Similar techniques are described in WAPUG IUD Modelling Guide Rev 1 v28.

A check was made to ensure the original model predictions and damage costs for the 30 year return period events for each scenario were consistent and that any zero damage figures really did mean no flooding in the 30 year event. The check revealed some errors – some options in the Ellenbrook area worsened performance, contrary to any reasoning. Detailed checks on the model output and the consultant's report revealed inexplicable increases in flow volumes. In this case the interpolation technique can generate small



apparent changes in damage costs that are not real and such results were treated with caution or ignored. Interpolation will not work when storage solutions overflow in events with a return period <100 years.

8.6.2 Cost benefit analysis

A final worksheet (see the example extract above) brings together AADs from 2011 and 2040 'do nothing' and option scenarios and calculates benefits for each year between 2011 and 2040 (by linear interpolation).

Scheme costs and benefits are recalculated as present values (PVs) to enable options for schemes with varying capital (design/construction) and revenue elements (e.g. maintenance) to be compared, assuming a 30 year lifetime of the scheme.

The present value of the scheme is the notional sum of money that needs to be put aside (invested) now to fund the scheme. PV is affected by inflation and investment interest rates. The SWMP makes no allowance for inflation and uses a 3.5% investment rate, as suggested by Defra, over the next 30 years.

For modelling, notional AADs at 2011 for options were estimated from 2040 option AADs assuming the same ratio between 2011 and 2040 'do nothing' AADs.

Capital costs were generally estimated using the Suffolk County Council highways partnership schedule of rates (current at 2011). These were added at the appropriate date. Revenue costs are assumed to be annual.

Finally the net present value for benefits and costs and the benefit cost ratio is calculated for each option.

8.7 Evaluation of options for Lovetofts Drive / Lagonda Drive

The following table shows the 30 year return period results were consistent. The table (over) correctly shows zero damage costs for option 1.

Summary of Damage costs for 30 Year Return Period only							
Scenario	Do Nothing 2011	Do Nothing 2040	Option 1 – Offline tank 700cu m (for 30 min 30 yr RP as Clear model) – assume 1000cu m needed for critical duration	Option 2 – new SUDS along verges of Lovetofts Drive	Option 3 – Removal of surface water from combined system	Option 4 – Extension of rising main	Option 5 – Strategic SUDS including attenuation of Bury Rd Highways drainage to N or Bury Rd
30 Yr RP damage costs	**£169,320**	**£167,269**	**£0**	**£79,833**	**£93,887**	**£161,398**	**£109,087**

Option	PV cost	PV benefits	BCR	Comments
Option 1 – Offline tank 700cu m (for 30 min 30 yr RP as Clear model) – assume 1000cu m needed for critical duration	£1,867,021	£612,653	0.3	
Option 2 – new SUDS along verges of Lovetofts Drive	£279.066	£386,561	1.4	
Option 3 – Removal of surface water from combined system	£357,488	£369,466	1.0	Subject to review following AW study, extent of scheme unknown, costs set to give CBR = 1
Option 4 – Extension of rising main	£193,237	£18,081	0.1	
Option 5 – Strategic SUDS including attenuation of Bury Rd Highways drainage to N or Bury Rd	£99,517	£103,208	1.0	Scheme costs unknown, set to give CBR = 1 perhaps say Not Applicable (by developer)

Option 2 was taken forward to make use of new funds available in 2012 as described in section 9

8.8 Evaluation of options for Worsley Close / Ellenbrook

The table below shows inconsistent model results for options in the 30 year return period event. In each option the simulations have generated about 300 cum more runoff than for the 2040 'do nothing' event, thought to result in the increased damage costs for flood risk management options.

Summary of damage costs for 30 year Return Period					
Secario	Do Nothing 2011	Do Nothing 2040	Option 1 – Ensure outside grille is <10% blocked	Option 2 – SUDS in Stone Lodge Park	Option 3 – Offline Storage Tank in Stone Lodge Park
30 Year RP damage costs	**£187,803**	**£222,294**	**£235,212**	**£233,063**	**£226,904**

In the 30 year return period events both the storage and SuDS options overflowed and therefore made very little difference to flooding downstream. However, it is likely that in more common events the storage and SuDS systems will be more effective.

Simulation results from a wide range of return periods are needed to properly assess options.

The following table shows scheme costs estimated for the modelled option and potential benefits that might be possible – assuming the SuDS and tank options prevent all flooding in a 10 year return period event.

The 'clean grille' option assumes annual costs are £2,400; only a small benefit will make this cost beneficial.

Option	PV cost	PV benefits min	PV benefits max	BCR min	BCR max	Comments
Option 1 – Ensure outside grille is <10% blocked	£40,967	?		?	?	Small cost but might be very beneficial
Option 2 – SuDS in Stone Lodge Park	£31,690	?	£523,826	?	16.5	Low costs but may have high benefits
Option 3 – Offline Storage Tank in Stone Lodge Park	£123,223	?	£501,866	?	4.5	

More simulations are needed to properly determine benefits. The benefits may be substantially less than shown since some flooding from the surface water sewer is expected to remain downstream of the SuDS or storage tank. However this would be reduced further by improvements arising from the grille maintenance. (1m lower surcharge levels in a 30 year return period)

The table indicates:

- Maintenance of the grille may be worthwhile as costs are small and a relatively small reduction in damage costs would be cost beneficial. The assumption is that a particular maintenance regime will reduce blinding of the grille from 50% to 10% (on average).
- The SuDS system in Stone Lodge park appears to have the most potential. Further simulations for a range of events are needed and the benefit cost ratio and design could be optimised by examining a range of capacities and considering the use of SuDS combined with the outfall grille option.

8.9 Evaluation of options for Ancaster Road / Burrell Road

No options for relieving flooding in Burrell road were considered and some amendment to the options put forward for flood relief at Ancaster Road have been made as described later.

The table below appears to indicate very little benefit is achieved by any option. However this is not the case in reality.

Summary of Damage costs for 30 Year Return Period only							
Scenario	Do Nothing 2011	Do Nothing 2040	Option 1 – Additional SWS	Option 2 – Clean SW Outfall	Option 3 – Bolt down covers on combined system	Option 4 – Bolt down covers on combined system and provide new SWS	Option 5 – Bolt down covers on combined system & Clean SW Outfall
30 Yr RP damage costs	**£10,636**	**£10,993**	**£9,335**	**£10,362**	**£10,933**	**£10,362**	**£10,362**

When wider ranges of return periods are considered (using interpolation techniques) a different picture emerges as in the following table. This is because the options are expected to have the most effect on damages at return periods <30 years. For example, bolting down covers halves the frequency of flooding of the car park.

Option	PV cost	PV benefits	BCR	Comments
Option 1 – Additional SWS	£135,141	£4,342	0.03	
Option 2 – Clean SW Outfall	£9,615	£2,647	0.3	
Option 3 – Bolt down covers on combined system	£9,335	£45,841	4.9	Most costy beneficial
Option 4 – Bolt down covers on combined system and provide new SWS	£144,477	£82,654	0.6	Greatest benefits
Option 5 – Bolt down covers on combined system & Clean SW Outfall	£18,950	£71,409	3.8	

Cleaning sediment from the surface water system

This has replaced the agreed option 'more frequent maintenance – clearing highway gullies in Ancaster Road'.

Blockages of road gully grates due to sediments washed down from the unmade part of Ancaster Road can have a significant major effect on flooding. The gullies have been modelled very simplistically as the impact of varying degrees of gully serviceability cannot be accurately represented in the model.

Modelling partially blocked gullies may have provided useful information on responsibilities.

The consultant has, however, modelled the effect of sediment removal from the existing surface water outfall sewer from Ancaster Road, assuming the depth of silt is reduced from 200mm to 0.

Sediments tend to build up gradually in pipes with slow speeds of flow. As sediment builds up, the speed of flow eventually increases and a steady state depth of sediment is reached. It is likely the 200mm depth was the steady state and so after cleaning, the sediment is likely to return, especially at this location where sediments are washed down from the unmade road further up the catchment.

Ideally the option model should have included some sediment to be more representative of the situation between successive cleaning operations. However there is no meaningful data to base the rate of build up on.

When estimating the cost of maintenance options there is a problem deciding how frequently maintenance is needed and how to represent the effects of maintenance in a model. Records of sediment depths or grille blockages and maintenance (including costs) undertaken would assist in evaluating options

Based on experience, Ipswich Borough Council has assumed that an initial clean would cost £2,000 and thereafter £1,000 every two years.

Reinforcement of surface water sewer draining to river

Clear Environmental modelled this as a 375mm diameter outfall pipe with 300mm and 225mm diameter branches, to which 10 new highway gullies connect – each set to carry up to 15 l/sec. The report seems to indicate this pipe is too large in a 30 year return period event. The GIS mapping shows it carries a peak flow of 215 l/sec from the new pipe to the Orwell, whereas the expected max flow is 150 l/sec.

This is probably explained because flood water in the model is entering at manholes as well as gullies.

The consultant considered that due to shortcuts taken in modelling, the results are limited and do not reflect the true impact a new surface water sewer would have.

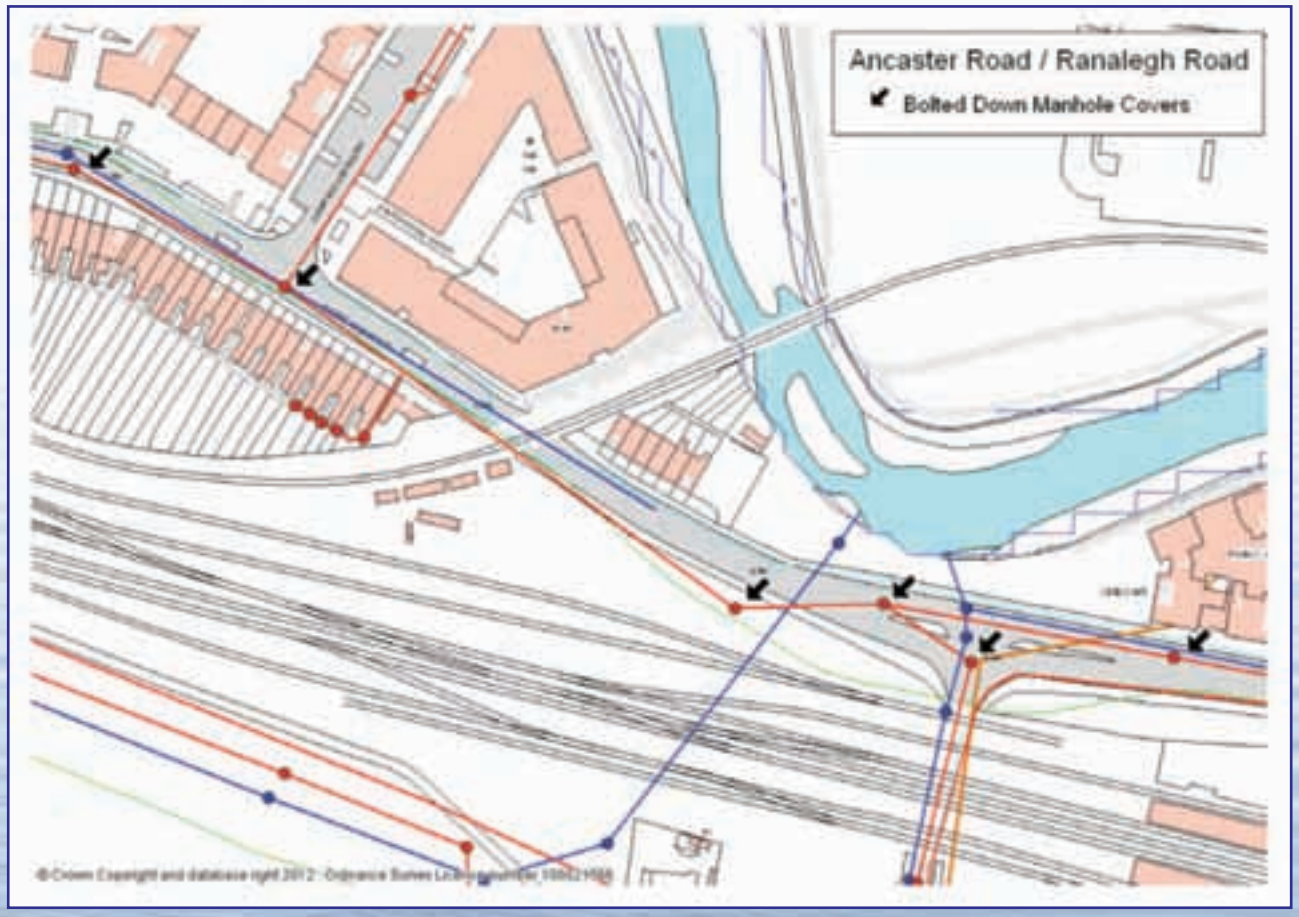
To refine the design and performance further, more detailed modelling is needed. Nevertheless, the results have been used in the benefit cost analysis.

Bolting down of private drain cover in footway of Pooley's Yard

The modelling for 'do nothing' and all option scenarios assumes the combined sewer manholes shown below are sealed and that there is an effective non return valve installed on the foul connection from the flats.

The consultant describe this private drain, however Anglian Water adopted such lateral drains under the public highway in October 2011.

During a heavy shower on 6 January 2012 flooding occurred and the following photographs show how sewage / surface water escaped from a bolted cover as well as the manholes on the connection from the flats.



The effect of sealing these two manholes was considered by assuming, in the 'do nothing' scenarios, sewage could escape whenever surcharge level exceeded ground level. A nominal estimate of £10,000 has been assumed for sealing these covers.

The option 'bolt down covers' option was carried forward to the action plan along with 'clean surface water outfall'. This is included since it is not known when the sediment depth was recorded, or how much is in it now.

Gully maintenance and road sweeping would be undertaken by the highway authority whenever reports from the public are received, so another action would be to ask local residents to report blocked gullies or gravel deposits on the highway.

8.10 Evaluation of options for London Road to Lavenham Road and Hadleigh Road

A full range of simulations were undertaken with no apparent model instabilities, so there was no need to interpolate or check the 30 year return period predictions.

One slight change in options was made. Options 2 and 3 assume the ditch was not deepened and is 100mm deep.

Options 1 and 1a are almost the same. 1a does not include costs for maintaining the SuDS or grille. SuDS should be maintained routinely by the highway authority.

It is suggested residents could ensure the grille is clear.

Option	PV cost	PV benefits	BCR	Comments
Option 1 – Deepen ditch to 300mm deep, maintain grille (10% blinded), maintain SuDS (Infiltration rate 50mm/Hr)	£23,020	£6,315	0.27	Cost includes annual maintenance of SuDS and monthly inspection/cleaning of grille
Option 1a – Deepen ditch to 300mm deep + maintenance of grille & SuDS – not including costs for maintaining SuDS or grille	£9,848	£6,315	1.28	Cost of ditch deepening included, SuDS or grille maintenance cost not included
Option 2 – Enlarge pond (to store 500 cum) + Maintenance of grille & SuDS – not including costs of maintaining SuDS & Grille	£10,558	£6,197	0.6	
Option 3 – Larger SuDS (+200 cum) & maintenance of SuDS and grille. Costs of maintaining SuDS and grille not included	£70,013	£425	0.0	

The larger SuDS option has little effect because the overflow from the SuDS peaks earlier than the runoff from the park, which is predominant.

It is suggested option 1a is taken forward with no further refinement or modelling.

8.11 Ipswich wide options – control of creep

Clear Environmental has provided full sets of simulations for 'do nothing' scenarios

- At 2011
- At 2040 with climate change and creep
- At 2040 with climate change
- At 2040 with creep

Flood mapping for the Ancaster Road and Ellenbrook areas has been used to derive the benefits that may accrue across Ipswich if increased flooding due to creep could be controlled. These areas were chosen because growth has no affect in them.

From section 7.5 the number of properties estimated to flood internally across Ipswich in a 200 year return period event at 2011 was 1525. The average annual damage (AAD) costs per property calculated for Ancaster and Ellenbrook were assumed to apply to 1525 properties across Ipswich and costs and benefits for the whole of Ipswich estimated as follows on the next page:

Option	PV cost	PV benefits	BCR	Comments
Option 1 – Enforcement results in 50% creep i.e. fully effective control of paved areas	£392,232	£402,260	1.0	Cost set to £22,000 per year to give BCR = 1
Option 2 – Enforcement results in 75% creep is partially effective control of paved areas	£204,835	£203,949	1.0	Cost set to £12,000 per year to give BCR = 1

For replacement or new paving >5 sq m at domestic properties planning permission is required unless the applicant drains the area to a permeable surface.

Assuming 50% of creep is due to increasing paved areas, the maximum benefit that might be gained is to reduce creep damage by 50% as shown in Option 1.

However, this is unlikely to be possible in practice since the local planning authority will not know where non-compliant paving is taking place; a publicity campaign is unlikely to be fully effective and not all paving will be correctly drained.

Some enforcement is taking place at present – Ipswich Borough Council's enforcement policy included in Appendix 12.15. However, this is very much on a reactive basis only when reports of non compliance are made by neighbours or highway inspectors and no specific records are being made. No publicity or spot checks have been undertaken.

Option 2 assumes what is probably a more realistic reduction. Cost benefit analysis shows it is worthwhile spending £12,000 per year on a Suffolk wide publicity campaign, monitoring and increased enforcement.

A rough estimate indicates perhaps 450 property owners per year are likely to pave areas >5 sq m in Ipswich resulting in increased AAD of £100,000.

If the planning authority needs to become involved in 30% of these then about 130 site inspections/ checks would be needed – costing circa £12,000 pa.

Monitoring and recording would enable the effectiveness of enforcement/ publicity to be managed and the above estimates to be refined.

The publicity campaign would reduce damages across Suffolk.

The Draft Local Flood Risk Management Strategy for Suffolk[6] (consultation draft April 2012 – see link in section 13) includes an objective to *'prevent increased flood risk as a result of new development by preventing additional water entering existing drainage systems, wherever possible'*.

6. Available on www.suffolk.gov.uk/floodrisk

9 Flood and Coastal Erosion Resilience Partnership Funding Bid for SUDS Scheme at Lovetofts Drive

On 28 June 2011, Suffolk County Council requested the project to consider making a bid for Flood and Coastal Erosion Resilience Partnership Funding (more usually known as FDGiA) for the retrofit SuDS option at Lovetofts Drive. Anglian Water agreed to this as a possible OFWAT pilot study into the use of SuDS to relieve sewer flooding and reduce the numbers of properties at risk. The initial bid was duly completed and an outline submitted to the Environment Agency in July 2011.

The project manager documented the basis for the bid and summarised comments / conclusions regarding the validity and model stability problems and the missing results needed to improve the benefit cost ratio and chances of success.

A revised bid was formulated using interpolated flood levels derived as described earlier in section 8.7. This was submitted in October 2011 and confirmed by the Regional Flood and Coastal Committee.

At the time of writing (April 2012) the detailed project design and appraisal is being undertaken by Anglian Water, prior to construction planned in 2012/13. The funding bid will cover part of the cost – the remainder being funded by Anglian Water.

10 Implementation and Review

This section includes:

- A description of existing actions to be implemented.
- A new action plan for capital and maintenance works.
- A new action plan for providing public information and advice.
- A proposed action plan for future SWMPs in Ipswich.
- Proposals for prioritisation of SWMPs across Suffolk.
- Advice and information for planning and highway authorities.
- Advice for the Suffolk Resilience Forum and emergency planning.
- Advice regarding the Water Framework Directive.
- Recommendations for future review.
- Lessons for future SWMPs.

10.1 Existing Ipswich-wide actions

The above assume the Ipswich Drainage and Flood Defence Policy (2001) (13) remains in force. This and the measures listed below apply to various sub-catchments (not just the 4 detailed study areas) throughout Ipswich.

Ipswich Borough Council's policy (commenced 2001) promotes SuDS to ensure new developments do not increase flood risk, and sets standards for flood protection and SuDS. The policy is effectively a quality system that also includes monitoring, responding to and recording flooding.

As a result of the policy the borough also undertakes inspection and maintenance of its adopted SuDS (mostly at Ravenswood).

Grass filter strip and shallow infiltration basin at Ravenswood. No gully pots or grates to block

Ipswich Borough Council's policy is likely to need reviewing when the developing Suffolk Local Flood Risk Management Strategy is adopted in October/November 2012 and when the national sustainable drainage systems (SuDS) standards come into force and the SuDS Approval Body (SAB) is set up (likely to be 2013).

The review should include proposals for designation of significant flood assets.

Other policies, practises or strategies currently in place should remain. These were described in section 5.8

- Anglian Water's capital programme.
- Prioritised list of highway drainage schemes (in Appendix 12.5) should be maintained in this report.
- Road sweeping focused on flood risk areas with trees.
- Pre-emptive cleaning of critical gully grates following receipt of flood warnings.
- Gully pots cleaned regularly by the highway authority.
- Ongoing education / liaison with highway design teams regarding new speed humps, other road improvements to ensure these do not worsen flooding or perhaps alleviate flooding.
- Development Management Policy DM4 of IBC's Core Strategy and Policies Development Plan (Dec 2011) (13) described in section 10.6.

Other recommendations from the SFRA (June 2011) (pages 112 –120) (Italics denote those which have not generally been put into practise) include:

- *Regular inspection of ordinary watercourses.*
- Policy not to permit drainage of surface water into land drains or piped watercourses unless they have been constructed to an acceptable standard and have adequate capacity.
- Policy not to allow piping or filling in of watercourses.
- *In the LDF Green Corridors should include watercourses sited in gardens or open spaces.* (Core strategy 9.35 refers to safeguarding and protecting flow routes)
- *The existing embankment which retains Holywells Canal adjacent to LDF sites 70 and 44 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 commence.*
- 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.
- Policy to resist any plans to raise paving levels around the Wet Dock (IBC Core Strategy 9.42).
- Requirements for site specific flood risk assessments.
- Restrictions on basements in areas susceptible to surface water flooding (SFRA page 114 and IBC Core strategy 9.41).
- Flood risk management measures using SuDS described in the SFRA include guidance on what types of SuDS should be used and a geological map.
- *Opportunities for strategic SuDS – need to identify areas suitable for retrofit SuDS before spaces for water are lost e.g. verges alongside Heath Road (SuDS scheme implemented) and Bixley Road (highway authority aware but not implemented).*
- *Need to identify sites for additional storage for surface water in flood zone 3 probably close to Anglian Water tanks at Stoke Bridge, Alderman Road recreation ground and Yarmouth Road.*

10.2 Proposed action plan – capital and maintenance

- The present value (PV) costs shown below are based on capital works being implemented in 2013. Costs include design fees and 25% contingencies and, if appropriate, operating costs for 30 years.

- PV benefits are the expected reduction in flood damage costs over 30 years. PVs assume a discount rate of 3.75% p.a.
- For further information on methodology see section 8.6.2. For details of scheme costs or benefits see appendices 12.28 to 12.33.
- Pictures and plans showing some of the proposals follow the table.

Priority Area	Option	PV Cost	PV Benefits	PV Benefits	BCR	Comments	Suggested Lead	Suggested Funding Source	Proposed Timing
Lovetofts Drive/ Lagonda Drive	Complete appraisal for option 2					Re verify model, complete simulations for options.	AW / Alliance	FDGiA & AW	2012
	Option 2 - new SUDS along verges of Lovetofts Drive	£280,000	£386,561	£387,000	1.4	Pilot scheme for OFWAT	AW	AW and FGOGiA	2012
	Option 5 - Strategic SUDS including attenuation of Bury Rd highway drainage to N of Bury Rd	£100,000	£103,208	£104,000	1.0	Included in IBC Development Brief March 2012. Costs shown have been set to give BCR=1	LPA/SAB	Developer	Probably by 2022
Worsely Close / Ellenbrook	Complete modelling	£10,000				Additional simulations required to evaluate benefits for options 1 and 2 below. Preliminary Estimate for additional simulations.	SCC	Subject to FDGiA Bid and agreement with AW	2012/13
	Option 1 - Ensure outfall grille is <10% blocked	£41,000		?		BCR>1 if annual cost<£2,400 @PV £41,000)	Residents	Residents	2012/3
	Option 2 - Environmental Assessment as required by IBC parks	£2,000					SCC but work by IBC Parks	FDGiA	2012/13
	Option 2 - SUDS in Stone Lodge Park	£32,000	£523,826	£524,000	16.4	Benefits assume no flooding in 10 Yr RP	IBC or AW	Subject to FDGiA bid	2013/14
Ancaster Road / Burrell Road	Option 5 Bolt Down covers on combined system & Clean SW Outfall	£19,000	£71,409	£72,000	3.8	Flood water heavily contaminated with sewage debris	AW	AW	TBC- hopefuly 2012/13
	Appraisal to determine whether other long term solutions for the combined sewer flooding are viable						AW	AW	after 2013/14
London Road / Lavenham Road / Hadleigh Road	Option 1a - Deepen ditch to 300mm deep + maintenance of grille & SUDS - not including costs for maintaining SUDS or grille.	£5,000	£6,315	£7,000	1.4		IBC	Residents or SCC/SWMP	2012/13
Ipswich Wide - Creep Control - Supports Draft Suffolk FRM Strategy	Option 2 - Enforcement results in 75% creep ie partially effective control of paved areas	£205,000	£203,949	£204,000	1.0	BCR is 1 if costs are £12,000 per year .	SCC	SCC	Oct 2012 onwards

Proposed SuDS in Stone Lodge Park

This plan shows outline proposals super-imposed on the 30 year return period flood extent for the 'do nothing' scenario.

Flows from the SuDS are limited to 3 l/sec by a bar screen and orifice.

This plan shows lines representing proposed earth banks superimposed on the 30 year return period flood extent for the option scenario at 2040.

The lines indicate grassed banks up to 800mm high.

This plan shows floodwater overtopping the banks. An emergency bypass and weirs would be required to prevent breaching of the banks and ensure the orifice control can easily be maintained in the event of blockage.

Grille at Ellenbrook

To work effectively the grille needs to be no more than 10% blocked Do nothing models assume 50%.

It is proposed local residents assist in keeping this clear using a rake or by contacting Anglian Water.

Grille and ditch at Milden Road

It is suggested the ditch and grille would be best maintained by residents. (Ipswich Borough Council does not own the ditch). Alternatively, the council could undertake clearance of vegetation and use of an excavator – subject to agreement and funding.

10.3 Proposed action plan: public information and advice

An agreed aim for the SWMP was *"To provide public information and advice on flood protection to improve customer service".*

The agreed engagement plan also proposed a public exhibition/drop in session to consult local residents on the proposed action plan. This event will be used to provide:

- Flood maps – with limitations explained.
- Information on the developing Suffolk Local Flood Risk Management Strategy.
- Responsibilities – Anglian Water's take over of private drainage from October 2011.

- Responsibilities – who to report flooding or blockages to.
- Advice on flood risk management and water quality improvement measures that residents can take:
  - Not to obstruct flood paths
  - Not to wash cement, fat, oil, or pesticides down drains
  - Not to increase impermeable paving of gardens
  - Use flood resistance and resilience measures. E.g.: barriers, flood resistant materials, flood plans and insurance
  - Utilise weather warnings

10.4 Proposed action plan: future SWMPs for Ipswich

The overall cost effectiveness of the SWMP approach has been considered by adding into the previous action plan table the costs of developing the SWMP:

SWMP development funded by DEFRA	£75,000
SWMP funding from AW	[redacted]
SWMP funding from IBC	£11,000

Blanked out -commercially sensitive

Priority Area	Option	PV Cost	PV Benefits	PV Benefits	BCR	Comments	Suggested Lead	Suggested Funding Source	Proposed Timing
Lovetofts Drive/ Lagonda Drive	Complete appraisal for option 2	[redacted]				Re verify model, complete simulations for options.	AW / Alliance	FDGIA & AW	2012
	Option 2 - new SUDS along verges of Lovetofts Drive	£280,000	£386,561	£387,000	1.4	Pilot scheme for OFWAT	AW	AW and FGDGIA	2012
	Option 5 - Strategic SUDS including attenuation of Bury Rd highway drainage to N of Bury Rd	£100,000	£103,208	£104,000	1.0	Included in IBC Development Brief March 2012. Costs shown have been set to give BCR=1	LPA/SAB	Developer	Probably by 2022
Worsely Close / Ellenbrook	Complete modelling	£10,000				Additional simulations required to evaluate benefits for options 1 and 2 below. Preliminary Estimate for additional simulations.	SCC	Subject to FDGIA Bid and agreement with AW	2012/13
	Option 1 - Ensure outfall grille is <10% blocked	£41,000		?		BCR>1 if annual cost<£2,400 (PV £41,000)	Residents	Residents	2012/3
	Option 2 - Environmental Assessment as required by IBC parks	£2,000					SCC but work by IBC Parks	FDGIA	2012/13
	Option 2 - SUDS in Stone Lodge Park	£32,000	£523,826	£524,000	16.4	Benefits assume no flooding in 10 Yr RP	IBC or AW	Subject to FDGIA bid	2013/14
Ancaster Road / Burrell Road	Option 5 Bolt Down covers on combined system & Clean SW Outfall	£19,000	£71,409	£72,000	3.8	If lood water heavily contaminated with sewage debris	AW	AW	TBC- hopefuly 2012/13
	Appraisal to determine whether other long term solutions for the combined sewer flooding are viable	[redacted]					AW	AW	after 2013/14
London Road / Lavenham Road / Hadleigh Road	Option 1a - Deepen ditch to 300mm deep + maintenance of grille & SUDS - not including costs for maintaining SUDS or grille.	£5,000	£6,315	£7,000	1.4		IBC	Residents or SCC/SWMP	2012/13
Ipswich Wide - Creep Control - Supports Draft Suffolk FRM Strategy	Option 2 - Enforcement results in 75% creep ie partially effective control of paved areas	£205,000	£203,949	£204,000	1.0	BCR is 1 if costs are £12,000 per year ,	SCC	SCC	Oct 2012 onwards
	totals	£845,000	£1,295,268	£1,298,000	1.5				

Overall the SWMP is found to be cost beneficial, even if the benefits for Option 2 at Worseley Close are found to be marginal.

The SWMP should be extended to look at the next priority areas:

- **Swinburne Rd to Bramford Lane**
- **Coltsfoot / London Rd / Campion Rd**
- **Portman Road area**
- **Maidenhall Approach / Rapier St. / Belstead Avenue / Wherstead Rd**

These are all areas where sewerage systems predominate and so it is assumed Anglian Water would wish to be involved and contribute to undertake 2-d modelling.

Anglian Water's model already includes 2-d mesh for the Swinburne Road area, but this will need to be revised to allow floodwater to flow from Meredith Road under the canopy of a filling station and on to Norwich Road.

Costs for modelling and evaluating options for these four additional study areas are expected to be less than for the current SWMP since there would be no development costs or learning curve, no software purchase and no study area prioritisation. Use can be made of the current methodology, workbooks and this report.

Estimated cost is £ 77,000.

If this second stage SWMP is also found to be cost effective, then the SWMP should be extended further to include lower priority areas and so on, until the costs of SWMP development plus the cost of any flood alleviation measures exceed the benefits.

In each case this report should be updated rather than completely re written.

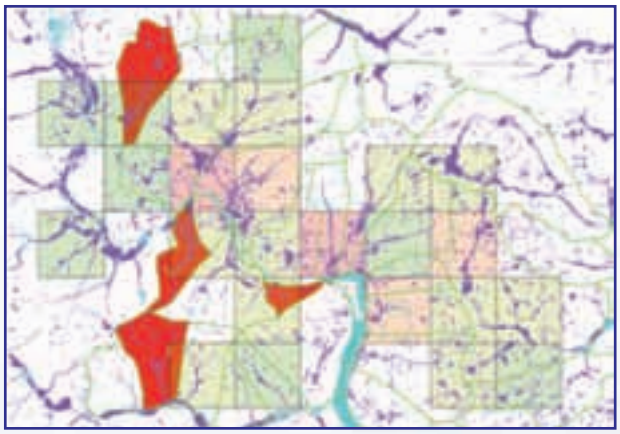
10.4.1 Possible Ipswich or Suffolk-wide action: raised floors

Existing data could be used to assess the likely affects of requiring floor levels in new buildings to be a certain minimum height above ground level.

Floor levels are normally only raised in new developments following a flood risk assessment. Enforcement could prove difficult, as development control and building control teams do not routinely check floor levels on site. Access requirements under part M of the building regulations may also be an issue in some circumstances.

10.5 Prioritisation of SWMPs across Suffolk

The map below shows the four detailed study areas, subject of this report, coloured in red, superimposed on the coloured squares from the Preliminary Flood Risk Assessment. The squares are coloured according to the number of properties within the flood map for surface water areas.



There appears to be little correlation between the top priority study areas and the coloured squares. This is because the SWMP prioritisation process considered many other factors.

The process for prioritising study areas described in section 6.11 should be followed across Suffolk, initially concentrating on areas where coloured squares are clustered together.

The PFRA identifies such clusters at Ipswich, Lowestoft, Bury St Edmunds, Haverhill, Newmarket and Sudbury. The first stage will be to map and identify study areas / catchments in these towns starting where the population at risk is highest.

The process for prioritising study areas detailed in section 6.11 should be followed for each cluster. Consideration should be given to updating the process using the newer flood maps for surface

water instead of the areas susceptible for surface water flooding maps.

10.6 Advice and information for planning and highway authorities

The Planning Inspectorate recently approved Ipswich Borough Council's Local Development Framework (LDF). It includes policy DM4 which confirms the council will apply the PPS25[7] flood policy hierarchy:

- Assess flood risk
- Avoid development in flood risk areas wherever possible
- Substitute
- Control – using SuDS and implement SWMP to manage flood risk

Where developments are affected by flooding shown in the strategic flood risk assessment (SFRA) a flood risk assessment is required even if the development is less than 1 Ha. Note – the Environment Agency's areas susceptible to surface water flooding is included in the current SFRA.

Developers preparing flood risk assessments should now make use of the new SWMP mapping. This will be more accurate than either of the Environment Agency surface water maps, but is only complete for localised areas. This report and the maps should be made available to planners and developers.

It appears the new flood map for surface water should replace the areas susceptible to surface water flooding map in the SFRA.

The SWMP report and flood maps should be included with other planning documents on the council's website.

Obstructions to the path of floodwater should not be permitted. Obstructions such as raised ground levels, speed humps, walls across the flow of water should not normally be permitted. Effectively this means designating mapped flood areas as 'blue corridors' (a concept promoted in the Suffolk Local Flood Risk Management Strategy).

SuDS designs may need to take into account the new SWMP flood maps. The SuDS Approval Body (when in place) or borough council will need to check that SuDS will not be affected by floodwater from off site.

10.7 Advice for the Local Resilience Forum

Flood hazard maps have also been produced for each of the four priority areas.

"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.

The formula below is used to calculate hazard ratings across flooded areas. The variation in hazard rating is mapped and can be used in considering the safety of developments.

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.

The following hazard map is for a 100 year return period at 2040 ('do nothing' scenario) at Gusford Community School, Sheldrake Drive where the highest hazards to people are predicted.

7. Now largely incorporated into the National Planning Policy Framework technical guidance

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

Depth (m)	Debris Factor	Velocity (m/s) 0	0.1	0.2	0.25	0.5	1	1.5	2	4	4.5	5
0.05	0.5	0.52	0.53	0.54	0.54	0.55	0.59	0.60	0.62	0.72	0.75	0.79
0.1	0.5	0.59	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
1.5	1	1.95	2.14	2.33	2.42	2.90	3.95	4.90	5.75	8.55	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

Below: Putting in new drainage pipe

A visit to the school revealed flooding has been a problem even though no reports have been received by the borough council. The school management has prevented water entering the school buildings by blocking off doors on the west side of the building.

The maps show small areas where the flood depth reaches 300mm with a speed of flow 0.5m/sec equating to a hazard rating of 1.3 or a "danger to most people".

This flooding will most likely result from a storm with a short duration – an hour or less – so floodwater will rapidly appear and disappear in minutes rather than hours.

It is suggested the school management are made aware of the severity of the hazard that flooding may occasionally present, and be encouraged to plan evacuations to avoid this area. The school management should also be encouraged to react to severe weather warnings now available over the web.

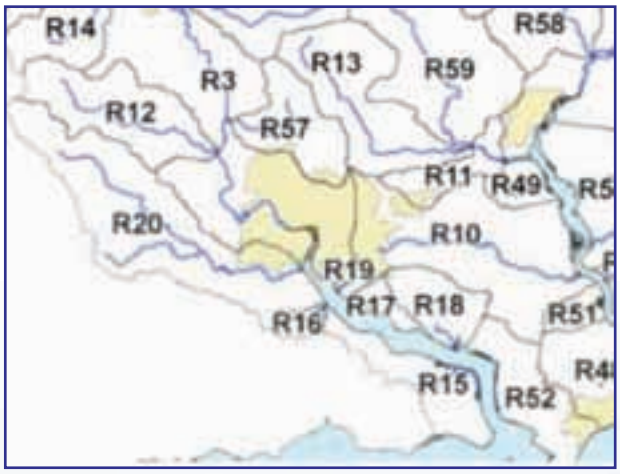
No critical infrastructure was found to be at risk of flooding within the areas studied by the SWMP.

10.8 Water Framework Directive

EEC directive 2006/60/EC is designed to integrate the way water bodies are managed across Europe. It requires all inland and coastal waters to reach good ecological status by 2015 through a catchment based system of River Basin Management Plans. These incorporate a programme of measures to improve the status of all water bodies (seas, rivers, lakes, etc).

The Anglian Region River Basin Management Plan provides example actions for local authorities – 'implement SWMPs' and 'promote use of SuDS , including retrofitting'.

Water quality standards and targets are listed in the plan for the local water bodies shown below:



Water body	Reference on map	Current Status	Target
Westerfrield Watercourse	R57	Good	Good
Orwell	R15	Good	Good by 2015
Orwell	R16	Moderate	Target is Good by 2017 but disproportionately expensive, technically "infeasible"
Orwell	R17	Moderate	Target is Good by 2017 but disproportionately expensive, technically "infeasible"
Orwell	R19	Good	Good
Mill River	R10	Moderate	Good chemical by 2015 Good rco 2027
Finn	R13	Poor	Good by 2027
Finn	R11	Moderate	Good by 2027

No relevant specific measures required to improve water quality are shown in the RBMP for these water bodies.

The SWMP Action plan does not include schemes specifically designed to improve water quality. However an agreed aim of the SWMP was to *"Seek Water Quality Improvements"* to assist with the River Basin Management Plan.

Most of the actions involve the use of SuDS, which would be cost-beneficial. The ditch improvement proposed at Chantry is more akin to maintenance than capital works and would very slightly increase peak flows into Anglian Water's surface water system. However, this would also reduce the flood flow that enters the combined sewerage system at Hadleigh Road. Here there is a combined sewer overflow structure (which occasionally discharges dilute sewage to the Gipping) so this would probably also result in a small improvement in river quality.

Control of creep, put forward as a SWMP action, could also prove beneficial.

10.9 Review

Under the Floods and Water Management Act, Suffolk County Council will have responsibility for monitoring and reporting implementation of the action plan.

Progress will be regularly reviewed to check whether actions have been undertaken satisfactorily or new legislation or data require the plan to be updated. As with the Suffolk Local Flood Management Strategy, this review will take place within a year and on a regular basis thereafter, particularly as additional SWMP studies are undertaken and the action plan is expanded.

The Suffolk Flood Risk Management Partnership will continue to work together to discuss progress and the Suffolk Joint Flood Scrutiny Panel will assist them in this respect.

According to the Defra guidance on SWMPs the plan should be formally reviewed and updated once every six years as a minimum but there are circumstances which might trigger an earlier review such as:

- Occurrence of flooding
- Additional data or modelling becoming available which may alter the understanding of risk
- Outcome of investment decisions by partners requiring revisions to the action plan
- Additional development or other changes which affect surface water flooding

Long term recording, monitoring and review of flood records should also be undertaken, as planned in the draft Suffolk Local Flood Risk Management Strategy. This should make use of historic records to set the baseline data.

10.10 Lessons for future SWMPs

1. Simulation results from a wide range of return periods are needed to properly assess options. Interpolation of results is sometimes possible but time consuming.
2. Modelling partially blocked gullies by setting flood type in ICM to 'gully 2d" enables more accurate modelling of highway runoff and may provide useful information on responsibilities.
3. When estimating the cost of maintenance options there is a problem deciding how frequently maintenance will be needed and how to represent the effects of maintenance in a model.
4. Records of how sediments build up or grilles block during maintenance intervals, together with costs, would assist in evaluating maintenance options.
5. The workbooks used in this SWMP for cost benefit analysis should be used for future SWMPs.
6. LiDAR data is unreliable in areas covered by trees and dense undergrowth and is unlikely to represent small watercourses narrower than the LiDAR resolution.
7. Small watercourses should be represented as channels in 2-d models, with channel depth determined by site survey relative to surrounding valid LiDAR levels. The use of

a linear connection between mesh and channel should be investigated rather than using dummy nodes.

8. Floor heights above ground level are difficult to assess and there is little point in being too precise due to inaccuracies of LiDAR and because 2-d models output average ground and water levels at each mesh element. Floor heights above average ground level at the relevant mesh element were estimated based on brickwork courses.

9. Estimated flood depths and damage costs should not be provided or published for specific properties but over a wide area. These will provide the best estimate of total damage costs.

10. Where areas are identified as being at significant flood risk, hazard maps should be produced and residents/emergency planners informed.

11 Proposals for Management and Maintenance of Data

Anglian Water will archive and keep the sewer models used for this study.

All other data is currently saved on Ipswich Borough Council's Nas06 Server. GIS maps and workspaces are saved on the GIS server – backed up daily. This will be transferred to Suffolk County Council as appropriate.

Copies of the final version of this report and appendices will be saved on the SharePoint system and available on both the Suffolk County Council website (**www.suffolk.gov.uk/floodrisk**) and Ipswich Borough Council's website alongside the SFRA and LDF documents.

12 Appendices

Appendices will be available on websites and the SharePoint site.

13 References

1	DEFRA SWMP Guidance, March 2010	**www.defra.gov.uk/publications/files/pb13546-swmp-guidance-100319.pdf.**
2	Planning Policy Statement 25 (PPS25), Communities and Local Government Revised March 2010	**www.communities.gov.uk/documents/planningandbuilding/pdf/planningpolicystatement25.pdf**
3	Ipswich Drainage and Flood Defence Policy, 2002	**www.ipswich.gov.uk/downloads/Ipswich_Flood_Defence__Drainage_Policy_rev_Aug_20091.pdf**
4	Building Regulation Part H	
5	Ipswich Local Development Framework	**www.ipswich.gov.uk/site/scripts/services_info.php?serviceID=72**
6	Ipswich Tidal Barrier Modelling Report, Halcrow, April 2009	
7	IBC Level 2 Strategic Flood Risk Assessment, May 2011	**www.ipswich.gov.uk/site/scripts/download_info.php?downloadID=1103**
8	WaPUG User Note 40, Couple 1D – 2D Modelling in Urban Areas	**www.ciwem.org/media/144958/WAPUG User Note 40 Overland flow v01 091104.pdf**
9	UKWIR Report, 10/WM/07/14, Impact of Urban Creep on Sewerage Systems	**www.ukwir.org/web/ukwirlibrary/93273**
10	M Allitt WaPUG Paper, Investigations into Urban Creep at 5 Cities, 2009	**www.ciwem.org/media/53157/Autumn2009_Paper_9.pdf**
11	CIRIA Report 156, Infiltration Drainage – Manual of Good Practice	
12	Revitalisation of the FSR/FEH rainfall-runoff method	**www.ceh.ac.uk/feh2/FEHReFH.html – defra**
13	WaPUG User Note 21, Catchment Data for the Wallingford Procedure Percentage Runoff Model	**www.ciwem.org/media/144861/WAPUG_User_Note_21.pdf**
14	WAPUG Code of Practice for the Hydraulic Modelling of Sewer System v3.001, Nov 2002	
15	Suffolk Preliminary Flood Risk Assessment, 2011	
16	Flood Defence Grant in Aid (FDGiA) Guidance	**www.environment-agency.gov.uk/research/planning/135234.aspx**

17	Multi Coloured Handbook – The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques, Flood Hazard Research Centre 2010	
18	WaPUG IUD Modelling Guide Rev1 v28	**www.ciwem.org/media/44495/WaPUG_IUD_Modelling_Guide_Draft_Rev1_v28_(June_09)_v01-001.pdf**
19	Flood Risks to People Phase 2 FD2312/TR2. DEFRA and Environment Agency (March 2006)	**http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=FJPProjectView&Location=None&ProjectID=12016&FromSearch=Y&FieldOfStudy=12&SearchText=FD2321&ShowDocuments=1&SortString=ProjectCode&SortOrder=Asc&Paging=10&FJP=1**
20	EU Water Framework Directive, EEC directive 2006/60/EC	**http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0060:EN:NOT**
21	Flood Risk Regulations 2009	**www.legislation.gov.uk/uksi/2009/3042/contents/made**
22	Anglian River Basin Management Plan, December 2009	**www.environment-agency.gov.uk/research/planning/124725.aspx**
23	Suffolk Local Flood Risk Management Strategy Draft Feb 2012	**www.suffolk.gov.uk/assets/suffolk.gov.uk/Emergency and Safety/Civil Emergencies/2012_01_23 Suffolk LFRMS.pdf**

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