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Cambridge City

Strategic Flood Risk Assessment

Final Report

February 2006

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Strategic Flood Risk Assessment

Final Report

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Glossary

AOD	Above Ordnance Datum
AVM	Automated Voice Messaging
CCC	Cambridge City Council
COW	Critical Ordinary Watercourses
DSM	Digital Surface Model
DTM	Digital Terrain Model
EA	Environment Agency
EFO	Extreme Flood Outline
FEH	Flood Estimation Handbook
FRA	Flood Risk Assessment
FSR	Flood Studies Report
FW	Foul Water
GIS	Geographical Information System
IDB	Internal Drainage Board
IFM	Indicative Flood Map
IFSAR	Interferometric Synthetic Aperture Radar
LAMP	Local Asset Management Plan
LiDAR	Light Detection and Ranging
MoD	Ministry of Defence
NFCDD	National Flood and Coastal Defence Database
NIAB	National Institute of Agricultural Botany
OS	Ordnance Survey
PPG25	Planning Policy Guidance Note 25
PPS25	Planning Policy Statement 25
QMED	Median Annual Maximum Flood (m^3/s)
SAR	Synthetic Aperture Radar
SCDC	South Cambridgeshire District Council
SFRA	Strategic Flood Risk Assessment
SoP	Standard of Protection
SuDS	Sustainable Drainage Systems
SW	Surface Water
WwTW	Wastewater Treatment Works

Acknowledgement:

All data provided by the Environment Agency which has been used in the compilation of this report remains the property of the Environment Agency and must not be relied on or used for any other project without the prior written authority of the Environment Agency being obtained.

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1 Introduction

1.1 Study Objectives

This report presents the findings of the Strategic Flood Risk Assessment (SFRA) carried out by Mott MacDonald for Cambridge City Council (CCC).

The work has been undertaken to provide an assessment of the risk of flooding to specific growth areas within Cambridge City and its implications for land use planning. In addition, the SFRA sets the criteria with respect to flood risk for the submission of planning applications in the future and for guiding subsequent development control decisions.

The SFRA has specific objectives, to:

- provide a detailed and robust assessment of the extent and nature of the risk of flooding in the areas likely to accommodate significant growth in the next plan period (to 2016);
- ensure that Cambridge City Council meets its obligations under the Planning Policy Guidance Note 25: Development and Flood Risk (PPG25), and its successor, Planning Policy Statement 25 (PPS25).

The guidance provided by the Environment Agency (the Agency) to Local Planning Authorities for Strategic Flood Risk Assessments explains that the purpose of such assessments is:

> "To identify the areas within a development plan that are at risk of flooding. To identify and detail those factors that are relevant to current and future flood risks and to outline polices to be applied to such areas to minimise and manage that risk."

Data used in this study has been collected on the basis that it is the best available within the timescale for the Local Plan. It is inevitable that the outputs from a study such as this will require updating as additional and more accurate data becomes available.

In accordance with the project brief and the accepted Mott MacDonald proposal, the study was carried out in two stages. Stage 1 comprised an extensive data collection exercise and culminated in the production of a draft Inception Report in early June 2005. This report was discussed with the Council and the Agency, at a meeting in July 2005. The report set out the findings of the inception study with respect to the adequacy of data to carry out the full SFRA, and the proposed methodology for analysis and production of the necessary flood risk mapping.

The Stage 2 study commenced at the beginning of July 2005 and proceeded with the overall strategic assessment of the flood risk, following the Environment Agency's guidance for Local Authorities Issue 4(b).

A draft Final Report was issued in August 2005, on which comments were received from both the Council and the Agency. This revised version of the Final Report takes account of issues raised in those comments.

1.2 Cambridge City

Topography and Hydrology: The City, as shown in Figure 1.1, covers an area of almost 41 km^2. The City is generally low-lying and slopes away from the chalk uplands to the south, at a maximum of around 40 m AOD on Limekiln Road. The land descends towards the Fenlands north of the City, where the level drops to less than 5 m AOD at the north-east corner of the city, near Fen Ditton. The City drains to a single river basin: the River Cam & Granta. This flows through the City from the south-west between Trumpington and the M11, through the centre of the City and then north-east past Fen Ditton towards its confluence with the Great Ouse at Upware. The Environment Agency Anglian Region Central Area, based in Brampton, is responsible for the operation and maintenance of the Main River flood defence assets and the flood warning for the Cam & Granta. Bin Brook, which flows into the City at the Stone Bridge on the Barton Road as far as its confluence with the River Cam near St John's College is also designated as Main River, largely due to the risk of flooding to properties on Grange Road. There are no Internal Drainage Boards (IDBs) within the City boundaries.

Geology: Cambridge City consists of four levels of free-draining terraces of glacial gravels over poorly draining dark brown clay. The present course of the River Cam has changed a number of times since the last glacial retreat and has left a number of buried and unrecorded silted river and tributary channels across the area[1].

Drainage: Aside from surface watercourses, much of the Cambridge City catchment is drained by a series of underground sewers, which outfall into surface watercourses including the River Cam, Bin Brook and the Awarded Watercourses. Foul water sewers take all waste water from the city to the Cambridge Wastewater Treatment Works (WwTW) at Milton. The older parts of the city, particularly in the more central area of Market Ward, drain into combined foul and surface water sewers, which can create overload problems at the WwTW.

Watercourse Maintenance: The responsibility for minor watercourses and flood defence assets lies with different organisations, e.g. landowners, Parish Councils, City Council, Anglian Water and the Environment Agency. The City Council is directly responsible for a number of watercourses defined as Awarded Watercourses or Awards, with a total length of some 23 km (15 miles). None of these watercourses have yet been designated Critical Ordinary Watercourses (COWs). This latter designation refers to watercourses identified by the Environment Agency and Local Authorities as posing a particular risk of flooding to property. The City Council is supporting the Environment Agency's initiative to have a number of these COWs en-mained, which will give the Agency specific powers with respect to flood risk.

Development: Cambridge City is rapidly expanding as a centre for technology and innovation and, along with surrounding South Cambridgeshire District, makes up the Cambridge Sub-Region, one of the fastest growing areas of East Anglia[2]. The Cambridgeshire Structure Plan 2003 sets a target of 47,500 additional homes to be built in the Cambridge sub-region between 1999 and 2016, of which 12,500 are to be constructed within Cambridge City. Much of this extra accommodation will be located on the fringes of Cambridge and, in some cases, will straddle Cambridge City and South Cambridgeshire District. Retail, commercial and industrial developments, together with the planned expansion in housing, constitute development areas which, in the City, are known as Areas of Major Change. The City Council has identified six Areas of Major Change, given in Table 1.1 below:

[1] p. 4, 'Cambridge Catchment – LAMP Report', FaberMaunsell, February 2003
[2] Cambridge Adopted Local Plan, 10.1, 21 November 1996

Table 1.1: Areas of Major Change

	Area of Major Change
1.	Cambridge East
2.	Southern Fringe
3.	Northern Fringe
4.	Land between Madingley Road and Huntingdon Road
5.	Land between Huntingdon Road and Histon Road
6.	Station Area

1.3 Definition of Flood Risk

In accordance with the latest guidance from the Environment Agency, the risk of a particular magnitude of event is presented in this report as the percentage likelihood of the event occurring in any one year. Thus a 1% event is that which has a 1% probability of occurring in any one year and a 0.1% event is that which has a 0.1% probability of occurring in any one year.

The equivalents in terms of "return period" are 1 in 100 years for the 1% event, and 1 in 1000 years for the 0.1% event.

1.4 Data Collection and Verification

Data collected for the Strategic Flood Risk Assessment is outlined in the following chapters:

- Ground Surface Data
- Main River Data (Environment Agency maintained – includes Rivers Cam & Granta and Bin Brook)
- Awarded Watercourse Data
- Flooding from Surface and Foul Water Sewers

A brief desk study has been made of the sewerage network, both surface and foul water sewers. Particular attention has been paid to the Station Road Area of Major Change where there are no Main Rivers or Ordinary Watercourses, but where sewer flooding could be an issue.

1.5 Interface with other Flood Risk Products

It is recognised that this SFRA is being carried out at a time when a number of other flood risk products are under development. In October 2004, the Environment Agency replaced its Indicative Flood Map (IFM), which had been in use for the past five years, with a range of new products covering England and Wales. Of these products, the Flood Zone Maps are of particular relevance to the SFRA work, since they show flood risk in terms of the PPG 25 Zones, as defined in Section 2 below. The Agency issued the first edition of the Flood Zone Maps to Local Planning Authorities in June 2004.

1.5.1 Differences between Agency Flood Zone Maps and SFRA Maps

The principal differences between the Agency Flood Zone Maps and the SFRA maps is that the former do not take account of flood defences, whereas for the SFRA the effect of defences is specifically included; also the SFRA identifies the Functional Floodplain on modelled Main Rivers.

The Functional Floodplain within the SFRA is taken as the extent of the 10% flood event, and therefore corresponds to Flood Risk Zone 3c in PPG25.

In addition, there will be some differences arising from the different methodologies used to derive the zone boundaries. The SFRA has used results from detailed hydrological and hydraulic modelling of Main Rivers to obtain flood levels, and has combined this with ground level information which is predominantly sourced from LiDAR techniques giving a vertical accuracy of +/- 15cm. For Ordinary and Awarded Watercourse in areas of particular concern, the SFRA flood extents have been derived by detailed site investigations.

For the Agency Flood Zone maps, the basic zoning has been based on a relatively coarse national hydrological model combined with a new national DTM sourced from Interferometric Synthetic Aperture Radar (IFSAR) techniques, giving a vertical accuracy of +/- 50cm. However, where better modelling is available, the Agency have included the outputs in the Zone 3 extent, in the many cases this is the same modelling as used in the SFRA, and therefore the outputs should be similar.

1.5.2 The Extreme Flood Outline

The consultant's proposal recommended that the 0.1% (1000-year) flood extent outline for the Strategic Flood Maps (Flood Zone 2) be taken from the Environment Agency Extreme Flood Outline (EFO). The Environment Agency emphasise the need for outputs of the SFRA to be compatible as far as possible with future Agency mapping and the National Flood and Coastal Defence Database (NFCDD). Since the extreme flood outline forms an important part of the Agency's new Flood Risk Mapping Strategy, there is a very strong case for its use in the SFRA. The EFO (Flood Zone 2 extent) is shown on the 1:10,000 scale flood risk maps which accompany this report.

The EFO takes no account of defences, as most man-made features have been removed from the digital terrain model (DTM) on which it is based. However, it is considered that this will make no significant difference to the 0.1% outline, since during such an event almost all defences would be completely overwhelmed. The 0.1% outlines also take account of substantiated historic flood information held by the Agency.

The EFO has been produced for the Agency by JBA Consultants. It uses a specially developed modelling technique called J-Flow to derive flood extents based on Flood Estimation Handbook (FEH) derived hydrology and a 2-dimensional flow spreading algorithm. The automated mapping process relies on a DTM created from the IFSAR survey undertaken by Intermap for the whole of England and Wales. This product is known as NextMap. The 0.1% outlines shown on the Cambridge City SFRA maps take account of modifications carried out by the Agency whereby all substantiated historic flood information held by the Agency has been included.

1.6 Project Outputs

The principal project output is the mapping of all areas within Cambridge City showing land classified to PPG25 Zones as set out in Table 6.1 below. Specific attention has been given to the six designated Areas of Major Change.

The maps accompanying this report are at 1:10,000 scale and show land classified to the appropriate PPG 25 Flood Risk Zone 1, 2, 3a, 3b and 3c. Maps have been produced for the present day (2005), and for 50 years time (2055) with the impact of climate change on river flows. The maps have been produced digitally with O.S. 1:10,000 scale mapping as a backdrop. There are six sheets covering the City. Hard copy versions of the present day and the 2055 maps have been prepared to accompany this report. A key plan to the map tiles is given as Appendix F and with the 1:10,000 maps. The maps are supplied in a GIS format compatible with MapInfo & ESRI GIS, and are attributed to suit Environment Agency and Cambridge City Council requirements. The maps show O.S. grid co-ordinates and are complete with a legend and title block, to the agreed style.

The Flood Risk Zones are delineated on the 1:10,000 maps by a colour scheme previously agreed with the Environment Agency. Light blue is used to show Zone 3 in areas where new mapping has been developed for the SFRA from either new or existing detailed modelling. Yellow is used for Zone 3 in areas assessed using engineering judgement; and light grey is used where the flood extents have been taken directly from the Agency Flood Zone Maps. The differentiation between Zone 3a (developed areas) and Zone 3b (undeveloped and sparsely populated areas) can be seen from the underlying O.S. mapping. Zone 3c (the functional floodplain) is shown as cross-hatched green shading.

Zone 2 is shown as dark grey and has come from the Agency Flood Zone Maps. Other layers incorporated in the GIS include the forecast 1% floodline for 2055, which has been added as a dark blue extension to those areas of Zone 3 where new mapping has been developed for the SFRA from either new or existing detailed modelling. All areas at less risk than Zone 2 are classified as Zone 1.

The SFRA outputs should be used in conjunction with the Flood Zone Maps, given that the Flood Zone maps include floodplain assessment on watercourses not covered by the SFRA. The Flood Zone Maps are intended for planning consultation purposes only, and the Agency's 'Flood Map' remains the main public dataset. The 'Flood Map' will include the locations of some defences and areas that benefit from new/high standard flood defences, when each has been thoroughly assessed.

This report accompanies the 1:10,000 scale maps and explains how the SFRA results were obtained.

N

River Cam

Bin Brook

River Cam

First Public Drain (East)

First Public Drain (West)

Madingley Road Ditch

Coldhams Brook

East Cambridge Main Drain

March Lane Ditch

Cherry Hinton Brook

Dawls Lane Ditch

Snobbs Stream

Fulbrooke

Vicars Brook

Hobsons Conduit

Hobsons Brook

Long Road Ditch

1

2

2

3

4

5

6

Location of Cambridge City within East Anglia

Legend

- Main River
- Awarded Watercourse
- Area of Major Change

Areas of Major Change

1 Cambridge East
2 Southern Fringe
3 Northern Fringe
4 Land Between Madingley Road and Huntingdon Road
5 Land Between Huntingdon Road and Histon Road
6 Station Area

Project Title

Cambridge City Council Strategic Flood Risk Assessment

Map Title

Cambridge City Council Area Figure 1.1

Mott MacDonald

CAMBRIDGE CITY COUNCIL

Scale: 1:40,000

February 2006

2 Ground Surface Data

2.1.1 LiDAR

Environment Agency LiDAR data covers most of the Areas of Major Change, with only isolated gaps in the coverage. Alternative level data, in the form of Nextmap SAR data was used to fill in any gaps in the LiDAR data.

Much of the LiDAR data that is available has either been filtered using an automatic filtering process, or is only available in unfiltered form. The filtering process can on occasion falsely remove features which would act as flood embankments, or even raise the underlying topography. The decision was therefore taken to work from LiDAR data in its unfiltered form. Although the use of unfiltered LiDAR creates some extra work in the mapping process, it was used to ensure that any natural or artificial embankments remain in the data. Features which do not act as a flood defence but are identified as high points in the LiDAR (e.g. wooded areas) were identified in a reviewing process of the mapping.

The LiDAR sensor provides a very dense sample of ground levels, which are then converted into a grid. The resolution of these grids is determined by the density of the samples, in general the grid resolution is 2 m. Taken together with the accepted vertical accuracy of +/- 15 cm, this indicates that in the areas covered, the LiDAR data provides a good representation of ground surface for the required flood zone mapping.

2.1.2 NextMap Digital Terrain Model

In areas which are not covered by the LiDAR data, the NextMap geo-referenced IFSAR data has been used. The vertical accuracy quoted by the IFSAR data suppliers Intermap for the Anglian Region is 0.5 m for the Digital Surface Model (DSM) and 0.7 m for the Digital Terrain Model (DTM) at a ground resolution of 5 m.

The DSM shows the first pulse return, and includes all returns from vegetation and flood embankments. The DTM is the processed form of the DSM with most features removed from the data. However some larger features remained after processing.

3 Main River Flood Data

3.1 General

The principal sources of data for obtaining the Main River flood extents are the various numerical modelling studies and flood mapping exercises which have been carried out over the last few years for the Agency by a number of consultants. These data sources are summarised in Table 3.1 below. A number of modelling reports covering Main Rivers not within the City boundaries, including Bourn Brook, the Rivers Cam and Granta upstream of the City boundary and the River Rhee, have also been used to aid the hydrological modelling of the River Cam to Flood Estimation Handbook standards.

Table 3.1: Main River Flood Data Sources

Watercourse	Reach covered	Date of Report	Report Authors and Software Used
River Cam	Byron's Pool to Jesus Green	May 1999	Mott MacDonald, HYDRO-1D dynamic
River Cam	Jesus Green to Bait's Bite	May 1999	Mott MacDonald, HYDRO-1D dynamic
Bin Brook	Barton Road to Cam Confluence	July 1999	Mott MacDonald, HYDRO-1D dynamic
River Cam & Granta	Henham to Byron's Pool (Cam) Bartlow to Cam Confluence (Granta) Arkesden to Cam Confluence (Wicken Water)	Nov 2004	Halcrow, ISIS
River Rhee	Barrington to Cam Confluence	Dec 2003	Halcrow, ISIS
Bourn Brook	Caxton to Cam Confluence	Jun 2003	Atkins, Mike 11
Bin Brook	Stone Bridge (Barton Road) to River Cam confluence	to be published	Halcrow, ISIS

3.2 River Cam

From 1996 to 1999 Mott MacDonald Ltd carried out modelling of the Cam. The most recent work prior to this SFRA study extended the model to cover the reach between Byron's Pool at Granchester, through Cambridge City, downstream as far as Bottisham Lock at Waterbeach. Details are given in the Report of May 1999. Other reports assess the impact of modelling on specific reaches including Byron's Pool to Jesus Green, Jesus Green to Bait's Bite and Bait's Bite to Bottisham Lock. In 2002, floodplain cross-sections were extended for a Flood Risk Assessment of a proposed development in Waterbeach and the model has also been used to assess the impact of another proposed development at the former Simoco site in Cambridge.

The 1999 hydraulic model uses HYDRO-1D software. The hydrology is based on the Flood Studies Report (FSR) methodology, which has since been superseded by the Flood Estimation Handbook (FEH). As part of this SFRA, the hydrological input to the model has been updated to take account of the Flood Estimation Handbook and of additional hydrometric data collected since the 1999 model was developed. See Appendix C for a summary of how the hydrology was updated using the FEH.

3.3 Bin Brook

The Environment Agency commissioned a study of Bin Brook from Halcrow in 2004. The report from this work is still under review and results from the model are not yet available. However, Mott MacDonald included Bin Brook from Stone Bridge on Barton Road as far as its confluence with the River Cam as part of the River Cam model through Cambridge (see Section 3.2 above). This model was constructed as an Addendum to the River Cam Improvements Study, Phase 2, in May 1999 due to the threat of flooding in Gough Way – 22 houses were flooded in May 1978 and a further 9 houses were surrounded by flood water. The catchment is ungauged and the hydrology was estimated using the Flood Studies Report and comparison with other local gauged catchments. For the SFRA, this hydrology has been updated using FEH methods.

4 Awarded Watercourse Data

Cambridge City Council is responsible for a large number of watercourses, which are designated as Awarded Watercourses and run through built-up areas at risk of flooding – many of which affect Areas of Major Change, e.g. Hobson's Brook runs through the Southern Fringe, and Coldham's Brook and the East Cambridge Main Drain run through the East Cambridge Area of Major Change. Cambridge City contains approximately 15 miles or 23 km of Awarded Watercourses, several of which have the potential to flood property.

The boundaries and extents of the designated Areas of Major Change are regularly reviewed by the Council in order to respond to potential changes in development and planning, so are large enough to cover a variety of potential site options. The six sites for major development considered in this study are listed in Table 1.1 and shown on Figure 1.1.

Hobson's Brook has been computationally modelled by Atkins Consultants from the culvert under the railway near Nine Wells as far as Long Road. The 100-year levels from this modelling show that the Brook does not go out-of-bank. The flood extent mapping reflects these findings.

Details of the Awarded Watercourses studied are given in Table 4.1 below. In some cases, the watercourse does not run within the boundaries of the Areas of Major Change but is close enough to have a potential impact in terms of flood risk.

The other watercourses listed in Table 4.2, but not surveyed include a number of small watercourses within the River Cam floodplain (Lama's Land Ditches, Queen's Green and Sheep's Green Ditches) and watercourses surveyed as part of other surveys (Cherry Hinton Hall Ditch and Daws Lane Ditch were investigated as part of Cherry Hinton Brook survey).

During the Study, investigations have been undertaken into flooding history and any specific flood assessments undertaken for these watercourses. All are covered by the different forms of ground surface data.

Reports on the investigation of each of these watercourses are included in Appendix B.

Table 4.1: Awarded Watercourses Identified for Appraisal

Area of Major Change	Watercourse Name	Total Length (metres)	Culverted Length (metres)
Cambridge East	March Lane Ditch	525	-
	East Cambridge Main Drain (nearby)	2,415	10
	Coldham's Brook (nearby)	2,395	230
	Cherry Hinton Brook (nearby)	1,850	5
Southern Fringe	Hobson's Brook	3,365	65
	Long Road Ditches (adjacent)		
	Vicar's Brook (downstream)	1,740	40
Northern Fringe	1st Public Drain East	2,714	109
Madingley Road and Huntingdon Road	Madingley Road Ditch	485	-
Huntingdon Road and Histon Road	8th Public Main Drain	80	-
	1st Public Main Drain West (nearby)	265	-
Station Road	*No Awarded Watercourses*	-	-
	Total	13,834	459

Cambridge City Council are currently in negotiations to have a number of their Awarded Watercourses designated as Critical Ordinary Watercourses (COWs). If agreement can be reached then these will be enmained and therefore maintained by the Environment Agency. These watercourses are given in Table 4.2 below.

Table 4.2: Watercourses proposed for Enmainment by CCC

Watercourse	Length of Open Watercourse (m)	Length of Culverted Section (m)
1st Public Main Drain	2,714	109
Cherry Hinton Brook	1,850	5
Cherry Hinton Hall Ditch	500	100
Coldham's Brook	2,395	230
Daws Lane Ditch	270	
East Cambridge Main Drain	2,415	10
Hobson's Brook	3,365	65
Lama's Land Ditches	155	
Queen's Green	345	
Sheep's Green Ditches	820	
Thorpe Way Ditch	190	
Vicar's Brook	1,740	40
TOTAL	16,759	559

Madingley Road Ditch, Long Road Ditches and March Lane Ditch are not targets for enmainment since they are not considered to pose a significant flood risk to property.

5 Flooding from Surface and Foul Water Sewers

The Cambridge Catchment Local Asset Management Plan (LAMP) Report (Reference 13) produced by Faber Maunsell in February 2003 gives a good indication of flooding problems within the foul and surface water sewerage systems of Cambridge City. This report lists flooding incidents from foul water, surface water and combined sewer networks in more detail.

5.1 Surface Water Sewer Problems

Models developed by Binnie and Partners in the early 1990s of various surface water catchments within Cambridge City identified a number of pinch points where flooding occurs. The surface water drainage networks and the principal areas at risk from flooding are summarised in Appendix D. This summary is not exhaustive as not all surface water sewers have been modelled.

- **East Cambridge Main Drain** – Surcharging was noted as a regularly occurring problem in this drain in the Mill Road area and two options were under consideration to relieve the problem. One involves duelling the existing sewer along Mill Road, while the second option would lead to the construction of a parallel sewer to the north along St Philip's Road. The status of these projects is not currently known.

  An option was also proposed by Binnie and Partners to reduce the potential for flooding in Ashbury Close by diverting the Coleridge Road sewer into the Davy Road sewer.

  There are also potential flooding issues in a number of other locations identified by the Binnie and Partners' WALRUS model (see Appendix D3) including Cherry Hinton High Street, Cherry Hinton Road, Marshall Road and Rustat Road.

  Since the model was completed, the Park and Ride on Babraham Road has been constructed, increasing flows along the central axis of the Perne Road/Brooks Road sewer. The LAMP Report recommends that the model should therefore be rerun with increased flows[3].

- **First Public Main Drain** – Principal flooding problems occur in the Halifax Road, Richmond Road, Oxford Road area. The solution proposed by Binnie and Partners was the construction of an overflow from the corner of Halifax Road to an adjacent branch in the recreation ground.

- **Other Surface Water Sewers** – A further three sewers were modelled by Binnie and Partners in 1989, to assess the closure of overflows into the foul water system to reduce the possibility of overload in the foul water system. The models revealed the vulnerability of sewers in Castle Street, Hobson Street, Midsummer Common and Scotland Road to flooding (see Appendix D5).

Surface drainage is also an issue for the Birdswood Road ditch in Coleridge Ward, which is not an Awarded Watercourse. The ownership and maintenance responsibility for this ditch is disputed between Cambridge City Council and Anglian Water.

[3] p. 15, 'Cambridge Catchment LAMP Report', FaberMaunsell, February 2003

5.2 Foul Water Sewer Problems

A number of deficiencies in the foul water sewerage system were identified by FaberMaunsell in their LAMP report – see Appendix E for a summary of the sewer systems in Cambridge City. The major flooding problems in Cambridge's foul sewers are largely associated with combined systems, particularly in the Coldham's Lane catchment where flow separation is being considered as a potential solution.

A Drainage Area Study undertaken by Binnie and Partners in the late 1980s identified the need for two major projects to relieve capacity in the foul water system:

- **Riverside Tunnel Project:** See Appendix E2 for details. This project also included the construction of surface and foul water sewers across Midsummer Common. This project was completed in the late 1990s[4].

- **Madingley Road Foul Water Sewer:** This is due to be constructed in association with proposed developments in the Madingley Road area. It is proposed that this sewer will connect into the Riverside Tunnel. This was proposed to start in summer 2000, but at the time of the LAMP report (February 2003) had not commenced.

5.3 Land Drainage Issues

Cambridge lies on the edge of the Fens where land drainage is necessary to direct runoff and groundwater from vast expanses of flat farmland with little or no natural drainage. In some areas of Cambridge natural drainage can be a problem, particularly near to surface watercourses in areas of flat, low-lying land.

One such location is the Gunhild Way estate, constructed in the mid 20th Century. The estate was once a poorly drained area of arable land before it was developed and it has since experienced problems due to runoff ponding in the gardens of houses on the estate. Three flood events have occurred in recent history: July 1979, September 1989 and October 2001. Water ponded in front or rear gardens but has not been known to affect the properties themselves

[4] p. 27, 'Cambridge Catchment LAMP Report', FaberMaunsell, February 2003

6 Data Assessment Criteria and Processes

6.1 General Criteria

It is required that Flood Risk Zones are defined in accordance with the criteria set out in PPG25. For land at risk from fluvial flooding, these criteria require differentiation according to the "sequential characterisation of flood risk" as shown in Table 6.1.

Table 6.1: Flood Risk Zones in PPG 25

Flood Zone	Level of Risk	Summary* of "Appropriate Planning Response"
1	Little or no risk. Annual probability of flooding < 0.1%	No constraints due to river flooding.
2	Low to medium risk. Annual probability of flooding 0.1 to 1.0%	Suitable for most development.
3a	High risk. Developed areas with annual probability of flooding 1.0% or greater	May be suitable for residential, commercial and industrial development provided the appropriate minimum standard of flood defence can be maintained for the lifetime of the development.
3b	High risk. Undeveloped & sparsely developed areas with annual probability of flooding 1.0% or greater	Generally not suitable for residential, commercial and industrial development unless a particular location is essential, e.g. for navigation and water-based recreational uses, agriculture and essential transport and utilities infrastructure, and an alternative lower-risk location is not available.
3c	High Risk. Functional floodplains.	Built development should be wholly exceptional and limited to essential transport and utilities infrastructure that has to be there.

* *For full details see Table 1 of PPG25.*

6.1.1 Zone 2 / Zone 3 Boundary

The principal criterion for differentiation between the PPG 25 Zone 2 and 3 is the 1% (100-year) event. The 1% flood extent outline for the Strategic Flood Maps has been obtained in accordance with the processes set out in Section 6.2 below.

6.1.2 Zone 1 / Zone 2 Boundary

The 0.1% (1000-year) extreme flood outline for the Strategic Flood Maps has been taken from the same source as for the Environment Agency Flood Zones. This is important since the Agency emphasise the need for outputs of SFRAs to be compatible as far as possible with their latest flood mapping products. Since the extreme flood outline forms an important part of the Agency's new Flood Risk Mapping Strategy, there was a very strong case for its use in the SFRA.

The 0.1% Flood Zone takes no account of defences as all man-made features have been removed from the NextMap DTM on which it is based. However it is considered that this will make no significant difference to the 1000-year outline since during such an event almost all defences would be completely overwhelmed. The 0.1% outlines shown on the final 2005 SFRA maps take account of modifications carried out by the Agency whereby all substantiated historic flood information held by the Agency has been included.

6.1.3 Zone 3c – Functional Floodplain

It has been agreed with the Agency that the functional floodplain should be defined by the extent of the 10% (1 in 10-year) flood outline. For Main Rivers this flood outline has been obtained using similar procedures as for the 1% outline.

6.2 General Methods for Determining the Flood Zones

In order to differentiate between Flood Zones 1, 2 and 3 the 0.1% and 1.0% flood outlines were plotted. In addition Flood Zone 3c was defined by plotting the 10% flood outline. As noted above, the 0.1% outline was taken from the Agency Flood Zone Maps. The 1% and 10% outlines were determined for each area as noted below. Appendix A details the specific flood risk consideration for each Area of Major Change.

6.2.1 Reaches with Existing Modelling

For all the Main Rivers considered, previous flood risk mapping work had been carried out for the EA. For the Cambridge City SFRA work, the 1% flood outline has been produced by abstracting from these hydraulic models the 1% water levels at regular intervals along the rivers. Ground level Digital Surface Models (DSM) have been created using LiDAR data supplemented as necessary by local site surveys and/or Nextmap data. The levels obtained from the models have been projected onto the floodplain until the flood level intersects the ground level. The intersection points have then been joined to form the flood outline.

The River Cam model from Byron's Pool to Bait's Bite produced by Mott MacDonald from 1996-99, was originally modelled using hydrological inputs from the Flood Studies Report (FSR), which was the U.K. standard reference for flood flow estimates at the time. The FSR has since been superseded by the Flood Estimation Handbook (FEH) and so for this SFRA the hydraulic model has been updated taking account of this new hydrological model.

One Awarded Watercourse has also recently been modelled. Atkins have produced a 1-D hydraulic model of Hobson's Brook, from the railway culvert downstream of Nine Wells as far as Long Road, on behalf of Cambridgeshire County Council. As for the Main Rivers, the 1% flood outline has been produced by abstracting from this hydraulic model the 1% water levels at regular intervals along the Brook and flood outlines produced.

All the work carried out within Cambridge has taken account of any existing defences. Such mapping is therefore fully suitable for providing the SFRA division between Flood Risk Zones 2 and 3. Areas defended from a 1% flood event are identified on the SFRA 1:10,000 maps.

6.2.2 Reaches without Cross Section Survey

Site visits were undertaken for the reaches with no existing cross section survey. The length of each watercourse was walked by an experienced engineer who made use of all the available information to plot indicative flood extents for the 1% event. This assessment made use of engineering judgement, catchment details and any historical information. Account was taken of culverts, bridges and other features which may significantly influence the behaviour of the watercourse under flood conditions. Watercourses where the flood outline has been determined by engineering judgement are identified by a dashed red centreline in the accompanying mapping and yellow is used for Zone 3 in areas assessed using engineering judgement.

This technique of assessment is referred to as Level A mapping, and was developed by Mott MacDonald in conjunction with South West Region of the Environment Agency where it has been used to assess the flood risk from over 2000km of ordinary watercourses. It has since been used in flood mapping for recent SFRA studies in Breckland, Huntingdonshire and South Cambridgeshire. The output from JFLOW modelling which forms the basis of the Agency flood zone maps, is taken into account in the Level A assessment. However it is noted that JFLOW does not take account of any man-made embankments or of structures which may have a significant impact on the real risk of flooding, particularly for smaller watercourses. Catchments smaller than 3km² generally do not have JFLOW or any other form of existing flood outline. The Level A assessment also uses data from FEH to give an indication of the magnitude of the 1% event, which when used together with the observed channel dimensions, gives a fair degree of confidence to the predictions of the flood outlines. The outlines produced from the Level A work take account of the estimated backing-up behind structures which would restrict 1% flows, but do not assume any specific blockages.

7 Additional Considerations

7.1 Recent Flood Events

As part of the SFRA for the City, data was collected on historic flood events on the Cam and its Main River tributary, Bin Brook. The most significant flood event of recent history in the City was that of October 2001, though the May 1978 event was used to calibrate the original hydraulic model of Bin Brook and the River Cam model. The 1978 flood event has been estimated to be a 130-year event at Jesus Green Lock[5].

It was agreed with the Council and the Agency that historic flooding outlines, unless incorporated into the Agency Flood Zone 1:1000 year outline, will not be shown on the final SFRA mapping.

For the Awarded Watercourses, recent flood events have been investigated as part of the methodology for mapping the flood risk areas. All identified records of flooding are held by the Agency at Brampton, though some records are also held by Cambridge City Council at the Guildhall. These records show that recorded flooding to property from Awarded Watercourses is minimal, though flood events have occurred in drainage ditches in the south east of the city in the estate around Gunhild Way (see Section 6.1).

7.2 Present and Proposed Land Use

Cambridge City is located in the centre of the East of England, covering an area of just over 41 km² and with a population of approximately 110,000. The city is an international centre for knowledge-based and high-technology industries, providing high levels of employment, particularly in the fields of scientific research, technology and medicine. The area is predominantly urban and suburban, with large areas of open land. The city lies in the southern half of Cambridgeshire, entirely surrounded by South Cambridgeshire District.

The Cambridgeshire Structure Plan 2003 sets a target of 12,500 additional homes to be built in Cambridge between 1999 and 2016[6]. The City Council's Local Plan strategy outlines policies and proposals for the development and use of land in the City for the period to 2016. The major growth areas have been identified; which will facilitate the step change in housing development, while making the maximum use of existing developed land. The development areas will also provide centres of employment allowing major local businesses and organisations, such the University of Cambridge and Addenbrooke's Hospital, to expand.

The Areas of Major Change identified by the Council for the purpose of the SFRA are listed in Table 1.1 and shown on Figure 1.1.

[5] Table 2.2, p. 5, 'River Cam Improvements, Phase 2 – Upstream of Byron's Pool to Jesus Green Lock, Part I', Mott MacDonald, September 1998
[6] Table B, p. xiii, Cambridgeshire and Peterborough Structure Plan 2003

7.3 Climate Change

It was agreed in the SFRA Project start-up meeting on the 14 April 2005 that the fluvial "Climate Change" scenario would be represented by an additional 20% on top of the 1% design flows used for the present day analysis. This assumption is in accordance with the recommendations of PPG25, which states in Section A8 of Appendix A that "Initial research has suggested that, for the Thames and Severn catchments, increases in peak flow of up to 20% for a given return period could be experienced within 50 years."

Where existing studies have not produced modelled results for a 20% increase in peak flow, the 1 in 200-year results have been used to map the 2055 outline. For similar recent studies the 200-year results have been found to be very similar to the climate change results.

Whilst this climate change allowance is probably conservative, given the range of predictions from other research, it is sufficiently large to give a good indication of the sensitivity of the flood extents to potential peak flow increases.

7.4 Assessment of Flood Defences

The SFRA mapping shows the location of all flood defences for which the Agency have responsibility. This is limited to a short section of the River Cam at Riverside. Defences at Riverside just downstream of the Elizabeth Way Road Bridge were constructed in the second half of 2002, following the October 2001 floods. The flood defences consist of a brick faced sheet piled wall with openings to allow residents to enter their houses. These openings can be closed using stoplogs during flood events. The wall is constructed to a 100-year Standard of Protection and protects 14 properties from 12-23 Riverside.

Flood defences on Ordinary Watercourses are generally the responsibility of riparian owners, although there is no formal register of such features. The City Council have no specific responsibility for flood defences.

7.5 Outflows from Sewage Treatment Works

There is concern within the Agency that new developments could lead to increases in discharges from sewage works resulting in the overloading of receiving watercourses and a consequent increase in flood risk.

A list has been obtained from Anglian Water, which includes all consented discharges from their sewage works in Cambridgeshire. The only sewage works in the City are at Milton, within the Northern Fringe Area of Major Change.

N

First Public Drain (East)

First Public Drain (West)

Madingley Road Ditch

River Cam

Bin Brook

Coldhams Brook

East Cambridge Main Drain

March Lane Ditch

Snobbs Stream

Hobsons Conduit

Fulbrooke

Vicars Brook

Cherry Hinton Brook

Daws Lane Ditch

Long Road Ditch

River Cam

Hobsons Brook

Location of Cambridge City within East Anglia

Legend

- Main River
- Awarded Watercourse
- Flood Warning Area

Project Title

Cambridge City Council Strategic Flood Risk Assessment

Map Title **Cambridge City Council Flood Warning Areas Figure 7.1**

Mott MacDonald

CAMBRIDGE CITY COUNCIL

Scale: 1:35,000

February 2006

References

Surface Watercourse Reports

Reference 1: River Cam Improvements, Stage 1 Report (Jesus Green Lock to Bait's Bite Lock): September 1996. Mott MacDonald.

Reference 2: River Cam Improvements, Phase 2, (Upstream of Byron's Pool to Jesus Green Lock): Part 1, September 1998. Mott MacDonald.

Reference 3: River Cam Improvements, Phase 2, Addendum 2 (Upstream of Byron's Pool to Jesus Green Lock): Part 1, July 1999. Mott MacDonald.

Reference 4: Final Report for the River Cam Improvements, May 1999. Mott MacDonald.

Reference 5: Rivers Cam and Granta Model Improvements, Model Construction and SoP Assessment, Final Report, November 2004. Halcrow Group Ltd.

Reference 6: River Rhee Standard of Protection Study, December 2003. Halcrow Group Ltd.

Reference 7: Bourn Brook SoP Study, Final Report, June 2003. Atkins.

Surface and Foul Water Drainage Reports

Reference 8: Cambridge Surface Water Sewerage Study: East Cambridge and First Public Drain Catchments, November 1991. Binnie and Partners.

Reference 9: Cambridge First Public Drain, April 1999. Binnie Black & Veatch.

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Reference 11: Cambridge City Sewerage Investigation – Capital Proposals, September 1989. Binnie and Partners.

Reference 12: Arbury Camp, Cambridge – Surface Water Drainage Strategy Report: Select Options, February 2002. WSP Development Ltd.

Reference 13: Cambridge Catchment Local Asset Management Plan (LAMP) Report, February 2003. FaberMaunsell.

Strategic Flood Risk Assessments

Reference 14: South Cambridgeshire District Council Strategic Flood Risk Assessment, Final Report, February 2005. Mott MacDonald.

Reference 15: South Cambridgeshire District Council Strategic Flood Risk Assessment, Inception Report, August 2004. Mott MacDonald.

Reference 16: Cambridge City Council Strategic Flood Risk Assessment, Inception Report, June 2004. Mott MacDonald.

Flood Risk Assessments

Reference 17: Draft Progress Report for Cambridge Airport Redevelopment, August 2003. Mott MacDonald.

Reference 18: Cambridge Business and Cultural Centre – Strategic Infrastructure Development Study: Drainage Infrastructure, March 29005. Mott MacDonald.

Reference 19: Addenbrooke's Access Road – Flood Risk Assessment (Draft for Review), March 2005. Atkins.

Development Studies and Local Plans

Reference 20: Cambridge East Area Action Plan, October 2004. South Cambridgeshire District Council & Cambridge City Council.

Reference 21: Cambridge Local Development Framework: Sustainability Appraisal Scoping Report (Redeposit Draft), October 2004. Cambridge City Council.

Reference 22: Cambridge Redeposit Local Plan, 2005. Cambridge City Council

Reference 23: Cambridge Local Plan 1996, www2.cambridge.gov.uk/living/local_plan, 1996 Cambridge City Council.

Reference 24: Cambridgeshire and Peterborough Structure Plan 2003, www.cambridgeshire.gov.uk/environment/plannning/policies/structure+plan, 2003 Cambridgeshire County Council.

Appendices

Appendix A Reports on Flood Risk Assessments for Areas of Major Change

Introduction

This section describes the six Areas of Major Change including their location, size, nature of the proposed development, the existing and proposed drainage arrangement and the assessed risk to the areas from surface watercourses. Detailed descriptions of the surveys carried out along Awarded Watercourses are given in Appendix B and inform the creation of the accompanying Flood Maps. Drainage studies of the development areas have not all been made available for this study, largely because outline or detailed assessments are still being carried out.

A1 East Cambridge

A1.1 Area Description

This Area of Major Change straddles the boundary between Cambridge City and South Cambridge District Councils and covers an area within the City of almost 115 ha. Ground levels range from 8.5 m AOD to 16 m AOD. All of the land within the City boundary is currently occupied by the airport. The Area is bounded by housing to the north-west, Barnwell Road to the west, Coldham's Lane to the south-west and housing to the south-east.

The principal watercourse impacting on the Area is March Lane Ditch, which runs from March Lane in north Cherry Hinton across the eastern side of the airport towards Teversham Fen. A series of open drains run across the south-eastern side of the Area and feed into March Lane Ditch. This watercourse becomes Allen's Farm Drain or the 6th Public Main Drain as it flows into South Cambridgeshire Distict. To the west, two larger watercourses run to the south and west of the development Area. These are Coldham's Brook and the East Cambridge Main Drain, which run parallel, then join on Coldham's Common, and flow into the River Cam just downstream of the railway bridge at Ditton Meadows.

The Cambridge Redeposit Local Plan states that up to 4,660 dwellings could be built in this Area within the City, as well as a further 5,000 houses in South Cambridgeshire (Reference 22).

A1.2 Drainage

A1.2.1 Current Situation

Surface water in the Area drains naturally in four directions from a watershed running east-west roughly along Newmarket Road. On the Cambridge City side of the Area, water flows in two directions, either westwards or eastwards:

- To the east, the north and east section of the airfield drains through Allen's Farm Drain (6th Public Drain) on the east side of the airfield, which runs along the outskirts of Teversham to Quy Water, and then into the River Cam via Bottisham Lode.

- To the west, the South Works hangers and south-west area of the airfield drain through Barnwell Local Nature Reserve into East Cambridge Main Drain and Coldham's Brook, which flows into the River Cam at Stourbridge Common.

A1.2.2 Proposed Development

Surface Water Drainage

The proposed development will lead to an increase in impermeable areas and therefore in storm water runoff which has the potential to increase flood risk in the downstream watercourses. It is also important to note that the development will require a detailed flood risk assessment (FRA) to be submitted as part of the planning application.

The Pre-Submission Public Participation Draft[7] outlines the measures to be taken to reduce the amount of runoff. It is anticipated that the development will take advantage of Sustainable Urban Drainage Systems (SUDS) as far as possible in order to reduce the effects of immediate runoff from impermeable areas. This will include the provision of water storage areas (including the current drainage network), which should be designed as multi-functional resources with the aim not only to store floodwaters, but also to be recreational areas and increase biodiversity within the development site. Reed beds within these water features will help to improve the quality of rainwater runoff. Other proposals for SUDS include:

- Surfacing minor roads and parking spaces with pervious materials;
- The provision of underground reservoirs to attenuate water in such a way as to reduce the peak runoff from the site;
- Two-stage open drains in addition to the drainage network already in existence;
- Linked wetland features to provide drainage, storage and an amenity with adjacent land serving as washland for temporary storage of floodwater.

The lowest sections of the Area will be set aside for the creation of a lake located to the east of the centre of the Area near Airport Way. This will not only provide flood attenuation but also act as a major recreational feature within an east-west green corridor leading from the town centre edge of the area to Teversham Fen.

Maintenance and Management

It is proposed to create a publicly accountable trust funded by commercial property developed within this Area of Major Change. Other potential maintenance bodies include the City Council and Anglian Water; however there are some concerns about their suitability to undertake drainage maintenance work. The Council are constrained by resources, although commuted sums and S106 agreements might offer opportunities. Anglian Water are a private company, as such for them to take on responsibilities it would be essential that measures were put in place to guarantee the long-term maintenance of the system.

[7] 'Pre-Submission Public Participation Draft', South Cambridge District Council & Cambridge City Council, June 2005

Water Conservation

Water conservation has also been included in the Cambridge East Area Action Plan as a means to encourage the developers not only to introduce attenuation measures into the management of waste water, but also to promote the principle of reusing and recycling water. While reusing rainwater runoff (e.g. rainwater harvesting) can potentially create ecological problems as flow to watercourses is reduced, it has been assessed that the goal of reducing consumption and recycling within the home is achievable for this development.

Colham's Brook, which flows as the higher of two parallel watercourses on Coldham's Common, possess a significantly low gradient and suffers as a result from inconsistent flows. In the past, Kingfishers were regularly observed in the reach between Barnwell Road and Galfrid Road; however in recent years, sightings have virtually ceased. There are clearly environmental and ecological benefits associated more consistent flows. However the options to regrade the channel and restore flows have been limited by the availability of funding. It is suggested that Coldham's Brook should be considered as a potential outfall for the East Cambridge development. This might allow Section 106 funding to be targeted to regrade the brook as far as its confluence with East Cambridge Main Drain (ECMD). It should be noted that such a proposal would require the provision of structures on Coldham's Brook to cross the lower level ECMD.

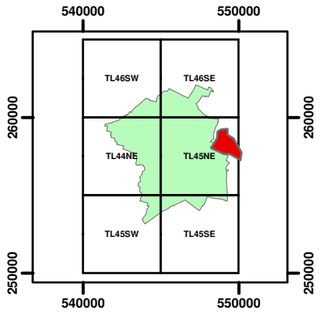
A1.3 Awarded Watercourses

1. Coldham's Brook and the East Cambridge Main Drain run within 50 m of the Cambridge East Area of Major Change. This is not close enough to cause flooding within the development site, but the flood outlines are included as part of the Strategic Flood Risk Assessment.
2. March Lane Ditch runs across the site as described in Section A1.1. This watercourse was surveyed on 4th July 2005 and the flood outline has been marked on the flood maps accompanying the report. It is important that all existing ditches at the development are maintained regularly, in order to remove vegetation and silt that could reduce the flow and flood storage capacity of the channels.

A1.4 Existing Flood Risk

Although the Area has a very shallow gradient, there is only a small risk of localised flooding in the 1% flood event. However, any increase in stormwater runoff as a result of increased impermeable areas would increase flood risk downstream of the Area. Although these areas are currently undeveloped it will be necessary to attenuate flows in order to avoid increasing flow peaks in the downstream system.

CITY PLAN



LEGEND

- Functional Floodplain (1in 10 Year Envelope)
- Zone 3 (1 in 100 Year Envelope)
- Zone 3 (from EA Flood Zone Maps)
- Zone 3 (1 in 100 year envelope)
  Envelopes derived from engineering judgement please also refer to EA Flood Zone
- Area of Major Change
- Main River
- Awarded Watercourses

Project Title

Cambridge City Council Strategic Flood Risk Assessment

Map Title

Cambridge East Figure A1

Mott MacDonald

CAMBRIDGE CITY COUNCIL

Scale 1:7,500 February 2006

A2 Southern Fringe

A2.1 Site Description

The Southern Fringe Area of Major Change is divided into two principal blocks of land: a larger block between Trumpington and Addenbrooke's Hospital and a smaller block adjacent to the Park and Ride on Monsanto property. The larger block currently comprises agricultural land surrounding the established Addenbrooke's Hospital and nearby residential developments. The western edge of this block is bordered by the village of Trumpington, while the railway line from Cambridge to London and the old Bedford railway line run through the centre of the block. The smaller block lies to the west of Trumpington Road on the site of the former (Monsanto) Plant Breeding Institute.

The full development Area is split between Cambridge City Council and South Cambridgeshire District Council, with the boundary running through the centre of the Area to the north of Nine Wells. However, only the part within Cambridge City is discussed in this report. A separate Strategic Flood Risk Assessment has been carried out for South Cambridgeshire District. The final report for that study includes consideration of those parts of the full development Area outside of the city boundary (Reference 14). This should also be referred to by prospective developers.

Together the blocks cover an area of approximately 150 ha including land within South Cambridgeshire District. For those parts of the development Area within South Cambridge District the topography is relatively hilly. Within the city boundary, however, the Area is fairly flat.

There are no Main Rivers within the borders of the Area. The closest is the Cam which runs within approximately 300 m of the western (Monsanto) block of land. The principal watercourse impacting on the eastern block is Hobson's Brook which runs from the south to the north of the Area, see Figure A2.

The Cambridge Redeposit Local Plan states that up to 3,320 dwellings could be built on the Area (Reference 22).

A2.2 Drainage

A2.2.1 Current Situation

Surface water at the site drains naturally in two directions away from the railway line running through the middle of the Area. Eventually the surface water flows via a series of drains from both sides of the Area into Hobson's Brook. Hobson's Brook divides and flows parallel with Vicar's Brook through the south of Cambridge before entering the River Cam at Coe Fen.

- To the east of the railway line, the Area drains towards the west and flows via drains into Hobson's Brook. These drains included a connection from Addenbrooke's Hospital, and a drain running along the district boundary providing much of the drainage for the south-eastern sections of the Area.

- To the west of the railway line, the Area drains directly into Hobson's Brook from both sides of the watercourse. Gradients here are generally very shallow.

- On the Monsanto site, surface water drains in a westerly direction towards the River Cam between Byron's Pool and Brasley Bridge

The watercourses downstream of the Area flood at peak flows. No information is currently available on the size of the possible development.

A2.2.2 Proposed Development

For any proposed development, measures will need to be taken with regard to drainage. This is likely to include balancing ponds to attenuate flood peaks resulting from increased runoff for the main part of the Area between Trumpington and Addenbrooke's Hospital.

Drainage proposals suggested for the western (Monsanto) block will have to take consideration of the River Cam corridor. Reed beds and attenuation ponds will have to be carefully designed to attenuate runoff, improve the water quality of such runoff and not impact on the adjacent river corridor.

A detailed Flood Risk Assessment will have to be submitted as part of the planning application.

A2.3 Cambridge Southern Fringe Watercourse System

The watercourse system in this Area is primarily Hobson's Brook, with other field drains feeding into the Brook throughout the area. These watercourses were inspected for this SFRA on 4 July 2005.

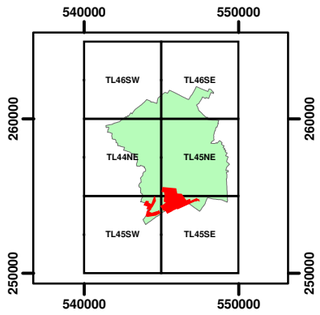
A2.4 Existing Flood Risk

There is currently only a small risk of flooding from a 100-year event, as the catchment size of Hobson's Brook is relatively small. However, there is flood risk to properties downstream of Long Road in Newton Road and Queensway, so runoff from new development upstream of the Long Road will have to be managed so as not to exacerbate the potential for flooding of properties bordering Hobson's Brook.

A2.5 Water Quality

It is important to note that the Hobson's Brook system is highly regulated. Hobson's Brook itself does not discharge directly to the River Cam, the flow of water exiting the watercourse being controlled by the manual operation of sluice gates. Because of this "closed system", the quality of water running off to Hobson's Brook is of particular importance. Flood Risk Assessments undertaken for developments which impact on the Hobson's Brook catchment must therefore include detailed consideration of water quality aspects.

CITY PLAN



LEGEND

Functional Floodplain
(1in 10 Year Envelope)

Zone 3
(1 in 100 Year Envelope)

Zone 3
(from EA Flood Zone Maps)

Zone 3
(1 in 100 year envelope)
Envelopes derived from engineering judgement please also refer to EA Flood Zone

Area of Major Change

Main River

Awarded Watercourses

Project Title
Cambridge City Council Strategic Flood Risk Assessment

Map Title
Southern Fringe Figure A2

Mott MacDonald

CAMBRIDGE CITY COUNCIL

Scale 1:12,500

February 2006

A3 Northern Fringe

A3.1 Site Description

The Area of Major Change occupies largely brownfield land on the western side of the Cambridge-Ely railway, which separates the Area from the left bank of the River Cam.

The Area is currently occupied by Anglian Water sewage works, the Cowley Road park and ride site, a golf driving range and the Cowley Road industrial estate to the east of First Public Main Drain. It covers an area of around 75 ha of which just under 53 hectares lies within the city boundary.

The Cambridge Redeposit Local Plan gives an indicative capacity for this site of 2,330 dwellings (Reference 22).

A3.2 Drainage

A3.2.1 Current Situation

The Area is largely flat. The sewage treatment works and the golf driving range slope gently towards the eastern edge of the Area along which runs the First Public Main Drain. Runoff from the Cowley Road Industrial Park at the south east corner of the Area also runs into the First Public Main Drain. This Awarded Watercourse runs from the Area to the north, underneath the A14 and into the River Cam opposite Biggin Abbey.

A3.2.2 Proposed Development

A detailed Flood Risk Assessment will be required as part of any planning application.

A3.3 Northern Fringe Watercourse System

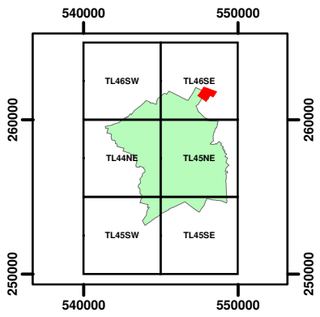
The watercourse system in this Area is primarily the First Public Main Drain, with a number of surface water drains feeding into the open watercourse from both banks. The First Public Main Drain was inspected for this SFRA on 30 June and 6 July 2005.

A3.4 Existing Flood Risk

There is currently only a small flood risk to the Northern Fringe Area, as the land is protected from extreme flows in the First Public Main Drain by the embankments along the watercourse. However, the eastern end of the Area is low and would be at risk from flooding should these embankments overtop or breach.

547000
548000
262000
261000
Gdns
Track
Dickerson's Pit (Lake)
FB
FBs
Visitor Centre
Crane Industrial Estate
Path
Thirteenth Public Drain
Drain
A1309
9m
Boro Const & CP Bdy
COWLEY ROAD
Co Const & CP Bdy
Sewage Works
8m
ORWELL FURLONG
Park & Ride Site
Golf Driving Range
COWLEY RD
First Public Main Drain
LC
COWLEY PARK
GAINSBOROUGH TO
GREEN PARK
MATLAND AVENUE
Depots
Allot
Depot
El Sub Sta
MILTON CP
Chesterton F
Caravan Park

CITY PLAN



LEGEND

- Functional Floodplain (1in 10 Year Envelope)
- Zone 3 (1 in 100 Year Envelope)
- Zone 3 (from EA Flood Zone Maps)
- Zone 3 (1 in 100 year envelope)
  Envelopes derived from engineering judgement please also refer to EA Flood Zone
- Area of Major Change
- Main River
- Awarded Watercourses

Project Title
Cambridge City Council Strategic Flood Risk Assessment

Map Title
Northern Fringe Figure A3

Mott MacDonald

CAMBRIDGE CITY COUNCIL

Scale 1:5,000

February 2006

A4 Land between Madingley Road and Huntingdon Road

A4.1 Site Description

This Area of Major Change is bordered by the Madingley Road to the south, the city boundary to the west, Huntingdon Road to the north east, and the built-up areas of Conduit Head Road, Storey's Way and Churchill College to the east.

The Area is located largely on agricultural land, though laboratories and farm buildings can be found in the eastern half of the Area. The Madingley Road Park and Ride lies at the southern edge of the Area. The area within the city boundary is just over 55 hectares.

An indicative capacity of 1,150 dwellings is given in the Cambridge Redeposit Local Plan (Reference 22).

A4.2 Drainage

A4.2.1 Existing Situation

Most of the Area is drained by a series of ditches flowing to the north west. Of these, the Madingley Road ditch is the largest and the only ditch to be designated an Awarded Watercourse. These ditches eventually flow into Washpit Brook, designated Main River, which eventually flows into Cottenham Lode. Runoff from the park and ride site is attenuated by a pond with an approximate plan area of 30 m by 10 m.

A4.2.2 Proposed Development

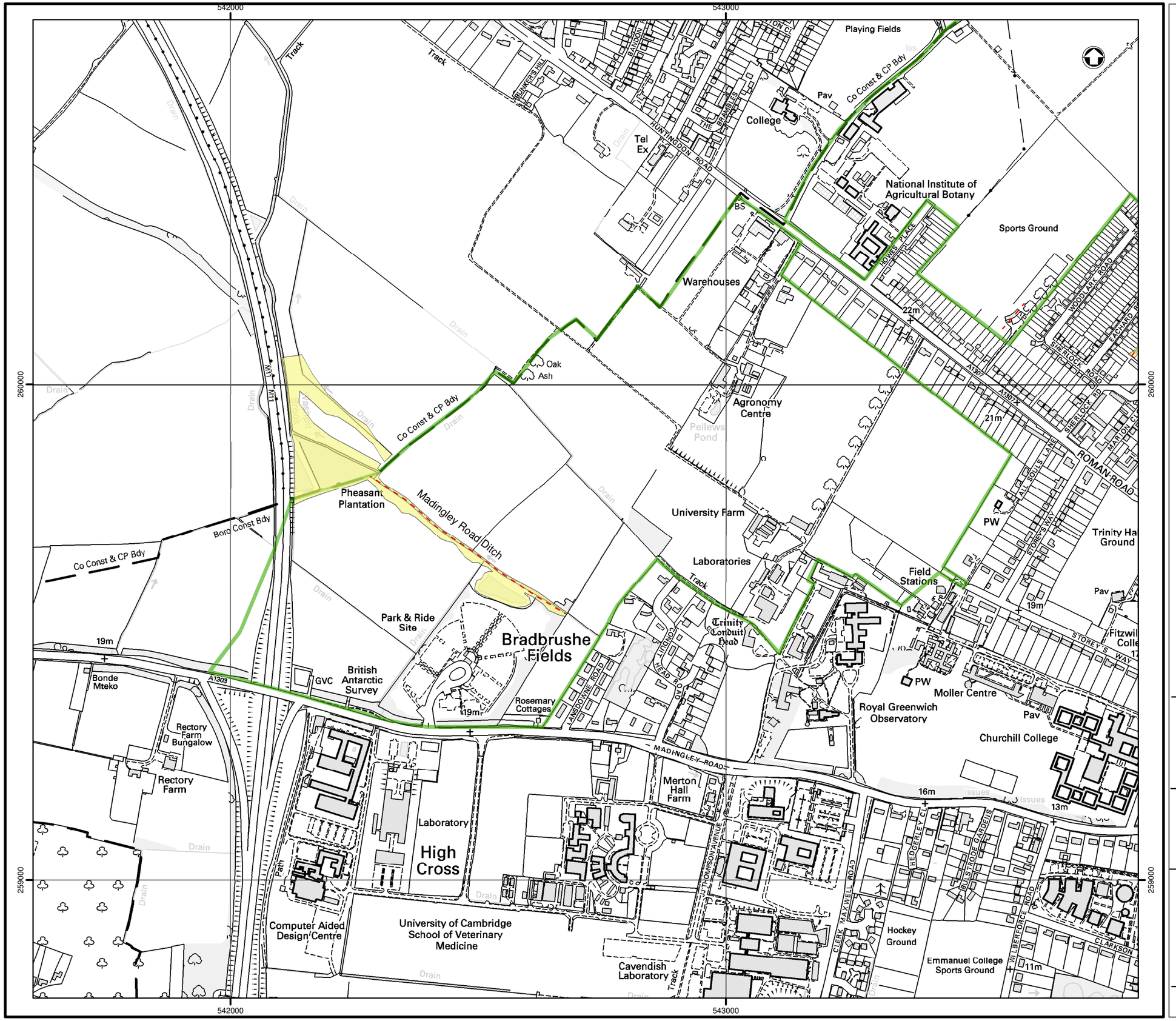
A detailed Flood Risk Assessment will be required as part of any planning application.

A4.3 Watercourse System on Land between Madingley Road and Huntingdon Road

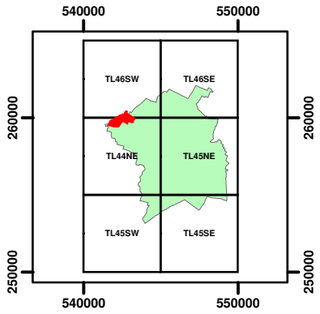
Madingley Road ditch has been surveyed as it is the largest of the drains mentioned above and the only Awarded Watercourse. A number of other ditches (not Awarded Watercourses) run parallel to the Madingley Road ditch – one to the south-west and two to the north-east delivering runoff into Washpit Brook.

A4.4 Existing Flood Risk

There is only a small risk of flooding from a 100-year event as the catchment size of Madingley Ditch is small. However, runoff from any new development will have to be attenuated so as not to increase the flood risk downstream of the Area.



CITY PLAN



LEGEND

Functional Floodplain (1in 10 Year Envelope)

Zone 3 (1 in 100 Year Envelope)

Zone 3 (from EA Flood Zone Maps)

Zone 3 (1 in 100 year envelope)

Envelopes derived from engineering judgement please also refer to EA Flood Zone

Area of Major Change

Main River

Awarded Watercourses

Project Title

Cambridge City Council Strategic Flood Risk Assessment

Map Title

Land Between Madingley Road and Huntingdon Road Figure A4

Mott MacDonald

CAMBRIDGE CITY COUNCIL

Scale 1:7,500 February 2006

A5 Land between Huntingdon Road and Histon Road

A5.1 Site Description

This Area of Major Change is bordered by Huntingdon Road to the south-west, the city boundary to the north-west, and the built-up areas of Woodlark Road, Tavistock Road, Martingale Close and Brierley Walk to the east and south-east.

The Area is located largely on agricultural land, though the National Institute of Agricultural Botany (NIAB) and Christ's and Sidney Sussex Sports Grounds can be found at the south-western end of the Area. The area within the city boundary is just over 52 hectares.

An indicative capacity of 1,780 dwellings is given in the Cambridge Redeposit Local Plan (Reference 22).

A5.2 Drainage

A5.2.1 Existing Situation

The Area slopes down from the south-west end to the north-east from a height of approximately 21 m AOD to approximately 14 m AOD. Surface water is directed into the NIAB drain system to the north of the Area. This system is an Awarded Watercourse as it leaves the Area to the north and east of Thornton Way and Thornton Close. This drain heads north-eastward towards Orchard Close and under the A14 before joining another drain (Awarded Watercourse) from Impington Farm and Woodhouse Farm.

A5.2.2 Proposed Development

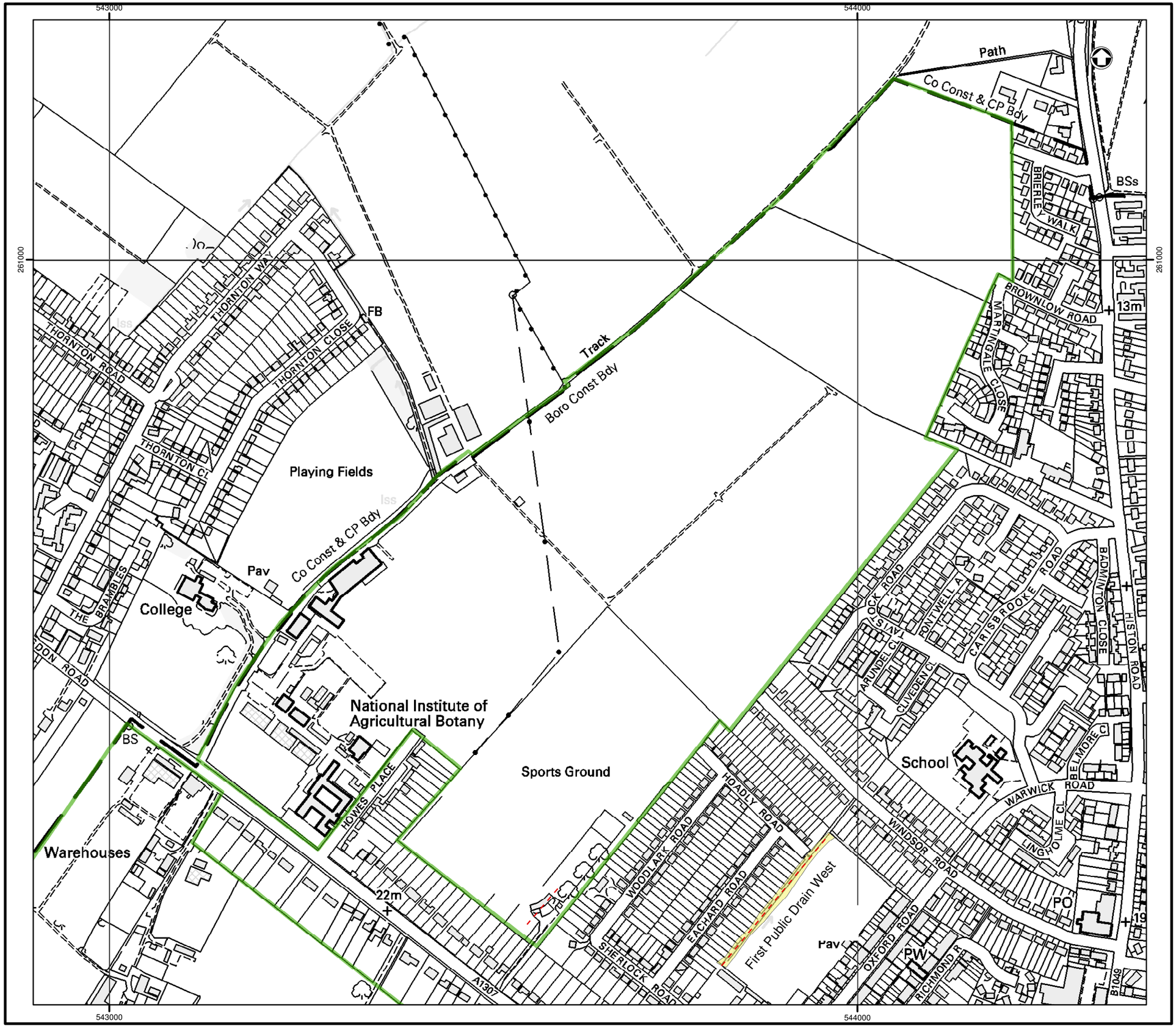
A detailed Flood Risk Assessment will be required as part of any planning application.

A5.3 Drainage System on Land between Huntingdon Road and Histon Road

There are no surface water drains visible on that part of the Huntingdon Road-Histon Road Area within the City boundaries.

A5.4 Existing Flood Risk

There are no Awarded Watercourses within this Area of Major Change, but runoff will have to be managed so as not to affect flows in drainage ditches downstream of the site.



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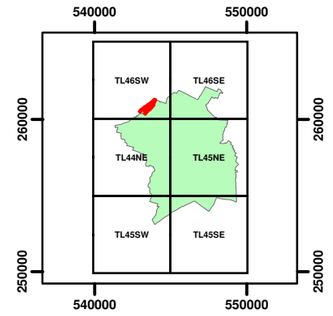


LEGEND

Functional Floodplain
(1in 10 Year Envelope)

Zone 3
(1 in 100 Year Envelope)

Zone 3
(from EA Flood Zone Maps)

Zone 3
(1 in 100 year envelope)

Envelopes derived from engineering judgement please also refer to EA Flood Zone

Area of Major Change

Main River

Awarded Watercourses

Project Title

Cambridge City Council Strategic Flood Risk Assessment

Map Title

Land Between Histon Road and Huntingdon Road Figure A5

Mott MacDonald

CAMBRIDGE CITY COUNCIL

Scale 1:5,000

February 2006

A6 Station Road Site

A6.1 Site Description

This Area of Major Change, allocated for mixed development, lies adjacent to Cambridge railway station, bordered by the railway lines and station to the east, Hills Road and Tenison Road to the west and Ravensworth Gardens to the north. Mott MacDonald have conducted an extensive drainage study of the proposed Station Road development to assess the capacities of surface and foul water drainage on the surrounding area and the impact of the development on sewer capacities. The study also proposes solutions to mitigate the effects of the development.

The Area is largely brownfield land formerly occupied by a Rank Hovis mill, car park, railway sidings and a Focus retail store. The area within the city boundary is approximately 7.5 hectares and no major watercourses (main river or awarded watercourses) flow through the site.

An indicative capacity of 650 dwellings is given in the Cambridge Redeposit Local Plan (Reference 22).

A6.2 Drainage at Station Road site

Much of the following information has been extracted from an Infrastructure Study carried out at the Station Road site on behalf of developers Ashwells[8]. There are no surface watercourses within this Area of Major Change. The nearest surface watercourse is the Hobson's Conduit, which flows beneath Brookland's Avenue around 900 m to the west. The investigations undertaken for the Station Road area therefore concentrate on the foul and surface water drainage systems currently existing, how the new developments will affect these systems, and what measures are proposed to mitigate these effects.

A6.2.1 Existing Situation

Foul Water:

The site is currently served by four main foul water sewers running along Hills Road (300 mm dia.), Station Road, Tenison Road and Devonshire Road (all 225 mm dia.). The Tenison Road sewer drains into the Station Road sewer, which in turn drains into the Hills Road sewer. This connects into the Trumpington Road main. The Devonshire Road sewer flows eastwards into the Mill Road and East Road sewers. A combined drain also runs from the Rank Hovis site into the Station Road foul water sewer.

[8] 'Cambridge Business and Cultural Centre – Strategic Development Study: Drainage Infrastructure', Mott MacDonald, March 2005

Surface Water:
Surface water sewers also run along Hills Road, Station Road, Tenison Road and Devonshire Road. The Hills Road, Station Road and Tenison Road sewers link up and flow into the Bateman Street sewer and finally into Vicar's Brook near the junction of Brookland's Avenue and Trumpington Road. There are also nearby surface water sewers on Brookland's Avenue – which runs into Vicar's Brook – and Devonshire Road, from where the water flows into the River Cam near Abbey Road. Surface water does not only flow into surface water sewers, however, 3.5 ha of the site is served by existing soakaways, while 1.5 ha flows into foul or combined sewers. The existing surface water sewers are already under-capacity, particularly the Station Road and Hills Road sewers, which are unlikely to be able to cope with a 30 year storm (peak discharge = 520 l/s for a 15 minute storm).

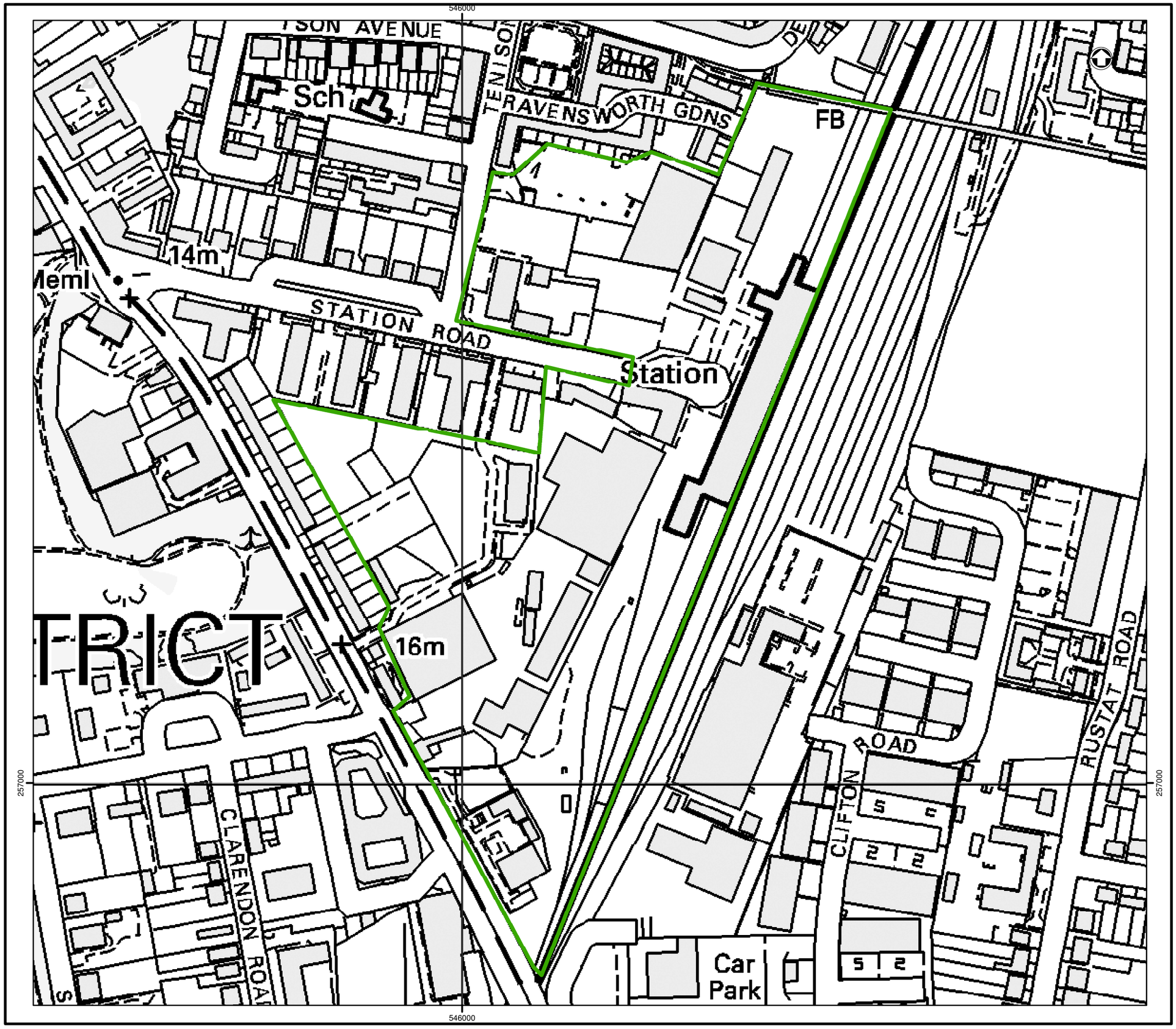
A6.2.2 Proposed Development

Foul Water:
Peak flows in the foul water sewers from the proposed new development will be as much as 50 l/s. This will lead to a significant increase in foul flows to all four discharge points from the site. However, it is proposed that the existing private surface water drains which are currently connected to the public foul sewers in Station Road should be removed. This will release extra capacity for the foul water system. It is important that this removal of private surface water drainage connections to the foul sewer is a condition of any planning application.

Surface Water:
The proposed development will lead to an increase in impermeable areas from 1.9 ha to 6.5 ha. The existing network does not have the necessary capacity, so attenuation to greenfield run-off rates would not solve the capacity problem on the existing network. As a result, the developers intend to attenuate all run-off from the site to allow flow rates, which the existing system can accept during a 30-year storm without flooding. Flows will be attenuated using modular underground storage structures such as 'Stormcell' or 'Stormblock'. These will limit the initial discharge from the development to 5 l/s during the first 60 minutes of any 30-year storm event.

During some storm durations in excess of a 30-year, 60 minute event, discharge levels from the site will be in excess of the discharge levels agreed with Anglian Water. When planning applications are being considered, careful consideration should be given to the level of any increased discharge from the site above the levels agreed with Anglian Water, particularly for long duration storms.

Using the Flood Studies Report as a hydrological model and MicroDrainage to model the proposed sewer network, it has been established that a total storage of 1,660 m^3 will be required to achieve the required level of attenuation. These attenuation tanks will be constructed off-line, in order that Anglian Water can adopt the sewers. Anglian Water do not currently adopt underground attenuation tanks and they will have to be maintained by the developer in the meantime.



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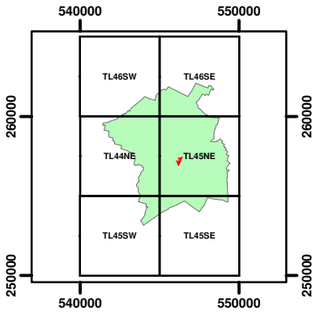


LEGEND

Functional Floodplain
(1in 10 Year Envelope)

Zone 3
(1 in 100 Year Envelope)

Zone 3
(from EA Flood Zone Maps)

Zone 3
(1 in 100 year envelope)
Envelopes derived from engineering judgement please also refer to EA Flood Zone

Area of Major Change

Main River

Awarded Watercourses

Project Title
Cambridge City Council Strategic Flood Risk Assessment

Map Title
Station Area Figure A6

Mott MacDonald

CAMBRIDGE CITY COUNCIL

Scale 1:2,500

February 2006

Appendix B Reports on Surveys of Awarded Watercourses within Cambridge City

Introduction

Assessment of flood extents for Awarded Watercourses as listed in Table 4.1 has been made following the procedures set out in Section 6.2.2 of the main report. Unless otherwise stated, assessments are made with the assumption that all flooding has resulted due to the studied watercourse alone, rather than the flooding being due to overland flow, sewer flooding or any other source.

In several cases, watercourses are referred to by more than one name according to the source of information. The names used for the watercourses in this report are those assessed to be in most common use.

Where a property is listed as being "at risk" this means that it has been assessed that in a flood event of severity 1% or greater, water would reach a level which was likely to cause flood damage to residential or commercial buildings. In such cases an assessment has also been made of the Standard of Protection (SoP) provided to the particular buildings.

Unless otherwise stated, inspections have been carried out from the upstream extent to the downstream extent of the channel length being studied.

Assessment of the catchment has been based on the best available data at the time of the study.

The following Awarded Watercourses which affect Areas of Major Change have been inspected:

Coldham's Brook (Cherry Hinton Brook), including Cherry Hinton Hall Ditch

Daws Lane Ditch

East Cambridge Main Drain

March Lane Ditch

Hobson's and Vicar's Brook, including Long Road Ditches

First Public Main Drain (East)

Madingley Road Ditch

Lama's Land, Queen's Green and Sheep's Green Ditches have not been inspected as they are all in the River Cam floodplain and therefore within Flood Zone 3 of the River Cam.

B1 Coldham's Brook (Cherry Hinton Brook)

This watercourse was inspected on the 1 and 4 July 2005, along with the East Cambridge Main Drain. It is an Awarded Watercourse and rises from a spring at the corner of Cherry Hinton Road and Cherry Hinton High Street. The watercourse flows through the south-western corner of Cherry Hinton continuing north alongside gravel pit lakes and a MoD training facility, across Coldham's Lane and Barnwell Road, through Coldham's and Stourbridge Commons to its confluence with the River Cam east of Chesterton. It may be noted that presently, little or no property drainage discharges to Coldham's / Cherry Hinton Brook. It is predominantly a natural watercourse, unlike its counterpart the East Cambridge Main Drain, which is very much, as its name suggests, a drain. The Cambridge East development area lies to the east of the watercourse. There are 26 structures on the main channel. For ease of description, the channel has been split into five roughly heterogeneous sections. The total length of channel is approximately 5.6 km.

The five sections of the Brook within the studied area having similar properties are as follows:

1. Giant's Grave springhead to Daws Lane allotments
2. Daws Lane allotments to Sainsbury's Superstore, Coldham's Lane
3. Sainsbury's Superstore, Coldham's Lane to Coldham's Common
4. Coldham's Common to Newmarket Road Bridge
5. Newmarket Road Bridge to confluence with the River Cam

Channel:

Section 1: This section extends from the brook's source at Giant's Grave spring to the allotment gardens on Daws Lane. The channel length is approximately 840 m.

Figure B1.1: Giant's Grave Spring at Cherry Hinton

The channel here varies in width from 1 to 2 m and is cut to a depth of approximately 1 m. Cherry Hinton Brook rises in Giant's Grave Spring, a low-lying clear water pond approximately 400 m^2 in area at the junction of Cherry Hinton Road and Fulbourn Road. The average bank height here is 0.3 m.

Figure B1.2: Property on Right Bank Downstream of Forest Road Culvert

The first structure on the watercourse is a culverted bridge at Forest Road. The culvert dimensions are 600 mm x 300 mm which is far smaller than the capacity of the channel. A wooden revetment just downstream of the bridge on the right bank may indicate a past history of erosion (see Figure B1.2). The properties on Forest Road and Mill End Road back immediately onto the watercourse. A few metres upstream of the culvert the channel was overgrown with vegetation at the time of inspection. Consultation with local property owners revealed no history of flooding in the last 64 years. The maximum observed water level during this time was approximately 200 mm below bank level at the rear of Forest Road.

A few metres downstream of the Forest Road culvert the channel splits into two, flowing around an area of parkland. The right channel is heavily vegetated with a number of footbridges providing access to the park. There are a total of three structures on the left channel. Two of these are access bridges having openings approximately 0.5 m in height and 1 m wide. The other is a flat weir occupying a part of the channel which has been widened to about 4 m to function as a pond area.

The two channels meet again at the southern fringe of the allotment gardens. At this point a drain also flows into the channel from the north-west. This channel drains upstream allotments, residential areas and school grounds. At the time of survey the drain was dry. No flood risks were identified from this drain.

Just downstream of the junction with the drain, a brick culvert provides access to allotments on the left bank. The channel here was heavily vegetated with a bank height of between 1.5 m and 2 m.

Section 2: This section extends from the allotment gardens at Daws Lane to the beginning of Sainsbury's Superstore. The channel length is approximately 1.2 km.

Figure B1.3: Coldham's Brook alongside Burnside

The bank height in this section falls steadily from 1.5 m to about 0.7 m at the footpath along Burnside. The channel width increases from 2 m to 3 m at this point. The distance between the crest of the bank and the surface of the water ranged from 200-400 mm at the time of the inspection. The water in the channel is generally stagnant. Just upstream of the Burnside properties the brook flows under an access road to allotments on the left bank. The culvert dimensions are 1 m x 0.5 m. One resident on Burnside stated there had been no flooding in the 6 years since they had been resident there.

Section 3: This section follows the channel through the grounds of Sainsbury's Superstore, under Coldham's Lane and Barnwell Road where the watercourse is carried across the East Cambridge Main Drain by a triple pipe aqueduct at the entrance to Coldham's Common. The reach length is approximately 420m.

Upstream of Barnwell Road the watercourse is generally referred to as Cherry Hinton Brook, and downstream of this point as Coldham's Brook.

Through Sainsbury's Superstore grounds, the brook is crossed by three access bridges. The channel width varies from 2.5 to 3 m and the bank height ranges from 2 to 3 m. The average water depth at the time of inspection was 15 cm. All three bridges have roughly the same dimensions of 2.5 m x 1 m. The upstream side of the second bridge is crossed by a 10 cm diameter pipe about 1 m from the bed level. The banks were covered with dense shrubbery, but the channel itself was generally clear and free from debris.

The brook then flows under Coldham's Lane and the railway line through a box culvert (approximately 1 m high by 2 m wide), protected by a trash screen. The channel proceeds under Barnwell Road, under two further footbridges and is then crossed by the East Cambridge Main Drain, which passes under Coldham Brook in culvert. The channel widens to 4 m downstream of Barnwell Road. The Barnwell Road bridge has a trash screen on the downstream side. The culvert dimensions are 2.3 m x 0.6 m. The bank height is approximately 2.5 m. The channel from Barnwell Road bridge to the footbridge is overgrown and the culvert dimensions of this footbridge were unrecordable.

Section 4: This section extends across Coldham's Common to Newmarket Road Bridge. Just upstream of Newmarket Road Coldham's Brook joins with the East Cambridge Main Drain. The reach length is approximately 1.7 km.

The channel width through this section ranges from 4 m at Coldham's Common Access Road to 1.5 m at Newmarket Road. The bank height rises from 1 m to 2 m at the Abbey Sports Centre and falls again to 1 m at the Abbey Stadium. Roughly 580 m downstream of the start of this section an access bridge from Barnwell Road crosses the brook. The culvert dimensions are 2 m x 1 m. The channel was heavily vegetated downstream of this point as far as the culvert (50 cm diameter) which takes the brook over the East Cambridge Main Drain. At the time of inspection, there was no flow in the channel from this point until the Sports Centre, suggesting leakage into the Main Drain (see Figure B1.4).

Figure B1.4: Dry Culvert on Coldham's Common

At the Abbey Stadium, the water depth was 0.3 m at the time of the inspection and the channel was again heavily vegetated. There are four access bridges to the Abbey Stadium South and East Stands. At Newmarket Road, the channel width is 1.5 m and the bank heights are 1.5 m on the left and 2 m on the right. A small culvert (300 mm diameter) in the left bank diverts flow west across the Common where it joins the lower level East Cambridge Main Drain. The combined channel then flows under Newmarket Road.

Section 5: This section sees Coldham's Brook (now combined with East Cambridge Main Drain) flow from Newmarket Road onto the River Cam floodplain at Stourbridge Common and Ditton Meadows. The reach length is approximately 1.4 km. The easternmost channel is joined by an open drain from Fen Ditton. The main channel is cut to 1 m deep and 2.5 m wide and was observed to be free of vegetation at the time of inspection. The brook is crossed by a railway bridge and two footbridges over footpaths in the floodplain of the River Cam before the it flows into the Main River.

Floodplain:

Section 1: The valley in the studied section comprises residential areas on both banks leading to allotment gardens and Cherry Hinton Hall park area on the left.

There is significant storage area at the source (Giant's Grave). This comprises a low-lying embanked area 4 to 5 m wide around the spring. The embankments are 2 to 3m high. Beyond these embankments are residential areas to the west and Cherry Hinton High Street immediately to the east. The brook flows behind Malvern Road and Forest Road properties. The properties on the left bank generally slope upwards to the channel.

Evidence from local residents suggests no history of flooding going back at least 64 years. However, it is possible that the banks may be overtopped in a 1% event. In such circumstances flow is most likely to be directed towards Cherry Hinton Hall and Daws Lane Allotment gardens.

Section 2: The valley in this section comprises a MOD training facility and three gravel pit lakes to the right, with residential areas, school grounds and allotments to the left.

For much of this reach the left bank is lower than the right and therefore land occupying this side of the channel is at risk of flooding. The properties most at risk are those in St Bede's Gardens and Crescent and those along Burnside. There is significant area for flood storage between these properties on the school grounds and allotments. Consultation with local residents reveals no history of flooding for at least the last 6 years.

Section 3: The catchment in this section comprises the Sainsbury's Superstore and car park, the A1134 roundabout to the west and a car park and TA centre on the right bank. An embanked railway also crosses the floodplain.

There is a previous history of flooding on Sainsbury's property in 1982. This section is crossed by six structures and the floodplain consists mainly of impermeable surfaces. The size of some of these structures is significantly less than the channel capacity, though the three Sainsbury's access bridges are sufficiently sized. In a 1% event there is likely to be significant runoff from the impermeable areas which, combined with the observed excessive rubbish in the channel and overgrown channel downstream of Barnwell Road Bridge, increases the risk of flooding in this section.

Section 4: The valley in this section comprises Coldham's Common with little developed area on the left bank and residential areas, allotments and the Abbey Sports Centre and Stadium on the right bank.

Over much of this section Coldham's Brook remains dry for significant periods. It is probable that the East Cambridge Main Drain takes most of the flow until the two channels converge again at Newmarket Road Bridge. Coldham's Common provides a large potential flood storage area on the left bank. To the right, the channel flows alongside Barnwell Road for 800 m and then residential areas and sports grounds for a further 800 m before reaching an area of allotment gardens and Abbey Stadium near Newmarket Road. The land generally slopes westwards alongside the Abbey Stadium. The culvert which diverts the brook back into the East Cambridge Main Drain is quite small (300 mm diameter). The size of the culvert combined with the vegetated channel and topography of the land is likely to cause flooding west onto the Common in a 1% event. It has been reported that the 300 mm outlet pipe linking the two channels has in the past become blocked, the most recent occurrence being attributed to vandalism. The resulting floodwater was reported as having come within 25 mm of the entrance lobby to the pool and as having entered the pump chambers.

Section 5: The valley in this section is bordered by the Cambridge-Ely Railway to the west and residential areas to the east before the watercourse drains into the Cam floodplain at Stourbridge Common and Ditton Meadows. There is a buffer of approximately 50 m either side of the channel from the residential areas before it enters the floodplain. The main flood risk here is posed by the River Cam. The Common lands here should be left free of development to function as a natural floodplain.

Existing Properties at Risk – Standard of Protection:

- Daws Lane Allotments and Cherry Hinton Hall outbuildings: standard of protection assessed as the 1.33% event,
- one property in St Bede's Crescent (nos 69-73): standard of protection assessed as the 1.33% event,
- all properties in Burnside: standard of protection assessed as the 2% event,
- Sainsbury's Superstore: standard of protection assessed as the 2% event,
- Abbey Sports Centre: standard of protection assessed as the 2% event.

Risk to Possible Development:

Given the size of the watercourse and its location in relation to the Cambridge East Area of Major Change, it is highly unlikely that Coldham's Brook will affect the proposed development areas. However, in relation to possible development closer to the brook, it is recommended that vegetation growth is controlled and that the channel be cleared when necessary, especially alongside the allotment gardens in Sections 1 and 2. The section between Sainsbury's and Barnwell Road should also be checked regularly for overgrowth and debris given the previous history of flooding here. Efforts should also be targeted to ensure that the pipe linking Coldham's Brook to the East Cambridge Main Drain does not become blocked.

Access for Inspection

Access is good for most of the channel. A public footpath runs alongside the channel for all of Section two and most of Sections one, three, four and five. There is no path behind Whitehill Road in Coldham's Common or from Newmarket Road Bridge to the disused railway bridge immediately upstream of Ditton Meadows where access is difficult, if not impossible.

B2 East Cambridge Main Drain

This watercourse was inspected on the 1 and 4 July 2005, along with Coldham's (or Cherry Hinton) Brook. It is an Awarded Watercourse and flows through Coldham's Common from Barnwell Road to Newmarket Road. The Cambridge East development area lies to the east of the watercourse. Bank heights range from 2 to 3 m along the length of the drain. However, they increase rapidly to 4.5 m on the left bank and 3.5 m on the right bank in places. The overall width of the channel is about 3 m although the channel has a greater capacity in places especially at Abbey Swimming Pool. Culvert and bridge dimensions are consistent throughout and there does not seem to be a significant risk of flow restriction at any of the structures. There are five structures on the channel and the approximate length of the channel is 1.9 km.

Channel:

The channel emerges from a surface water sewer at the point where Barnwell Road and the railway line intersect. Approximately 100 m downstream of this point the drain passes under Coldham's Brook at a low level. The channel is cut to 3.5 m deep here with a width of 3 m. The culvert is a concrete box with a height of 1 m, width approximately 2.5 m. At the time of inspection, there was heavy vegetation on both banks.

Figure B2.1: East Cambridge Main Drain passing under Coldham's Brook near Barnwell Road

The channel proceeds north through a patch of dense woodland until the culvert under Coldham's Common Road – an access road linking Coldham's Common with Barnwell Road. At the time of inspection, the water here was stagnant. The channel is very deep, on average 2.5-3 m to the bank top. The banks were covered with dense leafy vegetation. The culvert is approximately 2 m in diameter.

The channel then continues through woodland until it passes under Coldham's Brook again just south of Galfrid Road. The channel narrows here from 2 m to 1 m and the flow increases, possibly due to leakage from Coldham's Brook or groundwater seepage into the drain. The culvert dimensions are approximately 1 m wide and 1.7 m high. There is a trash screen on the upstream side of the culvert with the potential for build-up of debris.

Downstream of this point the channel widens again to 2.5 m. At the time of inspection, tide marks indicated a recent water depth of 1 m. The right bank between East Cambridge Main Drain and Coldham's Brook rises to 4.5 m with the left bank rising to 3.5 m. At the time of the inspection, the channel was generally clear of debris and vegetation and flowing freely.

At Abbey Swimming Pool the drain is crossed by two bridges – a road bridge upstream and a footbridge downstream of the pool. The road bridge has a clearance of 1.5 m above the channel bed. The overall channel width is 5 to 6 m with a bed width of approximately 3 m. The banks on both sides rise to 2m. Again there were tide marks indicating a recent flow of approximately 1 m depth.

Just downstream of the Abbey Swimming Pool and opposite the allotment gardens on the right, a 1 m diameter culvert takes the Drain under a footpath. Several metres downstream of this point the flow was observed to be sluggish, though there was evidence of high flows in the recent past. The drain is also joined from the south by a 340 m long ditch which drains properties to the east of Cambridge Retail Park. This tributary also acts as an outfall from surface water sewers serving the Colham's Lane and Cromwell Road area. The Main Drain bank heights in this area are 3 m on the right and up to 4 m on the left. Any flooding here would inundate Coldham's Common and endanger Abbey Pool. It is reported that as a reaction to heavy storms, the Main Drain runs close to bank full. Any additional flows from future development would have to be strictly controlled. The Abbey Stadium is not at risk as raised banks (approximately 1.5 m above ground level) alongside the drain are sufficiently high.

Figure B2.2: East Cambridge Main Drain passing under Newmarket Road

Just upstream of Newmarket Road Bridge, the drain receives diverted flow from Coldham's Brook via a small 300 mm diameter culvert in the right bank. At this point the drain ends and becomes Coldham's Brook. The brook flows under Newmarket Road via a 1.2 m diameter corrugated steel culvert.

Floodplain:

This watercourse runs largely through undeveloped land – Coldham's Common on the left bank and woodland, allotments and residential areas on the right bank. The capacities of the channel and structures are assessed to be generally enough to contain a 1% event. The trash screen on the upstream side of the second crossing with Coldham's Brook presents the only major risk of blockage. The potential for flooding does exist, however, where one bank is significantly lower than the other. This situation exists just before the Abbey Pool Sports Centre where the left bank is low, and opposite Cambridge Retail Park where the right bank is low. At these locations the topography of the land would take water onto the Common rather than into developed areas. However, the Sports Centre is assessed to be at risk in a 1% event.

Existing Properties at Risk – Standard of Protection:

Abbey Pool Sports Centre: standard of protection assessed as the 2% event.

Risk to Possible Development:

There is assessed to be no risk of flooding from the East Cambridge Main Drain to the Cambridge East Area of Major Change.

Access for Inspection:

The whole length of the channel is accessible via Coldham's Common.

B3 March Lane Ditch

This is an Awarded Watercourse draining northern Cherry Hinton and the south-eastern section of the airport site. The culvert outlet is at March Lane and the watercourse flows in a northerly direction across the airport lands before crossing into South Cambridgeshire District, where the watercourse is known as Allen's Farm Brook. From here the brook drains arable land and flows across Teversham Fen and into Quy Water. The length of the studied section of the drain is approximately 600 m.

Channel:

Throughout the studied length, the watercourse is around 1.3 m deep with arable farmland on the right bank and open grassland on the left bank. Around halfway along, a secondary ditch merges with the March Lane Ditch from the left and two structures cross the watercourse – a footbridge and a 500 mm diameter culvert. A third drain from the airport joins the main ditch a few metres further downstream before the ditch heads into a 500 mm high arch culvert. At the time of the inspection the upstream reach of the channel was clear, while downstream the channel was very overgrown.

Floodplain:

The valley comprises open areas of grassland and arable fields. As there is a shallow gradient in the area, flooding from the drain would be limited by the volume of water and the height of the banks. The risk of flooding from this drain would be greater on the right bank but would coincide with low points in the banks, especially at points with potential for channel blockage.

Existing Properties at Risk – Standard of Protection:

There are no existing properties at risk from this watercourse.

Risk to Possible Development:

It can be seen from the flood maps that the extent of the at-risk area is small, and it should be possible to plan the Cambridge East development so as to avoid creating any risk to property or infrastructure.

Access for Inspection:

Access via footpath running along left bank of ditch accessed from either March Lane, Cherry Hinton, or Airport Way, near Teversham.

B4 Hobson's and Vicar's Brook (including the Long Road Ditches)

The natural watercourse in this area flows from Nine Wells via Vicars Brook to the Cam. The section designated as Hobson's Brook downstream of Long Road is an artificial channel created in 1614 to carry water from the chalk springs at Nine Wells into the centre of Cambridge. Both Hobson's and Vicar's Brooks are classified as Awarded Watercourses within Cambridge City. From Nine Wells, Hobson's Brook runs across agricultural land to the south of the city, before a series of overspill weirs mark the start of Vicar's Brook. From here, Hobson's Brook runs under Brooklands Avenue as far as the conduit head at Lensfield Road, where the water feeds a network of pipes supplying college fishponds and the Cambridge 'runnels' with water. Vicar's Brook turns westwards at Brooklands Avenue and flows into the River Cam opposite Newnham Croft.

Hobson's Brook is managed by voluntary Trustees. The Trust appoints City Council Officers to attend to the daily running and administration of the Brook. Maintenance and other works are paid for through an invested legacy and annual grants from the City Council.

To ease reporting, the studied area has been broken into a number of sections with similar characteristics:

1. Nine Wells to disused railway bridges
2. Disused railway bridges to Long Road
3. Long Road to arch culvert at Porsons Road
4. Arch culvert at Porsons Road to Brooklands Avenue
5. Vicar's Brook from Brooklands Avenue to River Cam
6. Hobson's Conduit from Brooklands Avenue to Lensfield Road

Historic Flooding:

Flooding has occurred in the downstream reaches of the Brook in recent times. On 19 November 2004, an overflow pipe blocked during a flood event, causing the overflow pipe to surcharge and flood the western end of Brooklands Avenue and Trumpington Road. The Brook has also previously overspilled into the Botanical Gardens.

This section of Hobson's Conduit is at particular risk in flood events. Flow levels along the canalised section are currently regulated manually, solely to maintain aesthetics and to ensure there is sufficient volume (summer), or spare capacity (winter), in the channel to meet the needs of the operation of the runnels (April to October/November), and of private clients year round. A combination of weirs and overflows exist to assist regulation, because there is no effective outfall from the watercourse [9]. These points should to be taken into account in the preparation of flood risk assessments for developments which may impact on this area.

Channel:

Section 1: Hobson's Brook rises from 3 springheads located in a small area of woodland at Nine

[9] 'Addenbrooke's Access Road: Flood Risk Assessment – Draft Final Report', Atkins, March 2005

Wells to the south of Addenbrooke's Hospital. Water flows along a channel approximately 2 m wide with banks just over 1 m high. The bank height increases to as much as 2 m as the drain heads north towards Long Road.

Two structures are located halfway along this section: a railway bridge and a 1 m high arch culvert under a farm track. A field drain joins the course of Hobson's Brook around 450 m downstream of the railway bridge. Beyond this crossing, the Brook widens to around 3.5 m before reaching the disused railway bridges, though the bank height drops to around 1.2 m.

Figure B4.1: Hobson's Brook passing through Southern Fringe Area of Major Change

Section 2: A total of four bridges cross the brook at the disused railway, including two brick arches 4.5 m in length, a steel railway bridge 10.5 m in length and another brick arch bridge 4 m in length. Two pipes also cross the stream at low level, creating conditions for a potential blockage. The channel is restricted to 2.5 m width with further restrictions at the arches reducing the channel width to 1.5 m. The arches have a soffit level of 1.1 m above the bed. In addition to the bridges, two drains flow into the brook just downstream of the crossings.

The channel downstream of the railway bridges is still a deep cut drain with a mean channel depth of approximately 1.6 m. A narrow 20 m forested strip hugs the left bank and is lower than the right bank which borders on agricultural land. Two tributary drains flow into Hobson's along this reach from each side of the Brook – the one flowing across the arable land has a much larger capacity. Between here and Long Road, the channel becomes wider – up to 4 m – with banks dropping to a height of approximately 1.2 m. Just upstream of Long Road, both banks are wooded and the banks low.

Figure B4.2: Disused Railway Bridge

Section 3: At Long Road, the brook passes under the road through a small concrete box culvert, 1.1 m high and 1.4 m wide. Downstream, the channel is wide (2.5 to 3 m) and shallow with bank top heights approximately 1.2 m. The brook borders agricultural land on the right bank and a number of properties along Long Road, Barrow Road and Porson Road on the left bank. Interviews with local residents reveal that flooding of these properties has not occurred within the last 46 years.

A potential restriction along this reach is the brick arch structure at the end of Porson Road with a soffit height above bed of just 0.75 m and a width of 1.40 m. The banks are particularly low in this location (0.5 m). There is structural damage to the supporting brickwork of the culvert.

Section 4: The Long Road ditch joins Hobson's Brook just downstream of the arch bridge. This drains the field on the right bank of Hobson's Brook as well as the land on the eastern side of the railway line. This is a very deep ditch – up to 2.5 m – and with a bottom width of 1 m.

Vicar's Brook diverts from Hobson's Brook just 5 m downstream of the small arch into a culvert with a diameter of just 0.15 m. The flow in Vicar's Brook is limited by the capacity of this culvert at this point.

The two Brooks pass Clare College playing fields, flowing under the access road bridges with a clearance of 1 m. Hobson's Brook is 2.5-3 m wide at this point. A weir then diverts flood waters from Hobson's Brook into Vicar's Brook. This weir is fixed at a water level of 0.40 m, while the footbridge over the weir has a clearance of just 0.20 m, which may get blocked by debris.

The two Brooks run parallel as far as Brooklands Avenue separated by an area of woodland and allotments known as Empty Common.

Section 5: Vicar's Brook runs to the north-west in a channel alongside the Queensway flats. The right bank height up to Brooklands Avenue and Trumpington Road is considerable – as much as 3 m. However, the left bank opposite the flats is just under 1 m high. The watercourse then runs through an

arch culvert under Trumpington Road, 1.4 m high and 1.2 m wide, with an open security gate at the downstream outlet.

Figure B4.3: Vicar's Brook Culvert under Trumpington Road

The brook then flows along the southern edge of New Bit – a stretch of common grazing land up to the confluence with the River Cam. Bank heights up to the common land are around 2.5 m, but are lower on the left bank (1.5-2 m), where the stream abuts the gardens of a number of properties.

Section 6: Hobson's Brook flows under Brooklands Avenue via a bridge with a soffit height above bed of 1.1 m. Around 20 m downstream of the bridge there is a fixed weir approximately 2 m in width and with a crest level 0.60 m above the channel bed. The weir is topped with concrete paving slabs, so water flows through a gap around 20 cm in width. This could easily become blocked by debris and prevent floodwaters flowing into the culvert which runs underneath Trumpington Road and into Vicar's Brook.

Thereafter, the flow in Hobson's Brook is very low. The watercourse is perched with normal water levels approximately 0.5 m above the level of Trumpington Road. The channel is approx. 3 m wide with low banks. At the end of New Bit, the road rises above the level of the Brook and the watercourse passes through a channel similar in width, but with banks up to 1 m high as far as Lensfield Road, where water is diverted into a number of culverts to supply Trustee Clients with water and to operate the Trumpington Street and St. Andrews Street Runnels.

Floodplain:

Section 1: The valley in the studied reach comprises open arable fields on both banks.

In the 1% event, it is assessed that flooding would be limited to three areas: upstream of the culverts under the railway and the farm track and on the right bank coinciding with a low point on the bank. Otherwise flow would remain within bank, assuming that there are no blockages in the channel.

The railway bridges provide a possible restriction due to the presence of pipes crossing the channel at low level as well as the narrow width of the channel.

Section 2: The valley in this section comprises open arable fields on the right bank and a thin band of woodland separates the left bank from more arable fields. Although the banks are lower on the left, the extent of flooding would be limited due to the slope of the land in the woodland area. The extent of the flooding on the right bank, by contrast, would be limited by the volume of water out-of-bank, as there is very little gradient.

The main area of flooding in this section would be caused by water backing-up at the Long Road culvert, where water would flood into the woodland on both sides of the stream.

Section 3: The valley in this section comprises open arable fields on the right and residential areas to the left. The banks in this area are fairly low and the arch bridge creates a restriction which could lead to both banks being flooded during a 1% event. The greatest risk of flooding is to the area just upstream of this arch bridge, particularly on the low right bank, where flooding could be extensive. The land either side of the bridge is low, so the restricting structure would be bypassed easily. At the time of the inspection there was a large amount of debris in the channel which could block the channel and cause flooding.

Figure B4.4: Bridge at End of Porson's Road

Flooding is not expected to be extensive and no properties are likely to be affected, though gardens along the back of Porson Road and Barrow Road would be flooded.

Section 4: Downstream of the arch bridge, flooding would be predominantly on the land between Vicar's Brook and Hobson's Brook in Empty Common. On the right bank, Clare College pavilion may be at risk from flooding during a 1% event due to its proximity to the watercourse. There is no assessed flood risk to the Accordia development and the Nuclear Bunker.

Halfway along this reach, the weir diverts water away from the main channel of Hobson's Brook in high flows. The water is diverted down a small channel through woodland on Empty Common and via a 300 mm diameter pipe culvert into Vicars Brook. The land between the two channels is particularly low-lying and would become flooded during a 1% event. This is particularly important as it prevents areas upstream and downstream from flooding.

Just upstream of the Trumpington Road crossing on Vicar's Brook, the left bank lowers considerably as the brook flows past Queensway flats, which are at risk from shallow levels of flooding.

Section 5: Downstream of Trumpington Road, Vicar's Brook enters New Bit with common land on the right bank and the left bank backing onto the gardens of properties along Chaucer Road. The right bank is around 0.3 m higher than the left bank, so flooding is likely to occur in the back gardens of properties along Chaucer Road during a 1% event. The levels in the Upper River affect the Vicar's Brook confluence with the River Cam.

Section 6: Downstream of Brooklands Avenue, Hobson's Brook is perched above the level of Trumpington Road as it runs along New Bit, so New Bit and this section of the road should be retained as floodplain during a 1% event. A weir approximately 20 m downstream of the Brookland's Avenue crossing diverts flood flows along Hobson's Brook into Vicar's Brook, though this could easily become blocked by debris.

The banks are relatively low-lying alongside the Botanical Garden and the Lodge is at risk of flooding during a 1% flood event. Beyond Bateman Street, however, the banks are higher and flooding is unlikely to affect the houses downstream of Bateman Street.

Existing Properties at Risk – Standard of Protection:

- Queensway flats: standard of protection assessed as the 1.33% event
- The Lodge at the University Botanic Gardens: standard of protection assessed as the 1.33% event
- Clare College Pavilion: standard of protection assessed as the 1.33% event
- Two apartment buildings in Applecourt (Newton Road): standard of protection assessed as the 1.33% event
- Leys School buildings backing onto Coe Fen: standard of protection assessed as the 1.33% event

Risk to Possible Development:

A green corridor must be provided and maintained to allow out-of-bank flow during a 100-year event and to facilitate dredging and spreading of arisings. Vegetation growth must also be controlled. A number of structures should be modified and/or replaced including:

- The arch bridge at the end of Porson Road.
- The weir in Empty Common to control flood flows in Hobson's Brook to ensure that debris does not block the gap between the weir and the footbridge.
- The weir controlling flood levels in Hobson's Brook just upstream of the Brooklands Avenue bridge needs to be assessed as the inlet to the culvert could easily be blocked by debris.

Access for Inspection:

Access is generally good along the length of Hobson's Brook, although there is no public right of way alongside the Brook from the railway crossing to Long Road, though the fields are not difficult to cross. Access is not good for Vicar's Brook from its upstream boundary at Porson Road as far as Queensway. There is no path along this section of watercourse.

Figure B4.5: Plaque showing History of Hobson's Conduit

B5 First Public Main Drain (East)

The First Public Main Drain has a catchment area covering King's Hedges and Arbury. Much of the watercourse is culverted and maintained as a surface water sewer until the drain reaches the Science Park where flow emerges into open channel. It flows through the Science Park, around the Anglian Water Wastewater Treatment Works and into the River Cam downstream of the A14.

This channel emerges from a 3 m concrete box culvert at the southern edge of the Science Park. The channel itself is clearly artificial: reaches are straight and bends are usually extremely tight and at right angles. The channel has been divided into six fairly homogeneous sections to aid description.

Channel:

Section 1: The first section of the channel as far as Milton Road is approx. 1.5 m to 2 m in width at the bed. Banks on either side are approximately 3 m to 4m in height and at a slope of 1:1. Land on the left bank is generally at the same level as the bank top, but, on the south side of the Science Park, the land falls away by some 2 m. The banks were generally overgrown and could cause blockage if not maintained, though the channel itself was free of growth and was noted to be flowing well at the time of the inspection. In two locations, the banks are so steep that erosion has occurred, such that further slippage could cause blockage of the channel. Bank heights fall away to a height of 1.5 m towards Milton Road.

Figure B5.1: First Public Drain through Cambridge Science Park

There are two corrugated steel culverts along this reach with a bottom width of approximtely 3m and a height of approximately 1.5m.

Section 2: At Milton Road, the drain runs into a 1m high concrete box culvert 1.5 m wide at the inlet and 3 m wide at the outlet. An overflow culvert 3 m wide at the inlet and 2 m wide at the outlet allows flood flows under the road at a water depth of around 40 cm. The inlet has a trash screen and the outlet a security screen. Between these two screens is a 40 m long, 1.8 m diameter and 8 to 9 m deep inverted siphon which conveys flows between the structures either side of Milton Road. There are twin 1.05 m diameter culverts in place that act as overflows. At the time of the site visit, the inlet screen was observed to be partially clogged with debris, though water was flowing well.

Figure B5.2: Milton Road Siphon

Section 3: Downstream of Milton Road, the watercourse is approximately 1.5 to 2 m wide, while the right bank is approximately 1.5m high. The land on the right bank falls away towards the Cambridge Business Park. Again there is evidence of bank erosion and heavy bank vegetation, both of which could cause blockage to the drain.

Section 4: 400 m downstream of the Milton Road crossing, the Drain turns sharply left and through a twin barrel concrete box culvert. Each barrel is approximately 3 m in width, with a height of approximately 1.5 m. At the bend, gabions have been placed to protect the bank. Many of the stones have been washed away from the gabions and this bank (separating the First Public Main Drain from a minor drain) is potentially at risk of collapse.

Section 5: The section running to the east of the golf driving range is inaccessible, but the channel is approximately 3m wide with a left bank height of approximately 4 m and a right bank height of around 3 m. Thick vegetation is present on the right bank.

Figure B5.3: Cowley Road Bend and Culverts

Section 6: The following reach runs along the south east and east sides of the sewage treatment works. The channel is deep and wide along this section: 3 to 5 m wide, with a bank height of approximately 4 m to the sewage works and 3 m to the industrial estate at the end of Cowley Road. High water marks were visible along this section up to 0.5 m above bed level and water levels in this section of drain have reached 2 to 2.5 m above bed level in the last ten years, according to Anglian Water staff.

Figure B5.4: First Public Drain alongside Cambridge Wastewater Treatment Works

The culvert under the A14 consists of two 1.75 m diameter culverts and one 1 m diameter culvert raised around 0.5 m above the other two culverts. These would be a downstream restriction during a 1% event, though it has been assessed that a 1% event would not go out-of-bank in this reach of the drain. If water goes out of bank at Milton Road, then flows in this reach would be reduced, further lowering the chance of out-of-bank flow.

Figure B5.5: Triple Culverts under A14
(Smaller Culvert is Hidden by Vegetation on the Left Hand Side)

Before turning right (east) under the railway line, the City's First Public Drain and South Cambridgeshire's Ninth Public Drain converge. The combined watercourse then passes through three parallel culverts and on to discharge into the River Cam, downstream of Baits Bite Lock. Although this feature is in South Cambridgeshire's area, it is critical to the working of the watercourse and should be taken into consideration in any modelling carried out in relation to upstream flood risk.

Floodplain:

Despite the relatively large catchment area of the First Public Main Drain, the watercourse is unlikely to flood surrounding land as the banks are so high. However, there are points where the Drain is vulnerable:

1. The culvert at Milton Road is protected by a trash rack, which could become easily clogged by debris. The banks are low at this point. Water overtopping the banks here would flow southwards down the Milton Road before flowing eastwards along the Cambridge Business Park access road and towards the Chesterton sidings.

2. The right bank of the Drain downstream of the Milton Road crossing is only 1.5 m in height and water overtopping this bank would flow over the road and under the perimeter fence of the Cambridge Business Park and again towards the sidings.

Properties at Risk – Standard of Protection:

No properties are assessed to be at risk for the 1% event from the First Public Main Drain, though the private drainage network at the Cambridge Science Park has experienced flooding problems, particularly at the Conference Centre Gym Facilities. Overtopping has been assessed to occur during a 1% event at Milton Road culvert. Water would flow into Milton Road and into both the drain on the other side of the road and the Cambridge Business Park to the south, flowing eastwards towards the River Cam.

Risk to Possible Development:

There is assessed to be no risk to development on the Northern Fringe site for the 1% event, provided that the channel is maintained:

1. The channel should be kept free of vegetation, and vegetation along the banks should be trimmed back from the watercourse.

2. The channel banks need to be stabilised in locations where channel slippage has occurred.

3. Bends in the channel need to be reinforced to prevent erosion as is currently occurring to the gabions immediately upstream of the Cowley Road culvert.

Access for Inspection:

Access from the upstream end of the open channel as far as Cowley Road is good. However, the channel is inaccessible on the eastern side of the golf driving range. At the downstream end of the drain, permission must be obtained from Anglian Water to access the Drain as it runs along the south eastern and eastern edges of their Wastewater Treatment Works site.

Access to the lower reaches of the First Public Main Drain is through Milton Country Park, arrangements made via the park wardens.

B6 Madingley Road Ditch

This channel runs in a north-westerly direction along the northern side of the Park and Ride site before flowing into Washpit Brook at the Pheasant Plantation at the City Boundary.

Figure B6.1: Pond at Madingley Road Park and Ride Site

Channel:

The channel has a top width of around 4 to 5 m and a bed width of approximately 0.5 to 1 m. Banks have a height of approximately 0.8 to 1.5 m. The watercourse is heavily overgrown in places and the flow is assessed to be low for significant periods.

Floodplain:

Agricultural land on the right bank lies around 2m higher than the bed level of the ditch and there is no evidence of flooding on this side of the drain.

The ground slopes down towards the drain on the left bank. The ditch can be as little as 0.5 to 0.8 m wide in places. Flooding does occur within the Pheasant Plantation, so flooding may occur along the left bank up to 1.5 to 2 m away into the field adjacent to the stream during high return period flows in the field between the Park and Ride and the Pheasant Plantation. Water may also spill across the left bank into the attenuation pond at the Park and Ride.

Figure B6.2: Madingley Road Ditch between Park and Ride Site and Pheasant Plantation, showing ground sloping gently down towards watercourse

Existing Properties at Risk – Standard of Protection

No properties are at risk of flooding from Madingley Road Ditch.

Risk to Possible Development

Limited risk to development provided a green corridor is maintained for the channel and vegetation growth in the channel is cleared and controlled by facilitating an access strip for dredging and spreading.

Access for Inspection

The ditch was accessed from the Park and Ride Site, though a path runs alongside the ditch from the University Farm at the end of Conduit Head Road, so the watercourse can also be accessed from there.

B7 Daws Lane Ditch

This ditch originates at the outfall from a 120 m long culvert offtaking from Cherry Hinton Brook in the grounds of Cherry Hinton Hall. It flows for 270 m in a north westerly direction, with Daws Lane on its right bank until it reaches Walpole Road where it enters a 3 m wide, 1m deep concrete box culvert to pass under the road. The ditch emerges to the west of Walpole Road in the grounds of St Bede's School where it is known as the Birdswood Road Ditch. This ditch continues for a further 550 m parallel to Birdswood Road before discharging to the East Cambridge Main Drain via a 1050 mm sewer at Tiverton Way Allotments. As noted in Section 5.1 above, the ownership and maintenance responsibility for the Birdswood Road section of this ditch is disputed between Cambridge City Council and Anglian Water.

Channel:

The 270 m of Daws Lane Ditch was inspected in January 2006. At its upstream extent after emerging from culvert, the channel has a top width of around 6 m, and a bed width of approximately 1.5 to 2 m. Banks have a height of approximately 2.5 m on the right where Daws Lane runs beside the allotments, and 2.0 m on the left bank which abuts the grounds of Cherry Hinton Hall. At the time of the inspection for this report the watercourse was generally clear of vegetation with some minor accumulations of rubbish which had no significant affect on flow. Flow was generally slow with a water depth of some 0.05 m.

After 120 m the allotments on the right of Daws Lane give way to houses fronting onto St Bede's Crescent. After a further 60 m there is a footbridge over the watercourse from Daws Lane into the grounds of Cherry Hinton Hall. This comprises a wooden deck over a 3 m length of 1.05 m diameter concrete pipe.

At the approach to the culvert under Walpole Road (the end of Daws Lane Ditch) the watercourse has a bed width of approximately 1.5 m and banks 2 m high on the right bank and 1.5m high on the left bank. The entrance to the 3 m wide concrete box culvert is protected by a screen which has been vandalised.

Floodplain:

The allotments on the right bank are protected by an earth bank to the east of Daws Lane. It is assessed that the lower sections of the left bank may overtop in a 1% event allowing flood water to pond over small areas of the Cherry Hinton Hall grounds close to the ditch.

Downstream of the footbridge the houses on St Bedes Crescent, Nos. 127 to 149 (odds) are lower than those further upstream. However it is assessed that they would only be at risk of flooding if the culvert under Walpole road was to block.

Figure B7.2: Daws Lane Ditch, Upstream Extent

Existing Properties at Risk – Standard of Protection

It is assessed that there are no properties at risk for the 1% event from Daws Lane Ditch. However if there was a blockage of the Walpole Road culvert then the houses in St Bedes Crescent, Nos. 127 to 149 (odds) would be at risk.

The Standard of Protection to existing property from Daws Lane Ditch is assessed to be the 1% event.

Risk to Possible Development

It is understood that there is no new development proposed in the vicinity of Daws Lane Ditch

Access for Inspection

The ditch was accessed from Daws Lane.

Appendix C Summary of Hydrological and Hydraulic Modelling undertaken for River Cam

C1 Introduction

A model of the River Cam through Cambridge was originally constructed by Mott MacDonald in 1996 as part of the River Cam Improvements Project, using their in-house modelling software, Hydro 1-D. The initial phase from Jesus Green Lock to Baits Bite was extended upstream to Byron's Pool as Phase 2 of the same project and downstream to Bottisham Lock in 2002 in order to assess the flood risk to a proposed development in Waterbeach.

A further model of the Rivers Cam and Granta upstream of Byron's Pool was originally constructed by Bullen Consultants and later updated by Halcrow using ISIS software in 2002. The hydrological and hydraulic models used for this upstream stretch of the river has been used as a basis for adapting and verifying Mott MacDonald's Hydro 1-D model.

As part of the Strategic Flood Risk Assessment, the hydrological model for the River Cam was updated from procedures based on the Flood Studies Report (FSR) to those based on the Flood Estimation Handbook (FEH). Furthermore, Hydro 1-D has been updated from an MS DOS based version to a Windows compatible program. The hydrological model has also made use of the recently updated flood events records made available through the HiFlows-UK project.

C2 Hydrology

The upper limit of the model extends beyond Byron's Pool as far as the gauging stations at Dernford on the River Cam, Stapleford on the River Granta and at Burnt Mill on the River Rhee. The model has a further six inflows as far as Jesus Green Lock: the River Rhee, Bourn Brook, the Rhee-Cam confluence at Hauxton Junction, Hobson's Brook, Bin Brook and at Jesus Green itself. There is also a gauging station on the River Rhee at Burnt Mill near Haslingfield.

The gauging stations on the Rivers Cam, Granta and Rhee were all used to create models of the Rivers Cam and Granta[10] and the River Rhee[11] as part of 'Standard of Protection' studies carried out by Halcrow. The hydrological analysis of these gauging stations was detailed and thorough, so checks have been made of the analyses at Dernford and at Burnt Mill to assess their suitability for use in the Mott MacDonald Hydro 1-D model. QMED values were calculated from updated flow records extracted from the HiFlows-UK dataset, while growth curves were calculated using pooling groups and the FEH statistical method. Marginal differences between the Halcrow results and those calculated as part of this project can be attributed to one or two updates to the HiFlows-UK records since 2003 and differences in selecting stations for the pooling group. Peak flows for 10-year and 100-year floods at Dernford (Cam) and Burnt Mill (Rhee) were taken from the Mott MacDonald analysis as they are marginally higher than the Halcrow results, while the Halcrow peak flows at Stapleford (Granta) were used as there was no updated HiFlows-UK data for this station.

[10] 'Rivers Cam and Granta Model Improvements – Model Construction and SoP Assessment, Final Report', Halcrow, November 2004
[11] 'River Rhee – Standard of Protection Study', Halcrow, December 2003

Table C2.1: Gauging Stations Upstream of Byron's Pool

CEH Reference Number	Location	Watercourse	NGR
33021	Burnt Mill	Rhee	5415 2523
33024	Dernford	Cam	5466 2506
33027	Wimpole	Rhee	5333 2485
33051	Chesterford	Cam	5505 2426
33055	Babraham	Granta	5510 2504
33813	Meldreth	Mel	5378 2466

For the other inflows into the model, catchment descriptors were extracted from the FEH CD-ROM and used to calculate QMED. These values were then adjusted using the donor catchments of the Rivers Cam, Granta and Rhee. Growth curves were established in a similar way, using pooling groups based on catchment descriptors at the inflow points.

Design hydrographs were calculated using the FEH rainfall-runoff method and adjusted according to the peaks calculated using the statistical method. The rainfall-runoff method tends to overestimate flows as the catchment descriptors do not take into account the influence of groundwater in chalk catchments. The statistical method tends to underestimate flows as gauging stations in the area are designed to measure low flows rather than flood flows. As a result, gauging stations often drown and measuring high flows is therefore not easy. For instance, the gauging station at Dernford on the River Cam drowns before flow over the weir reaches the QMED value and the weir at Burnt Mill also drowns at high flows.

The HiFlows-UK project aims to correct some of these inaccuracies, but accurate rating curves will ultimately depend on the ability of the Environment Agency to take spot gaugings during flood events – a process which is often difficult and potentially inaccurate itself.

C3 Hydraulics

The hydraulic modelling was undertaken using a Hydro 1-D unsteady state model. This is basically the same model as used in the River Cam Improvements project carried out for the Environment Agency by Mott MacDonald from 1996 to 1999. The Hydro 1-D program has since been updated to run in Windows and this updated software has been used to run the model, though this will not alter the results obtained from the model. An addendum to Phase 2 of the 1999 project resulted in the addition of Bin Brook from the Stone Bridge on Barton Road as far as the confluence River Cam.

All cross-sections along the river are identical to those used in the River Cam Improvements Projects, so the hydraulics of the model have not been altered at all.

C4 Mapping

The modelled water levels at the cross-sections were converted to a continuous water surface taking into account floodplain flow and ineffective flow in built-up areas. Discontinuities were included at road and railway embankments and flood defences. The water surface was then intersected with the topographic surveys and the resulting flood extent reviewed and mapped. The review process was conducted using information from the models in conjunction with O.S. mapping and topographic levels.

As the unfiltered LiDAR was used in some locations, some discontinuities appeared, due to LiDAR returns from the tops of houses or trees. These were identified in the review process and, where appropriate, included within the flood envelope.

EFO output was used to provide the 0.1% envelope.

Appendix D Surface Water Sewers

D1 Background

Cambridge City has large areas of impermeable ground, so, aside from the surface watercourses, the city is drained by a network of drainage pipes, largely owned and maintained by Anglian Water.

The total length of surface water sewers within the Cambridge catchment is 309.2 km

D2 First Public Main Drain

The northern wards of Cambridge – Arbury, King's Hedges and the northern side of Castle – drain into the First Public Main Drain, with surface water runoff flowing into a main sewer which runs northwards along Histon Road before turning south-east along King's Hedges Road and finally north-east along Campkin Road before flowing into the open section of the First Public Main Drain. The open drain flows through the Science Park, around the Milton Wastewater Treatment Works and into the River Cam just downstream of the A14 crossing. A detailed description of the open channel section of the First Public Main Drain can be found in Appendix B5.

A WALRUS model created by Binnie and Partners in November 1991 showed two locations to be at risk from flooding during a 5-year 60 minute storm in the First Public Main Drain catchment:

- Histon Road, to the south of Carisbrooke Road as far as the Akeman Street junction
- The Halifax Road, Richmond Road, Oxford Road area, including an adjacent section of Huntingdon Road.

D3 East Cambridge Main Drain

The other major surface water catchment in Cambridge City is the East Cambridge Main Drain, which drains the wards of Queen Edith's, Coleridge and Cherry Hinton. The Cherry Hinton sub-catchment drains into Daws Lane sewer, which runs in an open ditch to the north of Cherry Hinton Hall and Birdwood Road before entering the main Perne Road/Brooks Road sewer.

Flows from Queen Edith's ward enter the Perne Road sewer at its southernmost extent. Flows enter the Perne Road/Brooks Road sewer at three main locations from Coleridge and Romsey wards: at the junction of Perne Road and Cherry Hinton Road, from Radegund Road and from Mill Road.

The main Brooks Road sewer then runs north-eastwards to join the open section of the East Cambridge Main Drain at the north-west corner of the Coldham's Lane/Barnwell Road roundabout. This open section flows across Coldham's and Stourbridge Commons and finally into the River Cam. A description of the open section of watercourse can be found in Appendix B2.

The East Cambridge Main Drain was modelled by Binnie and Partners in November 1991 using a WALRUS simulation. This showed flooding could occur during a 2-year 60 minute storm in seven separate locations throughout the catchment:

- Ashbury Close
- the junction of Davy Road and Rustat Road
- Mill Road to the south of the junction with Coleridge Road – flooding here has been confirmed by reports
- The southern end of Vinery Road
- Marshall Road
- Cherry Hinton Road, at the junction with Hills Road
- Cherry Hinton High Street

D4 Other Sewerage Systems

The rest of Cambridge City is drained by numerous small systems that flow directly into surface watercourses. From Trumpington, for example, surface water sewers drain either eastwards into Hobson's Brook (see Appendix B4) or westwards into the River Cam. Of these more minor surface water drainage networks, three catchments were investigated and modelled using WASSP-SIM by Binnie and Partners in September 1989 to assess the impact of closing overflows into the foul water sewers (see below). Other minor surface water networks, including City Centre, Coldham's Common, West Chesterton, East Road, Hobson's Brook, West Cambridge and East Chesterton networks have not been assessed.

D4.1 City Centre (Magdalene Street sub-catchment)

The Magdalene Street system drains the left bank adjacent to Magdalene Bridge, covering a catchment including Castle Street and Northampton Street, which outfalls into the River Cam just downstream of the bridge.

Modelling of this system showed the lower section of the Castle Street sewer to flood during a 5-year 30 minute storm, while the lower parts of the system are surcharged.

D4.2 City Centre (Midsummer Common sub-catchment)

This is the largest of the three catchments investigated by Binnie and Partners in 1989 and drains areas to the south of Midsummer Common as far as Parker's Piece, including Jesus Lane, Christ's Pieces, Hobson Street to the west and Burleigh Street to the east. The outfall to the River Cam is located on the right bank opposite the college boathouses to the north of Maid's Causeway.

It was assessed using a WASSP-SIM simulation that surcharging in sewers below Maid's Causeway and Burleigh Street would lead to flooding in Midsummer Common during a 5-year 30 minute storm. Flooding would also be experienced at the upper end of the system in Hobson Street and Christ's College.

D4.3 Water Street (West Chesterton)

Surface water from central Chesterton (Scotland Road, High Street and Water Street) drain to two River Cam outfalls near the junction of Water Street and Fallowfield.

The network simulation run by Binnie and Partners in 1989 predicts flooding in Scotland Road and slight flooding in Water Street during a 5-year 30 minute storm, though the report explained that the way the model simulates run-off, storage and time delay means that, in practice, flooding is unlikely to occur at this return period.

Appendix E Foul Water and Combined Sewers

E1 Background

The Cambridge catchment is designated by Anglian Water as that area which drains into the Cambridge Wastewater Treatment Works (WwTW). This catchment not only covers areas within the city, but the works also receive flows from the parishes of Cottenham, Fen Ditton, Girton (part), Great Shelford, Histon, Horningsea, Impington, Little Shelford, Milton, Rampton and Stapleford and covers a population of 145,501. Treated water from the Cambridge WwTW discharges into the River Cam upstream of the A14 road bridge at Milton. A total of 16 pumping stations out of 39 within the WwTW Cambridge Catchment are located within the city boundaries. Many of the older parts of the city have combined sewers.

Within the Cambridge catchment served by the Milton WwTW, the length of foul water and combined sewers is as follows:

- **Combined** 115.2 km
- **FW Sewers** 267.1 km

E2 Riverside Tunnel

The main interceptor tunnel runs from the north-west side of Cambridge in the Castle Ward to the Sewage Treatment Works at Milton, via Chesterton. Two branches run from Wilberforce Road and Madingley Road to the west and Histon Road and Victoria Road to the north and connect in Chesterton Road adjacent to the Graduate public house (manhole TL 4559 2400). From here the tunnel runs through the centre of Chesterton, along Chesterton Road, Scotland Road and Green End Road before heading across Cambridge Business Park to the Wastewater Treatment Works.

A third branch with sub-branches runs from the site of the former Riverside Pumping Station (demolished in the early 1990s) and Elizabeth Way and joins the main tunnel at Chesterton Hospital. There are also numerous connections to the tunnel from foul water sewers throughout north and central Cambridge.

E3 Abbey Ward

Abbey Ward is divided by Newmarket Road into two distinct catchments to the north and south. On the north side of the road, wastewater drains by gravity to the Abbey-Ditton Walk pumping station. The rising main thence takes flows from Ditton Walk on to Coldham's Lane main sewer. From the south of Newmarket Road, flows are taken from the Whitehill Road-Meadowlands Road area to Barnwell Road and on to Newmarket Road.

E4 Arbury Ward

Flows from the Arbury Ward can be divided into four catchments. In the north-west of the ward (St Alban's Road, Verulam Way, Molewood Close) waste drains to the Arbury-Histon Road Pumping Station and rises up to the Histon Road branch of the main tunnel to the wastewater treatment works.

The central/north-east area of Arbury ward, including Perse Way, Harding Way, Thirlby Close, Cockerell Road and Ferrars Way drains northwards to Alex Wood Road. Here a branch from Brimley Road joins and the combined flows head via gravity sewers to the junction of Arbury Road and Mansel Way and on through King's Hedges to the WwTW. Flows from the south of the ward, i.e. the area around Akeman Street and Stretten Avenue drain directly into the main tunnel along Histon Road and Victoria Road.

E5 Castle Ward

Flows from Storeys Way flow south to Madingley Road and from there, via gravity sewers, to the junction of Northampton Street and Castle Street, where they join the Madingley Road branch of the main tunnel.

Flows from the densely populated areas of Oxford Road, Halifax Road and Canterbury Street do not have clear records, but they appear to flow into the Histon Road branch of the tunnel as it turns eastwards into Victoria Avenue.

Flows from Windsor Road head into the top end of the Histon Road branch of the tunnel, while flows from the areas north of Windsor Road, i.e. around Tavistock Road and Brownlow Road are pumped by rising main from the Arbury-Histon Road Pumping Station.

E6 Cherry Hinton Ward

Cherry Hinton is served by four pumping stations bringing wastewater up to a level from where flows can drain by gravity from the western side of Cherry Hinton to Mill Road and into the main sewer opposite Vinery Road. The western and central areas of Cherry Hinton, including the areas around Coldham's Lane, the High Street, Mill End Road and Colville Road, drain by gravity into this sewer. The pumping stations in this ward are as follows:

- **Cherry Hinton-Forest Road** Drains the south-west of the ward to the east of Queen Edith's Way
- **Cherry Hinton-Fulbourn Old Drift** Drains new developments located along Fulbourn Old Drift
- **Cherry Hinton-Fox Gloves** Drains the Gazelle Estate in the north-east of Cherry Hinton.
- **Cherry Hinton-March Lane** Drains the north-west of Cherry Hinton in the vicinity of March Lane and Church End.

E7 Coleridge Ward

The north-east of Coleridge Ward, around Greville Road and Rustat Road flow into Coleridge Road and then follow a line south of Fanshawe Road and into Cherry Hinton Road. The Cherry Hinton Road sewer picks up flows from the southern side of the ward, before joining sewers heading from the south-eastern side of the ward at the Cherry Hinton Road-East Road junction, flows then head north accepting further inflow from the north-east of the ward. The Brooks Road sewer heads through Romsey Ward and across Coldham's Common to the Riverside branch of the tunnel.

There are three small pumping stations in the Coleridge Ward serving three small development areas – they are:

- **Coleridge-William Smith Close Pumping Station**
- **Coleridge-Clifton Industrial Estate Pumping Station**
- **Coleridge Derwent Close Pumping Station**

E8 East Chesterton Ward

Most flows from the south and east of the ward flow by gravity into the main sewers heading along Scotland Road and Green End Road, while flow from Ramsden Square and Woodhead Drive enters a sewer along Milton Road. This connects with the Green End Sewer at the junction of Milton Road and King's Hedges Road from where the sewer drains by gravity to the Treatment Works at Milton.

One pumping station in this ward drains a new development to the south-east of Nuffield Road.

E9 King's Hedges Ward

The Cambridge Science Park drains directly into the Milton Road sewer from East Chesterton and thence by gravity into the Treatment Works. Flows from most of the rest of King's Hedges connect into a main sewer along Campkin Road and head into a sewer at the eastern end of King's Hedges Road, which connects to the Milton Road sewer from East and West Chesterton

Two pumping station serve small areas of the sub-catchment at Cambridge Regional College and at Buchan Street at the north-west of King's Hedges.

E10 Market Ward

Much of the southern part of Market Ward flows into the main Mill Road sewer, largely via East Road, though sewers at the southern ends of Trumpington Road and Regent Street take rather more circuitous routes along Union Road and Fenner's Cricket Ground before reaching Mill Road.

Northern areas of Market drain around Jesus Lane and Maid's Causeway drain northwards along the southern boundary of Midsummer Common before flowing into the Elizabeth Way branch of the main tunnel.

E11 Petersfield Ward

The southern side of Petersfield – roads bordering Hills Road – drain into the sewer running below Hills Road. This sewer then flows into the Mill Road sewer via Fenner's or Tenison Road, where flows from the central portion of Petersfield Ward are accepted. A sewer runs from Mill Road along Gwydir Street and Sturton Street, picking up inflows from north Petersfield before finally flowing into the main tunnel at the Elizabeth Way branch.

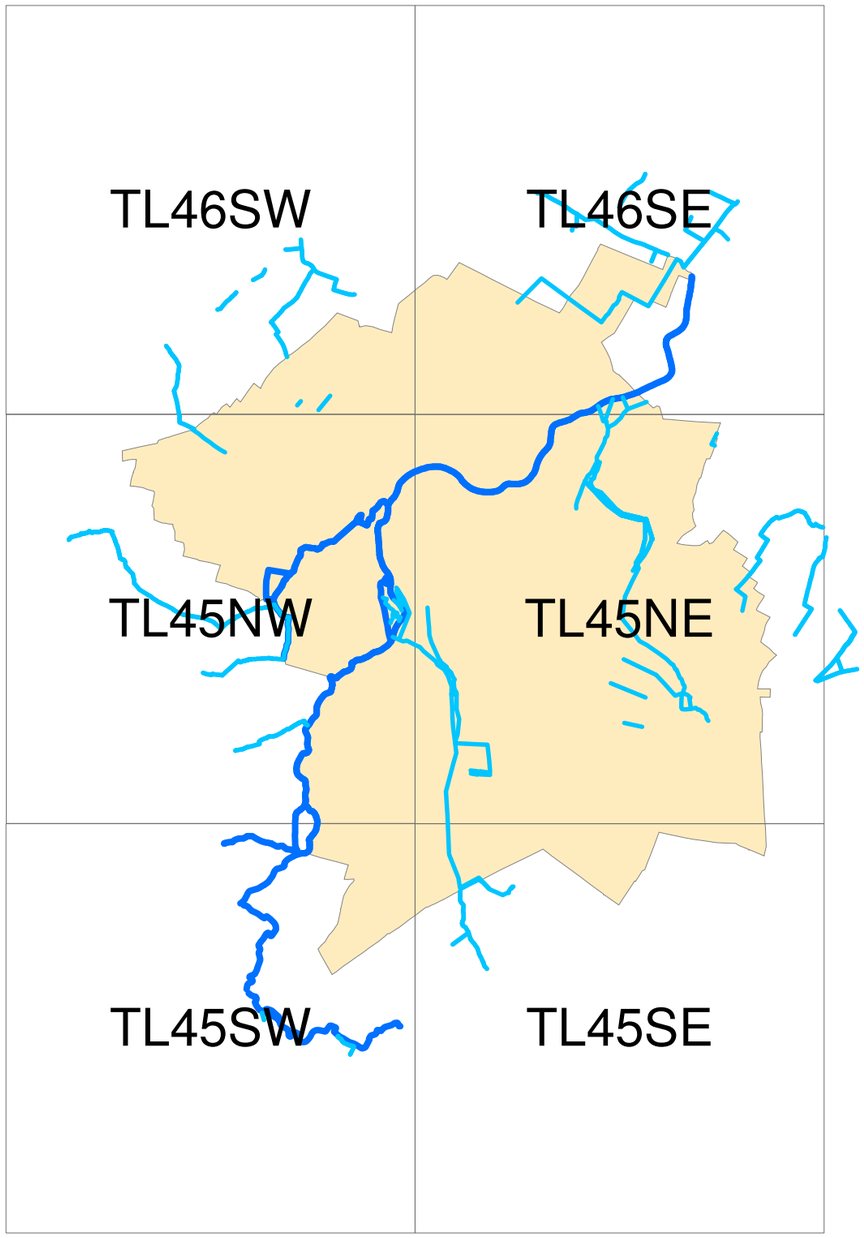
In the north-east of Petersfield flows head to the Newmarket Road sewer and into the main tunnel at the Riverside pumping station via Cheddar's Lane.

E12 Trumpington Ward

Flows from the areas to the north and west of the railway line flow northwards to the sewers running along Trumpington Road and Lensfield Road. East of the railway line (Purbeck Road, Luard Road), wastewater flows into sewers along Hills Road, which eventually flow north-eastwards into Mowbray Road. Foul water from Trumpington flows northwards along Trumpington Road.

The only pumping station within this ward is the Shelford Pumping Station, which brings wastewater from the very edge of the city along Shelford Road to the Trumpington Road main sewer.

Appendix F Key Plan for 1:10.000 Map Tiles



N

Location of Cambridge City within East Anglia

Legend

Main River

Awarded Watercourse

Project Title

Cambridge City Council
Strategic Flood
Risk Assessment

Map Title

Key Plan of 1:10,000 Map Tiles
Figure F

Mott MacDonald

CAMBRIDGE CITY COUNCIL

Scale: 1:75,000

February 2006

Appendix G Cambridge City Strategic Flood Maps – Present Day

Appendix H Cambridge City Strategic Flood Maps – with Climate Change to 2055