Sudbury and Great Cornard Surface Water Management Plan

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Synopsis:	This document is the Surface Water Management Plan for the town of Sudbury and Great Cornard, Suffolk. It includes information on surface water flooding, options to address this flooding and an action plan for managing risk.	

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- Environment Agency;
- Babergh District Council; and
- Anglian Water.

Executive Summary

This document forms a Surface Water Management Plan (SWMP) for the towns of Sudbury and Great Cornard, Suffolk, and was commissioned by Suffolk County Council (SCC). The SWMP has been undertaken adhering to the four-stage approach set out in Defra's SWMP Technical Guidance document (March 2010). The four stages are: Stage 1 – Preparation; Stage 2 – Risk Assessment; Stage 3 – Options; and Stage 4 – Implementation and Review.

Stage 1 involved preparing and scoping the requirements of the SWMP. This stage included:

- The collection and review of surface water data from relevant stakeholders;
- Building partnerships between risk management organisations responsible for local flood risk management; and
- Determining how these stakeholders will be engaged throughout the duration of the study.

Stage 2 assessed the causes of surface water flooding by:

- Updating the flood history to include recent incidents and describing the source and pathways of flooding; and
- Creating an integrated urban drainage (IUD) model to estimate flood risk and understand the flood mechanisms.

The model results have been used to identify the impact of surface water flooding on properties, businesses and/or infrastructure. Five areas, most at risk of flooding, have been classified as Critical Drainage Areas (CDAs).

Stage 3 investigated the costs and benefits of two flood risk mitigation schemes within two of the CDAs. The remaining CDAs include significant areas of proposed development and will be assessed when future planning applications are submitted.

The proposed schemes were represented in the model and their impact on flooding evaluated. A Cost-Benefit Analysis was completed to assess the economic feasibility of the schemes based on the Flood and Coastal Erosion Risk Management – A Manual for Economic Appraisal. Both options produced a favourable result with a benefit to cost ratio exceeding 1.0.

Stage 4 produced of an Action Plan with recommendations for the partners of the SWMP to assist with managing the risk of flooding to Sudbury and Great Cornard. The Action Plan is a 'living' document and should be reviewed and updated regularly. Particularly following:

- the occurrence of a surface water flood event, when additional data or modelling becomes available;
- the outcome of investment decisions by partners; and
- any additional major development or changes in the catchment which may influence the surface water flood risk within the towns.

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1 Background

Suffolk County Council (SCC) are a Lead Local Flood Authority (LLFA) and have a lead responsibility for managing the risk of flooding from surface water, groundwater and ordinary watercourses. Babergh District Council (BDC) is the second-tier local authority for the towns Sudbury and Great Cornard in south-west Suffolk. BMT were commissioned by Suffolk County Council (SCC) to prepare a Surface Water Management Plan (SWMP) for the towns of Sudbury and Great Cornard. This document presents the findings and recommendations of this plan.

1.1 What is a Surface Water Management Plan?

A Surface Water Management Plan is a study to understand the flood risk that arises from local flooding. Local flooding is defined by the Flood and Water Management Act 2010 as flooding from surface runoff, groundwater and ordinary watercourses.

A four-stage process is followed, outlined by Defra in their technical guidance document (2010). These stages are summarised below and in Figure 1-1:

Stage 1 Preparation: Preparing and scoping the project requirements. Establishing partnerships and cooperative ties.

Stage 2 Risk Assessment: Data gathering which informs decisions on identifying areas more vulnerable to surface water flooding and determine the appropriate level of assessment based on the information and requirements of the study.

Stage 3 Options: Range of options are identified, through stakeholder engagement, considering the available flood risk management measures. Cost benefit analysis supporting these decisions.

Stage 4 Implementation and review: Preparing an action plan, outlining agreed actions including: established responsibilities, timeframes and monitoring implementation to support the partnership.

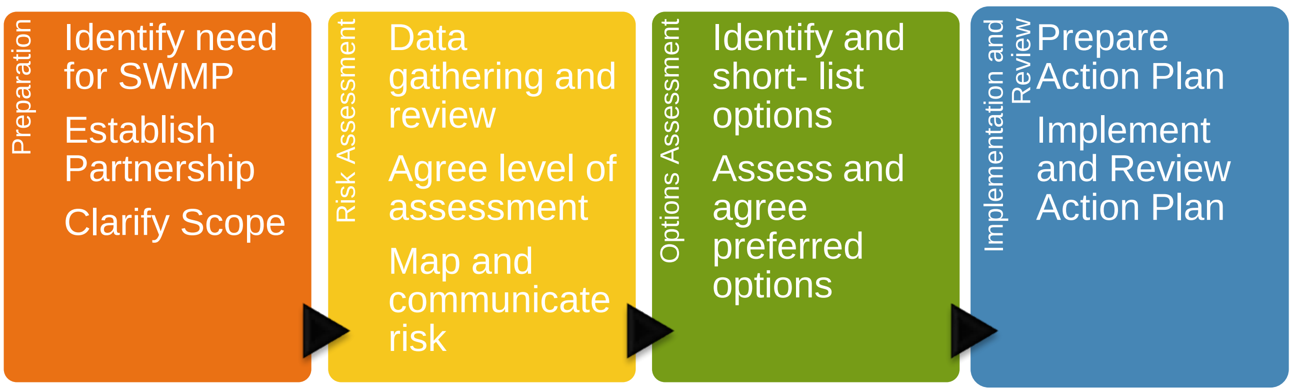

Figure 1-1 Summarised process flowchart of the Defra SWMP Phases

The aims of a SWMP are to:

- Develop a thorough understanding of surface water flood risk in and around the study area. This is to consider climate change, increasing urbanisation, and demographic and population;
- Identify existing and predicted areas of flood risk;

- Provide recommendations for holistic and integrated management of surface water management that improve emergency and land use planning, and support better flood risk and drainage infrastructure investments;
- Establish and consolidate partnerships between key stakeholders to facilitate a collaborative culture, promoting openness and sharing of data, skills, resource and learning, and encouraging improved coordination and collaborative working;
- Engage with stakeholders to raise awareness of surface water flooding, identify flood risks and assets, and agree mitigation measures and actions; and
- Deliver outputs to enable practical improvements or change where partners and stakeholders take ownership of their flood risk and commit to delivering and maintaining the recommended measures and actions.

The long-term action plan is used to holistically manage surface water and influences financial investment, flood control, public engagement and understanding, spatial planning and development control.

1.2 Links with Other Studies

The SWMP should not be viewed as a single separate flood risk document. Instead, it should be read in conjunction with other strategic and local flood risk documents. The studies relevant to this SWMP are:

- Suffolk Flood Risk Management Strategy (2016);
- North Essex Catchment Flood Management Plan (2009) and Summary Report (2009);
- Babergh District Council Level 1 and Level 2 Strategic Flood Risk Assessment (2009);
- Babergh District Council Water Sycle Study (2011);
- Suffolk County Council Preliminary Flood Risk Assessment (2011) and update (2017);
- National Flood and Coastal Erosion Risk Management Strategy (2011); and
- Local Development Documents – Local plan and subsequent updates.

The link between the SWMP and other studies is shown in Figure 1-2.

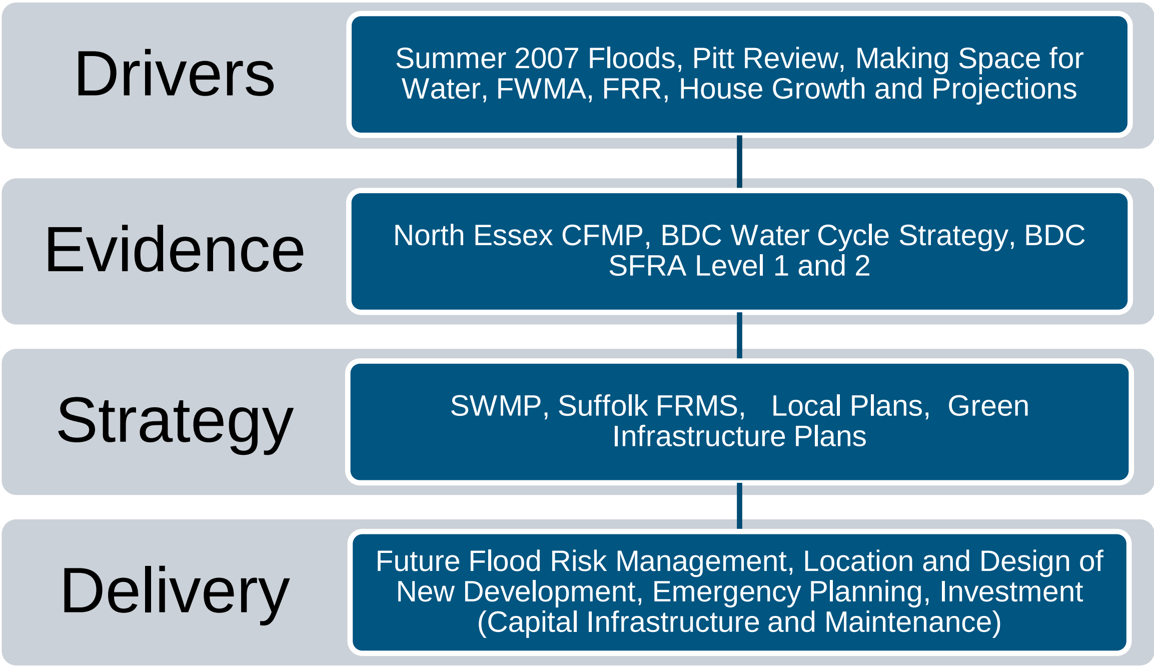

Figure 1-2 Links between SWMP and other plans

1.2.1 North Essex Catchment Flood Management Plan (CFMP)

Sudbury and Great Cornard are considered within the North Essex CFMP, in Sub-area 2, which includes the upper and middle Stour. The policy and policy units relevant to the study area are:

Policy 3 (Lower Blackwater and Upper and Mid Tributaries, Mid Colne and Stour): *Areas of low to moderate flood risk where we are generally managing existing flood risk effectively*. This policy will tend to be applied where the risks are currently appropriately managed and where the risk of flooding is not expected to increase significantly in the future. However, we keep our approach under review, looking for improvements and responding to new challenges or information as they emerge. We (the EA) may review our approach to managing flood defences and other flood risk management actions, to ensure that we are managing efficiently and taking the best approach to managing flood risk in the longer term.

The settlements in this sub-area have been built in the floodplain and as a result have a history of flooding. In the past flood defences have been constructed and maintenance work carried out on the rivers to reduce flood risk. Although flood risk is not expected to increase significantly in the future, as there is a concentration of people and property within the floodplain, it is still feasible and effective to continue with the current level of flood risk management. For the majority of this sub-area this will be achieved by continuing existing flood risk management activities. However, there may be alternative, more appropriate ways to manage flood risk at the current level. Alternative measures may include reducing flood risk maintenance in parts of the sub-area where there is a low flood risk. Reducing the need for continued maintenance could bring opportunities to improve the environmental quality of local watercourses.

The CFMP indicates that there are two brick wall defences at Sudbury to assist with managing the fluvial flood risk.

Actions specific to Mid Colne and Stour:

- Continue with the current flood risk management activities.
- Work with partners to develop emergency response plans for critical infrastructure and transport links at risk from flooding.
- Continue maintenance of Abberton Reservoir. Essex and Suffolk Water must carry out their duties under the Reservoirs Act.

1.2.2 Suffolk Flood Risk Management Strategy

Lead Local Flood Authorities (LLFAs) are required to produce a Local Flood Risk Strategy (LFRMS) under the Flood and Water Management Act (FWMA) 2010. The SWMPs, Preliminary Flood Risk Assessments (PFRAs), and their subsequent flood risk maps provide the necessary evidence-based to support the development of a Local Flood Risk Management Strategy (LFRMS). The LFRMS compliments and links to the Catchment Flood Management Plan (CFMP), Strategic Flood Risk Assessment (SFRA) and Asset Management Plan (AMP). The SFRMS is an important tool to allow everyone to understand and manage flood risk within the county.

The Suffolk Flood Risk Management Partnership (SFRMP) produced a Suffolk Flood Risk Management Strategy (SFRMS) in March 2016, with the purpose of understanding and managing flood risk within Suffolk. The strategy summarises the information available on the risk of flooding in Suffolk and ways to manage that risk. The Strategy identified and ranked areas within the County at risk of surface water flooding. Sudbury and Great Cornard was designated a priority group B area with an estimated 70 properties at risk. From this strategic assessment, the need for a SWMP for Sudbury and Great Cornard was identified.

1.2.3 Babergh Strategic Flood Risk Assessment (SFRA)

A Strategic Flood Risk Assessment (SFRA) is required by each local planning authority under the National Planning Policy Framework (NPPF). This provides a planning tool that guides the Council to make informed spatial planning and policy decisions.

The SFRA for the District of Babergh was produced by JBA in March 2009. The report identifies Sudbury as highly vulnerable to surface water flooding.

1.2.4 Babergh Water Cycle Study

A Water Cycle Study was completed for Babergh District Council (BDC) in 2011. The study considers the constraints that BDC may pose to future development and, where applicable, discusses the improvements necessary to achieve the required level of development throughout the planning period, until 2031, including:

- Water Resources and Supply;
- Wastewater Collection and Treatment;
- Water Quality and Environmental Issues;
- Flood Risk; and
- Demand Management and Sustainable Drainage Systems.

To assist the Council in determining the capacity of the water cycle for sustainable growth, the following five growth options were considered:

- Growth Option 1 – The current situation;
- Growth Option 2 – Former Regional Spatial Strategy Targets;
- Growth Option 3 – Draft Regional Spatial Strategy Review to 2031;
- Growth Option 4 – Alternative Growth Scenarios; and
- Growth Option 5 – The maximum capacity.

The report concludes that most elements of the water cycle have sufficient capacity to accommodate the growth levels considered, although some locations require the implementation of new infrastructure and/or mitigation measures.

1.2.5 Suffolk Preliminary Flood Risk Assessment

The Suffolk Preliminary Flood Risk Assessment (PFRA) is an assessment of:

- Floods that have taken place in the past; and
- Floods that could take place in the future.

The Preliminary Flood Risk Assessment (PFRA) was undertaken by Suffolk County Council to satisfy obligations under the Flood Risk Regulations 2009. The PFRA identified key areas in Suffolk where the potential risk of surface water flooding is thought to be greatest. LLFAs also have a responsibility to update their PFRA every 6 years. The most recent update was undertaken in 2017.

1.2.6 Local Development Plans

Work has begun on a new Joint Local Plan document for Babergh and Mid Suffolk districts, which will replace the 2006 Local Plan. The plan will set out how and where homes, jobs, community facilities, shops and infrastructure will be delivered and the type of places and environments BDC wants to create. It is an important document which will provide the strategy for the growth, setting out what and where development will take place up to 2036.

The Plan will set out a vision for the area and will include policies and land allocations. The current form of the plan identifies several strategic development locations within the study area. In particular, several sites in the upper catchment are proposed (Figure 1-3). Once adopted, the new Joint Local Plan will replace the existing local planning policies for both Babergh and Mid Suffolk.

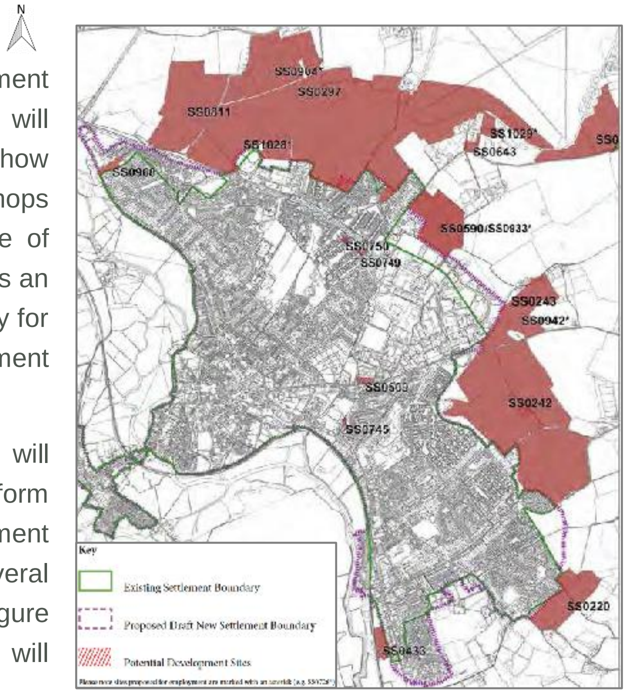

Figure 1-3 Proposed Site Allocations (Draft Joint Local Plan, 2017)

2 Preparation

2.1 Identifying the need for a SWMP

The Suffolk Flood Risk Management Strategy identified and ranked areas within the County at risk of surface water flooding. Sudbury and Great Cornard was designated a Priority Group B area with an estimated 70 properties at risk.

A SWMP for Sudbury and Great Cornard will add greater detail to the existing assessment of surface water flood risk and explore detailed approaches for tackling flood risk in a sustainable, cost effective way. In particular, a SWMP will address:

- The requirement to manage local flood risk under the Flood Risk Regulations (FRR) 2009 and the Flood and Water Management Act (FWMA) 2010.
- The need to identify critical drainage areas (CDAs) to inform emergency and land use planning decisions through an evidence-based approach.

2.2 Stakeholder Engagement and Partnership

To provide an integrated approach to surface water management, it is important that key stakeholders with responsibility for different flood mechanisms can work together in a coordinated effort. A Stakeholder Engagement and Communication Plan was established at the project inception to identify key stakeholders and how they will be consulted during this study. This partnership contains representatives from the organisations illustrated in Figure 2-1. These organisations have been consulted throughout the SWMP process and have provided key input at several stages of the study.

Figure 2-1 SWMP Key Partners

The key partners associated with the project are:

- Council representatives (including Council's project manager);
- Suffolk County Council;
- Environment Agency;
- Anglian Water;
- Suffolk Highways.
- Babergh District Council;
- Great Cornard Parish Council;
- Sudbury Town Council;
- Land owners / developers / LPAs; and
- Network Rail.

2.2.1 Roles and responsibilities

The Stakeholder Engagement and Communication Plan identified the roles and responsibilities for each of stakeholders, summarised within Table 2-1.

Table 2-1 Organisational Roles, Responsibilities and Powers

Organisation	Role	Responsibilities
Suffolk County Council	Lead Local Flood Authority. Provide advice on flood history in their administrative area and data as available.	Management of surface water, groundwater and other sources of flooding. Input to national strategy. Implement local flood risk management strategy. Monitor flooding, investigate causes and map the associated hazard with the source of flooding.
Council representatives (including Council's project manager)	Primary point of contact. All project communications to be delivered via the SCC project manager.	
Community and Emergency Advisor	Provide additional information should it be required.	
Environment Agency	National scale supervision over flood risk management decisions. Provide data and advice on interaction with downstream main river.	Strategic overview role for all sources of flooding, thus a key partner in the SWMP.

Organisation	Role	Responsibilities
Local Residents (particularly in the East Street area)	Provide additional information should it be required.	Raise concerns and may inform on historical flood event information for model validation.
Councillors (county/ district/ town and parish)	Provide high-level guidance on the adherence of project recommendations to broader policy objectives.	Representing their constituencies.
Anglian Water	Sewage Undertaker.	Operational and regulatory powers relating to the stormwater sewer network. Provision of data for the Anglian surface water sewer model and asset data.
Great Cornard Parish Council / Babergh District Council / Sudbury Town Council	Local Planning Authority. Riparian Owner. Engage as identified and required by study outputs (Sudbury Town Council).	Responsibilities transferred down from LLFA. Provide information should it be required. Input to National and Local statutory strategies. Ordinary water course management.
Suffolk Highways	Drainage infrastructure.	Provide advice and guidance on assets (culverts/bridges) and funding opportunities.
Land owners / developers / LPAs	Engage as identified and required by study outputs	Negate risk to future flood risk to future sites
Network Rail	Provide guidance on assets in the catchment	Contingency planning for flooded assets

2.3 Data Collection

Various sources of data were obtained for the SWMP study. A summary of the data made available for this study is provided in Appendix F. The key datasets were provided by the following partners:

- Suffolk County Council;
- Babergh District Council;

- Environment Agency; and
- Anglian Water.

2.4 Data review

2.4.1 Geographical Information and Administrative Boundaries

The towns of Sudbury and Great Cornard are located in south-west Suffolk, bordering Essex and are within the administrative area of BDC (Figure 2-2). The study area is approximately 14km^2 and has been defined from rainfall catchments that contribute surface water runoff to the towns.

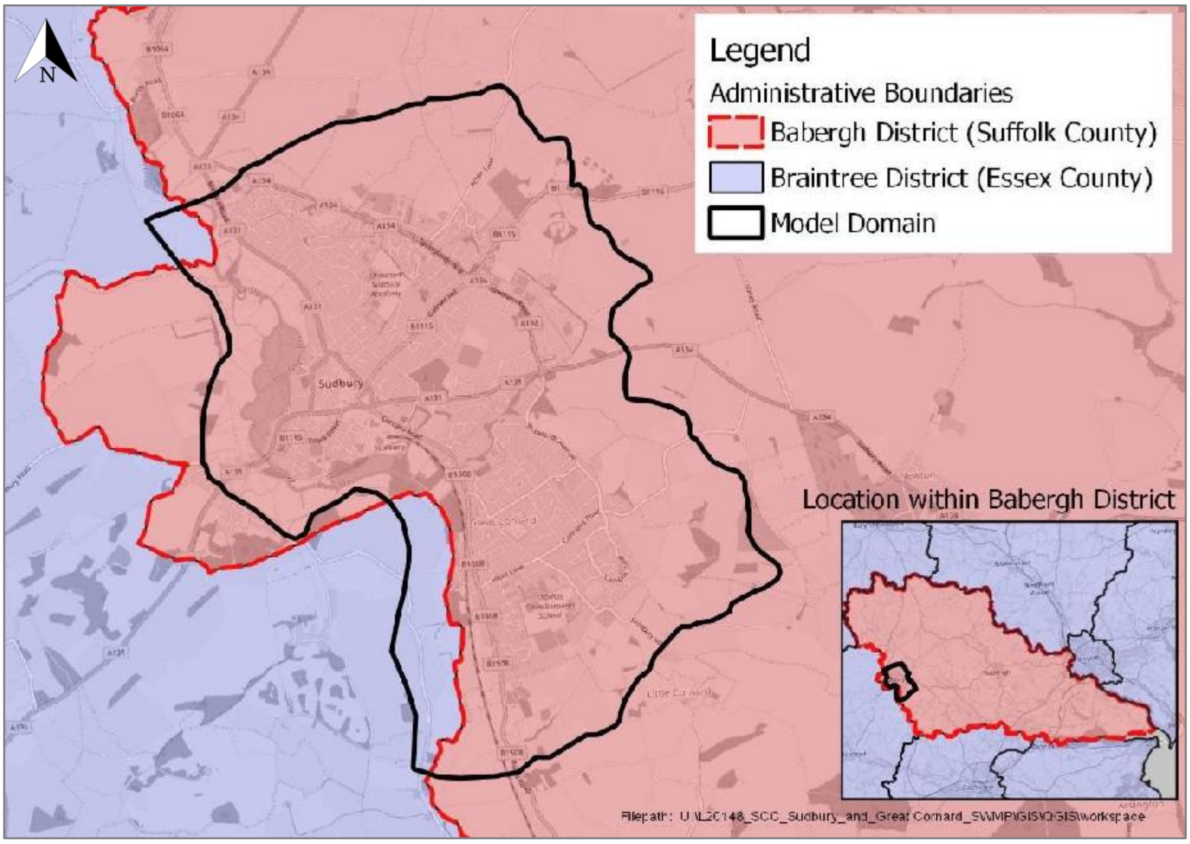

Figure 2-2 OS Map of the Administrative Boundaries and Study Area

2.4.2 Topography

Two digital ground elevation datasets are available for Sudbury and Great Cornard. The Environment Agency (EA) Light Detection and Ranging (LiDAR) open data set, and the Digital Terrain Model (DTM) derived for use in the Risk of Flooding from Surface Water (RoFfSW) mapping.

The EA LiDAR is available at 1m resolution for the eastern part of Sudbury and at a 2m resolution for the remainder of the study area.

The RoFfSW DTM (2012) is based on the EA LiDAR open dataset, but has been resampled to a 2m resolution. It has been pre-processed to enforce features such as raised building thresholds, road kerbs and floodplain structures. These modifications are relevant for the assessment of surface water flood risk to the Sudbury and Great Cornard study area.

The DTM generated for the RoFfSW mapping was predominantly used with inaccuracies in LIDAR details being addressed during the model build – refer to Appendix B for more details.

The topography of the study area is characterised by areas of high elevation in the east and north-east (maximum 71.8m AOD) falling to the south and west (minimum 20.9 AOD) onto the floodplain of the River Stour (Figure 2-3).

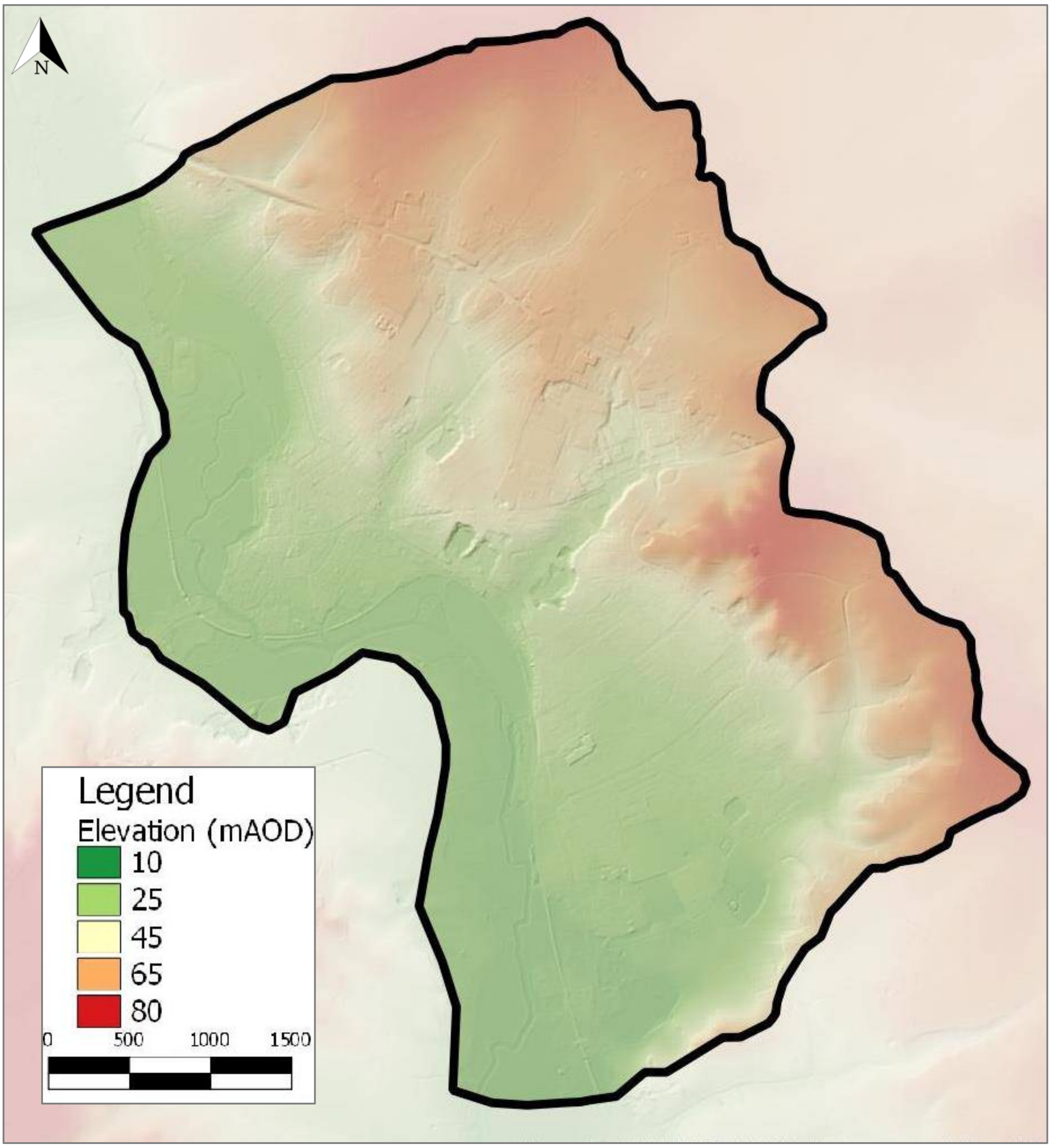

Figure 2-3 Study Area: Topography

2.4.3 Geology

The British Geological Survey (BGS) mySoil database indicates that the catchment is underlain by Clayey Loams, Sandy Loams, and Clay to Silt (Figure 2-4). These soils vary from relatively freely draining (Sandy Loams) to soils that impede flows (Clayey Loams).

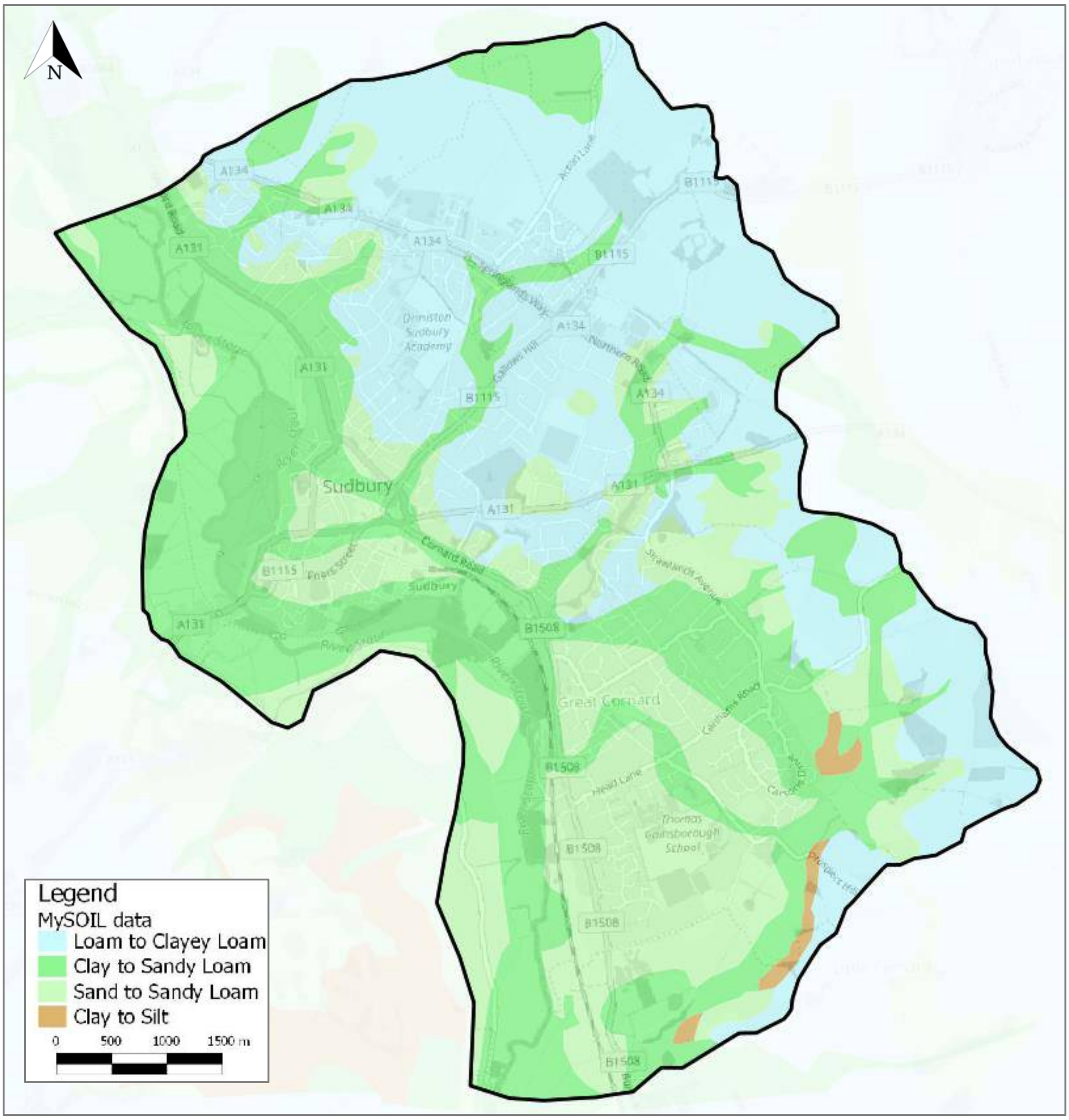

Figure 2-4 Study Area: Soil Properties

2.4.4 Landuse Land use

OS MasterMap (OSMM) is a consistent and maintained framework for the referencing of geographical information in Great Britain. It comprises detailed topographic, cartographic, administrative boundary, postal address, topological road network features positioned on the

National Grid and an Imagery Layer. Every OSMM feature has a unique identifier which is used to classify a feature. Based on the review of the OSMM

Sudbury and Great Cornard comprise a mix of permeable and impermeable land use (Figure 2-5. Within the urban extent, 74% is permeable ground, comprising general yards, forest, grass and parkland. The bulk of the hardstanding areas being the roads, residential buildings and the Chilton Industrial Estate located at the eastern extent of Sudbury.

The remaining rural land in the upper catchments to the North and East, and on the River Stour floodplain to the West, is classed as permeable grassland and forest and is farmland in reality.

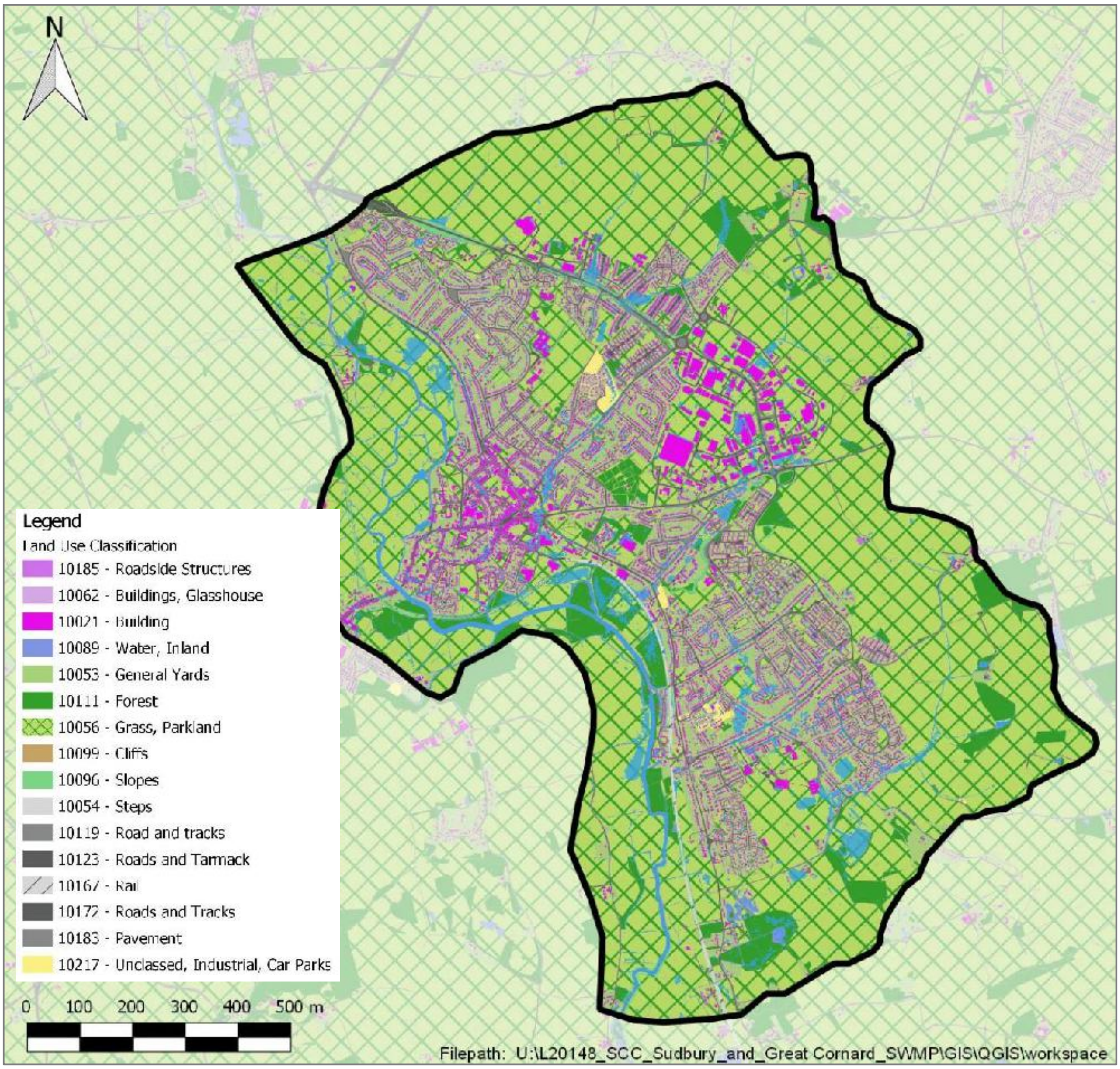

Figure 2-5 Study Area: Land Uses

2.4.5 Major Rivers and Waterways

The Detailed River Network (DRN) is a large-scale, accurate and fully attributed digital river centreline covering England and Wales. The DRN is can be used to view if a watercourse is a Main River, or other watercourse along with if it is known to be culverted or not (Figure 2-6). Primary rivers are the responsibility of the EA whilst all other river types/watercourse at the LLFAs responsibility)

The River Stour rises in the east of Cambridgeshire and flows in a south-easterly direction before discharging to the North Sea. The Stour is 108 km in length and drains an area of 1044 km^2 (Mills, 2003). The River Stour is a main river and is the responsibility of the EA and forms the natural western boundary of Sudbury and Great Cornard study area. A tertiary watercourse (LLFA responsibility) flows through Sudbury, which is largely culverted (Figure 2-6) Secondary and Tertiary Rivers (ordinary watercourses) from the rural upper catchment are routed through the towns and outflow to the River Stour and local floodplain. These drains increase the hydraulic connectivity from the upper catchment into the urbanised areas.

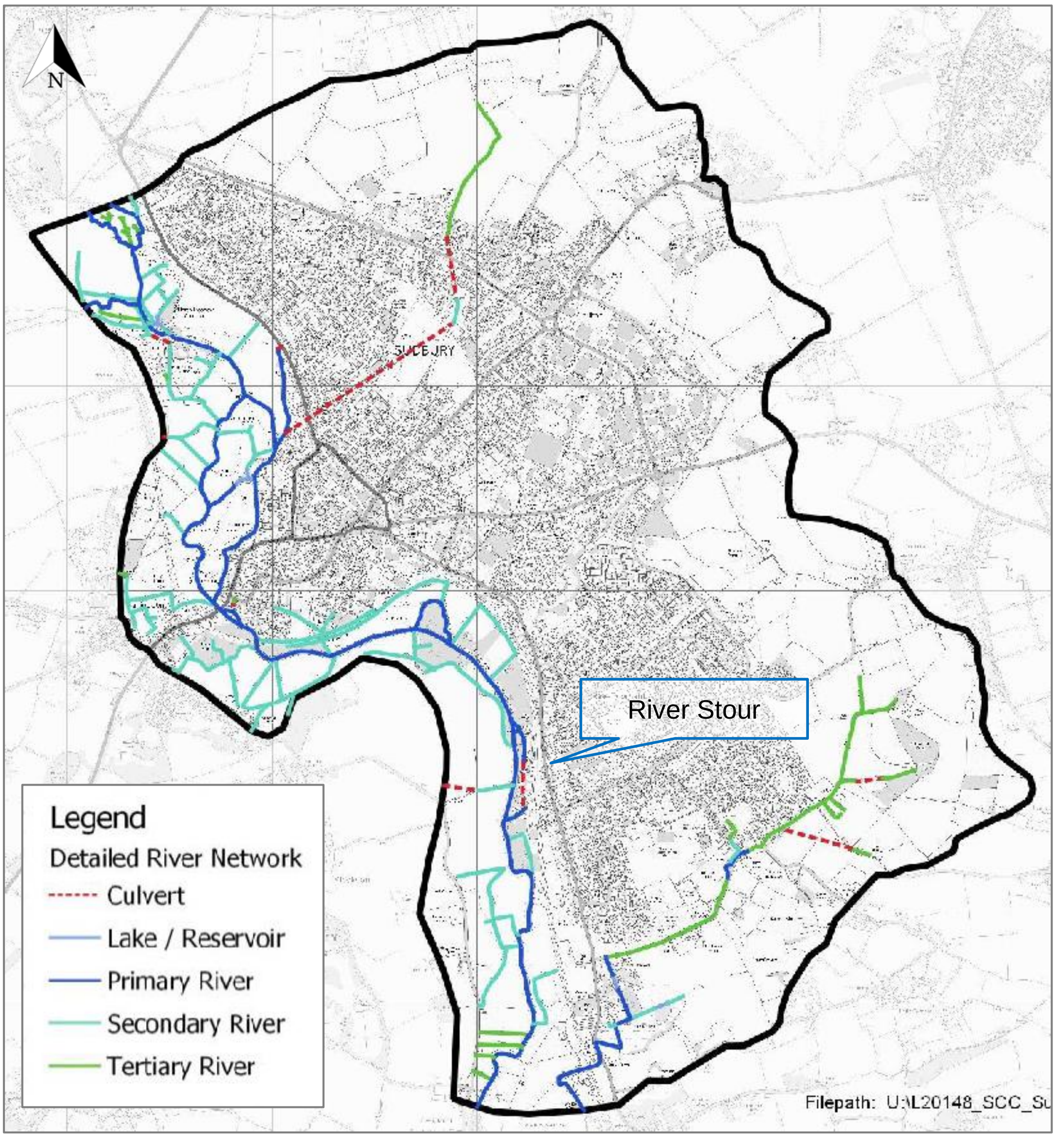

Figure 2-6 Study Area: River Classification

2.4.6 Sewer Asset Information

GIS datasets of the underlying drainage networks were provided by Anglian Water. The surface water network is separate from the foul system within Sudbury. The bulk of the drainage network within Great Cornard is labelled as foul. However, the general consensus of the stakeholders is that a combined stormwater and foul drainage network exists.

There are two distinct drainage networks, one for each of the towns that flow towards separate outfalls on the River Stour. This correlates with the topography of the floodplain, which shows a ridge through the Chiltern Industrial Estate, Newman Road Cemetery and Cornard Road Sainsbury's, dividing the two catchments.

Sewer asset data is available for most of Sudbury (Figure 2-7). Approximately 45% of pipes contain invert level information (Figure 2-7, pie chart) and 85% contain size information.

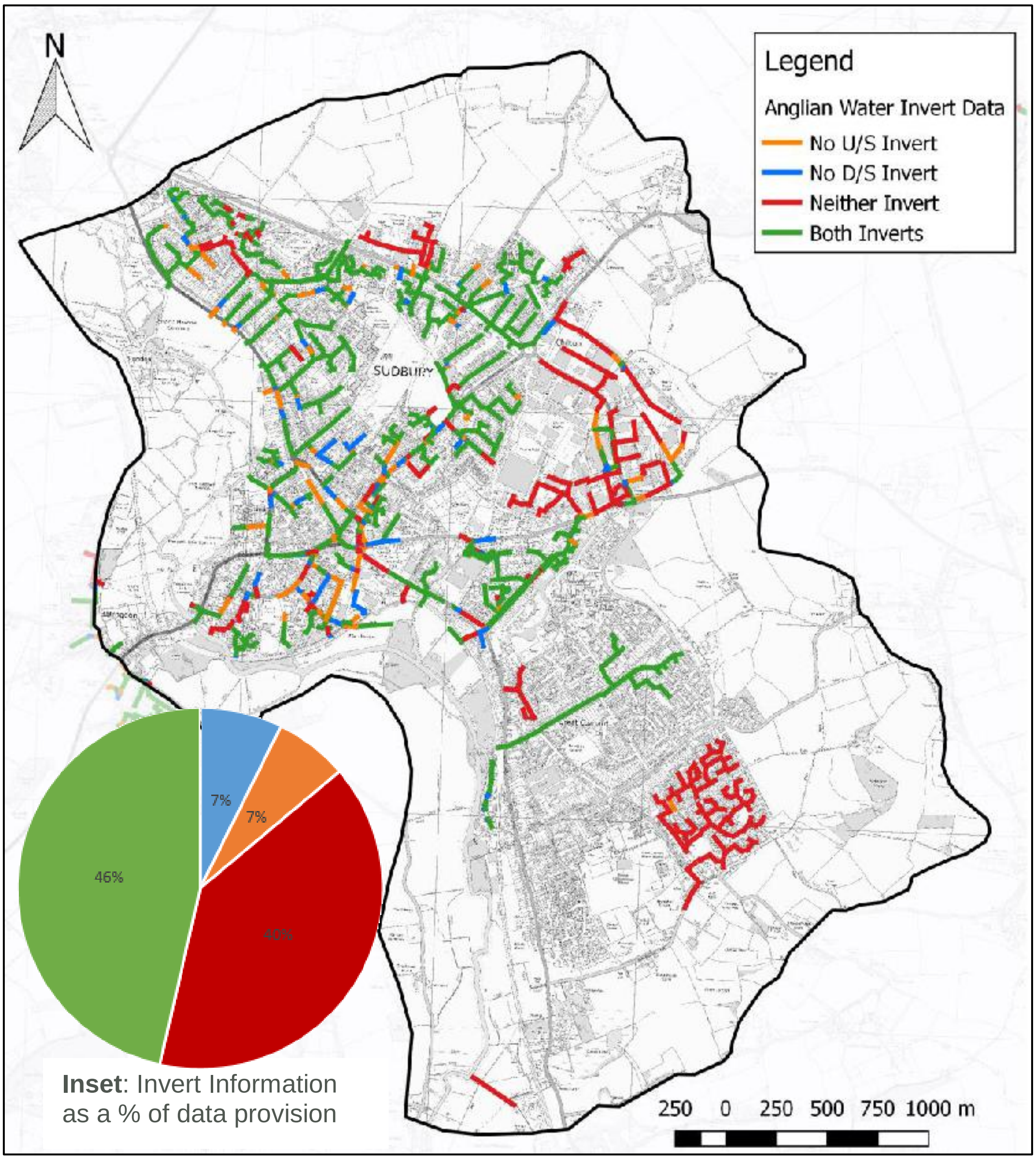

Figure 2-7 Anglian Water Drainage Network Invert Data

Information is generally missing at the network extremities, where pipe sizes tend to be smaller and have a reduced impact on the network storage volume. The connectivity of the drainage network is also incomplete in areas. In particularly, in west Sudbury where it is unclear how and where the drainage network discharges. In addition, the pipe directions are contrary to the slope of overlying floodplain and away from the River Stour. Manhole data was provided by AW. Within this dataset, 10% of the provided manholes are for the surface water system and had inverts. No information was provided on chamber sizes. Due to the paucity of data, this has not been included in the modelled datasets. In place of this, the automatic manhole create routines within TUFLOW have been utilised. This routine inserts appropriately sized manholes at pipe junctions and accounts for the associated hydraulic losses.

In Great Cornard, a combined stormwater and drainage network has been assumed, except at Pot Kiln Road and the South-Eastern corner of the town. Sewer asset information is sparse, of poor quality and the impact of the foul flows on the combined system unknown. As the drainage networks in Sudbury and Great Cornard are independent, and the quantity and quality of the asset data varies, different modelling methodologies are proposed for each town.

A fully integrated urban drainage (IUD) model is proposed for Sudbury with missing inverts and pipe diameters interpolated from the Anglian Water or DigDat datasets. In Great Cornard, a lack of data precludes a full IUD model being developed. Instead a 'Virtual Pipes' approach will be used where the surface water drainage is determined solely by the highways gullies, and does not require pipe asset data.

2.4.7 Highway Assets

The locations of highway gullies were supplied by Suffolk County Council as GIS layers. Additional gully locations have been digitised from aerial imagery or site inspection (Figure 2-8). The gully locations and grate types are used to define where and how much water can drain from, or surcharge to, the highways.

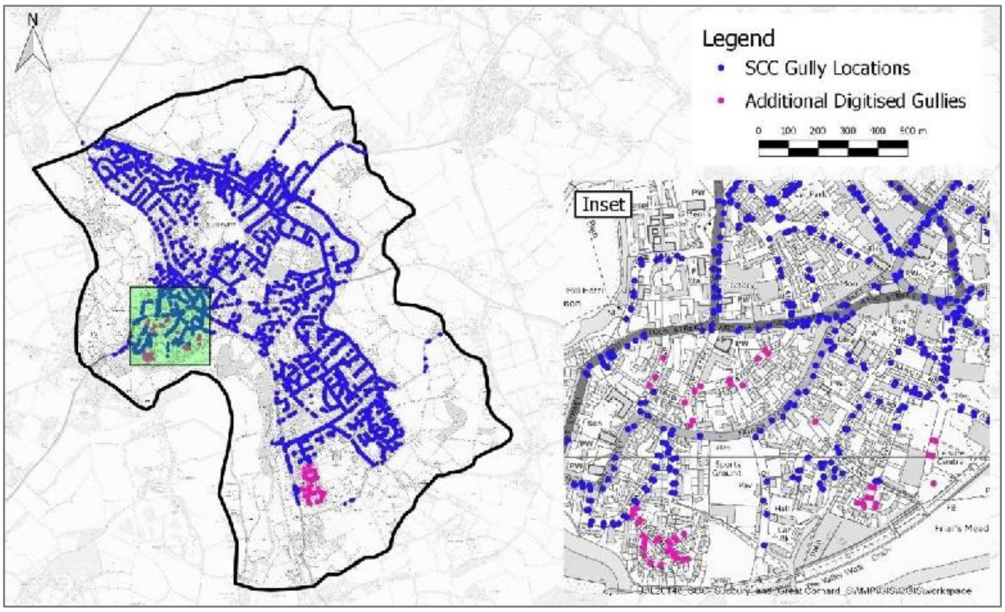

Figure 2-8 Known Gully Locations within the Study Area

2.4.8 Existing Flood Alleviation Measures

There are several fluvial flood defences on the River Stour in the study area (Figure 2-9). The defences are identified in the EA flood defence dataset and predominantly comprise of high ground and embankments with two raised walled sections.

In addition, there are several flood storage areas in the study area that influence surface water flooding, including:

- Two basins near East Street;
- A formal detention basin on Acton Lane;
- Underground storage in west Sudbury (Claremont Avenue);

- Wells Hall Road Basin; and
- A storage tank upstream of Pot Kiln Road.

A discussion of how they have been represented in the model can be found within Appendix B.

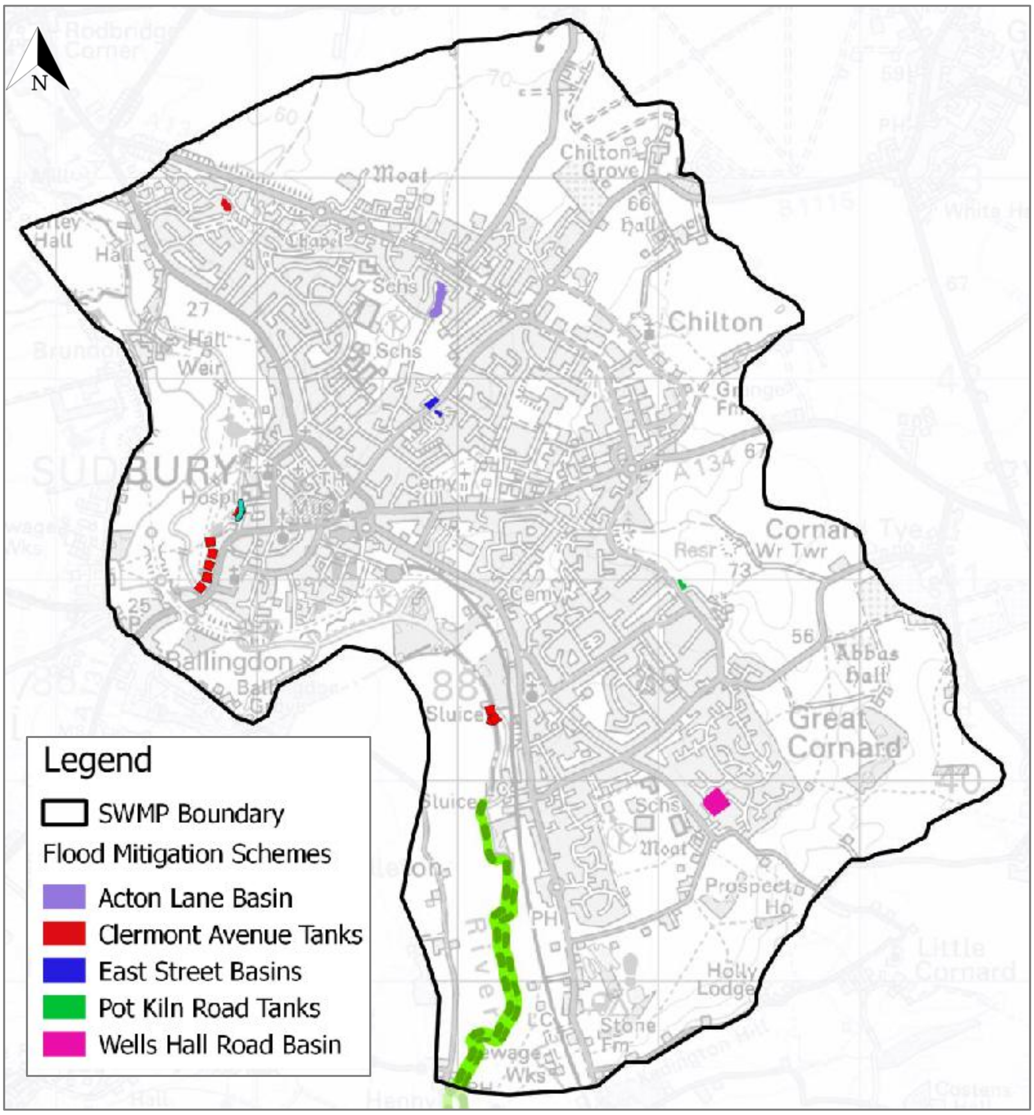

Figure 2-9 Study Area: Location of Existing Flood Schemes and Formal EA Defences

2.4.9 Flood Risk Receptors and Damages

At the time of writing, the towns of Sudbury and Great Cornard have a combined population of approximately 22,000[1]. The 2014 National Receptors Database (NRD) from the Environment Agency, provides point information on the type of flood receptors. This dataset can be filtered according to property type (Figure 4-2) and used to calculate the properties at risk and flood damages.

[1] Great Cornard Socio – Economic Profile, 2016 - link
Sudbury Socio – Economic Profile, 2016 – link

The direct/tangible flood damage to properties will be estimated using the data and techniques provided in the Flood and Coastal Erosion Risk Management – A Manual for Economic Appraisal (MCM). The key data provided as part of the MCM are depth-damage curves. These curves are used to correlate the depth of flooding at a property to a direct and tangible monetary cost. The curves are separated into a variety of types based on property type (residential, retail, industrial etc.), residential property age and ward social grade.

2.4.10 Groundwater Flood Risk Data.

The only information made available to the study was the EA Areas Susceptible to Groundwater Flooding dataset. This is a coarse 1 km gridded prediction or areas at a potential risk of groundwater flooding (AStGWF) produced in 2010. This data has uses the top two susceptibility bands of the British Geological Society (BGS) 1:50,000 Groundwater Flood Susceptibility Map. It shows the proportion of each 1km grid square where geological and hydrogeological conditions show that groundwater might emerge. This has been used to assess the risk of groundwater flooding within the study. No historical groundwater flooding records were highlighted within the data provided for this assessment. It should be noted that the AStGWF map is broad scale and does not provide a detailed analysis of groundwater. If more detailed data relating to the risk of groundwater flooding is required, it is recommended that the reader contact the BGS to obtain the Groundwater Flooding Susceptibility Maps.

2.4.11 Sustainable Drainage Systems

Sustainable drainage systems (SuDS) are likely to reduce overall flood risk and promote improved aquifer quality status. However, it is key to note improper application of SuDS could lead to groundwater flooding / drainage issues and contamination of the superficial deposit or aquifers, pervasively impacting the aquifer quality.

The EA provides guidance on infiltration SuDS on their website. SCC SFRMS also includes an appendix on SuDS that is relevant to this study. Councils, developers and their contractors should refer to these documents as they hold weight in decision of whether planning applications should be approved or rejected. Additional UK related reference materials can be found on the professional community website http://www.susdrain.org/resources/ which provides resource links and SuDS case studies and the CIRIA website http://www.ciria.org.

Management of groundwater flooding is highly specific to location and situation and as such associated costs of groundwater flooding is varied. Management of groundwater flooding should be driven through development control and building design. Suggested applications could include:

- Raising floor or ground levels in properties or avoid basements developments in areas considered prone to groundwater flooding.
- Timely replacement and renewal of leaking sewers, drains and water supply reservoirs. Water companies have clear ownership of the potential source. As such are incentivised to address their programme to manage leakage from infrastructure.
- Major upgrades to ground work i.e. newly construction or enlarged watercourses and improvements to the existing surface water drainage network to improve conveyance capacity

of the channel in surface water and fluvial events through and away from areas prone to flooding.

- Address specific localised flooding problems in areas via flood-proofing properties protection measures (i.e. raising the electrical sockets and sealing of building basements).

2.4.12 Historic Flood Incidents

Sources of flooding in the study area are diverse, with flood records dating back several decades. Figure 2-10 provides a graphical summary of available historical events (as provided by SCC, AW and the EA). Very little information is available on the probability, hazard or consequence of 'local' flooding incidents. This is a common limitation nationwide. Data collection has historically focussed on fluvial and tidal flooding, sometimes neglecting surface water, sewer, groundwater or ordinary watercourse flooding. Furthermore, surface water flooding incidents are sometimes mistaken for groundwater flooding incidents. For example, where runoff via infiltration seeps from an embankment, rather than locally high groundwater levels. Therefore, it is difficult to use this information to validate claims of flooding or the predictive capabilities of any hydraulic modelling.

There are no specific records pertaining to groundwater flooding in the study area. Additionally a lack of comprehensive groundwater information makes it difficult to accurately predict the location, timing and extent of groundwater flooding.

Further, The North Essex (CFMP) states that Sudbury has experienced several fluvial flood incidents in the past, with the most notable event being the 1968 flood. High water levels in the River Stour have the potential to exacerbate drainage issues in Sudbury, limiting the rate of discharge of the drainage network.

Based on reported flooding incidents, drainage issues have been persistent over a number of years in several areas. Consequently, a new surface water sewer was built in Great Cornard in the early 1990's, but ongoing urban expansion within the catchment continues to add pressures to the drainage network.

Babergh District Council's SFRA reported incidents of highways flooding on the:

- A1141 between Lavenham and Hadleigh;
- A134 & B1508 south of Sudbury; and
- B1064 between Long Melford and Sudbury.

Some of the areas that have experienced historical flooding are located within the corridors of 'lost' watercourses (that can be reactivated during a significant storm event). There are also areas of flooding caused by localised topographic low areas.

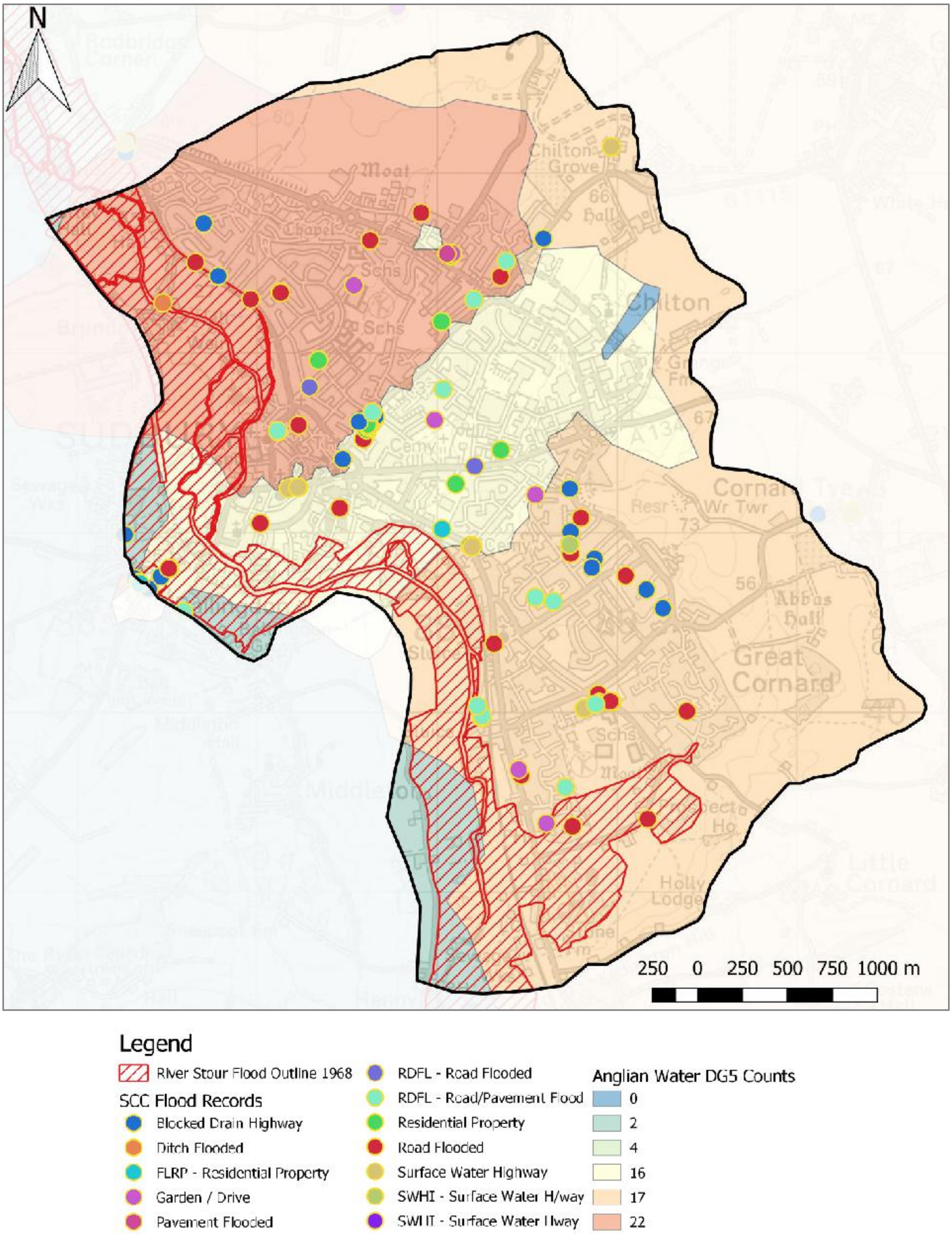

Figure 2-10 Recorded Flood Events

3 Risk Assessment

3.1 Sources of Flooding

Flooding can occur from multiple sources, including:

- **Surface water flooding**: also known as pluvial flooding, results from high intensity or prolonged rainfall, causing water to pond or flowing over the surface before reaching a drain or watercourse. Surface water flooding can be exacerbated when the ground is saturated, or baked dry, and the drainage network has insufficient capacity to capture the overland flow.
- **Ordinary watercourse flooding**: occurs when the discharge capacity of the watercourse is exceeded and water flows over the banks of the channel.
- **Sewer flooding**: occurs when the capacity of underground sewer systems is exceeded during heavy rainfall, resulting in flooding inside and outside of buildings. Poor maintenance or infrastructure failure can also lead to flooding from the sewer. High water levels in receiving waters can impede flow discharging at sewer outfalls and exacerbate sewer flooding.
- **Groundwater flooding**: occurs when the water level within the groundwater aquifer rises to the surface.

Risk management authority (RMA) are responsible for managing different sources of flooding as illustrated in Figure 3-1.

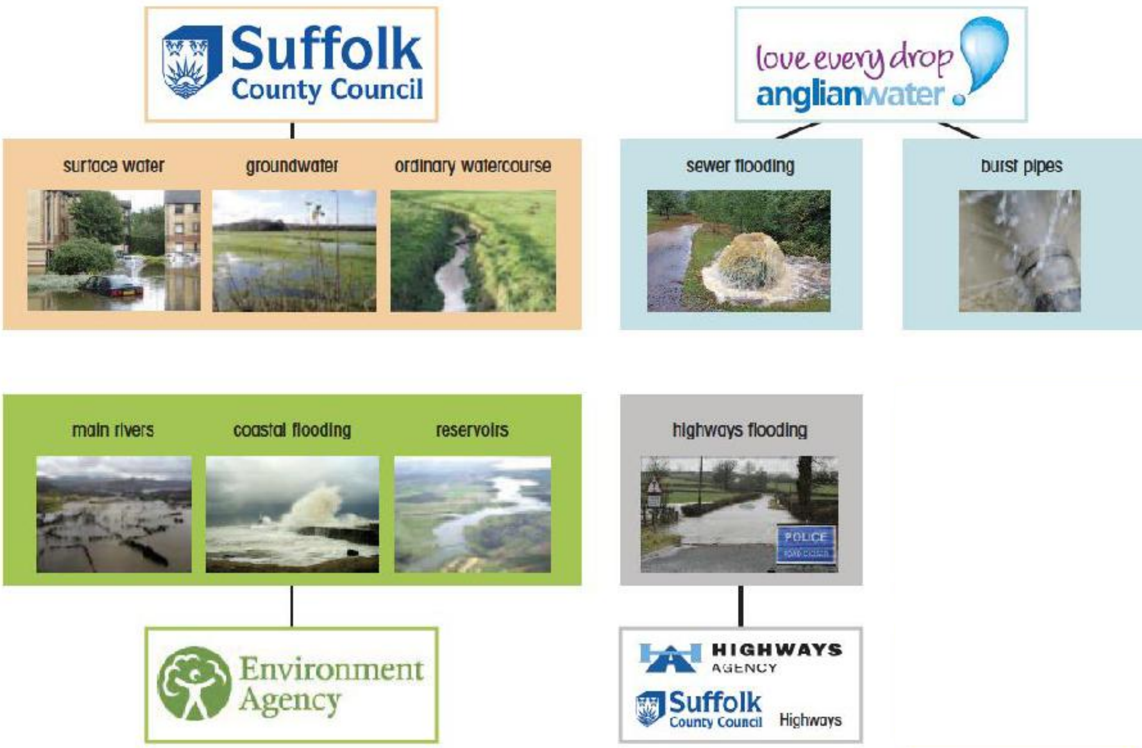

Figure 3-1 Flood Sources and RMAs Responsibility within the Study Area (SFRMS[2])

[2] Modified to show the RMAs relevant to this study.

3.2 Design Storm Events

The design storm approach is the most commonly used method in ungauged basins for determining design floods in engineering practice. Design storm events are storm events that have not occurred but are derived by synthesis of rainfall data and are attributed certain catchment conditions. The broad use of the design storm approach is due to its simplicity and low computational cost, as well as the availability of input rainfall data in form of intensity-duration-frequency (IDF) or depth-duration-frequency (DDF) curves.

Table 3-1 provides details of the design storm events, selected in consultation with the steering group, and guidance on the application of the model outputs.

Table 3-1 Storm event return periods and application

Modelled Storm Event	Application
1 in 10-year event *(10% AEP)*	Assists in determining the benefit of flood risk management options in higher frequency lower magnitude events.
1 in 20-year event *(5% AEP)*	Anglian Water utilise the 1 in 20 year to identify properties that might be at risk of flooding (internal and external). This storm event is also required for Flood and Coastal Risk Management Grant in Aid (FCRM GiA) funding applications as it assists with highlighting area at a very significant risk of flooding.
1 in 30-year event *(3.3% AEP)*	Assists in determining the benefit of flood risk management options, should partnership funding be sought. Anglian Water sewers are (now) typically designed to accommodate rainfall events with a 1 in 30-year return period or less. This storm event will identify areas that are prone to regular flooding and could be used by highway teams to inform maintenance regimes. Provides additional data for the Environment Agency Risk of Flooding from Surface Water (RoFfSW).
1 in 75-year event *(1.3% AEP)*	In locations where the likelihood of flooding is ≥1 in 75 years, insurers may not guarantee to provide property cover if it is affected by flooding. Results can be used to inform spatial planning whether properties can be guaranteed insurance; development may not be suitable where this cannot be guaranteed.
1 in 100-year event *(1% AEP)*	Can be overlaid* with EA Flood Zone 3 layer to show areas at risk under the same return period event from surface water and main river flooding. Provide evidence-based advice to planning authorities – Results are likely to differ from the fluvial event due to methods in runoff and routing calculations. Additionally, builds upon information provided for the RoFfSW for the Environment Agency.

Modelled Storm Event	Application
1 in 100-year event (plus climate change) Upper and Central bounds	NPPF requires that the climate change impacts are fully assessed. Spatial planning teams should refer to the Flood outline results to assess the sustainability of future developments. Upper Bound is a 40% increase whilst the central bounds is a 20% increase in rainfall.
1 in 1000-year event *(0.1% AEP)*	Can be overlaid* with EA Flood Zone 2 layer to show areas at risk under the same return period event from surface water and main river flooding. To be used by emergency planning teams when formulating emergency evacuation plans from areas at risk of flooding. Requested by the Environment Agency for updating the RoFfSW maps

* The two major assumptions underlying the classical design storm approach are:

1. the return periods of concurrent rainfall and peak discharge are assumed to be the same; and
2. the design flood of a given return period can be estimated based on a single critical rainfall duration, i.e., the rainfall duration that generates the highest peak discharge.

The first assumption is only a rough approximation because a rainfall event with a given return period leads to different peak discharges dues to temporal rainfall pattern, antecedent wetness, or spatial rainfall variability. The second assumption neglects the possible contribution of rainfall events of different durations on flood exceedance probabilities. Consequently, the design storm approach tends to underestimate flood probabilities.

3.3 Pluvial and Sewer Flooding

In an area drained by sewers, surface water flooding and sewer flooding need to be assessed collectively as they influence each other. Surface water flows into the sewers and sewers may surcharge to cause flooding or exacerbate surface water flooding. Water collected from roofs and on paved areas is typically directed into the sewers.

SCC and Highways England, as the Highways Authority for their roads, are responsible for maintaining the highway drainage system including kerbs, road gullies and the pipes which connect the gullies to the sewers and soakaways. The water authority, in this case Anglian Water, is responsible for maintaining the sewers. Figure 3-2 shows a representation of the different ownership of surface water drainage features on a highway.

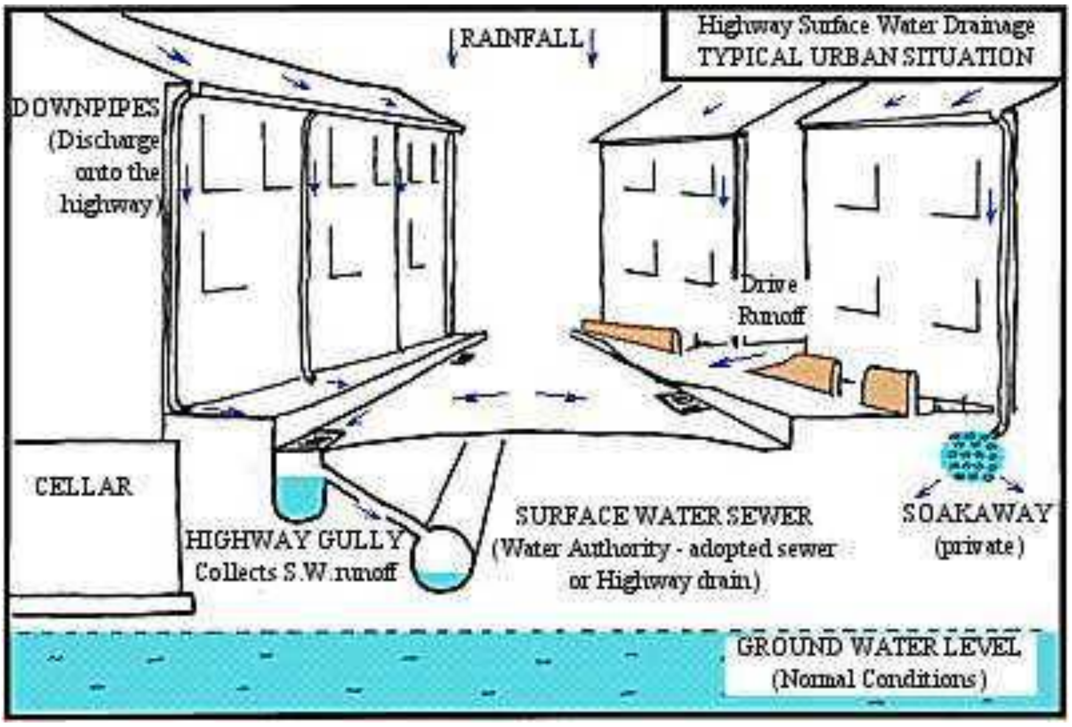

Figure 3-2 Stormwater Drainage Responsibilities[3]

Newer drainage system designs separate foul and surface water sewers. Anglian Water sewers are (now) typically designed to accommodate rainfall events with a 1 in 30-year return period or less.

The main causes of sewer flooding are:

- Lack of capacity in the sewer drainage networks: Often a consequence of the original design criteria requiring a reduced standard of protection that was acceptable at the time of construction;
- Lack of capacity in sewer drainage networks: Due to new developments within the catchment modifying the connectivity within the network, modifying catchment flow rates. Additionally, because of climate change modifying rainfall patterns and storm events;
- Exceedance of the sewer drainage networks capacity, due to storm events that are larger than the system was designed to cater for;
- Loss of capacity in sewer drainage networks when a watercourse has been fully culverted and diverted or incorporated into the formal drainage network (lost watercourses);
- Poor maintenance or failure of sewer networks which leads to a reduction in capacity and in cases leads to total sewer blockage;
- Failure of sewerage infrastructure such as pumping stations or flap valves leading to surface water or combined foul/surface water flooding;

[3] Source: http://www3.hants.gov.uk/roads/highway-flooding/highways-drainage/urban.htm

- Additional impervious surfaces (paved area i.e. driveways, building extensions) connected onto existing network without any control;
- Poor gully maintenance restricting transfer of flows into the drainage network; and
- Poorly maintained groundwater infiltration systems (i.e. damaged pipe networks).

3.4 Watercourses or Fluvial Flooding

Flooding from watercourses (also known as ‘fluvial flooding’ if a main/primary river or ordinary watercourse flooding from other river classifications) occurs when a watercourse cannot accommodate the volume of water that is flowing into it.

For the purposes of flood risk management fluvial flooding is separated into 2 categories, these are flooding from;

- Ordinary Watercourses – a source of local flood risk; and
- Main River – a source of strategic flood risk.

In general terms this distinction refers to the relative size of the watercourses involved, with Ordinary Watercourses (usually but not always) being smaller than Main Rivers.

The EA Detailed River Network (Figure 3-4) shows two ordinary watercourses within the study area and one main river (the River Stour). A review of the available data indicates that in 1968 the River Stour flooded within the study area with the flood extent visible within Figure 3-3.

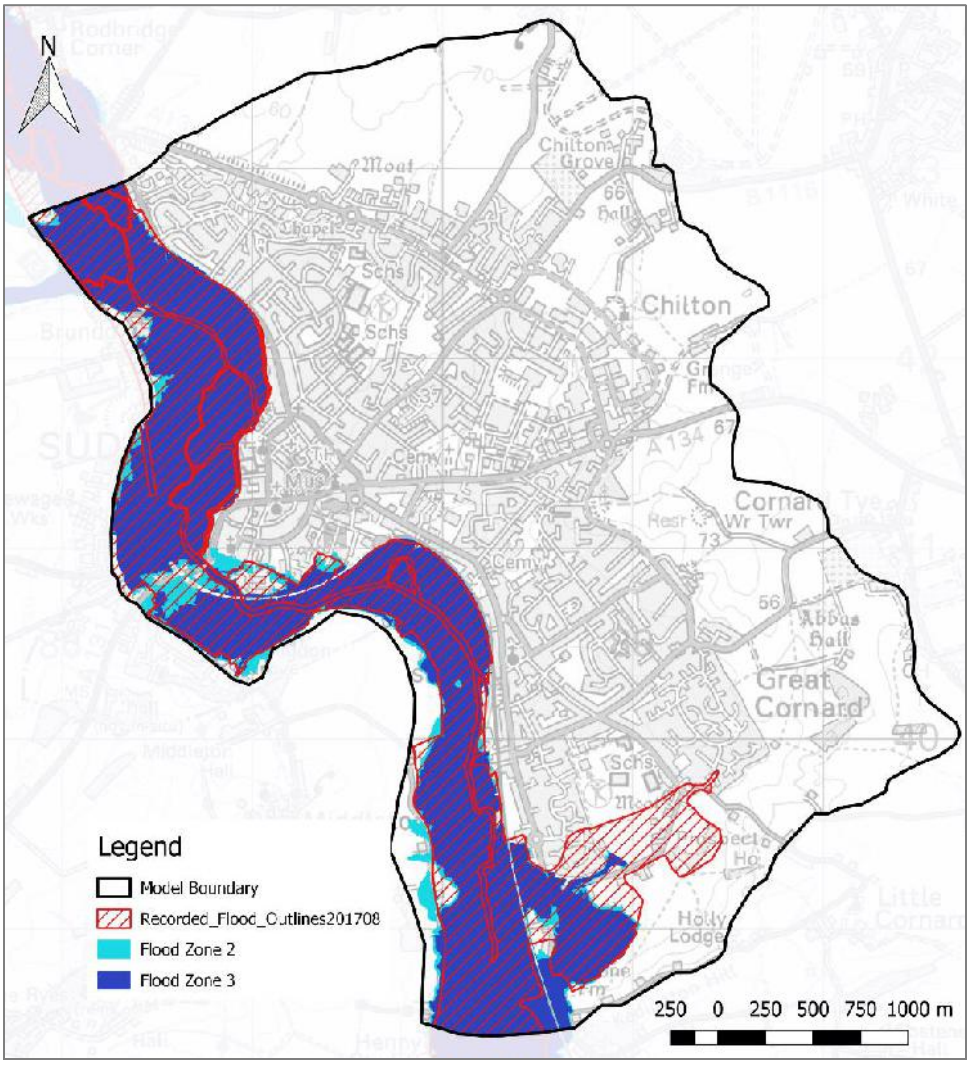

Figure 3-3 Flood Zones and Historic Flood Extent

Main river flooding has not been assessed further as part of this SWMP. More information on flooding from the River Stour can be found in the CFMP and SFRA reports. In addition, flood zones supplied by the EA provide a good representation of flooding from fluvial flood risk.

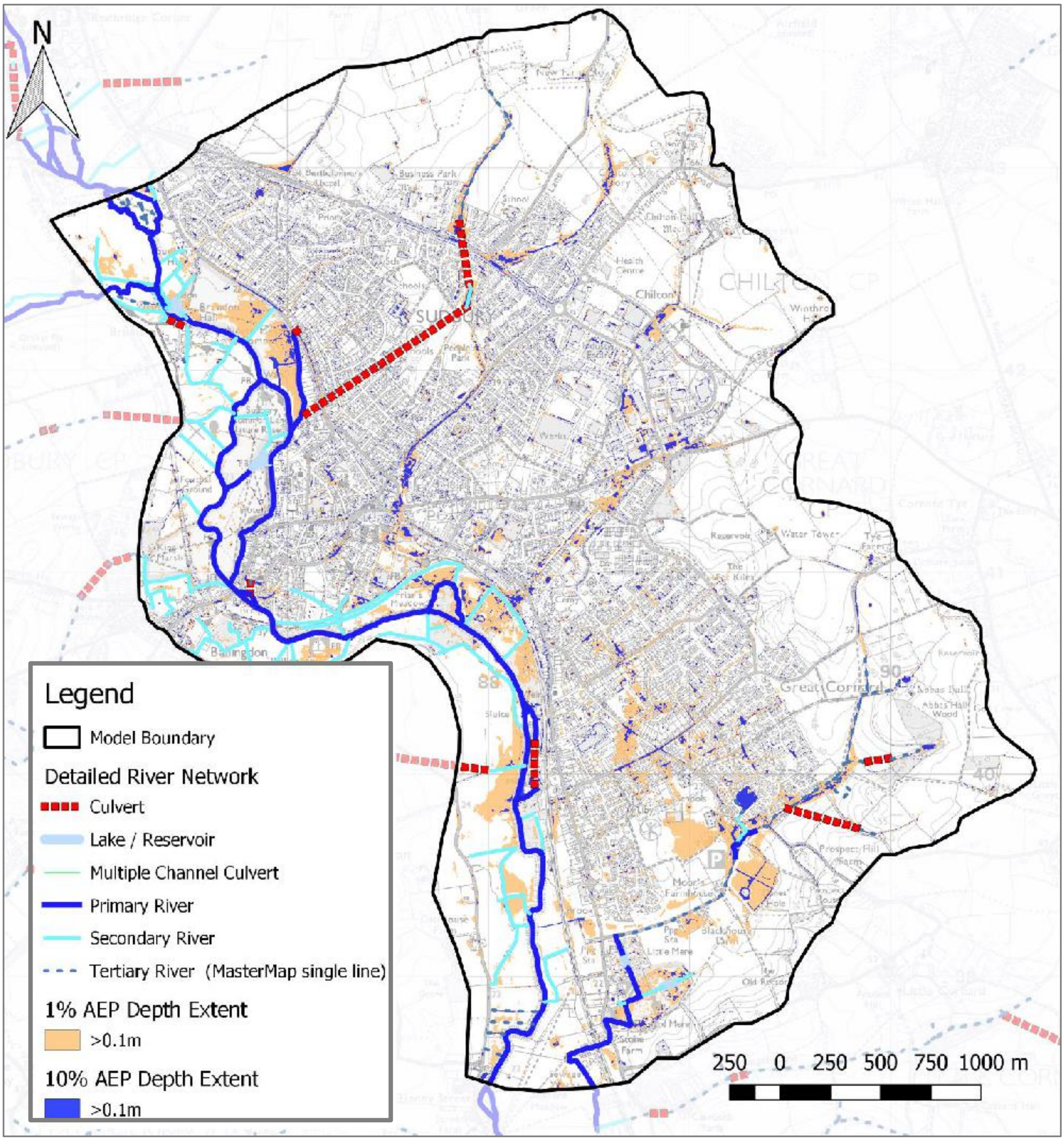

Figure 3-4 Detailed River Network Classifications

The ability of a watercourse to accommodate flood water depends upon the capacity of the watercourse's channel, its' floodplain and the amount of water that enters its catchment during a flood event. When a watercourse becomes overloaded, flooding beyond the area of the floodplain can occur. Where rivers are separated from their floodplain by embankments or flood defences this may lead to flooding from overtopping or due to a breach of those banks and defences.

While the storage capacity of the watercourse and the functional flood plain can be determined by assessment of the watercourse, it is important to recognise that the rate of inundation can be affected by factors that are remote from the river itself. The flow of water in a watercourse is dependent upon the rate of run-off from the entire river catchment.

Measures that might increase the rate of water flowing into a watercourse can be remote from the flooding that occurs as a result of any works. Significant reductions in flooding can be achieved if the rate of water flowing into river systems can be effectively managed at source.

3.5 Groundwater Flooding

Groundwater flooding relates to water discharging from permeable sub-surface strata either at specific locations (such as a spring) or over a wide diffuse location (typical in Karst systems) and inundates low lying areas.

The potential for groundwater flooding events arises when groundwater levels increase to the point where the water table meets the ground surface level and inundates low lying land. The resultant flood impacts may be distant from groundwater discharging locations through developed overland flow paths and increased stream discharges resulting in downstream flooding.

The event duration for groundwater flooding is considered temporally longer than that of pluvial flooding - a longer lead time over weeks to months for sufficient water table levels to develop and may discharge for days to weeks.

The flood mechanics associated with groundwater influenced events can be classified as:

- Springs emerging at the surface;
- Direct contribution to channel flow;
- Inundation of drainage infrastructure; and
- Inundation of low-lying property.

Groundwater flooding is not deemed a risk to life in most instances due to the flood mechanics.

The EA AStGWF map (Figure 3-5) indicates that the southern and north western extent of the study area may be susceptible to groundwater flooding. Areas within the centre of Sudbury are at a low vulnerability (<25%) risk. Areas most susceptible to groundwater flooding are in locations close to the river corridor where the groundwater level is likely to remain high (≥50% <75%, ≥75%).

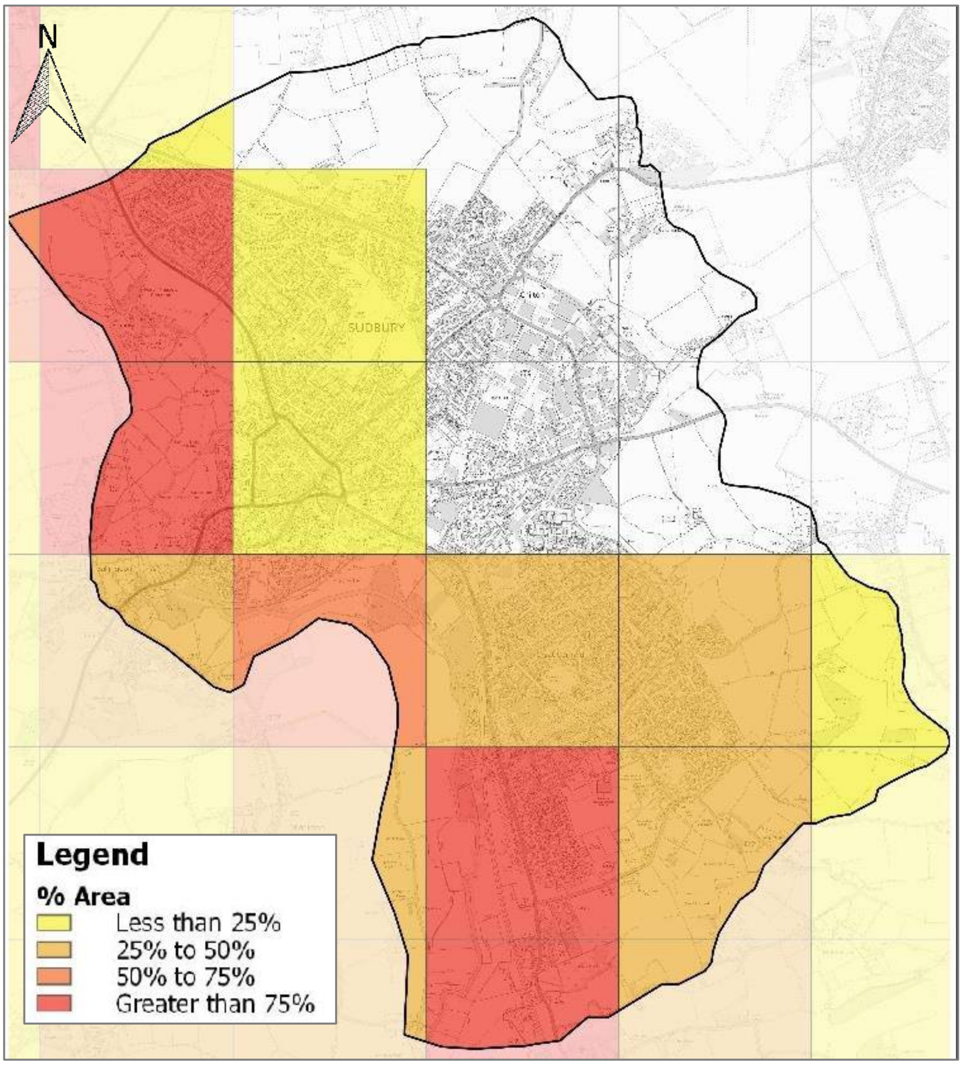

Figure 3-5 Environment Agency Areas Susceptible to Groundwater Flooding

3.6 Integrated Assessment of Local Flood Risk

An integrated hydrological and hydraulic modelling approach has been used to assess the causes and consequences of surface water flooding in the Sudbury and Great Cornard. The following section summarise the modelling methodology, with an in-depth description provided in Appendix B.

The TUFLOW software was selected for modelling surface water flood risk because of its accuracy, stability and enhanced functionality.

Design storm events with different return periods, or Annual Exceedance Probability (AEP), are modelled with the rainfall applied directly to the ground surface. Rainwater can infiltrate, if the ground is permeable and not saturated, pond on the surface or flow overland.

Flows in the sewer and ordinary watercourses are modelled in one-dimension – as the variables (depth, velocity and hazard) change in one defined direction along the pipe or channel. Overland flow is modelling in two-dimensions - horizontal velocity components (Vx and Vy) or, alternatively, velocity vector magnitude and direction throughout the model domain.

The model domain was determined from the topography of the terrain and known drainage assets. A high resolution 2m model cell size was selected to capture the fine scale urban features that impact surface water flooding.

The overland, ordinary watercourse and sewer models are linked at the highways gullies and channel banks, respectively, to create an integrated model. Where sewer asset data exists, a fully Integrated Urban Drainage Model was developed. Where sewer information was lacking, or the data quality was too poor, a 'Virtual Pipes' approach was adopted. It should also be noted that the antecedent conditions of the catchment were considered to be dry in all modelled return period events.

4 Flood Risk Areas

4.1 Summary of Flood Risk

The results of the risk assessment, combined with site visits and a detailed review of existing data and historical flood records, indicate that there is a moderate risk of ordinary watercourse and groundwater flooding in Sudbury and Great Cornard.

The risk assessment indicated a moderate to high risk to Sudbury and Great Cornard from surface water and sewer flooding – particularly as rainfall intensities increase with climate change. The results indicate that the surface water flood risk is widely dispersed across the study area. Areas that intersect with the historic watercourses are at particular risk, as these are reactivated in extreme storm events. For example, the East Street flowpath from Elizabeth Court to its discharge point at the River Stour. Areas adjacent to obstructions to flow (raised road, embankments etc) are also a risk, as water ponds upstream of these constrictions. Flow routes such as East Street and Cat's Lane are predicted to experience flooding in lower magnitude storm events, where other flow routes such as Davidson Close and Clermont Avenue experience property flooding in larger magnitude events.

As part of this study, GIS data and mapped outputs of maximum water depth and hazard for each of the storm event return periods have been prepared and are presented in Appendix E. The maximum flood extents for four different storm events have also been stacked in Figure 4-1. This illustrates the increase in flood extents with decreasing Annual Exceedance Probability (AEP) storm events. In general, surface water flooding across the study area is low to moderate in the lower order rainfall events (e.g. 10% AEP) and is predicted to experience greater levels of flooding across the study area during higher order (e.g. 1% AEP) storm events. This is reflected in the analysis of risk to properties, businesses and infrastructure that is discussed below.

The modelling assumptions and limitations (Appendix B) should always be considered when basing decisions of the map outputs.

Figures highlighting the impacts on the capacity of the modelled piped drainage system can be located within Appendix E. These figures illustrate how full the modelled pipe network gets along with the duration of time that these assets are full during the model simulation.

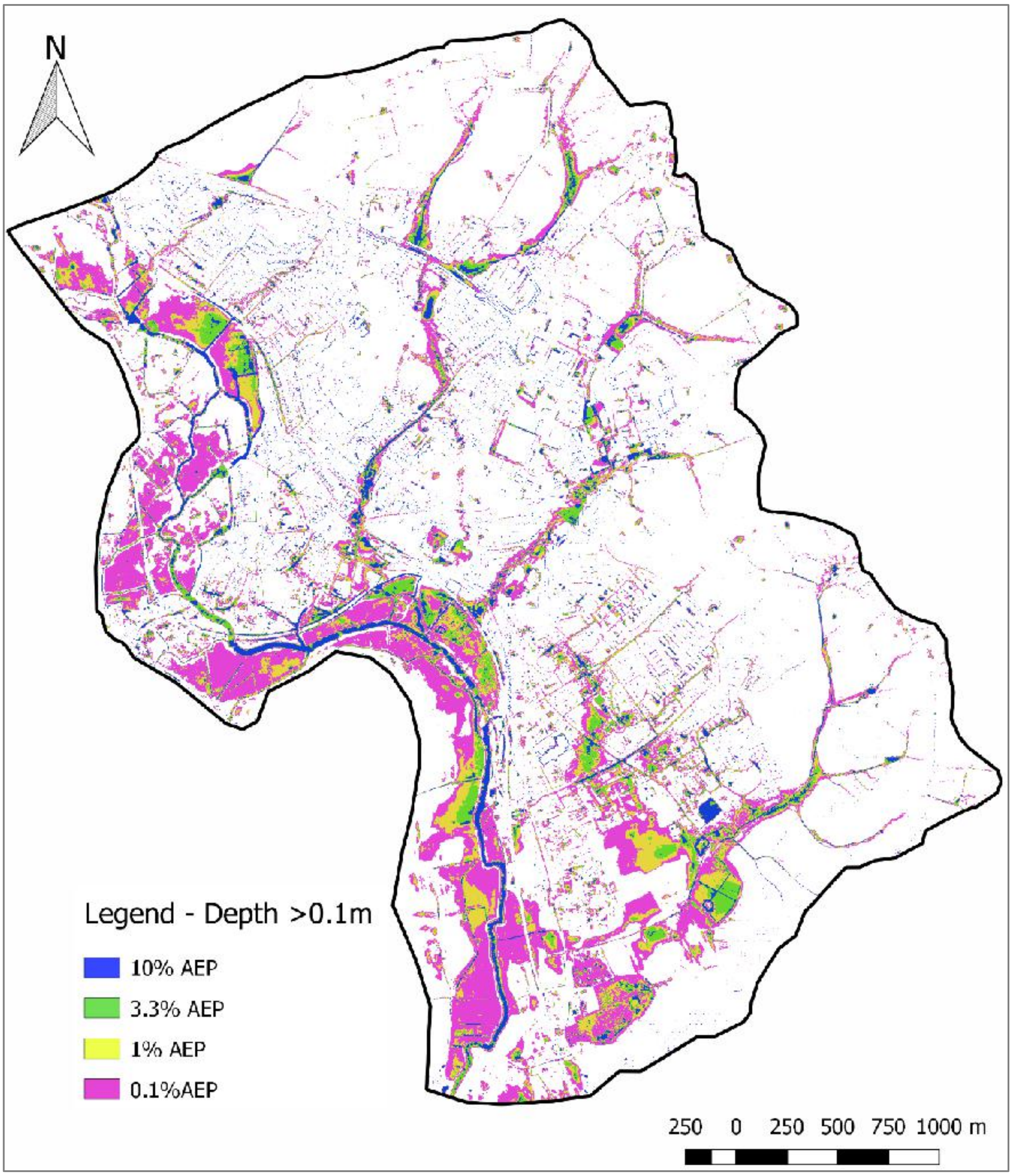

Figure 4-1 Flood Extent Difference Between Low and High Probability events

4.2 Risk to Existing Properties & Infrastructure

Maps of the predicted maximum surface water flood depths and extents have been generated from the hydraulic model results and are included in Appendix E. The properties at risk of surface water flooding and associated damages have been calculated both catchment-wide and at an individual CDA level to support the flood mitigation assessment.

Figure 4-2 shows the location and type of properties in the study area. Figure 4-3 identifies the properties at risk and the event that they are first inundated. – the flood extent from a 1% AEP storm event has been placed in the background for reference.

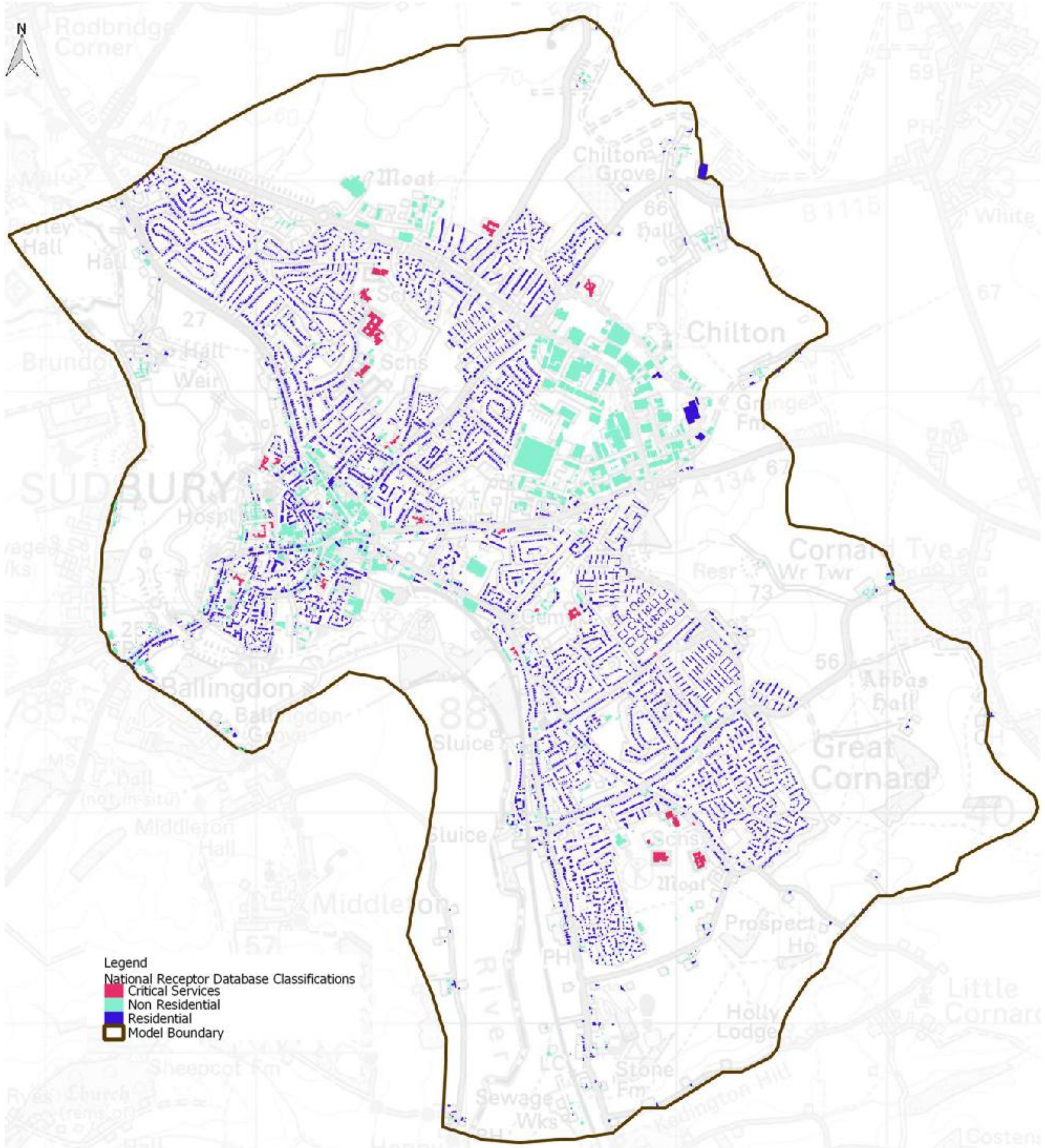

Figure 4-2 National Receptor Database Classifications

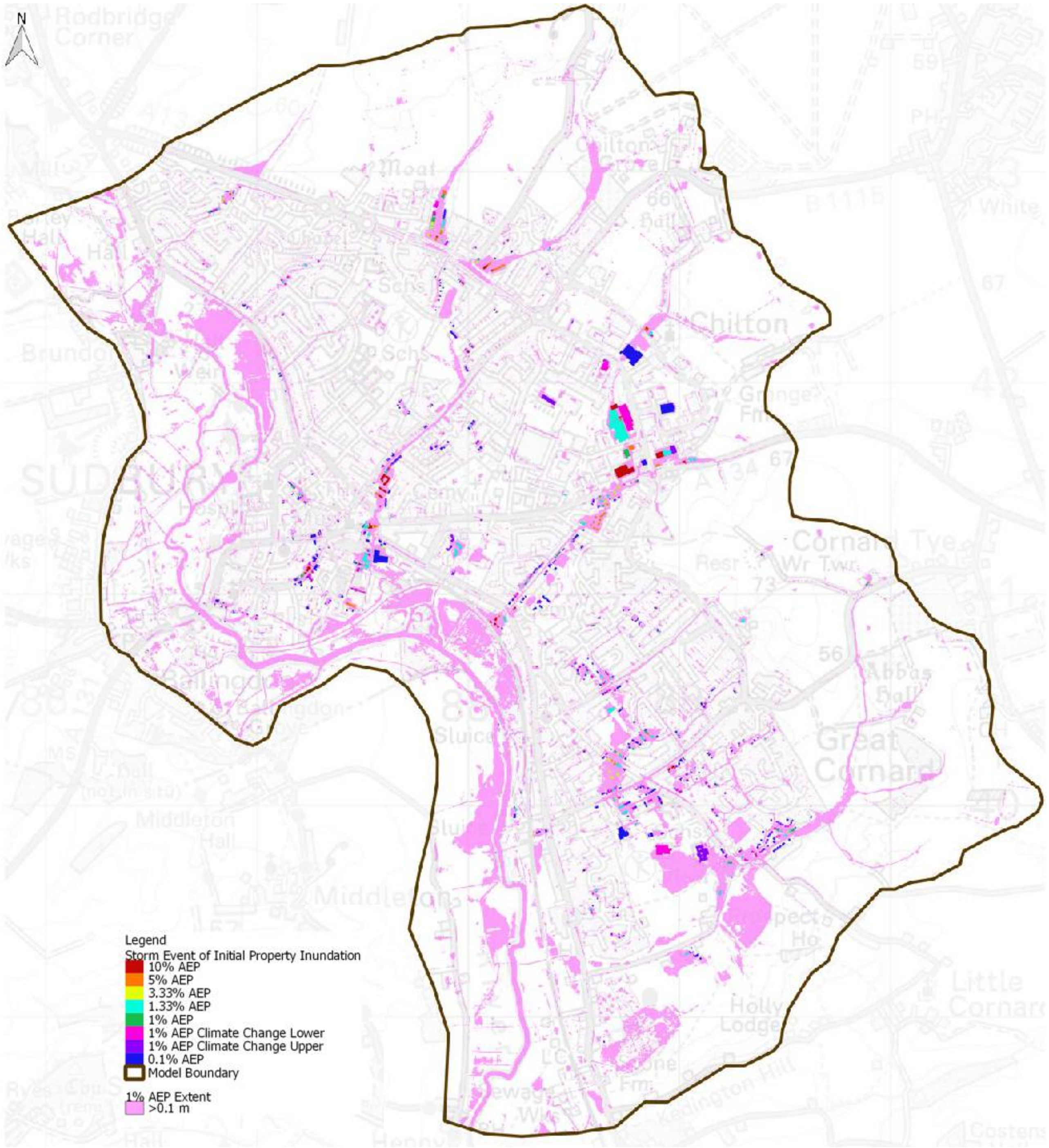

Figure 4-3 Properties at Risk and associated Storm Event

The number of receptors predicted to be at risk of flooding is presented within Table 4-1. This is presented graphically in Figure 4-4 with Table 4-2 providing a summary of costs associated with flooding.

Table 4-1 Properties at Risk of Surface Water Flooding

AEP	Baseline Scenario			
	Residential	Non-Residential	Critical Services	TOTAL
10%	36	12	0	48
5%	101	19	0	120
3.33%	127	29	0	156
1.33%	239	54	0	293
1%	278	63	0	341
0.10%	826	151	4	981
1% RCC Central	390	89	1	480
1% RCC Upper	511	106	3	620

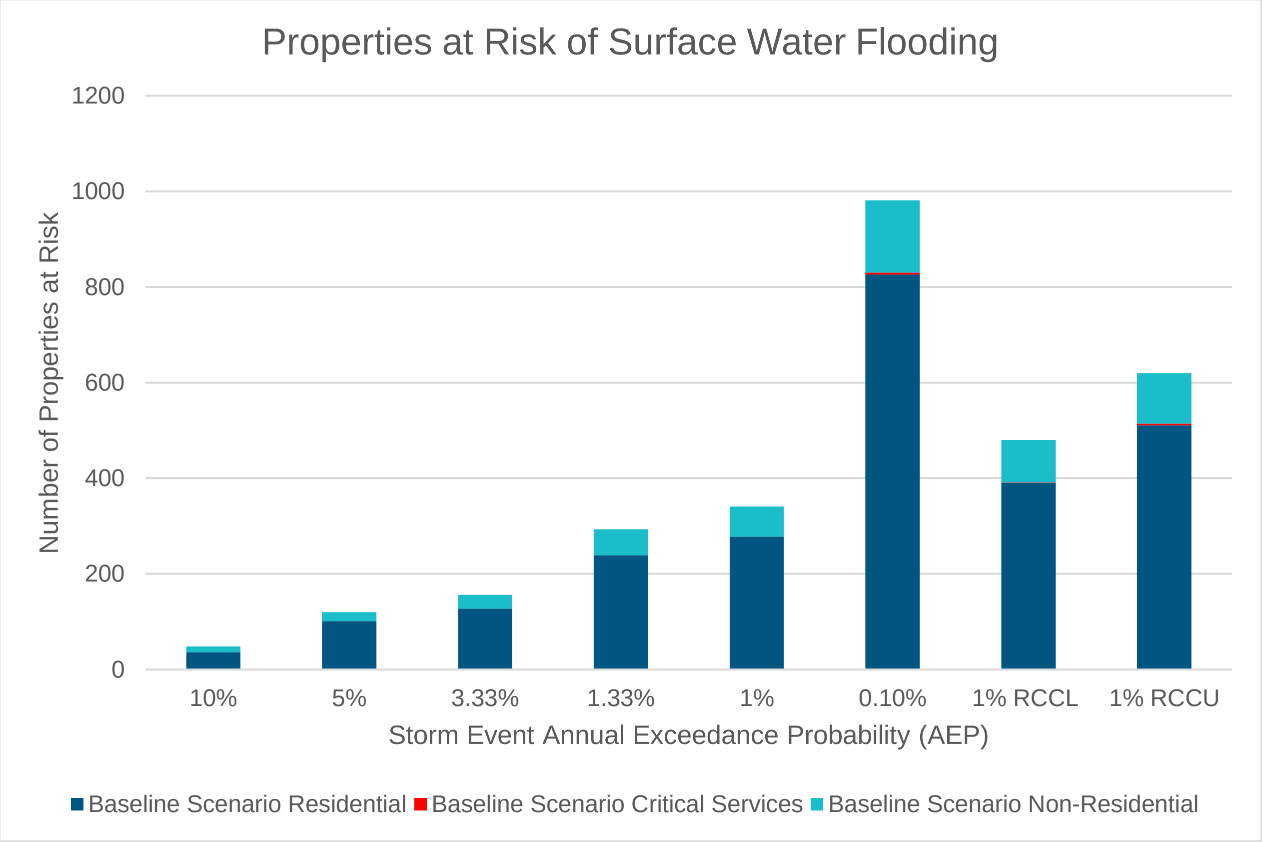

Figure 4-4 Properties at Risk of Surface Water Flooding

Table 4-2 Surface Water Flood Damages

AEP	Baseline Scenario			
	Residential	Non-Residential	Critical Services	Total
10.0%	£ 1,444,700	£ 1,427,600		**£ 2,872,400**
5.0%	£ 2,075,100	£ 1,766,000		**£ 3,841,200**
3.33%	£ 3,013,900	£ 2,027,300		**£ 5,041,200**
1.33%	£ 6,868,400	£ 12,621,700		**£ 19,490,200**
1.0%	£ 7,991,900	£ 13,153,700		**£ 21,145,600**
0.1%	£ 20,983,200	£ 30,891,500	£ 1,159,300	**£ 53,034,000**
1% (Climate Change Central Bound)	£ 9,911,600	£ 21,449,900	£ 547,000	**£ 31,908,500**
1% (Climate Change Upper Bound)	£ 14,127,200	£ 22,844,362	£ 916,800	**£ 37,888,400**
			Average Annual Damage	**£ 1,462,600**

4.3 Effect of Climate Change

The likelihood and intensity of summer rainfall events is predicted to increase in Eastern England as a result of climate change. Consequently, surface water flood risk may become more frequent and severe in the future.

To analyse and effectively capture the range of uncertainty in future climate projections the central (20% increase) and upper peak (40% increase) rainfall intensity allowances of projections have been modelled and reported for a 1 in 100-year return period storm event (1% AEP). This is based on the updated 2016 Environment Agency guidance that recommends assessing both allowances in small catchments to convey the range of potential impacts of climate change (Appendix B). Figure 4-1 provides a direct comparison of the maximum flood extents for 1% AEP storm event with the to the upper peak rainfall intensity allowances.

The area of red indicates where the upper bound climate change events results indicate that flood depths are predicted to be greater along with an increase in hazard. This increase is most obvious in topographic low points that have flow obstructions (raised ground downstream) and along valleys due to the ability for flood depths to be greater and / or experience an increase in flood depth and velocity.

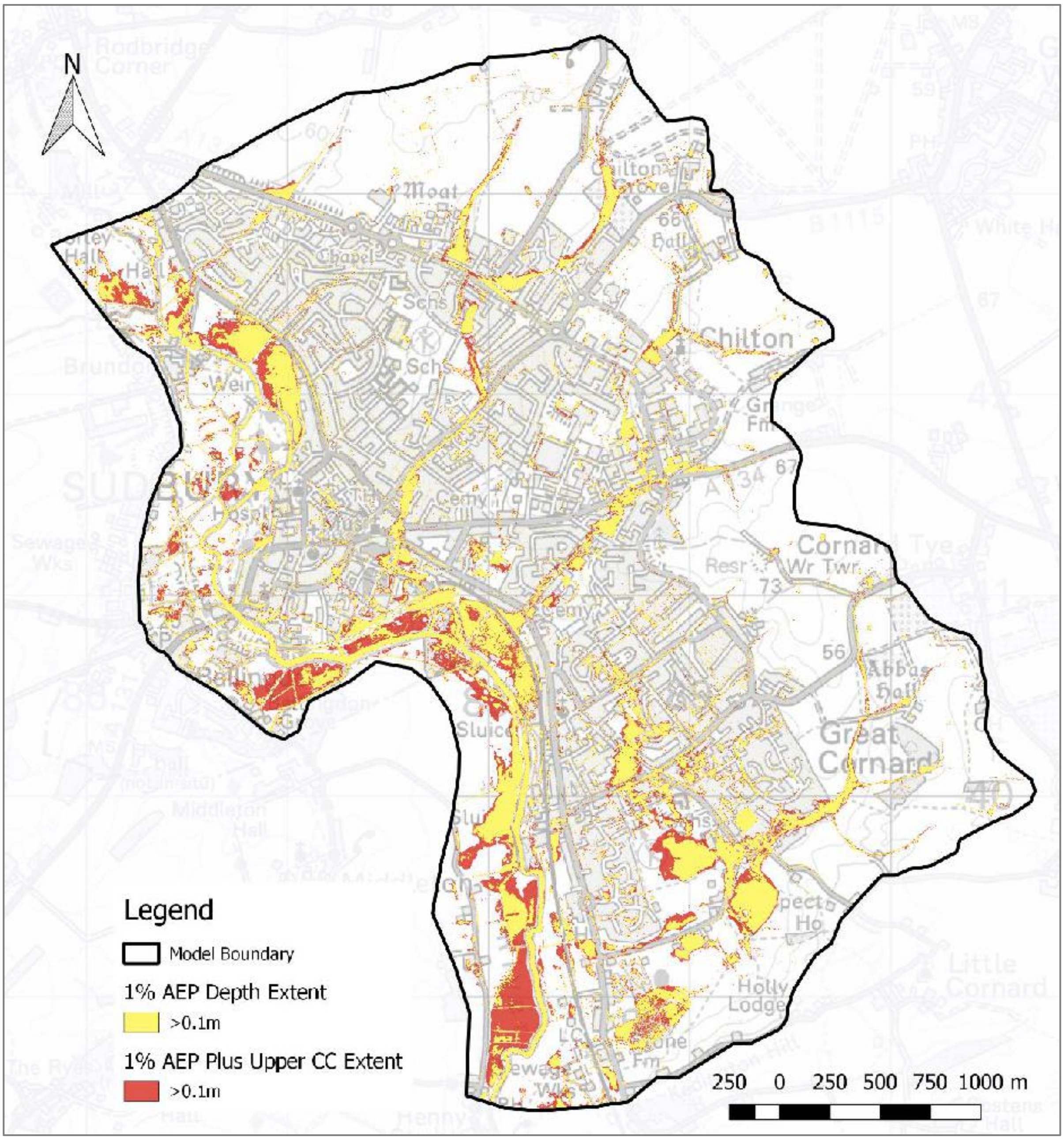

Figure 4-5 Impact of Climate Change on the Maximum Flood Extent: 1% AEP Storm Event

4.4 Risk to Future Development

Several areas within the study areas have been identified for future development (Section 1.5). It is important that the surface water flood risk identified within this study is taken into consideration in the site allocation process. Development at these locations could either assist or exacerbate the risk to existing properties within the towns. It is recommended that these developments adhere to specific policy relating to surface water management in this document in addition to the requirements of NPPF.

Figure 4-6 highlights the locations of the proposed development sites along with several surface water flood extents. This highlights the importance of managing and if possible, reducing the volume of runoff discharging from any of these sites. It is recommended that the SCC and BDC require that all developments include a betterment to existing rates to assist with the reduction of flood risk within the towns.

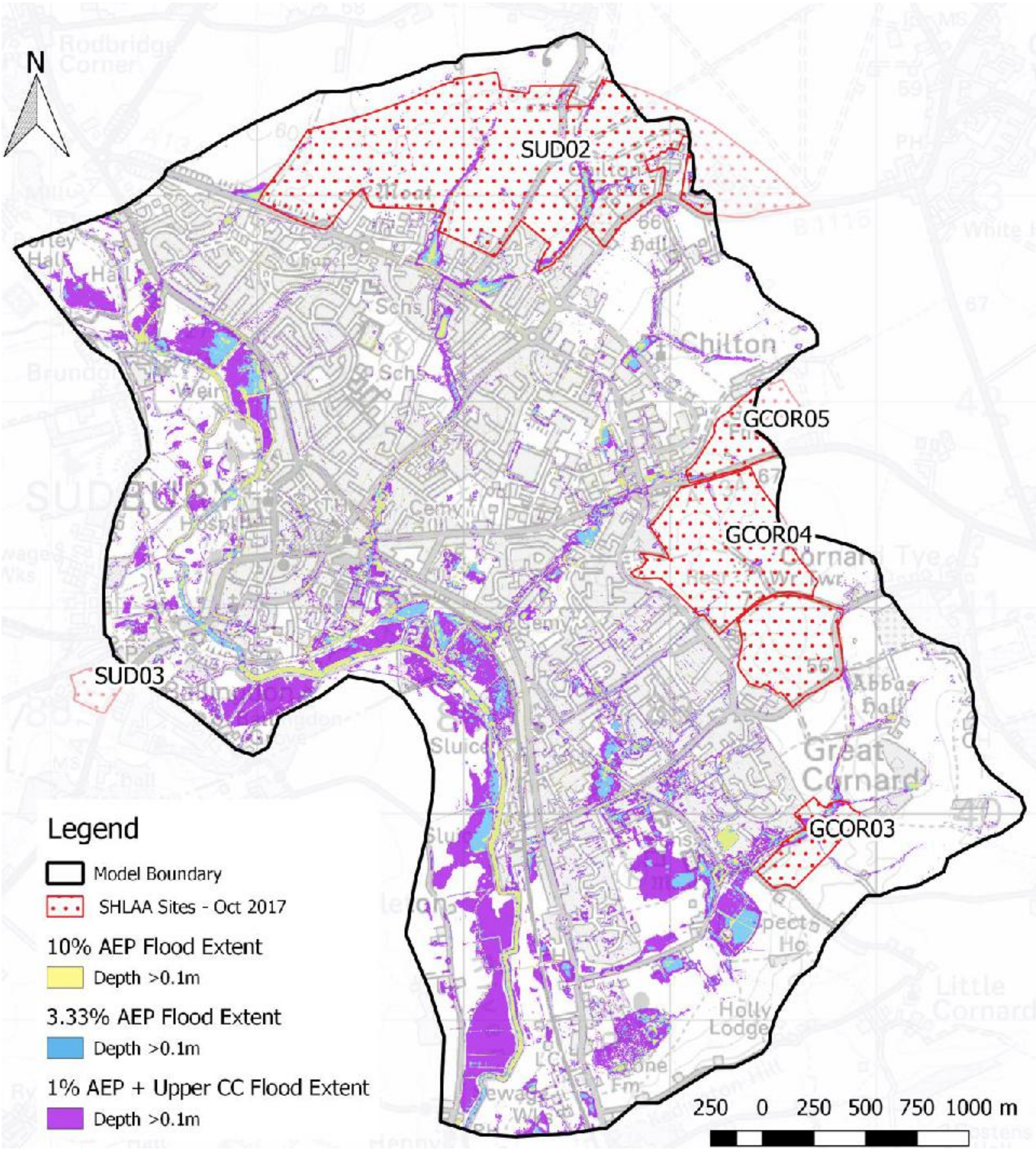

Figure 4-6 Proposed Strategic Housing Sites and Predicted Flood Extents

4.5 CDA Selection Criteria

One of the aims of the SWMP is to determine which areas should be prioritised for further risk assessment. Areas identified at more severe risk of flooding in the detailed and intermediate risk assessment were designated as Critical Drainage Areas (CDAs). A CDA can be described as a discrete geographic area (usually a hydrological catchment) where multiple or interlinked sources of flood risk cause flooding during a severe rainfall event thereby impacting people, property or local infrastructure.

The upstream 'contributing' catchment, the drainage and surface water catchments and potentially downstream areas of influence, spatially describe a CDA. CDAs are usually located within Flood Zone 1, but extend to other flood zones where a clear surface water flood risk (dominant in cause) is observed historically or in the modelling. To spatially define a CDA we have considered:

- Pluvial Flood depth and hazard extent: CDAs include areas that experience high flood depths and/or hazard to people;
- Predicted impact to properties and infrastructure: including residential and commercial properties, main roads, rail networks, hospitals and schools. Access to hospitals or evacuation routes is critical in higher magnitude events;
- Groundwater flood risk: based on groundwater monitoring data and the EA AStGWF datasets identifying areas vulnerable to groundwater flooding;
- Sewer capacity and potential surcharging: based on information obtained from Anglian Water on sewer flooding assessment;
- Historic flooding: locations that are known to be susceptible to surface water flooding;
- Source, pathway and receptor: holistic consideration of flooding within the CDA; and
- Cross boundary linkages and appropriate definition of area: CDA selections that are free of political or administrative boundaries, including the hydraulic catchment contributing to the CDA and the area available for flood mitigation options.

4.6 CDA Assessment

Five areas have been classified as CDAs within the study area. Figure 4-7 presents the CDA boundaries along with the maximum flood depths for the 1% AEP storm event and the locations of surcharging gullies. Each CDA is considered in turn in the following section. Maximum depth and hazard maps for all storm events for individual CDAs are provided in Appendix B.

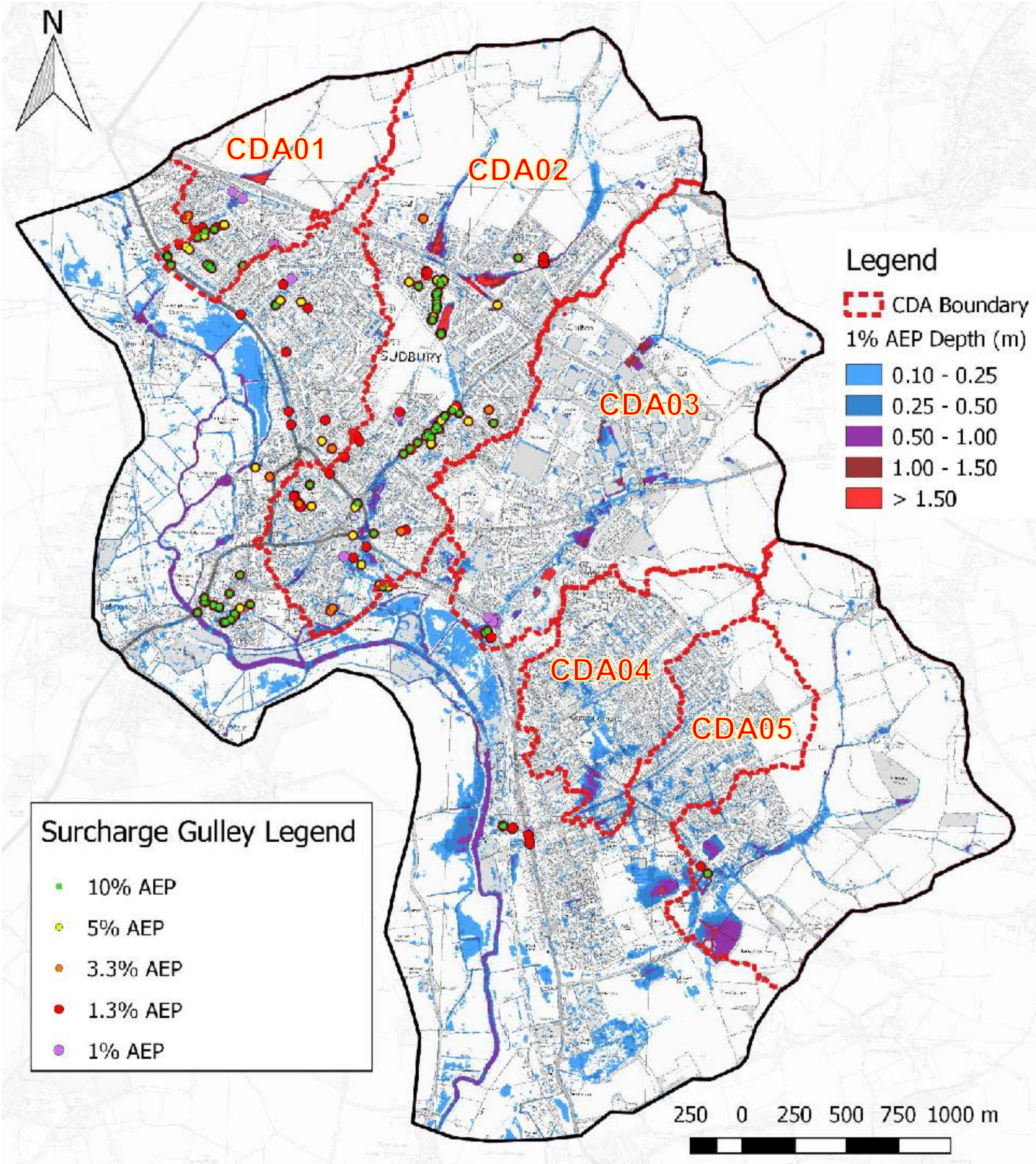

Figure 4-7 Proposed Critical Drainage Areas with Predicted 1 in 100 Year Event (Surface Water Flooding) Results

4.7 Overview of Flood Risk within CDA 01 – Clermont Avenue

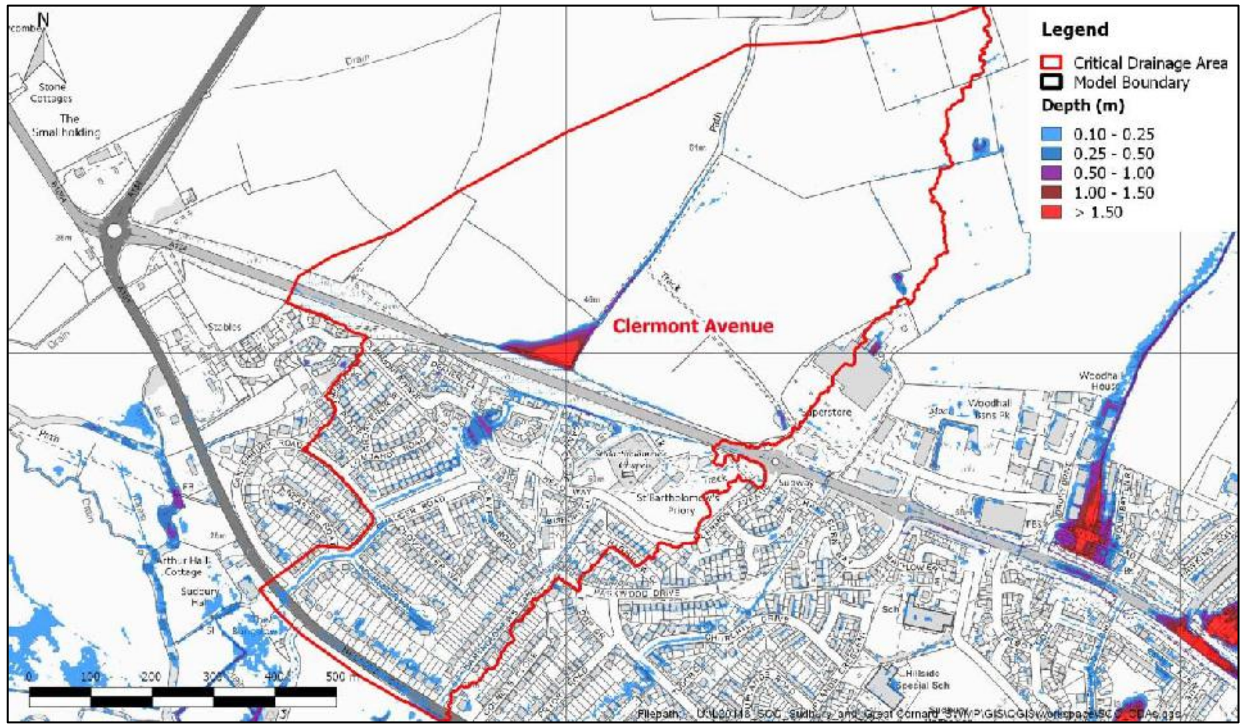

Figure 4-8 CDA 01 – 1% AEP Storm Event, Maximum Depth

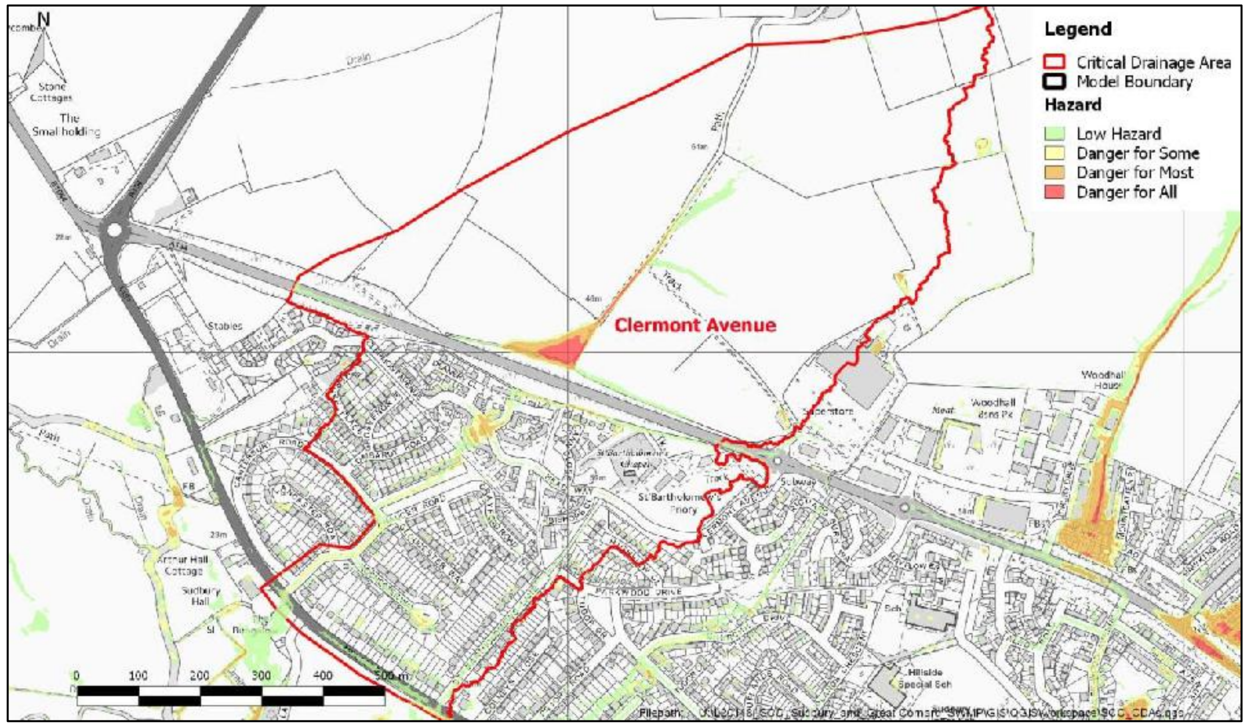

Figure 4-9 CDA 01 - 1% AEP Storm Event, Maximum Hazard

Source
The source for flooding in Clermont Avenue CDA is primarily from overland flow originating in the rural upper catchment to the north east. The upper catchment is primarily fields underlain by loam and clay-loam.
Pathway
Flow within in the CDA is conveyed through a topographic depression to a basin upstream of the A134. There is no overland flow connection through the A134 and the road is not shown to overtop in all storm events modelled. There is a piped connection from upstream of the A134 through the CDA. The pipe network echoes the overland flowpath, moving south west towards the River Stour. There are large storage tanks located under Clermont Avenue. Both overland flow and piped drainage enters the River Stour floodplain in a drainage ditch south of Melford Road.
Receptor
Properties on Clermont Avenue are shown to be impacted in events greater than the 5% AEP storm event. Additional properties downstream on Chaucer Road are shown to be impacted in events greater than the 1.33% AEP storm event.

Table 4-3 CDA 01 – Clermont Avenue, Property Count Estimation

AEP	Residential	Non-Residential	Critical Services	TOTAL
10%	1	0	0	1
5%	3	0	0	3
3.33%	7	0	0	7
1.33%	11	1	0	12
1%	12	1	0	13
0.10%	23	1	0	24
1% Climate Change Allowance, Lower	16	1	0	17
1% Climate Change Allowance, Upper	19	1	0	20

Table 4-4 CDA 02 – Clermont Avenue, Damage Estimation

AEP	Residential	Non-Residential	Critical Services	TOTAL
10%	£20,700	£0	£0	£20,700
5%	£49,400	£0	£0	£49,400
3.33%	£118,000	£0	£0	£118,000
1.33%	£203,300	£10,500	£0	£213,700
1%	£241,700	£10,500	£0	£252,200
0.10%	£555,500	£10,500	£0	£565,900
1% Climate Change Allowance, Lower	£339,700	£10,500	£0	£350,100
1% Climate Change Allowance, Upper	£427,200	£10,500	£0	£437,700
Average Annual Damage				**£15,100**

4.8 Overview of Flood Risk within CDA 02 – East Street

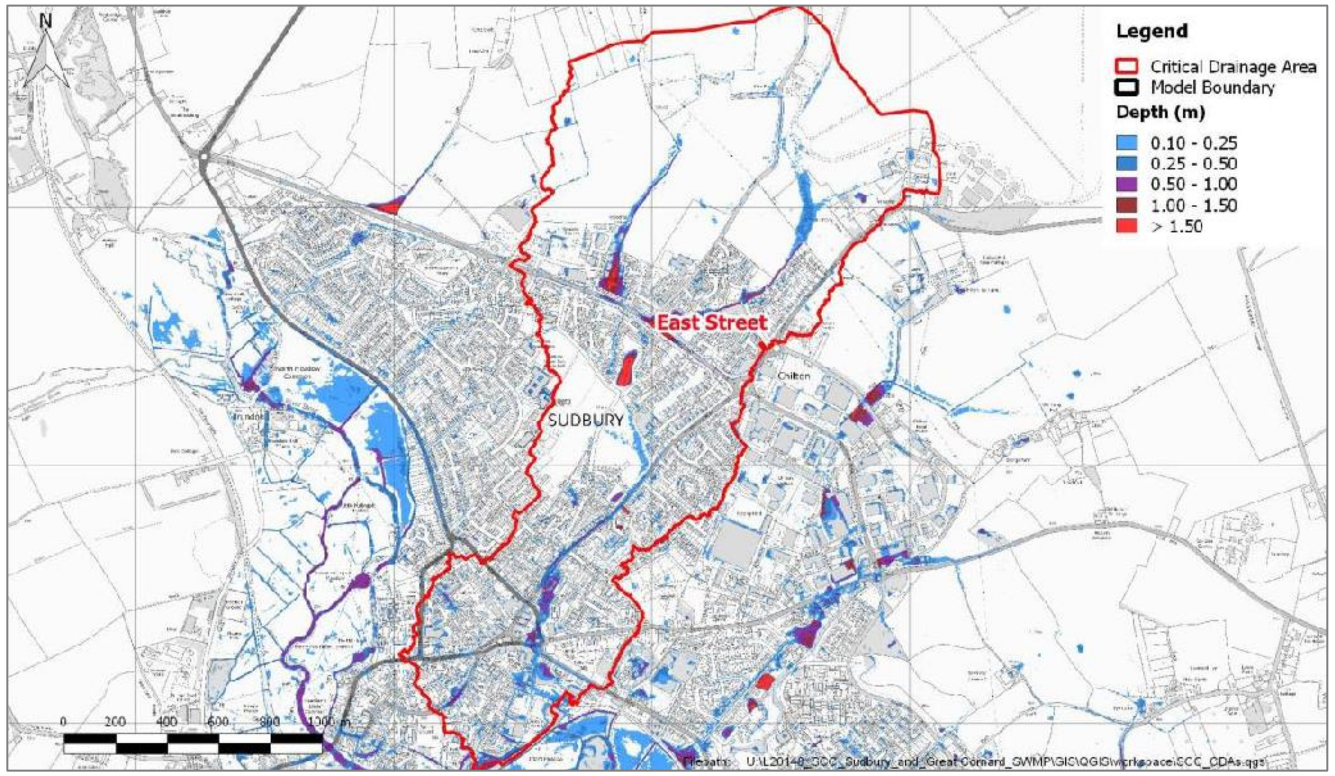

Figure 4-10 CDA 02 - 1% AEP Storm Event, Maximum Depth

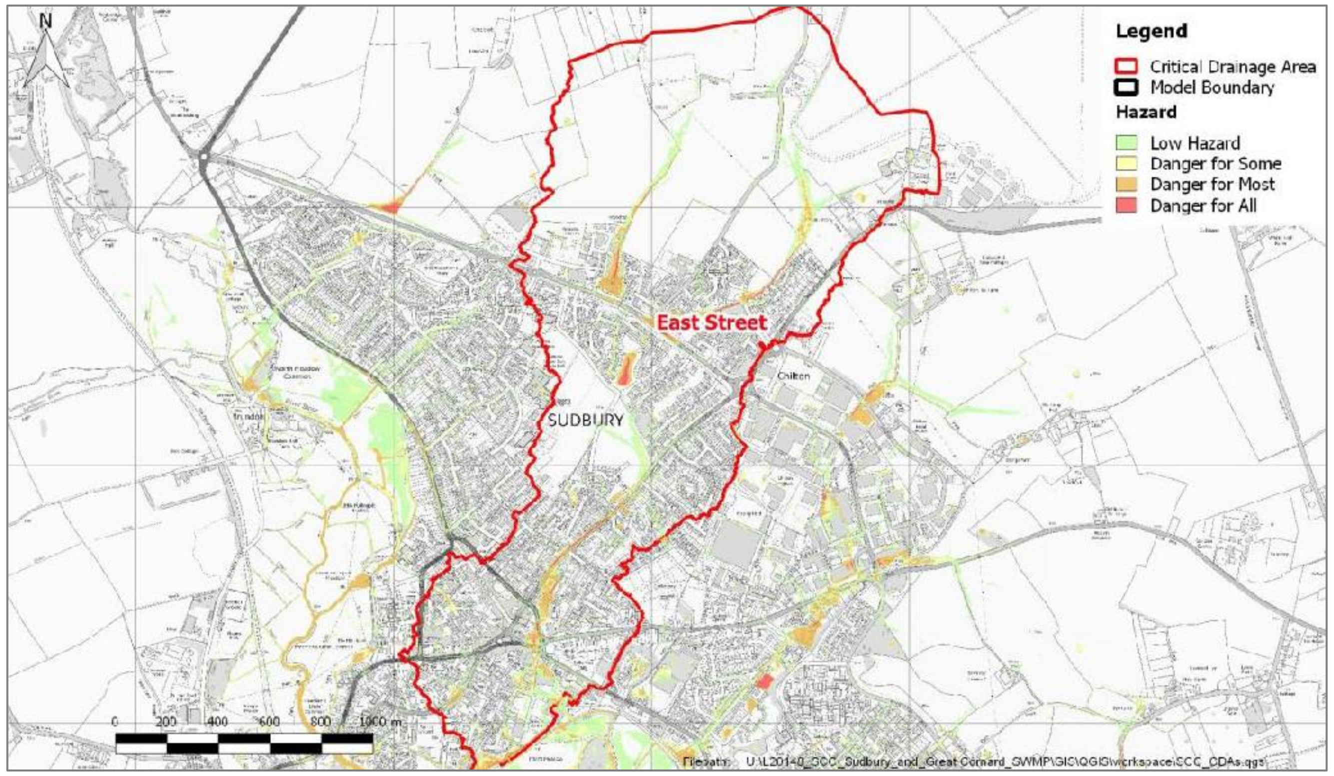

Figure 4-11 CDA 02 - 1% AEP Storm Event, Maximum Hazard

Source
Surface water runoff in the East Street catchment is sourced from the rural upper catchment and the incremental suburban catchment along the flowpath. Although most of the catchment is suburban, the steeper rural catchment generates substantial overland flow.
Pathway
The surface water runoff is conveyed through two unnamed open channels in the upper catchment. The eastern channel passes between Drury Drive and Mountbatten Road, the second is adjacent to St Mary's Close and passes under Aubrey Drive. These channels are not formalised until adjacent to the town. Flow in the channels is conveyed by pipes to the Essex Avenue Flood Meadow. The basin is a large formal basin with outlet structure (technical note Appendix B). Piped flow from the outlet structure joins the trunk sewer under East Street. The model predicts surcharging from the gullies along East Street can occur in a s little as the 10% AEP storm event. Overland flow from the incremental catchments of Meadow Fields and Waldingfield Road converge at East St. Flow moves down East Street before following the topography and moving through urban areas near Cavendish Way, King Street roundabout and Great Eastern Road. The flowpath, both piped and overland, discharges into an open ditch leading to the River Stour.
Receptor
Three key clusters of receptors are impacted in all modelled storm events by the East Street flowpath; Mountbatten and Grenville Road in the north east, Aubrey Drive and Raleigh Close in the north west and East Street between Elizabeth Court and Waitrose.

Table 4-5 CDA 02 – East Street, Property Count Estimation

AEP	Residential	Non-Residential	Critical Services	TOTAL
10%	28	5	0	33
5%	60	8	0	68
3.33%	67	13	0	80
1.33%	94	23	0	117
1%	106	28	0	134
0.10%	277	69	0	346
1% Climate Change Allowance, Central	135	41	0	176
1% Climate Change Allowance, Upper	167	48	0	215

Table 4-6 CDA 02 – East Street, Damage Estimation

AEP	Residential	Non-Residential	Critical Services	TOTAL
10%	£1,160,700	£121,600	£0	£1,282,300
5%	£1,155,400	£293,100	£0	£1,448,400
3.33%	£1,451,700	£458,100	£0	£1,909,800
1.33%	£3,127,900	£885,200	£0	£4,013,100
1%	£3,514,700	£1,074,900	£0	£4,589,600
0.10%	£6,806,300	£5,083,200	£0	£11,889,500
1% Climate Change Allowance, Central	£3,469,200	£1,591,400	£0	£5,060,600
1% Climate Change Allowance, Upper	£5,116,800	£1,906,600	£0	£7,023,400
Average Annual Damage				**£500,300**

4.9 Overview of Flood Risk within CDA 03 – Cat's Lane

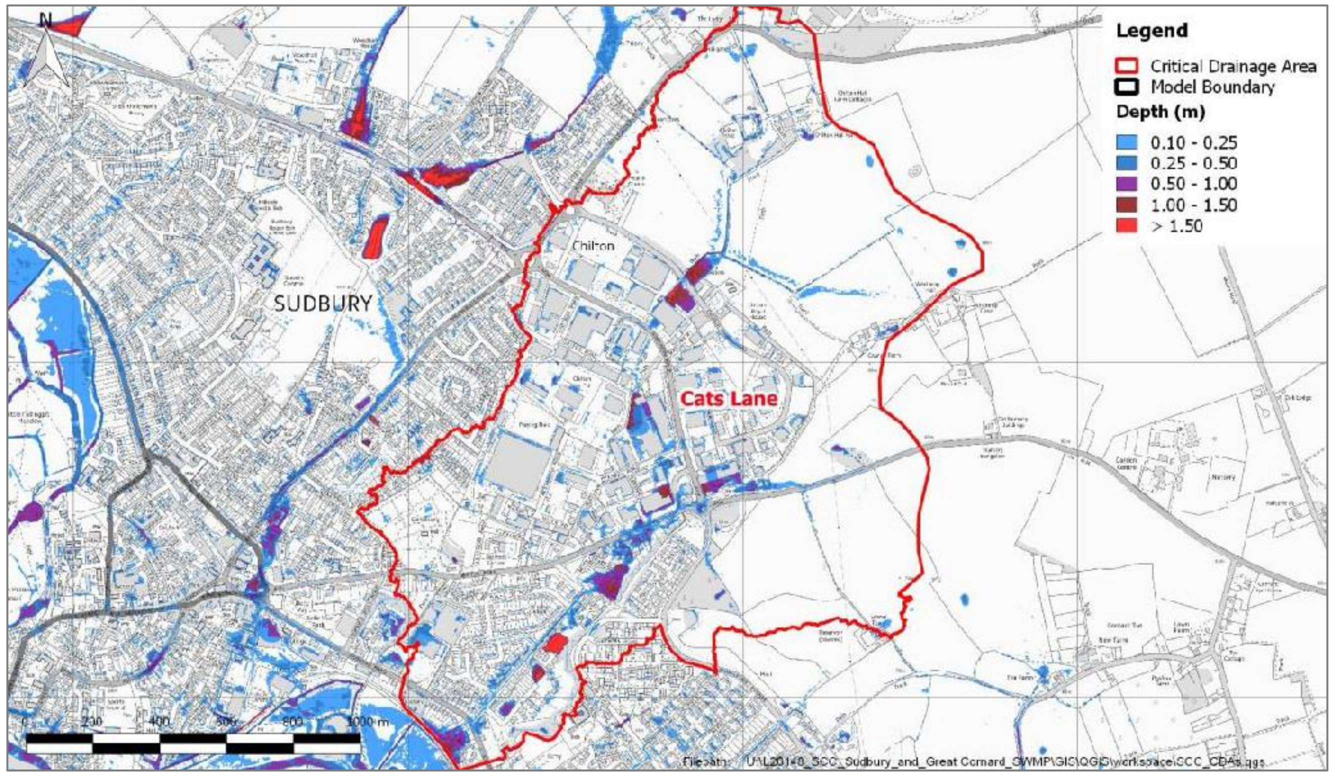

Figure 4-12 CDA 03 - 1% AEP Storm Event, Maximum Depth

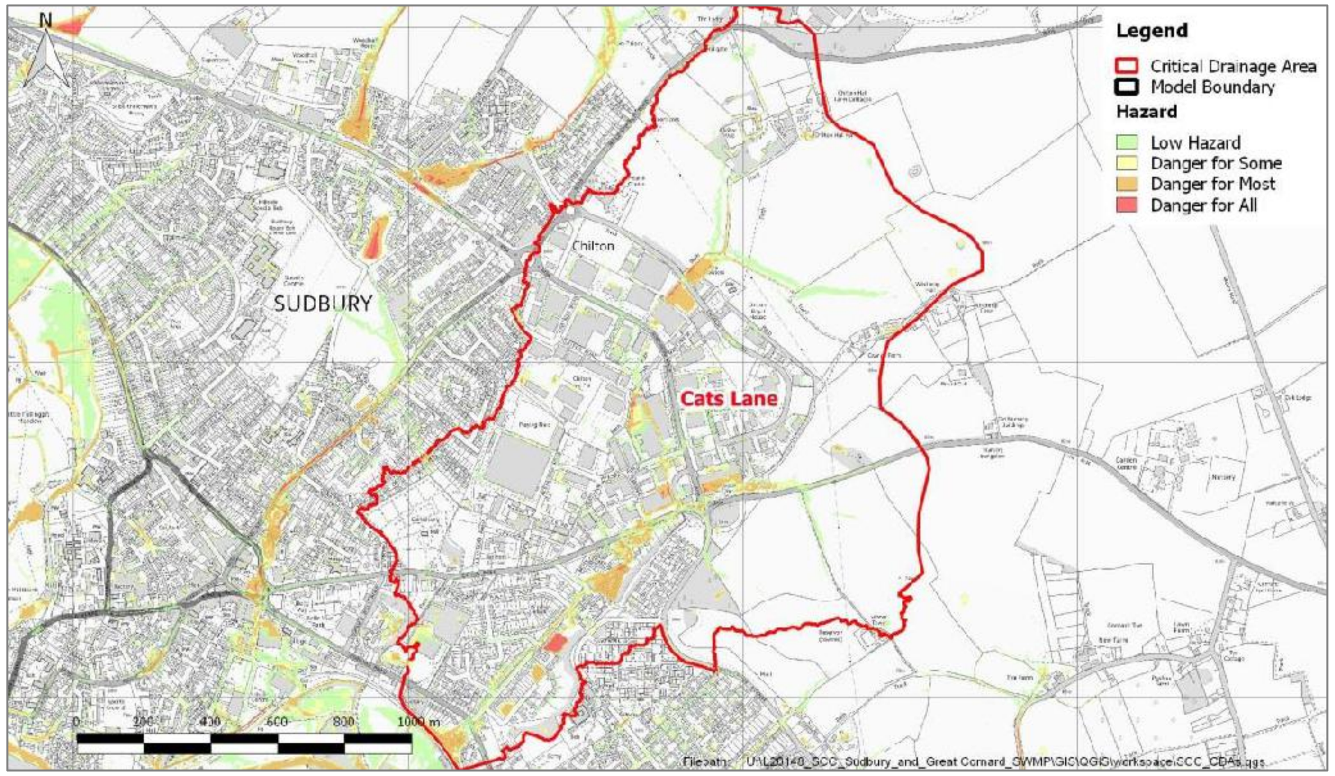

Figure 4-13 CDA 03 - 1% AEP Storm Event, Maximum Hazard

Source
Runoff in the Cat's Lane CDA is generated in the rural upper catchment to the north and east of the Chilton Industrial Estate area. The northern catchment is larger than the eastern catchment and contributes more runoff to the industrial estate. Runoff is also generated through the incremental catchment down to the outlet.
Pathway
Surface water runoff is conveyed both overland and in culverts through the Chilton Industrial Estate. There is considerable uncertainty associated with the underground drainage throughout this CDA. The northern and eastern flowpaths converge on Newton Road near the A134 roundabout. Heading downstream, the flowpath enters a series of topographical depressions, the first of which is on Better Cocker Grove and Maldon Court near the Maldon Grey Pub. Excess runoff spills out of the depression and travels south west down Cat's Lane towards the B1508 roundabout. Flow ponds behind the roundabout near King's Meadow before moving through a culvert in the disused railway and entering the River Stour floodplain.
Receptor
A greater proportion of non-residential properties are impacted in this CDA, due to the larger number of industrial properties. In particular, industrial properties adjacent to the flowpaths and A134 roundabout. Downstream of Newton Road, most receptors are residential. Key clusters of properties affected are located on Maldon Court, Cat's Lane and King's Meadow.

Table 4-7 CDA 03 – Cat's Lane, Property Count Estimation

AEP	Residential	Non-Residential	Critical Services	TOTAL
10%	5	7	0	12
5%	30	11	0	41
3.33%	37	14	0	51
1.33%	52	23	0	75
1%	63	24	0	87
0.10%	124	39	1	164
1% Climate Change Allowance, Central	78	28	0	106
1% Climate Change Allowance, Upper	90	31	1	122

Table 4-8 CDA 03 – Cat's Lane, Damage Estimation

AEP	Residential	Non-Residential	Critical Services	TOTAL
10%	£175,400	£1,306,100	£0	£1,481,500
5%	£660,500	£1,473,000	£0	£2,133,500
3.33%	£921,400	£1,540,700	£0	£2,462,100
1.33%	£1,483,400	£11,536,100	£0	£13,019,500
1%	£1,775,500	£11,821,300	£0	£13,596,800
0.10%	£3,856,300	£24,387,700	£78,700	£28,322,700
1% Climate Change Allowance, Central	£2,236,200	£19,465,900	£0	£21,702,100
1% Climate Change Allowance, Upper	£2,591,800	£20,387,600	£29,000	£23,008,400
Average Annual Damage				**£812,400**

4.10 Overview of Flood Risk within CDA 04 – Recreation Ground

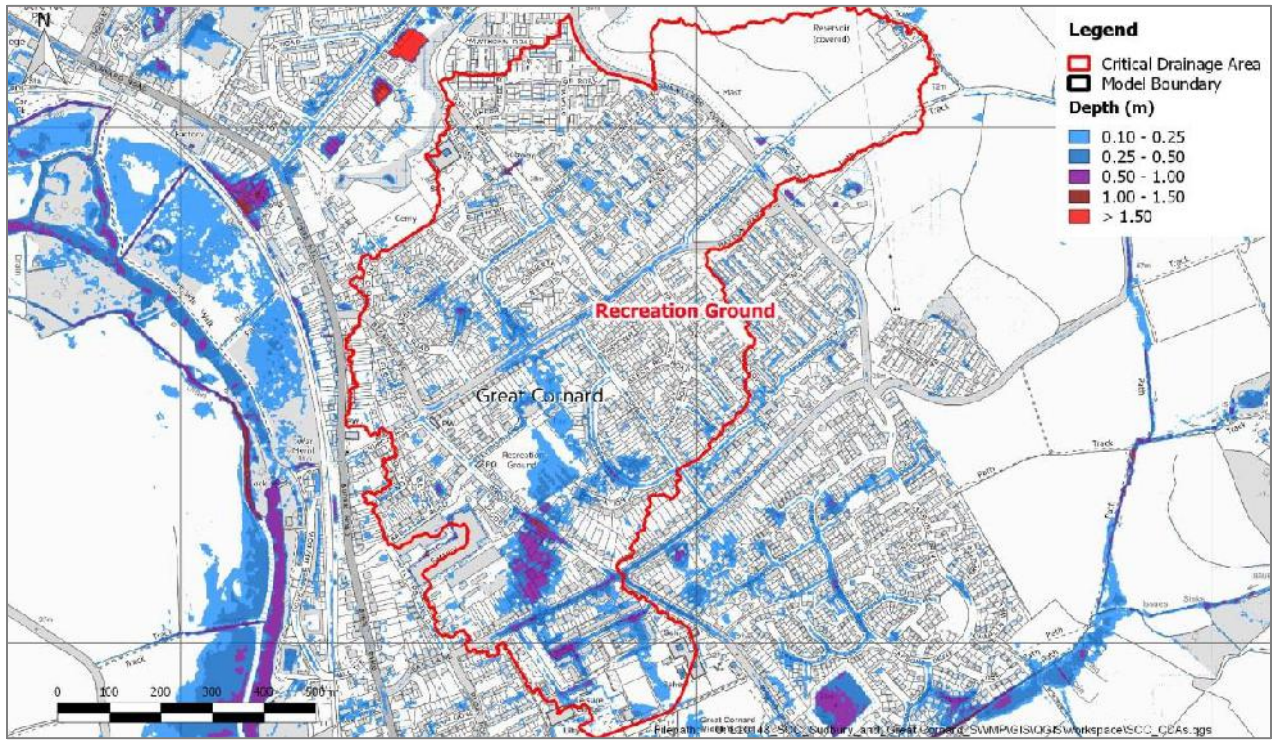

Figure 4-14 CDA 04 - 1% AEP Storm Event, Maximum Depth

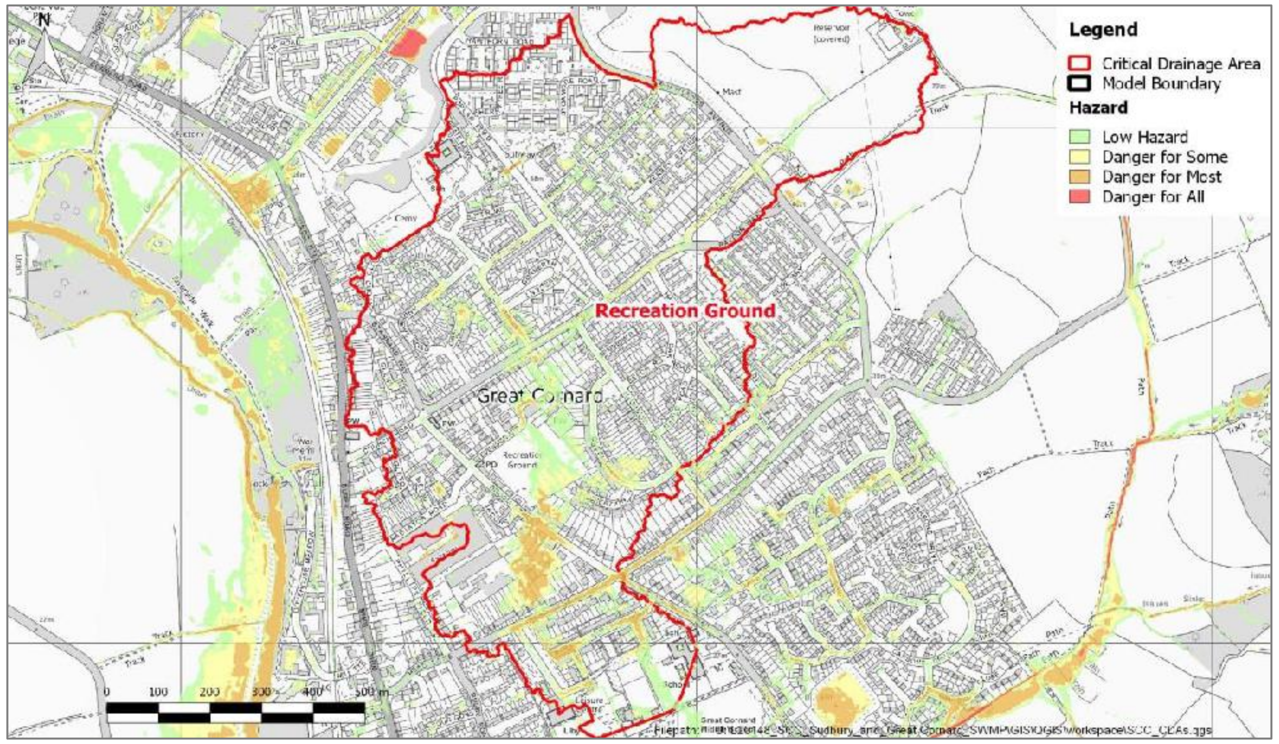

Figure 4-15 CDA 04 - 1% AEP Storm Event, Maximum Hazard

Source
Surface water flooding is generated primarily through runoff from the sub-urban area in Great Cornard. There is a small rural area contribution at the upstream edge of the catchment. However the remainder of the catchment is typically low density residential.
Pathway
Unlike the Sudbury CDAs, Great Cornard CDAs are dominated by slow moving and ponded surface water. Surface runoff collects at low points on St Andrews Road and Pot Kiln Road near Kiln Drive. Flood water ponds and moves slowly towards the Great Conard recreation ground, entering in the north corner near Highbury Way. Continuing downstream, surface water moves across Broom Street and ponds near Head Lane. At Head Lane runoff from Canhams Road and the upper catchment joins ponded surface water from the lower catchment. Downstream of Head Lane, flood water ponds and weirs into Nursey Road and towards Thomas Gainsborough School. The CDA is terminated at the school and surface water no longer moves downstream, instead it ponds and slowly infiltrates and drains away through available gullies.
Receptor
Most receptors in the recreation ground CDA are residential, reflecting the sub-urban nature of the CDA. Flow in the upper catchment is largely confined to roads and the model results predict that minimal properties are impacted. However, in the lower catchment broad ponding and flow perpendicular to streets means a wide range of property is impacted. Key clusters of impacted properties include Pot Kiln Road near St Andrews Road, Broom Street and Head Lane downstream of the Recreation Ground and Nursery Road.

Table 4-9 CDA 04 – Recreation Ground, Property Count Estimation

AEP	Residential	Non-Residential	Critical Services	TOTAL
10%	0	0	0	0
5%	4	0	0	4
3.33%	9	1	0	10
1.33%	41	3	0	44
1%	49	4	0	53
0.10%	172	16	1	189
1% Climate Change Allowance, Central	77	6	0	83
1% Climate Change Allowance, Upper	108	9	0	117

Table 4-10 CDA 04 – Recreation Ground, Damage Estimation

AEP	Residential	Non-Residential	Critical Services	TOTAL
10%	£0	£0	£0	£0
5%	£94,000	£0	£0	£94,000
3.33%	£327,800	£11,600	£0	£339,400
1.33%	£1,090,600	£109,600	£0	£1,200,200
1%	£1,277,200	£123,300	£0	£1,400,500
0.10%	£4,566,100	£968,600	£10,700	£5,545,500
1% Climate Change Allowance, Central	£2,009,200	£177,300	£0	£2,186,500
1% Climate Change Allowance, Upper	£2,847,100	£254,500	£0	£3,101,600
Average Annual Damage				**£56,900**

4.11 Overview of Flood Risk within CDA 05 – Davidson Lane

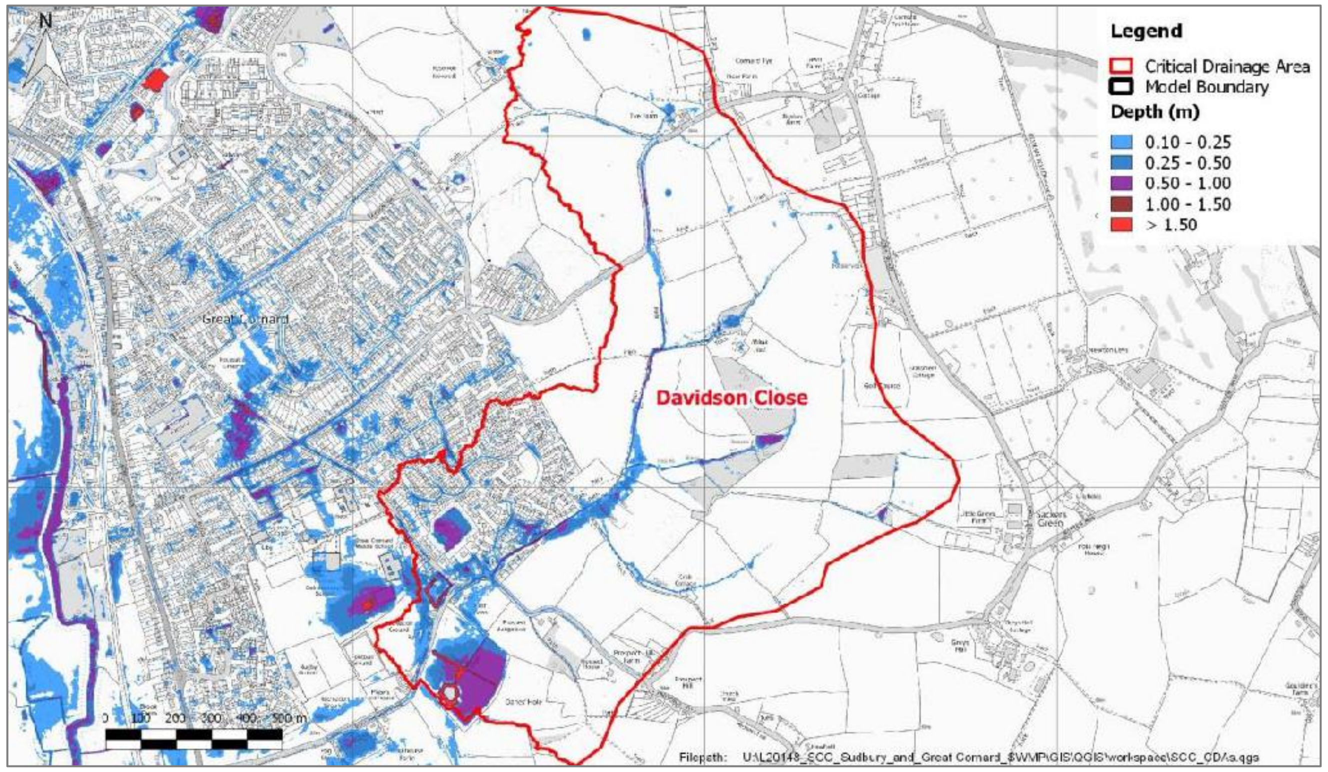

Figure 4-16 CDA 05 - 1% AEP Storm Event, Maximum Depth

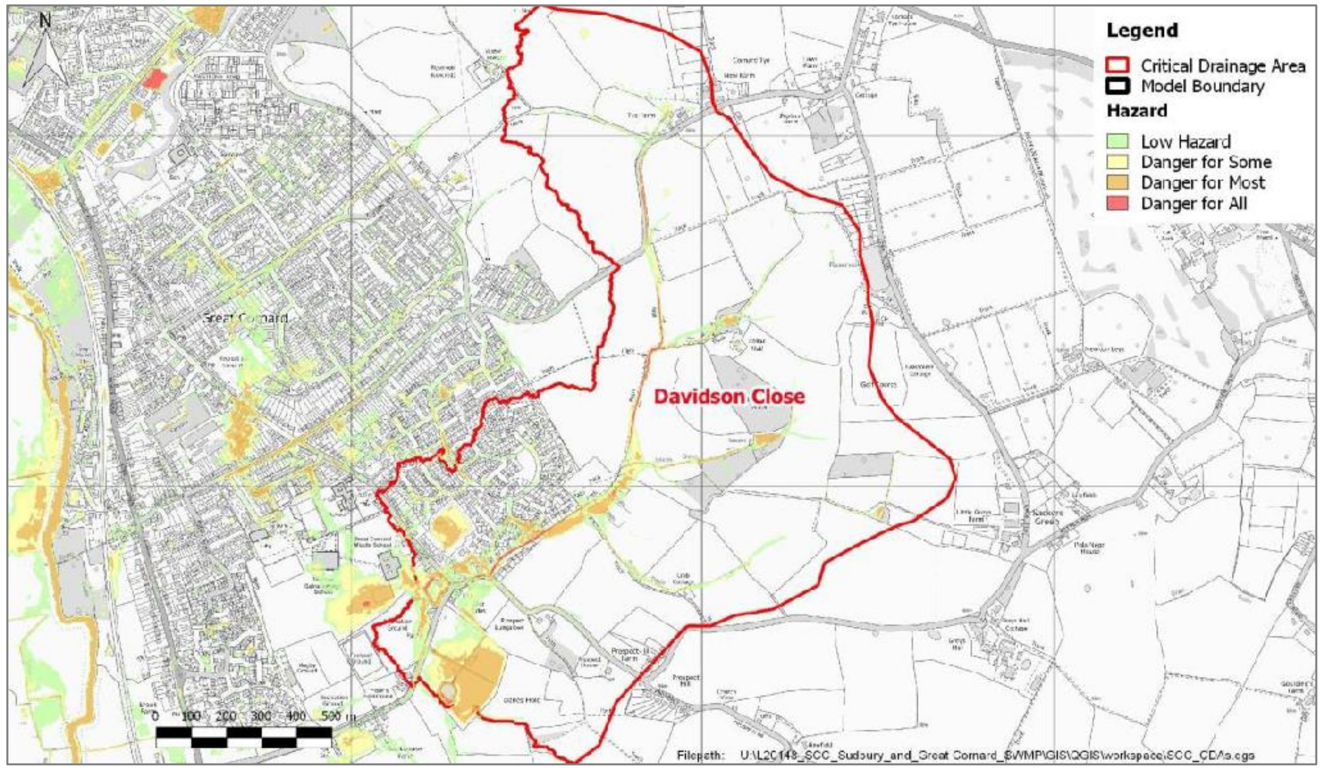

Figure 4-17 CDA 04 - 1% AEP Storm Event, Maximum Hazard

Source
Surface water flooding in the Davidson Close CDA is generated in the substantial upstream catchment. The catchment is predominately rural and extends to cover Cornard Tye. The catchment is underlain by a mix of Clay to Sand and Sandy Loam. The upper catchment is broken up into four sub-catchments contributing to the main flowpath.
Pathway
Runoff is conveyed through minor open ditches in the upper catchment. When the channel reaches the sub-urban extent near Davidson Close and Chaplin Court, it forms an open channel about 1.5m wide. In higher flow events, the adjacent fields also convey overland flow. The channel moves through back gardens and drainage easements on Davidson Close, Eldred Drive before passing under Prospect Hill Road. Downstream of Prospect Hill Road, surface water ponds on the grounds of Great Cornard Country Park and allotments. The CDA terminates at the Country Park on Blackhorse Lane. Very little overland is conveyed to the River Stour as surface water largely ponds and infiltrates.
Receptor
As the catchment is predominantly rural, receptors are restricted to clusters around Davidson Close and Eldred Drive. Receptors are first predicted to be impacted in storm events greater than the 5% AEP.

Table 4-11 CDA 04 – Davidson Lane, Property Count Estimation

AEP	Residential	Non-Residential	Critical Services	TOTAL
10%	0	0	0	0
5%	0	0	0	0
3.33%	1	1	0	2
1.33%	9	2	0	11
1%	12	3	0	15
0.10%	64	4	0	68
1% Climate Change Allowance, Central	26	3	0	29
1% Climate Change Allowance, Upper	37	3	0	40

Table 4-12 CDA 05 – Davidson Lane, Damage Estimation

AEP	Residential	Non-Residential	Critical Services	TOTAL
10%	£0	£0	£0	£0
5%	£0	£0	£0	£0
3.33%	£29,000	£17,000	£0	£46,000
1.33%	£236,900	£24,000	£0	£260,800
1%	£365,300	£54,400	£0	£419,800
0.10%	£2,291,000	£65,900	£0	£2,356,800
1% Climate Change Allowance, Central	£756,100	£56,500	£0	£812,600
1% Climate Change Allowance, Upper	£1,124,900	£57,900	£0	£1,182,800
Average Annual Damage				**£17,100**

4.12 Comparison of CDA Flooded Properties

A review of the total number of flooded properties within each CDA can assist with prioritising any future flood risk alleviation investigations. Figure 4-18 presents the number of flooded properties within each CDA for all storm events. Figure 4-19 shows the properties flooded for each AEP storm event as a percentage per CDA.

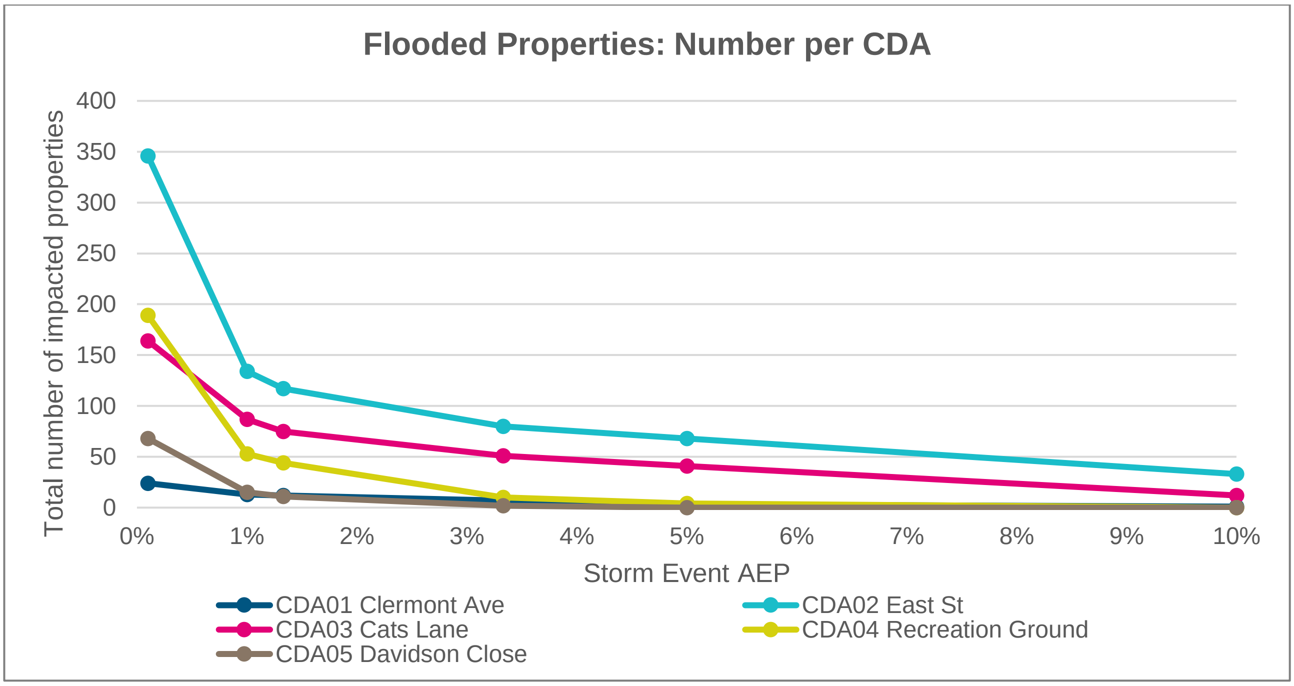

Figure 4-18 Total Number of Flooded Properties per CDA

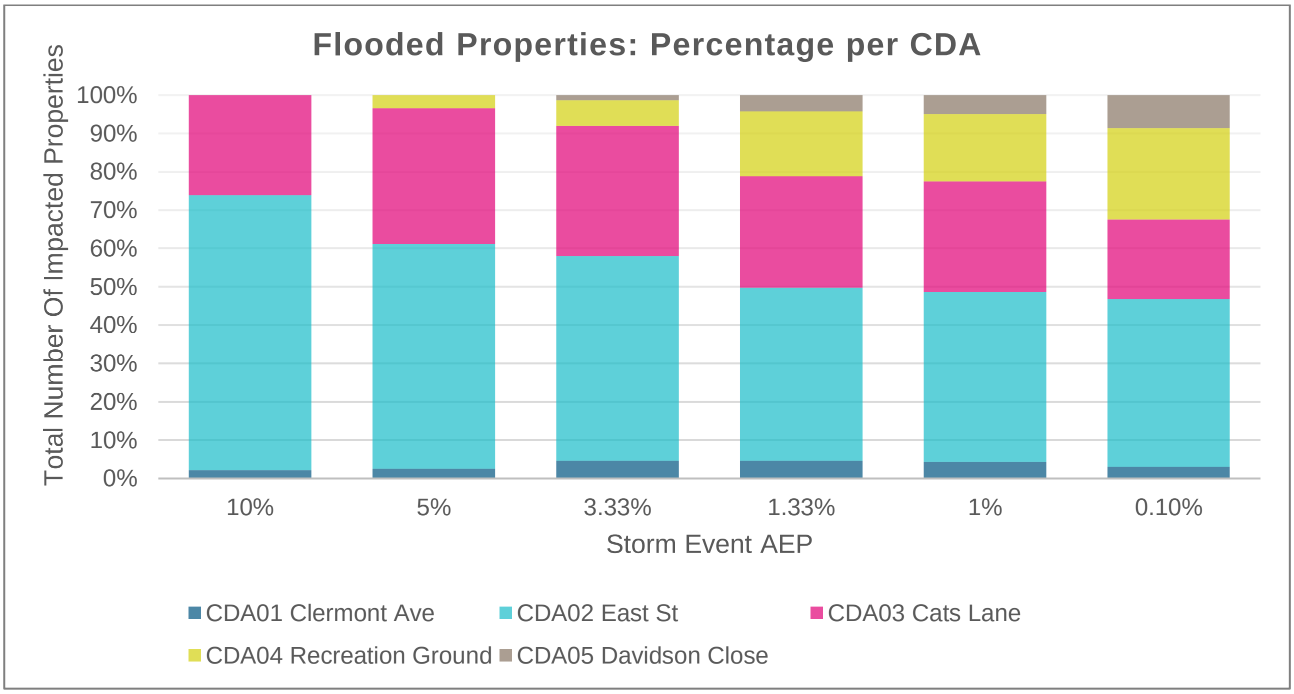

Figure 4-19 Percentage of Flooded Properties per Storm Event

5 Options

Options can be either a single measure or combinations of measures that have the potential to manage current and future surface water flood risk, or to meet other SWMP objectives. The aim of the options analysis it to shortlist and assess a suite of measures and agree the preferred options for inclusion in the Action Plan.

5.1 Selection Process

The options assessment follows the high-level methodology described in the Defra SWMP Guidance and focusses on highlighting areas for further analysis and immediate 'quick win' actions (Figure 5-1).

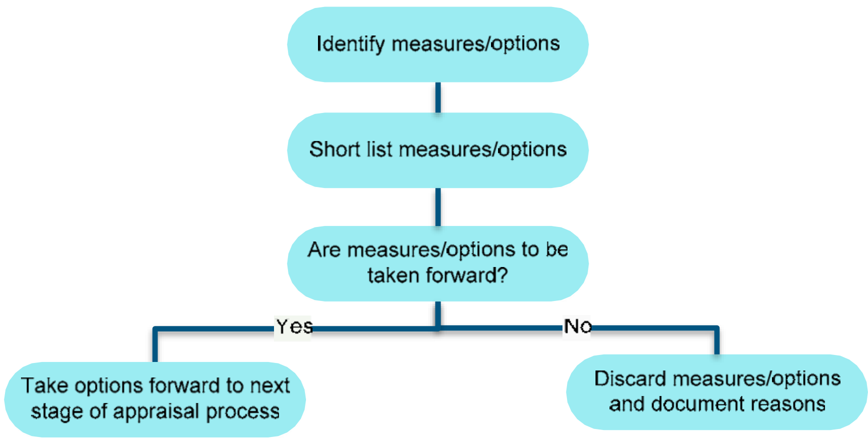

Figure 5-1 Process of identifying and short-listing options and measures (Defra SWMP Guidance)

Measures can typically be classified as methods which influence either source control, pathway management or receptor management. A short description of each has been identified below:

- **Source Control**: Source control measures target a reduction in the volume and rate of surface water runoff through storage and promotion of infiltration to alleviate flow into the receiving drainage network. Retrofitting SuDS (e.g. wetlands, green roofs, bioretention basins etc.) and other methods for reducing flow rates and volume.
- **Pathway Management**: Measures targeted to manage the overland and underground flow pathways. For example, increasing capacity in drainage systems or separation of foul and surface water sewers.
- **Receptor Management**: Modifications to properties, businesses and the environment that are affected by flooding. For example, improved warning and education or flood resilience measures.

Table 5-1 describes the typical measures used to mitigate surface water flood risk.

Table 5-1 Typical Surface Water Flood Risk Management Measures

Description		Measure(s) Considered
Do Nothing	Make no intervention / maintenance	None
Do Minimum	Continue existing maintenance regime	None
Improved Maintenance	Improve existing maintenance regimes e.g. target improved maintenance to critical points in the system.	Improved Maintenance Regimes Other 'Pathway' Measures
Planning Policy	Use forthcoming development management policies to direct development away from areas of surface water flood risk or implement flood risk reduction measures.	Planning Policies to Influence Development
Source Control, Attenuation and SuDS	Source control methods aimed to reduce the rate and volume of surface water runoff through infiltration or storage, and therefore reduce the impact on receiving drainage systems.	Green roofs Soakaways Rain gardens / Bioretention Swales Permeable paving Rainwater harvesting Detention Basins Ponds and Wetlands Land Management Practices
Flood Storage / Permeability	Large-scale SuDS that have the potential to control the volume of surface water runoff entering the urban area, typically making use of large areas of green space. Upstream flood storage areas can reduce flows along major overland flow paths by attenuating excess water upstream, which reduce the demands on downstream networks.	Detention Basins Bioretention Basins Ponds and Wetlands Managing Overland Flows (Online Storage) Land Management Practices Other 'Source' Measures Other 'Pathway' Measures
Separate Surface Water and Foul Water Sewer Systems	Where the settlement is served by a combined drainage network separation of the surface water from the combined system should be investigated. In growth areas separation creates capacity for new connections.	Separation of Foul and Surface Water Sewers
De-culvert / Increase Conveyance	De-culverting of watercourses and improving in-stream conveyance of water.	De-culverting Watercourse(s) Other 'Pathway' measures
Preferential / Designated Overland Flow Routes	Managing overland flow routes through the urban environment to improve conveyance and routing water to watercourses or storage locations.	Managing Overland Flow (Preferential Flowpaths) Temporary or Demountable Flood Defences Other 'Pathway' measures

5.2 SuDS Opportunities

Locations have been identified where there may be opportunities to manage surface water by retrofitting SuDS to store and slow down the rate at which surface water flows within the study area. Opportunities to retrofit SuDS in Sudbury and Great Cornard have been considered based on available land and targeting key flow paths that contribute to flooding.

In collaboration with SCC staff, CDA02 and CDA04 were identified as areas where the availability of green space could facilitate ‘quick win’ options. Rural land in the upper catchment of CDA01, CDA03 and CDA05 has been excluded from this assessment based on land ownership.

Section 4.4 discussed proposed development within study area. There is an opportunity to use future developments to assist in managing the flood risk within Sudbury and Great Cornard. Appropriate planning controls on discharge, and opportunities to attenuate additional runoff from these sites can help free up capacity within the existing drainage system. Suitable drainage strategies should be prepared by the developer in consultation with SCC and BDC.

5.3 Selected Options for Modelling

Two flood risk management measures, at Aubrey Drive and the Great Cornard Recreation Ground, have been implemented in the model to assess the impact on surface water flood risk (Figure 5-1).

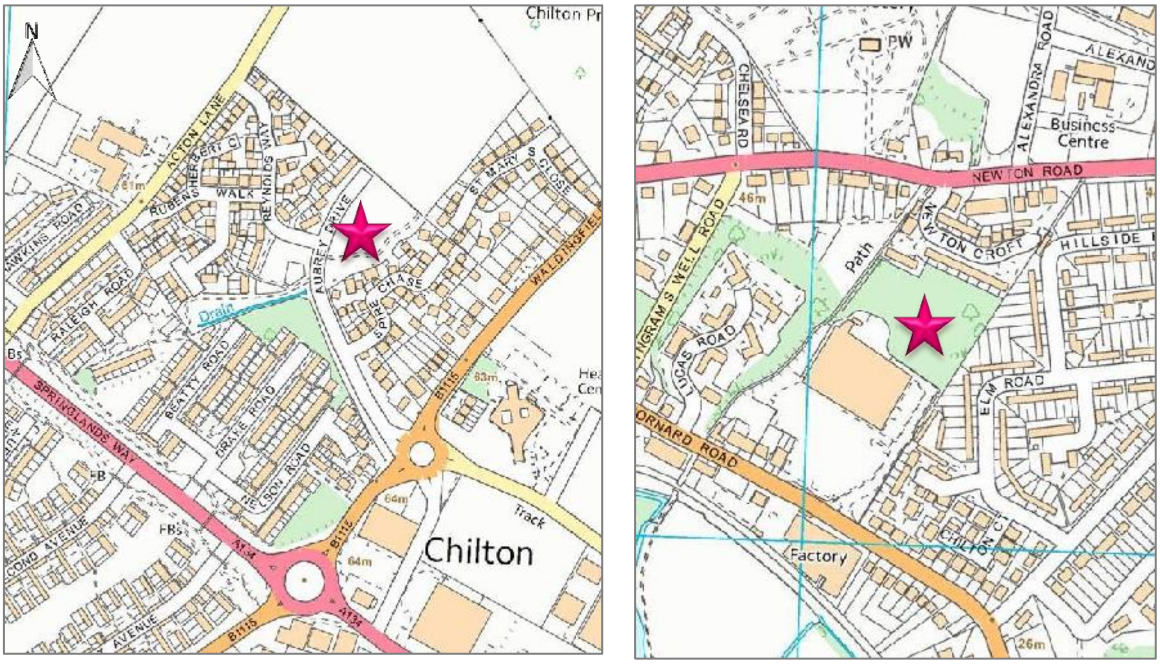

Figure 5-1 Location of Modelled Options Aubrey: Drive (left) and Great Cornard Recreation Ground (right)

A third mitigation option was trialled in Davidson Close, Great Cornard. This mitigation option was not progressed due to a very low likelihood of a cost-beneficial outcome. The factors that informed this decision were low number of inundated properties and constrained topography.

In addition, the uncertainty associated with the Essex Avenue Flood Meadow negated the ability to further investigate mitigation options at this location. However, a high-level desktop analysis of the basin impact has been carried out and is presented within Appendix B. The purpose of this analysis is to highlight the potential standard of protection of the basin and its connectivity to the downstream drainage network.

5.3.1 CDA02: Aubrey Drive

Aubrey Drive is located within CDA02 and has been identified as a key flood risk area. Surface water flow is conveyed from the rural upper catchment past Chilton Priory where it enters a formalised ditch near St Mary's Close. The ditch passes under Aubrey Drive via culverts before continuing as an open channel towards Raleigh Road. At the downstream end of the open channel, a culvert conveys flow to the Essex Avenue Flood Meadow. In events lower the 10% AEP, surface water flow moves past the downstream culvert inlet and into properties on Raleigh Road.

The proposed mitigation option for Aubrey Drive consists of two basins and low flood walls (Figure 5-2). Options were investigated further upstream, but were discarded due to future development proposals. Figure 5-3 and Figure 5-4 show the street view of the proposed basin locations.

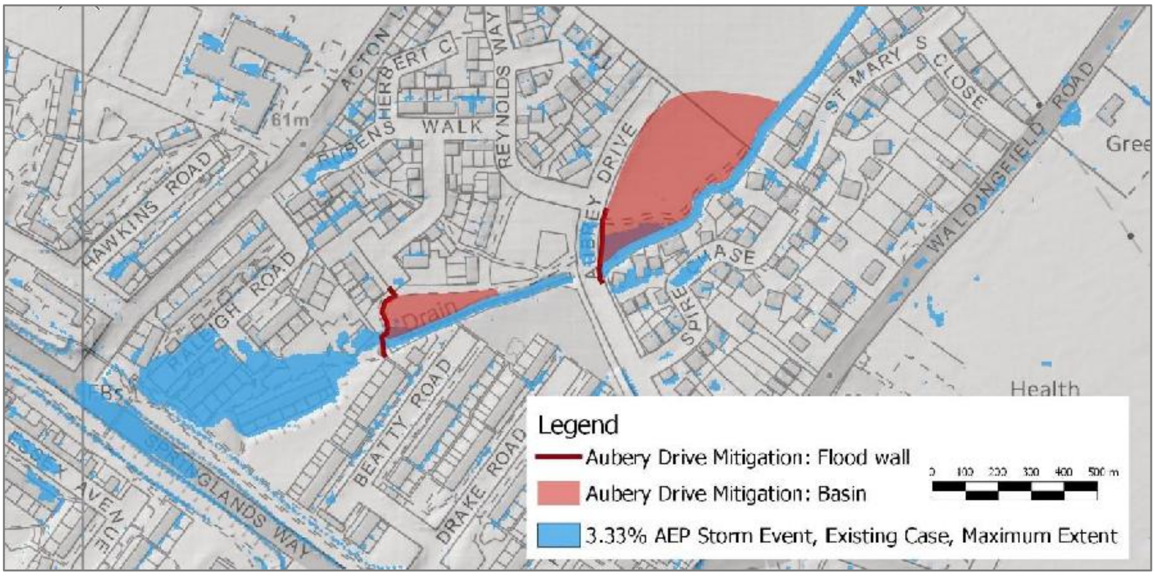

Figure 5-2 Aubrey Drive, Mitigation Layout

Figure 5-3 Street View from Aubrey Drive: Upper Basin Location

Figure 5-4 Proposed Street View from Turner Close: Lower Basin Location

The two basins require an excavation volume of 7,250m^3 (Figure 5-5). The area cut has been maximised to store the greatest possible volume of flood water whilst still maintaining some community amenity in the parks. Additional details on the basin can be located within Appendix B.

Figure 5-5 Aubrey Drive Mitigation: Topographic Changes

The flood walls are at the downstream edge of the basins, and in the case of the upstream basin, adjacent to Aubrey Drive. The wall on the upper basin is on average less than 1m high, with a maximum height of 1.4m. The walls on the lower basin are on average 0.5m high with a maximum height of 0.9m. The culvert connecting the basins has been reduced from a 0.9m diameter culvert to a 0.375m diameter culvert. In addition, the pipe at the downstream basin outlet has been reduced from a 0.325m diameter pipe to a 0.225m diameter pipe.

Aubrey Drive mitigation scheme is effective for all modelled storm events. The greatest impact on flooding occurs in the 3.33% AEP storm event where there is a reduction of 0.71m in flood level on Rayleigh Road (Figure 5-6). Figure 5-6 and Figure 5-7 show the change in flooding extents – green colours represent a reduction in flood depth, whilst red colours highlight an increase.

Figure 5-6   Aubrey Drive: Flood Depth Difference, 10% AEP to 1.33% AEP Storm Events

Figure 5-7 Aubrey Drive: Flood Depth Difference, 1% AEP to 0.1% AEP Storm Events

A slight increase in flooding occurs at the sag point on Aubrey Road because the flood wall inhibits flows from the road into the channel. However, flooding on the road can drain due to the presence of road gullies. If this option is taken forward to Outline or Full Business Case, it is recommended that the road is surveyed to determine the exact levels and if it can be reconfigured to drain towards the western (downstream) basin.

Table 5-2 shows the reduction in property flooding for all storm events associated with the proposed scheme at Aubrey Drive. The greatest reduction in flooded properties occurs for more frequent, higher probability storm events (e.g. 3.33% AEP).

Table 5-2 CDA 02: Properties at Risk of Flooding: Baseline vs. Mitigation

AEP	Baseline Scenario				Mitigated Scenario				Difference
	20% Most Deprived	20% - 40% Most Deprived	60% Least Deprived	TOTAL	20% Most Deprived	20% - 40% Most Deprived	60% Least Deprived	TOTAL	
10%	0	32	1	33	0	17	1	18	-15
5%	0	67	1	68	0	38	1	39	-29
3.33%	0	79	1	80	0	51	1	52	-28
1.33%	0	113	4	117	0	99	4	103	-14
1%	0	130	4	134	0	115	4	119	-15
1% RCCC	0	171	5	176	0	153	6	159	-17
1% RCCU	0	207	8	215	0	188	8	196	-19
0.10%	0	324	22	346	0	293	22	315	-31

Table 5-3 presents the associated reduction in flood damages in CDA 02. The greatest reduction in property damages occurs in the 1% AEP upper climate change scenario storm event. The benefit in Annual Average Damages (AAD) of this scheme is estimated to be £200k.

Table 5-3 CDA 02: Estimated Flood Damage: Baseline vs. Mitigation

AEP	Baseline Scenario				Mitigated Scenario				Difference
	20% Most Deprived	20% - 40% Most Deprived	60% Least Deprived	TOTAL	20% Most Deprived	20% - 40% Most Deprived	60% Least Deprived	TOTAL	
10%	£0	£1,272,300	£10,000	£1,282,300	£0	£520,900	£10,000	£530,900	-£751,400
5%	£0	£1,438,300	£10,100	£1,448,400	£0	£1,051,800	£10,100	£1,061,900	-£386,500
3.33%	£0	£1,896,300	£13,500	£1,909,800	£0	£1,414,000	£13,500	£1,427,500	-£482,300
1.33%	£0	£3,919,200	£93,900	£4,013,100	£0	£3,019,600	£93,900	£3,113,500	-£899,600
1%	£0	£4,490,600	£99,000	£4,589,600	£0	£3,584,800	£99,000	£3,683,800	-£905,800
1% RCCC	£0	£4,921,700	£138,900	£5,060,600	£0	£4,831,400	£161,700	£4,993,100	-£67,500
1% RCCU	£0	£6,790,900	£232,500	£7,023,400	£0	£5,788,500	£232,500	£6,020,900	-£1,002,500
0.10%	£0	£11,328,100	£561,400	£11,889,500	£0	£11,081,000	£561,200	£11,642,200	-£247,300
AAD				**£500,300**				**£292,400**	**-£207,900**

5.3.2 CDA 04: Great Cornard Recreation Ground

Ponding near Broom Street leading to Head Lane and Nursey Lane was identified as a key flood risk area. Surface water runoff moves down from the steeper rural catchment and north east Great Cornard. Runoff moves slowly though the Great Cornard Recreation Ground before ponding near Head Lane, Broom Street and Nursey Street. This area in Great Cornard differs from the surrounding topography in that it has a very shallow grade and flood risk is dominated by low velocity flows and ponding.

The Great Cornard Recreation Ground mitigation option consists of a wedge-shaped basin, with the deepest area adjacent to the south east fence (Figure 5-8). The basin will require an excavation volume of 2,560m^3. The basin size was limited to maintain a functional pitch adjacent to Stevenson Approach. The flood wall follows the alignment of the existing fence line and is on average 0.4m high. These dimensions should be optimised through a detailed design process.

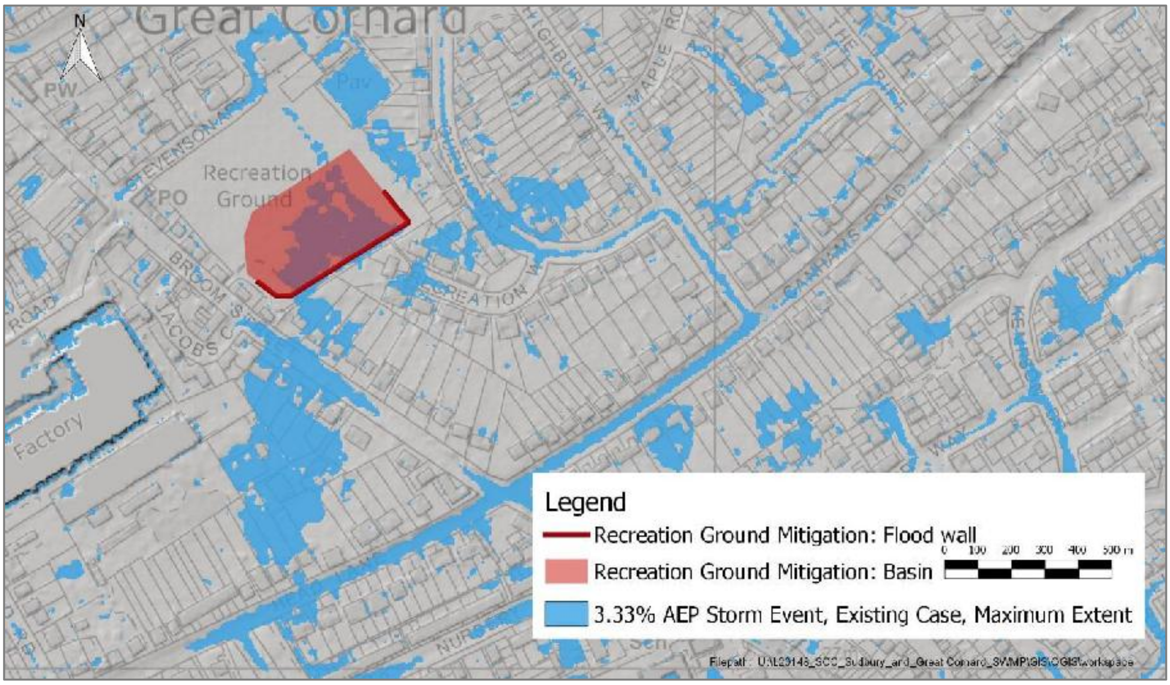

Figure 5-8 Recreation Ground, Mitigation Layout

The current condition of the park and proposed bund location can be seen in Figure 5-9 and Figure 5-10. The post mitigation terrain changes can be seen within **Error! Reference source not found.**.

Figure 5-9 Street View from within the Recreation Ground: Bund Location

Figure 5-10 Street View from Stevenson Approach

The basin reduces the volume of flow crossing Broom Street and moving to pond on Head Lane and Nursery Road. The maximum flood depth between Broom Street and Head Lane is reduced by 0.30m in the 3.33% AEP storm event and 0.11m in the 1% AEP event (Figure 5-12 and Figure 5-13).

There is considerable uncertainty in the urban drainage in Great Cornard. Drainage in this area is represented by Virtual Pipes (Appendix B). Consequently, no drainage regimes have been proposed in the basin concept design. It is recommended that drainage network survey is undertaken to fully assess the drainage options in the basin.

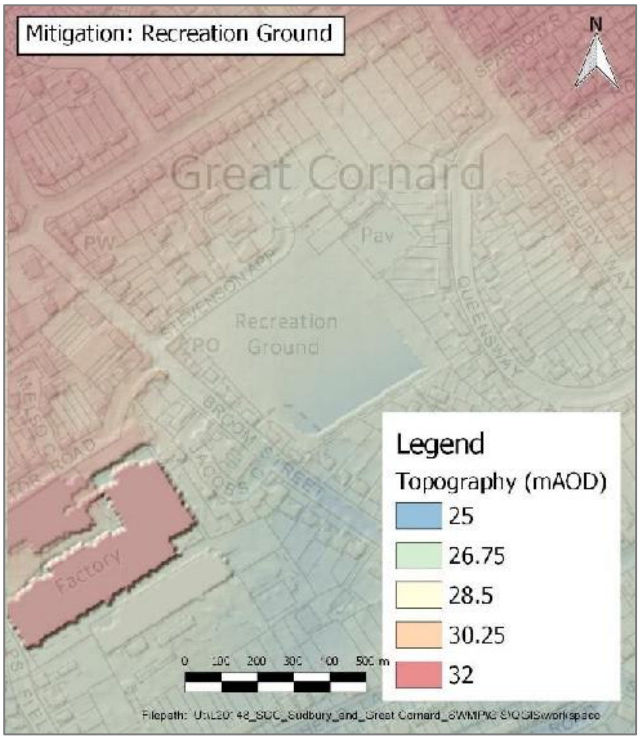

Figure 5-11 Recreation Ground: Topographic Changes

Figure 5-12 Great Cornard Recreation Ground: Flood Depth Difference, 10% AEP to 1.33% AEP Storm Events

Figure 5-13 Great Cornard Recreation Ground: Flood Depth Difference, 1% AEP to 0.1% AEP Storm Events

If this option is taken forward to more detailed assessments, it is recommended that the rear of the properties, adjacent to the proposed flood wall, is surveyed to assist with optimising the bund/wall height.

Table 5-5 shows the reduction in flooded properties associated with the proposed scheme in Great Cornard Recreation Ground. There are minor benefits to all modelled flood events, excluding the 10% AEP storm event, where there is no existing flood risk to properties. The greatest reduction in flooded properties occurs during the 3.33% AEP storm event.

Table 5-5 CDA 04: Properties at Risk of Flooding: Baseline vs. Mitigation

AEP	Baseline Scenario				Mitigated Scenario				Difference
	20% Most Deprived	20% - 40% Most Deprived	60% Least Deprived	TOTAL	20% Most Deprived	20% - 40% Most Deprived	60% Least Deprived	TOTAL	
10%	0	0	0	0	0	0	0	0	0
5%	0	0	4	4	0	0	2	2	-2
3.33%	0	0	10	10	0	0	3	3	-7
1.33%	8	0	36	44	8	0	32	40	-4
1%	13	0	40	53	11	0	37	48	-5
0.10%	61	1	127	189	59	1	127	187	-2
1% RCCC	24	0	59	83	22	0	54	76	-7
1% RCCU	35	0	82	117	33	0	77	110	-7

Table 5-6 shows the associated reduction in flood damages in CDA 04. The greatest reduction in flood damage to properties is predicted for the 3.33% AEP storm event and exceeds £280k. The benefit in Annual Average Damages (AAD) of this scheme is estimated to be £10k.

Table 5-6 CDA 04: Estimated Flood Damages: Baseline vs. Mitigation

AEP	Baseline Scenario				Mitigated Scenario				Difference
	20% Most Deprived	20% - 40% Most Deprived	60% Least Deprived	TOTAL	20% Most Deprived	20% - 40% Most Deprived	60% Least Deprived	TOTAL	
10%	£0	£0	£0	£0	£0	£0	£0	£0	£0
5%	£0	£0	£94,000	£94,000	£0	£0	£40,800	£40,800	-£53,200
3.33%	£0	£0	£339,400	£339,400	£0	£0	£57,200	£57,200	-£282,200
1.33%	£173,000	£0	£1,027,200	£1,200,200	£172,300	£0	£857,300	£1,029,600	-£170,600
1%	£235,100	£0	£1,165,400	£1,400,500	£210,800	£0	£1,031,200	£1,241,900	-£158,500
0.10%	£1,358,800	£19,900	£4,166,800	£5,545,500	£1,360,600	£20,000	£4,128,800	£5,509,400	-£36,100
1% RCCC	£485,100	£0	£1,701,400	£2,186,500	£484,600	£0	£1,535,600	£2,020,200	-£166,300
1% RCCU	£715,500	£0	£2,386,200	£3,101,600	£692,300	£0	£2,227,400	£2,919,700	-£181,900
AAD				**£56,900**				**£46,800**	**-£10,100**

5.3.3 Cost Benefit Analysis

A cost benefit ratio has been calculated for the modelled options within CDA02 and CDA04. This provides an estimate of the initial feasibility of the proposed options. A ratio of over 1.0 indicates that the benefits of the scheme outweigh the costs and it should be considered for further study or implementation. A ratio of less than 1.0 indicates that the costs are higher than the expected benefits.

The damages have only been estimated for direct tangible losses and do not include additional factors such as prolonged business closure, clean-up costs, physical or psychological injury, cultural or community losses or critical infrastructure knock-on effects (Appendix F). Therefore, schemes with a cost benefit ratio of less than 1.0 may still be feasible when indirect or intangible benefits are considered.

Indicative capital costs for each of the mitigation schemes is provided in Table 5-7.

Table 5-7Indicative Costs of Mitigation Measures

Option Location	Option Components	Unit price £	Quantity	Unit	Capital Cost
CDA02: Aubrey Drive	Basins	30[4]	7,247	m^3	£217,410
	Flood walls	500[5]	107.1	m	£53,550
	Outlets from basins	4500	2	nr	£9,000
	Culvert faceplates	800	2	nr	£1,600
				TOTAL	**£281,560**
				Total Including 50% optimism bias	**£422,340**
CDA04 Great Cornard Rec Ground	Basins	30	2,567	m^3	£77,010
	Flood walls	500	157	m	£78,500
	Outlet	4500	1	nr	£4,500
				TOTAL	**£160,010**
				Total Including 50% optimism bias	**£240,015**

The cost benefit ratio uses the net present value of the costs associated with scheme construction and maintenance (estimated at 10% of total cost per year), and the average annual benefit expected to be returned by the scheme in reducing flood damages. The current treasury long-term discount rates for the expected life of the scheme have been used in the net present value calculation (**Table 5-8**).

Table 5-8 Discount Rate[6]

Period of Years	Discount Rate
0-30	3.5%
31-75	3.0%
76-125	2.5%

[4] cost at £30/m2 CIRIA 2007
[5] http://www.susdrain.org/files/resources/evidence/defra_suds_costings_housing_daniels_cross_.pdf
[6] HM Treasury (2003)

Over the next 100 years the net present values and cost benefit ratio of the scheme are:

Table 5-9 CDA Options Cost Benefits Results

	Net Present Value	
	Mitigation 1 – CDA02 Aubrey Drive	Mitigation 2 – CDA04 Great Cornard Rec Ground
Costs	£1,641,355	£932,779
Benefits	£6,078,624	£5,082,838
Cost Benefit Ratio	3.7	5.4

The calculated cost benefit ratios are above 1, which suggests that the proposed flood mitigation options are feasible and should be considered for further study or implementation. Further assessment will confirm any constraints on construction/design, and any optimisation that can be undertaken to further reduce the capital costs of the scheme.

5.4 Options - Throughout Sudbury and Great Cornard

There are several options that SCC and BDC should investigate or implement as soon as possible, irrespective of whether they are within a CDA or not. These include:

- Retrofitting SuDS within suitable locations throughout the towns. An audit of council owned buildings should be undertaken to identify those that can be retrofitted with green roof areas, permeable paving and rain gardens;
- On-going (and targeted) maintenance of the drainage network;
- Improving resilience to flooding (Property Level Protection) in areas at risk of predicted flooding;
- Public Awareness education to inform people of their responsibilities;
- Reviewing Planning and Development control policies to ensure upstream (and infill) developments do not increase the flood risk to others and, where possible, offer a net benefit to the catchment.

5.5 Recommendations for all CDAs

Before commencing work to mitigate flooding in a CDA, a combination of actions should be undertaken to further confirm the flood risk, reduce costs of a preferred option / measure and where possible refine the benefit of the proposed scheme. The following recommendations should be undertaken in all CDAs:

- Maximise attenuation in the upper rural catchments. Consider restricting the discharge from new developments to pre-climate change rates and or limit the ultimate discharge rate for the development to ensure a betterment to the towns (e.g. restrict all runoff to Q_{bar} rates);

- Reduce urban creep within the CDA and increase the permeability of existing plots (e.g. de-pave);
- Undertake a detailed feasibility study which includes:
    - Asset investigations (e.g. Inspection / CCTV of existing infrastructure to confirm condition, size and connectivity);
    - Initial underground service investigations (obtain and review relevant service plans);
    - Internal confirmation within SCC / BDC to confirm the use of rain gardens (within open spaces, roundabouts, carpark bays, etc.) and permeable paving SuDS elements within the borough where areas are identified to be suitable. The benefits of these features should be included within any detailed modelling / assessment of the CDA;
    - Confirmation of land ownership issues and determine if private open space can be utilised to reduce the flood risk within the towns; and
    - Optimised sizing and locating of proposed measures / options based on updated data and constraints.
- Initial consultation:
    - Discussions with the Flood Steering Group and residents / land owners to confirm historic flooding;
    - Internal discussions with the SCC / BDC team; and
    - Discussions with EA and Anglian Water to establish any opportunities for scheme collaboration and determine the potential for funding (FDGiA funding, Local Levy Funding, AMP 7 etc.).

5.6 Links to Funding Plans

The local investment plans and initiatives should be considered when assessing measure feasibility and targeting funding. The same holds true for committed future investment within the catchment. Potential funding avenues to flood alleviation work in Sudbury and Great Cornard have been identified below; meeting the criteria of these incentives could provide a cost effective and holistic approach to surface water flood risk management:

- Environment Agency Flood Defence Grant in Aid (FDGiA) funding;
- Anglian Water Business Plan / Asset Management Plan;
- Babergh District Council Infrastructure Delivery Plan (2013);
- Major housing and commercial development is an opportunity to retro-fit surface water management measures (housing associations and private developers);
- SCC Highways department investment plans;
- Local Enterprise Plans (funding plan for delivery of the Local Plans); and
- Local Green Infrastructure Delivery Plans;

6 Proposed Surface Water Management Policy

6.1 District and County Wide Policy

CDAs delineate the areas where the impact of surface water flooding on properties is expected to be greatest. Acknowledging that CDAs do not account for all the areas that could be affected by surface water flooding, SCC and BDC should implement policies which will reduce the risk from surface water flooding throughout the towns. This can be achieved by promoting and applying Best Management Practises to the implementation of SuDS and the reduction of runoff volumes.

It is recommended that the Council consider implementing the following policies to reduce flood risk:

Policy 1: Proposed 'brownfield' redevelopments of more than one property or area greater than 0.1 hectare are required to reduce post-development runoff rates for events up to and including the 1 in 100 year return period event (1%AEP) with an allowance for climate change (in line with NPPF and UKCIP guidance) to that of a Greenfield condition (calculated in accordance with IoH124) without the projected climate change allowances.

Policy 2: Developments located in Critical Drainage Areas (CDAs) and for redevelopments of more than one property or area greater than 0.1 hectare should seek betterment to a Greenfield runoff rate (calculated in accordance with IoH124). It is recommended that a SuDS treatment train is utilised to assist in this reduction.

The Councils may also wish to consider the inclusion of the following policy to manage the pollutant loads generated from proposed development applications:

Policy 3: Best Management Practices (BMP) are required for development applications greater than 0.1 hectare within the catchment. The following load-reduction targets must be achieved when assessing the post-developed sites SuDS treatment train (comparison of unmitigated developed scenario versus developed mitigated scenario):

- 80% reduction in Total Suspended Sediment (TSS);
- 45% reduction in Total Nitrogen (TN);
- 60% reduction in Total Phosphorus (TP); and
- 90% reduction in litter (sized 5mm or greater).

6.2 Using the SWMP to influence specific development proposals

Where development is proposed in an area covered wholly or partially by a CDA, this should trigger a Flood Risk Assessment, as already required under NPPF. Whilst some small-scale developments may not be appropriate in high risk areas, in most cases it will be a matter of ensuring that the Flood Risk Assessment considers those items listed above and considers some or all of the following site-specific issues:

- Are the flow paths and areas of ponding correct, and will these be altered by the proposed development?
- Has the site been planned sequentially to keep major surface water flow paths clear?
- Has exceedance of the site's drainage capacity been adequately dealt with? Where will exceedance flows run off the site?
- Could there be benefits to existing properties at risk downstream of the site if additional storage could be provided on the site?
- In the event of surface water flooding to the site, have safe access to / egress from the site been adequately considered?
- Have the site levels been altered, or will they be altered during development? Consider how this will impact surface water flood risk on the site and to adjacent areas.
- Have inter-dependencies between utilities and the development been considered (for example, the electricity supply for building lifts or water pumps)?

7 Action Plan

The SWMP identified a wide range of actions that should be undertaken to manage surface water within Sudbury and Great Cornard. An Action Plan has been developed to outline the responsibilities and implications of both structural and non-structural preferred options discussed in Phase 3 of the SWMP. The Action Plan details the methods, timescale and responsibility of each proposed action.

The general actions are non-structural and encourage improved surface water management through planning policy and public education and awareness. SCC must ensure the SWMP is aligned as closely as possible to their local strategy; this Action Plan. The full Action Plan is included in Appendix A of this report.

7.1 Action Plan Details

The Action Plan is a simple summary spreadsheet, formulated by reviewing the previous phases of the SWMP. It includes a useful set of actions relating to the management and investigation of surface water flooding. The Action Plan is a live document and should be maintained and regularly updated by SCC (the LLFA) as actions are progressed and investigated. New actions may be identified by the SCC and partners, or may be required by changing legislation and guidance over time.

The Action Plan identifies:

- General flood risk management actions to integrate outcomes and new information from this study into the practices of other SCC services and external partner organisations;
- Policy actions to assist SCC to manage future developments in the context of local flood risk management;
- Asset and Maintenance actions to prompt review of current schedules in the context of new information presented in this study;
- General CDA actions to be implemented across all CDAs identified within this study.

7.2 Review Timeframe and Responsibilities

Proposed actions have been classified into the following categories:

- Short term: Actions to be undertaken within the next one to three years;
- Medium term: Actions to be undertaken within the next one to five years; and
- Long term: Actions to be undertaken beyond five years.

The Action Plan only considers the relative priorities of actions within the study area of Sudbury and Great Cornard. Suffolk County Council are currently reviewing the need to update several of their SWMPs across the county. Some partner organisations, including the Environment Agency, Suffolk County Council and Anglian Water have flood risk management responsibilities beyond the geographic scope of this study. Therefore, the priority of actions within Sudbury and Great Cornard will have to be assessed against actions in other areas.

An annual review of the High and Medium Priority actions is recommended. This allows forward financial planning in line with external partners and internal budget allocations. Low priority actions should be reviewed on a two to three-year cycle.

7.3 Sources of funding

Funding for local flood risk management may come from a wide range of sources, including:

- New developments (directly through the developer or through CIL)
- Defra (Flood Defence Grant in Aid);
- Suffolk County Council (highways);
- Babergh District Council;
- Anglian Water;
- Businesses and owners of large properties (e.g. industrial estates); and
- Local communities.

7.4 Ongoing monitoring

The partnership arrangements established as part of the SWMP process should continue beyond the completion of the SWMP, in order to discuss the implementation of the proposed actions, review opportunities for operational efficiency and any legislative changes.

The SWMP Action Plan should be reviewed and updated once every six years as a minimum, but there may be circumstances that may trigger a review and/or an update of the Action Plan in the interim, for example:

- Occurrence of a surface water flood event;
- Additional data or modelling becoming available, which may alter the understanding of risk within the study area;
- Outcome of investment decisions by partners is different to the preferred option, which may require a revision to the Action Plan, and;
- Additional (major) development or other changes in the catchment which may affect the surface water flood risk.

The Action Plan should act as a live document that is updated and amended on a regular basis.

7.5 Incorporating new datasets

The following tasks should be undertaken when including new datasets in the SWMP:

- Identify new dataset;

- Save new dataset/information; and
- Record new information in a log so that next SWMP update can review this information.

7.6 Updating SWMP Reports and Figures

In recognition that the SWMP will be updated in the future, the report has been structured in chapters according to the SWMP guidance provided by Defra. By structuring the report in this way, it is possible to undertake further analyses on a particular source of flooding and supersede the relevant chapter, whilst retaining the original versions of other chapters.

In keeping with this principle, the following tasks should be undertaken when updating SWMP reports and figures:

- Undertake further analyses as required after SWMP review;
- Document all new technical analyses by rewriting and replacing relevant chapter(s) and appendices;
- Amend and replace relevant SWMP maps;
- Update options and action plan; and
- Reissue to departments within the SCC and other stakeholders.

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Appendix A Action Plan

Appendix B Model Development Technical Note

Appendix C Flood Records

Flood history in Sudbury and Great Cornard.

Date	Location	Flooding Source	Description of flood impact
Nov 1762	Sudbury	Fluvial	Bures bridge destroyed on the Stour near Great Cornard, downstream bridge damaged at Ford Street.
May 1903	Sudbury	Rainfall	Low-lying meadows in Sudbury flooded
June 1903	Sudbury	Rainfall	Parts of Sudbury flooded
Jan 1947	Sudbury, Ballingdon	Unknown	134 properties and streets flooded
11-14 March 1947	Stour catchment	Snowmelt	Major flood in Stour catchment, including Sudbury
15 Sept 1968	Stour catchment	Rainfall	Major flood event with property flooding recorded in Ballingdon (Sudbury)
11 Oct 1987	Sudbury, Hadleigh, Long Melford	Rainfall Hurricane Fish	Major flooding with many properties affected
28 June 2014	East Street & Elisabeth Court	Prolonged period of heavy rain. Possible exceedance of design capacity of surface water drainage system. SCC Highway drainage Anglian Water surface water Large catchment to drain	14 domestic properties with internal flooding of main living, garages, and gardens. Rain water from properties is discharged onto pavement from a large number of properties in East Street and adjoining roads.
N/A	Queensway, Great Cornard	Rainfall	20 Queensway has experienced internal property flooding (SCC has no formal record of this). Happened once in his 25 years of known record (current tenant). More common that road and gardens flood, made worse by road traffic splashing water against properties and making the damage worse. (Mr Brown)
N/A	Nursery Rd in Gt Cornard	Persistent rainfall	The flooding occurs at the first junction in Nursery Rd where there is a slight dip in the road, exceeding the kerb height. It is known it to take 48 hours to disperse. (Will Hunt)

Date	Location	Flooding Source	Description of flood impact
N/A	King St Sudbury	Rainfall	Local road raising to kerb level causing SW into commercial property (David Pearl)
N/A	Nursery Rd	Rainfall	During heavy rainfall, the road becomes flooded as the drain cannot cope with the amount of surface water on the road (over kerb height. House opposite unable to get their car/work van as the water is too deep to walk through. Ongoing issue (Tennent of 12 years).
N/A	Nursery Road	Rainfall	After significant rainfall a large area of the road and depending on the water depth, part of the footpath at the bottom of the driveway floods. Can take days - up to a week to subside (Homeowner)
N/A	The Close, Banham drive, Sudbury	Rainfall	Surface water reaches the zebra crossing by The Close and Banham drive. Water collects at the crossroads of East Street, Constitution Hill and Upper East Street.
N/A	Wells Hall Road to Nursery Road	Rainfall	Surface water at the crossroads at Wells Hall Road to Nursery Road, footpath floods and at the entrance of Nursery Road past the slip road on the left. Pedestrians can't use the footpaths due to flooding.

* Table adapted from SFRA Flood history for the Babergh district

Appendix D Study Area Mapping

Appendix E Predicted Model Results

Flood maps for maximum depth and hazard have been produced for the 1 hour storm event. The intervals used to map the depth results are consistent with that used for the Risk of Flooding from Surface Water (RoFfSW) map by the EA and has been reproduced below:

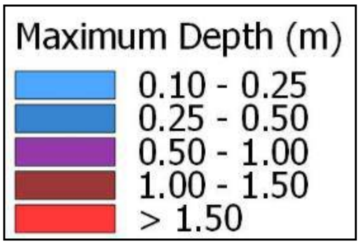

Figure E 1 Mapped Depth Intervals

The flood hazard result is based on the Flood Hazard Rating as defined by the DEFRA/Environment Agency guidance document[7]. Flood hazard is classified based upon the following formulae:

$$Flood\ Hazard\ Rating\ (HR) = d \times (v + 0.5) + DF$$

Where:

d = depth of flooding (m)

v = velocity of flood waters (m/s)

DF = Debris Factor, according to depth

A Debris Factor of 0.5 was used for depths less than and equal to 0.25m, and a debris factor of 1.0 was used for depths greater than 0.25m. Following calculation of the flood hazard rating, a flood hazard category is assigned based on the criteria as outlined within Table E 1and Figure E 2 below

Table E 1 Hazard Rating Category

Flood Hazard		Description
Low	<0.75	**Caution** – Flood zone with shallow flowing or deep standing water
Moderate	0.75 – 1.25	**Dangerous for some (i.e. children)** – Flood zone with deep or fast flowing water
Significant	1.25 – 2.5	**Dangerous for most people** – Flood zone with fast flowing water
Extreme	>2.5	**Dangerous for all** – Flood zone with deep fast flowing water

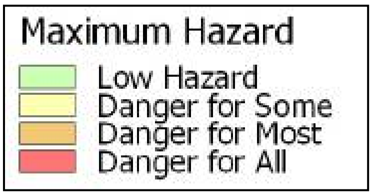

Figure E 2 Mapped Hazard Intervals

[7] Flood Risk Assessment Guidance for New Development - FD2321/TR1 (DEFRA/Environment Agency, March 2006).

Appendix F Calculation of Flooded Properties and Damages

Calculation of Flooded Properties

For fluvial and coastal flooding a simple counting methodology, looking at the number of property points which fall inside the flood outline, gives a good approximation of the number of properties in areas affected by flooding (Figure 1, left).

Flooding from surface water is typically more dispersed and fragmented, for example in narrow corridors between and around buildings, and therefore it is more challenging to count the flooded properties. A much higher proportion of properties are situated at the edge of an area at risk of flooding, which means a judgement must be made as to which properties to count.

Buildings are often modelled with raised footprints. In some cases the surrounding area is shown as flooded when the building itself appears dry or largely dry (Figure F 1, right), although flooding shown around the perimeter may result in property flooding. In the example provided, if properties at risk from surface water flooding were counted using the property points method for fluvial and coastal flooding, no properties would be counted. Consequently, counts of properties at risk of surface water flooding are extremely sensitive to the method used, and the assumptions made.

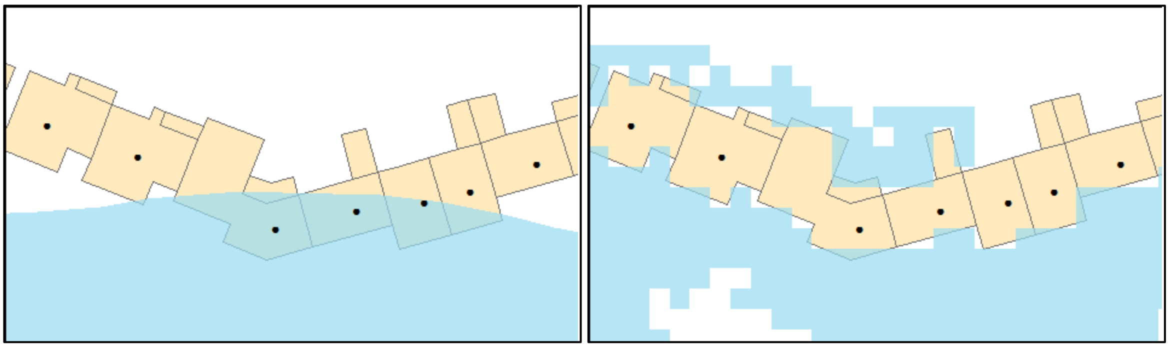

Figure F 1 Property Centre Points. Left: Fluvial Flooding. Right: Surface Water Flooding

The EA methodology uses the NRD property points and building footprints from the OSMM Topographic Area layer. The building footprints are buffered to reduce the gridded effect of the raised building footprint and flood extent. The recommendation for the buffer size is the modelled grid size, therefore a 2m buffer has been applied. The analysis is then carried out on the buffered building boundary and is adjusted for internal building perimeters, for example when properties are terraced or semi-detached.

The proportion of the buffered boundary where the depth is greater than a specified threshold is calculated, as shown by the blue line in Figure F 2 and attributed to the NRD property points dataset. The analysis is done for the 10%, 5%, 3.33%, 1.33%, 1%, 0.1% and 1% with Climate Change allowance, Lower bound and Upper bound AEP storm events. Different depth thresholds for each event are assessed (200mm).

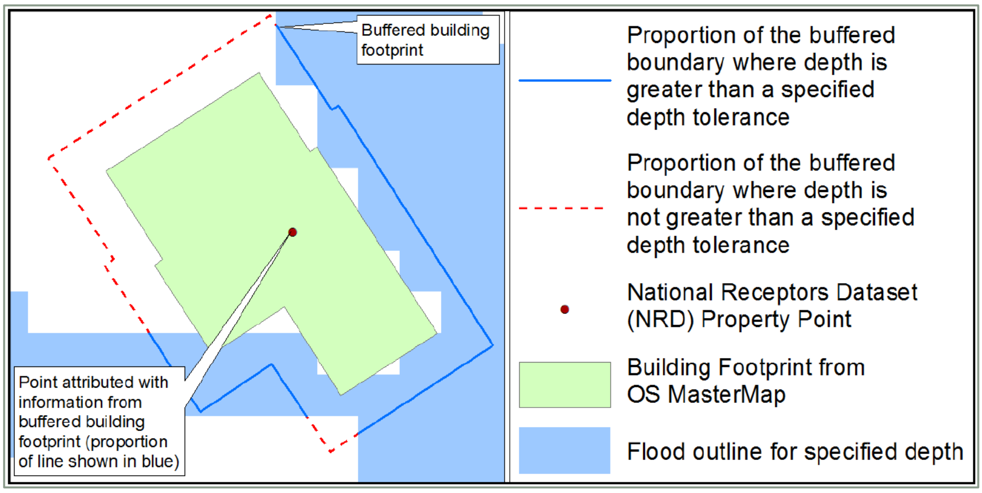

Figure F 2 Basic Principles of Analysis (Source EA, July 2014)

The points dataset is then filtered according to local judgement on the proportion of the buffered building boundary and depth threshold to produce locally applicable counts of properties that are at risk of surface water flooding.

The properties at risk of surface water flooding within Sudbury and Great Cornard has been selected using the following criteria:

≥ 50% wetted perimeter AND ≥ 0.2m depth threshold

Each building polygon that met either criteria was marked as ‘flooded’. For multiple properties within one building (e.g. units within a multi-storey building) only basement and ground floor properties are counted. Property counts have been calculated separately for residential, non-residential properties and critical infrastructure for the all modelled storm events.

Calculation of damages

The direct/tangible flood damage to properties within Sudbury and Great Cornard has been estimated using the data and techniques provided in the Flood and Coastal Erosion Risk Management – A Manual for Economic Appraisal. Direct/tangible losses for flooded households include: damage to building fabric; household inventory items; and clean-up costs.

Three levels of analysis are available:

1. **Overview** - a desktop assessment to provide a good first approximation which can be useful to identify areas where more detailed analysis is required;
2. **Initial** - a more detailed appraisal which takes into account property type as well as age where further assessment of household loss potential is considered warranted; and
3. **Full-Scale** - this assessment refines the damages estimated by factoring in the social grade along with the property age. This appraisal type reflects socio-economic influence as an area average.

A combination of factors leads to a number of different depth-damage curves. It is important to understand which parameters and assumptions need to be applied at the start of an appraisal so that the correct damage curve can be applied.

For each assessment level, the depth-damage curves for residential properties depend on:

1. The **length of the storm duration -** short (<12 hours) and long (12 hours – 2.9 days); and

2. The **level of warning given to residents** – this is factored into the damage curves via a percentage reduction in the household inventory.

The depth-damage curves for non-residential properties include an additional storm duration; extralong (3-7 days). Non-residential underground cellars are also taken into account and shorter flood warning lead times (4 hours) are considered due to potential for substantial stock savings even at short lead-times.

In this study, an overview assessment of flood damage has been undertaken that assumes:

1. A short duration storm event – this is considered most appropriate for convective cloud burst type events which are generally associated with surface water flooding;
2. No warning – due to short lead times and current uncertainty in predicting convective cloud burst type events; and
3. Per square metre damages – damages have been calculated per square metre based on the OSMM building polygon floor areas.

A review of the estimated damages is provided within the following section.

Average Annual Damage

The benefits of flood protection are calculated as the expected value of annual flood losses averted. Average Annual Damage provides an indication of the annual cost of flooding to a community. It is calculated by determining the damages associated with various design floods multiplied by the likelihood of occurrence across a range of floods. Large events that normally cause substantial damage may not contribute a great deal to the average annual costs due to their low probability. AAD is best understood as the average of flood damages calculated over many years. The ADD has been presented per CDA in the following section.

Appendix G Data Register

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