



Thames Gateway South Essex



Strategic Flood Risk Assessment



Prepared by Scott Wilson Ltd for The Thames Gateway South Essex Partnership Ltd

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Thames Gateway South Essex

Strategic Flood Risk Assessment

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PREFACE

Purpose:

The purpose of this report is to provide a Strategic Flood Risk Assessment for the Thames Gateway South Essex region. This includes the methodology and data collection exercises used to identify and address flooding issues from a high-level viewpoint to subsequently assist in strategic level planning for the region.

The Thames Gateway South Essex Partnership includes the following organisations:

- Thames Gateway South Essex
- Basildon District Council
- Castle Point Borough Council
- Rochford District Council
- Southend Borough Council
- Thurrock Borough Council

Objective:

The SFRA objective is to aid the partner authorities in their development process through the application of the Sequential Test as required by PPG25 and the impending PPS25. It assesses the flood risks posed to the region and outlines the main hazard zones in order to further aid the development planning process.

Limitations:

The SFRA approach was outlined in the Phase 1 Inception Report (Faber Maunsell, 2005). All methodologies, including breach parameters, have been agreed with the Environment Agency in accordance with the current best practice at the time of completion.

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GLOSSARY

Term	Definition
Breaching	Failure of a flood defence structure such that the crest of the existing defence is lowered allowing water to pour over or through the defence. This may lead to rapid inundation of the land behind the defence.
Flood plain	Area adjacent to river, coast or estuary that is naturally susceptible to flooding.
Hard Flood Defence	Engineered, structural defence often constructed using brick, concrete or metal, e.g. floodwall, sheet piling, or earth embankment with additional engineered toe protection.
Hazard	The potential for something to cause harm, for example a flood, independent of its likelihood of occurring
Inundation	Flooding.
Local Development Framework (LDF)	The core of the updated planning system (introduced by the Planning and Compulsory Purchase Act 2004). The LDF comprises the Local Development Documents, including the development plan documents that expand on policies and provide greater detail. The development plan includes a core strategy, site allocations and a proposals map.
Overtopping	Passage of floodwater over a defence. May range from wind-driven spray to severe overflowing when flood levels exceed the defence crest level.
Risk	The probability or likelihood of an event occurring.
Soft Flood Defence	A non-structural method of flood defence, often a strategic approach such as managed retreat or flood forecasting and warning system.
1 in 100 year event	Event that on average will occur once every 100 years. Also expressed as an event, which has a 1% probability of occurring in any one year.
1 in 100 year standard	Flood defence that is designed for an event, which has an annual probability of 1%. In events more severe than this the defence would be expected to fail or to allow flooding.
Permissive Powers	Powers which may be used, but where there is no statutory duty for them to be used.
Green Grid	Thames Gateway London Partnership has been co-ordinating the Green Grid. The objective of the Green Grid is to: Create a better environmental context for development; Enhance biodiversity and ecological values; and Improve flood risk management opportunities.
Freeboard	Height of flood defence crest level (or building level) above the designed water level.
Residual Risk	Residual Risk is a term often used in impact and risk assessment across a variety of topics. For this reason, it is also a term that is often inappropriately applied or

misused. In a general sense, residual risk is usually taken to refer to that portion of overall risk that remains once risk-aversion measures have been put in place. In a flood risk sense therefore, residual risk can be seen as the risk of flooding that remains after flood defence measures have been implemented.

Acronym	Definition
CFMP	Catchment Flood Management Plan
DCLG	Department of Communities Local Government
DEFRA	Department of Environment, Food and Rural Affairs
DEM	Digital Elevation Model
DPD	Development Plan Documents
EA	Environment Agency
FRA	Flood Risk Assessment
GIS	Geographical Information Systems
GLA	Greater London Authority
INTERREG III B	Interreg III programmes are a European Community Initiative to stimulate transnational cooperation in the EU between 2000 and 2006.
LDA	London Development Agency
LDD	Local Development Documents
LDF	Local Development Framework
LDS	Local Development Scheme
LiDAR	Light Detection and Ranging
LPA	Local Planning Authority
NFCDD	National Flood and Coastal Defence Database
NNR	National Nature Reserve
ODPM	Office of the Deputy Prime Minister
PAR	Project Appraisal Report
PPG25	Planning Policy Guidance Note 25: Development and Flood Risk
PPS25	Planning Policy Statement 25: Development and Flood Risk

RFRA	Regional Flood Risk Assessment
RPG	Regional Planning Guidance
RSS	Regional Spatial Strategy
SAR	Synthetic Aperture Radar
SCI	Statement of Community Involvement
SCP	Sustainable Communities Plan
SEA/SA	Strategic Environmental Appraisal / Sustainability Assessment
SFRA	Strategic Flood Risk Assessment
SMP	Shoreline Management Plan
SPG	Supplementary Planning Guidance
SRDF	Sub Regional Development Framework
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage Systems
TGLP	Thames Gateway London Partnership
TGSE	Thames Gateway South Essex
UDP	Unitary Development Plan

EXECUTIVE SUMMARY

Background

Scott Wilson Ltd was commissioned by the Thames Gateway South Essex Partnership in January 2006 to undertake a Strategic Flood Risk Assessment (SFRA) of South Essex, based on a Brief issued by the partnership. The Brief, prepared by Faber Maunsell (October 2005) set out the approach and general methodology including assumptions for the main SFRA report.

The Thames Gateway South Essex Partnership (TGSEP) incorporates Thurrock Borough Council, Basildon District Council, Castle Point Borough Council, Southend-on-Sea Borough Council, Rochford District Council, Essex County Council and other public and private sector partners. This project was carried out in collaboration with the Environment Agency's Anglian Region, and a draft of this report was submitted to the Agency for their comments and observations, mutually acceptable amendments have been incorporated into this final SFRA report.

Flood Risk in South Essex

It is no surprise in reflection of the historic flooding events that have affected South Essex, that most of the 40km coastline is defended from tidal flooding by embankments, hard defences and moveable barriers. These defences provide a level of defence to existing communities and land interests which is generally considered acceptable by the Environment Agency. In addition, the Environment Agency has an ongoing programme of maintenance of the defences and is currently undertaking a major series of studies collectively known as the 'Thames 2100' project which are focused on the future flood defence requirements in the area and the need for replacement or enhancement of flood defences post-2030.

One of the main assumptions included in the Brief, was that the existing defences should be regarded at their present defence height and condition for the next fifty years. Taking this into account the main focus of the SFRA was therefore placed on the residual risk of flooding from a breach event in the flood defences.

Planning Objectives

The primary objective of the study was to enable the five participating local authorities to undertake sequential testing inline with government flood risk and development policy guidance documents - PPG25 and impending PPS25 - to inform the development of their emerging Local Development Framework (LDF) documents.

The purpose of the SFRA was to assist the development of the LDF's by identifying flood risk areas and outlining the principles for sustainable development policies, informing strategic land allocations and integrating flood risk management into the spatial planning of South Essex. The SFRA thereby forms an essential reference tool in the future spatial planning of the region.

Report Layout

The main background and methodology information, including guidance on approaching the sequential test using the hazard mapping, and potential measures for residual risk management are discussed in this main SFRA report. For each participating authority a suitable appendix has been compiled to include a background information on that area with regards to flood risk, additional requested information as part of the SFRA Brief and associated hazard mapping and depth mapping

for that area. The general figures to accompany the main SFRA, such as location maps and topography etc are included in Appendix A.

Report Scope

The SFRA study, based on the findings and conclusions of the Brief, was to include the following main topics including agreed supplementary work for the participating authorities:

- Identification and mapping of flood risk zones as defined in PPG25 for the South Essex region;
- Identification and mapping of residual risk flood zones within Flood zone 3, into high, medium and low risk areas, to allow more detailed consideration of the sequential test;
- Undertake 2D hydraulic modelling of specified breach locations to inform definition of hazard zones, taking into consideration the effects of climate change. (25 breach locations were identified initially with a further nine locations identified and modelled during the course of the study);
- Flood risk assessments for a number of development areas within the area of South Essex. (Thurrock borough council subsequently defined three specific locations).
- Consideration of surface water and flood storage areas within the area of Basildon;
- Consideration into the probabilities of various breach sources for the area of Canvey Island;
- Preparation of guidance and application methods for the SFRA, taking into account emerging PPS25 (at the time of writing this report, only the draft consultation PPS25 had been released) in the sequential test, and the potential use of hazard zones to assist in future planning policy and integration of flood risk management into spatial planning.

Flood Sources

In total thirty-four potential breach locations were identified in the existing defences, within the respective fourteen defined flood cells covering the participating local authorities of Thurrock, Southend, Castle Point, Rochford and Basildon. These locations were identified in liaison with each individual local authority, to ensure that they reflected the key proposed or likely development areas in future LDF's.

The starting point of the hydraulic modelling, which forms the key deliverable of the SFRA, was to produce high quality topographic mapping for the entire area of South Essex. This allowed assessment of the fourteen flood cell boundaries and formed the basis of the 2D hydraulic modelling. A detailed hazard of 'flood consequence' methodology, previously developed by Scott Wilson and agreed by the Environment Agency, was then applied to the hydraulic modelling results. This allowed the definition of area of high, medium and low residual risk as a result of the identified breach scenario.

Flood risk on fluvial rivers is less well documented in the SFRA, due to the predominant concern expressed in the Brief towards greater consideration on tidal flooding. Fluvial flood risk, which varies on a spatial and temporal scale in South Essex, is addressed within the specific area appendices. A precautionary approach to the categorisation of fluvial associated flood zones within South Essex has been applied.

Surface water and groundwater data for the study area was limited, although several drainage reports for Canvey Island, Thurrock and Basildon were made available. These reports were reviewed and incorporated into the completion of the relevant area appendices as required. The drainage reports did not identify flooding events relating to groundwater or surface water events.

Flood Mapping

The SFRA mapping information has been provided to the participating authorities and Environment Agency on a DVD, to allow incorporating of the GIS outputs into their existing systems, to facilitate access as required to planners, engineers and emergency response officers to enable a detailed understanding of the associated residual risk of flooding within South Essex.

The results of the SFRA are presented in the relevant local authority appendices as a set of A3 maps covering the study area, and show the residual flood risk at any point in terms of high, medium and low hazard, as a result of the specified breach scenarios.

Maps are presented flood cell by flood cell, and also by each specific breach event for both the 1 in 200-year and 1 in 1000-year event. These maps take into account the existing topography and existing flood defences, and allow further detail on levels of residual risk to be presented alongside the Environment Agency's floodplain maps, which estimate flood risk without the presence of existing defences.

Further Benefits

The SFRA additionally provides useful tools for use in emergency planning in the South Essex region. It is hoped that the study outputs, in particular animations of flooding at the local scale and flood depth and velocity mapping, will be used by partner local authorities or at County level, to inform the ongoing development of Emergency Plans. The consideration of the needs of residents during a severe flood event is a core theme of the emerging PPS25 guidance, as is the production of evacuation plans or similar documents for those areas where residual flood risk is of particular concern or existing development especially vulnerable.

1 INTRODUCTION

The Thames Gateway is an area of national priority for regeneration and has been earmarked for major development over the next 10 years. With such development come particular challenges with regard to sustainable development and flood risk. A Strategic Flood Risk Assessment (SFRA) aims to assist the planning process by identifying flood risk areas and outlining the principles for policies for sustainable development. This information should be used in strategic land allocations and development plans.

Scott Wilson was commissioned by the Thames Gateway South Essex (TGSE) Partnership Ltd to undertake the TGSE SFRA on behalf of the local authorities of Basildon District Council, Castle Point Borough Council, Rochford District Council, Southend-on-Sea Borough Council and Thurrock Council. The SFRA identifies flood risk issues relevant to both existing and proposed developments within the area of South Essex. The SFRA process also aids local authorities to meet the requirements of Planning Policy Guidance Note 25 (PPG25) 'Development and Flood Risk' and the emerging replacement Planning Policy Statement 25 (PPS25), expected to be published in Autumn 2006.

This SFRA is intended to sit alongside similar studies conducted in the East London region of the Thames Gateway, and North Kent, thereby providing complete coverage of the Thames Gateway Growth Area. The South Essex SFRA study extent is presented in Figure 1-1.

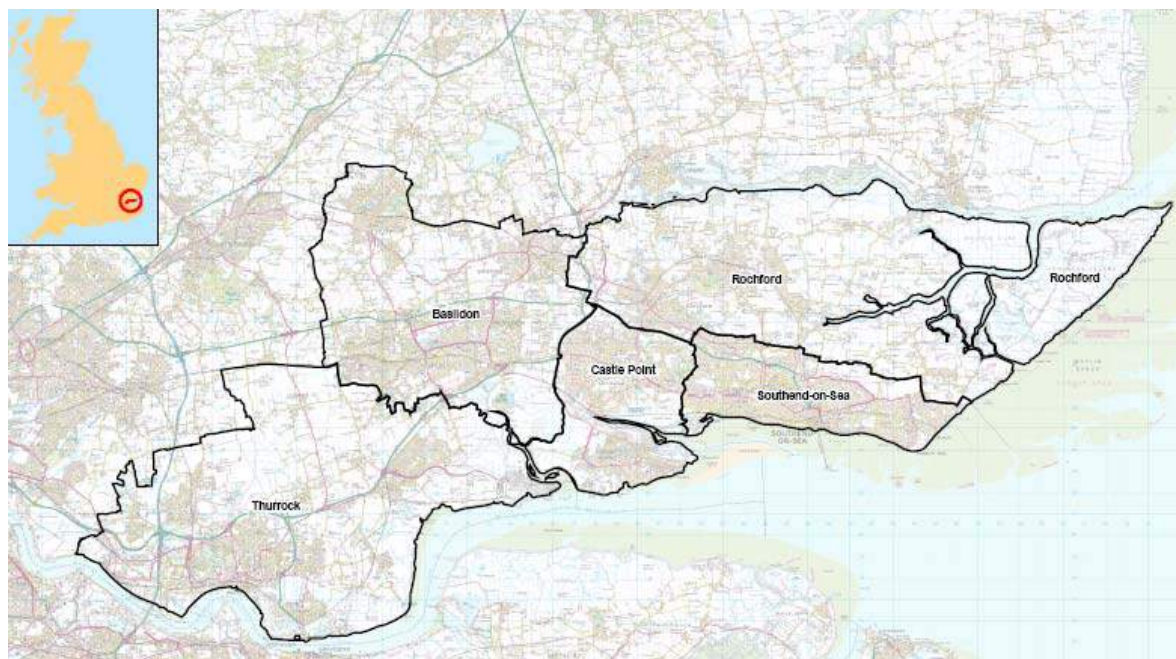


FIGURE 1-1 THE FIVE THAMES GATEWAY SOUTH ESSEX PARTICIPATING DISTRICTS AND SFRA STUDY EXTENT.

1.1 Scope and Objectives

This SFRA has been undertaken for the local authorities of Basildon District Council, Castle Point Borough Council, Rochford District Council, Southend-on-Sea Borough Council and Thurrock Council of the Thames Gateway South Essex area.

The SFRA should be regarded as an advisory study informing a suite of policies within each participating authority. The purpose of this SFRA is to:

- Assist the local planning authority (LPA) with defining appropriate areas and sub-areas (zones) to accord with the principles of PPG25 and emerging PPS25 policies;
- Enable a more detailed understanding of the flood risk issues relating to existing and proposed development;
- Identify areas which are vulnerable to flooding;
- Help identify particular land use types that might need to be restricted in areas vulnerable to flooding;
- Assess the degree of change as a result of climate change through the impact of likely sea level rise/raised water levels;
- Provide a heightened understanding of flood risk for partners of the Thames Gateway South Essex partnership and;
- Inform the planning process to enable integration of flood risk management into the strategic spatial planning of the South Essex region.

1.2 SFRA Approach

The SFRA was preceded by an Inception Report, completed in Autumn 2005 by Faber Maunsell. The Inception Report located and identified various categories and types of data that would be useful for completion of the SFRA. In addition to identifying available data, the Inception Report also outlined the study area extents, modelling approach and highlighted various specific flood risk issues for each local authority area.

The Inception report outlines the scope for the SFRA as follows:

- Flood risk should be considered as actual, current flood risk, taking into account the presence not only of existing flood defences but also any artificial features that could have a significant impact on flood risk to land protected by those defences or artificial obstructions.
- Although the Flood Risk Zones defined in PPG25 relate to risk in the absence of defences, the same numerical probability levels should be used to define flood risk categories and associated flood envelopes in this study, namely:

Flood Zone 1 - annual probability of flooding is less than 0.1%

Flood Zone 2 - annual probability of flooding is greater than 0.1% but less than 1% (fluvial) or 0.5% (tidal)

Flood Zone 3 - annual probability of flooding is greater than 1% (fluvial) or 0.5% (tidal)

- The SFRA mapping should provide a further breakdown of flood zones 2 and 3 based on the residual risk, to allow designation of 'high', 'medium' and 'low' risk areas for both flood zones 2 and 3.

- The results of the tidal embankment breach analyses undertaken for each of the authorities should be used to refine the SFRA.
- Climate change assessments should be made for 50 years time, assuming existing defences are maintained at their present defence height and physical condition over the next fifty years.

The Inception Report therefore forms the basis for the overall SFRA methodology, stressing the importance in this area of residual risk from tidal flooding. The Inception Report also highlighted issues that are specific to each of the five local authorities. These components are addressed in the relevant local authority appendices.

1.3 Synopsis

The SFRA has been structured as follows:

- Main Report: Strategic Flood Risk Assessment
- Appendix A: General Figures
- Appendix B: Basildon District Council
- Appendix C: Castle Point Borough Council
- Appendix D: Rochford District Council
- Appendix E: Southend-on-Sea Borough Council
- Appendix F: Thurrock Council

The main SFRA report details the processes and methodologies employed in the assessment and mapping of flood risk. It presents information on tidal and fluvial sources, giving an overview of flood risk data and flood pathways across the study area. The main report is divided into eleven chapters:

- Chapter 1 presents an introduction to the SFRA, scope and objectives;
- Chapter 2 sets the background of the study area in relation to flood risk;
- Chapter 3 presents an overview of planning policy relating to flood risk;
- Chapter 4 discusses other planning policy and documents relevant to the study area;
- Chapter 5 outlines the data collection process and comments on how it has been applied within the SFRA;
- Chapter 6 gives an understanding of the main sources of flooding;
- Chapter 7 details the methodology that has been applied to this SFRA;
- Chapter 8 provides general guidance to Local Planning Authorities and Developers with respect to breach and hazard mapping;
- Chapter 9 presents tools and options for understanding and managing residual risk;
- Chapter 10 details the digital data generated through this project, and includes the SFRA disk with relevant GIS layers; and
- Chapter 11 gives a list of references.

One of the key deliverables for the SFRA is accurate high quality mapping of flood risk zones and hazard zones. The relevant inundation flood maps and hazard maps detailing the high, medium and low classifications of zones 2 and 3 can be seen in the relevant authority appendices (Appendices B-F).

2 BACKGROUND

2.1 Thames Gateway South Essex

The Thames Gateway is an area of land stretching 40 kilometres eastwards from East London on both sides of the Thames and Thames Estuary. The South Essex area of the Thames Gateway consists of the five local authority areas of Basildon District Council, Castle Point Borough Council, Rochford District Council, Southend-on-Sea Borough Council and Thurrock Council. Figure A1, Appendix A presents a map of the SFRA study area. The area is almost entirely situated within the Environment Agency's (EA) Anglian Region, the exception being a 10km² area in the South Ockendon / Aveley area of Thurrock District, which is in the Environment Agency's Thames region.

The area has a mixture of heavily developed areas and large areas of rural landscape. The heavily developed areas are typically adjacent to the banks of the River Thames, with land use being mostly either industrial (for example Tilbury Docks) or high-density residential development (e.g. Southend-on-Sea or Canvey Island). Rural areas constitute much of the north and east of the study area.

The main watercourse in the area is the River Thames. Other main rivers in the area are the Rivers Roach, Crouch and the Mardyke. The River Crouch flows east from Wickford and then north of Hullbridge from where it forms the northern boundary of the Rochford District, eventually issuing to the North Sea at Foulness Point. The River Roach flows east from the town of Rochford, north of Southend, and joins the River Crouch at Wallasea Island, east of Burnham-on-Crouch. These watercourses have substantial estuaries as illustrated in Figure A2, Appendix A. The Mardyke is located in the west of the study area within the Thurrock Council area. The Mardyke flows south from Bulphan, towards South Ockendon, flowing to the north of Purfleet before issuing to the River Thames. There are several other smaller watercourses throughout the study area, however these are predominately tributaries of the main watercourses identified above.

Many of the watercourses in the area form the boundaries of island landmasses, such as Canvey Island and Foulness Island. Such formations are particularly prominent in the east of the region where the area is low-lying and dominated by marshland and wetland.

The Thames Estuary is an area increasingly at risk of flooding due to rising sea levels and increased rainfall intensity associated with the effects of climate change.

The most significant flood events in the South Essex area are the result of storm surges, coinciding with high spring tides to produce high tidal water levels.

2.2 History of Flooding

It is no great surprise that South Essex has historically experienced flooding on a large scale, as its southern and eastern boundaries are formed by very large coastal and estuary systems. Records of tidal flooding in the area of South Essex date back to 1099 (Met Office). Since Dutch engineers reclaimed some of the land in the 17th Century, there has been an almost constant building and updating of the defences, within a relatively structured management plan. For example, the Canvey Island Sea Defences Act passed in 1883.

The South Essex area suffered two major flood events in the 20th century, in 1928 and again in 1953. The 1953 flood affected eastern England and had the most significant consequence with 307 people losing their lives, a further 30,000 being evacuated and 24,000 properties destroyed. The overall cost of the disaster is estimated at over £5 billion in the current economic climate. Canvey Island was severely affected by this event.

The cause of this event was a storm surge that approached the Thames Estuary on the 31st January 1953. The high tide level was reached hours before the spring high tide was due at 1 am. As this surge coincided with a high spring tide, the level of water at Tilbury reached six feet above its predicted level (Thurrock Council, 2003a). This water quickly inundated the town. At the same time, a breach occurred in the floodwall, causing water to rush through the site, taking with it drums and equipment that subsequently crashed into buildings. The resulting inundation depth was approximately 2-3m (Thurrock Council, 2003a). Major devastation was commonplace throughout other areas of the region following the flood event, none more so than Canvey Island. Of the 307 fatalities, the hardest hit was Canvey Island where 58 people lost their lives. Canvey Island acts as an example of the unpredictable nature of flooding: the 1953 floods occurred despite extensive flood defence operations following the minor flood event in 1938 (Barsby, 2001).

In response to the major flood events, the UK Government initiated the construction of an improved flood defence scheme. Flood defence measures include barriers at Purfleet, Grays, Tilbury, Tilbury Fort, Shell Refinery, Canvey Island and the Holehaven and Benfleet barriers, as well as many kilometres of raised walls in both the upper and lower reaches of the estuary. The loss of life during the 1953 floods could have been avoided through a more comprehensive forecasting and warning system. Therefore, in addition to the hard engineered structural defences, the local authorities also aimed to improve the warning systems in the area (Thamesweb, 2003).

3 FLOODING AND PLANNING POLICY

As a result of major flood events in England and Wales in Easter 1998 and the winter of 2000/2001, the Government placed greater priority on flood risk management. In 2001 the Government published Planning Policy Guidance Note 25: Development and Flood Risk (PPG25) (DTLR, 2001), which outlined the Government's stance on flood risk issues related to development.

In keeping with the Government's programme, PPG25 was reviewed after three years. The review found that whilst the core themes of PPG25 were still valid, the guidance was inadequate and failed to ensure issues of flood risk were appropriately considered through the planning process. In light of these findings the Government intends to release a new Planning Policy Statement 25: Development and Flood Risk in the Autumn of 2006. A consultation version of this document was released in December 2005 and is discussed below.

3.1 Planning Policy Guidance on Flood Risk

PPG25 requires local authorities to undertake a risk-based approach to flooding in the preparation of local plans and development control decisions.

The tool local authorities are encouraged to use to undertake a risk based approach to flooding and planning is the Sequential Test.

3.1.1 *The Sequential Test*

The sequential test is aimed to ensure developments meet the principals set out in PPG25. This aims to provide an understanding of flood risk within an area, delineating the extent and nature of flooding in accordance with the flood risk zones set out in PPG25 (Table 3-1).

The sequential test characterises England and Wales into three Flood Zones:

- Flood Zone 1 – Little or No risk. Annual probability of flooding: River, tidal & coastal <0.1%;
- Flood Zone 2 – Low to Medium risk. Annual probability of flooding: River 0.1-1%, Tidal & coastal 0.1-0.5%; and,
- Flood Zone 3 – High risk. Annual probability of flooding, with defences where they exist: River $\geq 1\%$, Tidal & coastal $\geq 0.5\%$.

TABLE 3-1 COMPARISON OF FLOOD ZONES BETWEEN PPG25 AND PPS25

PPG25		PPS25
<ul style="list-style-type: none"> Flood Zone 1 Little or no Risk	<1 in 1000 years	<ul style="list-style-type: none"> Zone 1 Low Probability
<ul style="list-style-type: none"> Flood Zone 2 Low to Medium Risk	1 in 100 years (200 years for tidal sources) to 1 in 1000 years	<ul style="list-style-type: none"> Zone 2 Medium Probability
<ul style="list-style-type: none"> Flood Zone 3 High Risk	>1 in 100 years for fluvial sources or 1 in 200 years for tidal sources	<ul style="list-style-type: none"> Zone 3 High Probability
<ul style="list-style-type: none"> 3a Developed areas 		<ul style="list-style-type: none"> 3a High Probability(Flood Risk Vulnerability Classification)
<ul style="list-style-type: none"> 3b Undeveloped and sparsely developed areas 		
<ul style="list-style-type: none"> 3c Functional Floodplain 		

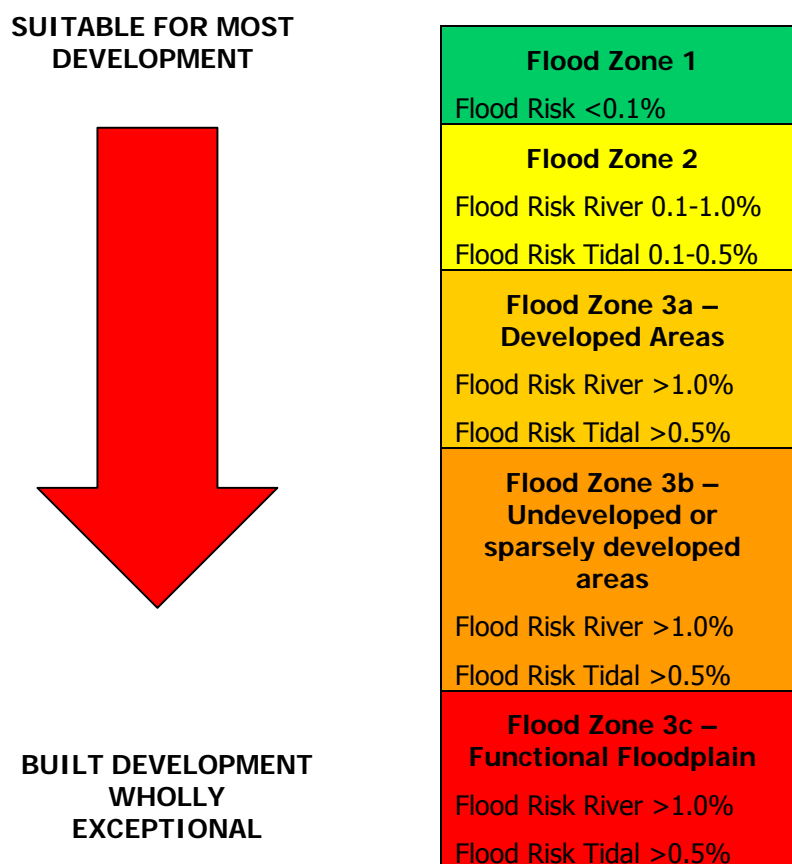
The sequential test is referred to in Paragraph 30 of Planning Policy Guidance 25 (PPG25). Paragraph 30 encourages Local Planning Authorities to give priority in allocation of development and granting of planning permission to land in lower areas of flood risk. The Guidance recommends that planning authorities give priority to developable land within Flood Zone 1 and then in descending order through Flood Zones 2 and 3. The initial order of priority for allocation of developable land is shown in Figure 3-1.

Local authorities are encouraged to consider the position of sites in relation to flood zones and give priority in allocations to those sites in lower risk areas. Strategic Flood Risk Assessments are designed to assess flood risk throughout local authority areas and present information for use in informing land allocations through the Sequential Test. In addition, SFRAs should also assist local authorities in developing policies to manage flood risk in accordance with the principles of sustainability whilst achieving the aims of the local authority.

Flooding is not the only constraint to planning and allocation of developable areas. Consideration needs to also be given to developing sustainable communities and reuse of brownfield sites in preference to Greenfield land. These considerations may also feed into the planning process when determining priorities for development areas.

Local Authorities are also expected to demonstrate that there is no available alternative developable land within a lower risk flood zone before allocating land for development within Flood zones 2 or 3.

FIGURE 3-1 PPG25 SEQUENTIAL TEST APPROACH



3.2 Planning Policy Statement on Flood Risk

Since the introduction of PPG25 in 2001 a range of flood risk issues has arisen for which PPG25 does not provide pragmatic advice. This has led to local interpretations of the guidance and variations in policies regarding development in flood risk areas. As a result, an updated policy document, Planning Policy Statement 25: Development and Flood Risk (PPS25) (ODPM, 2005) has been produced. This was released for consultation in December 2005. The consultation period ended in February 2006 with the final PPS25 due for release in Autumn 2006.

3.2.1 Strategic Approach

Within PPS25, SFRA's are identified as one tier in a three-tiered strategic approach to address flooding issues within the planning framework. At the widest level, Regional Flood Risk Assessments (RFRA) are to be undertaken by Regional Planning Boards. These should identify and give consideration to broad flooding issues and be informed and influenced by other high level assessments such as Catchment Flood Management Plans (CFMP) and Shoreline Management Plans (SMP).

Strategic Flood Risk Assessments (SFRA) are to be undertaken at a Local Authority level and have due regard to catchment wide flooding issues. Where available they should build on the findings of

RFRA's. They are required to identify flood risk areas from all flood sources and use their findings, through the Sequential Test, to inform land allocations in the preparation of their Local Development Documents (LDDs).

At the most detailed level are site specific Flood Risk Assessments (FRAs), these are detailed assessments of flood risk for development sites. These should build on the findings of SFRA's (where available) and demonstrate the risk to and from the site for all flood sources. Where necessary and appropriate they should propose flood mitigation measures and ideally use the findings to inform the site Masterplan.

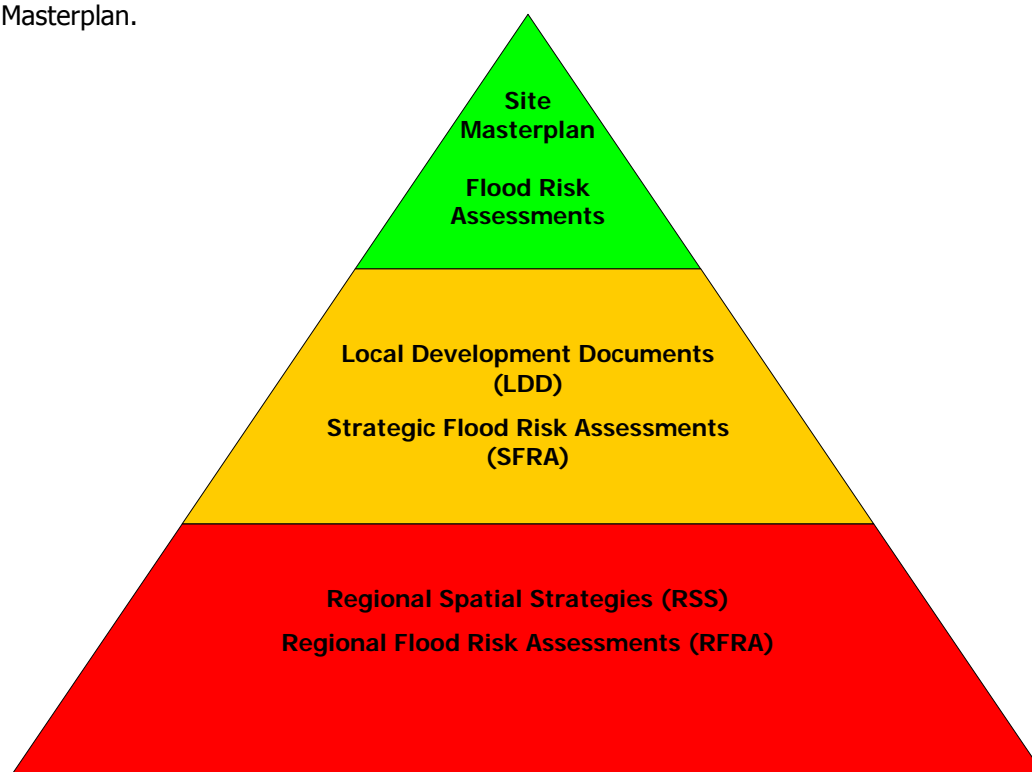


FIGURE 3-2 DIAGRAM TO DEMONSTRATE THE TIERED FLOOD RISK ASSESSMENT APPROACH IN RELATION TO PLANNING DEVELOPMENT.

3.2.2 Additional Guidance Provided in Draft PPS25

The Draft PPS25 document gives more detailed information about the application of the Sequential Test than the guidance contained in PPG25. The primary aim of the sequential test is to steer development towards Flood Zone 1 land and away from Flood Zones 2 and 3.

Before allocating land for development in Flood Zones 2 and 3, The Local Authority must be satisfied that there are no reasonable alternative options in Flood Zone 1.

Strategic Flood Risk Assessments should be used by the Local Authority to identify which areas of land under their jurisdiction are within Flood Zone 1 – Low Probability, Flood Zone 2 – Medium Probability of Flooding and Flood Zone 3 – High Probability of Flooding. Flood Zone 3 is further broken down into two categories Flood zone 3a – High Probability of flooding and Flood Zone 3b – Functional Floodplain. Flood zone classifications for the sequential test vary slightly in PPS25 from PPG25. Table 3-1 shows a comparison of flood zones between the two documents.

Once the boundaries of each zone have been determined, the local authority can then refer to Table D2 (contained in PPS25) in conjunction with Table D1 (contained in PPS25) to determine what types

of new development should be placed where and what types of redevelopment are appropriate in certain areas. In flood zones 3a and 3b where there is an apparent need for a type of development listed as inappropriate in Table D1, the Exception Test must be passed.

The Exception Test is stated in the following extract from Paragraph D10 of the Draft PPS25

- a) *'The development makes a positive contribution to sustainable communities, and to sustainable development objectives of the relevant LDD (Having reached at least the 'submission' stage of the Development Plan Document Process – see Figure 4 of PPS12: Local Development Frameworks);*
- b) *the development is on developable brownfield land or where there are no reasonable alternative options on developable brownfield land;*
- c) *a flood risk assessment demonstrates that the residual risks to people and property (including the likely effects of climate change) are acceptable and can be satisfactorily managed; and*
- d) *the development makes a positive contribution to reducing or managing flood risk.'*

The proposed development must pass each part of the Exception Test and the methods used to demonstrate compliance must be open and transparent

Specific Guidance on applying the findings of the SFRA and sequential test criteria in Tables D1 and D2 of Draft PPS25 is presented in Chapter 9.

3.2.3 A Balanced Approach

The replacement of PPG25 with PPS25 represents a fundamental shift in policy approach away from the previous reactive resolution of flooding problems as a result of development towards the effective management of flood risk within the planning system.

There are a number of constraints placed upon the local planning system. Development must facilitate the social-economic needs of a community and spatially sit within the existing development framework of landscape and infrastructure as well as providing an acceptable level of safety for residents. Therefore, it is important that a balance is established between development need and the risk it may pose upon existing and future dwellers of the area as a result of flooding. The Environment Agency established the concept of 'Balanced Management', published in 2003:

'...the Environment Agency's vision for the Thames Estuary is one of balanced management which allows for economic growth while protecting, enhancing and making the most of natural resources... the successful integration of long-term flood risk management is a vital element in this strategy'.

The EA is a statutory consultee in the Town and Country Planning process. The EA provides advice to Local Authorities to ensure the management of flood risk is done in an effective manner as part of the planning process. The Department of Communities Local Government (DCLG) encourages Local Authorities to undertake a sequential flood risk test to meet the requirements as set out in PPG25. This will provide an understanding of flood risk within their area, delineating the extent and nature of flooding in accordance with the flood risk zones set out in PPG25. This must consider the planning context, and provide the framework for robust and sustainable flood risk management solutions within those areas where a balance is required between susceptibility to flooding and wider spatial planning pressures.

Independent research carried out by the Association of British Insurers (ABI) shows that implementing PPG25 policies effectively in new housing development in the Thames Gateway could reduce potential flood risk losses by over half, and in the other growth areas by 96%.

4 STATUTORY PLANNING FRAMEWORK

The chapter provides an analysis of statutory and non-statutory planning guidance at a national, regional and local level.

4.1 Overview

There is a hierarchy of planning policy and planning guidance documents that was considered whilst compiling this report. These include:

- National level: Planning Policy Guidance (PPG), Planning Policy Statements (PPS) and national legislation (The Planning and Compulsory Purchase Act 2004), Making Space for Water, The Sustainable Communities Plan;
- Regional level: the Draft East of England Plan, Essex and Southend on Sea Replacement Structure Plan, Greening the Grid; and
- Local level: Thurrock, Rochford, Castle Point, Southend-on-Sea and Basildon Local Plans, Transforming and revitalising Thurrock: A Framework for Regeneration and Sustainable Growth, Thames Gateway Development and Investment Framework.

The planning process is driven by legislation and policy at national, regional, and local level. Flood Risk is a core issue to be considered when making land use decisions. The challenge of a Strategic Flood Risk Assessment is to develop pragmatic solutions that take account of the various requirements of these policies, and deliver guiding principles to steer future development in a sustainable manner whilst mitigating flood risk.

4.2 Structure of the Planning System

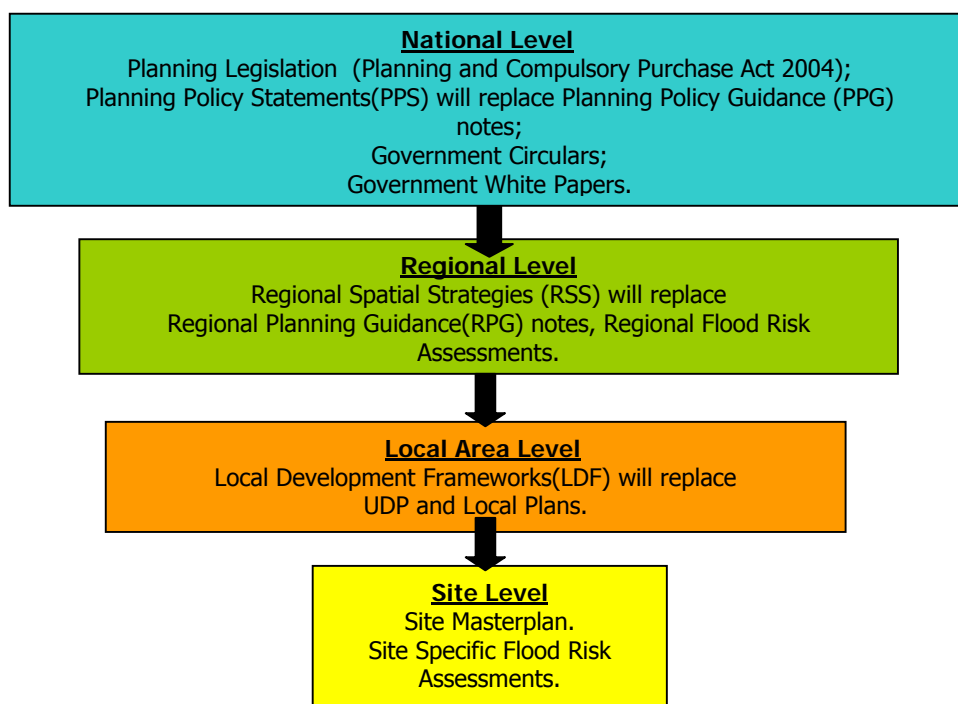


FIGURE 4-1 OVERVIEW OF THE PLANNING SYSTEM STRUCTURE AND THE FLOOD RISK APPROACH

4.3 National Planning Policy

4.3.1 *Planning and Compulsory Purchase Act 2004*

This SFRA has been produced in a period of transition for the planning system, following enactment of the Planning and Compulsory Purchase Act 2004. This has affected all tiers of the planning system, and has necessitated major changes at regional and local level. This is reflected in national, regional and local targets.

Currently, Planning Policy Guidance is being systematically replaced by statements, which provide '...statements of government policy on nationally important land use and other planning matters, supported where appropriate by a locational framework¹.'

4.3.2 *Planning Policy Statement (PPS) 1: Delivering Sustainable Development*

The application of PPS25 will be closely linked with the application of Planning Policy Statement (PPS) 1: Delivering Sustainable Development published in February 2005. PPS1 sets out the parameters for planning policy for delivering sustainable development across the planning system. It advocates that local authorities need to take into account the risks of flooding when producing development plan policies. PPS1 emphasises that new development should be avoided in areas that are at risk of flooding and sea level rise, unless such development meets the needs of the wider objectives of sustainable development. Therefore, planning authorities are advised to ensure that developments are 'sustainable, durable and adaptable'.

4.4 National Planning Guidance

4.4.1 *Planning Policy Guidance (PPG) 25: Development and Flood Risk*

The introduction of PPG25 published in July 2001 reinforced the responsibility that Local Authorities have to ensure that flood risk is understood and managed effectively using a risk-based approach as an integral part of the planning process. PPG25 is due to be replaced by Planning Policy Statement 25. This change in policy guidance represents a shift from the previous reactive resolution of flooding problems as a result of development to the effective management of flood risk within the planning system.

Chapter 3 presents more information about PPG25 and the difference and similarities presented in the consultation draft of PPS25.

4.4.2 *Making Space for Water*

During 2004, the Department for Food and Rural Affairs (DEFRA) undertook a consultation exercise, the object of which was to engage a wide range of stakeholders in the debate regarding the future direction of flooding strategy. The consultation document 'Making Space for Water' set out the following aim:

'To manage the risks from flooding and coastal erosion by employing an integrated portfolio of approaches which reflect both national and local priorities, so as to:

- *Reduce the threat to people and their property; and*

¹ PPG 1: General Policy and Principles, 1997, Para, 13

- *Deliver the greatest environmental, social and economic benefit, consistent with the Government's sustainable development principles.²*

Thus, the aim of the strategy is to balance the main pillars of sustainable development (i.e. social, economic and environmental).

Making Space for Water examines the impact of climate change on flood levels. Experts consider that the primary impacts on flood risk will be from changes in precipitation, extreme sea levels and coastal storms. DEFRA and the EA will produce revised guidance for use by those implementing flood and coastal erosion risk management measures. The revised guidance, to be finalised by the end of 2006, will ensure that adaptability to climate change through robust and resilient solutions becomes an integral part of all flood and coastal erosion management decisions.

Making Space for Water emphasises the Government's commitment to ensure that a pragmatic approach to reduce flood risk is adopted. However, the paper notes that 10 per cent of England is already within mapped areas of flood risk. Contained within these areas are brownfield sites which policy has identified as a priority for future housing provision. The document asserts that over the past five years 11 per cent of new houses were built in flood risk areas, including most of the houses proposed for the Thames Gateway under the Sustainable Communities Plan.

The plan advocates the use of EU funding streams, such as INTERREG IIIB, to enable local authorities to undertake trans-national projects aimed at advancing knowledge and good practice in flood risk management. Making Space for Water envisages PPS's to provide a stronger and clearer requirement for FRAs. Moreover, the document encourages integration with water management initiatives, in particular Catchment Flood Management Plans³. The document proposes that RSSs and Local Development Frameworks should take full account of strategic flood risk assessment and incorporates the sequential approach as set out in PPG25.

At the development control level, the document encourages local planning authorities to follow the existing guidance to require site-specific flood risk assessment. The Plan encourages Local Authorities to give full weight to the advice issued by the EA in response to consultations on planning applications. Only in exceptional cases should permission be granted against the Environment Agency's advice. In addition, the use of (local) flood risk assessments as supporting documents to planning applications in areas of flood risk is encouraged. The document proposes that if mitigating measures are shown to be required, they should be fully funded as part of the development.

4.4.3 The Sustainable Communities Plan

The Sustainable Communities Plan (SCP), launched by the ODPM in February 2003, identifies the Thames Gateway as the largest of the government's four growth areas. The five Districts that are the subject of this SFRA lie within the Thames Gateway. The challenge for the new Regional Spatial Strategies, the Sub Regional Strategies and the Local Development Frameworks will be to reconcile the SCP's requirement to identify sufficient land for large volumes of new homes to be built in the Thames Gateway, whilst ensuring that the sites allocated satisfy sustainability criteria specifically with regard to the avoidance of flood risk.

The SCP identifies development in the Thames Gateway as a national priority. The Plan recognises the following factors as key tools to support regeneration in the area:

² *Making Space for Water-Developing a new Government strategy for flood and coastal erosion risk management in England* DEFRA, 2004

³ *Catchment Flood Management Plans are voluntary plans through which the Environment Agency works with other key decision makers in river catchments to identify and agree policies for sustainable flood risk management*

- Located within close proximity to London;
- The strategic location of major transport links to the continent;
- One of the largest concentrations of brown field sites in the country; and
- Creates an opportunity for 232,000 new jobs and 128,500 homes between 2001-2016 as key factors to support regeneration of the area.

The Plan reiterates that the development of sustainable communities and regenerating existing areas will be avoided in unsustainable locations in terms of flood risk. The plan states *'development proposals will be subject to flood risk assessment in consultation with the Environment Agency.'*⁴. Furthermore, the Plan suggests that development will be concentrated on brownfield land and protected by flood defence infrastructure. Many of the proposed development areas lie within the Thames Gateway tidal floodplain. The DCLG states that *'...redevelopment of many previously used sites in the Gateway gives the opportunity to put in place more sustainable flood defences... and to plan the location of development according to flood risk assessment'*⁵.

4.5 Regional and Strategic Planning Policy

4.5.1 Draft East of England Plan

The Draft East of England Plan or Regional Spatial Strategy (RSS) sets out the regional strategy for planning and development in the East of England to the year 2021. The plan provides policy direction for matters such as economic development, housing, the environment, transport, and waste management.

The Plan plays a significant role in contributing to sustainable development and sets out policies which address the needs of the region and key sub- regions. These policies provide a development framework for the next 15 to 20 years that will influence the quality of life, the character of places and how they function, and will inform strategies and plans.

The East of England is one of the largest of the English regions with an area of 19,000 square kilometres. It extends from the fringes of London in the south to the North Norfolk coast. The area is generally considered low-lying in character with parts at or below sea level.⁶ It is a region of diverse landscape with a rich built environment and is of national heritage importance.

The Plan highlights population growth in the East of England within the last few decades. This has been driven by inward migration from the rest of the UK, principally from London due to job opportunities and low house prices making commuting to London a viable proposition. A key objective of the Plan is to ensure these demands are accommodated in a sustainable manner.

The Plan identifies key drivers of change in the region, which are most likely to influence the scale and location of development within the next 20 – 30 years. They include:

- Social progress which recognises the needs of everybody;

⁴ Sustainable Communities Plan, Para 3.12

⁵ Sustainable Communities Plan, ODPM in February 2003,

⁶ East of England Plan, page 36, para 4.69

- Effective protection of the environment;
- Prudent use of natural resources; and
- The maintenance of high and stable levels of economic growth and employment.

Furthermore, the Plan identifies regeneration as a key objective in South Essex, which can be achieved through jobs-led growth, higher levels of local economic performance, and a more sustainable balance of local jobs and workers. Additionally, the sub-regional plan for South Essex has set out specific targets for Thurrock, Castle Point, Basildon, Rochford and Southend-on Sea as:

- 55,000 new jobs by 2021 (30,000 of those by 2011); and
- 43,800 dwellings by 2021 (19,350 by 2011).

A key objective of the Plan is to minimise the risk of flooding within the region. The Plan states that the coastline is naturally dynamic, with strong natural processes. These processes, principally coastal erosion, can result in a rise in sea level and increase stress on flood defences. Consequently, climatic change, also a contributor to increasing sea levels, is highlighted as a key issue that will need to be addressed.

The Plan states that climate change *'will be inevitable over the period of this strategy and for many years into the future. It will impact on existing development and natural resources and must influence our decisions about the location of future development. Areas now at risk from flooding will become more vulnerable and there will be new areas. Sea level rise in the region may be between 22 and 82 centimetres above the current level by 2080. This is expected to have significant impacts on coastal and low-lying areas. Water is likely to become scarcer in the summer months adding to the supply-demand issues already faced in this driest of the English regions. Changes in biodiversity may occur in response to climate change. Climate change is also likely to cause disruption in international trade and the region's vulnerability to this needs to be reduced'*.

4.5.2 The Essex and Southend on Sea Replacement Structure Plan

The Essex and Southend on Sea Replacement Structure Plan has been prepared jointly by Essex County Council and Southend on Sea Borough Council and was adopted by both authorities in April 2001 and covers the period to 2011.

The adopted Plan forms part of the statutory development plan for the combined areas of the two authorities. The Plan provides strategic guidance for land use planning decisions for example, new housing, employment land, town centres, transport, and conserving the environment.

A key objective of the Structure Plan is to:

- 'Protect, conserve and enhance the special landscape nature conservation, and heritage qualities of the undeveloped coastline;
- Prevent new development in coastal areas being at risk from flooding, erosion and land instability; and
- Balance and reconcile interests in sensitive coastal areas'.

The Essex and Southend on Sea Structure Plan recognises the insufficient supply of water resources within the County. In accordance with the sustainability principles of the Plan, the demand for water resources can be effectively managed by controlling the location, scale and phasing of

development. Furthermore, the Plan advises that development should be focused in locations where adequate water resources already exist. Alternatively, development is recommended in areas where the new provision of water resources can be made without adversely affecting the environment.

The Plan recognises the importance of maintaining or enhancing the water quality of coastal waters and inland watercourse. It is advised that new development, redevelopment, and land raising can have significant implications for flood risk. The Plan considers that new development within river or coastal floodplains may increase the risk flooding. Therefore, the Plan advises that development which threatens the stability and continuity of fluvial and tidal flood defences could place large areas at risk in terms of reducing the storage capacity of the flood plain and increase the surface run-off.

Policy NR12 advises the protection of water resources, and suggests that

'Development will only be permitted where:

- 1. Adequate water resources can be provided within the plan period without a materially adverse effect on the environment;*
- 2. There would not be a risk to existing water resources, including the flow and water quality of underground or surface water, or existing abstraction;*
- 3. Such development would not be at direct risk from tidal or fluvial flooding or likely to increase the risk of flooding elsewhere;*
- 4. There would be no materially adverse effect upon fisheries, nature conservation, archaeological remains, landscape and recreation in river and canal corridors, coastal margins and other waterside areas'.*

Essex and Southend on Sea Structure Plan states that the natural resources of the coast should be protected as they make a major contribution to the overall environmental quality of the area. The Coastal Protection Belt aims to protect the rural and underdeveloped coastline from development. Policy CC1 advocates the stringent restrictions placed on development in rural and the underdeveloped coastline.

Erosion is considered a dominant physical process occurring in over 90% of the Essex and Southend on Sea coastline, and affects both existing saltmarsh and landform. The Plan states that a significant proportion of the coastline is low-lying character. Furthermore, the Plan suggests that extensive areas are at risk from flooding; particularly areas below or at sea level. Therefore, the Plan advises development should not occur in areas at risk from flooding. Policy CC2 states that *'particularly where existing flood defences properly maintained would not provide an acceptable standard of safety over the lifetime of the proposed development, or where the construction of new coastal defences would be required'.*

DEFRA has overall responsibility for flood defence and protection in England. The protection of human life and existing property and the conservation of natural habitats is a core aim of coastal protection and flood defence works. However, planning permission is not required for improvements to existing flood defence works, but is required for new works. Policy CC3 states that the *'construction of new or replacement flood defence and coast protection works may be permitted provided they are essential: -*

- 1. To protect human life and existing property; and*
- 2. To conserve irreplaceable natural habitats'.*

The Plan supports development in previously developed areas along the coast and not on the undeveloped coastline. Policy CC4 states *'Development requiring a coastal location should be sited within the already developed areas of the coast defined in adopted local plans, particularly where this can promote urban regeneration and the conservation of areas of special architectural and*

historic interest, providing that where development is acceptable in locational terms, its bulk and scale must be compatible with the special character of the coast.

4.6 Regional Planning Guidance

4.6.1 South Essex Greengrid Strategy

The Thames Gateway South Essex Partnership produced the South Essex Greengrid Strategy in 2005. The vision of the Greengrid Strategy is to achieve “ a living system, threading through the urban and rural landscape, connecting places that are attractive to people, wildlife and business, and providing clean air, food, water, energy, minerals and materials”.

This is a radical vision, which places:

- Landscape at the heart of the development process; and
- Environmental process at the heart of sustainable development and the economy.

4.6.2 Greening the Gateway

Greening the Gateway was produced by ODPM in January 2004 and sets out the core principles that the Government believes should be adopted in the planning and design of green spaces in the Thames gateway. It is not intended to be a spatial plan, but calls for a network of attractive and accessible green spaces that link inner urban areas to rural areas, are multifunctional and can help to improve health, provide flood storage, filter pollution, encourage wildlife, provide shelter and a green framework within which people can enjoy living and working.

The Strategy emphasises Government targets for regeneration and new development. These are:

- 128,500 new homes built across the Gateway of which 35% will be affordable for rent by 2016; and
- 53,000 hectares of green space will be protected in the gateway.

4.7 Local Planning policy

The radical transformation of the current planning system has implied that at a Local Borough level, Unitary Development Plans (UDPs) and Local Plans will be phased out and replaced with Local Development Frameworks (LDF). The LDF comprises of a portfolio of documents that will guide land use decision. These documents include Local Development Scheme (LDS), Statement of Community Involvement (SCI), Local Development Documents (LDD) and a Sustainability Appraisal/Strategic Environmental Assessment. Where Local Plans are recently adopted, or preparation is at an advance stage, the process will continue to adoption, providing ‘saved policies’ for development control purposes. As the new Development Plan Documents will be adopted they will replace parts of the UDP or Local Plan. Supplementary Planning Documents will be similar to the current Supplementary Planning Guidance (SPG), which provide clear planning standards that will be used to determine and/or improve submitted development proposals.

A large proportion of Councils have undertaken their LDS. This is a public statement of the Council’s programme for the production of the new development framework and summarises the documents that will collectively form the Framework. The current transition period will provide the opportunity for Local Authorities to review and update their policies and ensure that the national and regional policy and guidance is followed. LDFs will need to take into account PPS25 sequential approach to assist in identifying development sites, land allocations and in managing existing development

proposals. Many of the LPA's recognise their susceptibility of flooding and require flood risk assessments to be carried out as part of the planning process.

Table 4-1 outlines the status of Thurrock, Rochford, Castle Point, Basildon, and Southend-on-Sea in relation to the status of their Local Plan, the status of their Local Development Schemes, and whether Supplementary Planning Guidance incorporates flood risk.

A review of South Essex Districts and Unitary Authorities has been carried out, to assess the provisions of flood risk measures within their Unitary Development Plans against the key principles of PPG25 (Table 4-2). Castle Point's UDP and Local Plan pre-dated the release of PPG25 and do not take flood risk into account within their policies of the existing UDP. The extent to which this has been articulated through individual development plans/frameworks varies quite significantly depending on the time of the adoption/publication. Clearly those published after PPG25 reflect the guidance contained within it, compared to those drafted before, do not necessarily conform to the guidance.

A large proportion of Plans were adopted post-2001 and therefore reflect the provisions of PPG25. However, Castle Point and Southend-on-Sea had less information as their Plans were adopted in 1998 and 1999 respectively. Under the new development plan system, described above, all of the LPAs have their Local Development Scheme adopted and expect to have their Local Development Documents adopted by 2007/2008. These will reflect the advice of PPS25.

As part of Thurrock's LDF the Council commissioned a Sustainability Appraisal (SA) to assess the sustainability of their emerging options and policies. The SA used an Objective Framework to establish the criteria used to assess the LDF, the Framework was informed by PPG 25 and PPS 25 in contributing to the flood risk objective (Objective 4, sub-objective 4.1). This ensures that flood risk will be taken into account throughout the plan making process.

The review found that the Borough of Castle Point does not make any reference to development within the floodplain. However, a flood risk assessment is mandatory with each planning application. Failure to submit a flood risk assessment will result in the application not being accepted. The Council have reallocated responsibility to the Environmental Agency for flood risk rather than develop policies to assist with guiding new development.

The Southend-on-Sea Local Plan was adopted in 1999, and as a result, a large proportion of opportunity sites identified in the Plan have since been developed.

4.8 Preliminary Recommendations

This section has provided a broad overview of existing planning policies and the extent to which they embrace the guidance in PPG25 and PPS25. These Policies recognise the risk of flooding and attempt to avoid development within the flood plain and attempt to ensure that where development is allowed, adequate measures are in place to mitigate this risk.

The completion of this SFRA during the early stages of their LDF development should enable the Local Authorities of South Essex to incorporate flood risk management into their LDF's and strategic spatial planning for the South Essex region. It is recommended that:

1. Requirements of PPS25 should be incorporated into Local Development Documents.
2. Emerging Local Plans should show consistency with the strategic framework provided by national guidance and RSS and should identify development sites in accordance with the PPS25 sequential test, unless exceptional circumstances dictate an alternative approach.

TABLE 4-1 CURRENT DEVELOPMENT PLAN STATUS

Local Authority	UDP/Local Plan	Timescales of Emerging LDF	Relevant SPG relating to Flood Risk	Notes
Thurrock	Thurrock Borough Local Plan, September 1997. Thurrock Unitary Development Plan Deposit, March 2003	Core Strategy Document: May 2008 Policies for the control of development Document: Adopted September 2008 Site Specific Allocations and Policies Document: Adopted May 2008	None identified	Available on website
Rochford	Rochford District Replacement LDP Second Deposit Draft, May 2004	Core Strategy Document: Adopted June 2008 Allocations Document: Adopted January 2009 Development Control Policies Document: Adopted March 2009	None identified	Available on website
Castle Point	Adopted Local Plan November 1998	Core Strategy and Generic Development Control Policies Document: Adopted November 2007 Allocations Document: November 2008	None identified	Available on website
Basildon	Basildon District Replacement Local Plan due to be adopted in mid July 06	Core Strategy Document: Adopted July 2009 Site Allocations Document: Adopted March 2011 Development Control Policies DPD: Adopted June 2010; Gypsy and Traveller Sites DPD: Adopted July 2009	None identified	Available on website
Southend-on-Sea	Southend-on-Sea Borough Local Plan (adopted 1st March 1994) and its First and Second Alterations covering the period 1996 to 2001 (adopted 13th October 1997 and 1st March 1999 respectively).	Core Strategy Document: Adopted March 2007 Criteria Based Policies and Site Allocations Documents: Adopted March April 2009	None identified	Available on website

TABLE4-2 ASSESSMENT OF DEVELOPMENT PLAN FLOODING POLICY AND SUPPORTING TEXT

Criteria	Structure Plan	Thurrock	Rochford	Castle Point	Basildon	Southend- on- sea
Development Plan Assessed	Essex Structure Plan	Thurrock Borough Local Plan, September 1997.	Rochford District Replacement Local Plan (Second Deposit Draft) May 2004	Local Plan 1998	Basildon Replacement Local Plan July 2005	No policy as such. Currently producing Flood Risk Assessment. That will influence forthcoming flood risk policies.
Does the Development Plan Policy include reference to:						
Identify the sequential approach being adopted to the identification of Development Sites (zones 1, 2 and 3a,b and c).	Yes	Yes	Not Included	Not included	Yes	Not included
Highlight the adoption of the precautionary principle to development	Yes	Not included	Yes	Not included	Yes	Not included
Recognition of susceptibility of land to flooding	Yes Policy CC2'Development Risk on the Coast' Policy CC4 'Development requiring a Costal Location'	Yes Policy RIV10	Yes	Not included	Yes	Not included
Recognition of flood risk and affect of climate change	Yes	Not Included	Not Included	Not included	Not Included	Not Included
Recognition of role of flood plains and washlands	Yes	Yes policy RIV 10	Yes	Not Included	Yes	Not Included

Criteria	Structure Plan	Thurrock	Rochford	Castle Point	Basildon	Southend- on- sea
Recognition of potential impact of defences on down stream	Yes Policy CC3 'Coast Protection and Flood Defence'	Yes Policy RIV 11	Yes	Not included	Yes	Not included
Request FRA/SFRA and identification of measures to deal with flood risk	Not included	Not included	YES - Policy NR9	Yes. Requires flood risk assessment for each application	Yes Policy BAS NE5 -	Not included
Identify need for the management of surface water run - off e.g. grey water recycling, rainwater harvesting or sustainable drainage systems SuDS	Yes Policy CC2'Development Risk on the Coast'	Yes Policy RIV 10	Yes Policy NR10	Not included	Yes Policy BAS NE6.	Not included

4.9 Local Planning Guidance

4.9.1 *Transforming and Revitalising Thurrock: A Framework for Regeneration and Sustainable Growth*

Transforming and Revitalising Thurrock: A Framework for Regeneration and Sustainable Growth was published in Autumn 2005 by the Thurrock Thames Gateway Development Corporation. The aim of the Framework is to maximise regeneration, and help guide and deliver growth.

The Framework highlights the Environment Agency's proactive involvement in mapping a large proportion of the Borough's flood risk area. The Framework states that flood risk is a Borough-wide issue. Furthermore, the Framework advocates that flood risk must be assessed at a regional and national level and '*will be integrated as required in all land projects, buildings and infrastructure that the Corporation is involved with, either through development control or direct engagement.*'

4.9.2 *Thames Gateway Development and Investment Framework*

Thames Gateway Development and Investment Framework (TGDIF) published by the Greater London Authority (GLA) in April 2004 is a framework which provides a 'shared vision for sustainable regeneration' which 'set(s) the context for investment priorities, land use planning and other interventions'. The TGDIF is a non- statutory document that:

'...builds upon the policies set out in the Mayor's London Plan and the Government's Sustainable Communities Plan, on detailed research commissioned by the LDA, and on the work carried out by the zone of change action groups in drafting area development frameworks'.⁷

The framework sets out priorities for investment to meet national and regional targets for development. The TGDIF echoes the government employment growth will be accommodated in the Thames Gateway opportunity areas. The majority of this development is envisaged to occur close to the tidal frontage of the River Thames and its tributaries, including much of South Essex, such as Thurrock, Castle Point and Southend-on-Sea. The Framework supports the Environment Agency, which is conducting a study into long-term risk management in the Thames Estuary to minimise the risks of flooding.

The total cost of the programme is £16 billion. Of this, £8 billion will be financed by the private sector, through provision of private housing, Section 106 of the Town and Country Planning Act contributions and provision of much of the physical infrastructure such as water and waste water systems. Central government will be expected to meet some of the costs through obligatory funding related to population growth of health and education facilities. The government is anticipated to meet funding to support the minimum target of developing 59,500 new homes, 43,800 of these are proposed within South Essex by 2021.

4.9.3 *The Environment Agency*

The Environment Agency's main responsibility in terms of flood risk is the management of flood risk through the implementation of flood management plans and physical measures i.e. flood defences. It is funded by DEFRA and the Treasury and although it is the largest flood defence authority in England and Wales, it shares its responsibilities with over 400 local authorities.

⁷ Thames Gateway Development and Investment Framework, GLA, 2004, page 3.

Maintenance and improvement of flood defences is generally the responsibility of the riparian landowner, unless otherwise agreed with the Environment Agency in which case they will be the responsible authority. Regarding the Thames, the Environment Agency has the power to enforce this responsibility, through the Thames River Prevention of Floods Amendment Acts 1879 – 1962.

The Environment Agency has powers to ensure that main rivers are maintained for the effective passage of flood flow and the management of water levels. This system operates under the Water Resources Act 1991. These are permissive powers so there is no obligation for the EA to carry out either maintenance or new works on main rivers. In South Essex, these powers extend to the main Thames tributaries, Mardyke, Roach and the Crouch.

5 DATA COLLECTION & SOURCES

5.1 Introduction

A wide variety of data was made available for the SFRA. The Inception Report (Faber Maunsell, 2005) identified the data available for the SFRA and the location of the data and/or key stakeholders.

In order to facilitate production of the SFRA, data identified in the Inception Report was screened to assess its use in production of the SFRA. Consequently not all the data identified by Faber Maunsell was used in the production of the SFRA. Further details of the data used in this assessment, how it has been used and the source/provider of the information are presented in Table 5-1. Additional tables are provided in the appendices detailing the data used to address the specific issues of individual authorities.

Further explanation of the data and its use within the SFRA is provided in Sections 5.2 to 5.9. The data has been grouped into categories relating to its primary use in the production of the SFRA.

The majority of the data was provided by the following organisations:

- Environment Agency
- Basildon District Council
- Castle Point Borough Council
- Southend-on-Sea Borough Council
- Thurrock Council
- Anglian Water

5.2 Topographic Data/Base Mapping

Topographic data used in the SFRA consists of LiDAR (Light Detection and Ranging) and SAR (Synthetic Aperture Radar) data, provided by the Environment Agency.

The LiDAR dataset consists of 258 2km² tiles, providing coverage of approximately 95% of the South Essex area. The LiDAR data provides elevations on a 2m grid with an elevation accuracy of $\pm 0.3\text{m}$. Further details of how LiDAR data is collected and processed can be found on the Environment Agency web site, <http://www.environment-agency.gov.uk>. SAR data is less accurate than LiDAR data with elevations provided on a 5m grid with a vertical accuracy of $\pm 0.5\text{m}$. SAR data is available for the entire South Essex area.

The data made available for this study also included helicopter flown LiDAR data of the flood defences along the River Thames.

Due to the greater accuracy of the LiDAR data, this was used wherever possible for the generation of the Digital Elevation Model (DEM) on which hydraulic modelling was undertaken. However in areas where LiDAR data were not available the SAR data was used to fill in the gaps in the LiDAR data.

Areas for which no LiDAR data were available (for areas in which hydraulic models were required) include areas administered by the Ministry of Defence (MoD) in the Rochford District, along the River Crouch and to the west of the study area. The methodology used for generation of the DEM is presented in Chapter 7. With the exception of the MoD sites, gaps and anomalies in LiDAR data can occur due to non-reflective land and areas of surface water, (e.g. lakes, ponds, and rivers), this results in null values within the dataset. The absence of LiDAR data for MoD sites is attributed to issues of national security.

LiDAR data was provided in two formats. The raw data presents elevations for all reflective surfaces, including features such as buildings and trees. LiDAR data is also available as filtered data, presenting the surface of the land excluding buildings and trees. The filtered data was used to create a Digital Elevation Model (DEM) of South Essex.

LiDAR data only provides surface levels for reflective objects. Therefore an important exercise was to identify areas where bridges, culverts and/or other major floodwater pathways existed. This was done by reviewing Ordnance Survey maps for the area, and some ground reconnaissance. Where bridges and/or structures that could significantly influence local flooding were identified, the DEM was manually adjusted during the model construction, to accurately represent the flow paths available to floodwater. This results in a more accurate flood model.

Ordnance Survey 1:50,000 and 1:2500 base mapping was used for the presentation of flood zones and hazard zones throughout the South Essex study area.

5.3 Flood Defences

GIS layers provided by the Environment Agency included 1:10,000 mapping of defences and defended areas within the South Essex area.

5.3.1 Tidal Defences

The nature of tidal flood defences at the breach locations (Chapter 7) identified by the South Essex Thames Gateway Partnership were determined through the use of the DEM, aerial photography, the National Flood and Coastal Defence Database (NFCDD) and knowledge of local Environment Agency flood defence officers.

The locations of flood defences were identified by querying the DEM. The defence type (earth embankment or hard defence) was determined from a review of high-resolution aerial photography (supplied in a digital format). Reference was also made to the NFCDD and/or drawings supplied by the Environment Agency that include details of the tidal defences covering the areas of:- Purfleet, Grays, Tilbury, Tilbury Fort, Shell Refinery, Holehaven Barrier, Benfleet Barrier and Canvey Island.

It is considered that there are gaps in the data that would require further work for future assessments. Most notably this includes more detailed condition surveys for flood defences, in particular privately owned defences in areas such as Shoeburyness.

5.3.2 Fluvial Defences

There is limited information available regarding fluvial defences for the South Essex area. 'Standard of Protection' reports were provided by the Environment Agency for the follow locations:

- Eastwood Brook at Eastwood (Halcrow, May 2000)
- Various Watercourses at Tilbury (Halcrow, June 2000)
- Prittlebrook at Southend (Halcrow, June 2000)
- River Crouch and Nevendon at Wickford (Halcrow, May 2000)
- River Roach at Rochford (Halcrow, May 2000)
- Various Watercourses at Basildon (Halcrow, May 2000)
- Stonehouse Sewer at Purfleet (Halcrow, May 2000)
- Benfleet Hall Sewer at South Benfleet (Halcrow, May 2000)

- Canvey Island (Posford Duvivier, July 2000)

In addition, several miscellaneous items were provided by local authorities relating to drainage and flood defence systems in their areas. However, these items do not provide comprehensive coverage of the fluvial defences present throughout the South Essex area.

Information regarding fluvial flood defences has been used in the Appendices.

5.4 Drainage

Due to the low-lying nature of much of the South Essex area and the presence of extensive flood defences, managed drainage forms an important feature in the area. Several reports were made available for the study relating to drainage arrangements for selected areas of the South Essex study area. These included Project Appraisal Reports for Canvey Island, and sites in Thurrock and Basildon.

These reports have been reviewed and provide useful information in the production of the Appendices, however they have provided little information to assist in completion of the main SFRA report.

5.5 Flood History

Limited historical information has been provided for use in the SFRA. The Inception Report presents anecdotal information collected through interviews with stakeholders and local authorities. The information predominately identifies areas that have been known to flood but does not elaborate in terms of flood sources, design standards or contributing factors. Consequently its application in the SFRA has not been considered.

Other historical data has been provided by Castle Point BC and Southend-on-Sea BC. This information consists of maps of Canvey Island and Southend highlighting areas known to have flooded in recent memory or during the 1953 floods, respectively. This information has been used in the preparation of the Appendices for these authorities.

5.6 Hydrometric Data

Hydrometric data was provided by the Environment Agency. This included the locations and alignments of Main Rivers, Critical Ordinary Watercourses (COWs), and catchment areas for watercourses throughout the South Essex area mapped at a scale of 1:10,000. The information was provided as GIS layers.

This information has been used in the SFRA to refine flood cells (see Chapter 7), where fluvial systems drain through to the coast or Thames estuary.

This information has also been used in the production of the Appendices and in responding to the specific issues of the members of the Thames Gateway South Essex Partnership.

5.7 Flood Risk

5.7.1 EA Flood Zone Maps

The Environment Agency has provided GIS layers presenting Flood Zones 2 and 3 for the South Essex area. The maps present the Flood zones for areas at risk of flooding from tidal sources (Thames estuary, North Sea etc) and for fluvial watercourses (main rivers and en-mained ordinary watercourses) throughout South Essex.

The flood maps have been generated by a combination of techniques. Areas at risk from tidal flooding have been identified by extrapolation of extreme tide level over the ground surface until the corresponding ground level is reached. Consequently anything below the extreme tide level is considered to be within a Flood Zone. This approach does not take into account the presence or effect of defences, flood routes as a result of topography, or the volume of water available for flooding as a result of the tidal cycle.

Flood Zones for fluvial river systems have been estimated in a similar manner. Flood levels have also been extrapolated across the ground surface to define the flood envelope, however, the flood envelope has also been refined with the results of section 105 hydraulic modelling and/or observations.

Whilst this source of data does not present a completely accurate estimate of flooding for tidal and fluvial sources throughout South Essex, it provides comprehensive coverage of the area and was the best available at the outset of the SFRA.

Additional data provided by the Environment Agency also included flood warning and flood watch areas.

5.7.2 Flood Risk Reports

Several other reports have been provided by the Environment Agency and stakeholders, relating to flood risk in the South Essex area. These include:

- research projects underway or recently completed for the Thames Estuary, investigating the effect of climate change on flood risk for the area (e.g. Thames 2100 Project),
- Strategic Flood Risk Assessments for neighbouring Thames Gateway areas, and,
- Catchment Flood Management Plans (CFMP) and Shoreline Management Plans (SMP).

5.8 Extreme Water Level/Tides Information

Information on extreme water levels used in this assessment was provided by the Environment Agency.

Extreme flood levels for the Thames Estuary were obtained from the Thames Estuary 2100 Project report. Extreme flood levels for the Rivers Roach and Crouch were obtained from the Roach and Crouch Flood Management study.

Where these reports did not address the return periods required for this study, the data was extrapolated or interpolated to provide the levels. Further details of this approach are presented in Chapter 7 (Methodology). For areas where no detailed information on sea level rise was provided it was assumed at 6mm per year, in line with the recommendations of Planning Policy Statement 25: Development and Flood Risk.

No information was available regarding storm surge levels or durations.

5.9 Planning Documents

5.9.1 Statutory Planning Documents

Several Statutory planning documents were available for this study, including information and draft reports currently being used in the preparation of Local Development Documents (LDDs).

Data provided by the stakeholder councils largely took the form of reports including various Local Plans and Unitary Development Plans (UDPs) and their associated maps. Each of these documents is at a different stage in the planning process, with some approaching the end of their design life.

Due to the differing ages of the plans their content varies depending on the guidance and best practice available at the time of their production. Therefore, the information presented in them is outdated, as the development sites outlined may have already been allocated and/or in development or operation. In addition, policies may no longer be adequate, especially where Local Plans were prepared prior to the release of PPG25 in 2001. Section 3 presents details of the planning documents reviewed for the SFRA.

Other important reference documents used also were the relevant Planning Policy Guidance Notes, in particular, PPG25: Development and Flood Risk, and the recent draft of Planning Policy Statement 25 (PPS25).

5.9.2 Non-Statutory Planning Documents

Several non-statutory planning documents were also reviewed in the preparation of the SFRA. These present the Government's and/or local government aspirations in several areas that may impact on flood risk in the future, such as the Greengrid Strategy, Greening the Gateway and the blue ribbon network.

5.10 Commentary on data gaps

The purpose of an SFRA is to present information for all sources of flooding. However, gaps in the data include information on secondary and tertiary sources of flooding such as groundwater and surcharged drainage. Although these are not likely to pose a significant risk (compared to flooding from tidal sources), they can potentially be very disruptive. More comprehensive information would be required to assess the impacts of secondary and tertiary flooding in South Essex.

TABLE 5-1 DATA SOURCES USED IN PRODUCTION OF THE SFRA

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Drainage	Drainage study for Canvey Island		Canvey Island Pumping Station catchment mapping	
Drainage	West Thurrock Main PAR Report	Atkins	Thurrock FRAs	
Drainage	Project Appraisal Report. Canvey Island Drainage System Volume 1	EA	Canvey Island Pumping Station catchment mapping	
Drainage	Project Appraisal Report. Canvey Island Drainage System Volume 2 (Appendices A to F)	EA	Canvey Island Pumping Station catchment mapping	
Drainage	Project Appraisal Report. Canvey Island Drainage System Volume 3 (Appendix G)	EA	Canvey Island Pumping Station catchment mapping	
Drainage	Surface Water Drainage General Plan of Trunk Sewers Washlands and Watercourses	EA	Basildon washland/flood storage area identification	
Drainage	Project Appraisal Report. Worlds End Pumping Station	EA	Thurrock FRAs	
Drainage	Essex River Authority. Basildon New Town Washland Locations (72/3456/73)	Essex River Authority	Basildon washland/flood storage area identification	
Drainage/ Flood Defence	Anglian Water Authority, Essex Sewage Division. Letter to DC Reynolds Esq re Responsibility for the Maintenance of Washlands	Anglian Water Authority	Basildon washland/flood storage area identification	

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Drainage/ Flood Defence	Basildon Development Corporation. Letter to GFH Griffin, Esq re Transfer of Property	Basildon Development Corporation	Basildon washland/flood storage area identification	
Drainage/ Flood Defence	Basildon Council. Letter to Divisional Engineer re Washlands	Basildon BC	Basildon washland/flood storage area identification	
Drainage/Flood Defence/Flood History	Castle Point B.C. Letter to Scott Wilson re Information from Castle Point for the SFRA	Castle Point BC	Canvey Island Pumping Station catchment mapping	
Drainage/Flood Defence/Flood History	Information from Castle point for the SFRA	Castle Point BC	General information	
Extreme Tides	Tidal Thames Extreme Water Levels Consultation – Draft report. Extreme Tide Levels for use in Section 105 Surveys (2nd edn)	EA, Halcrow		
Extreme Tides	Determination of Wave and Water Level Data - Technical Report	Halcrow		
Flood Defence	Thames tidal flood defences and their alignment	EA – NFCDD / aerial photographs (EA)	Assessment of defence type at breach locations	
Flood Defence	Various miscellaneous drawings of defences along the Thames from Purfleet to Tilbury and around Canvey Island were utilised.	Various/ misc.	Thurrock FRAs	
Flood Defence	Miscellaneous drawings of flood defences at Purfleet, Grays, Tilbury, Tilbury Fort, Shell Refinery, Holehaven Barrier, Benfleet Barrier and Canvey Island.	EA	Thurrock FRAs	
Flood Defence	Halcrow Water Flood Defence Standards of Protection: Eastwood Brook at Eastwood	EA		

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Flood Defence	Halcrow Water Flood Defence Standards of Protection: Various Watercourses at Tilbury	EA	Thurrock FRAs	
Flood Defence	Halcrow Water Flood Defence Standards of Protection: Prittlebrook at Southend	EA		
Flood Defence	Halcrow Water Flood Defence Standards of Protection: River Crouch and Nevendon at Wickford	EA		
Flood Defence	Halcrow Water Flood Defence Standards of Protection: River Roach at Rochford	EA	Defence Standard information in Appendices.	
Flood Defence	Halcrow Water Flood Defence Standards of Protection: Various Watercourses at Basildon	EA	Basildon washland/flood storage area identification	
Flood Defence	Halcrow Water Flood Defence Standards of Protection: Stonehouse Sewer at Purfleet	EA	Thurrock FRAs	
Flood Defence	Halcrow Water Flood Defence Standards of Protection: Benfleet Hall Sewer at South Benfleet	EA		
Flood Defence	Information regarding flood defences and standard of protection	EA		
Flood Defence	Flood Defence Standards of Protection: Canvey Island Final Report	Posford Duvivier	Canvey Island Pumping Station catchment mapping	
Flood Defence	DEFRA High Level Targets – Review of existing defences. Prepared for Southend-on-Sea B.C. 2004	Scott Wilson	Guidance documentation	
Flood Defence	Southend-on-Sea Pier to Thorpe Hall Avenue Flood Defence Improvements. Engineers Report	Halcrow		
Flood Defence	Anglian sea defence survey	EA		

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Flood Defence	National Flood and Coastal Defence Database	EA	Used for Defence Type and Condition figures	
Flood History	Southend-on-Sea B.C. Flood Extent Maps 1953 and 1968	Southend BC	Reference documentation	
Flood History	Coastal Flooding in Castle Point		Canvey Island Pumping Station catchment mapping	
Flood History	Coastal Flooding in Essex			
Flood History	Fluvial Flooding in Castle Point			
Flood Risk	Thames Gateway and Flood Risk Management – A Preliminary Assessment, 2003	EA	Reference documentation	
Flood Risk	Flood Risk Management in the Thames Estuary	S.Lavery, 2003	Reference documentation	
Flood Risk	Roach and Crouch Flood Management Strategy Report	EA / prepared by Halcrow	Establishment of extreme water levels along North Sea, River Roach and River Crouch	
Flood Risk	SFRA for Thames Gateway East London Partnership	Entec, JBA	Used for SFRA consistency approach	
Flood Risk	SFRA for Thames Gateway South Essex Appendix 2 – Partnership Members Data	Faber Maunsell	Used for SFRA consistency approach	
Flood Risk	Thames Gateway & Flood Risk Management - a Preliminary Assessment. The Impact of Climate Change on Storm Surges in the Thames Estuary. Discussion Document	Atkins		

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Flood Risk	Thames Estuary Flood Risk Management Plan (Phase 1) Project Appraisal Report 2003.		Guidance/ Reference documentation	
Flood Risk	The Association of British Insurers' flood risk of proposed developments in Essex	ABI, Entec	Reference documentation	
Flood Risk	Environment Agency: South Essex Catchment Flood Management Plan Inception Report December 2005	EA	Guidance/ Reference documentation	
Flood Risk	River Characteristics Survey: Flood Risk	HR Wallingford		
Flood Risk	Thames Estuary - Flood Risk Under Climate Change	Atkins		
Flood Risk	Gardiners Lane South Environmental Statement. Appendix L – Flood Risk Assessment	Entec UK	Basildon washland/flood storage area identification	
Flood Risk/ Non-statutory Planning	Southend-on-Sea Shoreline Management Plan – Volumes 1 to 3,	Mouchel Parkman		
Flood Risk/ Non-statutory Planning	Southend-on-Sea Shoreline Management Plan – Addendum 2,	Mouchel Parkman		
Flood Risk/ Non-statutory Planning	Thames Estuary 2100 Project, 2004	EA / prepared by Halcrow	Establishment of extreme water levels along River Thames	
Flood Risk/ Non-statutory Planning	Thames Estuary 2100 Project River Characteristics Survey –	EA and HR Wallingford	Reference documentation	

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Flood Risk/ Non-statutory Planning	Thames Estuary 2100 Project Impacts of Climate Change on the Thames Estuary – Literature Review Update.	EA and Atkins	Reference documentation	
Hydrometric	Critical Ordinary Watercourse information	EA	Used for figure A2, sources of flooding	Canvey Island Pumping Station catchment mapping
Hydrometric	Maps outlining the hydrometric catchments and catchment boundaries (scale of 1 to 50,000)	EA		
Hydrometric	Crouch and Roach Estuary Management Plan	Crouch and Roach Estuary Project, Essex County Council etc.	Draft used to supplement further info on condition of MOD defences in Rochford.	
Inception Report	Inception report for TGSE SFRA	SW	Guidance documentation	
Non-Statutory Planning	Greening the Grid	ODPM	Planning Guidance documentation	
Non-Statutory Planning	Thames Gateway Development and Investment Framework	GLA	Planning Guidance documentation	
Non-statutory Planning	Engines for Growth	London Thames Gateway Development Corporation	Planning Guidance documentation	

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Non-statutory Planning	Making Space for Water	Department for Environment, Food and Rural Affairs (DEFRA)	Planning Guidance documentation	
Non-statutory Planning	Gardiners Lane South Environmental Statement. Volume 1 Main Report	Entec UK	Basildon washland/flood storage area identification	
Statutory Planning	Planning and Compulsory Purchase Act 2004	Her Majesty's Stationery Office (HMSO)	Planning Guidance documentation	
Statutory Planning	Planning Policy Statement (PPS) 1 Delivering sustainable Development	Office of The Deputy Prime Minister's (ODPM)	Planning Guidance documentation	
Statutory Planning	PPS6: Planning for Town Centers	DCLG	Planning Guidance documentation	
Statutory Planning	Planning Policy Guidance (PPG) 3: Housing	DCLG	Planning Guidance documentation	
Statutory Planning	PPG4: Industrial, Commercial and Small Firms	DCLG	Planning Guidance documentation	
Statutory Planning	The Sustainable Communities Plan	DCLG	Planning Guidance documentation	

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Statutory Planning	East London Sub-Regional Development Framework	Greater London Authority (GLA)	Planning Guidance documentation	
Statutory Planning	The London Plan	GLA	Planning Guidance documentation	
Statutory Planning	Basildon Replacement Local Plan First Deposit, May 2004	Basildon BC	Used to identify development sites	
Statutory Planning	Castle Point Adopted Local Plan, Nov 1998	Castle Point BC	Used to identify development sites	
Statutory Planning	Castle Point Borough Council – Proposals Map Adopted November 1998	Castle Point BC	Used to identify development sites	
Statutory Planning	Castle Point Borough Council – Emergency Plan 1998	Castle Point BC	Used to identify development sites	
Statutory Planning	Castle Point Annex 4D and 4F from Emergency Preparedness	Castle Point BC	Used to identify development sites	
Statutory Planning	Planning Policy Guidance Note 25: Development and Flood Risk (PPG25) and Planning Policy Statement 25: Development and Flood Risk (PPS25).	DCLG	Planning Guidance documentation	
Statutory Planning	Rochford District Replacement Local Development Plan, Second Deposit Draft, May 2004	Rochford DC	Used to identify development sites	
Statutory Planning	Southend-on-Sea Core Strategy Development Plan Document. Stage 2 Public Participation on alternative approaches and preferred options for delivering strategic objectives	Southend BC	Used to identify development sites	

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Statutory Planning	Southend-on-Sea Borough Local Plan, March 1994	Southend BC	Used to identify development sites	
Statutory Planning	Thurrock Borough Local Plan. Written Statement and Annexe, Adopted September 1997	Thurrock BC	Used to identify development sites	Thurrock FRAs
Statutory Planning	Thurrock Borough Local Plan. Proposals Map Sheet 1: West (Scale 1:12500)	Thurrock BC	Used to identify development sites	Thurrock FRAs
Statutory Planning	Thurrock Borough Local Plan. Proposals Map Sheet 2: East (Scale 1:12500)	Thurrock BC	Used to identify development sites	Thurrock FRAs
Statutory Planning	Thurrock Unitary Development Plan. Written Statement, Deposit March 2003	Thurrock BC	Used to identify development sites	Thurrock FRAs
Statutory Planning	Thurrock Unitary Development Plan. Proposals Map Sheet 1: East (Scale 1:12500)	Thurrock BC	Used to identify development sites	Thurrock FRAs
Statutory Planning	Thurrock Unitary Development Plan. Proposals Map Sheet 2: West (Scale 1:12500)	Thurrock BC	Used to identify development sites	Thurrock FRAs
Statutory Planning	Thurrock Unitary Development Plan. Proposals Map Key	Thurrock BC	Used to identify development sites	Thurrock FRAs
Topographic/base mapping	LiDAR 258 tiles, 2km square (2m resolution).	EA, LPA,	Used to generate DEM	
Topographic/base mapping	Additional helicopter flyover LiDAR data outlining crest levels of flood defences at:	EA		
	• Along the entire river section of the River Roach;			
	• Along the entire river section of the River Crouch;			
	• At the Mucking Marshes (Stanford);			
	• At Westcliff-on-Sea to Southend Pier;			

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Topographic/base mapping	At West Thurrock Marshes (North of Stone Ness)			
Topographic/base mapping	SAR data. (5m resolution)	EA	Used to generate DEM	
Topographic/base mapping	Southend-on-Sea BC Flood Contour Maps			
Topographic/base mapping	County Council boundaries	EA	Used to define study area extents	
Topographic/base mapping	OS maps at 1:25,000	EA	Assessment of special features for modelling (minor watercourses, road and rail embankment, bridge openings etc.)	Mapping breach modelling results
Topographic/base mapping	OS Landline Basemap – Thurrock BC	EA	Thurrock FRAs	
Topographic/base mapping	OS Landline Baseline map – Basildon DC	EA	Basildon washland/flood storage area identification	
Topographic/base mapping	OS Landline –Castle Point proposal map – Castle Point DC	EA		
Topographic/base mapping	OS Landline Baseline map – Southend-on-Sea BC	EA		
Topographic/base mapping	Urban area extents and indicative flood risk zones	EA	Basildon washland/flood storage area identification	

Data Category	Type/reference	Source	Primary Contribution to SFRA	Secondary Contribution to SFRA
Topographic/base mapping	Basildon Landline Data	EA	Basildon washland/flood storage area identification	
Topographic/base mapping	Castle Point Landline Data	EA	Canvey Island Pumping Station catchment mapping	
Topographic/base mapping	Southend-on-sea Borough Council Ordnance Survey Landline Data	Southend BC		
Topographic/base mapping	Additional images were provided through aerial photography, both high-resolution aerial photographs and helicopter videos of flights along the flood defences.	25 cm aerial photographs from EA	Viewed to confirm defence type classification along some areas.	Assessment of defence type at breach locations
Topographic/Base Mapping	Wallasea Island Wetland Creation Project	Bullen Consultants	DEM refinement	
Topographic/Base Mapping	Wallasea Island Wetlands Project Area Details	Bullen Consultants	DEM Refinement	

6 FLOOD SOURCES, DEFENCES AND FLOODING MECHANISMS

The area of South Essex is extremely large, with coastal, fluvial and estuary systems, including a wide distribution of creeks and marsh areas, posing a wide range of flood risks. Within this SFRA a broad scale approach was required to focus on the flood risks with the largest possible consequences.

Much of the South Essex area is low-lying and the area includes the alluvial marshlands of Foulness, Canvey, Tilbury and the valleys of the Rivers Crouch, Roach and Mardyke. Much of the coastal zone is below mean high tide level and is protected by sea defences. Areas of higher ground exist near Basildon, South Benfleet and Hockley, and among the clay uplands surrounding the valleys of the Rivers Crouch and Mardyke.

Large sections of South Essex are protected from tidal flooding by embankments, hard defences and movable barriers. These include the Tilbury Docks Barrier, East Haven and Benfleet Tidal barriers and the Fobbing Horse tidal barrier at Canvey Island. The low lying areas behind the defences of Tilbury and Canvey Island are pump-drained through channels and ditches to tidal locked outfalls and pumping stations. Figure A3, Appendix A shows the classified defence type for the coastline of South Essex.

6.1 Flood Sources in South Essex

The following sections give details of the specific flood sources for the study area of South Essex. These can be seen in relation to the study area in Figure A2, with further information regarding type and standards of defence in Figures A3 and A4, Appendix A.

6.1.1 River Thames

The section of the Thames Estuary within the South Essex study area has a continuous form of flood defence including floodwalls, embankments, hard defence toe protections and natural saltmarsh systems. The main causes of major flooding events in this area would be through overtopping or a breach of flood defences, or through structural or mechanical failure of defences.

The communities along the Thames Estuary, including most of South Essex, are protected from tidal flooding by over 300 km of floodwalls, embankments and nine tidal barriers including the Thames Barrier, Tilbury Docks Barrier and Barriers at East Haven and Benfleet. In addition to this 35 major gates and over 400 minor gates are operated along the Thurrock and Canvey Island defences. Most of the present defence system was designed in the 1970s as a direct response to the damaging east coast floods of 1953.

The Thames Tidal Barrier lies 7km upstream of Thurrock's westerly boundary, and provides the city of London and riverside communities with a very high standard of river and tidal flood defence. Similarly, tidal barriers have been constructed at the mouth of Tilbury Docks, and across Benfleet Creek, Fobbing Creek and East Haven Creek at Canvey Island.

The defences along the Thames frontage of Thurrock, Castle Point and Southend are predominantly classed as 'hard defences' (Figure A3, Appendix A), and classified as being in good to excellent condition (Figure A4, Appendix A). This data was taken from the Environment Agency NFCDD database, but due to private ownership and accessibility issues does not form a continuous data set for the entire length of river frontage.

6.1.2 North Sea

The eastern boundary of South Essex is formed by the land/sea interface from Shoeburyness and North to the mouth of the River Crouch. This area is generally low-lying and fairly undeveloped in comparison to the southern Thames Estuary coastal zones. Tidal flooding is the main source along this boundary, which forms an exposed but defended coastline.

Tidal information for the North Sea in the Sheerness area is available from the Admiralty Tide Tables (UKHO, 2004). The reported mean high water spring tide at Sheerness is +2.9m OD and reported mean low water spring tide is -2.3m OD. These figures indicate a tidal range of 5.2m under normal conditions but do not account for waves or storm surge, which can increase the water level significantly.

The defences along this stretch of coastline consist of a combination of large earth embankments and hard defences (Figure 3A, Appendix A). The overall condition of these defences is classified as 'good condition in need of maintenance' (Figure 4A, Appendix A), however the protection standard (i.e. able to protect from flooding from a 1 in 1000 year event) of these defences is poor. From Shoeburyness northwards to Foulness Point, the Ministry of Defence owns much of the land behind the defences. Public access is restricted making it extremely difficult to assess the condition of defences and enforce required improvements to the standard of flood defence in this area. Specific defence surveys for this area estimate the average standard of defences to be approximately 5 years. This is well below the EA required standard of 200 years for developed areas.

6.1.3 River Crouch

The River Crouch extends from its source in Little Burstead to the east of Battlesbridge where it becomes tidal and forms part of the Crouch Estuary. The Crouch has a catchment size of 109.7km² and a main river length of 16km. Two thirds of the lengths of both the River Roach and Crouch are estuarine. The estuary banks are home to £650m of assets, 12,000 hectares of flood plain and 27,000 properties (Essex County Council, 2005).

The River Crouch is identified by the Environment Agency flood risk map as having extensive floodplains, with a 'significant' (or greater than 1.3% chance) risk of flooding. These catchment areas are fairly sparsely populated areas in comparison to areas in the south of the region.

The Roach and Crouch Estuary Management Plan (Environment Agency, 2005 currently in draft), outlines the management strategy for the Roach and Crouch estuaries. The plan recognises the need for managed retreat in order for the areas of saltmarsh to increase, thus dissipating some of the energy from wave action. This is outlined as a particularly relevant management strategy in order to combat the effects of sea level rise that is likely to render the already eroding hard sea defences in the region inadequate in the near future.

The defences through this area are formed through a mixture of hard defences, embankments and culverted watercourses of overall good condition but in some places in need of maintenance (Figures 3A and 4A, Appendix A).

6.1.4 River Roach

The River Roach originates in Rochford at the confluence of three tributaries, Hockley Brook, Payleight Brook and Noblesgreen Ditch. The river becomes tidal downstream of Rochford at Rochford Mills where another watercourse, the Prittle Brook, joins the river after flowing through Southend-On-Sea. These watercourses drain to the Roach Estuary, with a catchment area of 54.8km² and a combined tributary length of 20km.

The River Roach is identified by the Environment Agency flood risk map as having extensive floodplains, with a 'significant' (or greater than 1.3% chance) risk of flooding. These catchment areas are fairly sparsely populated areas in comparison to areas in the south of the region.

Within the 12,000ha of coastal floodplain surrounding the Rivers Crouch and Roach, there are a significant number of assets including over 2,700 properties and 168km of flood defences.

The main type of flood defence along the River Roach takes the form of earth embankments, combined with various revetment structures to provide additional toe protection from erosion and scour. These have largely been classified as 'hard' defences for the purpose of modelling in the SFRA in accordance with the EA's NFCDD classifications.

The draft Roach and Crouch Estuary Management Plan recognises that the crest levels of some of the existing defences are sufficiently low enough to result in a high probability of flooding in the absence of any defence improvements. The NFCDD database indicates the defences along the River Roach to be in generally good condition in need of maintenance (Figure A4, Appendix A), although this doesn't take into account the design standard of crest protection of the defences, highlighted as 5-10 years standard of protection in the Roach and Crouch Estuary Management Plan draft.

6.1.5 River Mardyke

Beginning in the Brentwood hills, the River Mardyke has two main sources at Langdon Hills and Cranham. The tributaries then converge to flow through a more enclosed valley, eventually discharging into the River Thames at Purfleet. The Mardyke catchment is 111.6km² and has a main river length of 18.5km. The Mardyke has been modified with a flood relief scheme, with channel widening and raised banks so that it is only overtopped in extreme events.

Wooden floodgates exist on the Mardyke where it joins the Thames at Purfleet. These gates are self-activating, closing under pressure from the rising Thames, thereby protecting the Mardyke from excessive tidal movement. These defences are currently undergoing improvement works by the Environment Agency.

The Mardyke is primarily a source of fluvial flood risk in the upper catchment areas, although if the defences at the Thames failed this system would experience tidal flooding behind the tidal gates. This source of flooding would have greater consequences in a heavily urbanised area than overtopping flooding upstream in relatively rural areas.

6.1.6 Anglian Water Sewer Flooding History Database

Along the estuary to the east, urban areas generally have a combination of gravity outfalls and pumps. Canvey Island has 12 surface water pumping stations and the low-lying Tilbury areas have numerous pumping stations to drain the low-lying marsh areas. The grazing marshes have extensive networks of channels to provide storage when the gravity outfalls are tide locked. The control of water levels has an important influence on their habitat and landscape value.

Anglian Water provides sewerage services for the entire study area. Anglian water maintain digital records of sewer blocks and flooding incidents, although these do not differentiate between surface water flooding, burst sewers and surcharging events etc.

6.2 Flood Defences in South Essex

This section describes some of the main flood defence types encountered in the SFRA study area, Figures A3 and A4 detail the classification and condition for each flood cell.

In general the condition of the defences is categorised as 'good' by the NFCDD (recent survey for the Thames 2100 project), but there are locations around the coastline where essential remediation and improvement works are required. Details of condition are given in Figure A4, Appendix A.

6.2.1 Earth Bunds (Earth Embankments)

Earth bunds, also known as earth embankments, protect an area from flooding by providing a mass of earth, which raises the surrounding land level preventing inundation from a specific direction. Typically the crest of a bund is flat and a minimum of 3m wide. Wider bunds have a reduced risk of breaching. Side slopes down from the crest to the natural level of the land have a gradient of 1 in 3 as a maximum, but the actual slope depends on the material used to construct the bund.

Bunds are constructed from mass fill material, the majority is usually earth, but other bulk fill material, such as aggregates, may be used to form the core. Bunds may be reinforced with piles, concrete retaining wall structures, or sheet pile walls driven through the crest, to provide structural stability, additional resistance to breaching and to raise the level of protection. In these situations the failure is significantly different. Therefore for breach analysis, reinforced earth bunds are classified as hard defences.

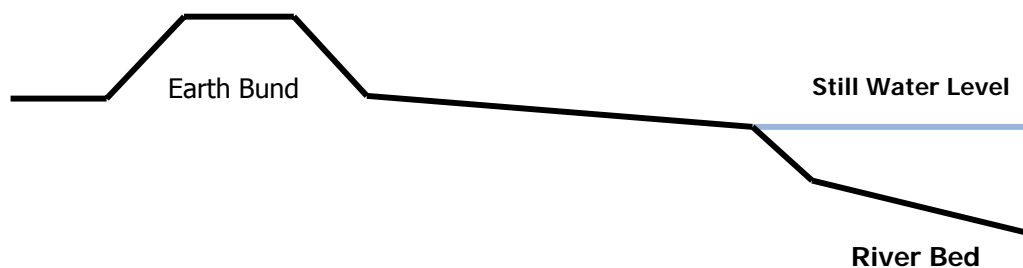


FIGURE 6-1 TYPICAL CROSS SECTION OF EARTH BUND

Bunds are typically covered with grass to prevent erosion. Where bunds may be subject to high flow velocities or wave action the bund may have a revetment on its watercourse face or rock armour to prevent scour and erosion. Bunds may be placed directly along the watercourse edge or setback and can often be used further inland to limit possible flood extents.

Defences along the Thames estuary were upgraded as part of the construction of the Thames Barrier and associated flood defences to provide flood protection until 2030. Reinforced earth bunds form the majority of the defences along the Thames estuary and are typically designed to provide a 1 in 1000-year flood protection standard.

Earth bunds in South Essex are a common defence structure along the North Sea and outer Thames Estuary boundaries often incorporating extra toe protection from scour and erosion.



PLATE 6-1 A GRASSED EARTH BUND EXAMPLE ALONG THE NORTH SEA COASTLINE IN ROCHFORD



PLATE 6-2 EARTH BUND (RIVER THAMES, THURROCK) FORMING SECONDARY DEFENCE BEHIND CONCRETE DEFENCE WALL. THE CREST OF THE EARTH BUND IS UTILISED AS A RECREATIONAL FOOTPATH.

6.2.2 *Revetment*

Revetments are armouring placed along embankments or natural channel banks to prevent erosion and scour from wave action and/or high flow velocities. The armouring may be constructed from a wide range of materials including concrete, Essex blocks (small rectangular blocks), or rock armouring.

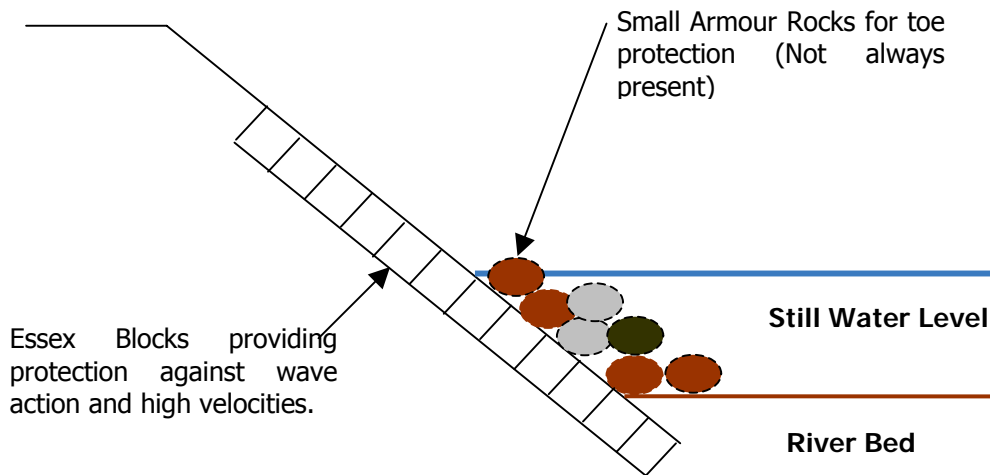


FIGURE 6-2 TYPICAL CROSS SECTION OF ESSEX BLOCK REVETMENT WITH ROCK ARMOUR TOE PROTECTION



PLATE 6-3 ESSEX BLOCK REVETMENT ON AN EARTH BUND WITH ADDITIONAL ROCK ARMOUR TOE PROTECTION PROVIDING GREATER STABILITY AT THE TOE OF THE STRUCTURE, REDUCING UNDERCUTTING AND EROSION (SOUTHEND).

6.2.3 River walls

River walls (also known as seawalls when used along open coastline) are protective walls built along the shoreline. They provide protection from high water levels and heavy wave action.

The majority of walls are constructed from steel reinforced concrete but can also be constructed from timber and sheet pile wall. Walls can vary in shape and style depending upon the requirements of the location.

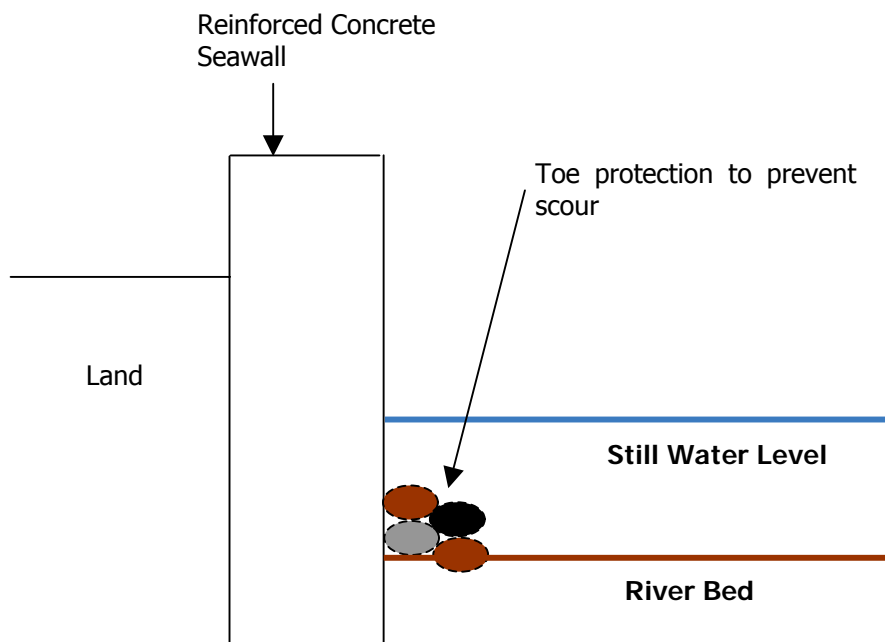


FIGURE 6-3 TYPICAL CROSS SECTION OF QUAY WALL.



PLATE 6-4 RIVER WALLS ALONG THE RIVER THAMES, TILBURY. THE WALL IS PROVIDING COASTAL FLOODING PROTECTION AND HAS CONCRETE APRONS AT THE BASE TO PROVIDE FURTHER PROTECTION AGAINST SCOUR.

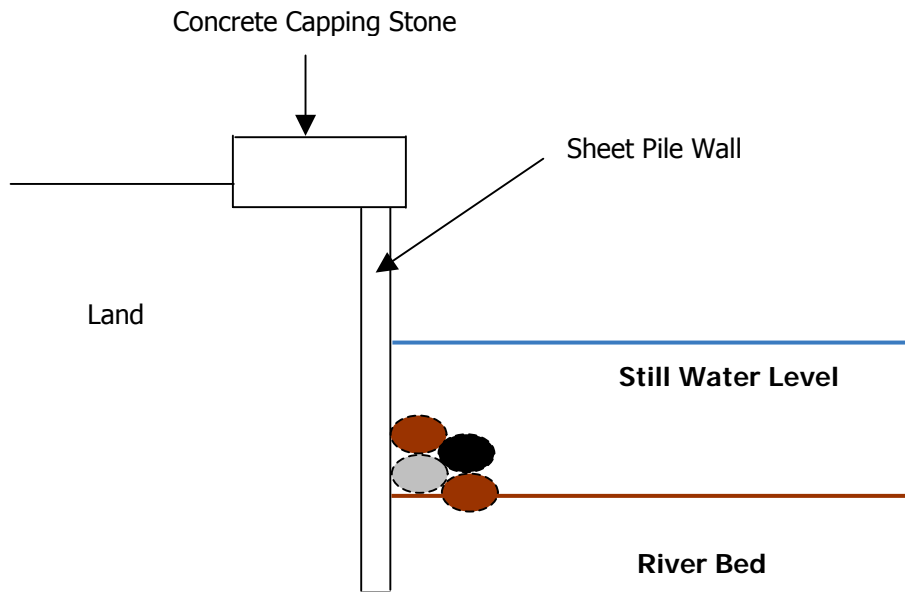


FIGURE 6-4 TYPICAL CROSS SECTION OF SHEET PILE WALL.



PLATE 6-5 EXAMPLE OF SHEET PILE WALL AS A PRIMARY FLOOD DEFENCE



PLATE 6-6 EXAMPLE OF SHEET PILE WALL AS A SECONDARY FLOOD DEFENCE

6.2.4 Floodgates

Where access is required through the flood defences, floodgates may be constructed. These are normally operated manually, and consist of a gate that is generally watertight with an appropriate crest height to prevent overtopping. The Environment Agency is generally responsible for floodgates, and is responsible for issuing tidal flood warnings and ensuring the floodgates are closed as necessary. In some places local agreements exist between the council and private landowners regarding floodgate operation.



PLATE 6-7 FLOODGATES AT CANVEY ISLAND

6.2.5 Culverts

Culverts are covered channels where flow passes through or under an obstruction (embankments, roads, railway lines, etc.) They are often constructed of a rectangular (also known as box) or circular channel section made from concrete. Culverts can be idealised as a large pipe where flow is rarely enough to fill the cross section.

Culverts are used as a means of controlling watercourse flow and function as a flood defence structure along fluvial watercourses. Culverted channels are often constructed with tide flaps at their discharge point to avoid surcharges and backflow during high tides.

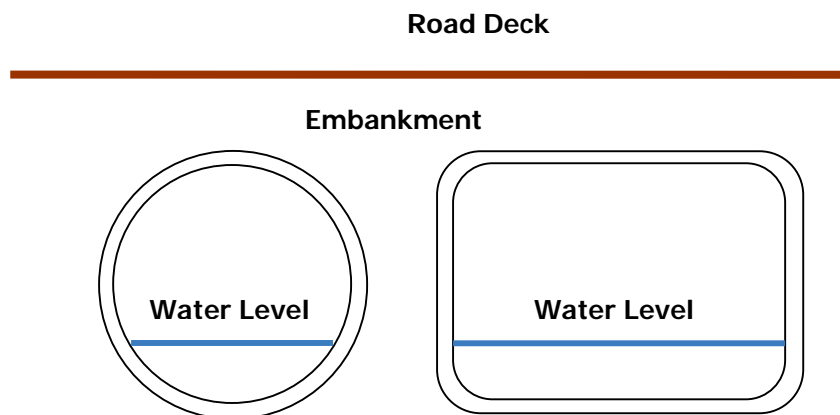


FIGURE 6-5 CROSS SECTION OF A CIRCULAR CULVERT AND BOX (RECTANGULAR) CULVERT

Culverts are commonly found in South Essex on smaller ordinary watercourses and drains on the marsh areas of Tilbury, supporting surface water drainage systems in areas such as Canvey Island. The culverts are generally marked as 'other' on Figure A3, and can be seen to follow many of the inland watercourses of South Essex.



PLATE 6-8 EXAMPLES OF CULVERTS INSTALLED THROUGH FLOOD DEFENCES SHOWING TIDE FLAPPED OUTFALLS TO PREVENT A BACKWATER EFFECT DURING HIGH TIDE EVENTS

6.2.6 Barriers

Barriers function as a flood defence structure through various mechanisms of rising, falling or rotating and may be automated or manually operated. The very nature of the defence is to provide a 'barrier' to the storm surge or extreme high tides, effectively blocking the influx of water into the channel and protecting the adjacent lands from inundation of floodwater.



PLATE 6-9 FOBBING HORSE BARRIER AT HOLEHAVEN, THURROCK

Barriers are typically of two constructions, Rising Segment Barrier or Falling Radial Barrier.

Rising Segment Barriers

Rising segment barriers consist of a circular segment, which in the closed position is recessed into the riverbed. The gate closes by rotating the segment out of the bed to an upright position providing a barrier against the flow.

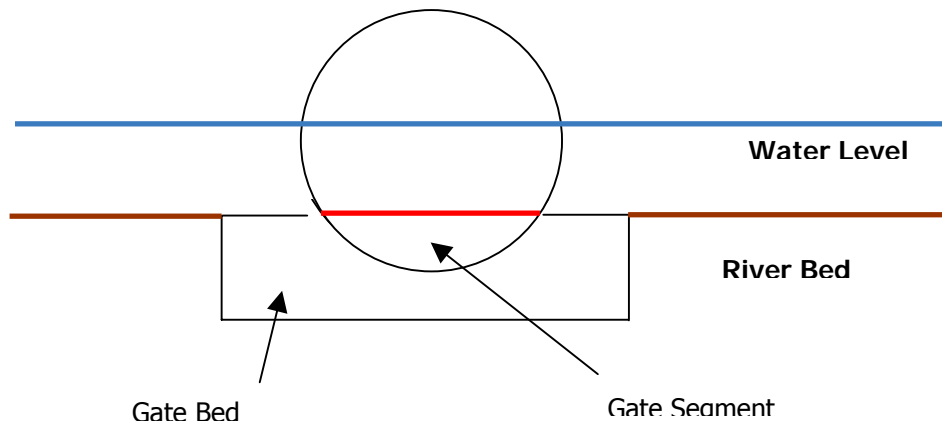


FIGURE 6-6 RISING SEGMENT BARRIER (OPEN POSITION)

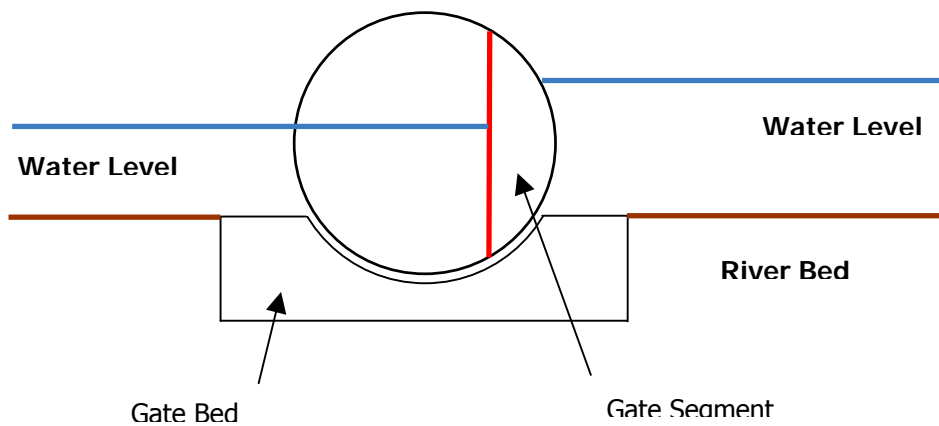


FIGURE 6-7 RISING SEGMENT BARRIER (CLOSED POSITION)

Falling Radial Barriers

Falling radial barriers have a circular segment, which in the open position is located above the water flow, typically housed under a bridge or such structure. When closed the segment lowers on to a concrete sill in the riverbed blocking the flow.

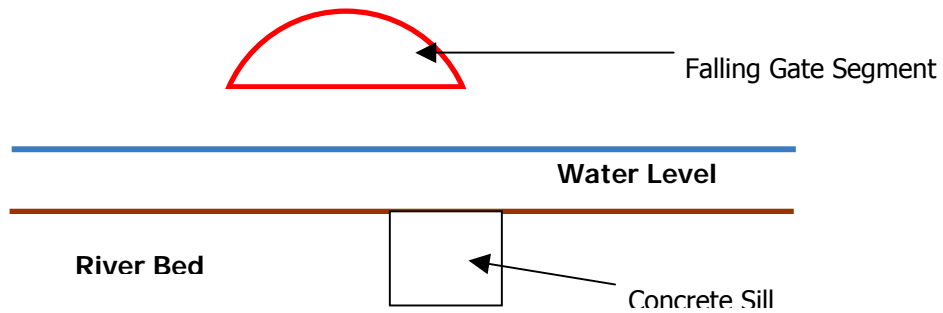


FIGURE 6-8 FALLING RADIAL BARRIER (OPEN POSITION)

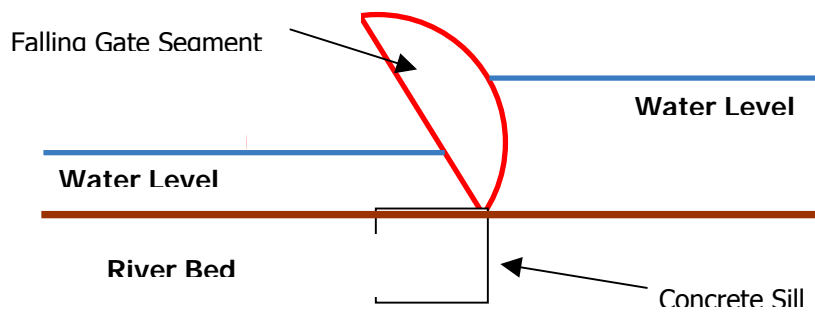


FIGURE 6-9 FALLING RADIAL BARRIER (CLOSED POSITION)



PLATE 6-10 BENFLEET BARRIER ACROSS BENFLEET CREEK AT CANVEY ISLAND.

PLATE 6-11 EAST CREEK BARRIER ACROSS EAST HAVEN CREEK AT THE CONFLUENCE WITH HOLEHAVEN CREEK ON CANVEY ISLAND.



A large barrier is built across the mouth of Tilbury Docks. The barriers in South Essex are all automated, and maintained by the Environment Agency.

Large wooden and concrete floodgates have been constructed at the mouth of the Mardyke and River Thames. The gates are self-activating and close under pressure from the rising River Thames, thereby protecting the Mardyke upper reaches from excessive tidal movement and floodwaters during extreme tide events. These defences are maintained by the Environment Agency.



PLATE 6-12 MARDYKE SLUICE GATE AND SUPPORTING STRUCTURE, THURROCK.

6.3 Flood Warnings

The Civil Contingencies Bill requires that the Environment Agency 'maintain arrangements to warn the public of emergencies'. The EA are responsible for issuing flood warnings to the public based on meteorological reports and forecasts, including the use of radar to track storms and rainfall intensity, and data from the national tide gauge network. The warnings are issued by local radio, supplemented by direct dial telephone systems and other local systems as appropriate.

The EA has general supervisory and other statutory duties for flood defence and flood warnings in South Essex. The work carried out to meet these duties includes:

- Maintaining main river channels and flood defence structures
- Providing and operating a flood warning service

The existing warning service provided by the EA applies only to flooding from rivers and the sea. Some parts of the country provide a nominal groundwater flood warning service. There is no obligation on Water Companies to provide warnings of flooding from sewers or drains.

The degree of advance warning that can be provided is critical to the amount of action that can be taken to prevent damage. However the ability to provide a minimum of 2 hours - the standard currently used in England and Wales for river flooding can vary considerably due to the geography of an area, the intensity of the rainfall and the type of weather systems causing the rain. In the case of flooding from the sea an entirely different set of natural parameters needs to be measured and assimilated into forecasting systems in order to provide predictions of sea level and wave height.

When conditions require, e.g. forecast high tide with high winds, the moveable flood barriers on the Thames at Fobbing and Tilbury are manned by EA staff and closed if necessary. A number of openings occur in the raised river defences along the Thames, and steel floodgates are erected at these points. A notable example exists at Grays Town Wharf. Here it has been agreed the floodgate will remain open to allow public access to the riverfront but EA staff will close it when high tides are a threat.

The cause of coastal flooding is usually from high tides and waves overtopping defences. High tides are predictable years in advance, but on their own seldom cause flooding.

Flooding on the coast is usually the result of a combination of high tides, storm surges and waves. Storm surges are caused by atmospheric conditions and wind action and are usually accompanied by strong winds that cause severe waves. DEFRA funds the Met Office to provide daily forecasts of surge and wave conditions that are used by the EA, in combination with tide levels and local knowledge, to provide coastal flood warnings.

The role of flood warnings in flood risk and residual risk reduction can be either a stand-alone measure or in combination with built defences. Flood warning as a stand-alone measure can reduce the consequences of flooding to properties by enabling reactive action to protect life and reduce the effect of flooding on property. Flood warning in combination with built defences can protect life and reduce damage in the event of the defence level being exceeded by the severity of the flood. In the case of much of South Essex this could take the form of a breach in the tidal defences.

The need for flood warnings in defended areas, such as South Essex, is particularly important as the consequence of flooding in areas where people's perception of flood risk is low can be significant. In such cases flood warning needs to work closely with local authority emergency planning to allocate potential evacuation routes and contingency plans following a flood event. The difficulties of issuing effective warnings of possible defence failure poses a significant challenge and in some cases it will not be practical to provide a reliable or timely flood warning service to an area because of the rapidity or unpredictable nature of flooding.

6.4 Flood Mechanisms in South Essex

The SFRA Inception Report identified that the main focus of the SFRA should be on breaching, as these events are likely to have the greatest consequence. Table 6-2 gives an overview of the sources of flood risk and an indication of the scale of consequence associated with such an event. This identifies the greatest consequence arising from overtopping or breaching of defences during extreme events. The terms for scale of consequence are broadly based on the number of dwellings an event might impact. The following scale, developed by Scott Wilson from previous flood risk experience in the Thames gateway area, has been used:

- Very large = 100+ houses/buildings
- Large = 50-100 houses/buildings
- Medium = 10-50 houses/ buildings
- Small = 1-10 houses buildings

This section describes the main flooding mechanisms throughout South Essex, providing a background for the flood risk analysis later in the subsequent Appendices.

6.4.1 Overtopping

Overtopping occurs when water passes over a flood defence. Low levels of overtopping may arise even when the defence crest level is higher than the water cycle, due to the action of winds, waves and spray. Higher levels of overtopping occur when water levels exceed the defence level and overflowing is occurring.

When flow exceeds the capacity of the channel to convey that flow the water in that channel will rise until the point is reached where the banks of the channel are overtopped. Water will then spill over the channel banks and onto adjoining land. With an upland river the adjoining land is its natural floodplain, which will generally be of limited extent and fairly well defined. In a downstream river where the gradient flattens the floodplain can be much wider (i.e. Tilbury marshes). Flood defences and urban development can significantly alter the natural flow paths within the floodplain area and affect the dispersion of floodwater.

The area of South Essex is predominantly flat low-lying land with small areas of high relief in the north and west. Marshland features heavily in this region including the West Thurrock Marshes, West and East Tilbury Marshes adjacent to the Thames with Bowers and Hadleigh Marsh around Benfleet Creek and Clements Marsh on the banks of the River Roach.

Flood defences are usually designed with a degree of 'freeboard', the height by which the crest level of the defence exceeds the design flood level. Main river and tidal embankments are designed to have a constant freeboard above their design level so, in theory, when they are overtopped the overflow should be small in volume and of uniform depth along the full length of the defence embankment, occurring during the highest water levels at the peak of the tide/flood. In reality the freeboard varies from point to point due to the natural subsidence of defences over time, and water heights can be exacerbated by wave action. Even so, the embankment acts like a weir limiting the rate of flow and volume over the embankment and limiting flooding velocities and volume to the immediate area.

Overtopping from a fluvial source is therefore likely to be lower in magnitude and volume than overtopping from tidal sources. This is because the source of water from a river is limited, and once the capacity of the channel has been increased through overtopping the general water level in the fluvial channel may recede below the defences. In tidal conditions this mechanism does not exist. The source of water is far greater from a tidal source, and will only cease to overtop when the tide levels have decreased below the height of the defences.

6.4.2 Breaching

Breaching of flood embankments is one of the main causes of major flooding in lowland areas. Breaches can occur in any situation where there is a defence which has a crest raised above adjacent land levels.

An earth embankment may be breached as a result of overtopping, which weakens the structure through erosion, eventually creating a breach in the defences. Breaches in tidal and fluvial embankments are more likely during high water level events including extreme tides or periods of high river flow. A fluvial breach in an embankment will result in the dispersal of floodwater from the channel resulting in a lowering of the water levels and flow through the breach. However with tidal embankments the level of water flow driving through the breach will remain unaffected by the volume flowing through the breach.

The time taken for a breach to be sealed can have a major effect on the extent and depth of flooding. This is discussed in more detail in section 7.4. In addition to the flood risk associated with a breach event, there is an implied flood hazard. The highest hazard exists in the period immediately following a breach, and usually, but not necessarily, in the areas closest to the breach. Floodwater flowing through a breach will be of high velocity and volume, dissipating rapidly across large low-lying areas, and possibly affecting evacuation routes. Flooding as a result of a breach in defences, either from fluvial or tidal sources, can be life threatening with far reaching consequences.

Breach Locations

The risk of flooding from breaches in flood defences was recognised by the Inception Report. Consequently the Inception Report specified that the SFRA should consider the risk to the South Essex area from breaches in local flood defences. To assist in this assessment the participating boroughs were asked to contribute specific breach locations they considered important for assessment. These are located such that they represent places of known weakness or vulnerability in the existing defences, or in locations where a breach would be expected to have the greatest consequence.

The breach locations specified by the participating boroughs are presented in Table 6-1

Breach Location	OS Grid Reference	Breach Location	OS Grid Reference
East Thurrock	TQ 687 761	Canvey Island 5	TQ 816 827
East Tilbury	TQ 693 785	Canvey Island 6	TQ 809 843
Mucking	TQ 702 810	Canvey Island 7	TQ 790 850
Tilbury	TQ 618 771	Barrier Benfleet Creek	TQ 791 855
West Thurrock	TQ 588 764	Barrier Vange Creek	TQ 740 843
Mardyke	TQ 548 788	Sh'ness Old Ranges	TQ 937 842
Holehaven Creek	TQ 744 838	Sh'ness New Ranges	TQ 955 860
Purfleet	TQ 564 771	Sh'ness East Beach	TQ 947 860
Tilbury Docks	TQ 626 755	Southchurch Park	TQ 901 848
Thames Haven	TQ 746 818	Old Leigh	TQ 842 856
Grays - Columbia	TQ 611 775	Wallasea Island	TQ 947 950
Grays–St Leonards	TQ 608 776	South Fambridge	TQ 855 962
Centurion Way	TQ 548 785	Paglesham	TQ 948 922
Canvey Island 1	TQ 752 834	Wakering Stairs	TQ 969 871
Canvey Island 2	TQ 771 826	Morrins Points	TQ 963 867
Canvey Island 3	TQ 781 820	Oxenham farm	TQ 957 887
Canvey Island 4	TQ 795 825	Paglesham Creek	TQ 923 938

TABLE 6-1 BREACH LOCATIONS AND SFRA REFERENCE

6.4.3 Mechanical or Structural Failure

Flooding may result from the failure of engineering installations such as tidal barriers, land drainage pumps, sluice gates and floodgates.

Structural failure in the context of this section is also taken to include the failure of hard defences along the South Essex coastline. Hard defences may fail through the slow deterioration of structural components such as the rusting of sheet piling, erosion of concrete reinforcement and toe protection or the failure of ground anchors. Such deterioration is often difficult to detect, so that failure when it occurs is often sudden and unexpected. Failure is more likely when the structure is under maximum stress, such as during extreme tides, when pressures on the structure are at its most extreme.

The risks associated with flooding of this type are difficult to quantify. The Environment Agency regularly monitors the condition of the flood defences in South Essex, and has a rolling five-year programme for maintenance of flood defences. Flooding resulting from mechanical failure has been considered in this SFRA in the context of barrier failure during extreme tides in the Thames, at the major flood barriers/structures of South Essex. These include the Mardyke, Tilbury Docks, East Haven and Benfleet, the results are detailed in the relevant appendices.

6.4.4 Localised Flooding

Surface Water

Localised flooding can occur as a result of severe storms, which are localised in extent and duration. The intensity of the rainfall in urban areas can create runoff volumes that temporarily exceed the natural or urbanised sewer and drainage capacities, creating 'flash' flooding, referred to in this document as Surface Water Flooding.

Surface water is the overflow from any urban runoff and from sewage systems when the rainfall intensity exceeds the capacity for the drainage systems. This will become a more common occurrence in the future, due to climate change and an increase in the number and intensity of convective storms. It is now fairly widely accepted that one of the main effects of climate change in the South East will be a higher intensity rainfall and winter storms, which will increase the risk of flooding from surface water.

In lowland areas such as South Essex, the topography results in dispersal over a wide area. Local flooding of this kind is often exacerbated by deficiencies in the local surface water drainage system, temporary blockages or saturated ground conditions. These can often be remedied through reactive management once they have been identified in a flooding event.

Groundwater

There is a risk of groundwater flooding in the South Essex region. Groundwater flooding usually occurs following a prolonged period of low intensity rainfall and although there are no records of significant groundwater flooding in the region, it is still a possibility. The future risk from this source is more uncertain than surface water as the climate change predictions indicate that although sea levels will rise, thus possibly raising groundwater levels, overall summer rainfall will decrease, therefore having a long-term effect of lowering the groundwater levels.

Although often disruptive, these types of flood are more suited to site specific Flood Risk Assessments than strategic-scale studies, especially when their consequence is compared against the greater hazard posed by breaching of a major flood defence embankment.

Data availability

Draft PPS25 states that all sources of flooding must be applied through the sequential test, to include surface water and groundwater. Records for surface water, groundwater and other historic flooding events from the participating authorities in South Essex have therefore been included in the relevant appendices. However, due to the unpredictability of this type of flooding, data collection is generally of a sporadic nature, and flood risk relating to surface and ground water should be addressed at a localised site-specific scale through the flood risk assessment process.

The data sets included in the appendices are not comprehensive and of little constructive use on a spatial scale. The Environment Agency hopes to identify areas prone to groundwater flooding as part of the Thames 2100 project, which has included analysing fire brigade information on the source of flood events they have attended. If surface water and groundwater flooding are to be considered on a strategic scale in future, local authorities, water companies and the Environment Agency need to consider improved methods for consistent and comprehensive data collection relating to this flood source.

TABLE 6-2 SOURCE PATHWAY RECEPTOR TABLE, CONSEQUENCE SUMMARY

Source	Pathway	Receptor	Scale of Consequence	Comments
				Further descriptions of the receptor areas and flood implications through breach scenarios are discussed in later chapters.
Tidal Flooding from the River Thames	Breach, overtopping of defences	Flood cells	Very large	A large number of significant infrastructures, industrial, commercial and residential developments are located along the banks of the Thames and could suffer severe flooding with significant risk to people.
Tidal Flooding from the North Sea	Breach, overtopping of defences	Flood cells	Very large	A large number of significant infrastructures, industrial, commercial and residential developments are located near the North Sea defences and could suffer severe flooding with significant risk to people.
Tidal/ Fluvial Flooding from the River Crouch	Breach, overtopping of defences	Flood cells	Large	Although less built up the flood cells in this area are quite extensive. Therefore a potential large number of developments could be flooded with significant risk to people.
Tidal/Fluvial Flooding from the River Roach	Breach, overtopping of defences	Flood cells	Large	Although less built up the flood cells in this area are quite extensive. Therefore a potential large number of developments could be flooded with significant risk to people.
Tidal/Fluvial flooding of Mardyke main river	Failure of tidal sluice would result in upper reaches and area behind sluice from fluvial overtopping of defences.	Property located in upstream area of the Mardyke sluice, and in the upper reach floodplains.	Medium to large	A failure in the sluice would result in either tidal inundation or the backing up of fluvial water. A small number of properties would be at risk directly upstream from the sluice and along the upper reaches. Possibly not of risk to life as flooding from this source would be gradual.
Surface Water Flooding	Drain blockage, saturated marshland and drainage systems. Failure of pumps or sluice outfalls.	Properties in the local vicinity of surface water drains, marsh systems, and upstream of sluice outfalls.	Small to Medium	A limited number of properties are involved with surface water flooding, which varies seasonally, and is limited in duration and volume. This should be addressed on a site-by-site basis in site specific Flood Risk Assessments.

Source	Pathway	Receptor	Scale of Consequence	Comments
Groundwater Flooding	Rising groundwater levels.	Properties in low-lying areas such as marshlands etc., civil infrastructure including road tunnels, underpasses, and excavation sites such as quarries.	Small to Medium	Further descriptions of the receptor areas and flood implications through breach scenarios are discussed in later chapters. A limited number of properties would be involved with groundwater flooding. Locally restricted through capacity and geology. Groundwater flooding is dependent on various factors, including abstractions, local geology etc. Groundwater levels are also subject to seasonal variation. This source of flooding should be addressed in site specific Flood Risk Assessments.
Structural/ Mechanical Failure in flood defences, i.e. failure to shut barrier.	If barriers unclosed would resemble Breach of defences.	Related Flood Cells, i.e. Tilbury Docks, by a failure in the Tilbury Barrier.	Very Large	A large number of properties could be at risk in the event of barrier failure. This could also result in a significant risk to people. Barriers by their very purpose tend to provide flood protection to large low-lying areas; therefore a failure could result in very large consequences.

NB: The Scale of consequence used in the table above refers to the number of properties effected, described in further detail in section 6.4

7 METHODOLOGY

The SFRA deliverables have been produced using a combination of data sources, including Flood Zone mapping provided by the EA and outputs from breach modelling analysis. This chapter presents the methodologies used in developing the Flood Zone and hazard category maps for this SFRA.

7.1 Digital Terrain Map (DEM) Generation

A key component in the SFRA is the representation of topography throughout flood prone areas of the study area. For the SFRA, various data sources, that were made available by the Environment Agency, were utilised (e.g. LiDAR, SAR, OS maps, aerial photography).

The platform used for the generation of the DTM was the GIS package Map Info Professional (version 8.0) and its daughter package Vertical Mapper (version 3.1).

The topographical information for the SFRA is primarily based on filtered LiDAR data provided by the Environment Agency. Filtered LiDAR data represents the "bare earth" elevation with buildings, structures and vegetation removed. Where LiDAR data was not available SAR data was used. Through use of this data, the DTM used in hydraulic modelling has the highest resolution possible (i.e. 2m for the LiDAR data and 5m for the SAR data).

7.2 Flood Cell Definition

The Inception Report (Faber Maunsell, 2005) presents the national grid references for several breach locations in tidal defences throughout South Essex. The breach locations were specified by the Thames Gateway South Essex Partnership based on local knowledge of defence condition, the location of future development sites, historical flooding events and/or the vulnerability of local communities. Figure A5-1 and Figure A5-2, Appendix A present the breach locations considered for the SFRA.

During the modelling analysis (detailed below), additional breach locations were proposed to supplement the breach locations identified in the Inception Report. These additional breach locations were selected based on a review of the modelled outputs from the initial breach locations and selected to enhance the quality of the modelled outputs. The additional breach locations are also shown in Figure A 5-1 and Figure A 5-2, Appendix A.

Integral to the modelling methodology (discussed in section 7.4) is the definition of flood cells. Flood cells are typically defined by prominent topographic features (relative to the flood source), which serve to constrain the movement of floodwater. Consequently, flood cell definition is largely independent of breach location, therefore a single flood cell may include a number of breach locations. Flood cells for the SFRA were defined from a review of the DTM and supporting OS 1:25,000 mapping.

For the South Essex study area 15 flood cells were defined. The flood cells are shown on Figure A 5-1 and Figure A 5-2, Appendix A. Table 7-1 presents the flood cell references (indicative of their location), the number of breach points located within each flood cell and the breach location reference.

A hydraulic model was constructed for each flood cell (further details are presented in section 7.4) enabling separate model runs to be undertaken for each breach location within a flood cell and for the extreme water level scenarios presented in Table 7-2.

TABLE 7-1 FLOOD CELLS AND THEIR ASSOCIATED BREACH LOCATIONS

Flood cell	Total Breach Locations	Breach Locations considered
Mardyke	1	THU06
Purfleet	3	THU05, THU08, THU13
Tilbury	3	THU01, THU04, THU09
Grays	2	THU11, THU12
East Tilbury	1	THU02
Mucking	1	THU03
Fobbing Marshes/South Benfleet	4	THU07, THU10, CAS08, CAS09
Canvey Island	7	CAS01, CAS02, CAS03, CAS04, CAS05, CAS06, CAS07
Hadleigh Marsh	1	SOU05
Southend	1	SOU04
East Southend	1	SOU01
Shoeburyness/Great Wakering	5	SOU03, SOU02, ROC04, ROC05, ROC06
Paglesham	2	ROC03, ROC07
Wallasea Island	1	ROC01
South Fambridge	1	ROC02
	Total	34

7.3 Extreme Water Level Derivation

The extreme sea water levels (1 in 200 year and 1 in 1000 year) associated with tidal flood events on the River Thames and the North Sea vary throughout the study area and consequently are specific to each breach location. The extreme sea water levels for the breach locations along the Thames Estuary are based on information generated under the Thames 2100 Project (Halcrow, 2005). Extreme water levels for the breach locations along the North Sea coast and along the Rivers Roach and Crouch are based on information presented in the Draft Roach and Crouch Estuary Management Plan (Halcrow 2006).

7.3.1 Climate Change

Estimates of the effects of climate change on extreme water levels are based on two sources of data. Climate change extreme water levels for the Thames Estuary have been obtained from the Thames 2100 project. This project has investigated the effect of a 6mm a year increase in sea level for the next 50 years and modelled its effect on extreme water levels throughout the Thames Estuary.

The Draft Roach and Crouch Estuary Management Plan does not present extreme water levels including for the effects of climate change. For the purpose of this assessment, it has been assumed that sea level rise in the North Sea will be the same as that used for the Thames 2100 project (6mm year⁻¹). This allowance is in accordance with DEFRA guidance for the Environment Agency - Anglian Region [DEFRA Flood and Coastal Project Appraisal Guidance Note FCDPAG 3]. The effect is an increase in the North Sea level of 300mm by 2055.

The extreme water levels for each breach location analysed in this assessment are presented in Table 7-2.

7.3.2 Tide curve

It is necessary to superimpose extreme sea levels onto a tidal curve. This enables a model run to accurately estimate the volumes of water flowing through a breach in defences taking into account the tidal cycle.

In general, the sea water level profile during a tidal flood event consists of two components, an astronomical tide and a surge residual. The astronomical tide is assumed to be independent of the metrological conditions. The tidal curve applied in this study has been obtained by superimposing an astronomical tide on a storm surge residual.

Astronomical tide

For the astronomical tide the mean spring tide at the breach location has been used. Mean Spring Tidal Water levels at the breach location were obtained from the Admiralty Tidal Tables (UKHO, 2004).

Storm Surge Profile

The surge component was simulated by a regular half-sinusoidal shaped water level increase. The duration of the surge event was assumed to be 40 hours (equivalent to 1.7 days). The storm surge peaks at the same moment as the second astronomical high tide.

The water levels during a tidal flood event can be found by summing the astronomical tide levels and the storm surge residual. An example of the sea water levels used for the breach modelling analysis is shown in Figure 7.1.

The repair time required to close a breach is considered to be 30 hours for a breach of an earth embankment and 18 hours for hard defences. The water level boundary used for the modelling includes three high tides in the case of a breach in an earth embankment and two high tides in the case of a breach in a hard defence.

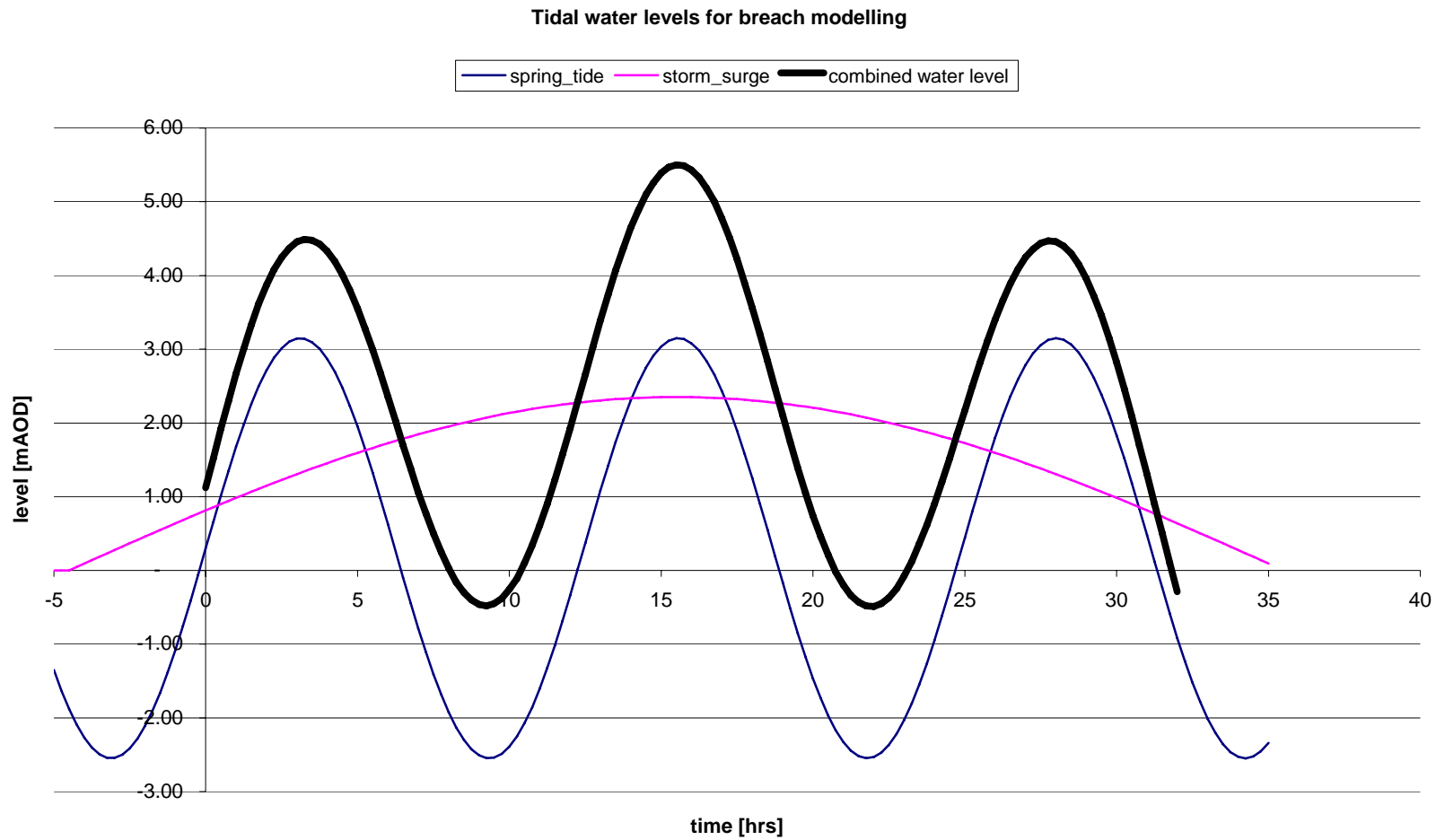


FIGURE 7-1 TIDAL CURVE USED IN ASSESSMENT OF BREACH EVENTS

TABLE 7-2 MAXIMUM SEA WATER LEVELS FOR BREACH LOCATIONS ANALYSED

Breach name	Breach Location	Easting	Northing	1 in 200 year level in 2005 [mAOD]	1 in 1000 year level in 2005 [mAOD]	1 in 200 year level in 2055 (including climate change allowance) [mAOD]	Exposure time *
THU01	Tilbury	568700	176100	5.32	5.67	5.64	Two tidal cycles
THU02	East Tilbury	569300	178500	5.19	5.54	5.51	Two tidal cycles
THU03	Mucking	570200	181000	5.13	5.5	5.46	Three tidal cycles
THU04	East Thurrock	561800	177100	5.51	5.81	5.8	Two tidal cycles
THU05	West Thurrock	558800	176400	5.55	5.85	5.84	Two tidal cycles
THU06	Mardyke	554800	178800	5.57	5.88	5.86	Two tidal cycles
THU07	Holehaven Creek	574400	183800	5.04	5.42	5.38	Two tidal cycles
THU08	Purfleet	556442	177162	5.56	5.87	5.85	Two tidal cycles
THU09	Tilbury Docks	562600	175500	N/a			
THU10	Thames Haven	574600	181800	N/a			
THU11	Grays Columbia Wharf Rd	561118	177570	5.55	5.85	5.84	Two tidal cycles
THU12	Grays St Leonards Close	560826	177666	5.55	5.85	5.84	Two tidal cycles
THU13	Centurion Way	554836	178550	5.56	5.87	5.85	Two tidal cycles
CAS01	Canvey Island 1	575200	183400	5.04	5.42	5.38	Three tidal cycles
CAS02	Canvey Island 2	577100	182600	5.04	5.42	5.38	Three tidal cycles
CAS03	Canvey Island 3	578100	182000	4.98	5.36	5.32	Three tidal cycles
CAS04	Canvey Island 4	579500	182500	4.91	5.29	5.26	Three tidal cycles
CAS05	Canvey Island 5	581600	182700	4.91	5.29	5.26	Three tidal cycles

Breach name	Breach Location	Easting	Northing	1 in 200 year level in 2005 [mAOD]	1 in 1000 year level in 2005 [mAOD]	1 in 200 year level in 2055 (including climate change allowance) [mAOD]	Exposure time *
CAS06	Canvey Island 6	580900	184300	4.91	5.29	5.26	Three tidal cycles
CAS07	Canvey Island 7	579000	185000	4.91	5.29	5.26	Three tidal cycles
CAS08	Barrier Benfleet Creek	579100	185500	4.91	5.29	5.26	Two tidal cycles
CAS09	Barrier Vange Creek	574000	184300	N/a			
SOU01	Sh'ness Old Ranges	593700	184200	4.6	4.95	4.93	Two tidal cycles
SOU02	Sh'ness New Ranges	595500	186000	4.48	4.78	4.78	Three tidal cycles
SOU03	Sh'ness East Beach	594700	185300	4.48	4.78	4.78	Two tidal cycles
SOU04	Southchurch Park	590100	184800	4.6	4.95	4.93	Two tidal cycles
SOU05	Old Leigh	584200	185600	4.85	5.23	5.1	Three tidal cycles
ROC01	Wallasea Island	594700	195000	4.52	4.79	4.82	Three tidal cycles
ROC02	South Fambridge	585500	196200	4.56	4.77	4.86	Three tidal cycles
ROC03	Paglesham	594800	192200	4.45	4.68	4.75	Three tidal cycles
ROC04	Wakering Stairs	596900	187100	4.48	4.78	4.78	Three tidal cycles
ROC05	Morrins Points	596300	186700	N/a			
ROC06	Oxenham farm	595700	188700	N/a			
ROC07	Paglesham creek	592300	193800	N/a			

* Exposure time reflects the exposure duration hours in tidal cycles, i.e. 18hours is two tidal cycles, 30 hours is 3 tidal cycles etc.

7.4 Breach Modelling

The Inception Report identified that the primary flood risk to the South Essex area was from tidal sources. An assessment of the flood sources throughout the South Essex area confirms that the largest potential impact from a single flood source is from tidal flooding. This is due to the relatively low-lying nature of the area with numerous tidal inlets and creeks including the Thames Estuary. As discussed in Chapter 6, flood protection for these areas is provided by man-made flood defences of various types and standards. Breaching of these man-made flood defences has the potential to generate the greatest flood risk hazard for this area. The Inception Report recognised this and specified that to assess the risk from tidal sources a 2D hydraulic modelling approach was required.

To assess flood propagation in events where the flood defences are breached, a hydraulic modelling analysis has been undertaken using the two-dimensional hydraulic modelling software MIKE21-HDFM (version 2005).

This section of the report discusses the methodology that has been applied for the hydraulic modelling analysis of the breach events. The choice of model is discussed, the model schematisation is described and the boundary conditions used are presented.

TABLE 7-3 OVERVIEW OF SFRA APPROACH

Source	Assessment in SFRA
Tidal Flooding from the Thames Estuary	Breach locations were specified along Thames Estuary to model potential consequences and related hazard zones within flood cells.
Tidal Flooding from the North Sea	Breach locations were specified along North Sea to model potential consequences and related hazard zones within flood cells.
Tidal/Fluvial Flooding from the River Crouch	Breach locations were specified along tidal stretches of the River Crouch to model potential consequences and related hazard zones within flood cells. Data from the breach analysis has been superimposed on EA Flood maps for fluvial stretches.
Tidal/Fluvial Flooding from the River Roach	Breach locations were specified along tidal stretches of the River Roach to model potential consequences and related hazard zones within flood cells. Data from the breach analysis has been superimposed on EA Flood maps for fluvial stretches.
Tidal/Fluvial flooding of Mardyke main river	To model potential failure of Mardyke sluice, a breach location was modelled at the mouth of the Mardyke. This assessed the potential tidal inundation from such an event and identified the associated flood area and hazard zones. Data from the breach analysis has been superimposed on EA Flood maps for fluvial stretches.
Structural/Mechanical Failure in operating engineered flood defences, i.e. failure to shut barrier.	Breach models have been undertaken at the main barrier locations of Tilbury, Mardyke and Canvey Island, to ascertain the scale of the consequences if they failed to close during high tidal conditions either through human error or structural failure.

7.4.1 Model and software selection

To achieve the study objectives, the model used to estimate the maximum flood conditions was required to:

- accommodate the effects of a flood flow (propagation of a flood wave and continuous change of water level);
- simulate the hydraulics of the flow that breach the flood defences; and
- generate detailed information on the localised hydraulic conditions over the flooded area in order to evaluate flood hazard.

To investigate the flood conditions resulting from every breach location over the study domain, the two-Dimensional (2D) hydraulic modelling software MIKE21-HDFM (MIKE21-Hydrodynamic Flexible Mesh Model, 2005 version) has been used.

MIKE21-HDFM simulates water level variations and flows for depth-averaged unsteady two-dimensional free-surface flows. MIKE21 is specifically oriented towards establishing flow patterns in complex water systems, such as coastal waters, estuaries and floodplains. The MIKE21 hydraulic modelling software is developed by Danish Hydraulic Institute (DHI) Water and Environment.

MIKE21-HDFM is a new modelling system based on a flexible mesh approach. The flexible mesh model has the advantage that the resolution of the model can be varied across the model area. The model utilises the numerical solution of two-dimensional shallow water equations.

7.4.2 Model extent and resolution

For each breach location, a MIKE21 flexible mesh model has been developed using the MIKE21 program, Mesh Generator. The mesh generator creates a mesh over the flood cell DTM using triangular elements (Figure 7.2). The element size varies throughout the model domain and depends upon the complexity of floodplain topographic features.

A MIKE21FM flexible mesh provides maximum flexibility for tailoring the grid resolution throughout the model domain. Using the flexible mesh module it is possible to generate a highly resolved mesh in areas of particular interest or in areas that are important from a hydrodynamic viewpoint and have a lower resolution in areas that have a lower priority reducing demands on computational resources.

To represent the hydraulics around the breach with a relatively high level of accuracy, a comparatively small element size has been applied in the vicinity of breaches. The breach has been represented by a minimum of 4 elements. A typical element size in the vicinity of a breach is 50 to 100m². Further from the breach locations the mesh is less resolved with a maximum element area of 2000m² on the floodplain.

Considerable parts of the study area are either urbanised or associated with man-made features (e.g. roads, embankments, walls, bridges). Urban areas and structures within the floodplain have the potential to affect the free flow of floodwater. Embankments, flood defences, significant water courses and other linear features that may be misrepresented by a large element area (2000m²) have been incorporated into the flexible mesh by creating break-lines parallel to the feature.

By adding break lines the mesh orientation is forced to follow the alignment of the features and the localised elevations of structures are used by the mesh generator rather than averaging over a 2000m² area.

The break lines of linear man-made features were schematised by reference to the DTM, 1:25000 OS maps and high-resolution aerial photographs. The crest levels of linear features, such as secondary flood embankments, road embankments and railway embankments, have been established by interrogation of the DTM. It should be noted that the features described above have been identified through a desk-top analysis only and have not been verified on the ground. **Results from the breach modelling which show strong dependence on barriers should therefore be used with caution.**

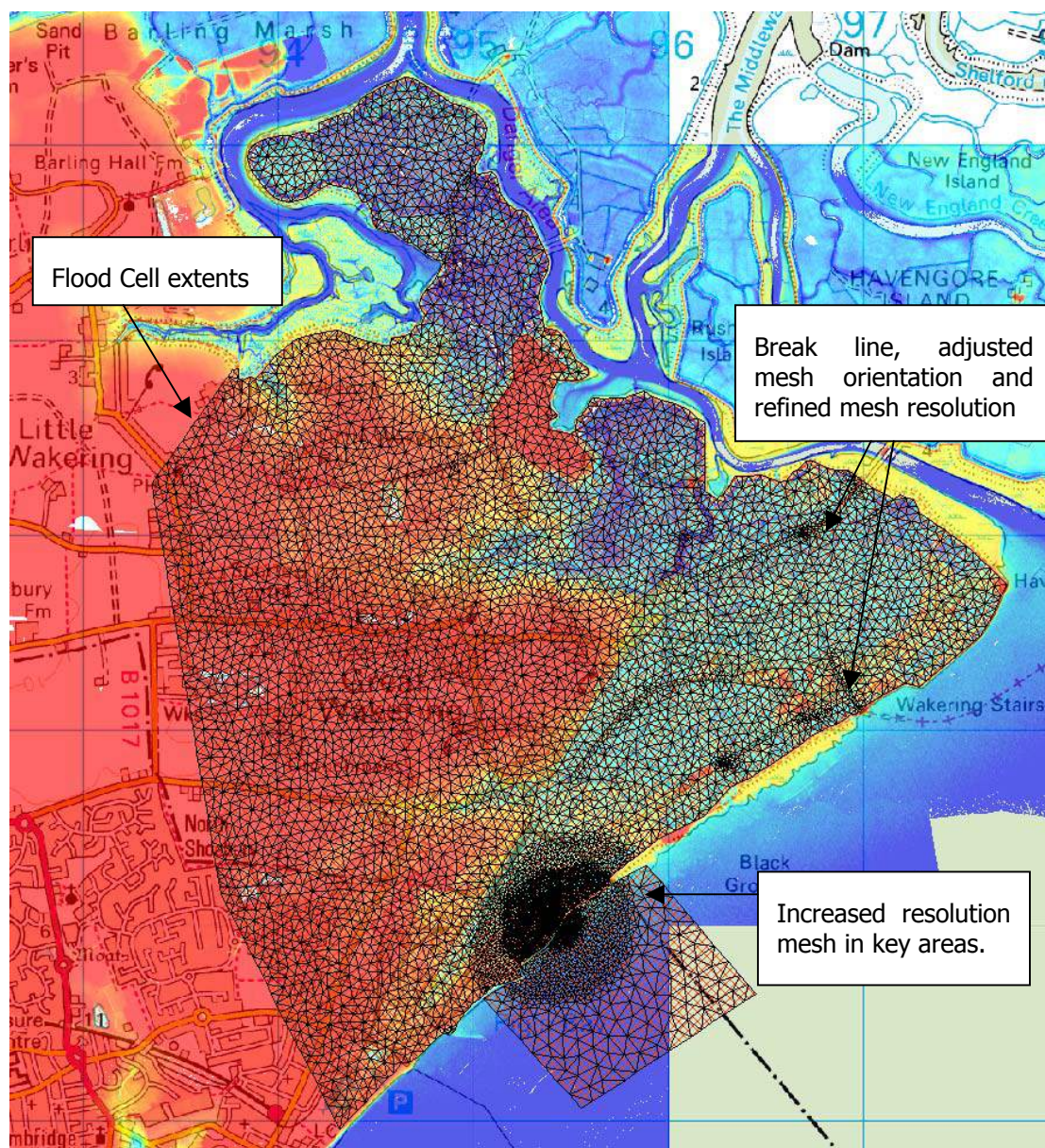


FIGURE 7-2 EXAMPLE OF MIKE 21 HD FLEXIBLE MESH

7.4.3 Breach specifications

Breach modelling was undertaken for 34 breach locations. Twenty-four locations were identified by the partnership councils through production of the Inception Report (Faber Maunsell, 2005) and ten additional breaches were proposed and agreed to enable more comprehensive mapping deliverables. The 34 breach locations considered for the SFRA are shown in Figure A5.1 to Figure A5.2, Appendix A.

The flood conditions (i.e. inundation rate, flood extent, depth of flooding) that may be experienced if a flood defence were to breach are a function of the breach dimensions, time required to repair the breach (exposure duration) and tidal conditions.

The breach dimensions and exposure duration were determined using the SFRA guidance "At Risk? Planning for Flood Risk in Yorkshire and Humber" (Environment Agency, 2004) and specifications from the Inception Report (Faber Maunsell, 2005).

The breach width and repair time (i.e. exposure duration) is determined on the location and type of embankment. For the SFRA, all flood defences at breach locations have been categorised as either, 'Hard Defences' or 'Earth Embankments'.

For each breach location, the type of embankment has been derived from inspection of aerial photographs, helicopter flight videos and 1:25000 OS maps. The breach widths and exposure durations applied to these defence types are presented in Table 7.3.

TABLE 7-4 DEFENCE TYPE BREACH WIDTHS

Location	Breach width [m]		Exposure duration [hours]	
	Earth Embankment	Hard defence	Earth Embankment	Hard defence
Thames Estuary	60 m	20 m	30 hours	18 hours
North Sea	60 m	20 m	30 hours	18 hours
Roach and Crouch estuaries	30 m	10 m	30 hours	18 hours

The base level of the breaches have been set to the lowest elevation of the land directly behind (landward) the flood defence. The elevations of land behind the flood defence have been established by interrogating the DTM. The adopted depths and dimensions for the 31 breach locations modelled are presented in Table 7.4.

In the hydraulic modelling undertaken for this study, the breach in the flood defence was present during the whole flood event, i.e. it is deemed to have occurred prior to the onset of the extreme tidal event. peak water level of the flood event. This is a conservative assumption.

It is important to note that the current condition of the defences has not been used as a criterion on which to base the breach dimensions. Instead, it has been assumed that over time all defences will be improved to the required standard. **In effect, no assessment has been taken of probability of failure.**

TABLE 7-5 BREACH CONFIGURATION FOR BREACH LOCATIONS ANALYSED

Breach name	Breach Location	Easting	Northing	Defence type	Breach width [m]	Base level of breach [mAOD]	Repair time [hrs]
THU01	Tilbury	568700	176100	Earth embankment	60	2.3	30
THU02	East Tilbury	569300	178500	Hard defence	20	1.2	18
THU03	Mucking	570200	181000	Earth embankment	60	2.0	30
THU04	East Thurrock	561800	177100	Hard defence	20	2.1	18
THU05	West Thurrock	558800	176400	Hard defence	20	2.25	18
THU06	Mardyke	554800	178800	Hard defence	20	-1.0	18
THU07	Holehaven Creek	574400	183800	Hard defence	20	1.5	18
THU08	Purfleet	556442	177162	Hard defence	20	1.0	18
THU09	Tilbury Docks	562600	175500	N/a			
THU10	Thames Haven	574600	181800	N/a			
THU11	Grays – Columbia Wharf Rd	561118	177570	Hard Defence	20	4.4	18
THU12	Grays – St Leonards Close	560826	177666	Hard Defence	20	4.85	18
THU13	Centurion Way, Mardyke	554836	178550	Hard Defence	20	5.1	18
CAS01	Canvey Island 1	575200	183400	Hard defence	20	2.0	18
CAS02	Canvey Island 2	577100	182600	Hard defence	20	2.7	18
CAS03	Canvey Island 3	578100	182000	Hard defence	20	1.5	18
CAS04	Canvey Island 4	579500	182500	Hard defence	20	1.0	18
CAS05	Canvey Island 5	581600	182700	Hard defence	20	2.5	18
CAS06	Canvey Island 6	580900	184300	Hard defence	20	2.0	18

Breach name	Breach Location	Easting	Northing	Defence type	Breach width [m]	Base level of breach [mAOD]	Repair time [hrs]
CAS07	Canvey Island 7	579000	185000	Hard defence	20	1.9	18
CAS08	Barrier Benfleet Creek	579100	185500	Hard defence	20	-0.5	18
CAS09	Barrier Vange Creek	574000	184300	N/a			
SOU01	Sh'ness Old Ranges	593700	184200	Hard defence	20	1.9	18
SOU02	Sh'ness New Ranges	595500	186000	Hard defence	20	1.8	30
SOU03	Sh'ness East Beach	594700	185300	Hard defence	20	4.0	18
SOU04	Southchurch Park	590100	184800	Hard defence	20	2.7	18
SOU05	Old Leigh	584200	185600	Earth embankment	60	3.2	30
ROC01	Wallasea Island	594700	195000	Earth embankment	30	1.2	30
ROC02	South Fambridge	585500	196200	Earth embankment	30	0.85	30
ROC03	Paglesham	594800	192200	Earth embankment	30	2.5	30
ROC04	Wakering Stairs	596900	187100	Earth embankment	60	3.2	30
ROC05	Morrins Points	596300	186700	N/a			
ROC06	Oxenham farm	595700	188700	N/a			
ROC07	Paglesham creek	592300	193800	N/a			

7.4.4 Boundary conditions

The MIKE21 breach models require one boundary condition to be defined. This is a time dependent head boundary (HT) at the seaward side of the breach location, which replicates the extreme tide levels/cycle during a tidal flood event.

PPG25 requires the consideration of tidal flood events with return periods of 1 in 200 years and 1 in 1000 years. In addition the potential impacts of climate change should also be considered.

For the breach modelling three tidal flood events were analysed for each breach location. The tidal flood events analysed were:

- A tidal flood event with a return period of 1 in 200 years in 2005
- A tidal flood event with a return period of 1 in 1000 years in 2005
- A tidal flood event with a return period of 1 in 200 years in 2055

7.4.5 Hydraulic Roughness

Hydraulic roughness represents the conveyance capacity of the vegetative growth, bed and bank material, channel, sinuosity and structures of the floodplain. Within the MIKE21 model, hydraulic roughness is defined by the dimensionless Manning's 'n' roughness coefficient.

Estimation of the hydraulic roughness was based on aerial photographs and utilisation of Environment Agency GIS layers of urbanised areas. Three material roughness classifications have been identified within the study area, including sea, urbanised areas and non-urbanised areas.

The assigned hydraulic roughness coefficients for the three defined areas is based on engineering judgement and available literature (e.g. Chow, 1979).

The applied Manning's 'n' roughness coefficients for the seabed, urbanised and non-urbanised areas were 0.03, 0.07 and 0.04 respectively.

7.4.6 Model Time-step

The model time step interval is very important with respect to the numerical stability of the hydraulic model.

The time step adopted in the MIKE21 models was chosen to ensure stability of the hydraulic models. The stability of the model is defined by two stability criteria, namely the courant number and the CFL stability condition.

In order to ensure numerical stability the courant number was kept smaller than 0.50 during the entire simulation whilst the maximum CFL stability condition was less than 1.0.

7.4.7 Model simulations undertaken

To investigate the flood conditions throughout the study area, several model simulations were undertaken. A total of 93 model simulations were undertaken; 3 flood scenarios (1 in 200 year, 1 in 1000 year and 1 in 200 year plus climate change) for 31 breach locations.

The model outputs of the individual model simulations can be found with the digital data presented in Chapter 10. The model results of the tidal flood event with a return period of 1 in 200 years in 2005 are also presented as digital animations showing the propagation of flooding on the floodplain.

7.4.8 Sensibility Review

To verify the model results a sensibility analysis was undertaken. During the sensibility analysis the model results were checked against the local topography throughout the flood cell. In addition, the predicted propagation of the flood flows was analysed using animations of the model results.

7.5 Definition of Hazard Categories

Breach analysis presents data to identify the residual risk of flooding from a failure of local defences. The mapping of hazard zones within South Essex presents the residual risk to provide an additional level of information to local planning authorities allowing them to make more detailed consideration of the sequential test and PPS25 vulnerability classifications within Flood Zone 3.

The breach model outputs of flood water depth and flow velocities have been used to determine flood hazard categories in Flood Zones 2 and 3. Flood hazard is a function of both the flood depth and flow velocity.

Flood Hazard categories have been determined for Flood Zones 2 and 3. The results relevant to each authority are presented in the relevant appendices. Each element generated by the MIKE21 Flexible Mesh generator has been assigned one of three hazard categories: "High hazard", "Medium hazard" and "Low hazard".

In most flood events the maximum hazard of a flood at a certain location is not experienced at the peak of the flood but before the maximum floodwater level occurs. This is point at which the greatest flood depths and velocities typically occur. To assess the maximum flood hazard during a flood event, the hazard level at each element of the MIKE21 mesh was assessed at every time step of the model simulation.

Definition of hazard zones

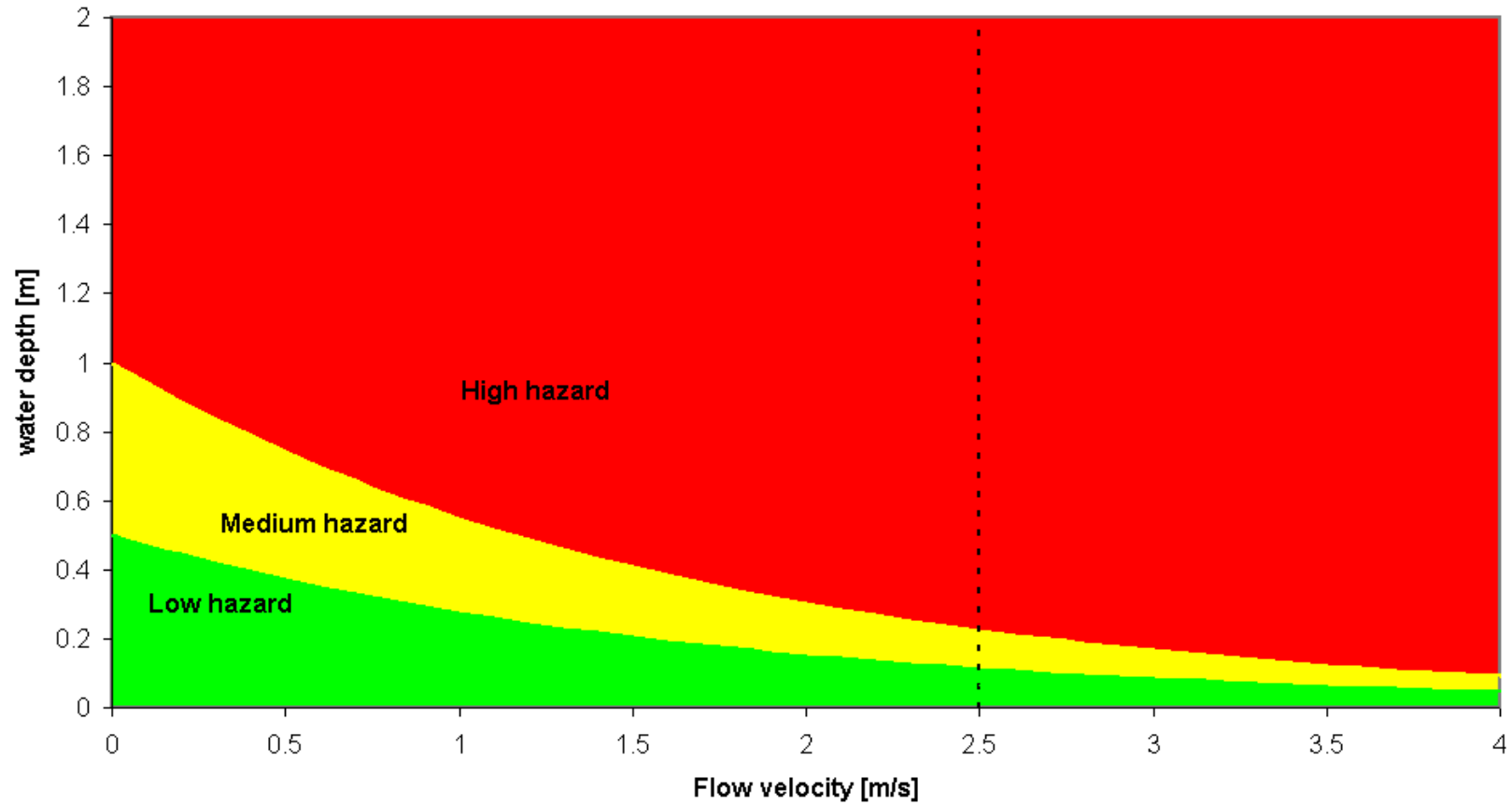


FIGURE 7-1 DEFINITIONS OF HAZARD ZONES

7.6 Mapping of Flood Zones & Hazard Zones

The mapping of flood risk zones has been undertaken using the GIS programme Map Info Professional 8. Flood and hazard zone maps have been produced for each flood cell. Flood cell maps have been produced to present the combined results of all breaches within a flood cell and the results of individual breaches (Appendices B-F). In addition, the inundation areas arising from breaches have been compared to the Environment Agency Flood Zone maps.

In areas where fluvial systems (the rivers Roach, Crouch, Mardyke and their tributaries) are present the Environment Agency Flood zones have been used directly.

Flood inundation maps have been contoured, whereas hazard zone maps have not. This is to highlight the relative uncertainty of hazard zone boundaries (defined by the flexible mesh elements) compared to flood inundation areas (defined by topographic features).

This also serves as a reminder that hazard zones are indicative and that the boundaries represented on the maps should not be considered definitive. Detailed flood risk assessments should seek to clarify hazard categories on a site-by-site basis.

7.7 Zone of Rapid Inundation

This refers to an area in the locality of a breach event or source of flooding, where a residual flood hazard would be highest as a result of high velocities and initial floodwater dispersal from a potential breach event. In general this suggests that development should be avoided within the first few hundred metres of the defences because there is a risk to all people exposed to floodwater (Environment Agency Flood and Coastal Defence R&D Programme, 2005). There is an inherent risk to properties in this area from the potential high floodwater velocities following a potential breach event.

Flood inundation animations have been supplied to the participating authorities and Environment Agency to provide further detail with regards the main flood routes and speed of inundation relating to a particular breach event. As discussed in Chapter 7.9

The East London Strategic Flood Risk Assessment (Entec 2005) assumed a 500m buffer zone, to include the zone of rapid inundation, however most of the East London SFRA area is highly urbanised. The study area for the South Essex SFRA included large areas of coastline and river/estuary areas that are largely rural, therefore breach locations were concentrated in dense urbanised areas such as Grays, Tilbury, Southend, Canvey Island etc. The existing breach scenarios provide information in relation to depth, speed and related hazard for the various flood cells in these specific areas.

However it is important to consider the probability of a breach event occurring, even in the sparsely populated areas. Therefore in rural areas where breach scenarios were not examined in greater detail, an assumption of 500m (Environment Agency Flood and Coastal Defence R&D Programme, 2005) for the zone of rapid inundation and associated high hazard would not be overly conservative. Although the local topography and existing defences would need to be considered, the definition of this area for a particular site or masterplan should be identified in a site specific flood risk assessment.

7.8 Functional Floodplains

A functional floodplain comprises an area of land where water has to flow or be stored in times of flood. The functional floodplain would flood with an annual probability of 1 in 20 (5%) in any year or is designed to flood in an extreme flood, or at another probability to be agreed between the LPA and the Environment Agency, including conveyance routes.

As the name implies the functional floodplains have the highest considered probability of flooding and as such are located in Flood Zone 3b of the sequential test (Draft PPS25). Draft PPS25 proposes the exclusion of various vulnerable development types from this flood zone. Therefore it is important to consider the location of functional floodplains in the future spatial planning and emerging LDF documents for an area.

The South Essex tidal floodplains are defended to a high standard and do not include any functional floodplains, the fluvial floodplains of the Mardyke would theoretically form functional floodplains, however this area is protected to the 1 in 25 year flood event and arguably does not form a functional floodplain.

Further floodplains of the Prittle and Eastwood Brooks in Rochford are currently under review by the Environment Agency, as is the area of Wickford in Basildon. These areas may contain functional floodplains but this information is not yet available, site specific flood risk assessments in these areas should identify whether the site lies in a functional floodplain as part of the sites flood zone classification.

7.9 Flood Inundation Animations

Animations for each breach have been produced as 'avi' files. The 'avi' files can be viewed using Microsoft Windows Media Player, a standard programme released under various version of the Microsoft Windows operating system. The animations show the local flood depth on 25k OS mapping based on a 5-minute interval. The animation files are presented as part of the digital data in Chapter 11.

8 FLOOD MAPPING AND APPLICATION

8.1 Introduction

The following section is intended for use in conjunction with the flood zone and hazard zone mapping presented in the SFRA (Chapter 7) and Appendices B-F of this report. Planning guidance indicating what type of development is likely to be appropriate in which flood zones is presented for both PPG25 (DTLR, 2001) and table D2 of the Draft PPS25 (ODPM, 2005). These tables can then be viewed in conjunction with the hazard zone mapping for specific areas to inform planning decisions and enable the LPA to go beyond the sequential test for planning or control of development within Flood Zones 2 and 3.

8.2 Flood Mapping

The strategic flood risk mapping of South Essex, and the preparation of hazard maps for 14 flood cells, has been primarily based on the results of the breach modelling carried out specifically for the purposes of this study. In addition to the PPG25 flood zone maps produced by the EA and the breach modelling within this study (see Appendices B-F), the authorities within Thames Gateway South Essex were keen to see a breakdown of Zone 3 into High, Medium and Low hazard to facilitate land allocation and assist in the local development framework production for these areas.

The depths for each hazard zone were selected subjectively in the context that they represent the risk to someone caught in floodwater, required to move a distance to safety. Other considerations in definitions of depth include range of heights and weights, people having to care for young children, the elderly, restricted movement and debris. The classification is however necessarily subjective in these respects.

The maps have been presented on an individual flood cell basis, and present a combined output of the breach model results within that flood cell (for individual breach model results refer to the DVD supplied in Chapter 10). Outside the boundary of the presented flood cell the modelling results are not displayed. To see a particular area's hazard map please refer to the relevant flood cell. The mapping does not include any flood or hazard mapping for the Kent area, for this information refer to the relevant Kent Thameside SFRA.

The hazard zone maps indicate the product of depth and velocity from a particular breach event, or combined breach event within the flood cell. These hazard classifications do not indicate a change in flood probability. It is essential to remember, when using the hazard zone maps, that **they represent hazard arising from one or more *specific* breach locations, and that hazard will almost certainly vary spatially if the breach locations are in different local areas.** Further issues in this respect should also be considered:

- Not all possible breach locations in any given authority area have been considered. Necessarily, the modelling study had to be limited to those locations thought most likely to lead to flood risk for specific development areas.
- Breach width and depth, though based on EA guidance, are arbitrary and do not necessarily represent the actual dimensions of a breach in a given location.
- Changes in inundation extent or hazard zone are non-linear to changes in breach location.

8.3 Hazard Zones

To facilitate detailed spatial planning, including site allocations, an in-depth assessment of flood risk in South Essex is required, taking into account the existing flood defences and including a more detailed consequence 'hazard' map for Flood Zones 2 and 3.

Hazard mapping presents the results of breach modelling within each flood cell of South Essex as defined in Table 7-1, and shown in Figures 5.1 and 5.2. These hazard maps enable a further breakdown of the EA flood Zone 3 into Low, Medium and High Hazard, using a consequence and risk methodology detailed in Chapter 7.

8.4 Suggested Application of the Sequential Test in South Essex

With the production of the Hazard Maps, the particular flood risk status of many areas within South Essex is recognised. Large areas of some authorities lie within Flood Zone 2 and 3 and thus, based upon the Sequential Test, are unsuitable for the majority of development types. However, such blighting is unacceptable in some key development areas, e.g. for socio-economic reasons, and the Hazard Zone system allows an appreciation of differing levels of hazard within the Sequential Test. The 'full' sequential test tailored for South Essex therefore becomes as shown in Figure 8-1.

The concept of the Sequential Test for South Essex relies on the user's understanding that when selecting a site for a given development type, or selecting from a range of development types for a specific location, the test must be followed in strict sequence.

Stage 1 of Figure 8-1 represents the PPG25/PPS25 Sequential Test. Steps A to C are to be followed, with each, from a flood risk point of view, being less desirable than the previous for a given development type (i.e. Flood Zone 2 is less desirable than Flood Zone 1). In every movement sequentially through the steps, the user must be confident that no site of a lesser flood risk is appropriate for the specific development under consideration.

Stage 2 of Figure 8-1 represents the additional Hazard Zone test for South Essex. To move to Stage 2 the user must again be confident that no site of a lesser flood risk is appropriate for the specific development under consideration. As before, each step represents, from a flood risk point of view, a less desirable site than the previous step.

As can be seen from the above schematic, the interrogation of Hazard Zone information is a series of further steps beyond the usual procedure of applying the PPG25/PPS25 Sequential Test.

It is intended that the Hazard Zones classification of low-medium-high remains subjective and is inherently relative to a specific site. A planning authority's decision to allocate development land within areas where Hazard Zone maps have been produced in this Strategic Flood Risk Assessment should examine all of 1) the vulnerability of the proposed development type to flooding, 2) the residual risk to the development and, 3) the options for management of residual risk.

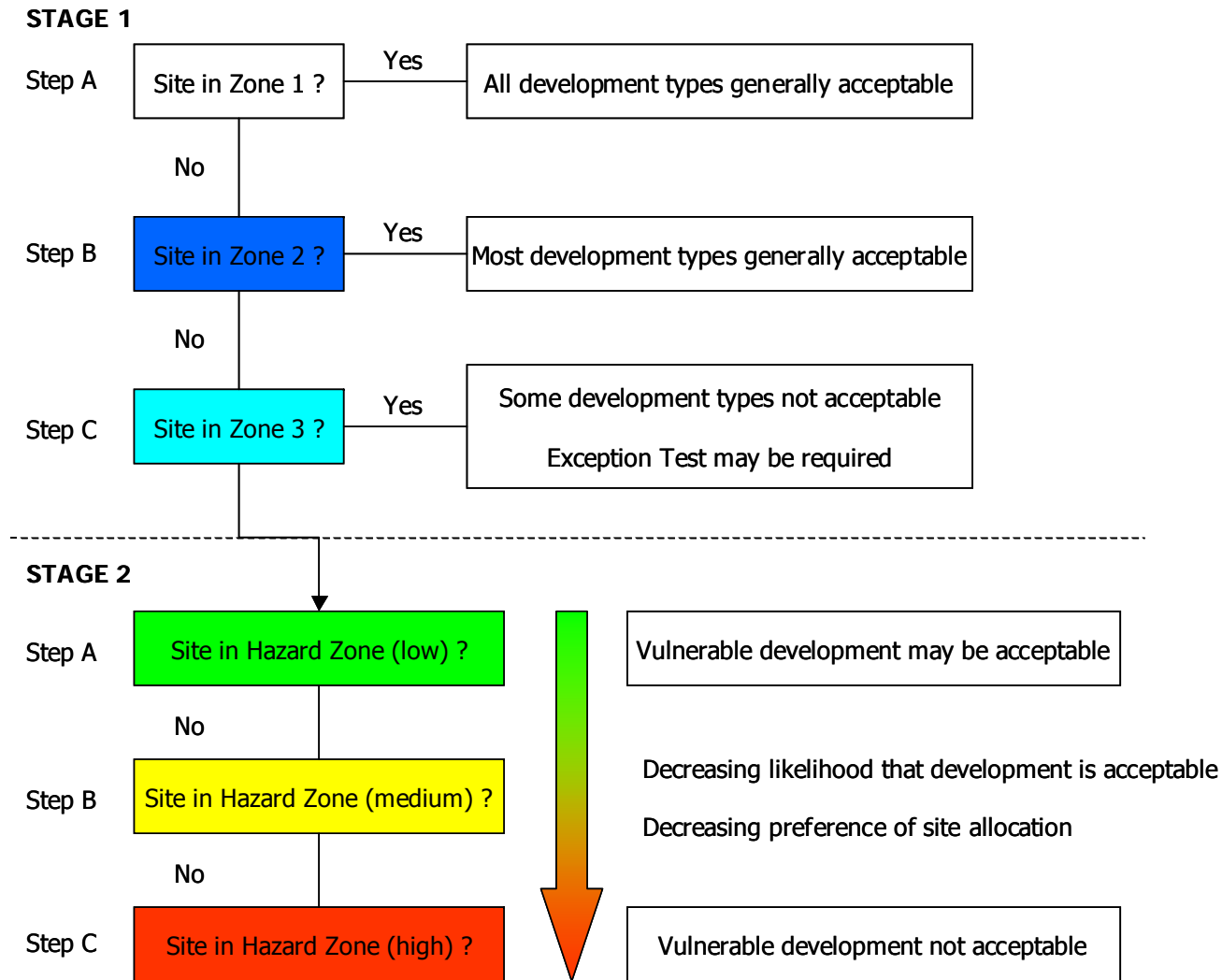


FIGURE 8-1 SUGGESTED STAGED SEQUENTIAL TEST FOR SOUTH ESSEX

8.5 Examples of Application

Application of the Sequential Test for South Essex is straightforward for those development proposals where site location is flexible and can be placed within a flood zone suitable for their intended use. Likewise, in an idealised situation, those areas highlighted by mapping as being of higher flood risk should be prioritised for non-sensitive use such as parks, playing fields etc, perhaps themselves providing part of local flood storage solutions or being integrated within the wider development goals of the region.

However, South Essex has many locations across all five of the authorities involved in this study, where flood risk cannot be avoided and locating development in Flood zone 2, or even 3, is necessary. For such cases, typical examples of application of Stage 2 of the Sequential Test for South Essex are provide below:

Example 1: New School, - no available locations within Flood Zone 1. The authority is required to locate this development within a specific population catchment area and is therefore constrained as to location. Application of the Sequential Test to the available sites finds that one site is in Flood Zone 2, the others in Flood Zone 3. The Flood Zone 2 site is preferred, flood mitigation considered and a Flood Risk Assessment prepared.

Example 2: New School – no available locations outside of Flood Zone 3. The authority is required to locate this development within a specific population catchment area and is therefore constrained as to location. Application of the Sequential Test to the available sites finds no site available outside of Flood Zone 3. The Exception Test (PPS25) is applied to justify location in Flood Zone 3. Various sites are considered and using the hazard zone maps the lowest hazard site is identified and selected. Flood mitigation and mitigation of residual risk (Flood warning, evacuation routes etc) are considered in a Flood Risk Assessment.

Example 3: Large Housing Development – proposed in Flood Zone 3 and high hazard zone. The authority considers alternative locations but no suitable location is available within Flood Zones 1 or 2 that also satisfies other planning objectives. The Exception Test is applied to justify location in Flood Zone 3. Review of the potential locations within Zone 3 using the hazard maps reveals a site in low hazard zone. This location is selected in preference to the high and medium hazard zone alternatives. Flood mitigation and mitigation of residual risk (Flood warning, no single-storey dwellings, raised finished floor levels etc) are considered in a Flood Risk Assessment.

Example 4: Large Housing Development – situation as example 3, above, but no alternative locations outside of Flood Zone 3, high hazard zone can be identified. The authority will require a full justification of the site selection, balancing flood risk and other planning objectives. If the need for the development is considered to outweigh flood risk issues then a detailed Flood Risk Assessment will be required, almost certainly including further site-specific flood modelling and mapping aimed at addressing residual risk concerns through comprehensive mitigation proposals.

A number of further considerations in addition to flood Hazard should be taken into account when allocating specific areas for development or placing one area ahead of another in terms of suitability for development. Potential evacuation routes, flood warning times and the time to peak flood hazard are some of the additional factors that should be taken into account. Further details are provided in Chapter 9.

8.6 Development 'Vulnerability'

Guidance regarding appropriate development in flood risk zones is provided in Table 1 of PPG25 and additional advice is given in the Flood Risk Matrix published by the Environment Agency. PPG25 is due to be replaced by PPS25 in autumn of 2006. At that time the guidance contained in section 6.3

will supersede the guidance given in this section, however at the development control level the requirements for flood Risk Assessments will remain similar.

At the time of writing PPS25 was only available in Draft form however it is due for final publication in Autumn 2006. Guidance in relation to appropriate types of development in Flood Risk Zones is provided in Table D2 of Draft PPS25. Development types are grouped according to their vulnerability to flooding. It is vulnerability information such as this which it is suggested is assessed with reference to Hazard Zones.

9 RESIDUAL RISK MANAGEMENT

9.1 Definition of Residual Risk

Residual Risk is a term often used in impact and risk assessment across a variety of topics. For this reason, it is also a term that is often inappropriately applied or mis-used. In a general sense, residual risk is usually taken to refer to that portion of overall risk that remains once risk-aversion measures have been put in place. In a flood risk sense therefore, residual risk can be seen as the risk of flooding that remains after flood defence measures have been implemented. In the South Essex context, residual risk management is therefore a series of measures that are available to prevent, control or minimise the consequences flooding that can occur despite flood defences (e.g. in event of a breaching of tidal defences, or surcharging of local stormwater drainage).

Application of the sequential test (and through PPS25 the vulnerability classification) to proposed developments aims to preferentially develop sites in lower risk areas. Where relocation to lower risk areas is not possible the proposed development will require defending against flood risk.

Many of the development sites identified in the Thames Gateway Development Investment Framework for South Essex are located within Flood Zone 3 – High Risk. The relocation of these potential sites to lower flood risk areas may not be possible for an area such as South Essex, where most of the region is low lying, vulnerable to flooding and where considerable equity is tied up in existing riverside property.

South Essex is defended from tidal flooding by numerous defence structures providing a varying standard of defence throughout the area. However, should these defences fail (as modelled by the breach analysis) the residual risk to a site/area would be realised.

Current planning policy encourages developers and Local Authorities to consider the consequences should defences fail and where possible ensure the residual risk is managed to acceptable levels.

Ensuring properties are defended to an appropriate design standard reduces flood risk. However, further options are also available should the residual risk to a development prove unacceptable. This chapter presents some of the information and options available to understand and manage residual risk.

9.2 Managing Residual Risk

Potential Evacuation and Rescue Routes

Flood Hazard in a particular area must be viewed in the context of the potential evacuation and rescue routes to and from that area. If the likelihood of inundation of evacuation routes is high, the LPA may wish to take a more conservative approach to the allocation of development types to certain areas than may be suggested by the hazard zone. This is may also be the case where the route to safe high ground is particularly long or the distance from the nearest emergency service to the flood zone is extensive.

Conversely, if the evacuation route in times of flood is extremely secure, there are multiple routes and the length of each route is fairly short, the LPA may wish to be more lenient with the types of development allowable in that area.

Flood Warning Procedures in Place

An additional consideration when determining the type of development that may be appropriate in certain areas is the type of flood warning procedure that exists or is proposed and the time between the flood warning and the flood peak. It may be necessary to locate certain development within areas of flood hazard, however the risk to life and property could be limited by robust flood warning and evacuation procedures.

Time to Peak of Flood Hazard

If a defence breaches suddenly during the peak of a flood the time to peak of the flood hazard is very short for those areas adjacent to the breach. Conversely, if a breach occurs early in the tidal cycle, the time to peak hazard may be enough to allow for evacuation of the area. In general, areas immediately adjacent to a breach will have the lowest time to peak for a flood hazard. The greater the time to peak of the hazard, the greater the time available for evacuation.

Managing Residual Risk

The following paragraphs present options available to mitigate residual risk. Not all options will be suitable for all types of development and all flood sources, therefore each method should be considered on a site-by-site basis with consideration of the flood source and the consequences such a scheme may have on flood risk elsewhere.

Recreation, Amenity and Ecology

Recreation, amenity, and ecology are often employed in various guises to mitigate the risk of flooding. This can be achieved through river restoration schemes and swales to increased open space serving to attenuate rainfall. SUDS can also be employed and where designed appropriately have ecological, amenity and recreational benefits.

The basic function of these systems is to increase storage capacity for floodwaters and/or the storage/conveyance of rainwater. These typically involve pools, ponds and drainage ditches, which can all add, depending on their size and specifications, to the amenity and ecological value of an area. These features contribute to the local amenity of the area both visually and aesthetically, providing attractive areas for recreation and as havens for wildlife, whilst assisting in flood management.

The desirability of adding to or creating green space in developed areas is well known. The concept of multifunctional green space was outlined by the ODPM and DEFRA in their 'Greening the Gateway' strategy. This is consistent with the Thames Gateway South Essex Partnership's plans to improve the ecological connectivity throughout the region whilst contributing to a reduction in flood risk. This is being pursued through initiatives such as the TGSE Greengrid Strategy.

Secondary Defences

Secondary defences are a fall back form of defence, lying behind the 'primary' defences performing a flood defence function to reduce residual risk to a site or flood cell.

Secondary defences can relocate and concentrate flood risk in particular areas away from vulnerable development types, or can delay the inundation of an area through increased storage of floodwater

and enhancement of flow routes. On a strategic scale these can include canal and water networks, designed to accommodate flood storage and facilitate flow of floodwater into storage areas.

Current planning documents such as 'Greening the Gateway' and more particularly along the Thames, the 'Blue Ribbon Network', assist in incorporating such water networks within larger planning frameworks, providing positive opportunities to assist in reducing the residual risk of flooding to a large area through secondary defences.

Land Raising

Land Raising is a mitigation option that requires careful consideration. In principle it entails raising the site above the flood level, thereby reducing floodwater depths and residual risk.

In practise however the implementation of land raising often results in locally reducing the flood storage capacity of an area for extreme events, potentially increasing the residual risk elsewhere. This requires detailed consideration of the wider scale implications of such an option on the flood cell.

Brownfield sites often require 'capping' as part of the remediation process prior to development. This type of infilling can have a similar effect on local storage and therefore the residual flood risk should be investigated fully as part of site specific flood risk assessments.

Partial land raising can be considered over particularly low lying flood cells on a much larger scale, where it may reduce the residual risk of a wider area. This could include the building up of low marshland areas immediately adjacent to defences, providing secondary defences to the wider flood cell.

Finished Floor Levels

Where developing in flood risk areas is unavoidable, the most accepted method of mitigating flood risk is to ensure habitable floor levels are raised above the maximum flood water level. This can substantially reduce the damage to property and significantly reduce the risk of injury and fatalities.

In areas of minimal floodwater depth, raising finished floor levels can usually be easily be accommodated in building design.

In areas where a substantial depth of floodwater is expected properties can incorporate a garage, utility area or public space on the ground floor with habitable areas above. Although practical, this method can also be unpopular due to difficulties in guaranteeing ground floors remain as non-habitable spaces for the lifetime of the development.

Flood Resilience

The Association of British Insurers in cooperation with the National Flood Forum has produced published guidance on how homeowners can improve the food resilience of their properties. These measures can not only improve properties against flood risk, by reducing the residual risk, but can also improve the insurability of homes in flood risk areas. The guidance identifies the key flood resistant measures as being:

- Replace timber floors with concrete and cover with tiles,
- Replace chipboard/MDF kitchen and bathroom units with plastic equivalents,
- Replace gypsum plaster with more water-resistant material, such as lime plaster or cement render,

- Move service meters, boiler, and electrical points well above likely flood level, and,
- Put one-way valves into drainage pipes to prevent sewage backing up into the house.
- Comprehensive advice on flood mitigation for homes and businesses is also given in the ODPM's 2003 report, 'Preparing for Floods'.

Flood Warning and Emergency Procedures

Flood Warning and Emergency Procedures tend to form part of a higher level management plan for the wider flood cell, including information such as repair procedures, evacuation routes and areas for refuge, flood warning dissemination and responsibilities.

Where not already developed, local planning authorities should consider the development Flood Warning and Emergency Procedures. These should identify areas at risk of flooding and determine appropriate emergency responses. When submitting flood risk assessments for developments within flood risk areas, developers should make reference to local Flood Warning and Emergency Procedures to demonstrate their development will not impact on the ability of the LA and emergency services to safeguard the current population.

Where already produced these documents should be updated to include the information generated by this SFRA. This will ensure that emergency plans are appropriate to the conditions expected during a flood event and that local authorities and emergency services are fully aware of the likely conditions and how this may affect their ability to safeguard the local population.

10 SUSTAINABLE DRAINAGE SYSTEMS

10.1 Background

Traditionally, built developments have utilised piped drainage systems to manage storm water and convey surface water run-off away from developed areas as quickly as possible. Typically these systems connect to the public sewer system for treatment and/or disposal to local watercourses. Whilst this approach rapidly transfers storm water from developed areas, the alteration of natural drainage processes can potentially impact on downstream areas by increasing flood risk and reducing water quality. Receiving watercourses are therefore much more sensitive to rainfall intensity, volume and catchment land uses after a catchment or areas of a catchment have been developed.

Due to the difficulties associated with up rating sewer systems it is uncommon for sewer and drainage systems to keep pace with the rate of development/re-development and the increasingly stringent controls placed on discharges to watercourses. As development progresses and/or urban areas expand these systems become inadequate for the volumes and rates of storm water they receive, resulting in increased flood risk and/or pollution of watercourses. Allied to this are the implications of climate change on rainfall intensities, leading to flashier catchment/site responses and surcharging of piped systems.

In addition, as flood risk has increased in importance within planning policy, a disparity has emerged between the design standard of conventional sewer systems (1 in 30 year) and the typical design standard flood (1 in 100 year). This results in drainage inadequacies for the flood return period developments need to consider, often resulting in potential flood risk from surface water/combined sewer systems.

A sustainable solution to these issues is to reduce the volume and/or rate of water entering the sewer system and watercourses.

10.2 What are Sustainable Drainage Systems?

Sustainable Drainage Systems (SuDS) are the Environment Agency's preferred method for managing the surface water run-off generated by developed sites. SuDS seek to manage surface water as close to its source as possible. Typically this approach involves a move away from piped systems to softer engineering solutions inspired by natural drainage processes.

In addition, they should be designed to take into account the surface run-off quantity, rates and also water quality ensuring their effective operation up to and including the 1 in 100 year design standard flood.

Wherever possible, a SuDS technique should seek to contribute to each of the three goals identified below with the favoured system contributing significantly to each objective. Where possible SuDS solutions for a site should seek to:

- Reduce flood risk (to the site and neighbouring areas),

- Reduce pollution, and,
- Provide landscape and wildlife benefit.

In keeping with the guidance of PPG25 and PPS25 local authorities should encourage the application of SuDS techniques. This chapter presents a summary of the SuDS techniques currently available and a review of the soils and geology of the Thames Gateway area, enabling local authorities to identify where SuDS techniques could be employed in development schemes.

The application of SuDS techniques is not limited to one technique per site. Often a successful SuDS solution will utilise a number of techniques in combination, providing flood risk, pollution and landscape/wildlife benefits. In addition, SuDS can be employed on a strategic scale, for example with a number of sites contributing to large scale jointly funded and managed SuDS.

10.3 SuDS Techniques

SuDS techniques can be used to reduce the rate and volume and improve the water quality of surface water discharges from sites to the receiving environment (i.e. natural watercourse or public sewer etc). Various SuDS techniques are available, however the techniques operate on two main principles:

- Infiltration
- Attenuation

All systems generally fall into one of two categories, or a combination of the two.

The design of SuDS measures should be undertaken as part of the drainage strategy and design for a development site. A ground investigation will be required to assess the suitability of using infiltration measures, with this information being used to assess the required volume of on-site storage. Hydrological analysis should be undertaken using industry approved procedures such as the Flood Estimation Handbook to ensure a robust design storage volume is obtained.

During the design process, liaison should take place with the Local Planning Authority, the EA, Thames Water and Anglian Water in order to establish that the design methodology is satisfactory and to also agree on a permitted rate of discharge from the site.

10.4 Infiltration SuDS

This type of Sustainable Drainage System relies on discharges to ground, where suitable ground conditions allow. Therefore, infiltration SuDS are reliant on the local ground conditions (i.e. permeability of soils and geology, the groundwater table depth and the importance of underlying aquifers as water resources etc) for their successful operation.

Various infiltration SuDS techniques are available for directing the surface water run-off to ground. However development pressures and a desire to maximise development potential often results in typically small areas available for infiltration systems. This small area, allied to the rapid rates of run off generation often require some form of attenuation as part of the infiltration

system. The storage may be provided in the sub-base of a permeable surface, within the chamber of a soakaway or as a pond/water feature.

Infiltration measures include the use of permeable surfaces and other systems that are generally located below ground.

Permeable Surfaces

Permeable surfaces are designed to allow water to drain through to a sub-base at a rate greater than the rain that falls onto the surface. Permeable surfaces act by directly intercepting the rain where it falls and are therefore true source controls. In theory this system would prevent any surface water running off the site, however in reality it is impractical to design permeable surfaces to directly infiltrate intense rainfall events. The permeable sub-base can be used to temporarily store infiltrated run-off underground allowing it to percolate into the ground below. Alternatively stored water within the sub-base can be discharged from the site.

Maintenance programmes will need to ensure that the surface is kept clear of silt and voids are clear. The use of grit and salt during winter months will adversely affect the drainage potential of paved surfaces, however this should not be required often as ice is less likely to form on these types of surfaces.

Types of permeable surfaces include:

- **Grass/landscaped areas:** Grassed or landscaped areas provide a permeable surface that allows for the infiltration of rain falling onto these areas, and potentially also run-off from adjacent impermeable areas. Grassed or landscaped areas are a relatively cheap SuDS measure however they are likely to be restricted to areas where vehicles are not present.
- **Reinforced Grass:** Techniques are available that allow grass to be incorporated into a pavement type surface. These provide varying ratios of hard-pavement to grass dependant on the site requirements. These range from concrete block arrangements to plastic meshes and can be utilised in those areas where the hard permanence of a typical pavement might be undesirable, such as in conservation areas, roadside verges, emergency services access, canal towpaths, farm tracks, rural settings etc. In the past these systems have been typically adopted for situations where a load bearing surface is required to fit into the surrounding environment, however these systems are often now installed for surface water management purposes. The grass/hard-pavement ratio will be one of the dominant factors that determine the rate of infiltration through to the sub surface.
- **Gravel:** A bed of gravel with a high void space on a permeable sub-base offers a cost effective solution for trafficked areas. Rain falling directly onto the area is able to infiltrate through to the sub-base.
- **Solid Paving with Void Spaces:** Solid paving can be installed in such a way that voids are present that can be in-filled with a permeable material such as grass or gravel etc. If this is to be used as a SuDS measure, a permeable sub-base is required to allow infiltration into the underlying ground and/or temporary storage to attenuate discharges .

- **Permeable Pavements:** Permeable pavements allow the rain falling directly onto the area to infiltrate through into a sub-base and where suitable, through into the underlying strata. Permeable pavements are constructed using porous concrete blocks allowing the infiltration of rainwater. Small projects of less than 100m² (depending on sub-grade permeability) can often be managed using 100% infiltration, whereas larger schemes will often require a combined system, with some form of attenuation provided as back-up for periods of exceptional flows. The use of geo-membranes can trap pollutants and prevent them being carried into the receiving environment. The use of an impermeable membrane beneath the sub-base will work to contain any pollutants within the sub-base. One major advantage of tanked permeable paving systems is that any significant contamination, for example, a diesel spillage, will be restricted to the immediate area and not transported into local sewers or watercourses. The performance of permeable pavements will dramatically decrease over a period of time with the clogging of voids and this should be taken into consideration during the design process and maintenance.

Sub-surface Infiltration

Where permeable surfaces are not a practical option more defined infiltration systems are available. In order to infiltrate the generated run-off to ground, a storage system is provided that allows the infiltration of the stored water into the surrounding ground through both the sides and bottom of the storage. These systems are constructed below ground and therefore may be advantageous with regards to the developable area of the site, however consideration needs to be given of construction methods and maintenance access to any development that takes place over an underground infiltration system. Consideration is also needed of the depth to the groundwater table. The provision of large volumes of infiltration/storage underground has potential cost implications and infiltration devices should not be built within 5m of a building, under a road or on a soil that may dissolve or be washed away.

Various methods for providing infiltration below the ground include:

- **Geocellular Systems:** Modular block systems can be used to provide an underground infiltration facility. The modular structures are usually made of plastic and can be staked side by side or on top of each other to construct an infiltration/storage unit of the required size. The modular blocks are usually sited upon a highly permeable sub-base through which the surface water run-off is discharged (usually through perforated pipes). The outlet from the pipes are restricted which causes the run-off to rise up through the sub-base into the geocellular storage system. The storage systems are usually tanked with a geomembrane. These types of systems are quick and easy to install, flexible in their configuration, and have minimal maintenance requirements (providing the inflow of silt is limited). While many manufacturers claim that their products are suitable for installation beneath roadways or car parks, their use in these areas should be taken with caution. Geocellular systems can also be utilised for providing storage without infiltration in order to attenuate discharge rates. In these situations the system is tanked with a geomembrane or similar.
- **Filter Drain:** A filter drain is a trench that contains a perforated or porous pipe that runs along its bottom. The trench is filled with a suitable filter material, granular material or lightweight aggregate fill, all with a high void space. The fill may be exposed at the ground surface or capped with turf, topsoil etc that allow the trench to flood (i.e. not an impermeable surface that could pressurise the trench). Surface water run-off generated by the site is directed through the perforated pipe which then flows into the trench and

infiltrates into the surrounding ground. Filter drains have been used extensively for road and car park developments, where they have been constructed in the verge and median strip.

- **Soakaway (Chamber):** Surface water run-off is directed to a chamber (normally square or circular) set in the ground with holes in the sides and base. This allows the stored water to soak into the ground. The storage capacity of soakaway chambers are limited and therefore they are more suited to serve individual dwellings rather than large developed areas. The chambers are prone to silting up and therefore need to be maintained.
- **Soakaway (Trench):** Where the linear space is available, soakaways that use a trench rather than a chamber may be used to manage the run-off from larger areas.
- **Soakaway (Granular Soakaway):** Similar to a filter drain, a soakaway (either chamber or trench) filled with a high percentage void, granular material can be used to store surface water run-off as it is infiltrated into the surrounding ground. The granular fill will offer structural strength to the soakaway although the storage volume will be substantially reduced.

10.5 Attenuation SuDS

Should it be found that the ground conditions are not favourable for infiltration techniques, the surface water run-off discharged from a site will need to be attenuated using on-site storage. While this is a SuDS technique that will reduce the rate of discharge from the site, the overall volume will not be minimised using on-site storage alone. An important factor that needs to be taken into consideration when assessing the suitability of on-site storage as part of a proposed development is the volume required and the associated impacts the storage will impose on development proposals and risks to neighbouring properties.

Should the use of infiltration to either partially or fully dispose of the surface water run-off from a developed site be found to be unfeasible, on-site storage will be required in order to attenuate the discharge from the site. An allowable rate of discharge from the site will need to be agreed with the Environment Agency, Thames Water/Anglian Water, and the Local Planning Authority. This can have significant implications to the proposed development with regards to the large volume of storage that may be required. On-site storage can be constructed both above ground and below ground with the above ground systems usually being the cheaper option on a cost per m³ of storage basis. It should be noted however that the below ground systems may pose less constraints on the developable area of the site.

On-site storage measures include basins, ponds, and other more engineered forms of storage underground.

Basins and Ponds

Basins are areas that have been recontoured (or alternatively embanked) to allow for the temporary storage of run-off from a developed site. Basins are drained in such a way that ensures that they are free from water in dry weather. Therefore between periods of rainfall they can be used for other purposes such as open public space, recreation etc. Basins treat run-off in a variety of ways i.e. settlement of solids in still water, absorption by aquatic vegetation or

biological activity etc. The construction of basins uses relatively simple techniques. Local varieties of vegetation should be used wherever possible and should be fully established before the basins are used. Access to the basin should be provided such that a maintenance programme can be implemented. This would include inspections, regular cutting of grass, annual clearance of aquatic vegetation and silt removal as required.

Various types of basins are available for utilising as SuDS measures. These include:

- **Detention Basins:** A detention basin is designed and constructed to store surface water run-off temporarily in order to attenuate flows over a minimal period of time. Detention basins provide better flow attenuation than floodplains as they store water until the flood has passed. The stored water is then released at a controlled rate after the storm to avoid flooding downstream. If the run-off is held back for long enough, solids start to settle out of the water, which improves water quality.
- **Extended Detention Basins:** If the period of detention increases to approximately 24 hours, the basin is referred to as an extended detention basin. This results in the surface water run-off being stored beyond the time normally required for attenuation which provides extra time for natural processes to remove some of the pollutants in the water.

Ponds

Ponds are similar to basins except that the outflow is configured such that a volume of water is contained during dry weather, usually for amenity, recreational, or agricultural/horticultural purposes. Ponds are designed to hold the additional surface water run-off generated by the site during rainfall events. Like basins, ponds are designed to control discharge rates by storing the collected run-off and releasing it slowly once the risk of flooding has passed. Ponds can provide wildlife habitats, water features to enhance the urban landscape and, where water quality and flooding risks are acceptable, they can be used for recreation. It may be possible to integrate ponds and wetlands into public areas to create new community ponds. Ponds and wetlands trap silt which may need to be removed periodically. Ideally, the contaminants should be removed at source to prevent silt from reaching the pond or wetland in the first place. In situations where this is not possible, consideration should be given to a small detention basin placed at the inlet to the pond in order to trap and subsequently remove the silt. Depending on the setting of a pond, health and safety issues may be important issues that need to be taken into consideration. The design of the pond can help to minimise any health and safety issues (i.e. shallower margins to the pond reduce the danger of falling in). A fence may also be useful for keeping children out.

Various types of ponds are available for utilising as SuDS measures. These include:

- **Balancing/Attenuating Ponds:** A balancing or attenuation pond is designed only to store surface water run-off and attenuate discharge until the flood/storm peak has passed. Therefore storage periods may not be long enough to significantly improve water quality capacity compared with ponds with longer retention times. They contain some water at all times with the water level fluctuating as the run-off passes through the device.
- **Flood Storage Reservoirs:** Flood storage reservoirs are very similar to balancing/attenuation ponds except that they are usually much larger. They are generally used to attenuate fluvial flood flows rather than surface water run-off from

developed areas and are therefore unlikely to be utilised as a SuDS measure. Should an existing flood storage reservoir in the vicinity of the proposed development be identified to offer spare capacity, then depending on ownership and agreement, it may be possible to utilise the spare capacity for storm water management of development sites.

- **Lagoons:** Should the surface water run-off have a high suspended solids content, a lagoon could be a suitable method for attenuating its discharge to the receiving environment. Lagoons are similar to balancing/attenuation ponds except that they are also designed for the settlement of suspended solids. Usually they are long and narrow in shape to ensure the longest retention time and therefore an efficient removal of suspended solids. However lagoons are usually free of vegetation and therefore do not provide any biological treatment.
- **Retention Ponds:** Retention ponds are designed to detain the surface water run-off for periods between several days to two weeks. This allows for a higher level of settlement, biological treatment and limited attenuation of flows. Retention ponds provide a greater degree of treatment than extended detention basins.
- **Wetlands:** A wetland is similar to a pond except that it has a high proportion of emergent vegetation in relation to open water. Wetlands use plants to make the treatment of surface water run-off more efficient and can allow the detention times required to fully treat the run-off to be reduced to a couple of weeks. Constructed wetlands are ponds with irregular perimeters and undulating bottom contours into which wetland vegetation is purposely placed to enhance pollutant removal from surface water run-off. Surface water run-off enters a constructed wetland through a forebay where the larger solids and coarse organic material settle out. The run-off discharged from the forebay passes through emergent vegetation which acts to filter organic materials and soluble nutrients. The use of constructed wetlands can be looked at from two perspectives. The first is that the wetland is used primarily to maximise pollutant removal from storm water run-off and also help to attenuate storm water flows. Alternatively, it may be used primarily to control storm water flows, with increased pollutant removal capabilities.

10.6 Alternative Forms of Attenuation

In many situations the development of a site may involve proposals that would inhibit the use of basins or ponds as a means of managing the surface water run-off discharged from the site. This may be due to space limitations, economic feasibility, or other issues such as health and safety etc. In these situations it may be appropriate to use a storage option that is viewed as being more 'engineered' than an open basin or pond. Most of these methods involve the provision of storage beneath the ground surface, which may be advantageous with regards to the developable area of the site, however consideration needs to be given to construction methods, maintenance access and to any development that takes place over an underground storage facility. The provision of large volumes of storage underground also has potential cost implications.

Methods for providing alternative attenuation include:

- **Deep Shafts:** Deep shafts can be utilised in areas with low groundwater tables. Shafts have small footprints and are therefore useful on sites with low land availability, however pumping from the shaft into the receiving drainage network will be required. Therefore substantial mechanical and electrical works will be required as potentially would major civil engineering requirements. With a relatively small cross-sectional area, a shaft would be prone to siltation at a rapid rate depending on the quality of the run-off. Therefore a maintenance programme would be required as would regular servicing of any pump works.
- **Geocellular Systems:** See previous discussion.
- **Oversized Pipes:** Oversizing the pipes that make up the on-site drainage network is a cost effective method that is often used for providing attenuation storage within the network. The main draw back with using this method is that it can be very difficult to obtain the required level of storage. This is because the pipe diameters are often restricted by the cover depths required and the need to gravity drain into an existing network. A solution to this is to lay multiple pipes side by side however this increases the excavation areas and may also place restrictions on the development footprint. The use of oversized pipes is not an effective method of providing on-site storage if the network is at a relatively steep gradient. This is because the storage at the upstream end of the pipe is unlikely to be utilised.
- **Rainwater Harvesting:** Rainwater harvesting is the process of collecting rain that falls directly onto roofs (and in some cases hardstanding areas) such that it can be re-used for not potable uses around the home or business (flushing toilets, washing machines, car washing and irrigation etc). The simplest form of rainwater harvesting involves the collection of run-off from a roof via a water butt situated at the bottom of a down pipe. This water can then be used for irrigation. For systems where the collected run-off is to be used for toilet flushing, washing machines etc, it is likely that the water would be pumped from a storage tank installed on the grounds of the property. Packaged systems are available although the costs (including ongoing maintenance) may outweigh the payback in terms of reduced water supply charges. There is, however, a feel good factor in using rainwater which otherwise would have gone to waste.
- **Tanks:** The use of tanks for the provision of storage to attenuate surface water run-off is varied in the number of options available. While most storage tanks are installed beneath the ground surface, above ground storage tanks may be feasible as part of industrial or commercial type developments where amenity issues or space are not significant restrictions. Tanks are likely to be prefabricated, but could also be constructed in-situ for below ground concrete tanks. Plastic and GRP tanks are also often utilised with sizes of up to 25m³ being available off the shelf (although larger tanks used above ground may have additional reinforcing requirements). Consideration must be given to below ground tanks with regards to cover depths, load bearings, and also invert depths should the tank be drained by gravity. The storage requirements need to be based on a sound hydrological assessment as undersizing the tank would be costly to remediate.
- **Green Roofs:** A roof area that is used for growing appropriate types of vegetation, which provides a degree of retention and attenuation, it also promotes evapotranspiration. In addition, vegetation and substrate can absorb a range of

pollutants. Green roofs are more suitable for public and institutional buildings that have good maintenance programmes and support. Green roofs are available in both prefabricates and in-situ construction however they are heavy systems and can have major structural implications for the building.

10.7 Combined Infiltration / Attenuation Systems

In most situations, SuDS systems include both infiltration and storage. Most of the techniques identified above can be used in combination, however dedicated infiltration and attenuation systems include Swales and filter strips.

- **Swales:** A swale is a grass-lined channel designed to control both the flow rate and quality of surface water run-off that is generated by the adjacent site. Not only does the water run down the sides of a swale at a reduced speed, but it can also be slowed further as it flows along the channel before being discharged from the site. This detention of the run-off also increases the infiltration from the swale.
- **Filter Strips:** A filter strip runs along the edge of a permeable area and is sloped to allow the sheet flow across the vegetated strip. Unlike a swale however, no storage is offered other than what is held back by the vegetation. The overland flow across the filter strip is likely to run into a water course at some point rather than being formally collected and discharged at a controlled rate from the site.

10.8 SuDS Suitability in the South Essex Area

The underlying ground conditions of a development site will often determine the type of SuDS approach to be used at development sites. This will need to be determined through ground investigations carried out on-site, however an initial assessment of a site's suitability to the use of SuDS can be obtained from a review of the available soils/geological survey of the area.

Tables 10.1 to 10.4 indicate the types of soils, drift deposits and solid geology that are present in the Thames Gateway area, and their likely suitability to infiltration measures. This is based on a review of:

- the Soil Survey of England and Wales 1993 – 1:250,000 Soils Maps (Sheet 6), and
- the Geological Survey of Great Britain (England and Wales) 1:50,000 Series Solid and Drift Edition Sheets 258/259 (1976), Sheet 257 (1976) and Sheet 271 (1977).

The Soils Map Legend and Geological Survey Memoir were also consulted as part of this assessment.

The tables present the ground conditions found in the South Essex area in terms of their permeability (Impermeable, Variably permeable and permeable) and the types of SuDS techniques that may be suitable for a site located on these materials. These definitions are

based on a review of available information and our experience and should not supersede site-specific data and ground investigations.

In the design of any drainage system and SuDS approach, consideration should be given to site-specific characteristics and where possible be based on primary data from site investigations. The information presented in the following tables is provided as a guide and should not be used to accept or refuse SuDS techniques.

TABLE 10.1: SOUTH ESSEX SOIL DEPOSITS & APPROPRIATE SUDS TECHNIQUES

Permeability	Soil Association	Geology	Soil Characteristics	Appropriate SuDS Techniques
Permeable	Fyfield 4	Mesozoic and Tertiary sand and loam	Deep well drained often stoneless coarse loamy and sandy soils. Some fine loamy soils with slowly permeable subsoils and slight seasonal waterlogging and some slowly permeable seasonally waterlogged fine loamy over clayey soils. Risk of water erosion	Infiltration and Combined Infiltration/Attenuation Systems
	Hucklesbrook	River Terrace Drift	Well drained coarse loamy and some sandy soils, locally flinty and in places over gravel. Slight risk of water erosion	Infiltration and Combined Infiltration/Attenuation Systems
	Hamble 2	Aeolian silty drift	Deep stoneless well drained silty soils and similar soils affected by groundwater, over gravel locally. Usually flat land	Infiltration and Combined Infiltration/Attenuation Systems
	Agney	Marine alluvium	Deep stoneless calcareous fine and coarse silty soils. Groundwater usually controlled by ditches and pumps. Flat land	Infiltration and Combined Infiltration/Attenuation Systems
	Wallasea 2	Marine alluvium	Deep stoneless clayey soils, calcareous in places. Some deep calcareous silty soils. Flat land often with low ridges giving a complex soil pattern. Groundwater controlled by ditches and pumps.	Infiltration and Combined Infiltration/Attenuation Systems
	Hurst	River Terrace Gravel	Coarse and fine loamy permeable soils mainly over reavel variably affected by groundwater	Infiltration and Combined Infiltration/Attenuation Systems
	Park Gate	Aeolian silty drift	Deep stoneless silty soils variably affected by groundwater	Infiltration and Combined Infiltration/Attenuation Systems
Variably permeable	Bursledon	Eocene and Jurassic loam and clay	Deep fine loamy soils with slowly permeable subsoils and slight seasonal waterlogging associated with deep coarse loamy soils variably affected by groundwater. Some slowly permeable seasonally waterlogged loamy over clayey soils. Landslips and associated irregular terrain locally	Infiltration and Combined Infiltration/Attenuation Systems
	Ratsborough	Drift over Eocene clay	Fine silty and fine loamy over clayey soils with slowly permeable subsoils and slight seasonal waterlogging. Some slowly permeable seasonally waterlogged fine loamy over clayey and clayey soils	Infiltration and Combined Infiltration/Attenuation Systems
	Shabbington	River Terrace Drift	Deep fine loamy and fine loamy over sandy soils variably affected by groundwater. Some slowly permeable seasonally waterlogged fine loamy over clayey soils	Infiltration and Combined Infiltration/Attenuation Systems
Impermeable	Unripened Gley Soils	Marine alluvium	Soils of variable texture flooded by high tides. Many are soft and unripened, others often on higher sites or of sandy texture, are firm and ripened. Frequently calcareous.	Attenuation Systems

	Windsor	Tertiary clay	Slowly permeable seasonally waterlogged clayey soils mostly with brown subsoils. Some fine loam over clayey and fine silty over clayey soils and, locally on slopes, clayey soils with only slight seasonal waterlogging	Attenuation Systems
	Hallsworth 1	Drift from Palaeozoic shale	Slowly permeable seasonally waterlogged clayey soils	Attenuation Systems
	Fladbury 3	River alluvium	Stoneless clayey, fine silty and fine loamy soils affected by groundwater. Flat land. Risk of flooding	Attenuation Systems
	Wallasea 1	Marine alluvium	Deep stoneless non-calcareous and calcareous clayey soils. Soils locally have humose or peaty surface horizons. Groundwater controlled by ditches and pumps. Flat land. Slight risk of flooding	Attenuation Systems

TABLE 10.2: SOUTH ESSEX DRIFT GEOLOGY DEPOSITS & APPROPRIATE SUDS TECHNIQUES

Permeability	Drift Deposit	Characteristics (where available)	Appropriate SuDS Techniques
Permeable	Blown Sand		Infiltration and Combined Infiltration/Attenuation Systems
	Alluvium	Mainly sand, silt and clay with some gravel	Infiltration and Combined Infiltration/Attenuation Systems
	Head	Variable pebbly sandy clay	Infiltration and Combined Infiltration/Attenuation Systems
	Sand and Gravel of unknown age		Infiltration and Combined Infiltration/Attenuation Systems
	Stanmore Gravel:	Well rounded flint gravel sandy and clayey in part	Infiltration and Combined Infiltration/Attenuation Systems
	Loam (River Brickearth)		Infiltration and Combined Infiltration/Attenuation Systems
	Sand and Gravel		Infiltration and Combined Infiltration/Attenuation Systems
	Kempton Park Gravel		Infiltration and Combined Infiltration/Attenuation Systems
	Taplow Gravel		Infiltration and Combined Infiltration/Attenuation Systems
	Lynch Hill Gravel		Infiltration and Combined Infiltration/Attenuation Systems
	Boyn Hill Gravel		Infiltration and Combined Infiltration/Attenuation Systems
	Black Park Gravel		Infiltration and Combined Infiltration/Attenuation Systems
	Marine or Estuarine Alluvium (Sands)		Infiltration and Combined Infiltration/Attenuation Systems
	Marine or Estuarine Alluvium (Shell Deposits)		Infiltration and Combined Infiltration/Attenuation Systems
Sand and Gravel		Infiltration and Combined Infiltration/Attenuation Systems	

Variably permeable	Till	Mainly chalky sandy and pebbly clay	Attenuation Systems
	Older Estuarine Alluvium		Attenuation Systems
Impermeable	Head Gravel	Abundant well rounded flint pebbles in clayey matrix	Attenuation Systems
	Brickearth	Clay	Attenuation Systems
	Coombe Deposits	The principal component is chalk	Attenuation Systems
	Marine Beach or Tidal flat deposits		Attenuation Systems
	Marine or Estuarine Alluvium (Undifferentiated or Clay)		Attenuation Systems

TABLE 10.3: THAMES GATEWAY SOLID GEOLOGY DEPOSITS & APPROPRIATE SUDS TECHNIQUES

Permeability	Solid Geology	Characteristics	Appropriate Techniques	SuDS
Permeable	Harwich Formation	Sand with black flint pebbles	Infiltration and Infiltration/Attenuation Systems	Combined Systems
	Thanet Beds	Sands	Infiltration and Infiltration/Attenuation Systems	Combined Systems
Variably permeable	Bagshot Beds(up to 23m)	Dominated by orange or pale yellow, fine grained sand, with this beds of pale grey clay.	Infiltration and Infiltration/Attenuation Systems	Combined Systems
	Claygate Beds (17 to 23m)	Comprises well-laminated, orange sands interbedded with pale grey to lilac clays.	Infiltration and Infiltration/Attenuation Systems	Combined Systems
Impermeable	London Clay (125 to 135m)	Consists mainly of dark bluish to brownish grey clay, containing variable amounts of fine-grained sand and silt; the latter is particularly abundant at the base and top of the formation.	Attenuation Systems	
	Woolwich Beds including Oldhaven Beds	Includes a variety of lithologies, laid down in a lagoon or estuarine environment. The most widespread facies comprises clay, packed with mollusc shells.	Attenuation Systems	
	Upper Chalk	White chalk with bands of flint	Attenuation Systems	

10.9 Further Information

The above information is intended to provide an introduction to the use of SuDS in the Thames Gateway area. The options available for the provision of SuDS is not exhaustive and new techniques are frequently developed. The consideration of utilising SuDS as part of a development will depend on many factors such as the underlying geology and drift layers, the depth of the groundwater table, site slopes, run-off quality, site restrictions, maintenance requirements, economical viability, groundwater protection and ecological considerations. The final drainage scheme and SuDS for a site should consider each of these elements in its design.

The following reference documents provide further information on SuDS, their benefits and limitations and how they can be employed:

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11 DIGITAL DATA

In addition to the printed maps and main SFRA report, a CD ROM containing the following is included in this chapter:

- Inundation mapping, showing the Environment Agency Flood Zones 1, 2 and 3 and the extent of the SFRA determined Flood Zones 1, 2 and 3 for South Essex.
- Hazard mapping for the 1 in 200 year, 1 in 1000 year and 50 years hence climate change maps for South Essex. These include the results for combined flood cells and individual breaches for each authority.
- Depth mapping for the boroughs of Castle Point and Thurrock
- Animations of each breach model.

The maps are produced in GIS format to facilitate input to the mapping systems of all participating authorities. The animations are recorded in *.avi format, which is easily viewed on windows media player. Windows Media Player can be downloaded from the following website:

<http://www.microsoft.com/windows/windowsmedia/player/download/download.aspx>

Hard copies of the maps are supplied in the appropriate Appendices. The maps should be used following consultation of the Flood Mapping and Application information in Section 8 of this report.

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Rochford District Council Strategic Flood Risk Assessment

Level 1 & 2 Final Report
February 2011



Prepared for:

Revision Schedule

Rochford DC Strategic Flood Risk Assessment – Level 1 & 2 Report February 2011

Rev	Date	Details	Prepared by	Reviewed by	Approved by
01	November 2010	Draft Report for Comment	Eleanor Cole Assistant Hydrologist	Elizabeth Gent Principal Consultant	Jon Robinson Technical Director
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02	February 2011	Final Report	Sarah Littlewood Assistant Flood Risk Specialist	Emily Craven Senior Consultant	Jon Robinson Technical Director

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Non Technical Summary

Overview

Rochford District Council, in partnership with Basildon Borough Council and Castle Point Borough Council, has commissioned Scott Wilson to produce a Strategic Flood Risk Assessment (SFRA) in accordance with Planning Policy Statement 25 (PPS25): *Development and Flood Risk*¹ and its accompanying Practice Guide².

This SFRA provides a revision to the Thames Gateway South Essex SFRA which was published in November 2006 and prepared under previous policy Planning Policy Guidance (PPG25) Development and Flood Risk.

The following report constitutes a Level 1 and Level 2 SFRA for Rochford District Council which will contribute to the evidence base for the plan-making process of the Local Development Framework (LDF), in particular the Core Strategy.

The purpose of the Level 1 SFRA is to collate existing data and information with respect to flood risk, sufficient to enable the application of the Sequential Test by the Council, i.e. to steer development towards areas of lowest flood risk. It is the role of the Council to undertake the application of the Sequential Test within their administrative area, guidance to assist in this process is included in Chapter 6.

Given the existing level of flood risk and the development pressure facing parts of Rochford, an 'increased scope' Level 2 SFRA has also been included in this report to provide more detailed flood risk information for those areas at medium or high risk of flooding. Hydrodynamic breach modelling has been undertaken at 7 locations around the tidal frontage to provide more detail on the nature of the residual tidal flood risk. In addition, modelling has been undertaken to simulate overtopping of the existing defences in order to assess the actual flood risk. Details of the modelling are included in Chapter 6 and Appendix E. The outputs of this modelling include maximum depth maps, hazard mapping and time to inundation mapping which are included in Appendices B, C and D respectively.

The findings from these assessments provide further specific information which will facilitate the application of the Exception Test, where required, and inform the preparation of site specific Flood Risk Assessments for individual development sites in the potential main development areas.

Review of Flood Risk in Rochford District

The results from the increased scope Level 2 SFRA confirm that parts of the district of Rochford are at significant residual risk of flooding from tidal sources.

Overtopping or a breach in the flood defences has the potential to result in flooding to depths of greater than 3m throughout Shoeburyness, Paglesham, Wallasea Island and South Fambridge putting existing development and occupants at great risk. Given the low lying nature of the coastline in this part of the district, flood waters are likely to propagate rapidly, greatly reducing the time available for warning and evacuation of residents, as was the case in the 1953 flood.

¹ CLG (December 2006, revised March 2010) Planning Policy Statement 25: Development and Flood Risk

² CLG (June 2008, revised December 2009) Planning Policy Statement 25: Development and Flood Risk

Policies adopted as part of the Catchment Flood Management Plan for the tidal parts of the Rochford district aim to reduce or cease existing levels of flood risk management now and into the future. It is therefore likely that the flood risk from tidal sources in this district will continue to increase over time.

In addition to flood risk from tidal sources, fluvial systems also pose a risk to parts of the Rochford district. The impermeable underlying geology and seasonally wet, deep clay soils in the western parts of the district lead to rapid runoff of surface water into local watercourses. The channelization of these watercourses increases the rapid conveyance of water downstream and leads to problems where watercourses converge.

Fluvial flooding primarily affects Rochford town, where the River Roach, Nobles Green Ditch and Eastwood Brook meet. A number of other smaller watercourses in Rawreth and Rayleigh also pose a fluvial flood risk.

Recommendations

It is strongly recommended that the mapping in this SFRA is used by Rochford Council Emergency Planners to continue to inform and update the development of Emergency Response and Evacuation Plans for the existing development and occupants throughout the district. Flood depth, hazard and time to inundation mapping should be used to inform routes of safe access and egress for existing development.

Under the Core Strategy proposals no development is proposed within areas defined as being at risk of flooding from tidal sources. However, it is possible that planning applications may come forward for redevelopment of individual properties within areas at risk of tidal flooding. Where this is the case, it is strongly recommended that development proposals are carefully assessed to ensure that they are safe in line with the recommendations provided in Chapter 10 of this report.

Information with respect to flood depths, hazard rating and time to inundation should be used to inform part c) of the Exception Test and the preparation of site specific Flood Risk Assessments. It is noted that this document is a strategic document, and therefore site specific assessments may need to be carried out, (for example consideration of an additional breach location of more significance to the site under assessment), however the SFRA should provide indicative information and Chapter 10 provides detailed guidance on the issues that need to be addressed as part of these assessments.

Similarly, where development is proposed in areas at risk of fluvial flooding, development control recommendations provided in Chapter 10 of this report should be used to determine the safety of the proposed development (in consultation with the councils emergency planners) and to ensure that the proposed development does not increase flood risk to surrounding areas or impact upon the ability of Rochford DC and their emergency services to safeguard the current population.

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Glossary of Terms

Climate change - a change in average weather or a change in the distribution of weather events around an average over a period of time e.g. greater or fewer extreme weather events.

Core Strategy - The Development Plan Document which sets the long-term spatial planning vision and objectives for the area. It contains a set of strategic policies that are required to deliver the vision including the broad approach to development.

Development Plan Documents (DPDs) - Spatial planning documents within the Council's Local Development Framework which set out policies for development and the use of land. Together with the Regional Spatial Strategy they form the development plan for the area. They are subject to independent examination. They are required to include a core strategy and a site allocations document, and may include area action plans if required; other DPDs may also be included, e.g. development control policies.

Defra - Department for Environment, Food & Rural Affairs.

Emergency Planning – Planning for and response to emergencies such as flooding, including consideration of the resilience of emergency infrastructure that will need to operate during flooding.

Environment Agency Flood Zones - Nationally consistent delineation of 'high' and 'medium' flood risk, published on a quarterly basis by the Environment Agency.

Flood Risk Assessment (FRA) – A site specific investigation carried out by site developers to be submitted as part of their planning applications. It assesses both current flood risk to the site and ensures development does not increase flood risk to the site or surrounding areas.

Flood Risk Vulnerability - PPS25 provides a vulnerability classification to assess which uses of land may be appropriate in each flood risk zone.

Flood Zone 1 - Low Probability - Flood Zone comprising land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any one year (<0.1%)

Flood Zone 2 - Medium Probability – Land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) or between 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1%) in any year.

Flood Zone 3a - High Probability – Land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year

Flood Zone 3b - Functional Floodplain - Land where water has to be stored or flow in times of flood

Formal Flood Defence - A structure built and maintained specifically for flood defence purposes.

Greenfield Runoff - The surface water runoff regime from a site before development. This is normally taken to mean the site in its natural state (i.e. no man-made developments on site).

LiDAR – 'Light Detection and Ranging' is an airborne terrain mapping technique which uses a laser to measure the distance between the aircraft and the ground. It therefore provides accurate topographical/contour mapping.

Local Development Framework (LDF) - The name for the portfolio of Local Development Documents. It consists of the Local Development Scheme, a Statement of Community Involvement, Development Plan Documents, Supplementary Planning Documents, and the Annual Monitoring Report.

Local Lead Flood Authority (LLFA) – Unitary authorities responsible for implementing the requirements of the Flood and Water Management Act, which gained Royal Assent in April 2010.

Mitigation – where flood risk cannot be avoided or controlled, mitigation measures should be applied to further reduce the risk of flooding and/or minimise the danger and damage caused by flooding to acceptable levels. This could include options such as non-habitable ground floors, resistant and resilient design, flood warning and evacuation plans.

Previously Developed (Brownfield) Land - Land which is or was occupied by a building (excluding those used for agriculture and forestry). It also includes land within the curtilage of the building, for example a house and its garden would be considered to be previously developed land. Land used for mineral working and not subject to restoration proposals can also be regarded as brownfield land.

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

Return Period – Return Period is a statistical measure of how often, on average, an event could occur. It is the inverse of Annual Exceedance Probability (AEP), where AEP is the probability of a storm event of given magnitude or greater occurring in any given year. It should be noted that both return period and AEP are probability measures, so for example an event which has a 5 year return period (or 20% AEP) has a 1 in 5 chance of occurring in any given year, and is expected to occur once every 5 years on average. The on average term is important - just because it has happened one year does not mean it will not occur again for the next 4 years; there is still a 1 in 5 chance each year of the storm, or a larger storm, occurring, but over a long period of time it is expected that a fifth of the years will have had a storm of that magnitude or larger.

Storm surge - An offshore rise of water level associated with a low pressure weather system. Water levels rise primarily due to the action of high winds upon the oceans surface.

Sustainable Development – “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (The World Commission on Environment and Development, 1987).

The Exception Test - If, following application of the Sequential Test, it is not possible (consistent with wider sustainability objectives) to demonstrate that there are no reasonably available sites in areas with less risk of flooding that would be appropriate to the type of development or land use proposed, the Exception Test may apply. PPS25 sets out strict requirements for the application of the Test.

The Sequential Test - Informed by a Strategic Flood Risk Assessment, a planning authority applies the Sequential Test to demonstrate that there are no reasonably available sites in areas with less risk of flooding that would be appropriate to the type of development or land use proposed.

1 in 200 year event - Event that on average will occur once every 200 years. Also expressed as an event that has a 0.5% probability of occurring in any one year.

1 in 200 year design standard - Flood defence that is designed for an event, which has an annual probability of 0.5%. In events more severe than this the defence would be expected to fail or to allow flooding.

1 in 1000 year event - Event that on average will occur once every 1000 years. Also expressed as an event that has a 0.1% probability of occurring in any one year.

1 Introduction

1.1 Background

- 1.1.1 Scott Wilson Ltd has been commissioned by Rochford District Council, in partnership with Basildon Borough and Castle Point Borough Councils to produce a Strategic Flood Risk Assessment (SFRA) in accordance with Planning Policy Statement 25 (PPS25): Development and Flood Risk³ and its accompanying Practice Guide⁴.
- 1.1.2 This SFRA provides a revision to the Thames Gateway South Essex SFRA which was published in November 2006 under previous policy Planning Policy Guidance (PPG25) Development and Flood Risk. The TGSE SFRA was prepared by Scott Wilson Ltd to aid the South Essex Strategic Planning Authorities of Essex County Council, Southend-on-Sea and Thurrock Borough Council and the Local Planning Authorities of Rochford District, Castle Point Borough and Basildon Borough Council in their planning and development control processes.
- 1.1.3 Due to differing timescales for the publication of their Local Development Framework, Thurrock Council and Southend-on-Sea Borough Council have commissioned separate SFRA's for their administrative areas. To this end the new partnership now includes Basildon Borough Council, Rochford District Council and Castle Point Borough Council. This report covers the area of Rochford District Council.

1.2 SFRA Structure

- 1.2.1 PPS25 defines a two staged approach to the completion of a SFRA as follows:
- Level 1** – A strategic overview of all potential sources of flooding which is sufficiently detailed to enable the application of the Sequential Test within the district, i.e. to steer development towards areas of Low flood risk.
- Level 2** – An 'increased scope' SFRA to provide more detail of flood risk where there is development pressure in areas that are at Medium and High risk and to facilitate the application of the Exception Test where necessary.
- 1.2.2 It is usual for the Level 1 and Level 2 report to be completed as separate reports. However, the completion of the previous SFRA and the more recent Scoping Report highlighted that due to the presence of fluvial systems in the district, as well as the impact of tidal flooding propagating from the east, there will naturally be areas where development pressure and flood risk conflict and where an increased scope Level 2 SFRA will be required. For ease of reference and in order to prevent duplication of material, a single SFRA report encompassing the requirements of Level 1 and Level 2 SFRA has been prepared for Rochford District Council.

1.3 Objectives

- 1.3.1 The objectives of the **Level 1** SFRA are as follows:

³ CLG (December 2006, revised March 2010) Planning Policy Statement 25: Development and Flood Risk

⁴ CLG (June 2008, revised December 2009) Planning Policy Statement 25: Development and Flood Risk

- Collate and review all available existing information on flood risk within the Rochford District Council study area from relevant stakeholders including the Environment Agency, Water Utility (Anglian Water), Highways Authority (Essex County Council) and the Local Authority;
- Map the tidal and fluvial Flood Zones based on the most up to date information at the time of writing provided by the Environment Agency, including the functional floodplain (fluvial outlines only) and an allowance for climate change;
- Map areas liable to suffer from surface water flooding through the use of the Environment Agency dataset 'Areas Susceptible to Surface Water Flooding' and local historical records;
- Provide an assessment of groundwater flooding including mapping based on British Geological Survey data;
- Refer to Anglian water data to provide an assessment of flood risk from sewer flooding using DG5 data and local historical records where available;

1.3.2 The objectives of the **Level 2** SFRA are as follows:

- Carry out an appraisal of the current condition of flood defence infrastructure and of likely future policy with regard to its maintenance and upgrade;
- Complete an appraisal of the likelihood and consequence of failure of flood risk management infrastructure, including an appropriate allowance for climate change;
- Provide mapping to illustrate the distribution of flood risk across flood zones to enable a sequential approach to site allocations within Flood Zones;
- Use Environment Agency areas susceptible to surface water flooding maps to identify critical drainage areas and the need for surface water management plans;
- Identify policies and practices required to ensure development satisfies the Exception Test

1.3.3 Overarching objectives:

- Provide guidance on the preparation of site specific Flood Risk Assessments (FRAs);
- Provide meaningful recommendations to inform policy, development control and technical issues;
- Provide guidance on the likely applicability of sustainable drainage techniques for managing surface water from key development sites.

1.4 Consultation

Anglian water

1.4.1 Anglian Water have been consulted in capacity as sewerage undertakers as part of this assessment. They are responsible for surface water drainage from development areas via **adopted sewers** and in some cases are responsible for the maintenance of SuDS systems. Anglian water maintain trunk sewers, however, they are not responsible for the gulleys or local drainage connections to trunk sewers.

Essex County Council

- 1.4.2 Essex County Council is the Highways Authority and is responsible for maintaining an effective **highway drainage system** including kerbs, road gulleys and the pipes which connect the gulleys to the trunk sewers and soakaways. The Highways Authority has been contacted and has provided information to this study with regard to highway flooding hot spots.
- 1.4.3 Essex County Council as lead local flood authority in accordance with the Flood and Water Management Act 'must develop, maintain, apply and monitor a strategy for flood risk management in its area' including flood risk from surface runoff, groundwater and ordinary watercourses.

The Environment Agency

- 1.4.4 The Environment Agency is the principal flood defence operating authority in England with permissive powers for the management of flood risk arising from **designated Main Rivers and the sea**. The Flood and Water Management Act 2010 has given the Environment Agency a statutory duty for the strategic overview of all flood and coastal flood risk management issues in England. The Environment Agency is also responsible for flood forecasting, flood warning and general supervision over matters relating to flood defence. The Environment Agency have been consulted and have provided Flood Zone outlines, information on flood history, flood defences and have reviewed this document prior to publication.

Rochford District Council

- 1.4.5 Rochford DC is responsible for undertaking flood defence works on **ordinary watercourses** which have not been designated as 'Main River'. Information provided on these watercourses as part of the Strategic Flood Risk Assessment was limited.

2 Study Area

2.1 Rochford District Study Area

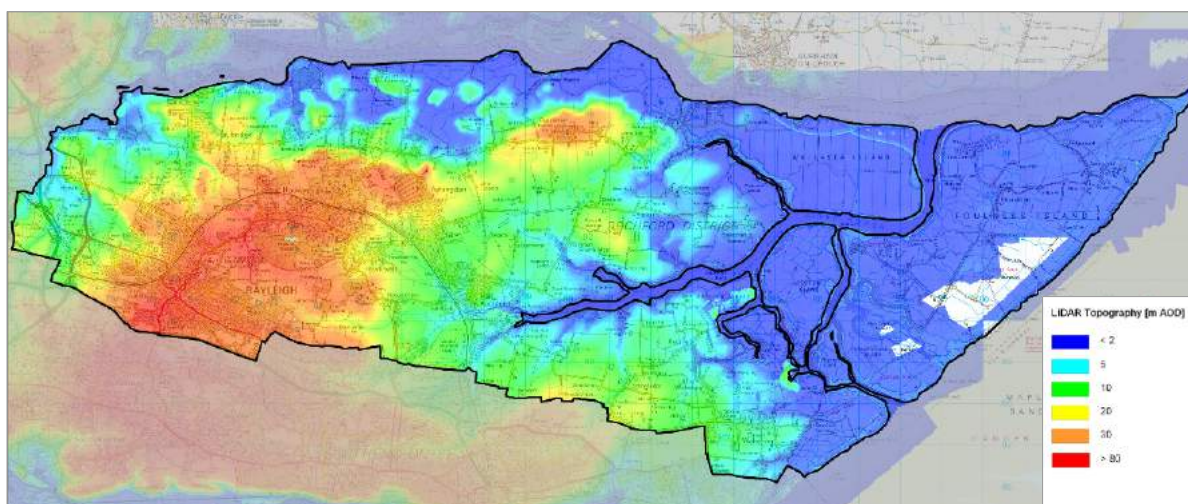
2.1.1 Figure A-1 identifies the study area covered by this SFRA. The administrative area of Rochford District Council is bordered by the North Sea in the east, the River Crouch in the north and the developed boroughs of Southend-on-Sea and Castle Point to the south. To the west, Rochford borders Basildon BC.

2.1.2 The district covers an area of approximately 17,000 hectares and has a resident population of approximately 83,200⁵. It is characterised by small scattered villages in the eastern part of the district and larger settlements on the western side including Ashingdon, Hullbridge, Hockley, Rayleigh and Rochford. The main centre of population in the district is Rayleigh in the southwest of the district.

2.2 Topography

2.2.1 The topography of the study area is shown in Figure A-2, an extract of which is provided in Figure 2-1 below. The eastern part of the district comprises low lying marshlands at or below mean high tide level. Further inland, levels rise and areas in the southwest of the district are located at elevations of approximately 80m AOD. The settlement of Canewdon in the north of the district is also elevated above the surrounding lower land. In the western parts of the district there are some significant slopes contributing to a greater likelihood for overland flow.

Figure 2-1 Extract from Figure A-2 Topography (LiDAR data, Environment Agency 2010)



2.3 Geology & Soils

2.3.1 The type of geology and soils in a particular region influence how surface water is conveyed and absorbed and therefore directly affects the likelihood and characteristics of flooding. The presence of impermeable rocks will lead to rapid and greater volumes of runoff, thereby increasing the risk of flooding downstream.

⁵ S1KS01 Usual resident population: Census 2001, Key Statistics of Urban Areas

- 2.3.2 Data from the British Geological Survey showing the solid and drift geology underlying the study area has been mapped in Figures A-3 and A-4. The predominant solid geology underlying the study area is Thames Group which comprises clay, silt, sand and gravel. This is impermeable and therefore rapid runoff into local watercourses can be expected.
- 2.3.3 Drift deposits are present across approximately half of the district. River terrace deposits are present either side of the River Roach around Little Wakering and Great Wakering and Rochford. These deposits comprise sand and gravel.
- 2.3.4 Deposits of alluvium are present along the eastern part of the district including Foulness Island and Wallasea Island. In addition, parts of the River Crouch floodplain are characterised by alluvial deposits including Hullbridge, and the area north of Ashingdon and Canewdon.
- 2.3.5 Soil characteristics have a significant affect on how the catchment responds to rainfall. The South Essex CFMP identifies a divide across the district with respect to soil characteristics. The west of the district around Rayleigh, Hullbridge, Hockley, Ashingdon and Hawkwell is characterised by seasonally wet, deep clay soils. These soils are relatively impermeable and therefore contribute to rapid runoff of surface water runoff, resulting in a greater risk of surface water flooding and causing watercourses to respond rapidly to rainfall.
- 2.3.6 The east of the district, including Rochford, Great Wakering and Foulness Island is characterised by the presence of silty and loamy soils. These are relatively permeable and therefore result in a relatively low rainfall to runoff conversion rate.

2.4 Hydrology

- 2.4.1 Main Rivers are defined as large or locally significant watercourses in England and Wales designated by Defra or the Welsh Assembly Government. A map of the Main Rivers is maintained by the Environment Agency and those within the Rochford District are shown in Figure A-6. Under the terms of the Water Resources Act 1991, prior written consent from the Environment Agency is required for any proposed works or structures in, under, over or within 9m of the top of the bank of a designated 'main river.
- 2.4.2 The entire northern and eastern boundary of the Rochford district is formed by tidally influenced watercourses including the River Crouch, River Roach and the North Sea. Extensive tidal floodplains associated with the estuarine extents of the River Roach and Crouch and the North Sea are present in the east of the district. These areas are sparsely populated.
- 2.4.3 Small, narrow floodplains associated with the Eastwood Brook and upper reaches of the River Roach affect localised areas of existing development in Rochford and Great Wakering.

3 Level 1 Assessment – Flood Risk Review

3.1 Overview

3.1.1 Strategic Flood Risk Assessments are required to consider all sources of flooding as set out in Annex C of PPS25 'Forms of Flooding'. This Chapter provides an overview of the different sources of flooding in the Rochford study area along with details regarding how each source is mapped and presented.

3.2 Fluvial Flooding

Sources

3.2.1 Fluvial flooding results from large rainfall events in the upper reaches of the catchment causing flows in excess of the carrying capacity of the channel. Where land is protected by fluvial flood defences, flooding can occur as a result of overtopping of the defences when the flood event is greater than that which the defences are designed for.

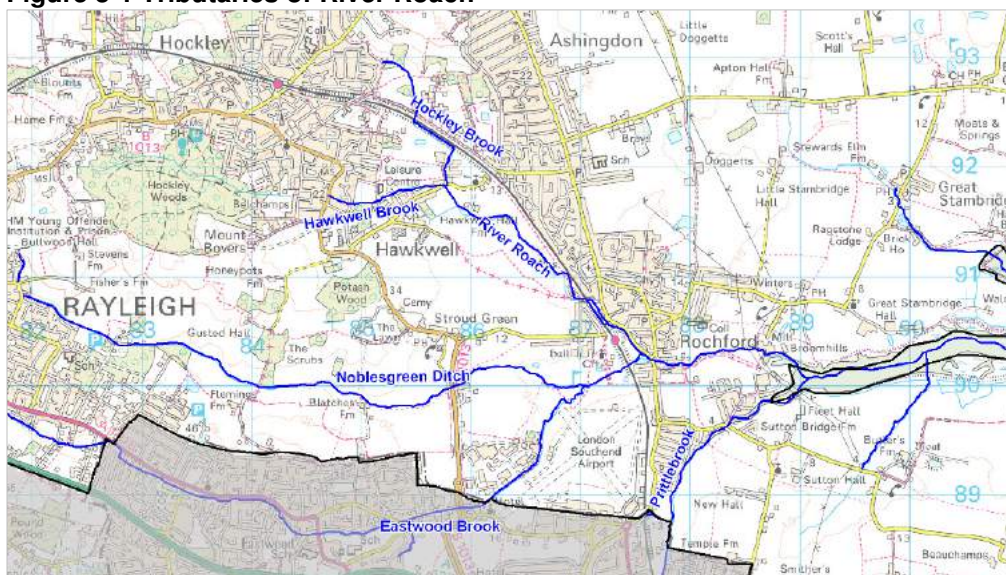
3.2.2 The main source of fluvial flood risk in the Rochford district is the upper reaches of the River Roach. There are five tributaries that contribute to flooding which are shown in Figure 3-1.

3.2.3 The Hawkwell Brook becomes a Main River at Thorpe Close in Hawkwell. It flows easterly through Hawkwell and joins the Hockley Brook at a confluence to become the River Roach. The Noblesgreen Ditch flows easterly from Rayleigh, towards Rochford where it then joins the River Roach.

3.2.4 The Eastwood Brook and Prittle Brook are predominantly located within the borough of Southend-on-Sea and have highly urbanised catchments. The Eastwood Brook follows the line of the A1015 and joins the Noblesgreen Ditch to the west of Rochford. The Prittle Brook flows easterly through Southend-on-Sea before turning northwards to meet the River Roach at Sutton Ford Bridge.

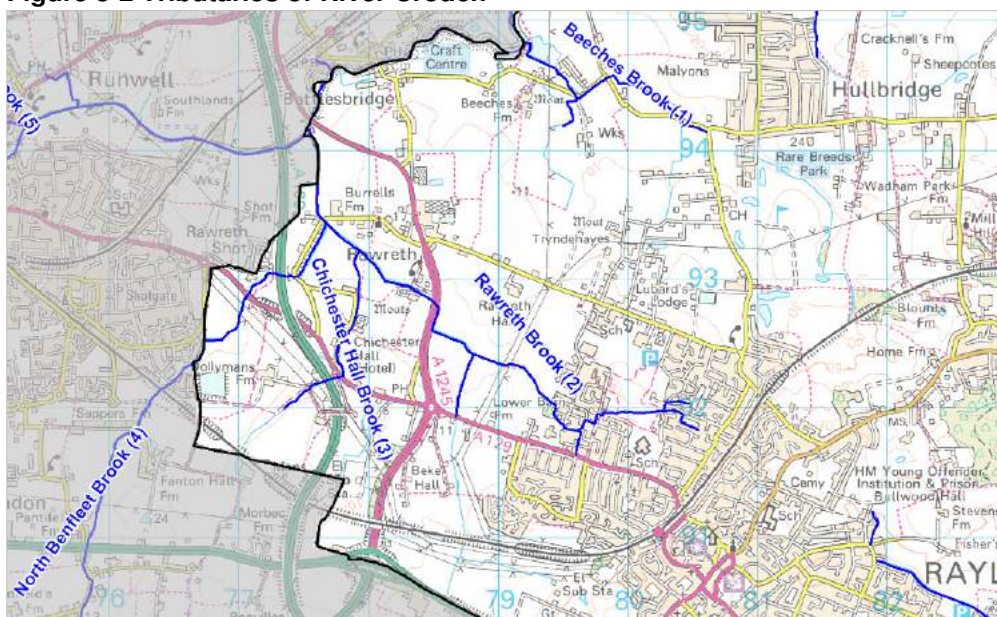
3.2.5 The River Roach is tidally influenced downstream of the Rochford Railway Station.

Figure 3-1 Tributaries of River Roach



- 3.2.6 The River Crouch is not a significant source of fluvial flooding in the study area as the river is tidally influenced along the length adjacent to the Rochford district. However there are several tributaries of the River Crouch within the western border of Rochford that pose a source of fluvial flood risk. These are the Rawreth Brook, Chichester Hall Brook, North Benfleet Brook and Beeches Brook and these watercourses are shown in Figure 3-2.
- 3.2.7 All of these watercourses are known to react rapidly to intense rainfall.

Figure 3-2 Tributaries of River Crouch



Historic Flooding

- 3.2.8 In 1968 exceptionally heavy rainfall led to extensive flooding within the Rochford district from tributaries of the River Roach including the Eastwood Brook and Prittle Brook. Rochford Golf Course was flooded to a depth of nine foot and up to 50 properties in Glenwood Avenue, to the south of Hockley, were affected. 78 properties were flooded in Rochford, located on Ashingdon Road, Church Street, St Andrews Road, Oak Road, Hall Road, Newlyn Lane and South Street.
- 3.2.9 In September 1958, 76mm of rainfall fell in two hours leading to flooding of properties in Rawreth and the evacuation of a number of families by boat.
- 3.2.10 Similar conditions of heavy rainfall in February 2001 were combined with high tides which led to tide locks on several Essex Rivers. Three properties were flooded in Rochford and 5 in Rawreth during these high water levels.
- 3.2.11 Following the event of 1968, several structural flood mitigation measures were undertaken along the channels of the River Roach tributaries to improve the standard of protection against flooding.
- 3.2.12 Given the risk of flooding from fluvial systems in Rochford, much of the area is covered by Environment Agency Flood Warning systems, further details of which are included in Section 4.3.

Flood Zones

- 3.2.13 Flood Zones are based on the probability of flooding occurring and are defined in accordance with the definitions in PPS25, which are shown in Table 3-1. The definition of flood zones does not take into account the presence of flood defences.

Table 3-1 PPS25 Fluvial Flood Zones (Table D.2 of PPS25, CLG 2010)

Flood Zone	Fluvial Flood Zone	Probability of Flooding
Flood Zone 1	Land assessed as having a less than 1 in 1000 annual probability of sea flooding in any year (less than 0.1%).	Low
Flood Zone 2	Land assessed as having between a 1 in 100 and 1 in 1000 annual probability of sea flooding in any year (between 1.0% and 0.1%)	Medium
Flood Zone 3a	Land assessed as having a 1 in 100 or greater annual probability of river flooding in any year (greater than 1.0%)	High
Flood Zone 3b	Land where water has to flow or be stored in times of flood, or land purposely designed to be flooded in an extreme flood event (0.1% annual probability). The 1 in 20 year annual probability floodplain is the starting point for consideration but local circumstances should be considered and an alternative probability can be agreed between the Local Planning Authority and the Environment Agency	Functional Floodplain

Flood Zone 3b – Functional Floodplain

- 3.2.14 The Functional Floodplains have the highest probability of flooding of all the Flood Zones defined within PPS25. A functional floodplain is defined as an area of land where water has to flow or be stored at times of flood or has an annual probability of flooding of 5% (i.e. from a 1 in 20 year return period event).

Flood Zone 3a with Climate Change

- 3.2.15 To ensure delivery of development that is sustainable now and in the future, PPS25 requires that the effects of climate change are taken into account and that Flood Zones with allowances for climate change should be presented.
- 3.2.16 PPS25 suggests that when completing an SFRA, planning bodies will need to agree how to factor climate change and over what time frame. The standard approach adopted by the Environment Agency in their Strategic Flood Risk Mapping is to include a net increase of 20% over and above peak flows, which is added to the 1 in 100 year flood event to account for climate change.
- 3.2.17 In areas where Flood Zone 3a plus climate change has not been modelled or mapped, Flood Zone 2 should be used as a surrogate for Flood Zone 3 plus climate change until such time that more detailed information is available, such as an EA Strategic Flood Risk Mapping (SFRM) study or a site-specific FRA.

Mapping

- 3.2.18 Flood Zone outlines have been provided by the Environment Agency for fluvial systems within the district. Table 3-2 provides a summary of the Flood Zones that have been provided. This information is mapped in Figures A-7 – A-10.

Table 3-2 Fluvial Watercourses in Rochford Study Area

Watercourse	Mapped in this SFRA			
	Flood Zone 3b	Flood Zone 3a	Flood Zone 3a + CC	Flood Zone 2
Prittle Brook	✓	✓	✓	✓
Eastwood Brook	✓	✓	✓	✓
Hawkwell Brook	✓	✓	✓	✓
Hockley Brook	✓	✓	✓	✓
Noblesgreen Ditch	Not available	✓	Not available	✓
Chichester Hall Brook	Not available	✓	Not available	✓
Rawreth Brook	Not available	✓	Not available	✓
Beeches Brook	Not available	✓	Not available	✓
North Benfleet Brook	Not available	✓	Not available	✓

Fluvial Flood Defences

- 3.2.19 Data from the National Flood and Coastal Defence Database (NFCDD) has been provided by the Environment Agency for the study area. Information regarding the standard of protection afforded by the fluvial and tidal flood defences is mapped in Figure A-12.
- 3.2.20 Flood defences along the fluvial watercourses are predominantly in the form of maintained channels. Figure A-12 demonstrates that there is some significant variation in the standard of protection provided by these channels in the area.
- 3.2.21 The Hawkwell Brook and Hockley Brook have maintained channels providing protection against the 100 year flood event. Along the fluvial section of the River Roach, the level of protection drops to the 30 year standard.
- 3.2.22 Sections of the Eastwood Brook and Prittle Brook are designed to protect against the 100 year event. In some sections of this watercourse, this decreases to just 10 – 17 year event.
- 3.2.23 The Rawreth Brook has maintained channels providing protection against the 50 year event.

3.3 Tidal Flooding

Sources

- 3.3.1 Rochford is at risk of tidal flooding from the North Sea and the River Crouch estuary. Tidal flooding is most likely to occur during storm surge conditions characterised by wind driven waves and low atmospheric pressure coupled with high spring tides. In areas protected from flooding by sea defences, tidal flooding can occur as a result of a breach in the defences, failure of a mechanical

barrier or overtopping of defences. Where defences are not present, flooding is typically widespread.

Historic Flooding

- 3.3.2 In January 1953 a tidal surge, 2.5m above the spring tide level, caused widespread flooding and loss of life across the whole region. Along the south bank of the River Crouch, from Battlesbridge to Canewdon, water overtopped the defences and propagated inland by up to a mile. In South Fambridge a breach, a mile and half long, occurred close to Land End Point leading to flooding of agricultural land and properties.
- 3.3.3 On Wallasea Island, 37 people were resident and trapped inside buildings or on roofs due to the rising water levels. On Foulness Island, 350 – 400 people were resident. A breach at Morris Point caused the waters to surge towards Landwick. Due to the low lying nature of the topography, the majority of the island was flooded. All access roads to the island were flooded and residents had no means of communication with the mainland.
- 3.3.4 Given the risk of tidal flooding in Rochford, much of the area is covered by Environment Agency Flood Warning systems, further details of which are included in Chapter 4.
- 3.3.5 As demonstrated during the events of January 1953, given the wide flat topography of the surrounding area, large areas are inundated very quickly following a breach event as flooding pathways are not very well defined.

Mapping

- 3.3.6 Tidal flood risk is mapped in a similar manner to fluvial flood risk. The definition of Flood Zone 3a is based on the 1 in 200 year flood event (0.5% AEP), rather than the 1 in 100 year event (1% AEP) used to map fluvial Flood Zones.

Table 3-3 Tidal Flood Zones (Table D.2 of PPS25, CLG 2010)

Flood Zone	Tidal Flood Zone	Probability of Flooding
Flood Zone 1	Land assessed as having a less than 1 in 1000 annual probability of sea flooding in any year (less than 0.1%).	Low
Flood Zone 2	Land assessed as having between a 1 in 200 and 1 in 1000 annual probability of sea flooding in any year (between 0.5% and 0.1%)	Medium
Flood Zone 3a	Land assessed as having a 1 in 200 or greater annual probability of sea flooding in any year (greater than 0.5%)	High
Flood Zone 3b	Land where water has to flow or be stored in times of flood, or land purposely designed to be flooded in an extreme flood event (0.1% annual probability). The 1 in 20 year annual probability floodplain is the starting point for consideration but local circumstances should be considered and an alternative probability can be agreed between the Local Planning Authority and the Environment Agency	Functional Floodplain

- 3.3.7 Flood Zones 2 and 3a with respect to tidal flood risk have been mapped on Figure A-7 along with the fluvial Flood Zones. The definition of flood zones does not take into account the presence of flood defences.

Tidal Flood Defences

- 3.3.8 The flood defences present in the Rochford district study area are typically earth embankments fronted by areas of intertidal mudflats or salt marsh habitats. The salt marsh acts to dissipate wave energy and reduce the probability of erosion due to tidal and river flow. The embankments work to protect an area from flooding by providing a mass of earth, which raises the surrounding land level and prevents inundation from a specific direction. Bunds may be reinforced with piles, concrete retaining wall structures or sheet pile walls driven through the crest to provide structural stability, additional resistance to breaching and to raise the level of protection. Where these reinforcements are absent, the earth embankment may be more susceptible to breaching, particularly in circumstances when the crest is overtopped by floodwaters.
- 3.3.9 Where bunds may be subject to high flow velocities or wave action the embankment may have a revetment or rock armour constructed on its seaward flank to prevent scour and erosion. Such flood defences are present around much of the frontage including Wallasea, Paglesham, South Fambridge and Shoeburyness.
- 3.3.10 Where access through the flood defences is required, floodgates may be constructed. These are usually manually operated and consist of a gate that is generally watertight with an appropriate crest height to prevent overtopping. The Environment Agency is responsible for floodgates and for issuing tidal flood warnings during which floodgates are closed as necessary.
- 3.3.11 Figure A-12 shows the level of protection provided by tidal flood defences in the study area. There is a manmade tidal seawall surrounding the tidal frontage of Paglesham and a secondary manmade clay embankment across Clements Marsh which protects the area from flooding up to a 1 in 50 year standard.
- 3.3.12 On the north bank of the tidal Roach estuary a blockwork revetment sea wall provides protection to Great Stambridge Hall and Rochford up to the 1 in 6 year flood event. On the southern bank of the estuary the level of protection varies between 1 in 4 to 1 in 8 year standard.
- 3.3.13 Around Wallasea Island new flood defences were completed in 2006 which included the restoration of the salt marshes.
- 3.3.14 The National Flood Risk Assessment dataset has also been mapped in Figure A-13. This dataset provides a broad assessment of the likelihood of flood risk to a site by predicting the likelihood that the centre of a 50m cell will be flooded. The methodology considers a number of different flood scenarios including a change in the distance from a given area to a river or the sea and the probability that flood defences fail. The dataset is constantly being updated with improved terrain data, local knowledge and the current condition of defences.
- 3.3.15 Figure A-13 demonstrates that a large part of the Rochford district is at 'significant' risk of flooding. This means that there is a 1 in 75 or greater annual probability (>1.3%) of flooding from the sea and or fluvial sources in any year.
- 3.3.16 More detailed information regarding the residual risk of flooding from overtopping and breaches of these flood defences at specific locations along the tidal frontage is included in Chapter 5.

3.4 Pluvial & Sewer Flooding

- 3.4.1 Pluvial flooding typically arises when intense rainfall, often of short duration, is unable to soak into the ground and/or enter drainage systems. It can run quickly off land, resulting in localised

flooding. The Pitt Review (2008) revealed that two-thirds of the flooding in Summer 2007 was a result of surface runoff in urban areas, as rainwater runs over the surface of the ground or ponds in low lying areas, and there is a growing likelihood of similar flooding in the future.

National Level Pluvial Modelling

3.4.2 Following extensive surface water flooding across England in July, the Environment Agency has undertaken a broad scale national mapping exercise of 'areas susceptible to surface water flooding'. This dataset has been mapped for the Rochford district study area in Figure A-11. When using this dataset, the following limitations should be considered:

- The mapping does not show the interface between the surface water network, the sewer systems and the watercourses;
- It does not show the susceptibility of individual properties to surface water flooding;
- The mapping has significant limitations for use in flat catchments e.g. the eastern portion of the district, including Wallasea Island and Foulness;
- This mapping excludes buildings, and uses a single rainfall event.

3.4.3 This mapping is intended for use by the Local Resilience Forums solely to inform emergency planning and should not be used for spatial planning decisions. In addition, the Environment Agency strongly recommend that local knowledge is applied to assess the suitability of the mapping as an indicator of surface water flooding before emergency planners make decisions based upon it.

3.4.4 In line with these recommendations, local flooding records supplied by Anglian Water (from their DG5 register), Rochford DC, Essex Fire & Rescue and the Environment Agency have been overlaid onto Figure A-11 to verify this data.

3.4.5 The Rochford District Multi Agency Flood Plan, which forms an appendix to the Essex Resilience Forum Multi Agency Flood Plan, also provides details of surface water flooding. In February 2001, a long period of consistent rainfall followed by 25mm of rainfall in 24 hours led to widespread surface water flooding in Rochford. Three properties are known to have experienced flooding in Rochford as well as five in Rawreth. In addition, in December 2002 – January 2003, heavy rainfall falling on already saturated ground led to rapid runoff and the flooding of four properties on Church Lane, Rawreth.

3.4.6 The Areas Susceptible to Surface Water Mapping highlights that the surface water flow paths follow the general topography of the area, as shown in Figure A-2. As to be expected, the predominant flow paths shown in the modelling correlate with the natural topographic depressions and the tributaries of the Rivers Roach and Crouch.

3.4.7 Incidents of surface water and sewer flooding recorded in Rochford, Rayleigh and Hawkwell correlate well with the modelled dataset. In addition, incidents recorded in Little Wakering also correlate with the modelling.

3.4.8 There are fewer incidents recorded to the north of the River Roach, which is to be expected given the lower concentration of urban development in this area.

3.4.9 When mapped against the national property database Defra reports that approximately 2360 properties are estimated to be susceptible to surface water flooding within the Rochford district. The following table provides a summary of the number of properties that may be susceptible to surface water flooding in each of the key settlement areas in Rochford.

Table 3-4 Number of properties susceptible to pluvial flooding in Rochford BC (Defra 2009)

Rank	Settlement	Properties
242	Rochford	1400
645	Rayleigh	400
741	Hockley	320
1046	Maylandsea	180
1897	Hullbridge	50
3336	Canewdon	10
	TOTAL	2360

- 3.4.10 Surface Water flood risk is clearly a concern in the district and there is an increasing need to consider the impact of rising sea levels as a result of climate change on the discharge of surface water runoff to tidal systems.
- 3.4.11 It is noted that the Environment Agency have commissioned a second edition of the Areas Susceptible to Surface Water Flooding dataset with greater accuracy anticipated called the 'Flood Map for Surface Water'. This models two storm events, incorporates the influence of buildings, and includes the influence of the sewer system and infiltration. This dataset was unavailable at the data collection stage of this project and has not been included in the SFRA. However, the 'Flood Map for Surface Water' and further borough wide pluvial modelling will be undertaken as part of the Surface Water Management Plan to be undertaken by Rochford District Council (also in partnership with Basildon BC and Castle Point BC) in spring 2011. Both of these datasets should be used to continue to develop and improve understanding of surface water flood risk posed to the study area and the potential options for mitigation and management of surface water flood risk.

3.5 Groundwater Flooding

- 3.5.1 Groundwater flooding occurs when water levels in the ground rise above surface elevations. Groundwater flooding may take weeks or months to dissipate, as groundwater flow is much slower than surface water flow therefore water levels take much longer to recede.
- 3.5.2 An assessment of the risk of groundwater flooding needs to be carried out; however, a quantified assessment of risk from groundwater flooding is difficult to undertake, especially on a strategic scale. This is due to lack of groundwater level records and the lack of predictive tools (such as modelling) that can assess the risk of groundwater flow and flooding following rainfall events.
- 3.5.3 The risk of groundwater flooding is considered to be greatest where areas are underlain by permeable rocks that form major aquifers. Data from the British Geological Survey showing the solid and drift geology underlying the study area has been mapped in Figures A-3 and A-4. The predominant solid geology underlying the study area is Thames Group which comprises clay, silt, sand and gravel.
- 3.5.4 The predominance of clay and deep loam to clay soils lead to a relatively impermeable surface where rapid runoff of surface water can be expected. This results in a greater risk of surface water flooding and causes local watercourses to respond rapidly to rainfall. However, the presence of such geology and soils also create an impermeable barrier to prevent groundwater rising to the surface and reduces the risk of flooding from groundwater.
- 3.5.5 The Environment Agency has been contacted and has confirmed that they have no records of groundwater flooding in the Rochford district study area.

- 3.5.6 Further detail with regard to groundwater flood risk across the district will be provided in the Surface Water Management Plan for Rochford DC which is anticipated in early 2011.

3.6 Artificial Sources

- 3.6.1 PPS25 requires that artificial water sources within the study area are identified as part of a SFRA. These include canals, reservoirs, ponds, and any feature where water is held above natural ground level.
- 3.6.2 There are a number of gravel pits along Creeksea Ferry Road to the east of Canewdon, however water is not held above the natural ground level and therefore these pits do not pose a significant flood risk to the surrounding area. In addition, these are located close to the tidal River Crouch and the Paglesham Ditch which drains to the tidal River Roach and therefore any potential overland flow from these gravel pits will be directed towards these watercourses rather than the Canewdon area.
- 3.6.3 There is an embanked water feature between Great Stambridge and Paglesham Eastend. The risk is considered to be low due to enforced management measures. In addition, this feature is located in a topographic depression in a rural location and the nearest properties are approximately 1km away, at a few metres higher. As a result the risk to surrounding areas is considered to be low.

4 Flood Risk Management & Warning Systems

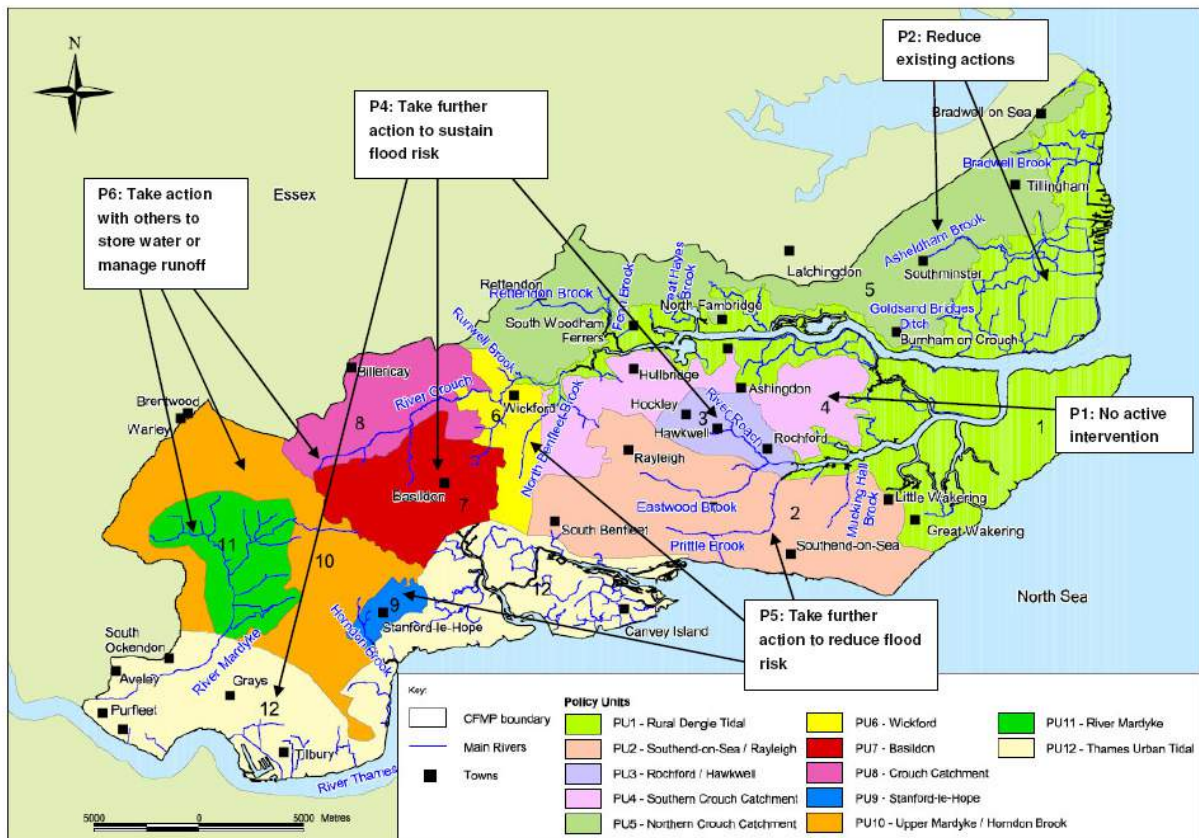
4.1 Introduction

4.1.1 Strategic Flood Risk Assessments are part of a wider collection of documents relating to flood risk management and warning. It is emphasised that SFRA reports are living documents which should be updated when Environment Agency datasets and other documents such as Catchment Flood Management Plans, Strategic Warning Systems and Shoreline Management Plans are updated and revised. This helps to contribute to a joined-up approach to flood risk management as a whole.

4.2 South Essex Catchment Flood Management Plan

4.2.1 The Catchment Flood Management Plan for South Essex was prepared by the Environment Agency and published in August 2008. The purpose of the CFMP is to develop policies for the long-term management of flood risk within the catchment, taking into account the likely effects of changes in climate, land use and land use management, and urban development. The policy approaches are defined for particular areas in the catchment and entail accepting, maintaining, reducing or transferring the flood risk. The policies for areas within Rochford District are shown in Figure 4-1 and summarised below.

Figure 4-1 South Essex CFMP Policy Areas (extracted from South Essex CFMP, 2008)



Preferred Policies

Policy Unit 1: Dengie Rural Tidal

- 4.2.2 This policy unit includes the tidal areas along the Rivers Crouch and Roach. Existing flood risk management measures include the extensive maintenance of arterial drains, rivers and brooks in the area. The selected policy for this area is Policy 2 to reduce existing flood risk management actions in this area, accepting that flood risk will increase with time.

Policy Unit 2: Rayleigh

- 4.2.3 Policy unit 2 includes the Rayleigh urban area and the Noblesgreen Ditch and Eastwood Brook. Existing flood risk management measures include dissemination of flood warnings and channel maintenance and improvements. The selected policy for this area is Policy 5, to take further action to reduce the flood risk, now and/or in the future, predominantly through improved flood warning service in the area and development control.

Policy Unit 3: Rochford & Hawkwell

- 4.2.4 This policy unit includes the upstream parts of the River Roach, Hawkwell Brook and Hockley Brook and urban areas of Rochford, Hawkwell and Hockley. Fluvial influences dominate in the upstream areas and tidal influences are present between Stambridge Mills and Rochford train station.
- 4.2.5 The selected policy for this area is Policy 4, to take further action to sustain the current level of flood risk into the future, responding to the potential increases in risk from urban development, land use change and climate change.

Policy Unit 4: Southern Crouch Catchment

- 4.2.6 This unit includes the rural areas to the south of the Crouch estuary including the urban areas of Ashingdon and Hullbridge. Current flood risk management in this area includes limited maintenance of the North Benfleet Brook, Rawreth Brook and a number of agricultural drains and ditches.
- 4.2.7 Within this area there is potential to restore the channels and floodplains thereby encouraging geomorphological and ecological biodiversity. Accordingly the selected policy for this unit is Policy 1, to cease all flood risk management activities.

4.3 Flood Warning Systems

- 4.3.1 The Civil Contingencies Act (2004) requires that the Environment Agency '*maintain arrangements to warn the public of emergencies*' including flood risk. The existing warning service provided by the Environment Agency applies only to flooding from rivers and the sea. There is no obligation on Water Companies to provide warnings of flooding from sewers or drains.
- 4.3.2 The Environment Agency are responsible for issuing flood warnings to the public based on meteorological reports and forecasts, including the use of radar to track storms and rainfall intensity, and data from the national tide gauge network. If flooding is forecast, warnings are issued using a set of four codes via the Environment Agency website, through TV and radio, SMS, fax, direct to your home via an automatic voice message and in some areas via public address systems. All existing development is included in the service under the 'opt out' policy; however any new development in the area will need to 'opt in' in order to benefit from the service.

4.3.3 The Environment Agency Flood Warning service consists of three warning messages as follows:

- **Flood Alert** - flooding is possible and that you need to be prepared.
- **Flood Warning** - flooding is expected and that you should take immediate action. You should take action when a flood warning is issued and not wait for a severe flood warning.
- **Severe Flood Warning** - there is severe flooding and danger to life. These are issued when flooding is posing significant risk to life or disruption to communities.

4.3.4 It should be noted that while it is a significant challenge to provide warning of a possible flood defence failure (breach) the likelihood of a failure is significantly increased during an extreme tide event. In this scenario, warnings of a high tide will have been issued to the local community who should be on alert.

4.3.5 The degree of advance warning that can be provided is critical to the amount of action that can be taken to prevent damage. It is anticipated that the Environment Agency will be able to provide at least 12 hours of warning time of extreme tides (i.e. 200 year event or greater (0.5% annual probability)).

4.3.6 Lead times for flood warnings from the Environment Agency with respect to fluvial systems are generally much shorter. For example, a lead time of 2 hours is expected for flooding on the Eastwood Brook close to the London Southend Airport site. Warning lead time availability is compounded by the rapid rate of water level rise in these watercourses in response to intense rainfall, the closeness of urban settlement to the Environment Agency's river level monitoring stations and the relatively short pathway from the sources of the watercourses to their respective points of outfall to estuary.

4.4 Rochford Emergency Flood Plan

4.4.1 The Civil Contingencies Act 2004 delivers a single framework for civil protection. Rochford DC are designated as a Category 1 responder and have a legal duty to assess local risks and use this information to inform emergency planning, put in place emergency plans and put in place arrangements to warn, inform and advise the public in the event of an emergency.

4.4.2 The Civil Contingencies Act (2004) defines an emergency as:

- *An event or situation which threatens serious damage to human welfare (e.g. loss of life, injury, damage to property).*
- *An event or situation which threatens serious damage to the environment (e.g. contamination).*

4.4.3 Flood Warning and Emergency Procedures tend to form part of a higher level emergency management plans for the wider area including information such as repair procedures, evacuation routes, refuge areas, flood warning dissemination and responsibilities.

4.4.4 Evacuation is where flood warnings provided by the Environment Agency can enable timely evacuation of residents to take place unaided, i.e. without the deployment of trained personnel to help people from their homes, businesses and other premises. Rescue by the emergency services is likely to be required where flooding has occurred and prior evacuation has not been possible.

- 4.4.5 Rochford DC has prepared a Multi Agency Flood Plan which should be read in conjunction with the Essex Resilience Forum (EFR) Multi Agency Flood Plan, of which it forms an appendix. The document includes details of the coverage of Environment Agency flood warnings and sets out the expected responses for individual agencies in line with the Essex Resilience Forum MAFP.
- 4.4.6 Six rest centres have been identified within the district. These are all located within Flood Zone 1 – Low Probability of flooding from tidal and fluvial sources.
- 4.4.7 The plan highlights that early consideration must be given to the evacuation of residents from Foulness Island and Paglesham due to the limitations of access and egress. It is recommended that the results from the Level 2 SFRA are provided to the Essex Resilience Forum to inform emergency planning procedures and update the MAFP where necessary.

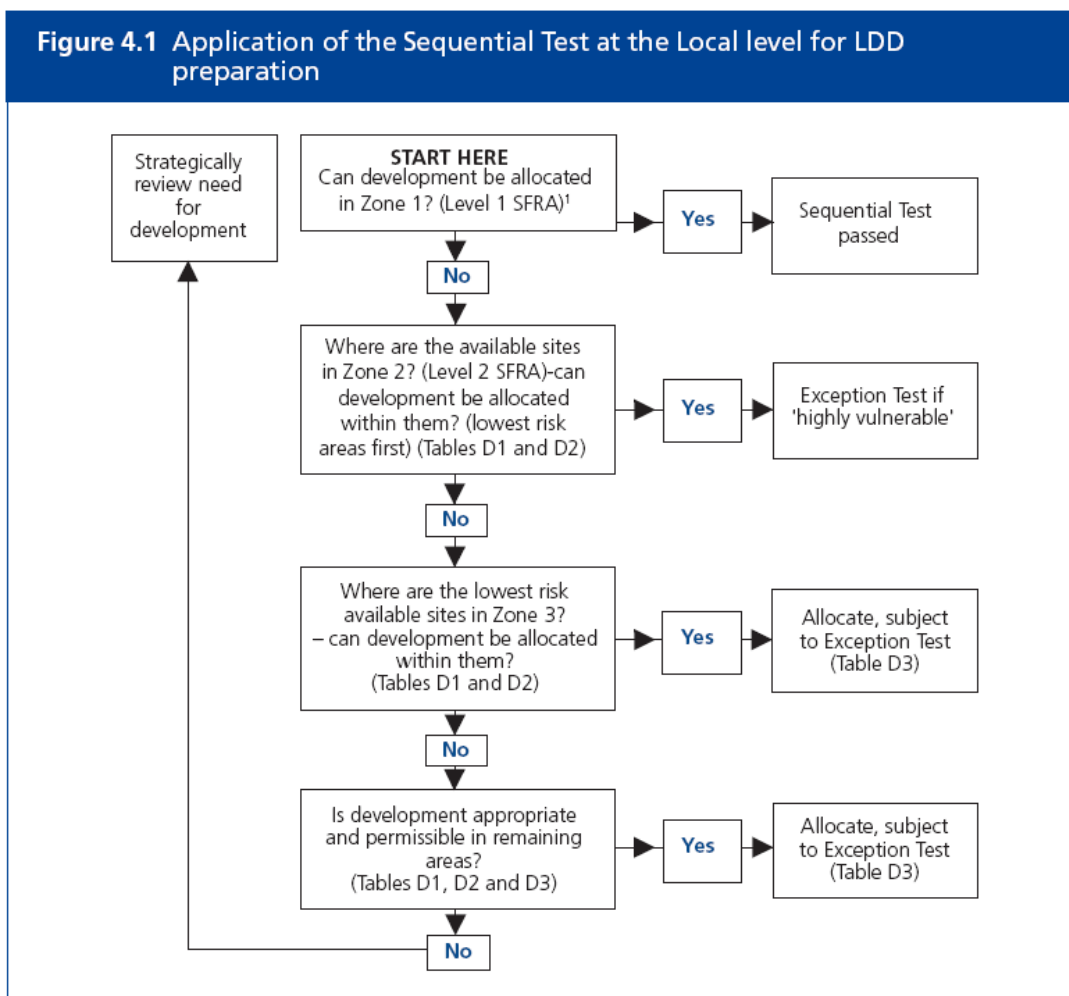
5 Guidance on the Application of the Sequential Test

5.1 Background

5.1.1 The sequential approach is a simple decision-making tool designed to ensure that sites at little or no risk of flooding are developed in preference to areas at higher risk. It should be applied at all levels and scales of the planning process, both between and within Flood Zones. All opportunities to locate new developments in reasonably available areas of little or no flood risk should be explored, prior to any decision to locate them in areas of higher risk.

5.1.2 The Sequential Test refers to the application of the sequential approach by Local Planning Authorities (LPA). This allows the determination of site allocations based on flood risk and vulnerability. Development should be directed to Flood Zone 1 wherever possible, and then sequentially to Flood Zones 2 and 3. In addition, development should be directed to areas of least flood risk within Flood Zone 2 and then Flood Zone 3, as identified within this SFRA. A flow diagram, extracted from the Practice Guide to PPS25, illustrating the application of the Sequential Test is provided in Figure 5-1.

Figure 5-1 Application of the Sequential Test, PPS25 Practice Guide, CLG 2009



Note

1 Other sources of flooding need to be considered in Flood Zone 1

Table 5-2 PPS25 Table D.2 Flood Risk Vulnerability Classification (CLG 2010)

Essential Infrastructure	<ul style="list-style-type: none"> • Essential transport infrastructure (including mass evacuation routes), which has to cross the area at risk, • Essential utility infrastructure which has to be located in a flood risk area for critical operational reasons, including electricity generating power stations and grid and primary substations; water treatment plants; and sewage treatment plants if adequate measures to control pollution and manage sewage during flooding events are in place. • Wind turbines.
Highly Vulnerable	<ul style="list-style-type: none"> • Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent.⁶ (Where there is demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure'.
More Vulnerable	<ul style="list-style-type: none"> • Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels. • Non-residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable	<ul style="list-style-type: none"> • Police, ambulance and fire stations which are not required to be operational during flooding • Buildings used for: shops; financial, professional and other services; restaurants and cafes; hot food takeaways; offices; general industry; storage and distribution; non-residential institutions not included in 'more vulnerable'; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place).
Water-Compatible Development	<ul style="list-style-type: none"> • Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel workings. • Docks, marinas and wharves. • Navigation facilities. • MOD defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

⁶ DETR Circular 04/00, paragraph 18: *Planning controls for hazardous substances.*
See www.communities.gov.uk/index.asp?id=1144377

5.1.3 PPS25 classifies developments according to their vulnerability and stipulates where the differing types of vulnerability are considered appropriate based on flood risk. The vulnerability classifications are shown in Table 5-2 and the compatibility matrix is shown in Table 5-3.

Table 5-3 PPS25 Table D.3 Flood Risk Vulnerability & Flood Zone Compatibility (CLG 2010)

Flood Risk Vulnerability Classification (Table D.2 PPS25)		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
FLOOD ZONE	1	✓	✓	✓	✓	✓
	2	✓	✓	Exception Test required	✓	✓
	3A	Exception Test required	✓	X	Exception Test required	✓
	3B	Exception Test required	✓	X	X	X

✓ – Development is appropriate (subject to the Sequential Test) ✗ – Development should not be permitted

5.1.4 The application of the sequential approach aims to manage the risk from flooding by avoidance. This will help avoid the promotion of sites that are inappropriate on flood risk grounds.

5.1.5 Rochford District Council must demonstrate that it has considered a range of possible sites in conjunction with the Flood Zone information from the SFRA and applied the Sequential Test, and where necessary, the Exception Test (see Appendix D of PPS25), in the site allocation process. In cases where development cannot be fully met through the provision of site allocations, LPAs are expected to make a realistic allowance for windfall development, based on past trends.

5.1.6 PPS25 acknowledges that some areas will (also) be at risk of flooding from flood sources other than fluvial or tidal systems. All sources of flooding must be considered when looking to locate new development. The other sources of flooding requiring consideration when situating new development allocations include:

- Surface Water;
- Groundwater;
- Sewers; and
- Artificial Sources.

5.1.7 These sources (as sources of flooding) are typically less understood than tidal and fluvial sources. Data primarily exists as point source data or through interpretation of local conditions. In addition, there is no guidance on suitable return periods to associate with floods arising from these sources. For example modern storm water drainage systems are constructed to a 1 in 30 year standard. Any storm event in excess of the 30 year return period storm would be expected to cause flooding. If a location is recorded as having experienced repeated flooding from the same source this should be acknowledged within the Sequential Test.

5.2 Using the SFRA to Apply the Sequential Test

5.2.1 The Sequential Test should be undertaken by Rochford DC and accurately documented to ensure decision processes are consistent and transparent. The Sequential Test should be carried out on potential development sites, seeking to balance the flood probability and development vulnerability of sites throughout the Local Planning Authority area.

5.2.2 The recommended steps required to undertaking the Sequential Test are detailed below. This is based on the Flood Zone and Flood Risk Vulnerability, and is summarised in Figure 5-1.

Recommended stages for LPA application of the Sequential Test

5.2.3 The information required to address many of these steps is provided in the accompanying GIS layers and maps included in this SFRA Report.

1. Assign potential developments with a vulnerability classification (Table 5-2). Where development is mixed, the classification should be determined by the element of greatest vulnerability.
2. The location and identification of potential development should be recorded.
3. The Flood Zone classification of potential development sites should be determined based on a review of the Environment Agency Flood Zone maps for fluvial and tidal sources and upon the Flood Zones presented in this SFRA. Where these span more than one Flood Zone, all zones should be noted.
4. The design life of the development should be considered with respect to climate change:
 - 75 years – up to 2085 for commercial / industrial developments; and
 - 100 years – up to 2110 for residential developments
5. Identify existing flood defences serving the potential development sites. However, it should be noted that for the purposes of the Sequential Test, flood zones ignoring defences should be used.
6. Highly vulnerable developments to be accommodated within the LPA area should be located in those sites identified as being within Flood Zone 1. If these cannot be located in Flood Zone 1, because the identified sites are unsuitable or there are insufficient sites in Flood Zone 1, sites in Flood Zone 2 can then be considered. If sites in Flood Zone 2 are inadequate then the LPA may have to identify additional sites in Flood Zones 1 or 2 to accommodate development or seek opportunities to locate the development outside their administrative area. Highly vulnerable development within Flood Zone 2 must pass the Exception Test. Highly vulnerable development is not appropriate within Flood Zones 3a and 3b.
7. Once all highly vulnerable developments have been allocated to a development site, the LPA can consider those development types defined as more vulnerable. In the first instance more vulnerable development should be located in any unallocated sites in Flood Zone 1. Where these sites are unsuitable or there are insufficient sites remaining, sites in Flood Zone 2 can be considered. If there are insufficient sites in Flood Zone 1 or 2 to accommodate more vulnerable development, sites in Flood Zone 3a can be considered. More vulnerable developments in Flood Zone 3a will require the application of the Exception Test. More vulnerable developments are not appropriate within Flood Zone 3b.
8. Once all more vulnerable developments have been allocated to a development site, the LPA can consider those development types defined as less vulnerable. In the first instance less vulnerable development should be located in any remaining unallocated sites in Flood Zone

1, continuing sequentially with Flood Zone 2, then 3a. Less vulnerable development types are not appropriate in Flood Zone 3b – Functional Floodplain.

9. Essential infrastructure should be preferentially located in the lowest flood risk zones, however this type of development may be located in Flood Zones 3a and 3b, provided the Exception Test is fulfilled.
10. Water compatible development has the least constraints with respect to flood risk and it is considered appropriate to allocate these sites last.
11. On completion of the Sequential Test, the LPA may have to consider the risks posed to a site within a flood zone in more detail in a Level 2 SFRA. By undertaking the Exception Test, this more detailed study should consider the detailed nature of flood hazard to allow a sequential approach to site allocation within a flood zone with the most vulnerable land uses being sited in the areas of least flood risk. Consideration of flood hazard within a flood zone would include:
 - flood risk management measures,
 - the rate of flooding,
 - flood water depth and or,
 - flood water velocity.

5.2.4 Where the development type is Highly Vulnerable, More Vulnerable, Less Vulnerable or Essential Infrastructure and a site is found to be impacted by a recurrent flood source (other than tidal or fluvial), the site and flood sources should be investigated further and the sequential test applied in line with paragraphs 4.8 to 4.12 of the PPS25 Practice Guide.

Windfall Sites

5.2.5 Windfall Sites are sites which become available for development unexpectedly and are therefore not included as allocated land in a planning authority's development plan.

5.2.6 Should a site become available that has not been allocated as part of the LDF process, the Sequential Test should be applied on an individual site basis and the developer will need to provide evidence to the LPA that they have adequately considered other reasonably available sites across the district. This will involve considering windfall sites against other sites allocated as suitable for housing plans.

5.2.7 The following steps should be followed for windfall sites:

1. Identify if the Sequential Test is required; Paragraph D.15 of PPS25 states that if the application is minor development or for a change of use, the Sequential and Exception Tests are not required. However, the application will still need to meet the requirements for FRAs and flood risk reduction as set out in Table D.1 of PPS25.
2. If the Sequential Test is required, identify which Flood Zone the site is located within using the Environment Agency flood maps and the Flood Zones presented within this SFRA. If comparing sites within the same Flood Zone the SFRA should be used to compare the variation in risk throughout the Flood Zone or site specific Flood Risk Assessments where available.
3. Agree scope and considerations for the site-specific Sequential Test and, where necessary, Exception Test with the LPA.

6 Level 2 Assessment of Tidal Flood Risk

6.1 Overview

6.1.1 It has been established that a large proportion of the study area is at residual risk of tidal flooding in the event that the existing defences are overtopped or fail.

6.1.2 In accordance with PPS25 and the Practice Guide, part of the requirement of the Level 2 SFRA is to provide an assessment of the residual risk, i.e. the risk remaining after flood risk management measures have been taken into account. As a result, hydrodynamic modelling has been undertaken at seven locations around the tidal frontage of Rochford to model the impact of a breach or overtopping of these defences.

6.2 Potential Flooding Mechanisms

6.2.1 Flood defences are designed and constructed to rigorous structural and geotechnical codes to a specific standard of protection or return period. If defences are subjected to a loading greater than the standard of protection, there is a significant likelihood that they will fail.

6.2.2 A breach in flood defences is defined as:

'The failure of a flood defence mechanism by which the structural integrity of the flood defence is compromised and part or all of the defence collapses allowing water to flow through'.

6.2.3 Overtopping of defences can be caused when:

'Flood waters exceed the lowest crest height of the flood defences or if high winds begin to generate significant swells in the ocean that bring waves crashing over the top of defences'

6.2.4 There are a number of potential circumstances and mechanisms which may lead to failure of flood defences, such as:

- Collision of shipping traffic with tidal wall;
- Hydrostatic water pressure during high tides;
- Vehicle collision;
- Floating object such as a partly submerged container;
- Damage to a pipeline running through a tidal wall;
- Damage or explosion of an installation on the landward side of the tidal wall;
- Floodgate being left open;
- Scouring and erosion of the landward side of the defence in the event of overtopping;
- Fissuring and desiccation of clay fill.

6.2.5 Breaches are more likely to occur during high water level events including extreme tides when loads on the defence will be greater.

- 6.2.6 The time taken for a breach to be blocked can have a major impact on the extent and depth of flood experienced. The highest flood hazard typically exists in the period immediately following a breach and usually but not necessarily in the areas closest to a breach.
- 6.2.7 Floodwater flowing through a breach in the defences will generally be of high velocity and volume, dissipating rapidly across large low lying areas. Flooding as a result of a breach in defences from tidal sources such as this can be life threatening with far reaching consequences. Breaching of the flood defences has the potential to generate considerable flood hazard and damage to homes and infrastructure.
- 6.2.8 As part of this SFRA, 2D modelling has been carried out to assess the impact of residual risks following a breach or overtopping scenario. A brief overview of the methodology is provided below and a full modelling methodology is provided in Appendix E.

Figure 6-1 Flood Defences & Modelled Flood Cells in Rochford District



ROC07 Block revetment on earth embankment. ROC07 Steel capped revetment.



ROC06 Loftmans Sluice.



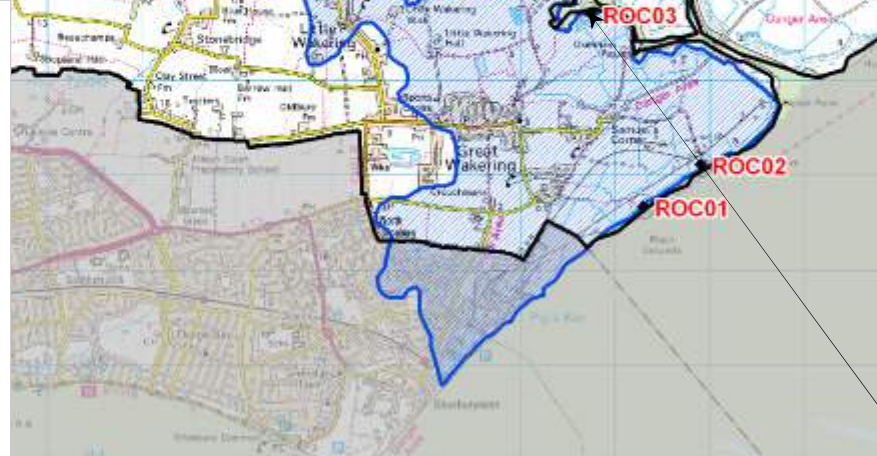
ROC05 Block revetment on earth embankment.



ROC04 Flood Gate at Paglesham.



ROC04 Block revetment on earth embankment.



ROC03 Block revetment on earth embankment.

6.3 Modelling Methodology

Breach Assessment

6.3.1 Details of the seven breach locations are included in Table 4-1 and their location is shown on Figure A-1 in Appendix A and Figure 6-1.

Table 6-1 Breach Names and Characteristics

Code	Flood Cell	Breach Name	Easting	Northing	Breach Width [m]
ROC01	Shoeburyness	Morrin's Point	596298	186654	200
ROC02	Shoeburyness	Wakering Stairs	596900	187100	50
ROC03	Shoeburyness	Oxenham Farm	595745	188694	50
ROC04	Paglesham	Paglesham Eastend	594816	192185	50
ROC05	Wallasea	Grapnells, Wallasea Island	594700	195000	50
ROC06	Paglesham	Loftmans Farm, Paglesham Creek	592310	193790	50
ROC07	South Fambridge	South Fambridge	585500	196200	50

6.3.2 The following flood events were simulated for each of the breach locations:

- 1 in 200 year event (0.5% AEP) present day, 2010
- 1 in 200 year event (0.5% AEP) with climate change, 2110
- 1 in 1000 year event (0.1% AEP) present day, 2010
- 1 in 1000 year event (0.1% AEP) with climate change, 2110

Overtopping

6.3.3 Modelling has also been undertaken in order to assess the impact of overtopping of the existing defences, without consideration of a breach in the flood defences. The following flood events were simulated for each of the four flood cells (Shoeburyness, Paglesham, Wallasea & South Fambridge):

- 1 in 200 year event (0.1% AEP) with climate change, 2110
- 1 in 1000 year event (0.1% AEP) with climate change, 2110

6.3.4 A detailed description of the modelling methodology is included in Appendix E. The following section describes the generation and mapping of the outputs from the hydrodynamic modelling.

6.4 Modelling Outputs

Maximum Flood Depth

6.4.1 The flood depth maps included in Appendix B show the maximum depth of flooding which is experienced at each individual element in the model throughout the entire simulation. The maximum flood depth is obtained from the water level achieved at each point in the model, minus the LiDAR topographic level at that point.

- 6.4.2 The peak depth will occur at different times depending upon the location of the model under consideration. For example, immediately adjacent to the breach location or defences that experience overtopping, the peak depth will be experienced around the same time as when the tidal water level boundary peaks. However peak depths inland, some distance away from the defences will be experienced at a later time when water has spread further throughout the model. The flood depth map therefore presents a worst case and conservative scenario.
- 6.4.3 Figures B-1 to B-4 in Appendix B show the maximum flood depth for all of the modelled breach scenarios. These are 'composite' maps and therefore illustrate the maximum depth experienced from all seven breach locations.
- 6.4.4 Figures B-5 and B-6 show the maximum flood depths as a result of overtopping of the defences.

Hazard Rating

- 6.4.5 Flood hazard is a function of the flood depth and flow velocity at a particular point in the floodplain. Each element within the model is assigned one of four hazard categories 'Extreme Hazard', 'Significant Hazard', 'Moderate Hazard', and 'Low Hazard'.
- 6.4.6 The derivation of these categories is based on the methodology in Flood Risks to People FD2320⁷ using the following equation:

$$\text{Flood Hazard Rating} = ((v+0.5)*D) + DF \quad \text{Where } v = \text{velocity (m/s)}$$

$$D = \text{depth (m)}$$

$$DF = \text{debris factor}$$

- 6.4.7 The depth and velocity outputs from the 2D hydrodynamic modelling are used in this equation, along with a suitable debris factor. For this SFRA, a precautionary approach has been adopted inline with FD2320; a debris factor of 0.5 has been used for depths less than and equal to 0.25m, and a debris factor of 1.0 has been used for depths greater than 0.25m.

Table 6-2 Hazard categories based on FD2320, Defra & Environment Agency 2005

Flood Hazard		Description
Low	HR < 0.75	Caution – Flood zone with shallow flowing water or deep standing water
Moderate	0.75 ≥ HR ≤ 1.25	Dangerous for some (i.e. children) – Danger: flood zone with deep or fast flowing water
Significant	1.25 > HR ≤ 2.0	Dangerous for most people – Danger: flood zone with deep fast flowing water
Extreme	HR > 2.0	Dangerous for all – Extreme danger: flood zone with deep fast flowing water

- 6.4.8 Figures C-1 to C-4 in Appendix C are composite maps showing the maximum flood hazard rating for all of the modelled breach scenarios. These are 'composite' maps and therefore illustrate the maximum depth experienced from all seven breach locations.
- 6.4.9 Figures C-5 and C-6 show the flood hazard as a result of overtopping of the defences.

⁷ Defra and Environment Agency (2005) FD2320 Flood Risks to People

Time to Inundation

- 6.4.10 The time taken for floodwaters to propagate from the breach location has also been mapped using the following methodology. This information is useful for assessing the length of time before floodwaters reach a particular site and therefore the time available for evacuation to a place of safety.
- 6.4.11 Time zero is set to the time when tidal water enters the breach. This means that the <1 hour band encompasses all areas that are inundated (wet) within the first hour of water travelling through the breach and into the flood cell. Further bands have been produced to show wet cells at: 1-4 hours, 4-8 hours, 8-12 hours, 12-16 hours and 16-20 hours.
- 6.4.12 Time to inundation is specific to each breach location; therefore mapping of each of the 7 breach locations is provided in Appendix D. Mapping has been provided for the 1 in 1000 year plus climate change to 2110 event and the 1 in 200 year plus climate change to 2110 event. The 1 in 1000 year plus climate change to 2110 event represents the most conservative scenario and should be used for emergency planning purposes. Lower return period events including scenarios for present day scenarios are likely to lead to a lower time to inundation across the flood cells.

6.5 Limitations

Flood Depth and Hazard Rating

- 6.5.1 It should be noted when using flood hazard zone maps that they **represent the hazard arising from one or more specific breach locations, and that the hazard will almost certainly vary spatially if the breach locations are moved.** This is also the case for the flood depth maps and time to inundation maps.
- 6.5.2 Other limitations that should be noted include:
- Not all possible breach locations have been considered. The modelling study had to be limited to those locations thought most likely to lead to flood risk for specific development areas.
 - Breach width and depth, though based on Environment Agency guidance, are arbitrary and do not necessarily represent the actual dimensions of a possible breach in a given location.
 - Changes in inundation extent or hazard zone are non-linear to changes in breach location.
 - Hazard mapping is developed as a product of the depth, velocity and a debris factor from a particular breach event or combined breach event within a given flood cell. These hazard classifications do not indicate a change in the flood probability.

Time to Inundation

- 6.5.3 The values presented for time to inundation are indicative only. The modelling methodology used for this study produces results from a breach occurring prior to the second and largest tidal cycle. This allows water to overtop where defences are below the water level during the first tidal cycle. The modelling method also allows the rapid inundation of land immediately behind the breach where water has accumulated on the seaward side of the breach.

6.6 Modelling Results

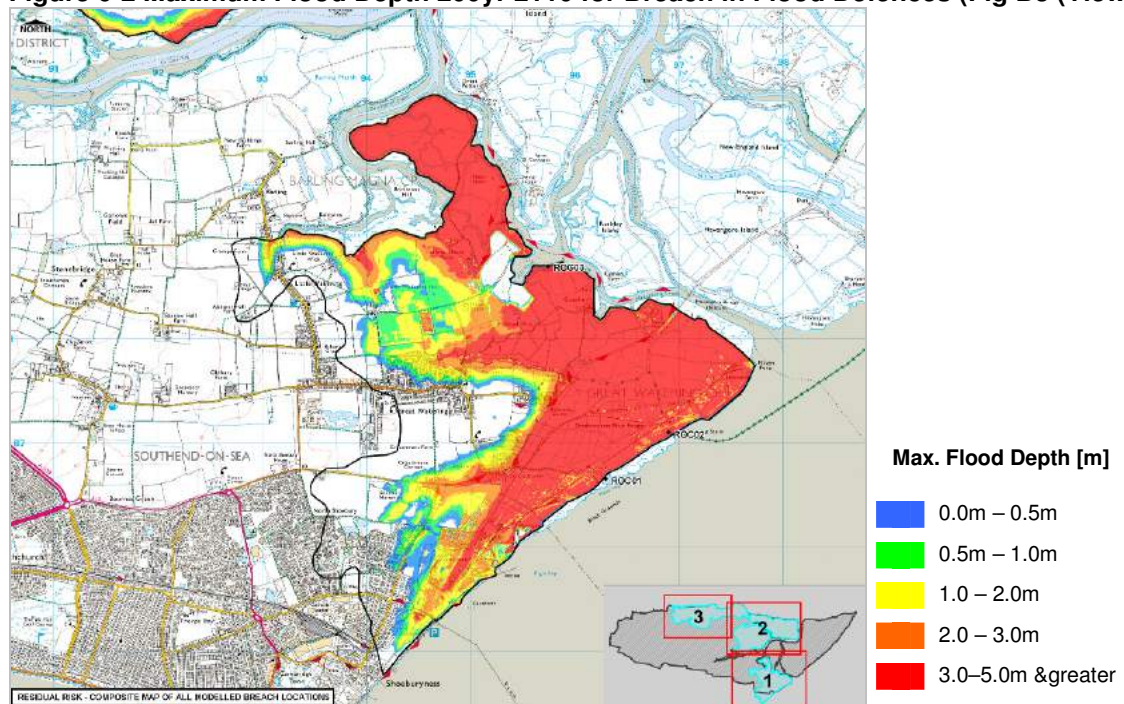
6.6.1 The remainder of this Chapter comprises a review of the residual tidal flood risk within each of the flood cells. All mapping is provided in full in Appendices B, C and D.

Shoeburyness Flood Cell: Review of Residual Flood Risk

Breaches (ROC01, ROC02, ROC03)

6.6.2 Three breach locations have been modelled within this flood cell. Figure 6-2 shows the composite flood depth map for these three breach events for the 1 in 200 year flood event, including allowances for climate change to 2110. Flood depths are shown to reach greater than 3m across the eastern part of the flood cell. Existing development at Oxenham, Cupid's Corner, Halfway House Farm, Landwick Cottages and Samuel's Corner, the Sewage Works adjacent to Havengore Creek and the northern part of Great Wakering experiences significant flood depths.

Figure 6-2 Maximum Flood Depth 200yr 2110 for Breach in Flood Defences (Fig B3 (View 1))

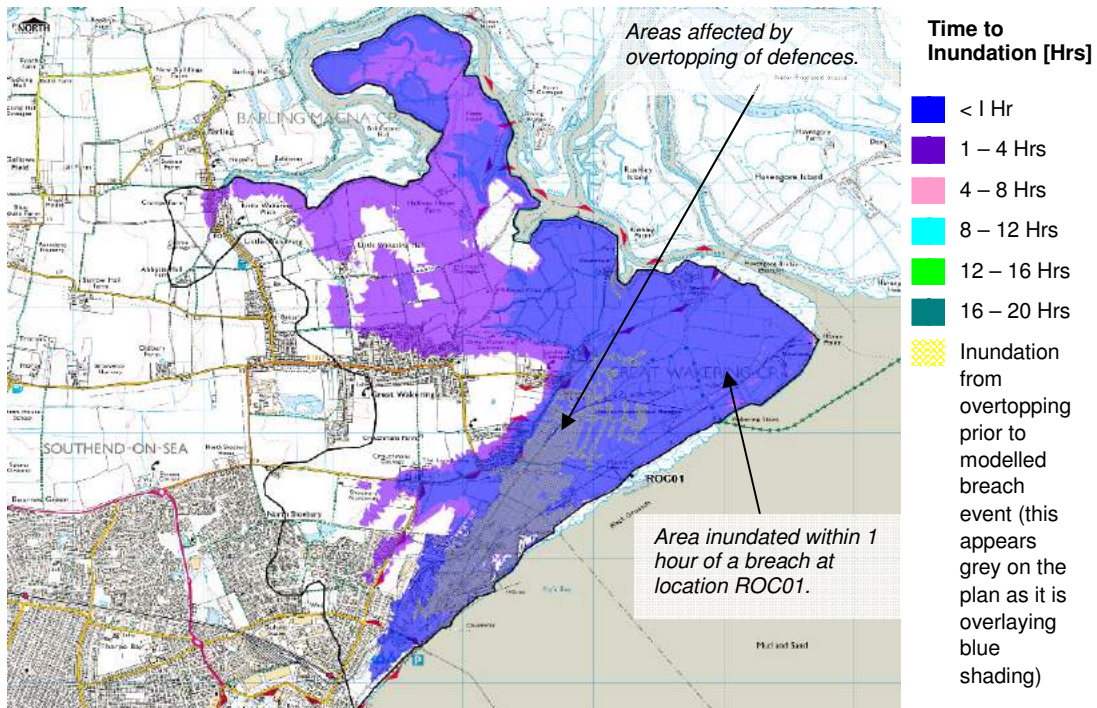


6.6.3 Figure 6-3 overleaf demonstrates that during the 1 in 200 year flood event, including allowance for climate change to 2110, flood waters inundate the flood cell rapidly. Floodwaters inundate the Shoeburyness New Ranges and reach Landwick Cottages within 1 hour, and the whole flood cell is inundated within 2 hours of the breach event, providing limited time for evacuation of residents.

6.6.4 The B1017 forms the primary evacuation route from Great Wakering. Access and egress from the smaller villages is not possible during these flood events.

6.6.5 There are no new developments planned within this area as part of the Rochford Core Strategy. However ad hoc planning applications may be submitted for the redevelopment of individual properties. Where this is the case, proposals should meet the requirements of PPS25 and those outlined in Chapter 9 of this report.

Figure 6-3 Time to Inundation from ROC01, 1000yr plus Climate Change (Fig D1)



Overtopping

6.6.6 Modelling shows that the flood defences along the Shoeburyness frontage are overtopped during the 1 in 200 year event including an allowance for climate change. Figures B5 and B6 demonstrate that this overtopping leads to similar flood depths and extents to those experienced during a breach event.

Paglesham Flood Cell: Review of Residual Flood Risk

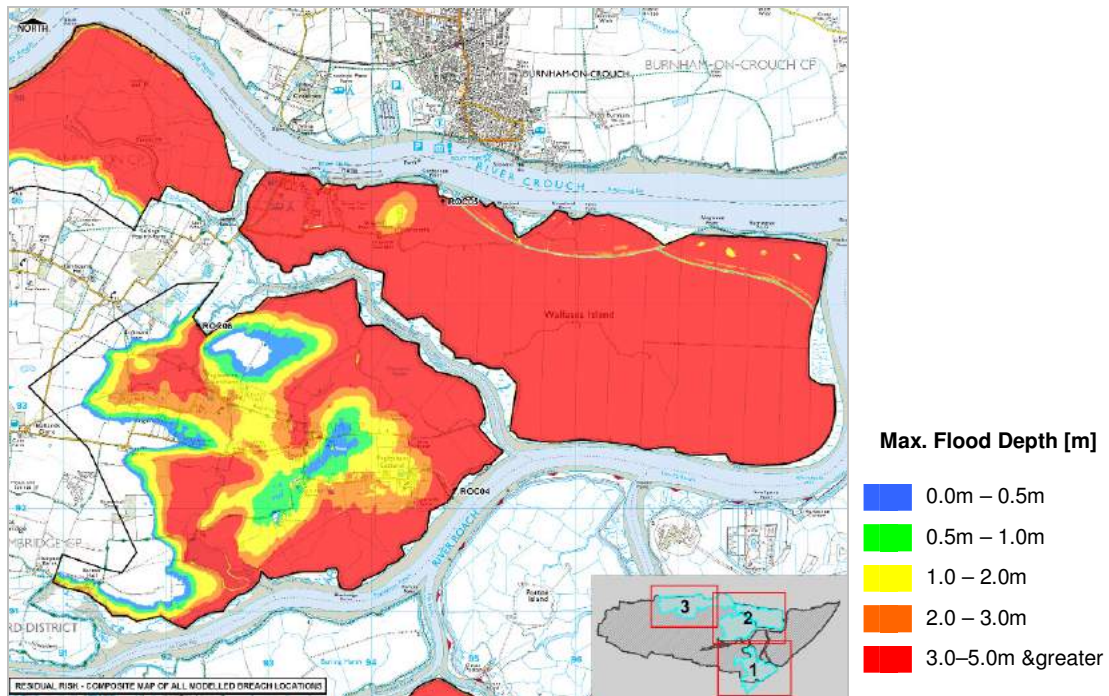
Breaches (ROC04, ROC06)

6.6.7 Two breach locations have been modelled in the Paglesham flood cell. Figure 6-4 shows the composite flood depth map for these breach events for the 1 in 200 year flood event, including allowances for climate change to 2110.

6.6.8 Floodwaters initially spread around the eastern edge of Paglesham where the topography is low lying. Maximum flood depths are experienced in Clements Marsh and in the south of the flood cell. Floodwaters spread inland and inundate Paglesham Churchend and Pagelsham Eastend to depths of between 1-3m. The access routes to these settlements are also inundated to depths of 3m causing significant problems for access and egress for occupants.

6.6.9 Current development comprises small villages and isolated buildings and connecting minor roads. Although there is no development proposed for this part of the district, ad hoc planning applications may be submitted for redevelopment of individual properties. Where this is the case, proposals should meet the requirements of PPS25 and those outlined in Chapter 9 of this report.

Figure 6-4 Maximum Flood Depth 200yr 2110 for Breach in Flood Defences (Fig B3 (View 2))



Overtopping

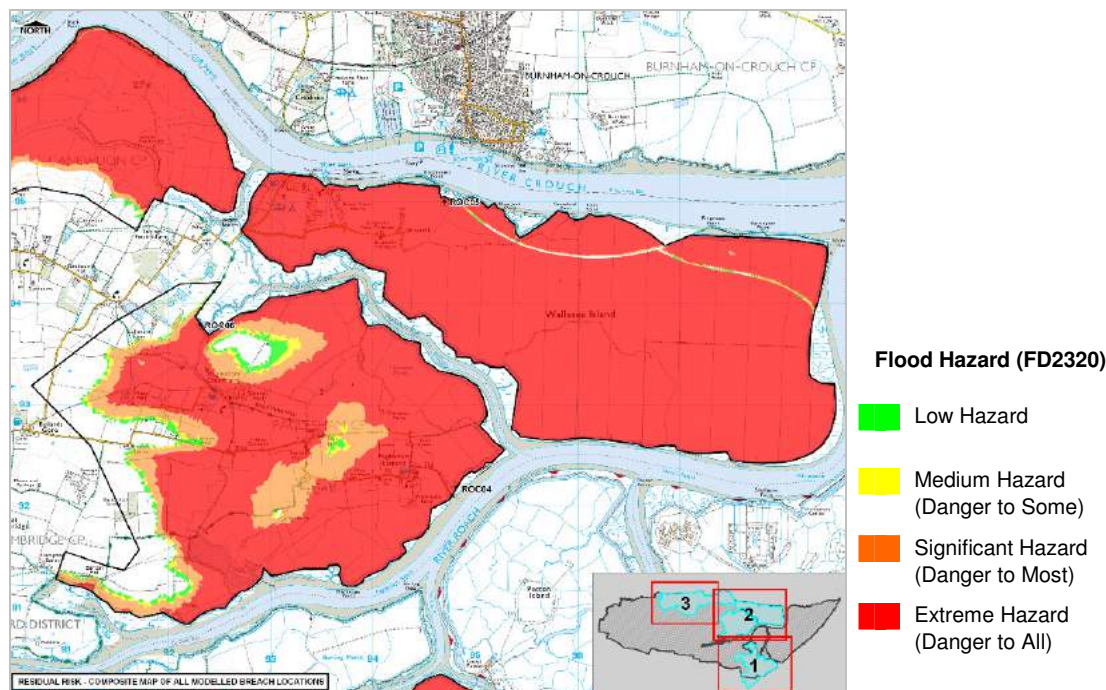
- 6.6.10 Modelling shows that the flood defences along the Paglesham frontage are overtopped during the 1 in 200 year event including an allowance for climate change. Figures B5 and B6 demonstrate that this overtopping leads to flood depths and extents very similar to those experienced during a breach event.

Wallasea Island Flood Cell: Review of Residual Flood Risk

Breach (ROC05)

- 6.6.11 One breach location, ROC05, has been modelled within the Wallasea Island flood cell. Figure 6-4 shows the composite flood depth map for the 1 in 200 year flood event, including allowances for climate change to 2110. This figure shows that Wallasea Island experiences significant flooding and floodwaters cover the whole of the island to depths of greater than 3m. Such depths of flooding correspond to an ‘extreme’ hazard rating, which signifies ‘danger to all people’, as shown in Figure 6-5.
- 6.6.12 Access to existing development is severely restricted during a breach which has implications for emergency services and the safe evacuation of occupants of the island.
- 6.6.13 Apart from the marina, there is limited development on Wallasea Island; two small villages and a caravan and camping park. In light of the extreme hazard, no development is planned in this area. However ad hoc planning applications may be submitted for the redevelopment of individual properties. Where this is the case, proposals should meet the requirements of PPS25 and those outlined in Chapter 9 of this report.

Figure 6-5 Flood Hazard 200yr 2110 for Breach in Flood Defences (Fig C3 (View2))



Overtopping

6.6.14 Modelling shows that the flood defences around Wallasea Island are overtopped during the 1 in 200 year event including an allowance for climate change. Figures B5 and B6 demonstrate that this overtopping leads to similar flood depths and extents to those experienced during a breach event.

South Fambridge Flood Cell: Review of Residual Flood Risk

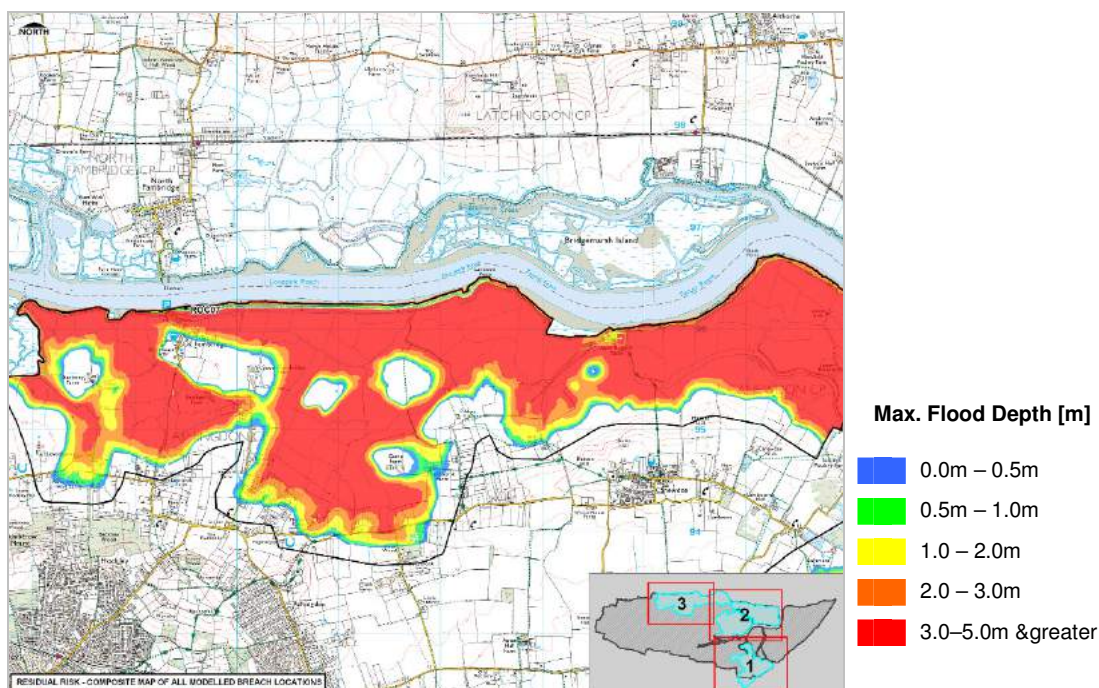
Breach (ROC07)

6.6.15 One breach location, ROC07, has been modelled in the South Fambridge flood cell. Figure 6-6 shows the composite flood depth map for the 1 in 200 year flood event, including allowances for climate change to 2110. This figure shows that floodwaters propagate along the riverfront to the east of the breach with depths of 3m and greater. A number of isolated farms such as Raypitts Farm, Brenham Farm and Scaldhurst Farm are shown to be at risk of flooding, as well as the northern part of South Fambridge.

6.6.16 The majority of the remaining area of inundation is allocated Landscape Improvement Area, Coastal Protection Belt and Special Landscape Area. No development is planned for this area, however ad hoc planning applications may be submitted for the redevelopment of individual properties. Where this is the case, proposals should meet the requirements of PPS25 and those outlined in Chapter 9 of this report.

6.6.17 It should also be noted that under the policy for this area as part of the Catchment Flood Management Plan is to reduce existing flood risk management actions in this area, accepting that flood risk will increase with time. Therefore future development in this area should be restricted where possible to ensure that the risks are not increased.

Figure 6-6 Maximum Flood Depth 200yr 2110 for Breach in Flood Defences (Fig B3 (View 3))



6.6.18 These flood risk maps should be used to inform emergency planning in the area, in order to help to reduce the risks associated with flooding in this part of the district.

Overtopping

6.6.19 Modelling shows that the flood defences along this part of the tidal frontage are overtopped during the 1 in 200 year event including an allowance for climate change. Figures B5 and B6 demonstrate that this overtopping leads to similar flood depths and extents to those experienced during a breach event.

7 Guidance on the Application of the Exception Test

7.1 Overview

- 7.1.1 The aim of the Sequential Test is to steer all development towards areas of lowest risk. However, PPS25 recognises that in some exceptional circumstances, it may not be possible to locate development within areas of low flood risk. Where the Sequential Test has been carried out and it is shown that there are no reasonably available sites in lower flood risk areas, the Exception Test will then be required in some circumstances.
- 7.1.2 Through the application of the Exception Test any additional wider sustainability benefits resulting from development can be taken into account in order to demonstrate that the benefits for development of a site outweigh the flood risks to the development and its occupants.

7.2 What is the Exception Test?

- 7.2.1 The Exception Test comprises three criteria, described below, all of which must be satisfied for development in a flood risk area to be considered acceptable.

Part A – Wider Sustainability to the Community

- 7.2.2 It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by this SFRA.
- 7.2.3 For this element to be passed, the site must be shown to positively contribute to the aims and objectives of the Council's Sustainability Appraisal. Where this is not the case, it must be considered whether the use of planning conditions or S106 agreements could make it do so. If neither of these are possible, the site is not deemed to pass part 'a' and the allocation should be refused.

Part B – Redevelopment of Previously Developed Land

- 7.2.4 The development should be on developable previously developed land or, if not, it must be demonstrated there is no such alternative land available.
- 7.2.5 Planning Policy Statement 3: Housing defines previously developed land as:
'Previously-developed land is that which is or was occupied by a permanent structure, including the curtilage of the developed land and any associated fixed surface infrastructure.'
- 7.2.6 The definition includes defence buildings, but excludes:
- Land that is or has been occupied by agricultural or forestry buildings.
 - Land that has been developed for minerals extraction or waste disposal by landfill purposes where provision for restoration has been made through development control procedures.
 - Land in built-up areas such as parks, recreation grounds and allotments, which, although it may feature paths, pavilions and other buildings, has not been previously developed.
 - Land that was previously-developed but where the remains of the permanent structure or fixed surface structure have blended into the landscape in the process of time (to the extent that it can reasonably be considered as part of the natural surroundings).

- 7.2.7 There is no presumption that land that is previously-developed is necessarily suitable for housing development nor that the whole of the curtilage should be developed.

Part C – Safe from Flood Risk

- 7.2.8 A Flood Risk Assessment (FRA) must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, reducing flood risk overall. At the level of strategic planning the SFRA must be used in order to assess the potential feasibility of providing flood risk management measures for site allocations/broad development locations.
- 7.2.9 Further detail regarding the definition of ‘safe’ development is included in Chapter 9 ‘Site Specific Flood Risk Assessments’.

8 Site Specific FRA Guidance

8.1 Overview

- 8.1.1 This Level 1 and Level 2 SFRA provide a comprehensive collation of existing flood risk information in the area. The hydrodynamic breach modelling undertaken as part of the Level 2 assessment provides new information on the potential risks and hazards from tidal sources. However the scope of this document is strategic and therefore it is vital that site specific Flood Risk Assessments are produced by those proposing development in flood risk areas.
- 8.1.2 It is probable that flood risk exists within an area that has not been highlighted in the SFRAs either because the information has not existed or due to other factors, for example the location of breach assessments relative to development areas. Therefore, site specific FRAs are required to assess the flood risk posed to proposed developments and to ensure that where necessary and appropriate, suitable mitigation measures are included in the development. They should use information from the SFRA, where this is helpful or strengthens the assessment.
- 8.1.3 This section presents recommendations and guidance for site-specific FRAs prepared for submission with planning applications within the Rochford district.

8.2 When is a Flood Risk Assessment required?

- 8.2.1 PPS25 states that in the following situations a Flood Risk Assessment should always be provided with a planning application:
1. The development site is located in Flood Zones 2 or 3;
 2. The area of the proposed development site area is 1 hectare or greater in Flood Zone 1. This is to ensure surface water generated by the site is managed in a sustainable manner and does not increase the burden on existing infrastructure and/or flood risk to neighbouring property. Surface water management will also need to be considered as part of the Flood Risk Assessment for sites of 1 hectare or greater in Flood Zone 2 and 3; and
 3. The development site is located in an area known to have experienced flooding problems from any flood source.
- 8.2.2 The Environment Agency provides flood risk standing advice for applicants and agents on their website <http://www.environment-agency.gov.uk/research/planning/82587.aspx>. This includes information on when a Flood Risk Assessment is required and advice on the contents of FRAs for various development types in Flood Zones 1, 2 and 3.

8.3 What does a Flood Risk Assessment include?

- 8.3.1 The PPS25 Practice Guide (CLG 2010) sets out a staged approach to site specific Flood Risk Assessments, with the findings from each stage informing both the next level and the site Masterplan throughout the development process. Table 8-1 provides a summary of these levels.
- 8.3.2 FRAs should always be proportionate to the degree of flood risk in each case and appropriate to the scale, nature and location of the proposed development as well as its vulnerability.

Table 8-1 Levels of Site Specific FRA, PPS25 Practice Guide (CLG 2009)

FRA Level	Description of Report Content
<p style="text-align: center;">Level 1 Screening Study</p>	<p>The Level 1 Flood Risk Assessment is intended to identify any flooding or surface water management issues related to the development site that may require further investigation. The study should be based on readily available existing information, including:</p> <ul style="list-style-type: none"> • SFRA, • Environment Agency Flood Maps, • Standing Advice <p>The Level 1 Flood Risk Assessment will determine the need for a Level 2 or 3 FRA.</p>
<p style="text-align: center;">Level 2 Scoping Study</p>	<p>Where the Level 1 Flood Risk Assessment indicates that the site may lie in an area at risk of flooding, or may increase flood risk elsewhere due to runoff, a Level 2 Flood Risk Assessment should be carried out. This report will confirm sources of flooding which may affect the site and should include the following;</p> <ul style="list-style-type: none"> • Appraisal of available and adequacy of existing information; • Qualitative appraisal of the flood risk posed to the site, the potential impact of the development on flood risk on and off the site; • An appraisal of the scope of possible measures to reduce the flood risk to acceptable levels. <p>This Level may identify that sufficient quantitative information is already available to complete a Flood Risk Assessment appropriate to the scale and nature of the development.</p>
<p style="text-align: center;">Level 3 Detailed Study</p>	<p>Undertaken if the Level 2 Flood Risk Assessment concludes that further quantitative analysis is required in order to assess flood risk issues related to the development site.</p> <p>This Level should include:</p> <ul style="list-style-type: none"> • Quantitative appraisal of the potential flood risk to the development; • Quantitative appraisal of the potential impact of development on the site under investigation on flood risk on and off the site; • Quantitative demonstration of the effectiveness of any proposed mitigation measures.

8.3.3 Annex E of PPS25 presents the minimum requirements for a Flood Risk Assessment as follows:

- Consider the risk of flooding off-site arising from the development in addition to the risk of flooding on-site to the development;
- Identify and quantify the vulnerability of the development to flooding from different sources and identify potential flood risk reduction measures;
- Assess the remaining ‘residual’ risk after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular development;
- Consider the vulnerability of those that could occupy and use the development, taking account of the Sequential and Exception Tests and the vulnerability classification, including arrangements for safe access as prescribed by Planning Policy Statement 25 (PPS25) and associated guidance;
- Consider the ability of the soil to receive surface water runoff generated on site, and how it would be stored and managed, along with how the proposed layout of development may affect drainage systems; and
- All calculations must fully account for current climate change scenarios and their effect on flood zoning and risk.

- 8.3.4 At all stages, Rochford DC and where necessary the Environment Agency and Anglian Water should be consulted to ensure the Flood Risk Assessment provides the necessary information to fulfil the requirements for Planning Applications.
- 8.3.5 The following Chapter provides more detailed guidance and best practice on specific requirements that should be addressed as part of a site specific FRA for developments in Rochford, in order to demonstrate that the proposed development is 'safe' in accordance with PPS25.

9 Guidance for Developers & Emergency Planning

9.1 Overview

- 9.1.1 The following sections provide guidance and best practice on what should be addressed within a site specific FRA for developments in Rochford in order to demonstrate that the proposed development is 'safe' in line with PPS25. The FRA Checklist in Appendix B of the PPS25 Practice Guide is also a useful tool for developers or others involved in the preparation of a planning application for which an FRA is required.
- 9.1.2 It should be noted that the specific definition of 'safe' development will vary for each individual site based on location and development vulnerability. It is therefore recommended that developers liaise with Rochford Emergency Planners on a site by site basis to establish whether the consideration of evacuation potential, inundation onset times, rates of rise, flood hazard and depth, floor levels, refuge potential and the key points for working up a site level Response Plan are likely to help in delivering a safe development.

9.2 Risks of Developing in Flood Risk Areas

- 9.2.1 Developing in flood risk areas can result in significant risk to a development and site users. It is possible to reduce the risk through the incorporation of mitigation measures; however, these do not remove the flood risk altogether and developments situated in the floodplain will always be at risk from flooding. This creates Health and Safety considerations, possible additional costs and potential displacement of future residents during flood events, which could result in homes and businesses being uninhabitable for substantial periods of time.
- 9.2.2 The guidance in this chapter should identify the requirements of a FRA and the main flood risks posed to the site; additional issues to consider include the following:
- Failure to consider wider plans prepared by the Environment Agency or other operating authorities may result in a proposed scheme being objected to;
 - Failure to identify flood risk issues early in a development project could necessitate redesign of the site to mitigate flood risk;
 - Failure to adequately assess all flood risk sources and construct a development that is safe over its lifetime could increase the number of people at risk from flooding and/or increase the risk to existing populations;
 - Failure to mitigate the risk arising from development may lead to claims against the developer if an adverse effect can be demonstrated (i.e. flooding didn't occur prior to development) by neighbouring properties/residents;
 - Properties may be un-insurable and therefore un-mortgageable if flood risk management is not adequately provided for the lifetime of the development;
 - By installing SuDS without arranging for their adoption or maintenance, there is a risk that they will eventually cease to operate as designed and could therefore present a flood risk to the development and/or neighbouring property;
 - The restoration of river corridors and natural floodplains can significantly enhance the quality of the built environment whilst reducing flood risk. Such an approach can significantly reduce the developable area of sites or lead to fragmented developments,

however positive planning and integration throughout the master planning process should resolve these potential issues.

9.3 Planning Requirements

PPS25 Sequential & Exception Tests

- 9.3.1 A site specific FRA for a proposed development should demonstrate that the development is in accord with the LPA's site allocations. Where the site has not been sequentially tested, the FRA should provide the necessary information to enable the LPA to do so. If the Exception Test is required, the FRA should provide the necessary evidence to support part c) of the test.

Development behind existing flood defences

- 9.3.2 *'Development should not normally be permitted where flood defences, properly maintained and in combination with agreed warning and evacuation arrangements, would not provide an acceptable standard of safety taking into account climate change⁸.*
- 9.3.3 Rochford DC as the planning authority must take the flood hazard fully into account when drafting Local Development Documents and considering planning applications.
- 9.3.4 Risks will be greatest close to flood defences and as such where possible Rochford DC should seek opportunities to set back developments from defences. This will also facilitate the need for the Environment Agency to gain access to defences for maintenance and upgrades.
- 9.3.5 Other raised infrastructure such as roads or rail embankments should be considered in terms of their potential to provide secondary defences.

Flood Zone 3b Functional Floodplain

- 9.3.6 PPS25 defines Flood Zone 3b Functional Floodplain as *'land where water has to flow or be stored in times of flood'*. The definition remains open to interpretation and agreement between the Environment Agency and the Local Planning Authority, however, areas which would naturally flood with an annual exceedance probability of 1 in 20 (5%) or greater are often used as a starting point for delineation of Functional Floodplain and have been used to map Flood Zone 3b in this SFRA.
- 9.3.7 Paragraph 4.91 of the PPS25 Practice Guide states that existing developed areas are not generally defined as part of the Functional Floodplain. In these cases, PPS25 advocates an approach whereby the high level of flood risk is acknowledged and recognised without applying the strict policy restrictions associated with Functional Floodplain.
- 9.3.8 Existing developed areas lying within Flood Zone 3b are present within the district, for example in the southern parts of Rochford town. The classification of whether or not a site within these areas lies within the Functional Floodplain should be identified on a site by site basis as part of a site specific Flood Risk Assessment.
- 9.3.9 Where it can be demonstrated that the existing buildings exclude floodwater, these buildings are not considered to be part of the Functional Floodplain. Where the existing buildings do not exclude floodwaters, the site is Functional Floodplain and further redevelopment of the site is only permitted for Water Compatible land uses or Essential Infrastructure subject to the satisfaction of the Sequential Test and Exception Test, in accordance with PPS25.

⁸ PPS25 Development and Flood Risk CLG 2010

- 9.3.10 Where a site is not considered to be located within Functional Floodplain, any future redevelopment should be restricted to less vulnerable land uses. More vulnerable land uses should be actively discouraged and should only be considered within sites of an equivalent existing land use.
- 9.3.11 Any future redevelopment within this area must result in a reduction in the flood risk to and from the proposed development, and opportunities should be sought to create areas for the storage and conveyance of floodwaters. Further information and guidance for potential developers is included in Section 9.5.

9.4 Emergency Planning Considerations

- 9.4.1 Details regarding Flood Warning Systems and provision for Emergency Planning have been discussed in Chapter 4.
- 9.4.2 It is recommended that the results from the hydrodynamic modelling with respect to anticipated flood depths and time to inundation is used by the Essex Resilience Forum to inform emergency planning procedures and update the MAFP where necessary.
- 9.4.3 The figures included in Appendix D demonstrate that the time available for the safe evacuation of occupants located in the floodplain is extremely limited. In most of the modelled scenarios, floodwater inundates the majority of the flood cell within 1 hour. As a result, it is vital that flood warnings are adhered to and acted upon during periods when the risk of high tides and overtopping is increased.
- 9.4.4 Evacuation Plans for individual developments located within areas at risk of flooding should be prepared by developers in conjunction with the borough-wide Emergency Plan to direct people to safety during times of flood. This may include details of flood warning mechanisms and an evacuation route away from the site to an area outside the floodplain, or to a place of safe refuge within the development itself.
- 9.4.5 When submitting FRAs for developments within flood risk areas, developers should make reference to this strategic Emergency Plan and Environment Agency flood warning systems to demonstrate that their development will not impact on the ability of Rochford DC and the emergency services to safeguard the current population. The flood hazard in a particular area must be viewed in the context of the potential evacuation and rescue routes to and from that area and discussed as part of a site specific FRA.

9.5 Development Control Recommendations

Sequential Approach

- 9.5.1 Where the development includes development types of varying vulnerability in accordance with the definitions in PPS25, Paragraph D8 of PPS25 states that developers should apply the sequential approach to the allocation of land uses *within* the development site. This process should ensure that elements of the redevelopment that are of greater vulnerability are located in parts of the site at lowest risk.

Access and Egress

- 9.5.2 Paragraph 8 of PPS25 requires that the LPA, in determining planning applications should “ensure that all new development in flood risk areas is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed”.
- 9.5.3 Wherever possible, access routes should be provided above the design flood level for the 1 in 200 year + CC level. Where this is not possible limited depths of flooding may be appropriate, provided that the proposed access is designed with appropriate signage and other measures to make it safe. The acceptability of the proposed access should be assessed using Table 13.1 of Defra Research document FD2320/TR2: FRA Guidance for New Developments which takes into account the flood depth, velocities and risk of debris within the water. The access/egress route should fall within the “white cells” of this document.
- 9.5.4 When assessing access and egress, the following should also be considered:
- The **vulnerability and mobility** of those in danger of flooding; development for highly vulnerable users e.g. disabled or the elderly, should be located away from high-risk areas. Whilst the Sequential Test accounts for the vulnerability of the intended use of the development, no specific consideration is made for the vulnerability of the end users of the site. A proposed residential development for highly vulnerable end users (elderly, physically impaired etc) will still fall under the ‘More Vulnerable’ classification in Table D.2 of PPS25 and the Sequential and Exception Tests will apply accordingly. Where development for highly vulnerable end users cannot be avoided, safe and easy evacuation routes are essential.
 - The **time to inundation** mapping relates to the amount of time it takes for a flood event to reach a specific point. Flood events with a very short time to peak provide very little time and opportunity for evacuation. This is typically the case if a defence structure is breached or fails because the inundation will be rapid, resulting in a short time to peak for the areas local to the breach. On the other hand, during tidal events, should a breach occur early in the tidal cycle, the time to peak could be a lot slower which would allow evacuation procedures to be undertaken. Typically, areas immediately adjacent to a breach location will have a shorter time to peak than areas set back from the flood defence.
- 9.5.5 It may not be possible for all developments to be proposed in areas where both safe access and egress can be guaranteed during a flood. In this situation, the potential implications for development should be considered by assessing the following:
- Probability of flooding;
 - Expected flood hazard;
 - Likelihood of occupancy during flooding, based on the proposed use;
 - Acceptability of disruption based on the proposed use;
 - Availability of safe refuge;
 - Potential for the provision of key services (e.g. water, electricity, telecommunications)
 - Expected rate and rise of inundation by floodwaters.
- 9.5.6 The following aspects are considerations for development with respect to inundation times from a residual risk event. Actual flood risk may be require stricter considerations and should be agreed

early in the planning process with the LPA (in consultation with emergency planners and the Environment Agency).

- 9.5.7 1-4 Hours – For any residential development located within areas defined by a time to inundation of less than 4 hours, finished floor levels for sleeping accommodation should be set above the flood level. Refuge should be provided for all developments in this area above the flood level. It is noted that although provision of a place of dry refuge plays an important role in reducing the overall level of flood risk, it does not by itself make a development 'safe'. Further consultation should be sought from Rochford District Emergency Planners regarding this issue.
- 9.5.8 4-8 Hours – For residential development classified within the 4-8 hour time to inundation, where possible finished floor levels should be located 300mm above the 1 in 200 year flood level including allowances for climate change. Safe refuge should also be provided above the flood level and egress and access routes determined to Flood Zone 1. For redevelopment of existing residential units that are ground floor level, finished floor levels should be raised as high as practically possible, with resilience measures used up to the 1 in 200 year floor level where necessary.
- 9.5.9 8-12 Hours – For development located within the 8-12 hour extent and greater, there is a greater period of time before inundation by floodwaters and therefore potential for occupants to evacuate developments and move to the Flood Zone 1 on the mainland. For redevelopment of existing residential units that are ground floor level, finished floor levels should be raised as high as practically possible, with resilience measures used up to the 1 in 200 year flood level where necessary.

Provision of Safe Refuge

- 9.5.10 In exceptional circumstances, a building may remain safe during a flood event but safe access and egress to and from the building may not be guaranteed. The acceptability of the development will then be dependent upon an assessment of the probability of flooding; expected flood hazard; likelihood of occupancy during flooding; how acceptable the disruption would be; the provision of safe refuge; availability of key services; and the expected duration of inundation by floodwaters.
- 9.5.11 Safe refuge must be located above the design flood level and be freely accessible by all occupants of the development via internal staircases from all areas that are below the design flood level. Paragraph E3 of PPS5 states that consideration should also be made of the impact of the extreme flood and that users of the development should not be placed in danger from associated flood hazards.

Finished Floor Levels

- 9.5.12 Where development in flood risk areas is unavoidable, the most common method of mitigating flood risk to people is to ensure habitable floor levels are raised above the maximum flood water level with an allowance of 300mm freeboard. This can substantially reduce the damage to property and risk of injury and fatalities.
- 9.5.13 Where minimal depths of floodwater are experienced, raising finished floor levels may be included into building design. This may be possible in areas of fluvial and/or surface water flood risk. Where floodwater depths are more substantial the practice of raising finished floor levels may not be possible.
- 9.5.14 In some cases it may be considered appropriate for ground floor uses to be restricted to Less Vulnerable uses, such as commercial use, garage, utility areas and public space, with habitable areas above.

- 9.5.15 Any hazardous substances held in commercial properties should be stored above the flood level to reduce the risk of contamination during a flood event.

Basement Dwellings

- 9.5.16 Basement dwellings are classified as 'Highly Vulnerable' according to PPS25 (CLG 2010). As such they are not permitted within Flood Zone 3a and must pass the Sequential & Exception Test should they be proposed for Flood Zone 2. Basements dwellings should therefore be discouraged within areas at risk of fluvial, surface water or groundwater flooding. Where they are constructed, access must be situated 300mm above the design flood level, and waterproof construction techniques should be employed to avoid seepage during flood events. An assessment of groundwater conditions will also be required to inform the structural integrity of the basement construction. Similar problems can also occur where excessive surface water ponding occurs close to the sides of buildings, leading to significant infiltration. Surface water flow paths should be assessed to ensure that this does not occur, and to inform the strategic location of SuDS and techniques to route flows around the edge of buildings.
- 9.5.17 It is recommended that Rochford DC adopt a policy of refusing applications for basement dwellings that are within the Flood Zone 2 extent (1 in 1000 year flood outline).

Flood Resilient / Resistant Design

- 9.5.18 The Association of British Insurers in cooperation with the National Flood Forum has published guidance on how homeowners can improve the flood resilience of their properties (ABI, 2004). These measures not only reduce flood risk to properties, by reducing residual risk, but can also improve the insurability of homes in flood risk areas. The guidance identifies the key flood resistant measures for different construction methods, further details can be found in the CLG's 2008 report, *Improving the Flood Resilience of New Buildings* and the ODPM's 2003 report, *'Preparing for Floods'* (ODPM, 2003b).
- 9.5.19 In the document *'Improving the Flood Performance of New Buildings, Flood Resilient Construction'*, a number of design strategies are detailed including the Water Exclusion Strategy and Water Entry Strategy. Resistance measures are aimed at preventing water ingress into a building (Water Exclusion Strategy); they are designed to minimise the impact of floodwaters directly affecting buildings and to give occupants more time to relocate ground floor contents. These measures will probably only be effective for short duration, low depth flooding, i.e. less than 0.3m.
- 9.5.20 For flood depths greater than 0.6m, it is likely that structural damage could occur in traditional masonry construction due to excessive water pressures. In these circumstances, the strategy should be to allow water into the building, i.e. the Water Entry Strategy.
- 9.5.21 The principle behind the Water Entry Strategy is not only to allow water through the property to avoid the risk of structural damage, but also to implement careful design in order to minimise damage and allow rapid re-occupancy of the building. PPS25 considers these measures to be appropriate for both changes of use and for less vulnerable uses where temporary disruption is acceptable and suitable flood warning is received.
- 9.5.22 Materials will be used which allow the passage of water whilst retaining their structural integrity and they should also have good drying and cleaning properties. Alternatively sacrificial materials can be included for internal and external finishes; for example the use of gypsum plasterboard which can be removed and replaced following a flood event. Flood resilient fittings should be used to at least 0.1m above the design flood level. Resilience measures are either an integral part of the building fabric or are features inside a building that will limit the damage caused by floodwaters.

- 9.5.23 Further specific advice regarding suitable materials and construction techniques for floors, walls, doors and windows and fittings can be found in 'Improving the Flood Performance of New Buildings, Flood Resilient Construction' (CLG, 2007).

Flow Paths and Floodplain Compensation

- 9.5.24 Where development plans result in a reduction of the *fluvial* floodplain it is essential that new floodplain storage capacity is provided to compensate for any lost storage. The Environment Agency requires this to be provided on a 'Level for Level, Volume for Volume Basis'. *N.B. Any encroachment into tidal floodplains does not normally require compensation storage unless the flood cell is small or should there be concerns that flood flow paths would be altered to the detriment of existing development.*
- 9.5.25 Potential overland flow paths should be determined and appropriate solutions proposed to mitigate the impact of the development, for example through the configuration of road and building layouts to preserve existing flow paths and improve flood routing whilst ensuring that flows are not diverted towards other properties. In addition, any raising of the land as part of the development, for example, to achieve safe access, will need to be carefully considered as part of the FRA to ensure that no obstruction is made to flood flow routes.

Land Raising

- 9.5.26 Land raising can have mixed results when used as a secondary flood alleviation measure. It can be an effective method of reducing flood inundation on certain areas or developments by raising the finished ground levels above the predicted flood level. However, it can result in the reduction in flood storage volume within the flood cell. As a result, floodwater levels within the remainder of the cell can be increased and flooding can be exacerbated elsewhere. Level for level compensatory storage should be provided where any loss of fluvial floodplain storage has occurred as a result of land raising or developing within the undefended floodplain.
- 9.5.27 Partial land raising can be considered in larger, particularly low lying, areas such as marshlands. It may be possible to build up the land in areas adjacent to flood defences in order to provide secondary defences. However, again the developer should pay due regard to the cumulative effects of flooding such as increasing flood risk elsewhere.
- 9.5.28 It should also be remembered that although land raising may allow for development above the flood level, it may also create a 'dry island' which may still not overcome the issue of a safe access/egress route from the site. This must be considered where land raising is suggested as mitigation for developing in an area liable to flooding.

Recreation, Amenity and Ecology

- 9.5.29 Recreation, amenity and ecological improvements can be used to mitigate the residual risk of flooding either by substituting less vulnerable land uses or by attenuating flows or both. Examples include the development of parks and open spaces through to river restoration schemes. The aim of these techniques is to increase flood storage and the storage and conveyance of rainwater. Typical schemes include arrangements of pools, ponds and ditches, although these are best suited to larger sites and masterplan areas.

Secondary Defences

- 9.5.30 Secondary defences are those that exist on the dry side of primary defences. Typically, their main function is to reduce the risk of residual flooding following a failure or overtopping of the primary defences.
- 9.5.31 Secondary defences can relocate floodwaters away from certain areas or reduce the rate of flood inundation following a residual event. Examples of secondary defences include embankments or raised areas behind flood defence walls, raised infrastructure e.g. railways or roads and, on a strategic level, canals, river and drainage networks. The latter are a form of secondary defence as they are able to convey or re-direct water away from flood prone areas even if this is not their primary function.
- 9.5.32 The benefits of a secondary defence to a new development must be weighed up against the potential adverse effects to existing development in the same area, since Paragraph 5 of PPS25 requires that new development should be 'safe without increasing risk elsewhere'.

Sewer Flooding

- 9.5.33 In areas at risk of sewer flooding, a site specific FRA should assess the level of risk to the site. Anglian Water should be approached to obtain any information regarding sewer flooding records in the area and any recent capital improvement works undertaken, which should be reviewed in relation to local topography and potential flow paths to determine the actual risk to the site. This will allow appropriate mitigation measures to be incorporated where necessary.

Groundwater Flooding

- 9.5.34 Due to the scarcity of information with respect to groundwater flood risk in the district and the limitations in using historic data to define current flood risk, it is recommended that a site specific investigation of geology and groundwater levels is undertaken in proportion to the nature and scale of the proposed development. Local groundwater monitoring should be identified and where possible analysed to assess ground water levels as part of a FRA, in addition to detailed geology mapping which identifies potential spring lines.
- 9.5.35 In addition, consideration should be made for the impact of excavation works prior to construction on the risk of groundwater flooding to the site.

Surface Water Flooding

- 9.5.36 Development typically increases the coverage of impermeable areas and therefore contributes to increased overland flows. As part of a site specific FRA for new developments, an assessment of surface water runoff and temporary flood storage on the site should be undertaken. Development should seek to reduce surface water runoff rates through the appropriate application of Sustainable Drainage Systems (SuDS).
- 9.5.37 Potential overland flow paths should be determined and appropriate solutions proposed to minimise the impact of the development, for example by configuring road and building layouts to preserve existing flow paths and improve flood routing, whilst ensuring that flows are not diverted towards other properties elsewhere.
- 9.5.38 Under the Flood and Water Management Act (2010), all new development must demonstrate that all measures have been taken to manage runoff on site before connection to the sewer is permitted. Due to the highly urbanised nature of parts of Rochford, source control options will be an important method of surface water management. Rainwater harvesting, green roofs, permeable

gardens and landscaped public realm areas, will be essential elements of new developments to facilitate the minimisation of runoff.

- 9.5.39 It is essential that the design of SuDS is considered early in the design process for a development area to ensure that a coordinated and integrated system can be implemented. Under the Flood and Water Management Act (2010), it will become the responsibility of Essex County Council to adopt and maintain these drainage systems into the future and therefore an integrated approach to surface water management across new development areas will need to be established.

10 Core Strategy Development Locations

10.1 Future Growth & Development

- 10.1.1 Under the provisions of the Planning and Compulsory Act 2004, Rochford DC is in the process of preparing a folder of policy documents called the Local Development Framework which translate strategic policies for wider the area into locally applicable planning policies.
- 10.1.2 The Core Strategy sets out the proposed allocation of future development within the district in order to meet the housing requirements set by the Regional Spatial Strategy for the East of England; the East of England Plan. A summary of the position of this SFRA with respect to the relevancy of Regional Spatial Strategy is provided in the following position statement.

SFRA Position Statement

Regional Spatial Strategy (RSS) for the East of England: The East of England Plan

The East of England Plan published by the Communities and Local Government (CLG) provided a broad development strategy for the region for a 15 to 20 year period. It also informed the preparation of Local Development Documents (LDD) and regional and sub-regional strategies.

Following the election of a coalition government in May 2010, a Devolution and Localism Bill has been confirmed which intends to *'shift power from the central state back to the hands of individuals, communities and councils'*. This Bill includes legislation to scrap the RSS.

While the Secretary for State for Communities and Local Government has confirmed that RSS will be revoked, at the time of writing there is no replacement for the RSS, therefore the RSS will be referred to as the current planning policy document for the purposes of this report.

- 10.1.4 The East of England Plan requires a minimum of 4600 dwellings to be provided in the District between 2001 and 2021. In addition, the LPA is required to plan for delivery of housing for at least 15 years from the date of adoption of the Core Strategy (2010) and in so doing assume that the average annual requirement of 250 units will continue beyond 2021 to 2025.
- 10.1.5 In order to deliver these dwellings, the Core Strategy identifies a number of extensions to the existing residential envelope within the district. In addition, opportunities for the redevelopment of employment land for residential units have also been identified at four locations across the district. The key areas for future development within Rochford are summarised in the Table 10-1 and included in Figure A-5 of Appendix A.
- 10.1.6 The majority of the locations allocated for potential residential development have been located in accordance with the sequential approach, advocated by PPS25 and are within Flood Zone 1 – Low Probability of flooding from fluvial and tidal sources. However four of the development locations are located wholly or partially within Flood Zones 2 and 3, as shown in Table 10-1.

Table 10-1 Core Strategy Development Locations

Core Strategy Policy	Development Location	Dwellings pre 2021	Dwellings post 2021	Flood Zone(s)
H2 – Extensions to residential envelope pre-2021	North of London Road, Rayleigh		550	1,2,3
	West Rochford	450	150	1,2
	West Hockley	50		1
	South Hawkwell	175		1
	East Ashingdon	100		1
	South West Hullbridge		250	1
	South Canewdon		60	1
H3 – Extensions to residential envelope post-2021	South East Ashingdon		500	1
	West Great Wakering		250	1
H1 – Redevelopment of employment land for residential use	Rawreth Lane Industrial Estate			1,2,3
	Eldon Way / Foundry Industrial Estate			1
	Stambridge Mills			1,2,3
	Star Lane Industrial Estate			1

10.1.7 In addition to these proposals for future housing development, a number of Area Action Plans are being developed in the Rochford district, including:

- Hockley Area Action Plan;
- Rochford Area Action Plan;
- Rayleigh Area Action Plan; and
- London Southend Airport and Environs Joint Area Action Plan (in collaboration with Southend-on-Sea Borough Council).

10.1.8 The Area Action Plans for Rayleigh and Hockley are located within Flood Zone 1, associated with low probability of flooding from fluvial and tidal sources. The Rochford Area Action Plan and the Southend London Airport and Environs Joint Area Action Plan are located within or close to Flood Zones associated with greater flood risk.

10.2 Area Assessments

10.2.1 The remainder of this Chapter provides an individual assessment of the development locations and Area Action Plan areas that are at risk of flooding. A summary of the proposed use of the site and the vulnerability classifications is provided, along with recommendations regarding development control and emergency planning requirements, specific to these areas.

North of London Road, Rayleigh

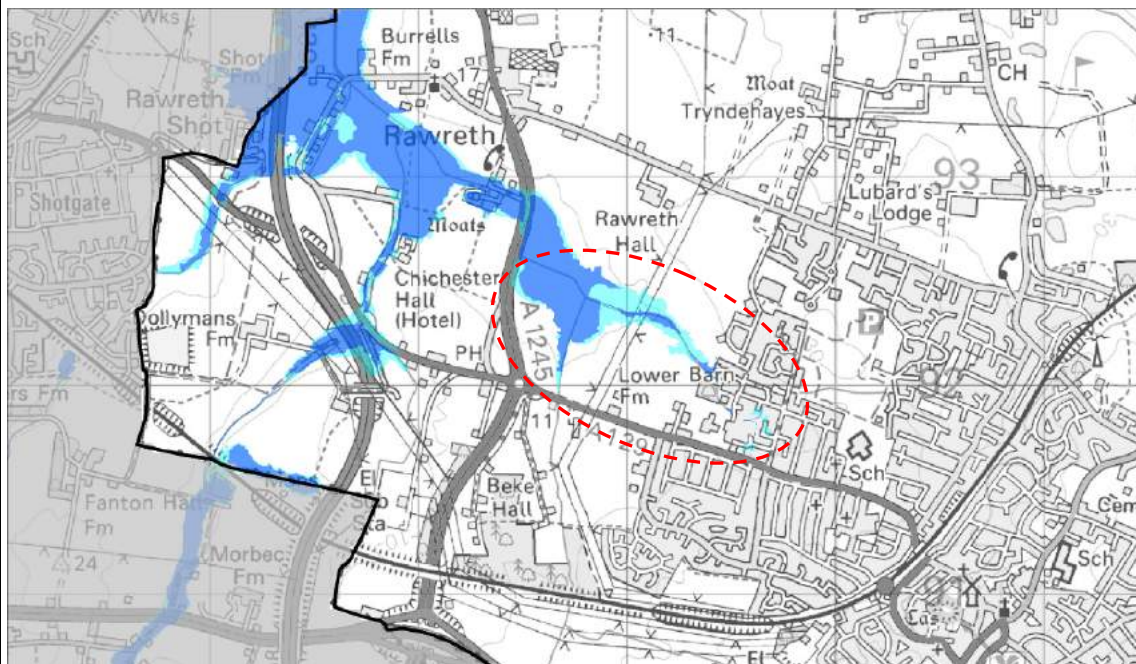
Proposed Site Use

Residential development
 Primary School
 Park land in between built environment and A1245
 Youth and community facilities
 Play space

PPS25 Vulnerability Classification

More Vulnerable
 More Vulnerable
 Water-compatible
 Less Vulnerable
 Water-compatible

Environment Agency Flood Zone Map



This area is at risk of flooding associated with the Rawreth Brook. Parts of the site are classified as Flood Zone 2 – Medium Probability of flooding, and Flood Zone 3a – High Probability.

Development Control Recommendations

Sequential Approach

All future development should be steered towards Flood Zone 1 in accordance with the sequential approach. More vulnerable development, including residential, should be located within Flood Zone 1.

Finished Floor Levels

Detailed modelling may be required to more accurately determine the flood zones in this area and determine the flood level to inform development design. Finished floor levels should be set 300mm above the 1 in 100 year flood level, including allowances for climate change for the lifetime of the development (100 years for residential development).

Floodplain Compensation

Any encroachment into Flood Zone 3a that results in loss of storage in the floodplain should be compensated for on a level for level and volume for volume basis.

Surface Water Management

Future development must make adequate provision for the sustainable management of surface water on the site. Due to the underlying geology, infiltration techniques are unlikely to be suitable and therefore attenuation techniques are recommended. Further guidance regarding SuDS is supplied in Chapter 11 of this report.

West Rochford

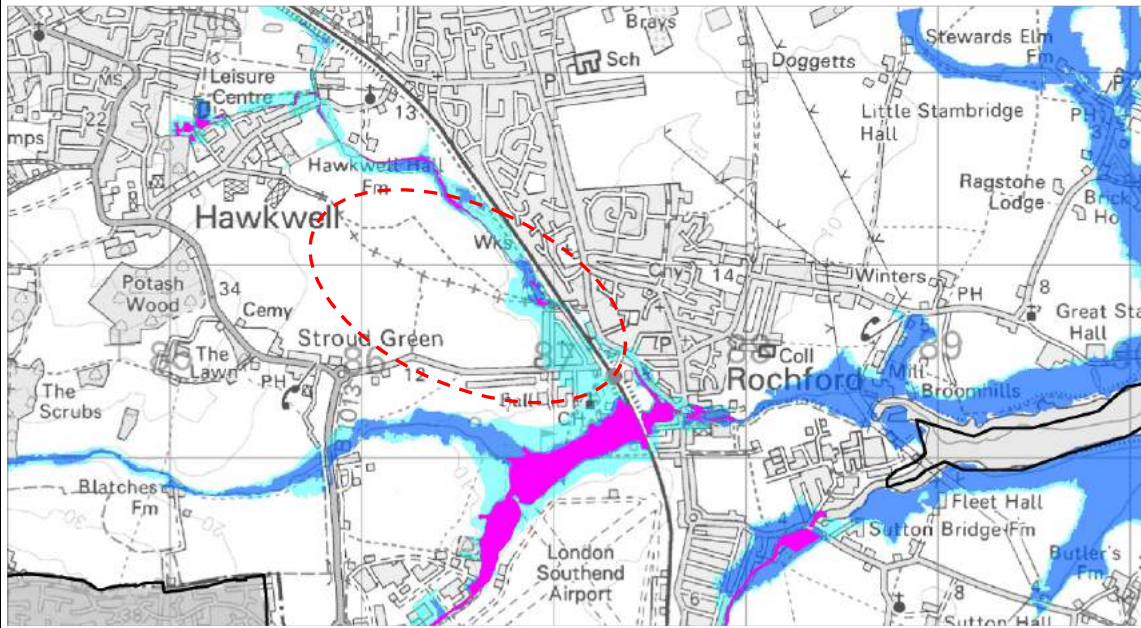
Proposed Site Use

Residential development
 Primary School and Early Years Childcare Provision
 Youth facilities and community facilities
 Public Open Space & Play space

PPS25 Vulnerability Classification

More Vulnerable
 More Vulnerable
 Less Vulnerable
 Water-compatible

Environment Agency Flood Zone Map



The fluvial section of the River Roach flows along the eastern edge of the site. This part of the site is located in Flood Zone 2 Medium Probability of flooding associated with this watercourse.

Development Control Recommendations

Sequential Approach

All future development should be steered towards Flood Zone 1 in accordance with the sequential approach. More vulnerable development, including residential, should be located within Flood Zone 1.

Finished Floor Levels

Finished floor levels should be set 300mm above the 1 in 100 year flood level, including allowances for climate change for the lifetime of the development (100 years for residential development).

Floodplain Compensation

Any encroachment into Flood Zone 3a that results in loss of storage in the floodplain should be compensated for on a level for level and volume for volume basis.

Surface Water Management

Future development must make adequate provision for the sustainable management of surface water on the site. The geology within this part of the district is River Terrace Deposits, underlain by Thames Group Clay. Infiltration testing will be required to determine the prospect of using infiltration drainage techniques. Further guidance regarding SuDS is supplied in Chapter 11 of this report.

Rawreth Industrial Estate

Proposed Site Use

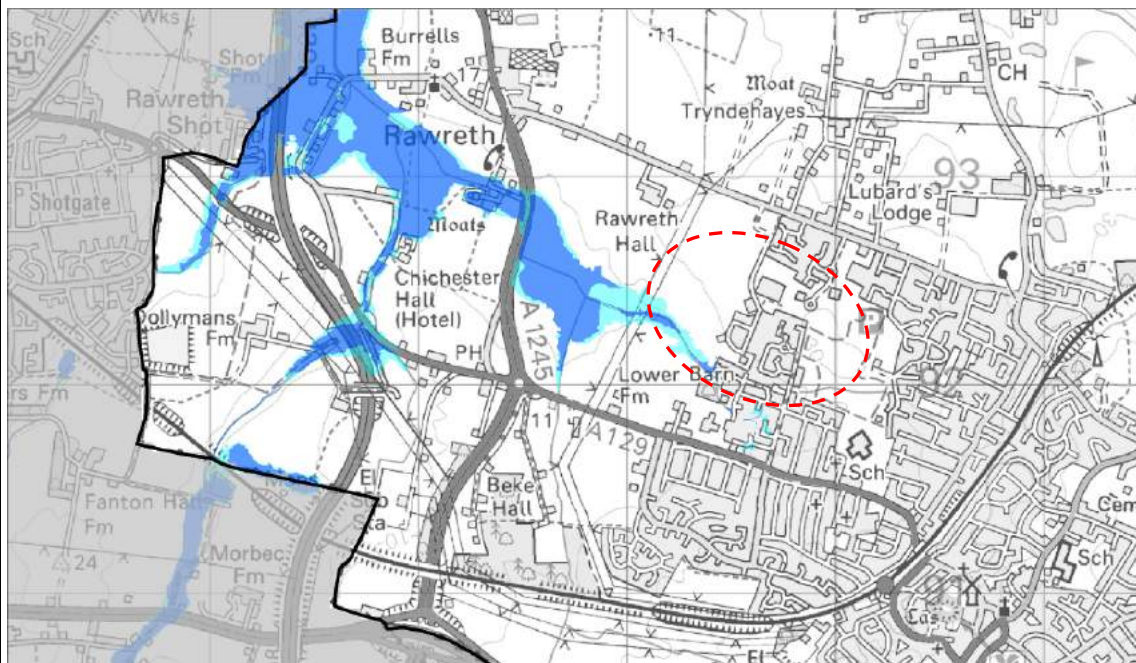
Residential development
 Contribution towards new primary school in North of London Rd,
 Rayleigh residential development
 Public Open Space & Play space
 Public transport infrastructure improvements and service
 enhancements

PPS25 Vulnerability Classification

More Vulnerable
 More Vulnerable

 Water-compatible
 Essential Infrastructure

Environment Agency Flood Zone Map



This area is at risk of flooding associated with the Rawreth Brook. Parts of the site are classified as Flood Zone 2 – Medium Probability of flooding, and Flood Zone 3a – High Probability.

Development Control Recommendations

Sequential Approach

All future development should be steered towards Flood Zone 1 in accordance with the sequential approach. More vulnerable development, including residential, should be located within Flood Zone 1.

Finished Floor Levels

Detailed modelling may be required to more accurately determine the flood zones in this area and determine the flood level to inform development design.

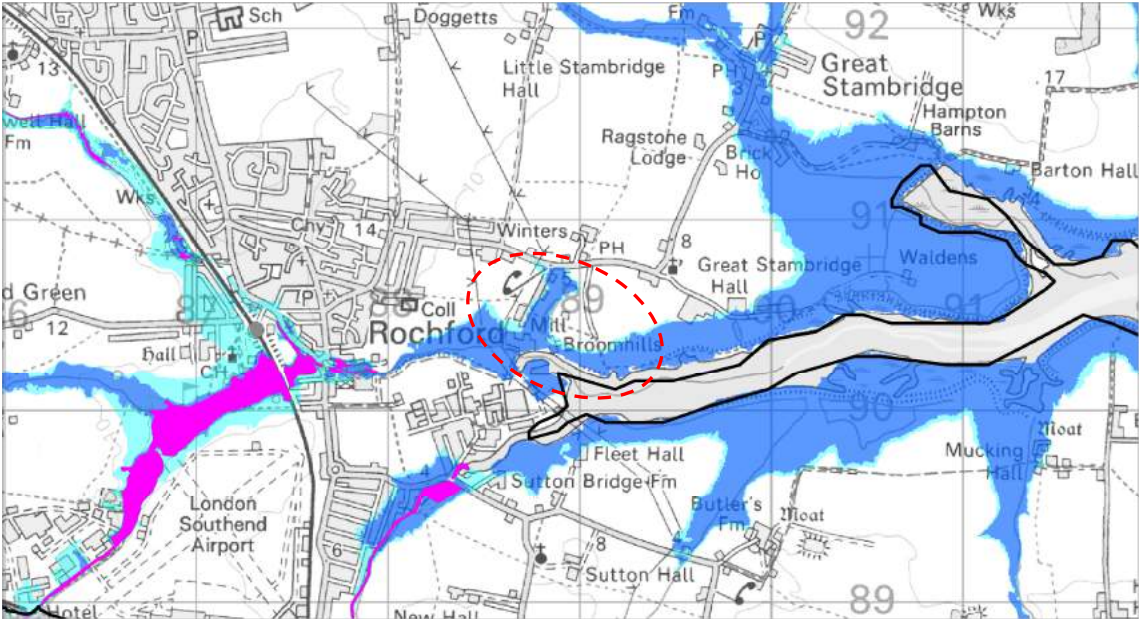
Finished floor levels should be set 300mm above the 1 in 100 year flood level, including allowances for climate change for the lifetime of the development (100 years for residential development).

Floodplain Compensation

Any encroachment into Flood Zone 3a that results in loss of storage in the floodplain should be compensated for on a level for level and volume for volume basis.

Surface Water Management

Future development must make adequate provision for the sustainable management of surface water on the site. Due to the underlying geology, infiltration techniques are unlikely to be suitable and therefore attenuation techniques are recommended. Further guidance regarding SuDS is supplied in Chapter 11.

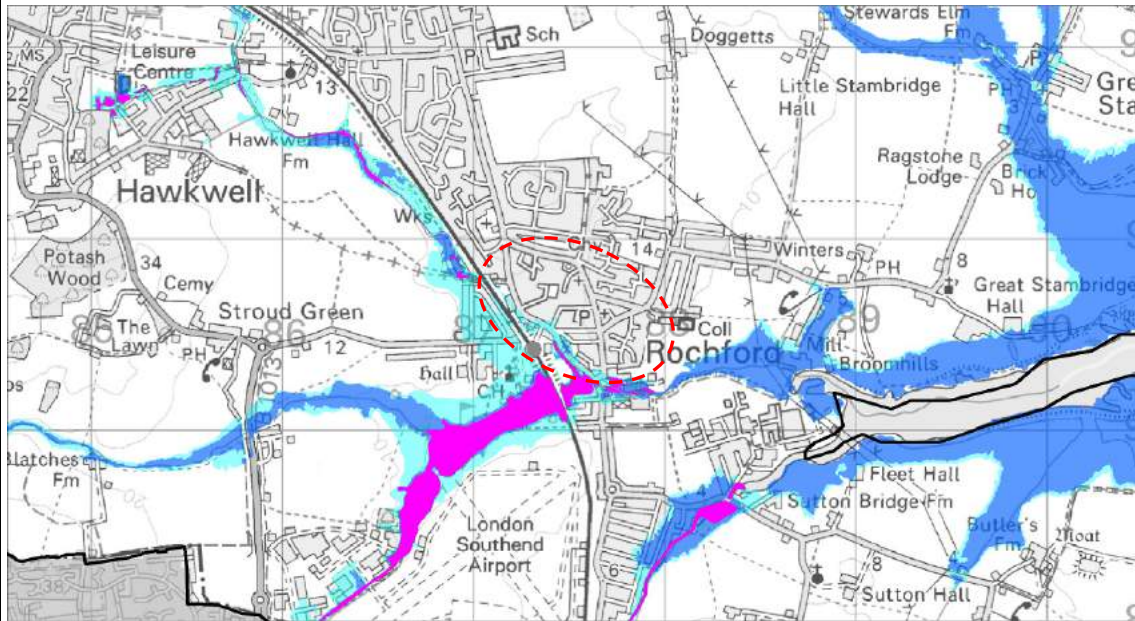
Stambridge Mills, Rochford	
<p>Proposed Site Use Residential development Flood defence Public transport infrastructure improvements and service enhancements Public Open Space & Play space</p>	<p>PPS25 Vulnerability Classification More Vulnerable Water-compatible Essential Infrastructure Water compatible</p>
<p>Environment Agency Flood Zone Map</p>  <p>Stambridge Mills is located on the north bank of the tidal River Roach. The site is located within Flood Zone 3a – High Probability of flooding from tidal sources.</p>	
<p>Development Control Recommendations</p> <p><u>Sequential Approach</u> It should be noted that at the time of writing the approach of favouring non-Green Belt, PDL, Flood Zone 2/3 sites ahead of Green Belt, Flood Zone 1 locations is currently being considered through the examination of the Core Strategy. When asked whether it was appropriate for RDC to include Stambridge Mills within its schedule of potential residential development site, the Inspector at a recent appeal concluded: “I agree with the Council that, having regard to the presumption against inappropriate development in PPG2 and to the encouragement in PPS3 to direct new housing to previously-developed land, land in the Green Belt should not be considered to be suitable for housing development in preference to Stambridge Mills” (para. 236 of Inspector’s report).</p> <p><u>Finished Floor Levels</u> Finished floor levels should be set 300mm above the 1 in 200 year flood level, including allowances for climate change for the lifetime of the development (100 years for residential development).</p> <p><u>Access & Egress</u> Safe access and egress, above the 1 in 200 year flood level (0.5% AEP) including allowances for climate change must be provided from all parts of the development to an area in Flood Zone 1.</p> <p><u>Surface Water Management</u> Future development must make adequate provision for the sustainable management of surface water on the site. The geology within this part of the district is River Terrace Deposits, underlain by Thames Group Clay. Infiltration testing will be required to determine the prospect of using infiltration drainage techniques. Further guidance regarding SuDS is supplied in Chapter 11 of this report.</p> <p><u>Emergency Planning</u> This area is covered by the Environment Agency’s Flood Warning Service. A Flood Evacuation Plan should be prepared for future occupants of the site detailing access and egress routes and evacuation procedures.</p>	

Rochford Area Action Plan (AAP)

Proposed Site Use
 Mixed Use

PPS25 Vulnerability Classification
 Various

Environment Agency Flood Zone Map



Rochford is located at the confluence of the Noblesgreen Ditch, the Eastwood Brook and the River Roach from flowing from Hawkwell. The majority of the Area Action Plan is located in Flood Zone 1 – Low Probability, however the River Roach flows along the southern edge of the Area Action Plan area and is tidally influenced in this area.

Development Control Recommendations

Sequential Approach

All future development should be steered towards Flood Zone 1 in accordance with the sequential approach. More vulnerable development, including residential, should be located within Flood Zone 1.

Finished Floor Levels

In areas affected by fluvial flooding, finished floor levels should be set 300mm above the 1 in 100 year flood level, including allowances for climate change for the lifetime of the development (100 years for residential development). In areas at risk of tidal flooding from the tidal River Roach, the 1 in 200 year flood level including allowances for climate change should be used to set the finished floor levels.

Access & Egress

Safe access and egress, above the 1 in 200 year flood level (0.5% AEP) including allowances for climate change must be provided from all parts of the development to an area in Flood Zone 1.

Surface Water Management

Future development must make adequate provision for the sustainable management of surface water on the site. The geology within this part of the district is River Terrace Deposits, underlain by Thames Group Clay. Infiltration testing will be required to determine the prospect of using infiltration drainage techniques. Further guidance regarding SuDS is supplied in Chapter 11 of this report.

Emergency Planning

This area is covered by the Environment Agency's Flood Warning Service. A Flood Evacuation Plan should be prepared for future occupants of the site detailing access and egress routes and evacuation procedures.

London Southend Airport and Environs Joint Area Action Plan (JAAP)

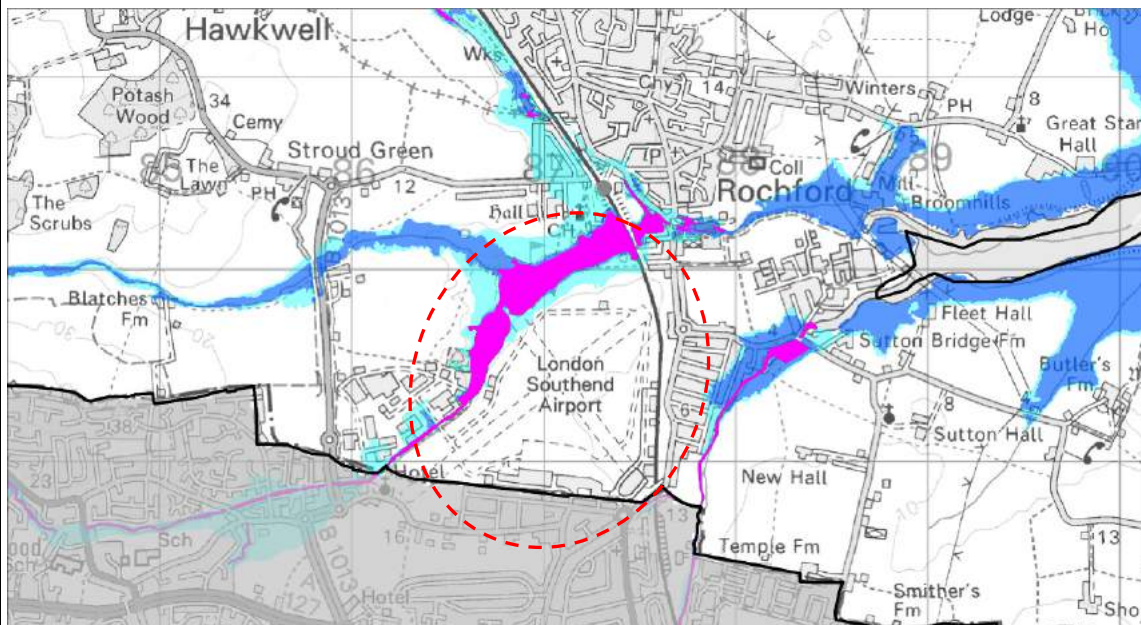
Proposed Site Use

Airport
 Business Use
 Leisure and Public Open Space
 Railway Station
 Car Parking

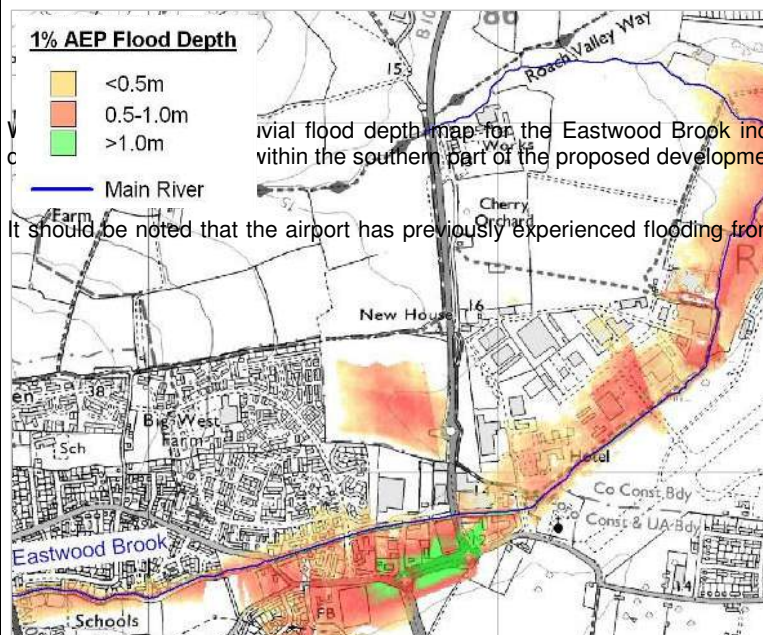
PPS25 Vulnerability Classification

Essential Infrastructure
 Less Vulnerable
 Water-compatible
 Essential Infrastructure
 Less Vulnerable

Environment Agency Flood Zone Map



The Eastwood Brook flows along the western and northern edge of the London Southend Airport. The flooding mechanism for this watercourse is described as ‘overtopping of river banks leading to low velocity flooding in most areas with flood depths ranging between 0.3m and 0.5m’ (Table 3.17 included in the Catchment Flood Management Plan). The Environment Agency has assigned this watercourse a ‘high priority’ natural channel maintenance regime and they provide flood warning with a 2 hour lead time.



The river flood depth map for the Eastwood Brook included in the CFMP it can be seen that flood within the southern part of the proposed development area.

It should be noted that the airport has previously experienced flooding from the Eastwood Brook including in 1981 when the brook burst its banks leading to flooding of the airport hanger.

Source: Environment Agency, South Essex Catchment Flood Management Plan, 2008

Development Control Recommendations

Sequential Approach

All future development should be steered towards Flood Zone 1 in accordance with the sequential approach. No development is permitted within Flood Zone 3b.

Finished Floor Levels

In areas affected by fluvial flooding, finished floor levels should be set 300mm above the 1 in 100 year flood level, including allowances for climate change for the lifetime of the development (100 years for residential development).

Flood Resilient Design

For the buildings located adjacent to the Eastwood Brook, it is recommended that flood resilient construction methods are used up to the 1 in 100 year flood level including allowances for climate change.

Floodplain Compensation

Any encroachment into Flood Zone 3a that results in loss of storage in the floodplain should be compensated for on a level for level and volume for volume basis.

Surface Water Management

Future development must make adequate provision for the sustainable management of surface water on the site. Given the proximity of the Eastwood Brook, there may be potential to discharge to this watercourse. It should be noted that in the if a rainfall event coincides with the Eastwood Brook being in flood, the outfall for the development drainage system may become surcharged leading surface water flooding.

Any discharge to this main river will require consent from the Environment Agency and will require attenuation to discharge at a flow rate to be confirmed with the Environment Agency (potentially Greenfield runoff rate). SuDS should be used in order to manage surface water on site to meet the discharge requirements. The geology within this part of the district is River Terrace Deposits, underlain by Thames Group Clay. Infiltration testing will be required to determine the prospect of using infiltration drainage techniques. Further guidance regarding SuDS is supplied in Chapter 11 of this report.

Emergency Planning

This area is covered by the Environment Agency's Flood Warning Service and flood warnings are issued for the Eastwood Brook with a lead time of 2 hours. It is recommended that a Flood Evacuation Plan is prepared for future occupants of the site detailing flood response procedures and evacuation routes.

- 10.2.2 It is noted that flood risk advice and guidance for the JAAP area has also been provided as part of the Level 2 Strategic Flood Risk Assessment prepared on behalf of Southend-on-Sea Borough Council. This information is reproduced in Appendix G of this report for reference.

11 Guidance for the Application of SuDS

11.1 Introduction

11.1.1 In addition to tidal and fluvial flooding, there is a risk of localised surface water flooding in Rochford as a result of the increased occurrence of extreme rainfall events and underlying clay soils, particularly in the western half of the district. This risk is likely to increase over time as a result of climate change and changes in the local environment such as paving of front gardens.

11.1.2 The risk from surface water flooding can be mitigated through the use of Sustainable Urban Drainage Systems (SuDS). SuDS seek to manage surface water as close to its source as possible, mimicking surface water flows arising from the site, prior to the proposed development. Typically this approach involves a move away from piped systems to softer engineering solutions inspired by natural drainage processes. PPS25 indicates that Regional Planning Bodies and Local Authorities should promote the use of SuDS for the management of surface water runoff generated by development.

11.1.3 SuDS should be designed to take into account the surface run-off quantity, rates and also water quality ensuring their effective operation up to and including the 1 in 100 year design standard flood including an increase in peak rainfall up to 30% to account from climate change.

11.1.4 Wherever possible, a SuDS technique should seek to contribute to each of the three goals identified below with the favoured system contributing significantly to each objective:

1. Reduce flood risk (to the site and neighbouring areas),
2. Reduce pollution, and,
3. Provide landscape and wildlife benefits.

11.1.5 These goals can be achieved by utilising a management plan incorporating a chain of techniques, (as outlined in Interim Code of Practice for Sustainable Drainage Systems 2004), where each component adds to the performance of the whole system:

Prevention	good site design and upkeep to prevent runoff and pollution (e.g. limited paved areas, regular pavement sweeping)
Source Control	runoff control at/near to source (e.g. rainwater harvesting, green roofs, pervious pavements)
Site Control	water management from a multitude of catchments (e.g. route water from roofs, impermeable paved areas to one infiltration/holding site)
Regional Control	Integrate runoff management systems from a number of sites (e.g. into a detention pond)

11.1.6 This chapter presents a summary of the SuDS techniques currently available and a review of the soils and geology of the study area, enabling Rochford DC to identify where SuDS techniques could be employed in development schemes.

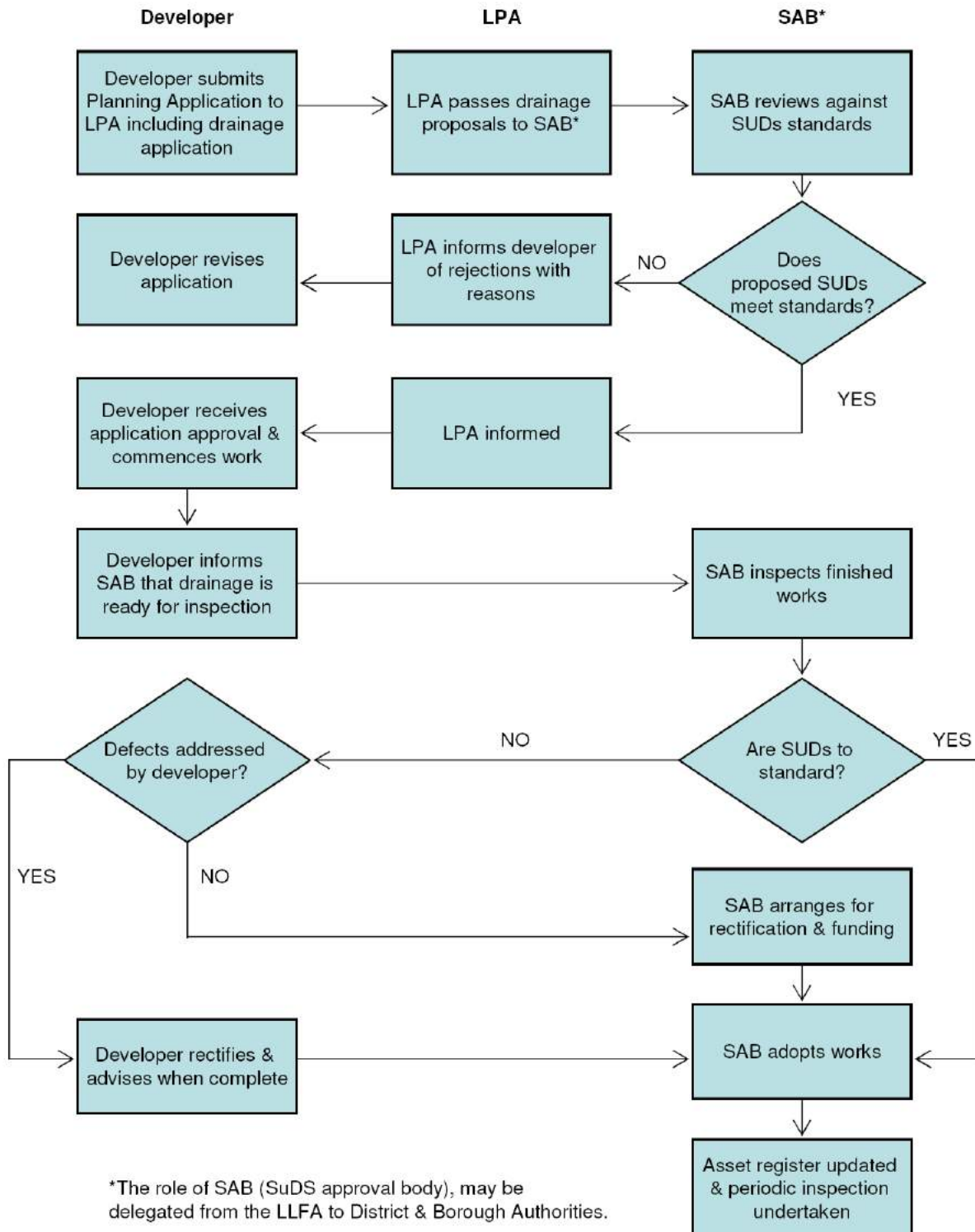
11.1.7 The application of SuDS is not limited to a single technique per site. Often a successful SuDS solution will utilise a combination of techniques, providing flood risk, pollution and landscape/wildlife benefits. In addition, SuDS can be employed on a strategic scale, for example with a number of sites contributing to large scale jointly funded and managed SuDS. It should be noted, each

development site must offset its own increase in runoff and attenuation cannot be “traded” between developments.

11.2 Regulatory Position

- 11.2.1 Until 2010 there were no legally binding obligations relating to the provision and maintenance of SuDS. In April 2010, the Flood and water Management Act gained Royal Assent and with it came a number of responsibilities for Unitary and County Authorities, defined as Lead Local Flood Authorities (LLFAs), which in this case is Essex County Council. In relation to Rochford DC, Essex County Council are required to:
- Investigate and record flooding incidents;
 - Produce an asset register of all flood risk related assets;
 - Develop a preliminary flood risk assessment;
 - Adopt and maintain SuDS.
- 11.2.2 In their document, ‘Flood and Water Management Act 2010 – What the Flood and Water Management Act means for property developers’, Defra set out details regarding the process of SuDS approval by the relevant Local Lead Flood Authority as follows:
- 11.2.3 Plans for a proposed drainage system will need to be approved prior to construction, by the SuDS Approving Body (SAB) which will be the unitary or county council for the area, in this case Essex County Council. This applies to both permitted developments and those that require planning permission. This will ensure that SuDS are also included in construction that may cover large surface areas, but does not require planning permission.
- 11.2.4 Where both planning permission and SuDS approval are required, it is anticipated that the processes will run together. Applications for the drainage system and for planning permission will be submitted together to reduce burdens for the applicant. The planning authority will notify the developer of the outcome of both the planning permission and drainage approval at the same time, including any conditions of approval. Regulations will set out a timeframe for the approval of drainage application by the SAB, so the planning process is not delayed.
- 11.2.5 At the time of writing, the organisational arrangements for SuDS approval adoption in Essex County Council are still to be clarified. Figure 11-1 provides a suggestion of a potential overview process that could be used when a planning application is submitted. However, it is noted that it is also possible for the role of SuDS Approving Body to be delegated by the Lead Local Flood Authority to Local Planning Authorities.
- 11.2.6 In addition, Anglian Water, the local waste water provider has set out adoption standard for SuDS. The Council currently expect all new SuDS systems to meet the adoption standards outlined by Anglian Water to ensure their long term maintenance.

Figure 11-1 Potential SuDS Approval Process (Scott Wilson 2011)



11.3 SuDS Techniques

11.3.1 SuDS techniques can be used to reduce the rate and volume and improve the water quality of surface water discharges from sites to the receiving environment (i.e. natural watercourse or public sewer etc). Various SuDS techniques are available and operate on two main principles:

- Infiltration
- Attenuation

11.3.2 All systems generally fall into one of these two categories, or a combination of the two.

11.3.3 The design of SuDS measures should be undertaken as part of the drainage strategy and design for a development site. A ground investigation will be required to assess the suitability of using infiltration measures, with this information being used to assess the required volume of on-site storage. Hydrological analysis should be undertaken using industry approved procedures, to ensure a robust design storage volume is obtained.

11.3.4 During the design process, liaison should take place with the Local Planning Authority, the LLFA, the Environment Agency and if necessary, the Water Undertaker to establish a satisfactory design methodology and permitted rate of discharge from the site.

11.3.5 *Reference should be made to the SuDS Manual CIRIA C697 for best practice on the planning, design, construction, operation and maintenance of SuDS.*

11.4 Infiltration SuDS

11.4.1 This type of Sustainable Drainage System relies on discharges to ground, where suitable ground conditions are suitable. Therefore, infiltration SuDS are reliant on the local ground conditions (i.e. permeability of soils and geology, the groundwater table depth and the importance of underlying aquifers as a potable resource) for their successful operation.

11.4.2 Development pressures and maximisation of the developable area may reduce the area available for infiltration systems. This can be overcome through the use of a combined approach with both attenuation and infiltration techniques e.g. attenuation storage may be provided in the sub-base of a permeable surface, within the chamber of a soakaway or as a pond/water feature.

Permeable Surfaces

11.4.3 Permeable surfaces are designed to intercept rainfall and allow water to drain through to a sub-base. The use of a permeable sub-base can be used to temporarily store infiltrated run-off underneath the surface and allows the water to percolate into the underlying soils. Alternatively, stored water within the sub-base may be collected at a low point and discharged from the site at an agreed rate.

11.4.4 Permeable paving reduces runoff during low intensity rainfall, however, during intense rainfall events some runoff may occur from these surfaces.

11.4.5 Programmes should be implemented to ensure that permeable surfaces are kept well maintained to ensure the performance of these systems is not reduced. The use of grit and salt during winter months may adversely affect the drainage potential of certain permeable surfaces.

11.4.6 Types of permeable surfaces include:

- Grass/landscaped areas
- Gravel
- Solid Paving with Void Spaces
- Permeable Pavements

Sub-surface Infiltration

- 11.4.7 Where permeable surfaces are not a practical option more defined infiltration systems are available. In order to infiltrate the generated run-off to ground, a storage system is provided that allows the infiltration of the stored water into the surrounding ground through both the sides and base of the storage. These systems are constructed below ground and therefore may be advantageous with regards to the developable area of the site. Consideration needs to be given to construction methods, maintenance access and depth to the water table. The provision of large volumes of infiltration/sub-surface storage has potential cost implications. In addition, these systems should not be built within 5 m of buildings, beneath roads or in soil that may dissolve or erode.
- 11.4.8 Various methods for providing infiltration below the ground include:
- Geocellular Systems
 - Filter Drain
 - Soakaway (Chamber)
 - Soakaway (Trench)
 - Soakaway (Granular Soakaway)

Table 11-1 Suitability of Infiltration Methods towards with respect to the wider aims of SuDS

INFILTRATION METHOD	REDUCE FLOOD RISK (Y/N)	REDUCE POLLUTION (Y/N)	LANDSCAPE AND WILDLIFE BENEFITS (Y/N)
Permeable Surface	Y	Y	N
Sub-surface Infiltration	Y	Y	N

11.5 Attenuation SuDS

- 11.5.1 If ground conditions are not suitable for infiltration techniques then management of surface water runoff prior to discharge should be undertaken using attenuation techniques. This technique attenuates discharge from a site to reduce flood risk both within and to the surrounding area. It is important to assess the volume of water required to be stored prior to discharge to ensure adequate provision is made for storage. The amount of storage required should be calculated prior to detailed design of the development to ensure that surface water flooding issues are not created within the site.
- 11.5.2 The rate of discharge from the site should be agreed with the Local Planning Authority and the Environment Agency. If surface water cannot be discharged to a local watercourse then liaison with the Sewer Undertaker should be undertaken to agree rates of discharge and the adoption of the SuDS system.
- 11.5.3 Large volumes of water may be required to be stored on site. Storage areas may be constructed above or below ground. Depending on the attenuation/storage systems implemented, appropriate maintenance procedures should be implemented to ensure continued performance of the system.

On-site storage measures include basins, ponds, and other engineered forms consisting of underground storage.

Basins

11.5.4 Basins are areas that have been contoured (or alternatively embanked) to allow for the temporary storage of run-off from a developed site. Basins are designed to drain free of water and remain waterless in dry weather. These may form areas of public open space or recreational areas. Basins also provide areas for treatment of water by settlement of solids in ponded water and the absorption of pollutants by aquatic vegetation or biological activity. The construction of basins uses relatively simple techniques. Local varieties of vegetation should be used wherever possible and should be fully established before the basins are used. Access to the basin should be provided so that inspection and maintenance is not restricted. This may include inspections, regular cutting of grass, annual clearance of aquatic vegetation and silt removal as required.

Ponds

11.5.5 Ponds are designed to hold the additional surface water run-off generated by the site during rainfall events. The ponds are designed to control discharge rates by storing the collected run-off and releasing it slowly once the risk of flooding has passed. Ponds can provide wildlife habitats, water features to enhance the urban landscape and, where water quality and flooding risks are acceptable, they can be used for recreation. It may be possible to integrate ponds and wetlands into public areas to create new community ponds. Ponds and wetlands trap silt that may need to be removed periodically. Ideally, the contaminants should be removed at source to prevent silt from reaching the pond or wetland in the first place. In situations where this is not possible, consideration should be given to a small detention basin placed at the inlet to the pond in order to trap and subsequently remove the silt. Depending on the setting of a pond, health and safety issues may be important issues that need to be taken into consideration. The design of the pond can help to minimise any health and safety issues (i.e. shallower margins to the pond reduce the danger of falling in, fenced margins).

11.5.6 Various types of ponds are available for utilising as SuDS measures. These include:

- Balancing/Attenuating Ponds
- Flood Storage Reservoirs
- Lagoons
- Retention Ponds
- Wetlands

Table 11-2 Suitability of Attenuation Methods towards the 3 Goals of SuDS

INFILTRATION METHOD	REDUCE FLOOD RISK (Y/N)	REDUCE POLLUTION (Y/N)	LANDSCAPE AND WILDLIFE BENEFITS (Y/N)
Basins	Y	Y	Y
Ponds	Y	Y	Y

11.6 Alternative Forms of Attenuation

11.6.1 Site constraints and limitations such as developable area, economic viability and contamination may require engineered solutions to be implemented. These methods predominantly require the provision of storage beneath the ground surface, which may be advantageous with regards to the

developable area of the site but should be used only if methods in the previous section cannot be used. When implementing such approaches, consideration needs to be given to construction methods, maintenance access and to any development that takes place over the storage facility. The provision of large volumes of storage underground also has potential cost implications.

11.6.2 Methods for providing alternative attenuation include:

- Deep Shafts
- Geocellular Systems
- Oversized Pipes
- Rainwater Harvesting
- Tanks
- Green Roofs

11.6.3 In some situations it may be preferable to combine infiltration and attenuation systems to maximise the management of surface water runoff, developable area and green open space.

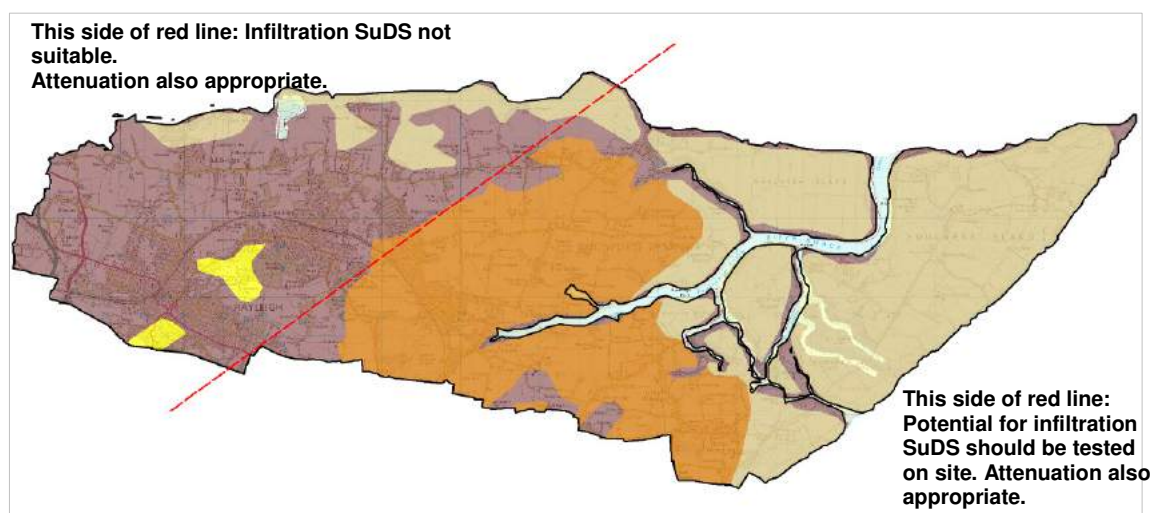
11.7 SuDS Suitability in Rochford District

11.7.1 Figure 11-2 provides a generalised summary of the underlying geology and suitability of sustainable drainage systems within the Rochford district. A divide across the district can be seen with respect to geology and soil characteristics, and thereby the suitability of SuDS.

11.7.2 In the west of the district, including the area around Rayleigh, Hullbridge, Hockley, Ashingdon and Hawkwell, the geology is predominantly clay and are no drift deposits overlying this area. The soils are relatively impermeable and surface water typically runs off rapidly. As a result infiltration SuDS are not deemed suitable for this area. The use of attenuation measures should be explored when considering site design and layout.

11.7.3 The east of the district, including Rochford, Great Wakering and Foulness Island is characterised by the presence of river terrace deposits and alluvium. These are relatively permeable and therefore result in a relatively low rainfall to runoff conversion rate. There may be potential for the use of infiltration SuDS in these areas, however on site infiltration testing should be undertaken on a site by site basis to determine its suitability. The underlying geology in this area is still clay and therefore it is likely that attenuation measures will be more suitable in this area as well.

Figure 11-2 Indicative Geology & SuDS Suitability in Rochford



- 11.7.4 As stated above, it should be noted that Figure 11-2 provides an indicative overview of the potential suitability of infiltration SuDS throughout the district. The suitability of a proposed site for the use of different SuDS will need to be determined on a site by site basis. Investigation will be required including geology, infiltration rates and groundwater vulnerability. Where infiltration SuDS are used, consideration may need to be given to pollution control.

12 Conclusions & Recommendations

12.1 Conclusions

- 12.1.1 The results from the increased scope Level 2 SFRA have confirmed that the district of Rochford is at risk of flooding from tidal sources.
- 12.1.2 Overtopping or a breach in the flood defences has the potential to result in flooding to depths of greater than 3m throughout Shoeburyness, Paglesham, Wallasea Island and South Fambridge putting existing development and occupants at great risk. Given the low lying nature of the coastline in this part of the district, flood waters are likely to propagate rapidly, greatly reducing the time available for warning and evacuation of residents, as was the case in the 1953 flood.
- 12.1.3 Policies adopted as part of the Catchment Flood Management Plan for the tidal parts of the Rochford district aim to reduce or cease existing levels of flood risk management now and into the future. It is therefore likely that the flood risk from tidal sources in this district will continue to increase over time.
- 12.1.4 In addition to flood risk from tidal sources, fluvial systems also pose a risk to parts of the Rochford district. The impermeable underlying geology and seasonally wet, deep clay soils in the western parts of the district lead to rapid runoff of surface water into local watercourses. The channelization of these watercourses is also leading to rapid conveyance of water downstream and leading to problems where watercourses converge.
- 12.1.5 Fluvial flooding primarily affects Rochford, where the River Roach, Noblesgreen Ditch and Eastwood Brook meet. A number of other smaller watercourses in Rawreth and Rayleigh also pose a fluvial flood risk.

12.2 Recommendations

- 12.2.1 It is strongly recommended that the mapping in this SFRA is used by Rochford Council Emergency Planners to continue to inform and update the development of Emergency Response and Evacuation Plans for the existing development and occupants throughout the district. Flood depth, hazard and time to inundation mapping should be used to inform routes of safe access and egress for existing development.
- 12.2.2 Under the Core Strategy proposals no development is proposed within areas defined at risk of flooding from tidal sources. However, it is possible that planning applications may come forward for redevelopment of individual properties within areas at risk of tidal flooding. Where this is the case, it is strongly recommended that development proposals are carefully assessed and that both developers and the LPA take advice from the emergency services and emergency planners when considering the safety of future users of the proposed developments to ensure that they are safe in line with the recommendations provided in Chapter 10 of this report.
- 12.2.3 Information with respect to flood depths, hazard rating and time to inundation should be used to inform part c) of the Exception Test and the preparation of site specific Flood Risk Assessments. It is noted that this document is a strategic document, and therefore specific assessments may need to be carried out, (for example consideration of an additional breach location of more significance to the site under assessment), however the SFRA should provide indicative information and Chapter

10 provides detailed guidance on the issues that need to be addressed as part of these assessments.

- 12.2.4 Similarly, where development is proposed in areas at risk of fluvial flooding, development control recommendations provided in Chapter 9 of this report should be used to determine the safety of the proposed development and to ensure that the proposed development does not increase flood risk to surrounding areas or impact upon the ability of Rochford DC and their emergency services to safeguard the current population.

12.3 Living Document – SFRA Maintenance & Updates

- 12.3.1 For an SFRA to serve as a practical planning tool now and in the future, it will be necessary to undertake a periodic update and maintenance exercise. This section clarifies what specific actions are recommended to ensure correct maintenance and updating of the SFRA.

GIS Layers

- 12.3.2 GIS layers used in this SFRA have been created from a number of different sources, using the best and most suitable information available at the time of publishing. Should new Flood Zone information become available, the data should be digitised and geo-referenced within a GIS system. A copy of the current dataset should be created and backed up and the new data should then be merged or combined with the current data set.
- 12.3.3 For example, should updated modelled outlines delineating Flood Zone 3b on the Prittle Brook become available, the current FZ3b outline should be edited to ensure that the newest data is displayed and that the old data is overwritten.
- 12.3.4 For other GIS layers such as the historical flood outlines or the sewer flooding information, it is likely that data will be added rather than be replaced. For example, where a new sewer flooding incident is reported in the catchment, a point should be added to the sewer flooding GIS layer rather than creating a new layer.
- 12.3.5 All GIS layers used in the SFRA have meta-data attached to them. When updating the GIS information, it is important that the meta-data is updated in the process. Meta-data is additional information that lies behind the GIS polygons, lines and points. For example, the information behind the SFRA Flood Zone Maps describes where the information came from, what the intended use was together with a level of confidence.

OS Background Mapping

- 12.3.6 The SFRA has made use of the OS 1:25000 and 1:50000 digital raster maps. Periodically these maps are updated. Under the HDC OS License, it is likely that these maps will be updated throughout the whole of the Rochford GIS system. Updated maps are unlikely to alter the findings of the SFRA.

Data Licensing Issues

- 12.3.7 Prior to any data being updated within the SFRA, it is important that the licensing information is also updated to ensure that the data used is not in breach of copyright. The principal licensing bodies relevant to the SFRA at the time of publishing were the Environment Agency (Thames Region), Ordnance Survey and Anglian Water. Updated or new data may be based on datasets from other licensing authorities and may require additional licenses.

Flooding Policy and PPS25 Practise Guidance Updates

- 12.3.8 This SFRA was updated inline with policy and guidance that was current in September 2010, principally PPS25 (DCLG December 2009) and the accompanying Practice Guide (March 2010). Furthermore, guidance and recommendations issued in the Pitt Review (Pitt 2008) and the subsequent Floods and Water Management Act (2010) have been incorporated into this updated revision. Should new flooding policy be adopted nationally, regionally or locally, the SFRA should be checked to ensure it is still relevant and updates made if necessary.

Stakeholder Consultation and Notification

- 12.3.9 The key stakeholders consulted in the SFRA were Rochford District Council, Anglian Water and the Environment Agency. It is recommended that a periodic consultation exercise is carried out with the key stakeholders to check for updates to their datasets and any relevant additional or updated information they may hold. If the SFRA is updated, it is recommended that the Environment Agency and the Emergency Planning Department are notified of the changes and instructed to refer to the new version of the SFRA for future reference.

Frequency of Updates and Maintenance

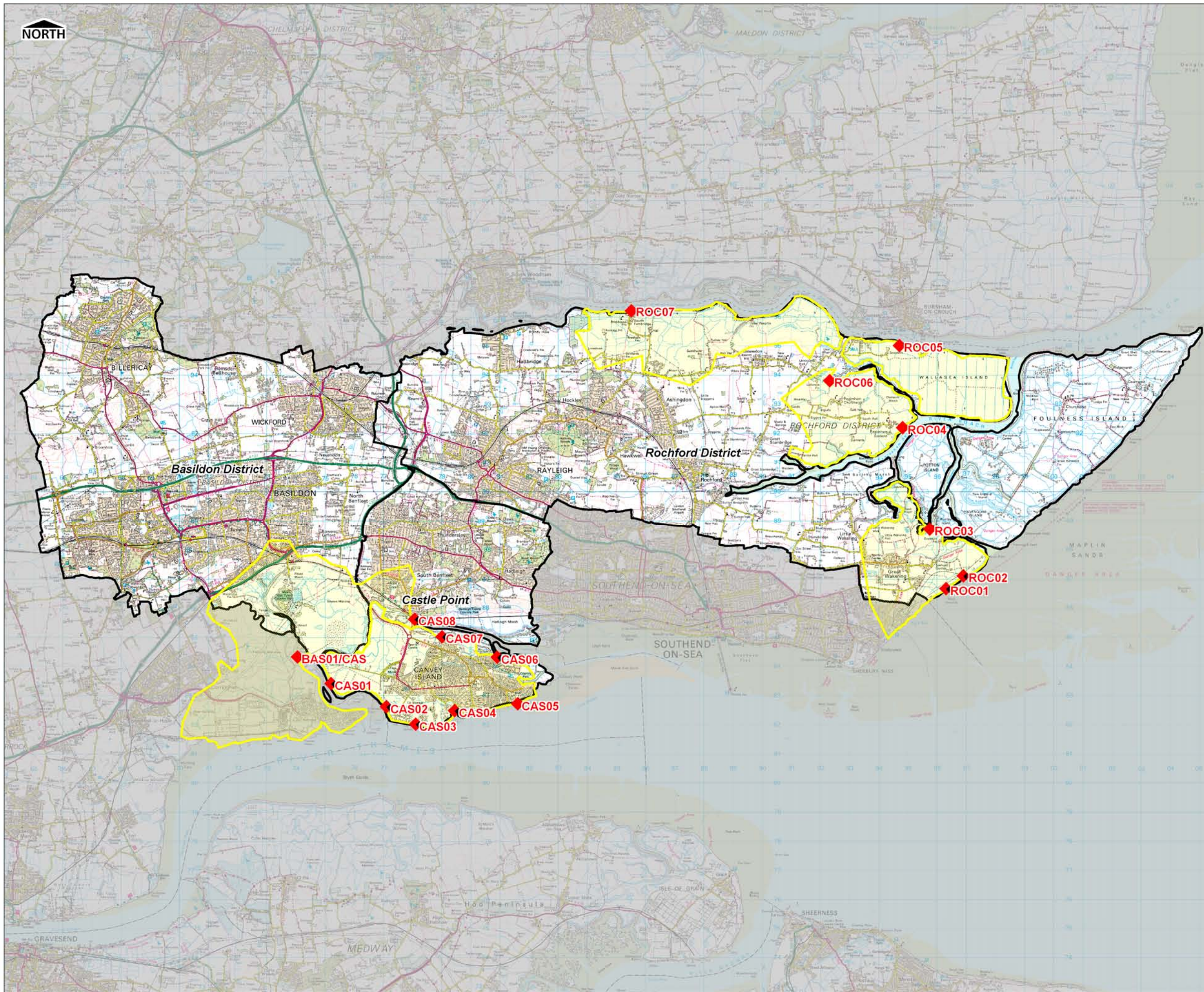
- 12.3.10 It is recommended that the SFRA is maintained on an annual basis. Should any changes be necessary, the SFRA should be updated and re-issued.

References

- CLG (March 2010) Planning Policy Statement 25: Development and Flood Risk
- CLG (December 2009) Planning Policy Statement 25: Development and Flood Risk Practice Guide
- CLG (May 2007) Improving the Flood Performance of New Buildings, Flood Resilient Construction'
- Defra/Environment Agency (2005) Flood Risk Assessment Guidance for New Development: Phase 2, R&D Technical Report FD2320/TR2
- Defra (March 2005) Making Space for Water – Taking forward a new Government strategy for flood and coastal erosion risk management in England.
- Defra (March 2010) Surface Water Management Plan Technical Guidance: Living Draft
- Defra. (2009) National Rank Order of Settlements Susceptible to Surface Water Flooding.
- Environment Agency (August 2008) South Essex Catchment Flood Management Plan.
- The Flood Risk Regulations 2009 (November 2009)
- HMSO (April 2010) Flood and Water Management Act Chapter 29
- Pitt, M. (2008) Pitt Review - Learning Lessons from the 2007 Floods.
- Rochford District Council Multi Agency Flood Plan Version 1 July 2010.

Appendix A: General Figures

Figure A01	Study Area & Breach Locations
Figure A02	LiDAR Topographic Survey
Figure A03	Bedrock Geology
Figure A04	Superficial Geology
Figure A05	Rochford Growth Areas
Figure A06	Main Rivers & Critical Ordinary Watercourses
Figure A07	Fluvial & Tidal Flood Zones – Overview of the District
Figure A08	Fluvial & Tidal Flood Zones – Hawkwell
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Figure A11	Areas Susceptible to Surface Water Flooding & Surface Water Flooding Records
Figure A12	Flood Defences Design Standard (NFCDD)
Figure A13	NaFRA (National Flood Risk Assessment Dataset)



- KEY**
- District/Borough Boundary
 - Breach Modelling Flood Cells
 - ◆ Breach Locations & Label



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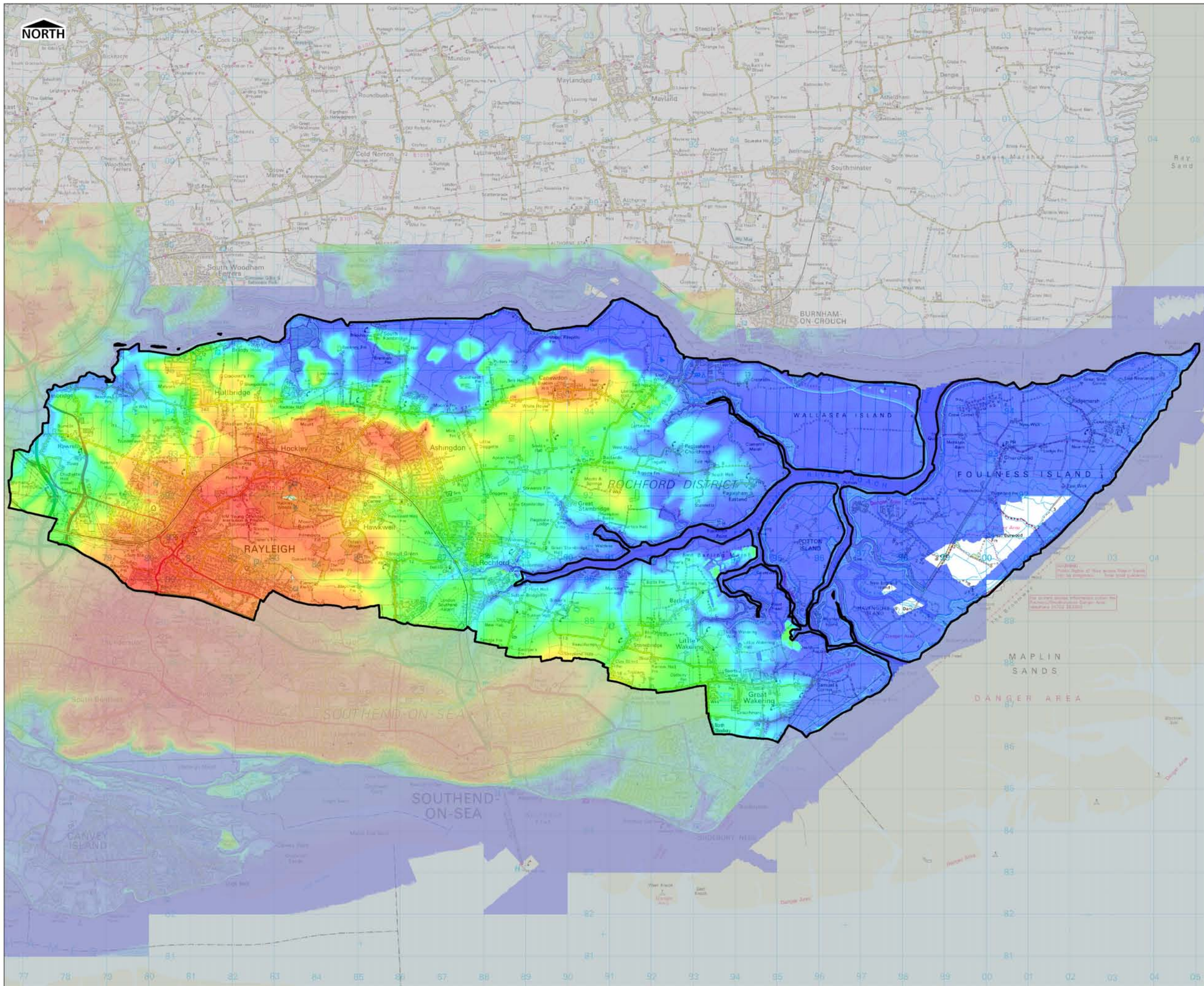
THAMES GATEWAY SOUTH ESSEX
 STRATEGIC FLOOD RISK ASSESSMENT

THAMES GATEWAY SOUTH ESSEX
 STUDY AREA



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FIGURE A-1



KEY

Rochford District Boundary

LIDAR Topography [m AOD]

- < 2
- 5
- 10
- 20
- 30
- > 80

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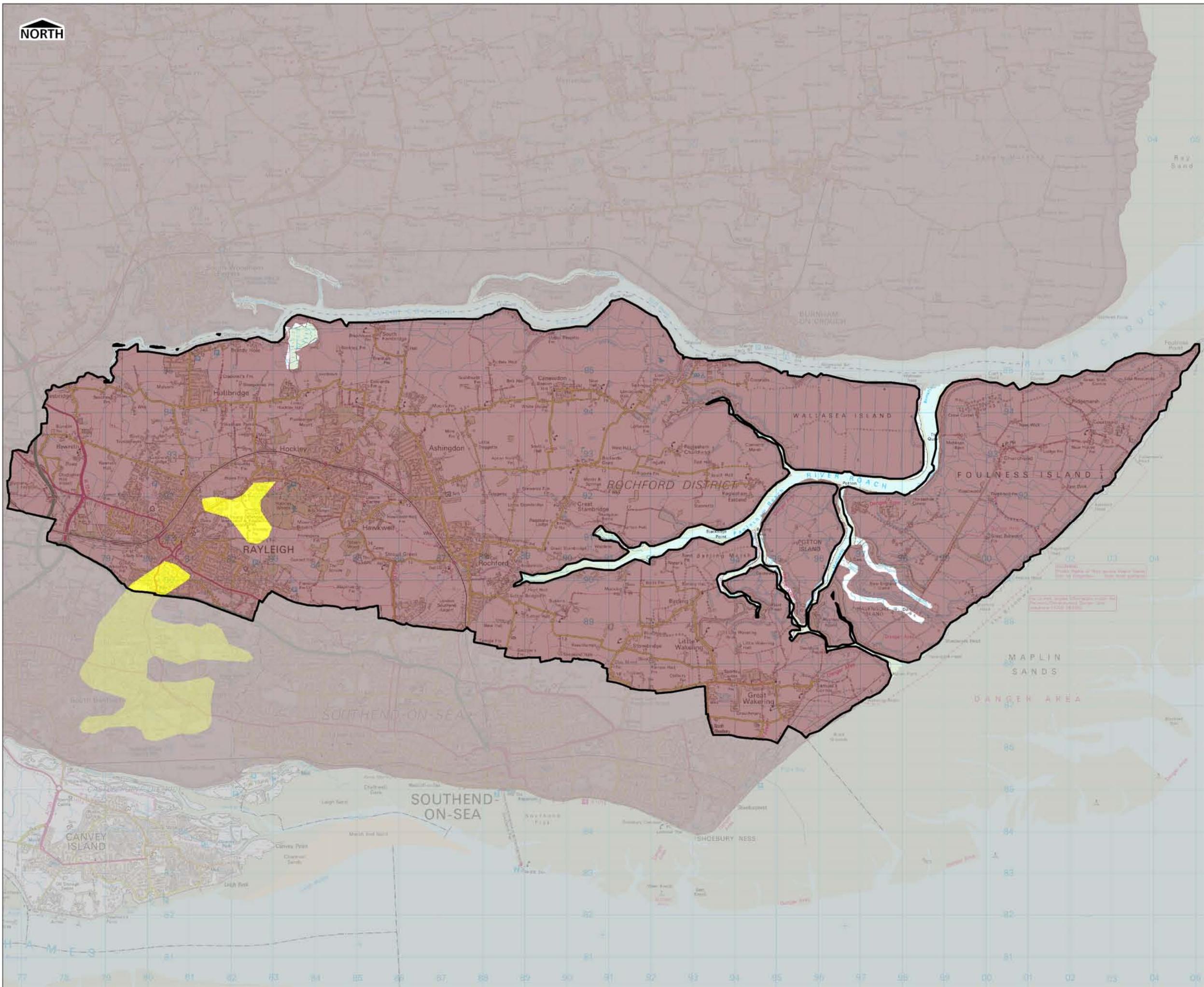
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LIDAR TOPOGRAPHIC DATA



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FIGURE A-2



KEY

Rochford District Boundary

Bedrock Geology

Thames Group
(Clay, Silt, Sand, Gravel)

Bracklesham & Barton Groups
(Sand, Silt, Clay)

Lambeth Group
(Clay, Silt, Sand, Gravel)

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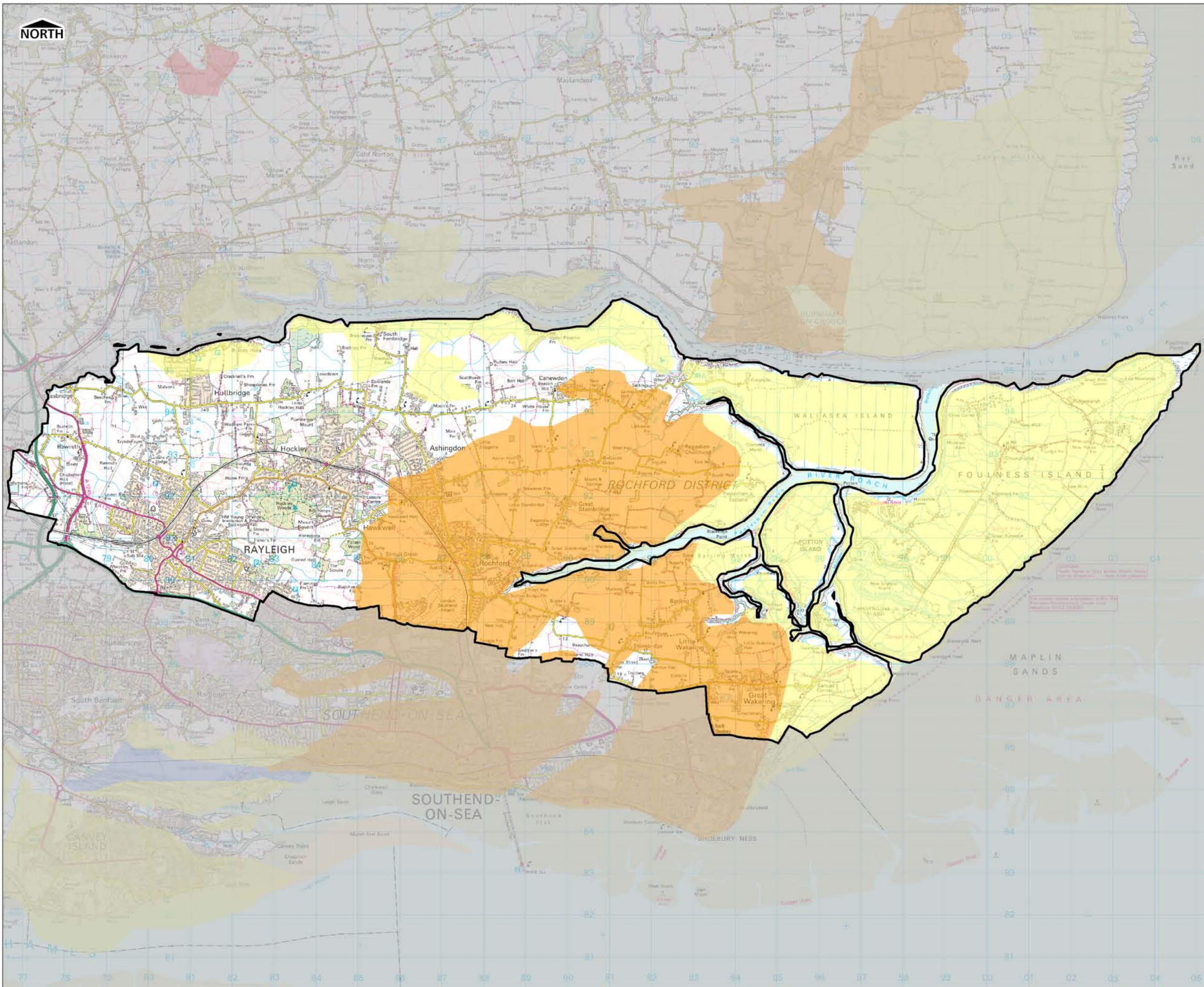
BEDROCK GEOLOGY



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FIGURE A-3



KEY
 Rochford District Boundary

- Superficial Geology**
- Alluvium
 - Brickearth
 - River Terrace Deposits
 - Sand and Gravel
 - Glacial Sand and Gravel
 - Landslip

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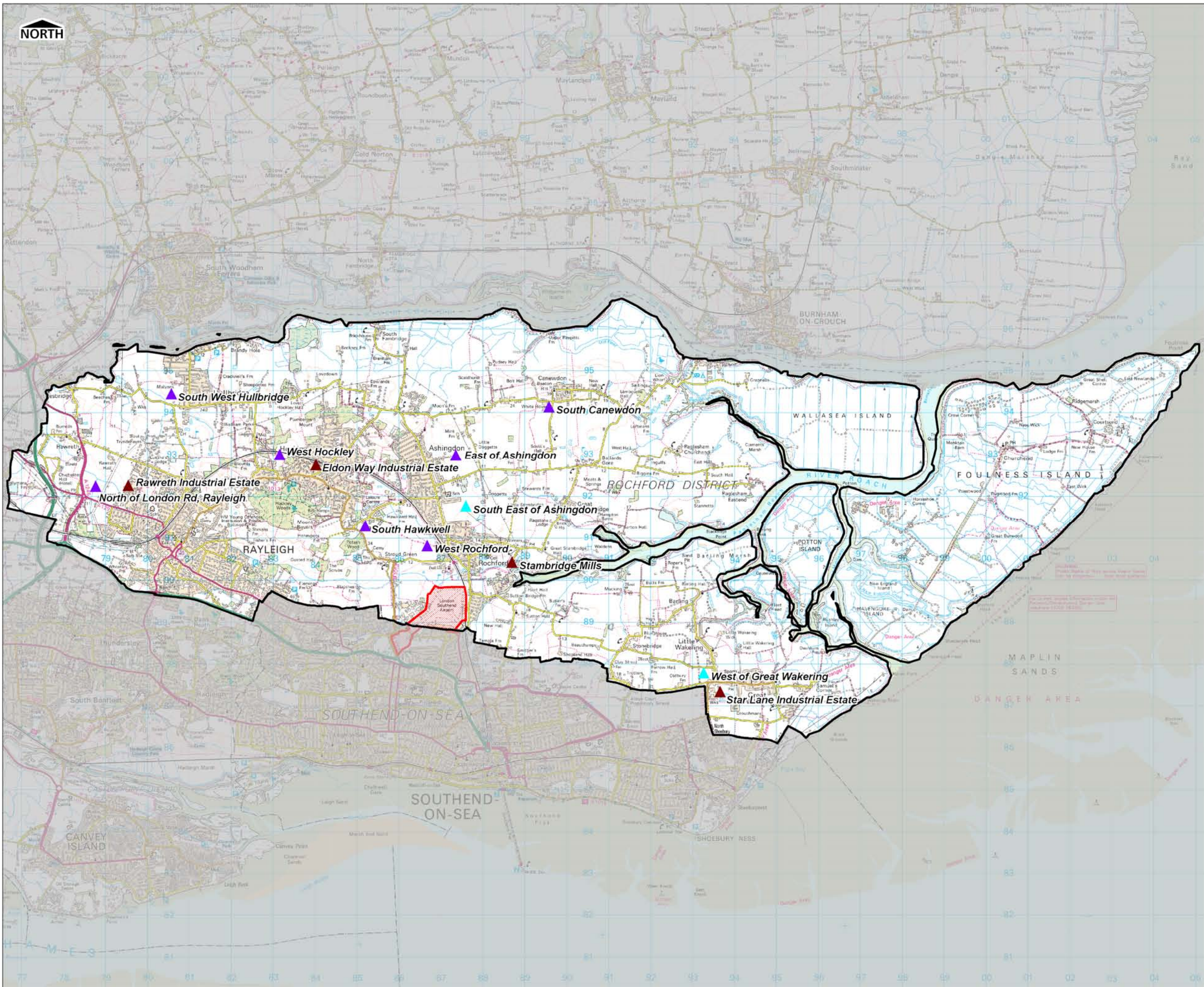
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SUPERFICIAL GEOLOGY





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FIGURE A-4



KEY

-  Rochford District Boundary
- Core Strategy Development Locations**
-  Extensions to Residential Envelope pre-2021
-  Extensions to the Residential Envelope post 2021
-  Redevelopment of Employment Land for Residential Use
-  London Southend Airport & Environs Joint Area Action Plan

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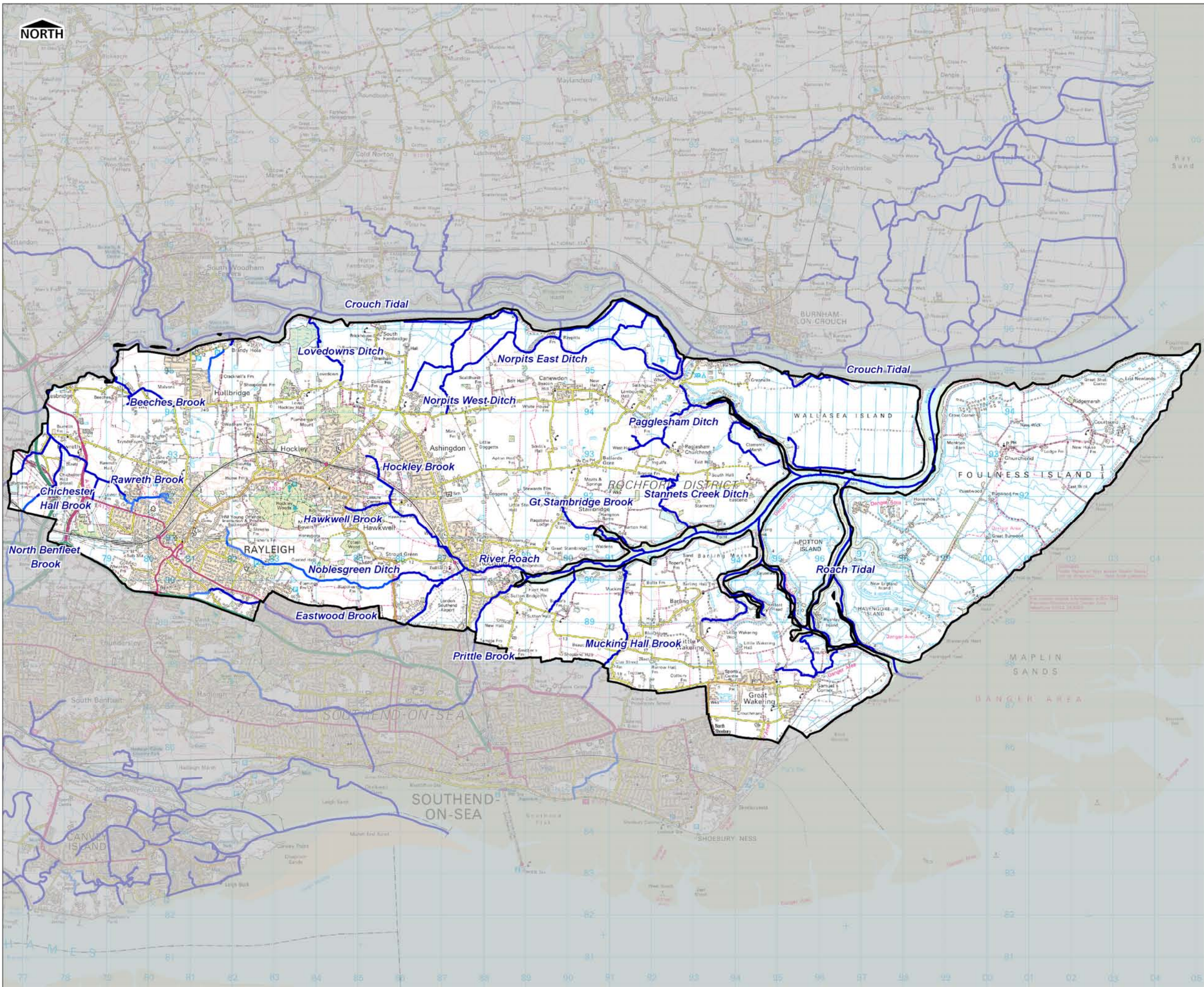
CORE STRATEGY
 DEVELOPMENT LOCATIONS



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FIGURE A-5



- KEY**
- Rochford District Boundary
 - Environment Agency Main Rivers
 - Critical Ordinary Watercourses

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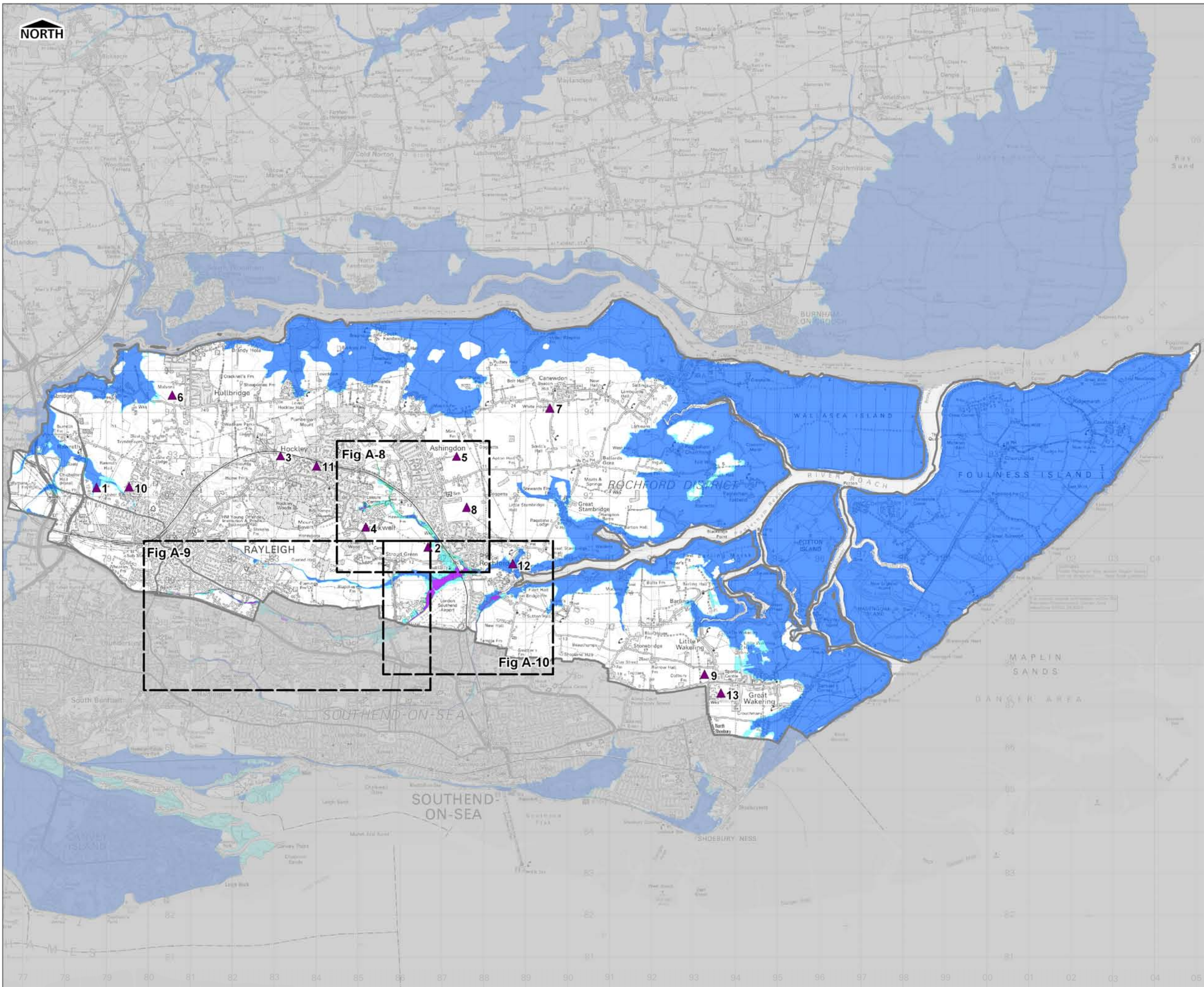
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 STRATEGIC FLOOD RISK ASSESSMENT**

**EA MAIN RIVERS & CRITICAL
 ORDINARY WATERCOURSES**



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FIGURE A-6



- KEY**
- Rochford District Boundary
- Flood Zones**
- FZ 2 - Low Probability
 - FZ 3a - High Probability
 - FZ 3a including Climate Change
 - FZ 3b - Functional Floodplain
- ▲ Core Strategy Development Areas**
- 1 North of London Rd, Rayleigh
 - 2 West Rochford
 - 3 West Hockley
 - 4 South Hawkwell
 - 5 East Ashingdon
 - 6 South West Hullbridge
 - 7 South Canewdon
 - 8 South East Ashingdon
 - 9 West Great Wakering
 - 10 Rawreth Lane Industrial Estate
 - 11 Eldon Way / Foundry Industrial Estate
 - 12 Stambridge Mill
 - 13 Star Lane Industrial Estate

USER NOTE
 Flood Zones have been provided by the Environment Agency's Flood Risk and Mapping Department for the watercourses where modelling is available. The Main Report of the SFRA should be consulted to identify the source of the flood outlines and the modelled return periods used to delineate each flood zone.

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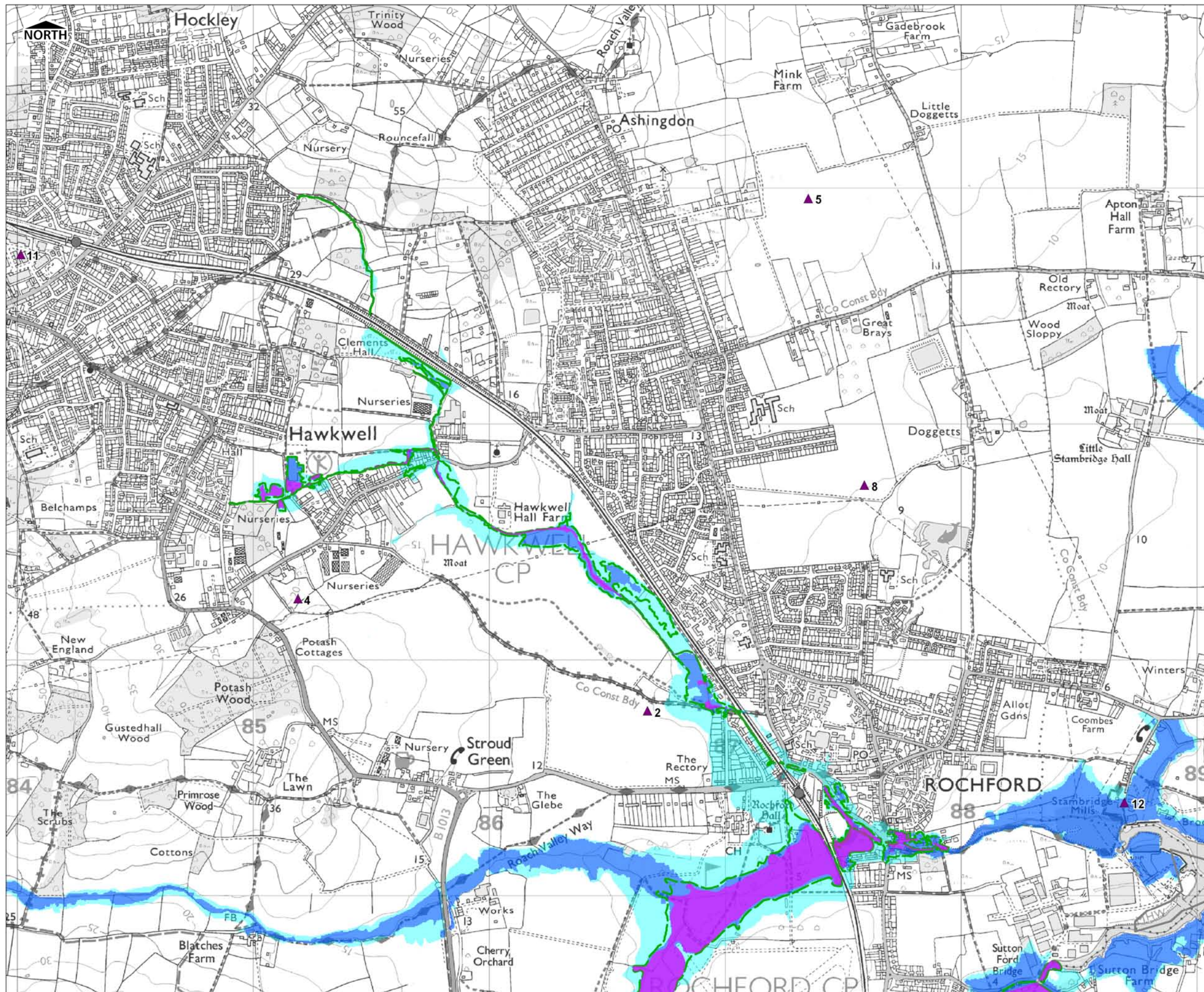
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 STRATEGIC FLOOD RISK ASSESSMENT

FLOOD ZONES



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FIGURE A-7



KEY

□ Rochford District Boundary

Flood Zones

- FZ 2 - Low Probability
- FZ 3a - High Probability
- FZ 3a including Climate Change
- FZ 3b - Functional Floodplain

▲ **Core Strategy Development Areas**

- 1 North of London Rd, Rayleigh
- 2 West Rochford
- 3 West Hockley
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- 6 South West Hullbridge
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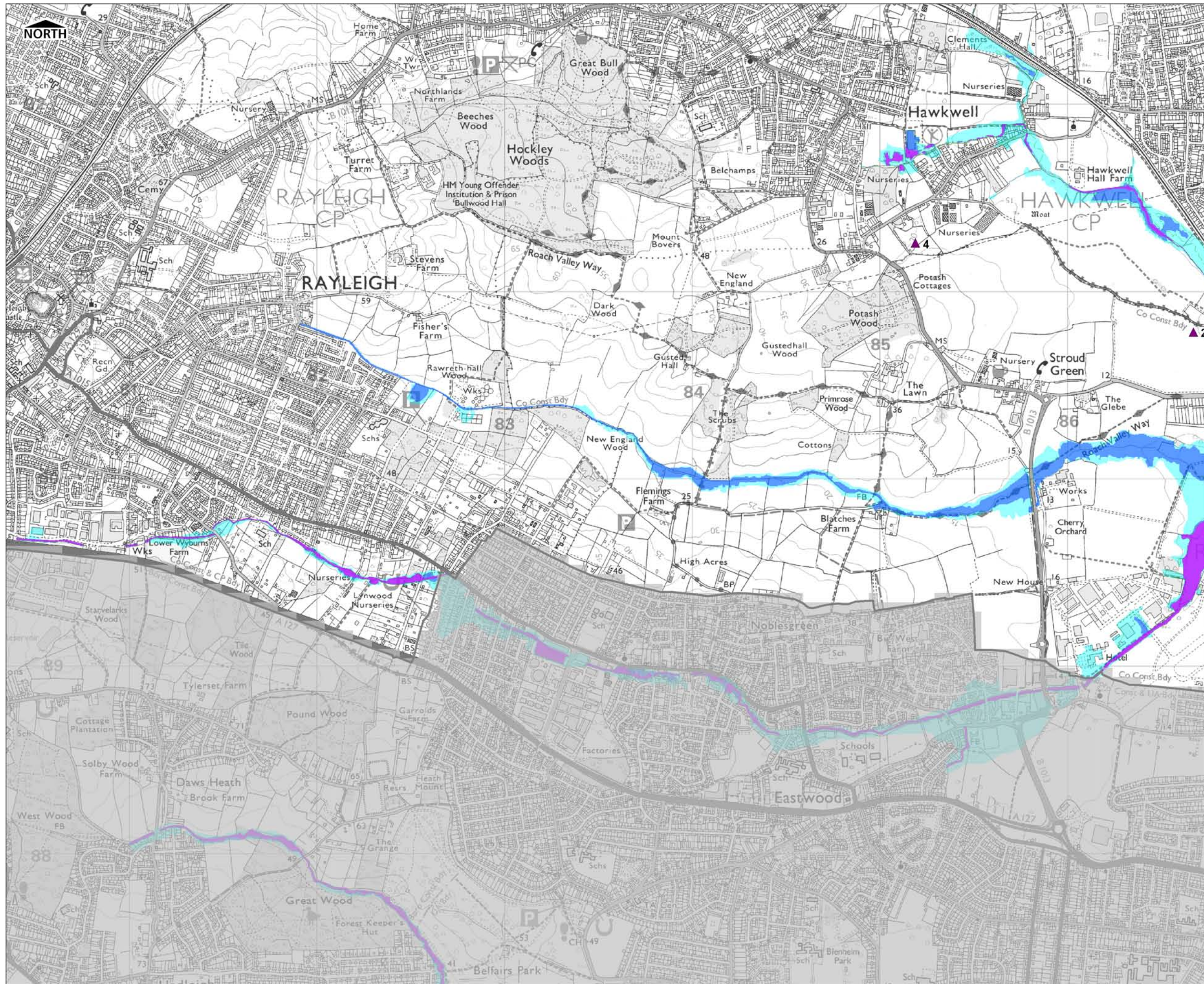
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FLOOD ZONES - HAWKWELL



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FIGURE A-8



KEY

□ Rochford District Boundary

Flood Zones

- FZ 2 - Low Probability
- FZ 3a - High Probability
- FZ 3a including Climate Change
- FZ 3b - Functional Floodplain

▲ Core Strategy Development Areas

- 1 North of London Rd, Rayleigh
- 2 West Rochford
- 3 West Hockley
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- 13 Star Lane Industrial Estate

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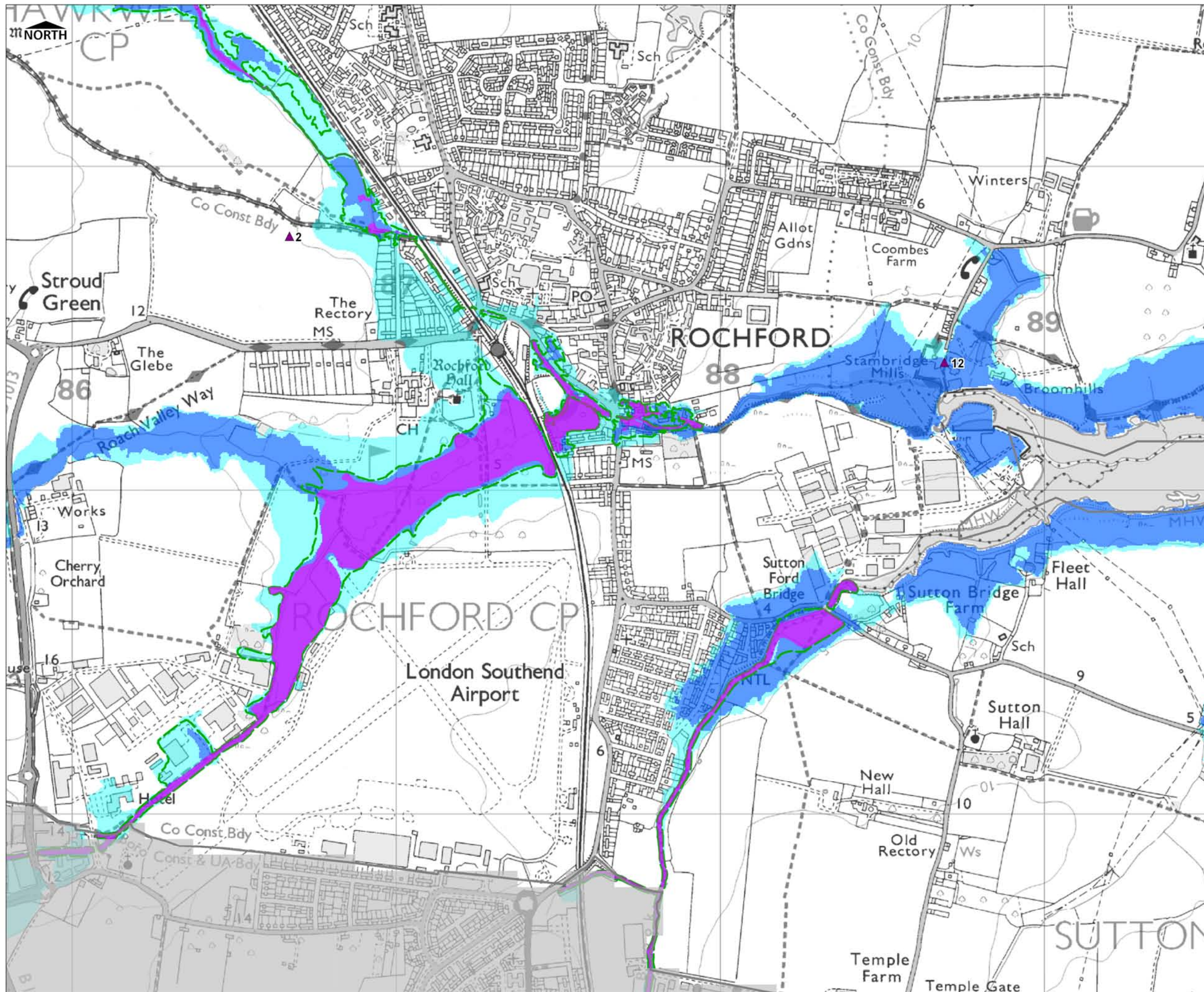
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FLOOD ZONES - RAYLEIGH



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FIGURE A-9



KEY

□ Rochford District Boundary

Flood Zones

- FZ 2 - Low Probability
- FZ 3a - High Probability
- FZ 3a including Climate Change
- FZ 3b - Functional Floodplain

▲ Core Strategy Development Areas

- 1 North of London Rd, Rayleigh
- 2 West Rochford
- 3 West Hockley
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- 13 Star Lane Industrial Estate

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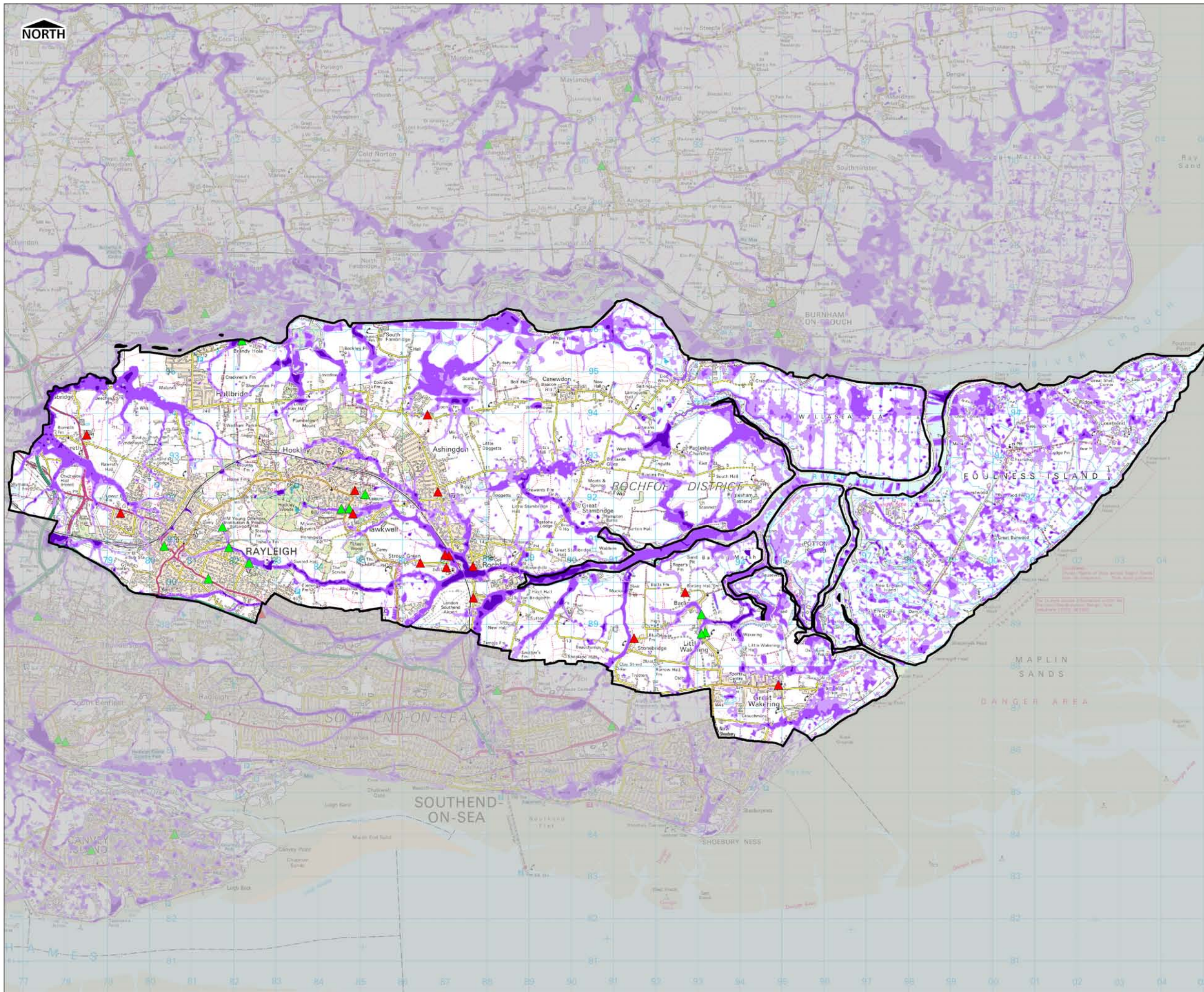
FLOOD ZONES - ROCHFORD



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FIGURE A-10



KEY

- Rochford District Boundary

- Areas Susceptible to Surface Water Flooding (Environment Agency Dataset)**
- Less
- Intermediate
- More

- ▲ Records of Flooding within Rochford DC
- ▲ Sewer Flooding Records (Anglian Water DG5 Records)

USER NOTE

The Areas Susceptible to Surface Water Flooding dataset provides national coverage and has been produced using a highly simplified method that excludes urban sewerage and drainage systems, excludes buildings, and uses a single rainfall event. It is noted that this mapping is intended for use by the Local Resilience Forums solely to inform emergency planning and should not be used for spatial planning decisions. In addition, the Environment Agency strongly recommend that local knowledge is applied to assess the suitability of the mapping as an indicator of surface water flooding before emergency planners make decisions based upon it.

In line with these recommendations, incidents of flooding recorded by Rochford DC and records of sewer flooding supplied by Anglian Water from their DG5 register have been used to verify the ASTSW dataset.

The surface water flow paths follow the general topography of the area, as shown in Figure A-2, and the predominant flow paths from the modelling correlate with the tributaries of the Rivers Roach and Crouch.

Incidents of surface water and sewer flooding recorded in Rochford, Rayleigh and Hawkwell correlate well with the modelled dataset. In addition, incidents recorded in Little Wakering also correlate with the modelling.

There are fewer incidents recorded to the north of the River Roach, which is to be expected given the lower concentration of urban development in this area.

Further assessment of surface water across the district will be completed as part of the Surface Water Management Plan for the Rochford DC.

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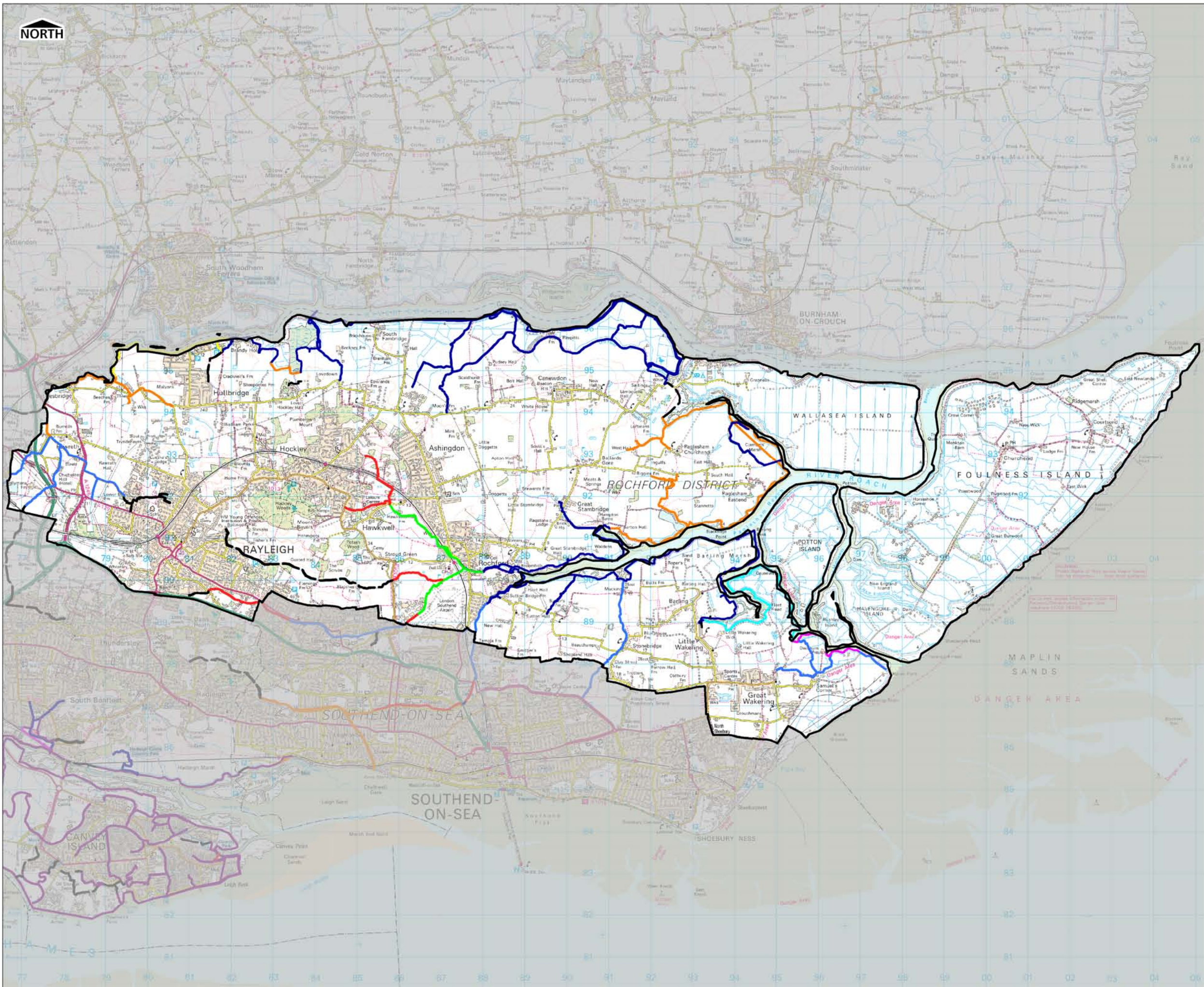
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

AREAS SUSCEPTIBLE TO SURFACE WATER FLOODING



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FIGURE A-11



KEY

Rochford District Boundary

Defence Design Standard [NFCCD Dataset]

- 1000yr
- 200 - 1000yr
- 100 - 200yr
- 50 - 100yr
- 40 - 50yr
- 30 - 40yr
- 20 - 30yr
- 10 - 20yr
- 0 - 10yr
- Unknown

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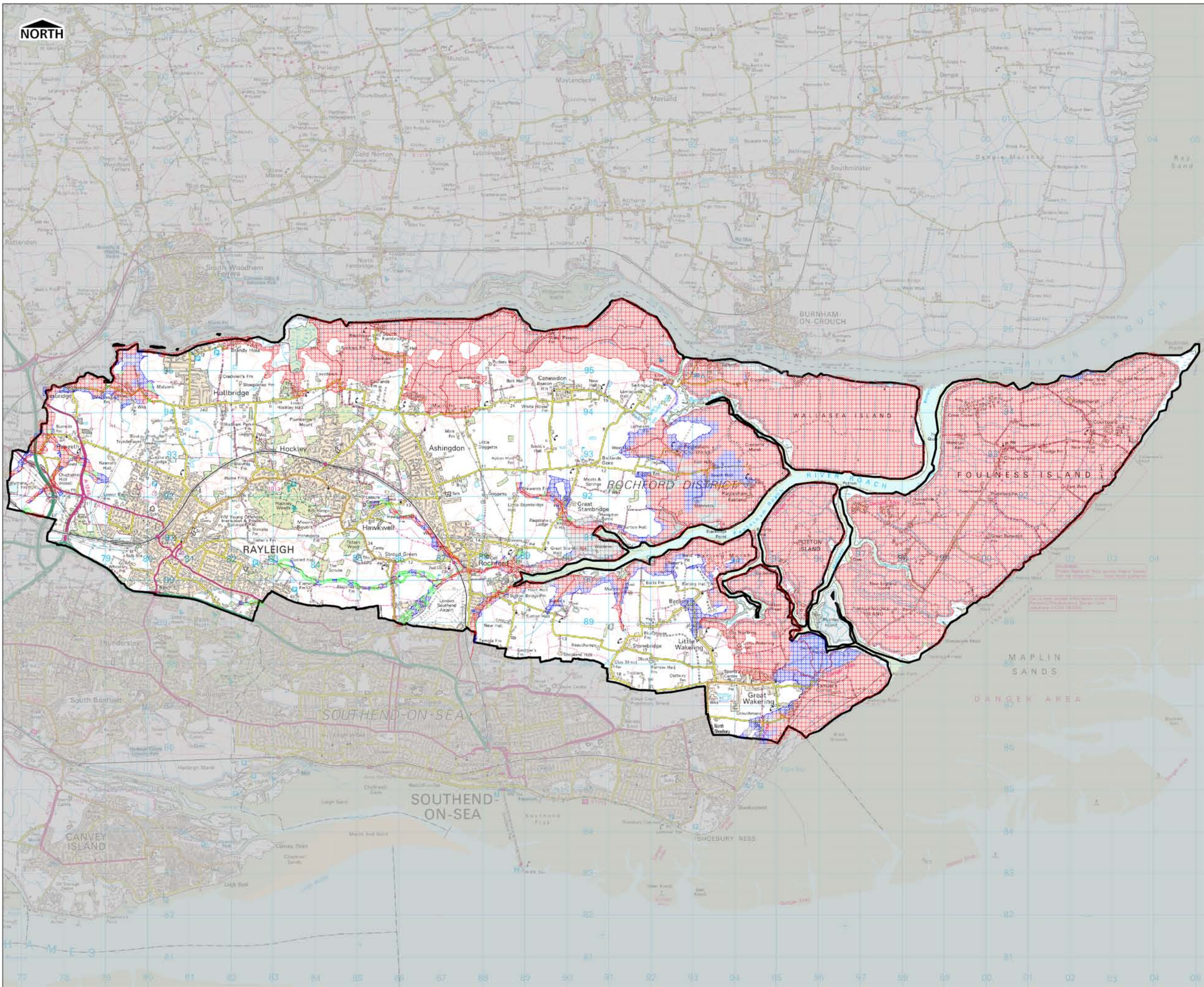
THAMES GATEWAY SOUTH ESSEX
 STRATEGIC FLOOD RISK ASSESSMENT

FLOOD DEFENCE DESIGN STANDARD
 [NFCCD]



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FIGURE A-12



KEY

- Rochford District Boundary

- National Flood Risk Assessment (NaFRA) Probability Bandings**

- Low (1 in 200 chance or less, in any given year)
- Moderate (1 in 75 - 1 in 200 chance, in any given year)
- Significant (> 1 in 75 chance in any given year)
- No Result

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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

NATIONAL FLOOD RISK ASSESSMENT [NaFRA]



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FIGURE A-13

Appendix B: Depth Mapping

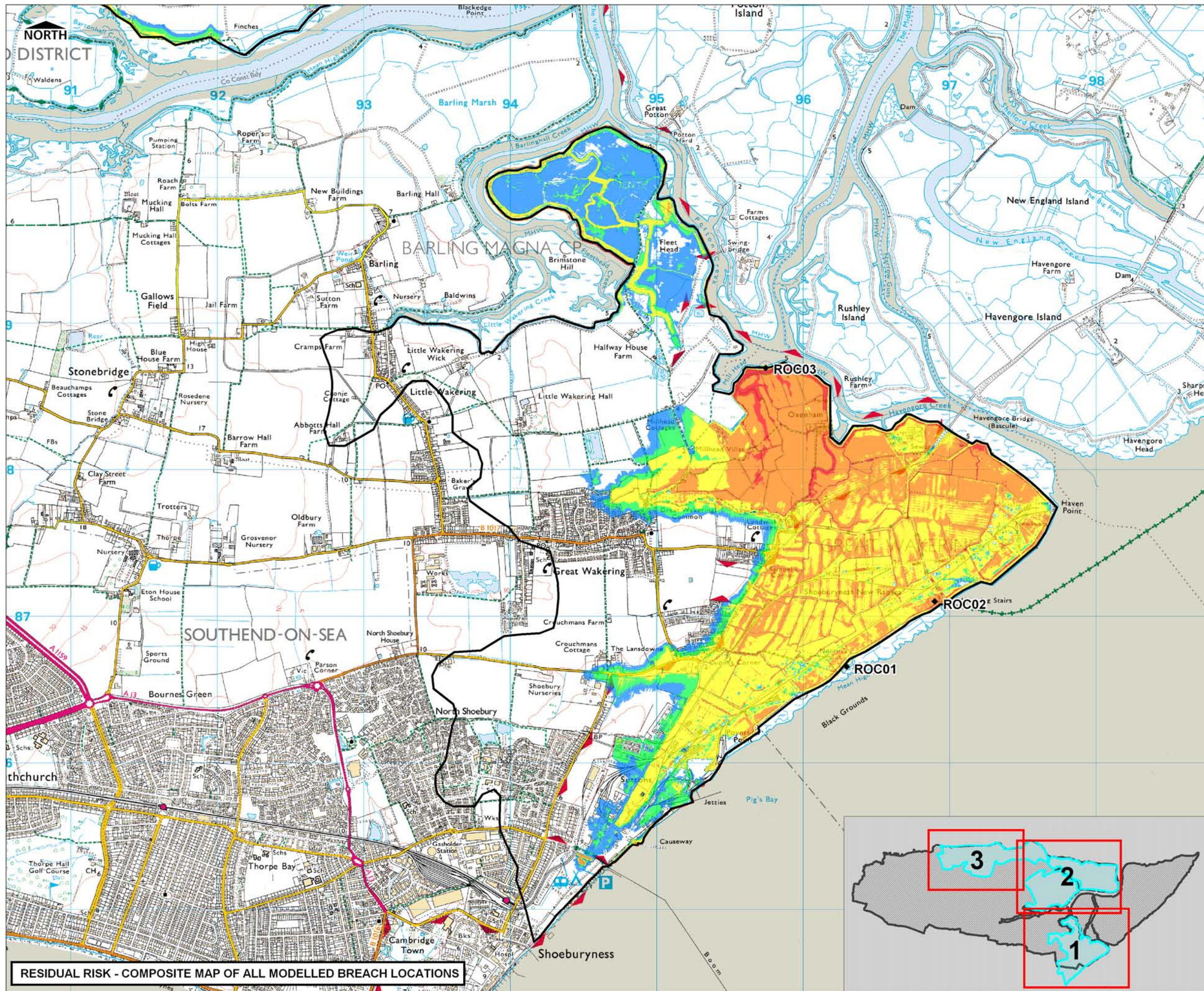
Residual Risk – Composite of Breach Results and Overtopping

(Composite Results for all breaches; ROC01, ROC02, ROC03, ROC04, ROC05, ROC06, ROC07)

- B1 (View 1-3)** Maximum Flood Depth from Breaches & Overtopping (1 in 0200yr event, 2010)
- B2 (View 1-3)** Maximum Flood Depth from Breaches & Overtopping (1 in 1000yr event, 2010)
- B3 (View 1-3)** Maximum Flood Depth from Breaches & Overtopping (1 in 0200yr event, 2110 incl. CC)
- B4 (View 1-3)** Maximum Flood Depth from Breaches & Overtopping (1 in 1000yr event, 2110 incl. CC)

Potential Impact of Overtopping of Defences

- B5 (View 1-3)** Maximum Flood Depth from Overtopping (1 in 0200yr event, 2110 incl. CC)
- B6 (View 1-3)** Maximum Flood Depth from Overtopping (1 in 1000yr event, 2110 incl. CC)



KEY

— Flood Cells ◆ Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

TECHNICAL NOTE

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It should be noted that the breach width and depth, though based on EA guidance, are arbitrary and do not necessarily represent the actual dimensions of a potential breach at a given location. A thorough description of methodology and assumptions is included within the SFRA Main Report.

USER NOTE

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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE MAXIMUM FLOOD DEPTH 0200YR (2010)

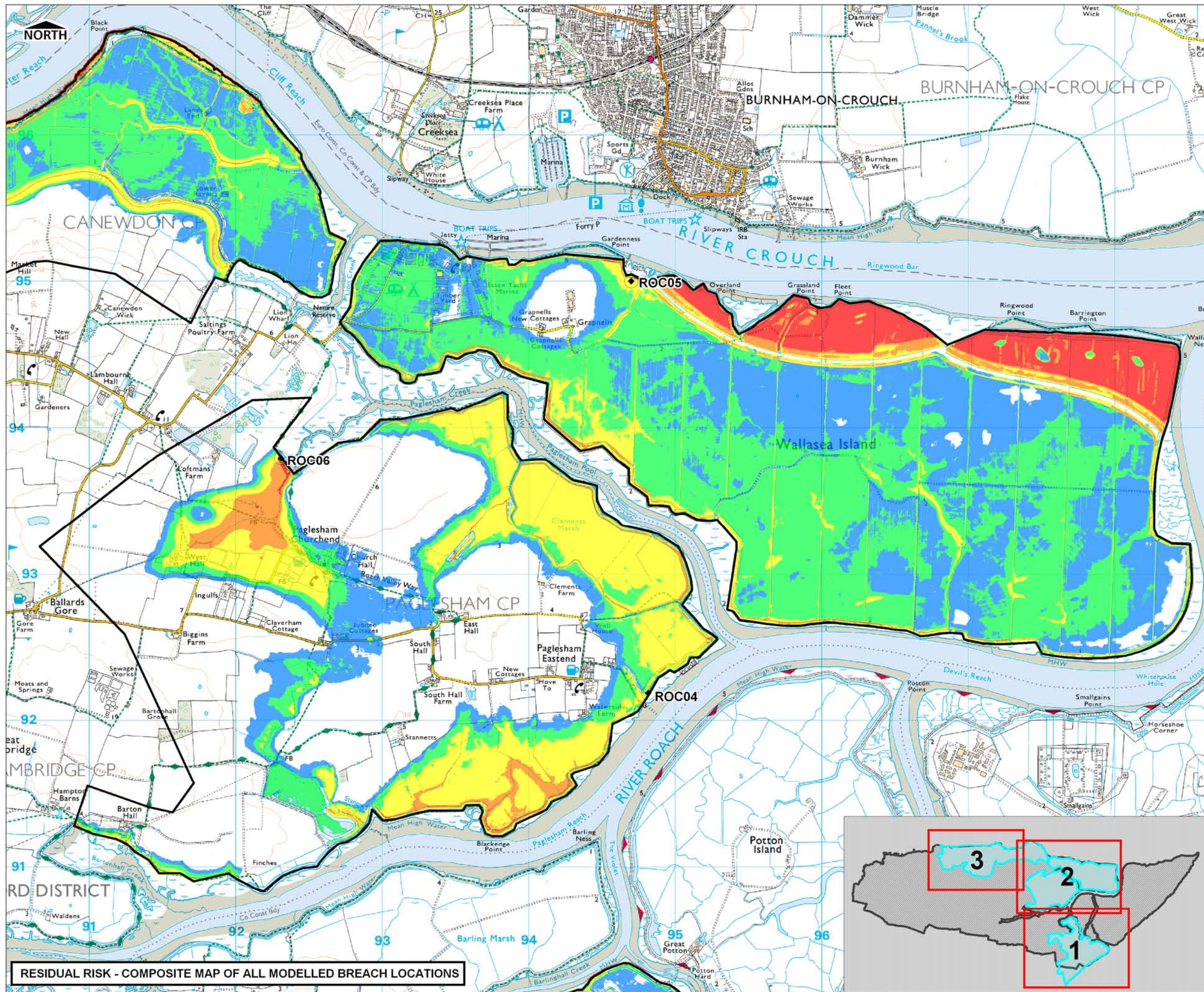
ALL BREACHES (ROC01-ROC07) & OVERTOPPING



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FIGURE B-1 (View 1)



KEY

— Flood Cells ◆ Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

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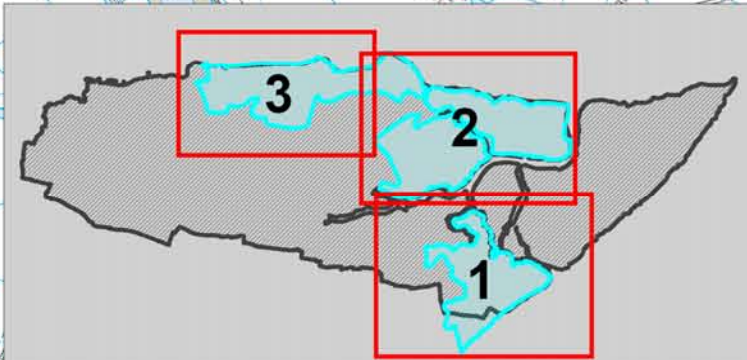
COMPOSITE MAXIMUM FLOOD DEPTH 0200YR (2010)

ALL BREACHES (ROC01-ROC07) & OVERTOPPING

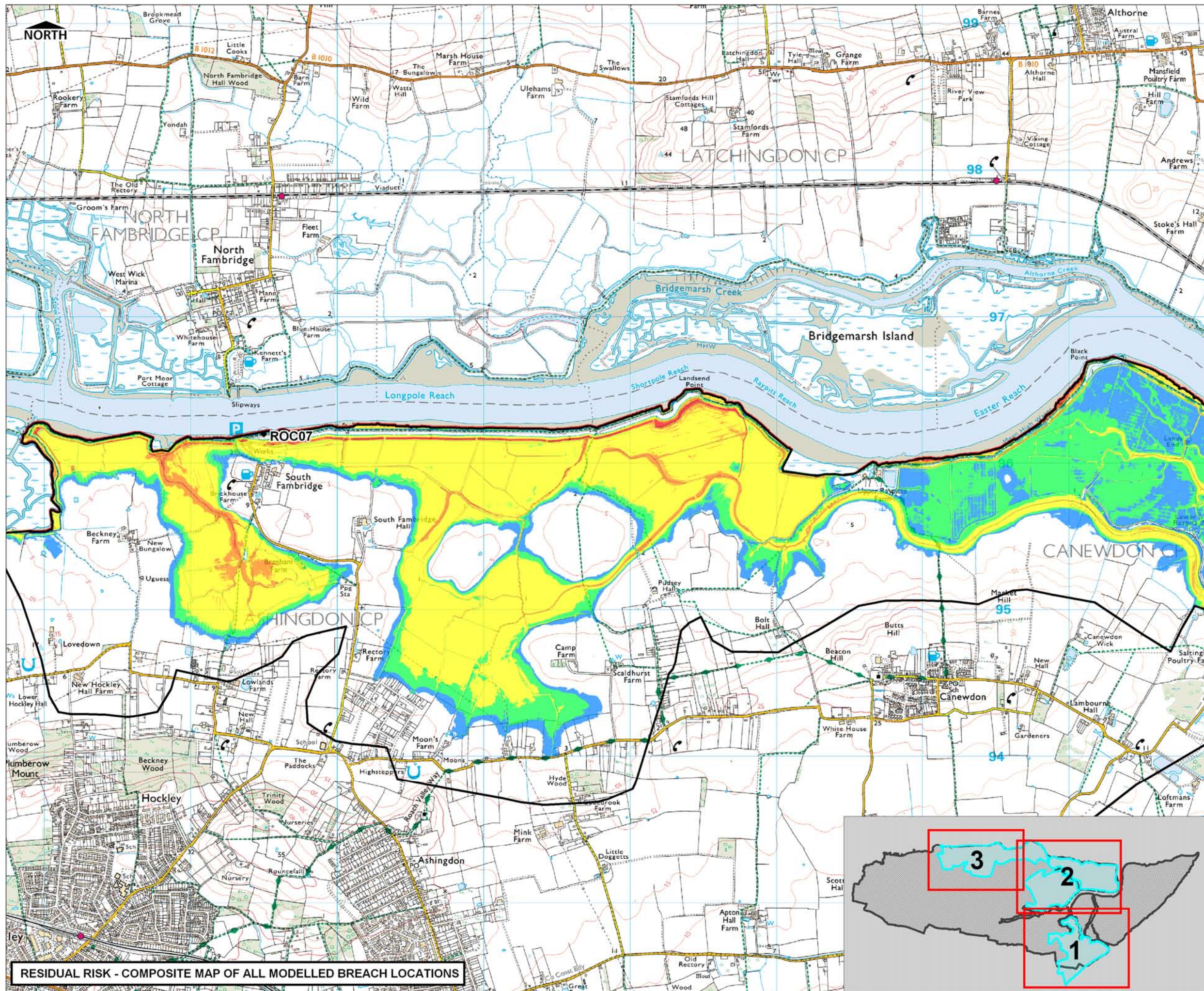


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FIGURE B-1 (View 2)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS



KEY

— Flood Cells ◆ Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

TECHNICAL NOTE

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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**COMPOSITE MAXIMUM FLOOD DEPTH
0200YR (2010)**

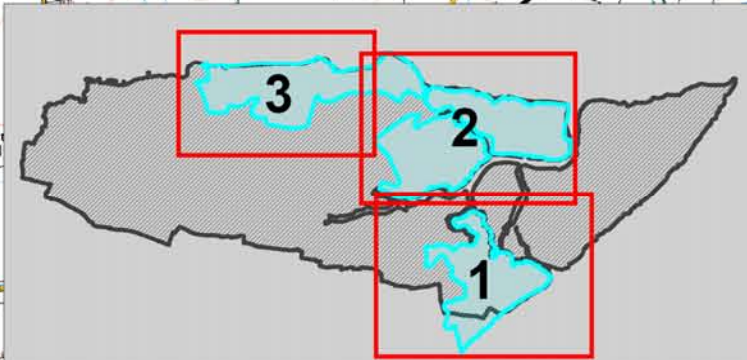
ALL BREACHES (ROC01-ROC07) & OVERTOPPING

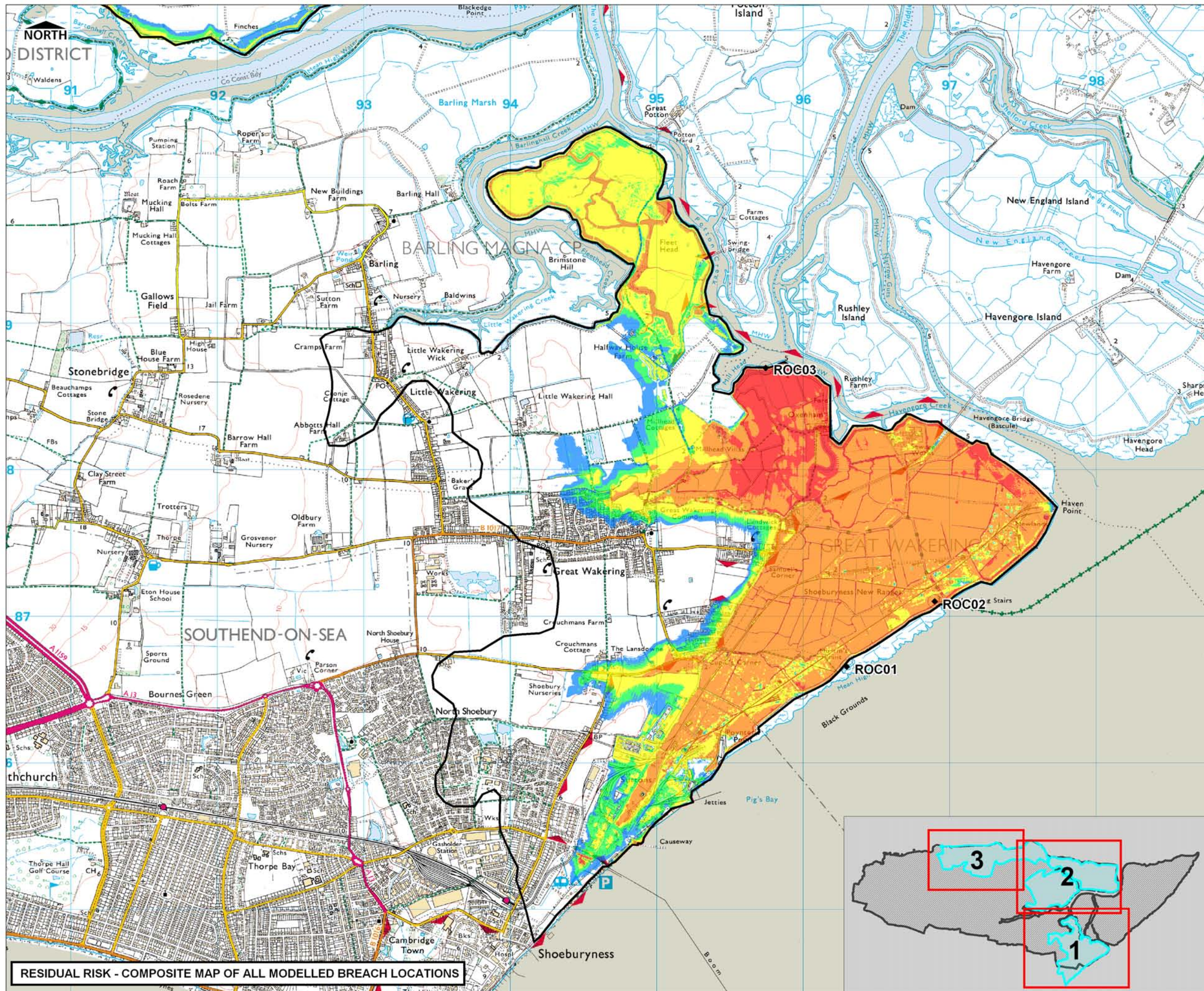
Basildon Council castlepoint Rochford District Council

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DRAWING NUMBER
FIGURE B-1 (View 3)

RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS





KEY

— Flood Cells ◆ Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

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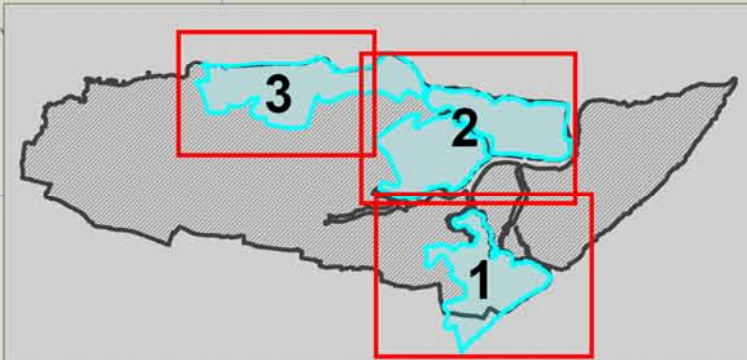
COMPOSITE MAXIMUM FLOOD DEPTH 1000YR (2010)

ALL BREACHES (ROC01-ROC07) & OVERTOPPING

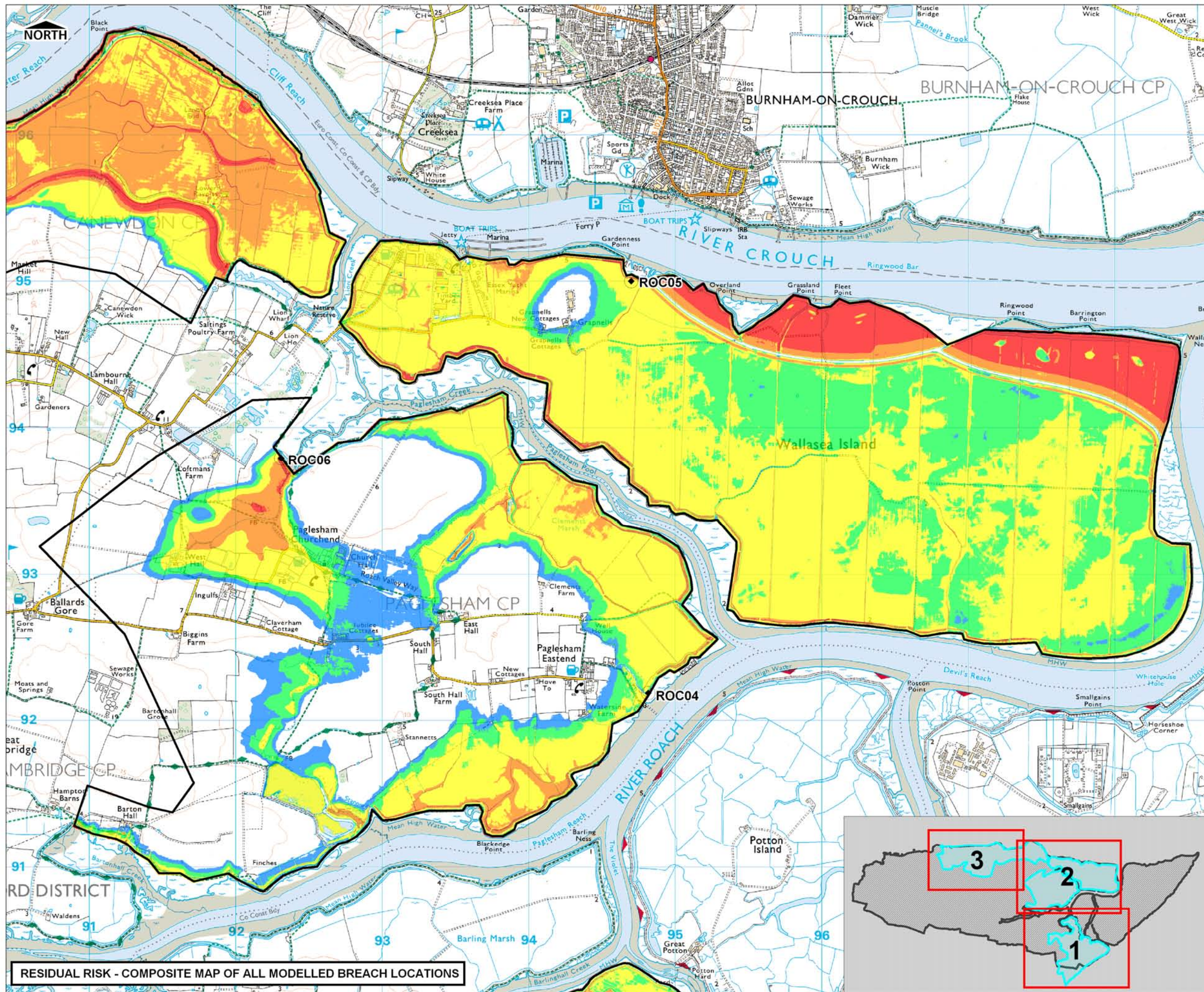


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FIGURE B-2 (View 1)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS



KEY

— Flood Cells ◆ Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

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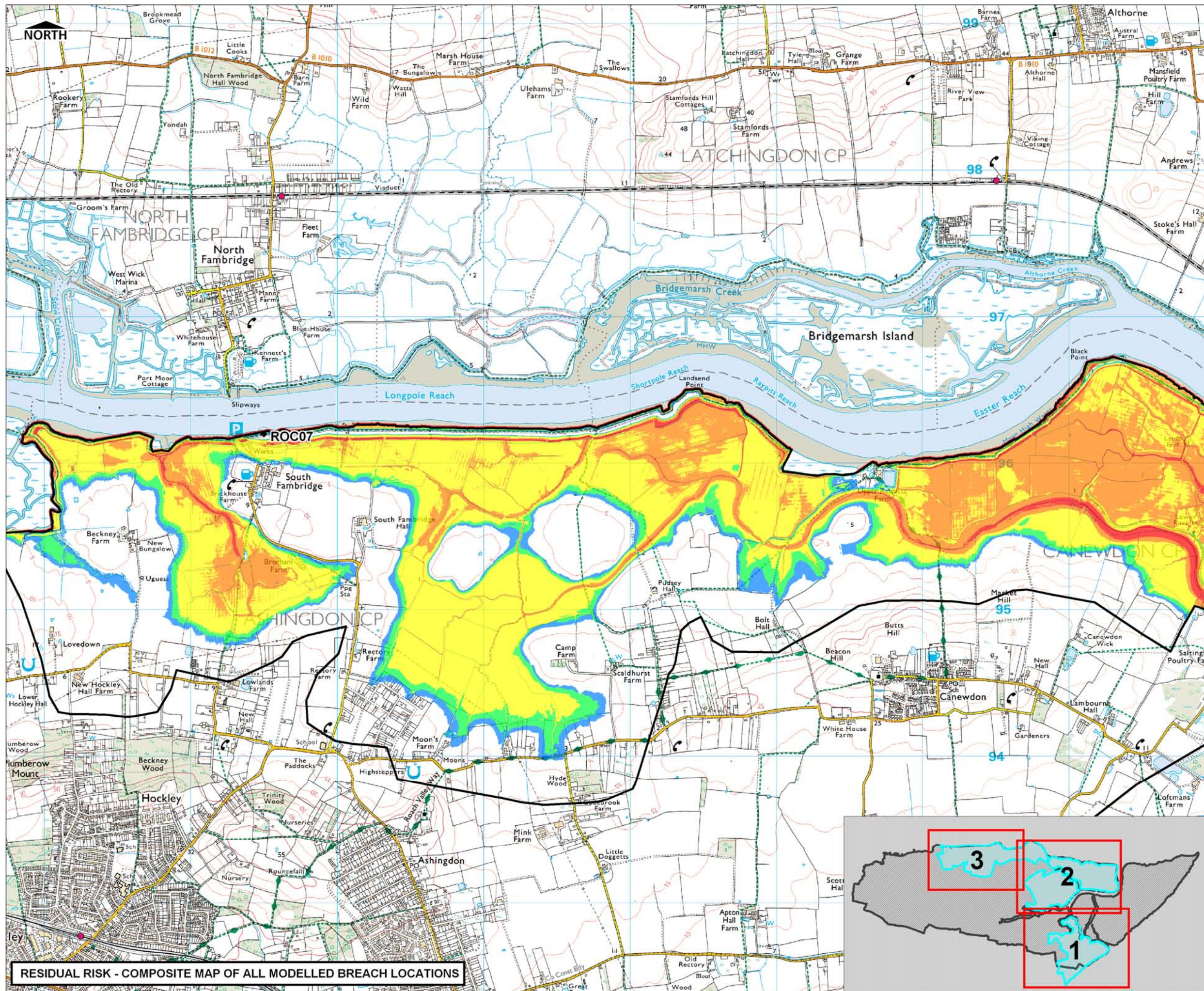
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE MAXIMUM FLOOD DEPTH 1000YR (2010)
ALL BREACHES (ROC01-ROC07) & OVERTOPPING



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FIGURE B-2 (View 2)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS

KEY

- Flood Cells
- Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

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COMPOSITE MAXIMUM FLOOD DEPTH 1000YR (2010)

ALL BREACHES (ROC01-ROC07) & OVERTOPPING

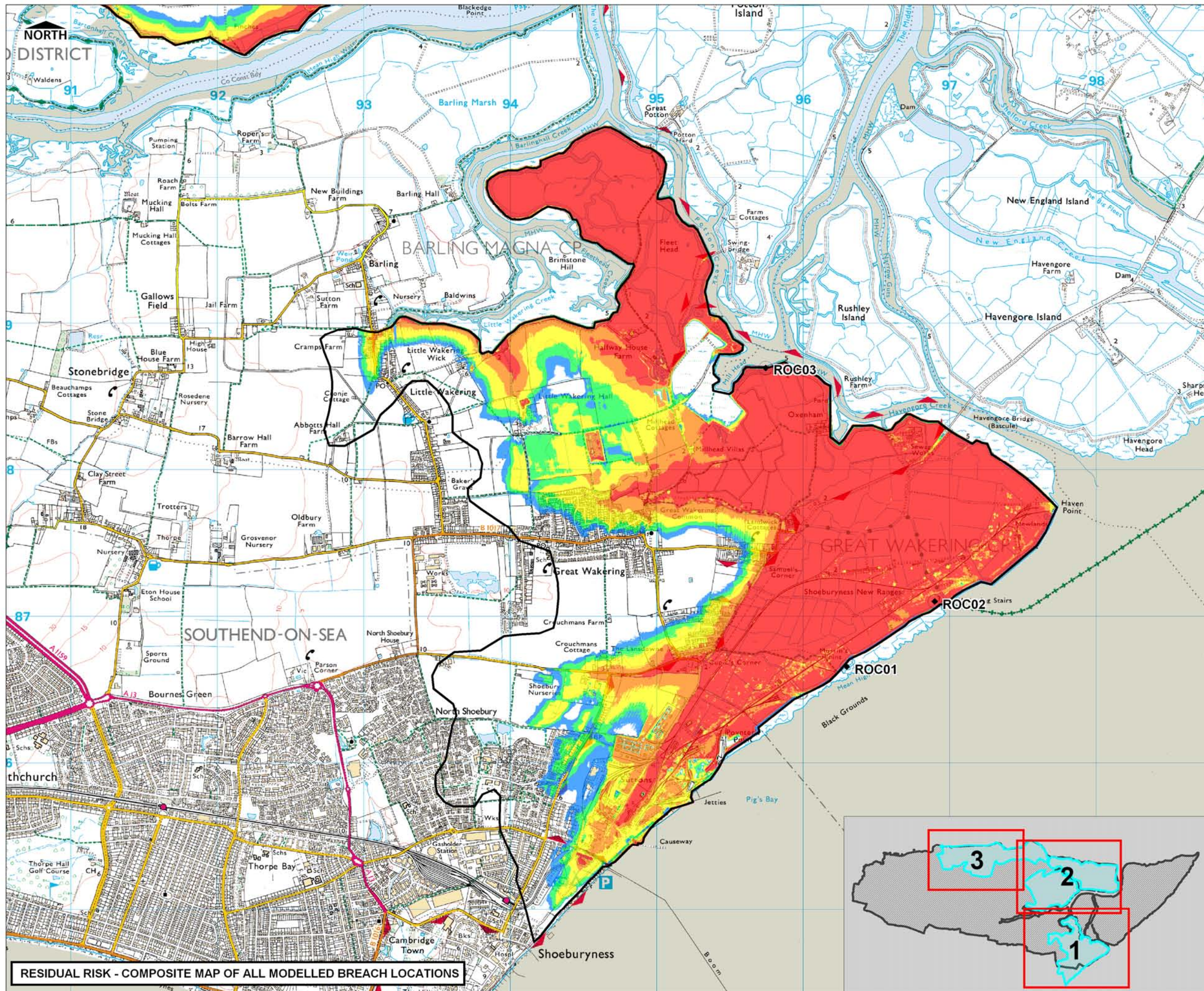


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FIGURE B-2 (View 3)



KEY

— Flood Cells ◆ Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

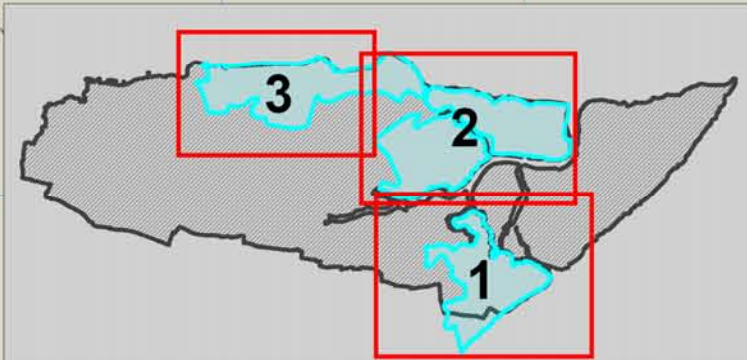
COMPOSITE MAXIMUM FLOOD DEPTH 0200YR (2110)

ALL BREACHES (ROC01-ROC07) & OVERTOPPING

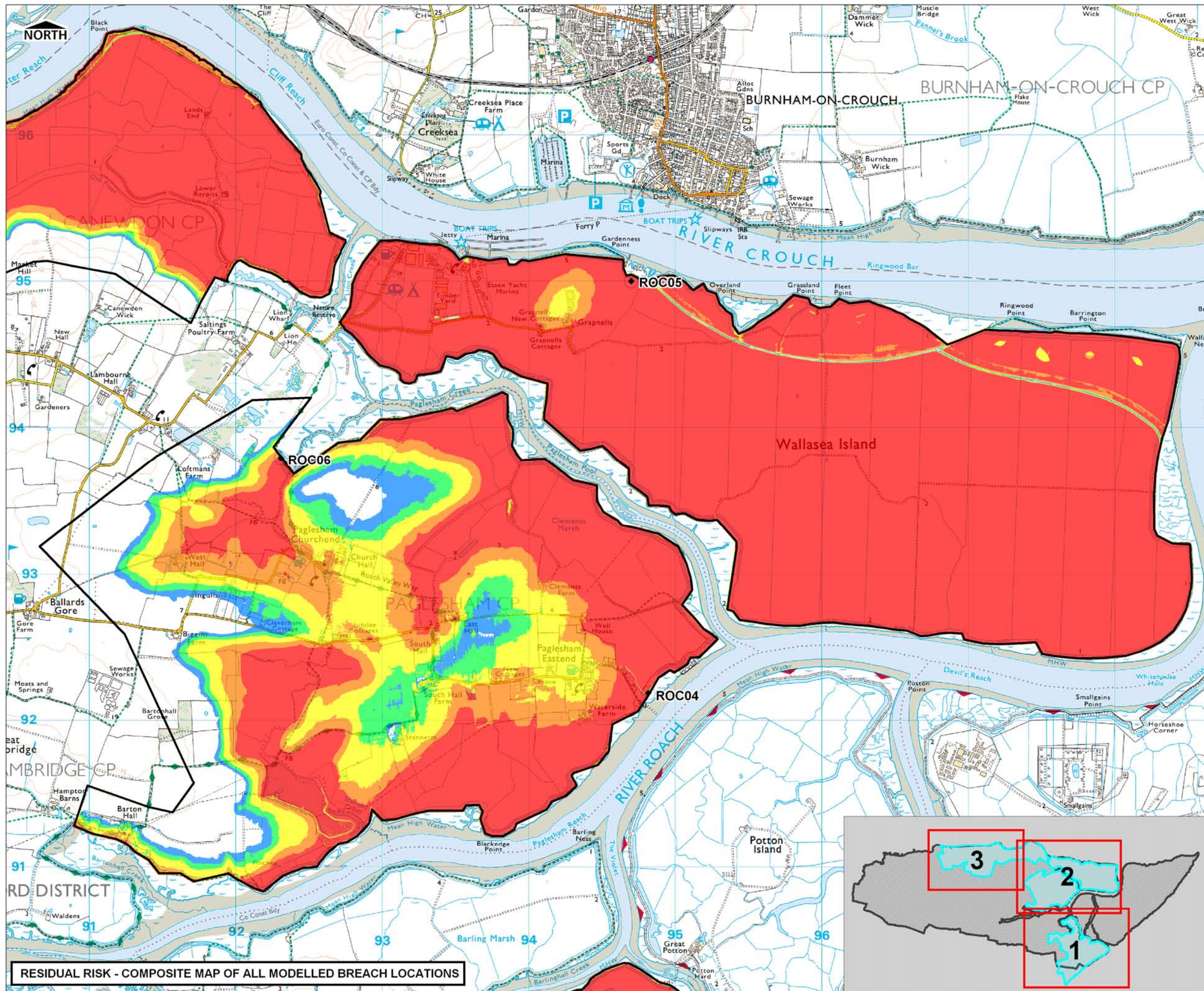


Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
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DRAWING NUMBER
FIGURE B-3 (View 1)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS



KEY

— Flood Cells ◆ Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

TECHNICAL NOTE

Hydraulic modelling has been undertaken using 2-D hydraulic modelling software MIKE21-HDFM (ver. 2009), to assess the effect of breaches at specified points and/or overtopping of defences. The model simulates 3 tidal cycles with the peak level occurring on the second peak and two slightly smaller peaks either side. Breaches in the defence walls are modelled to occur immediately before the peak tidal level to assess the potential impact of rapid inundation of floodwater.

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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

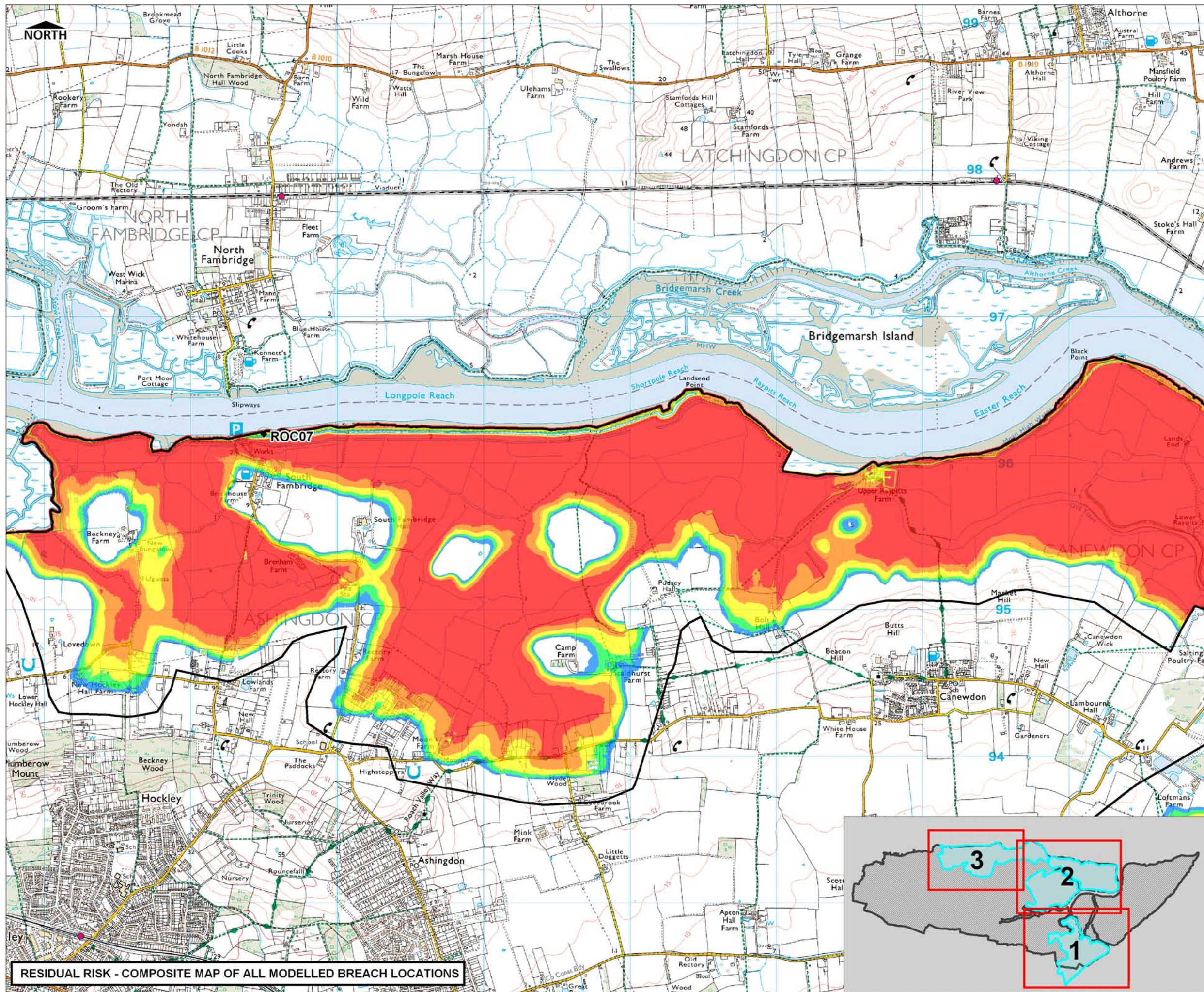
**COMPOSITE MAXIMUM FLOOD DEPTH
0200YR (2110)**

ALL BREACHES (ROC01-ROC07) & OVERTOPPING

Basildon Council castlepoint Rochford District Council

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE B-3 (View 2)



KEY

— Flood Cells ◆ Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

TECHNICAL NOTE

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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

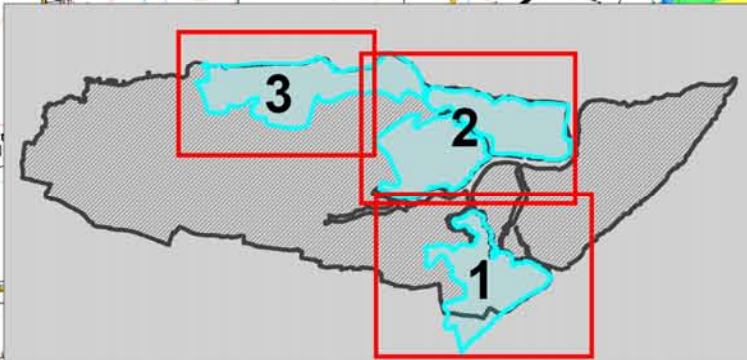
**COMPOSITE MAXIMUM FLOOD DEPTH
0200YR (2110)**

ALL BREACHES (ROC01-ROC07) & OVERTOPPING

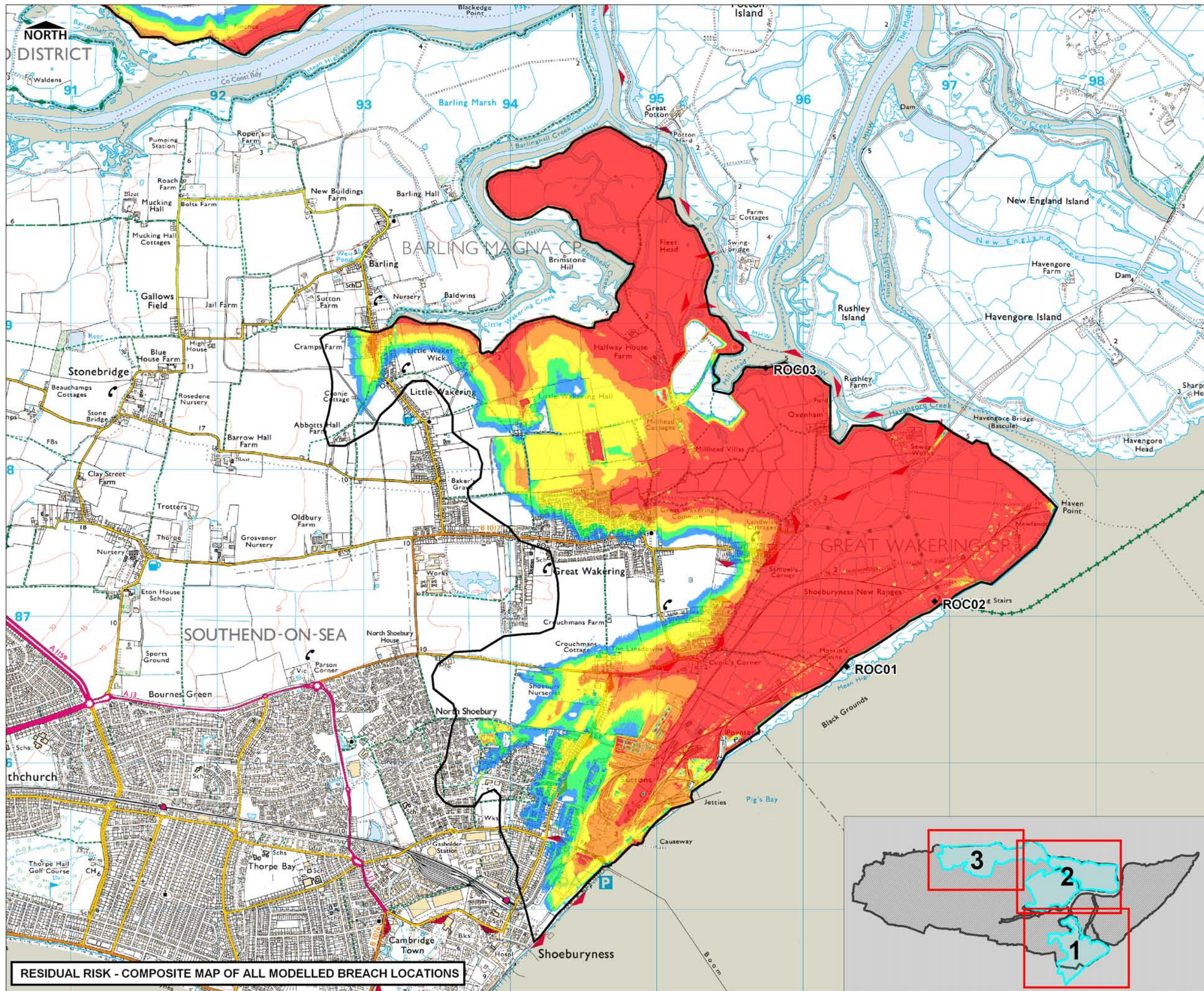
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Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE B-3 (View 3)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS



KEY

— Flood Cells ◆ Breach Location

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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

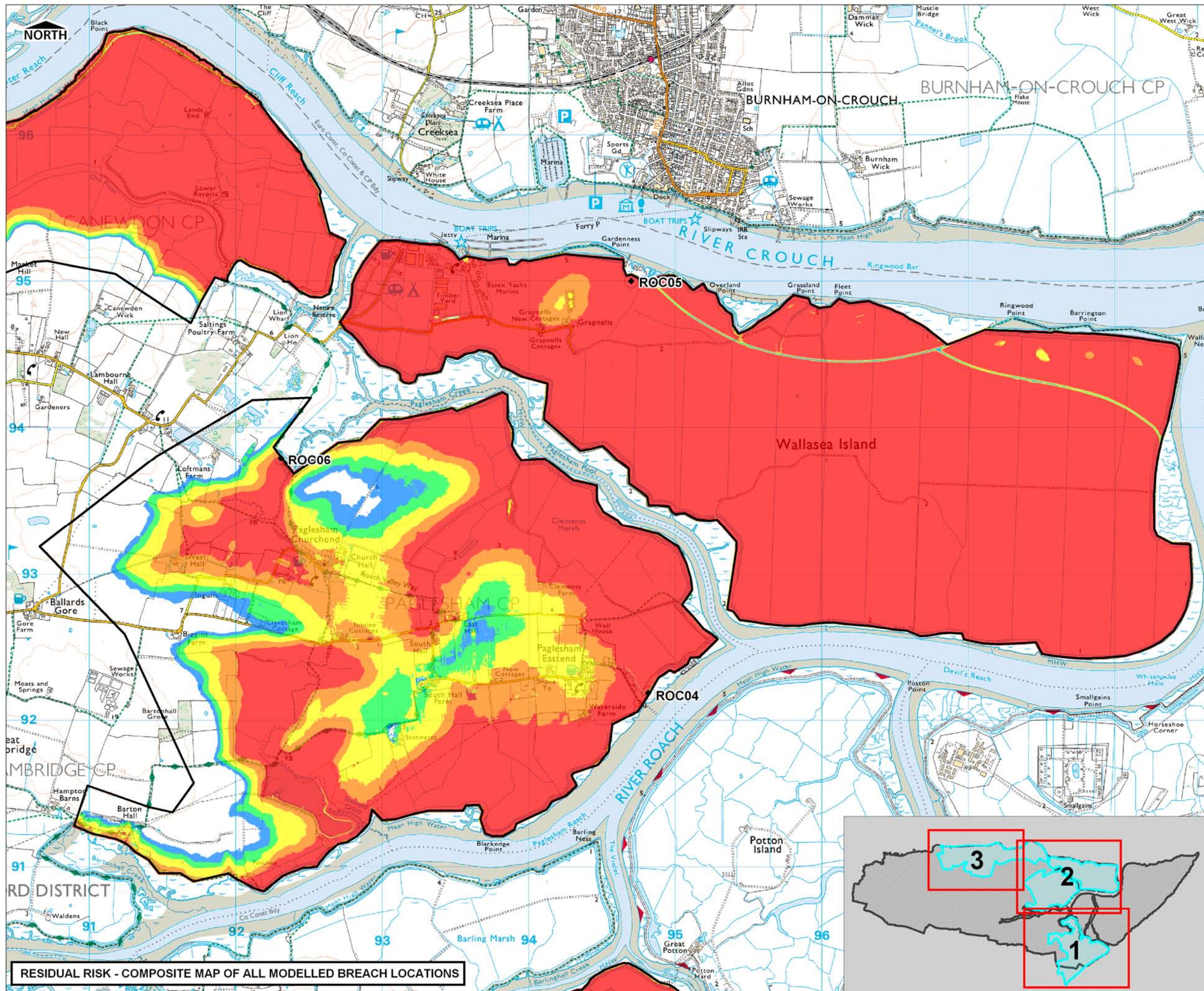
COMPOSITE MAXIMUM FLOOD DEPTH 1000YR (2110)

ALL BREACHES (ROC01-ROC07) & OVERTOPPING



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE B-4 (View 1)



KEY

— Flood Cells ◆ Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

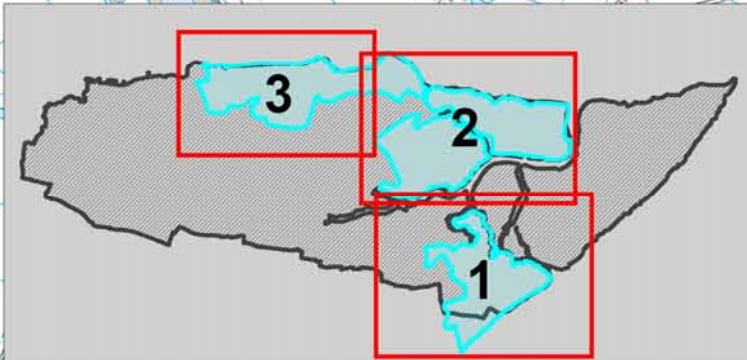
COMPOSITE MAXIMUM FLOOD DEPTH 1000YR (2110)

ALL BREACHES (ROC01-ROC07) & OVERTOPPING

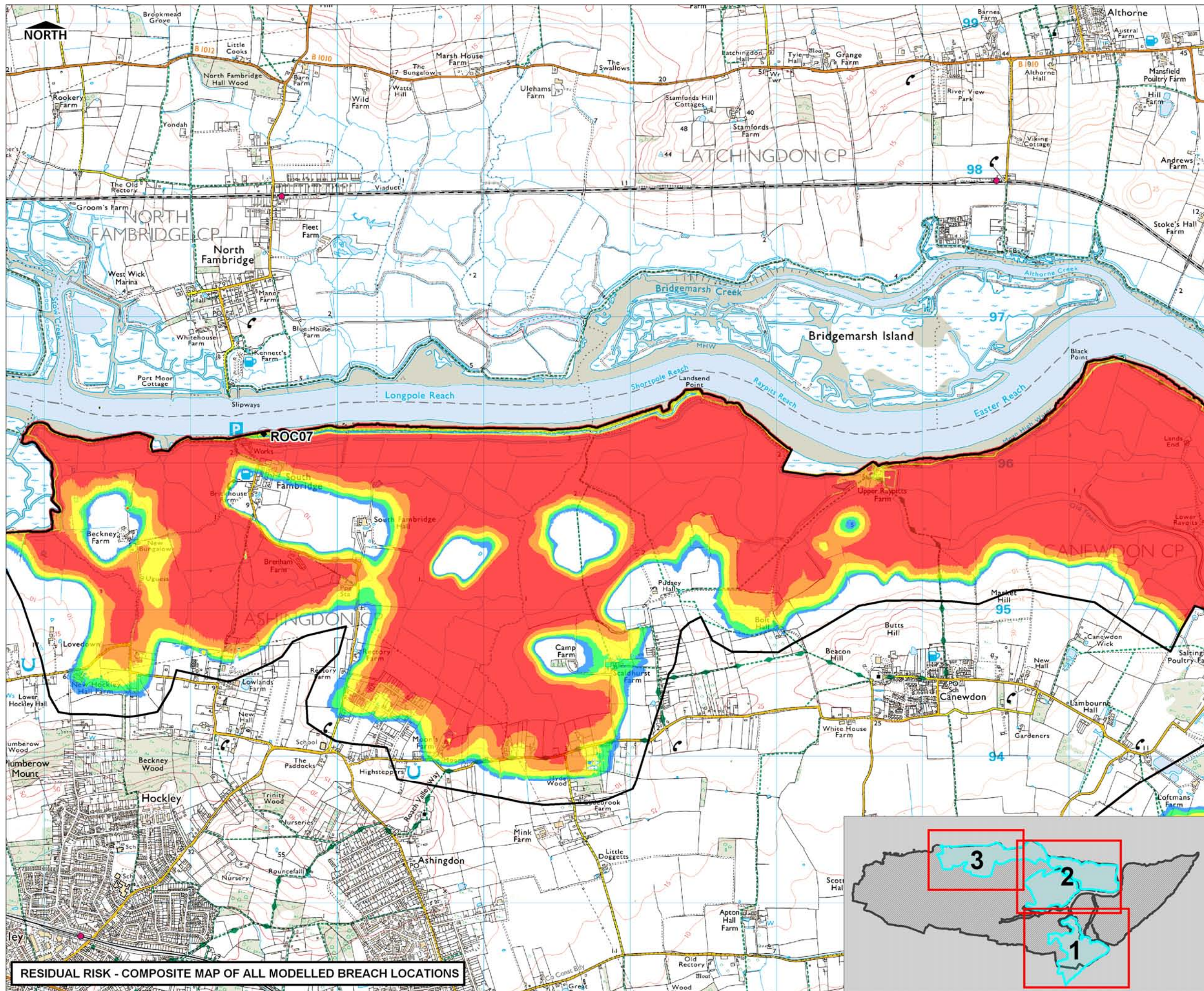


Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE B-4 (View 2)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS



KEY

— Flood Cells ◆ Breach Location

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

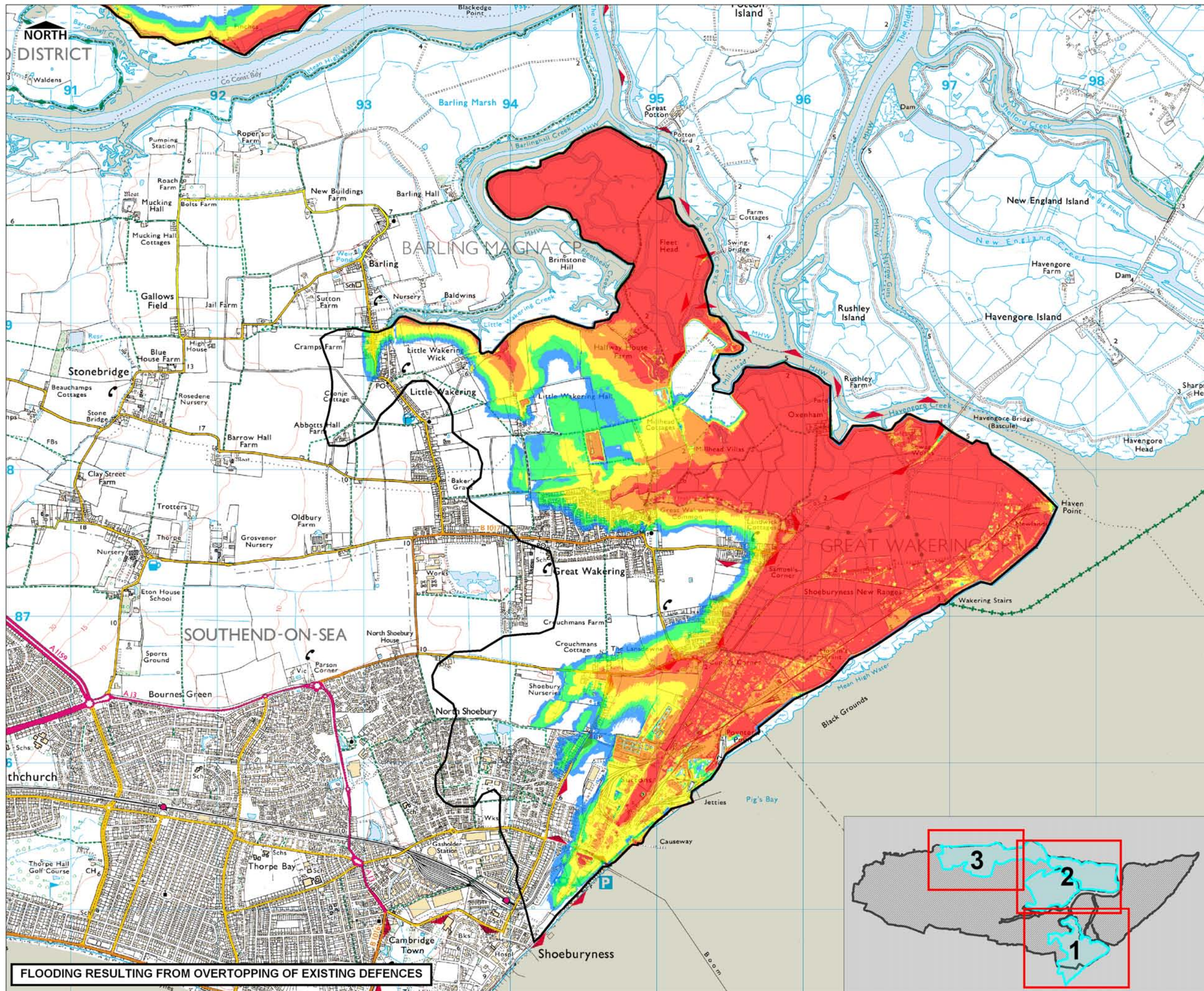
**COMPOSITE MAXIMUM FLOOD DEPTH
1000YR (2110)**

ALL BREACHES (ROC01-ROC07) & OVERTOPPING

Basildon Council castlepoint Rochford District Council

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE B-4 (View 3)



KEY

- Flood Cells
- Maximum Flood Depth [m]**
- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

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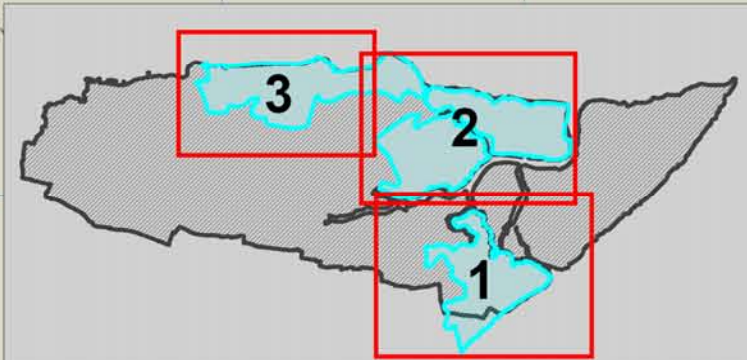
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**THAMES GATEWAY SOUTH ESSEX
 STRATEGIC FLOOD RISK ASSESSMENT**
**COMPOSITE MAXIMUM FLOOD DEPTH
 0200YR (2110)
 OVERTOPPING**

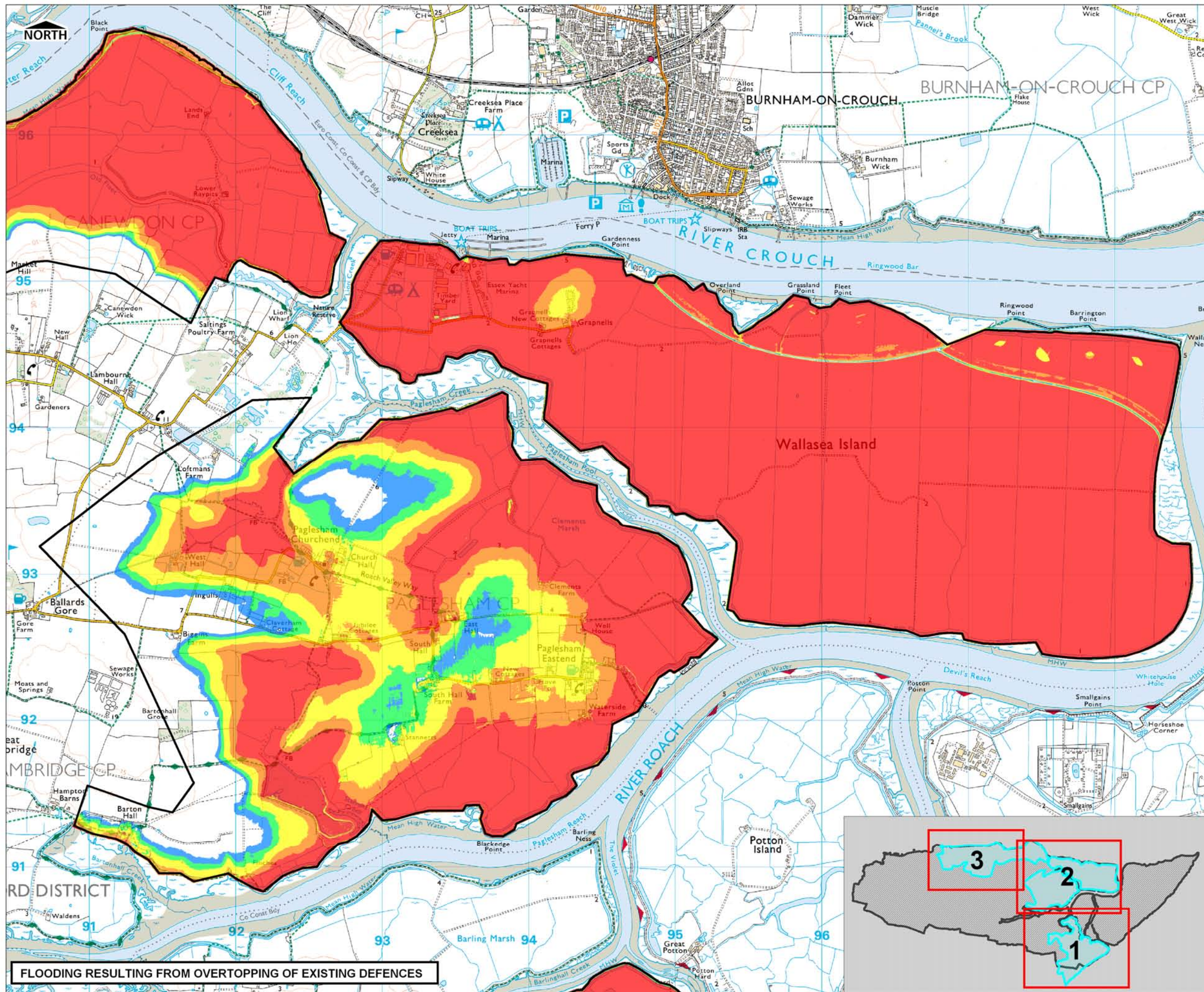
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 6-8 Greencoat Place
 London, SW1P 1PL
 Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE B-5 (View 1)



FLOODING RESULTING FROM OVERTOPPING OF EXISTING DEFENCES



KEY

— Flood Cells

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
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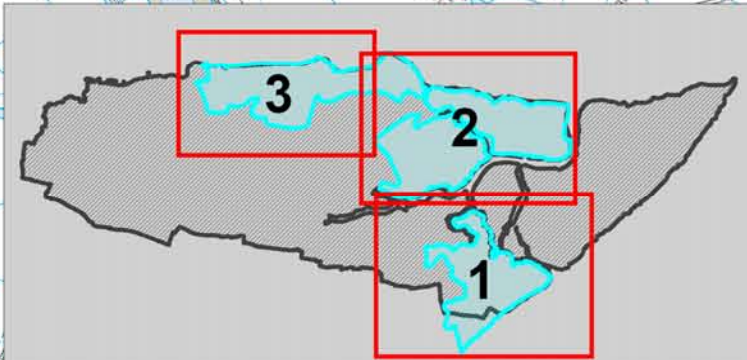
**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**COMPOSITE MAXIMUM FLOOD DEPTH
0200YR (2110)
OVERTOPPING**

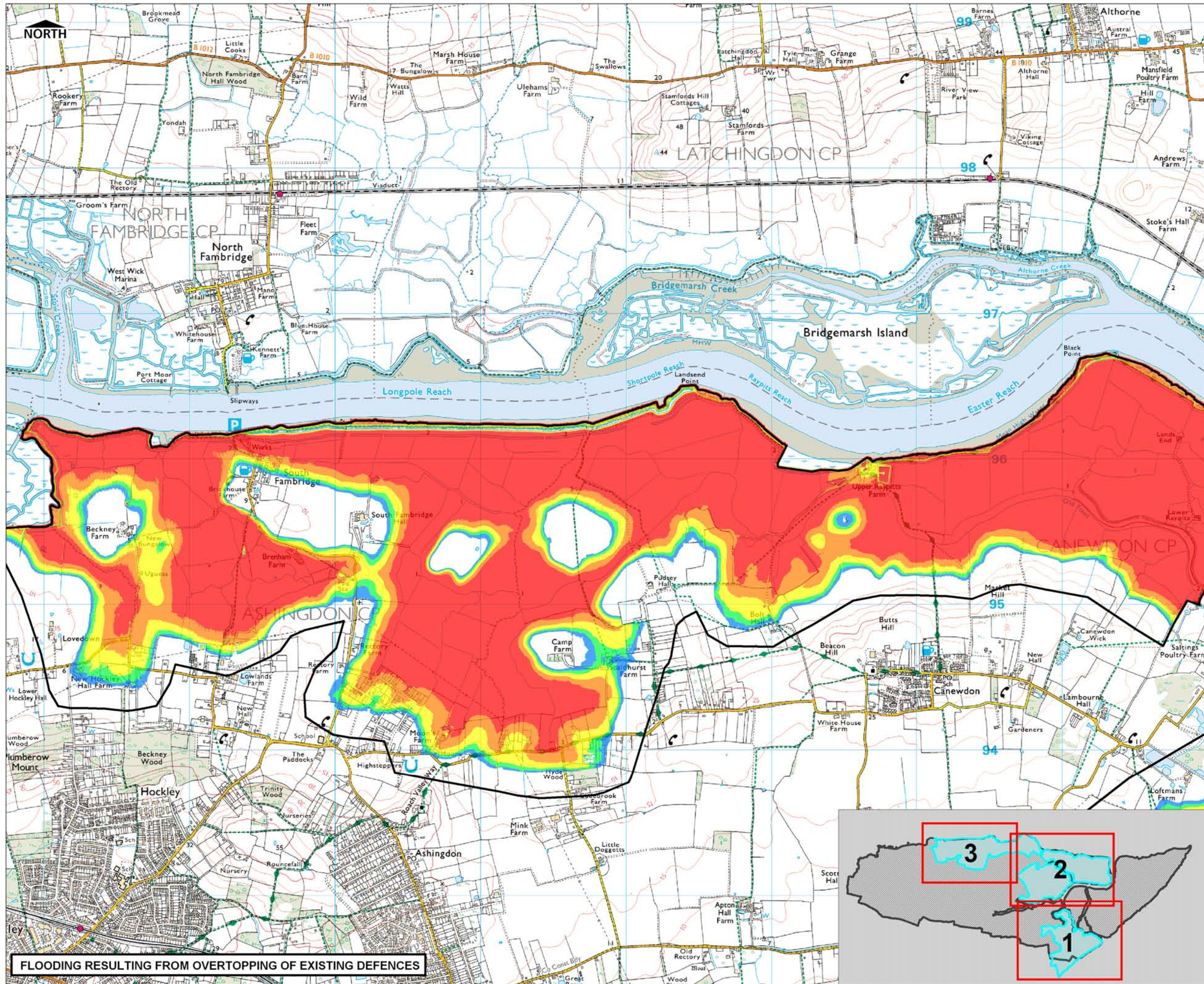


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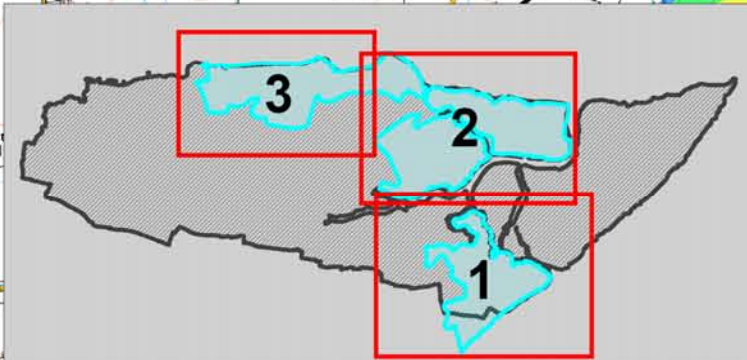
DRAWING NUMBER
FIGURE B-5 (View 2)



FLOODING RESULTING FROM OVERTOPPING OF EXISTING DEFENCES



FLOODING RESULTING FROM OVERTOPPING OF EXISTING DEFENCES



KEY

- Flood Cells
- Maximum Flood Depth [m]**
- 0.0m to 0.5m
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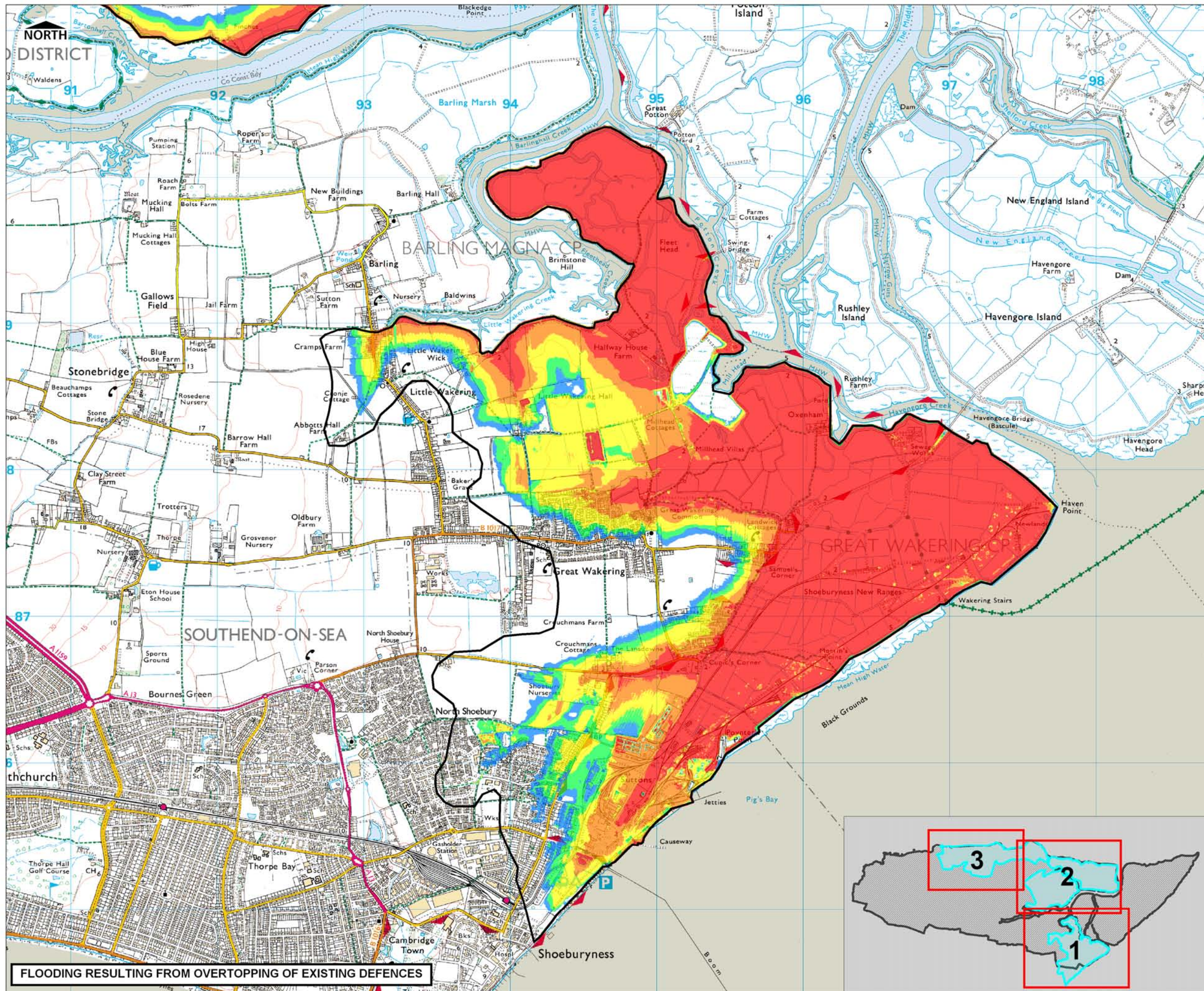
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**THAMES GATEWAY SOUTH ESSEX
 STRATEGIC FLOOD RISK ASSESSMENT**
**COMPOSITE MAXIMUM FLOOD DEPTH
 0200YR (2110)
 OVERTOPPING**

Basildon Council castlepoint Rochford District Council

Scott Wilson
 6-8 Greencoat Place
 London, SW1P 1PL
 Tel: (020) 7798 5000

FIGURE B-5 (View 3)



KEY

— Flood Cells

Maximum Flood Depth [m]

- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

TECHNICAL NOTE

Hydraulic modelling has been undertaken using 2-D hydraulic modelling software MIKE21-HDFM (ver. 2009), to assess the effect of overtopping of defences. The model simulates 3 tidal cycles with the peak level occurring on the second peak and two slightly smaller peaks either side.

The mapped scenario shows the actual risk of flooding; that resulting solely from overtopping of existing defences.

The maximum flood depth is calculated by subtracting the LIDAR topographic data from the peak water level achieved at each element in the model throughout the simulation.

A thorough description of methodology and assumptions is included within the SFRA Main Report.

USER NOTE

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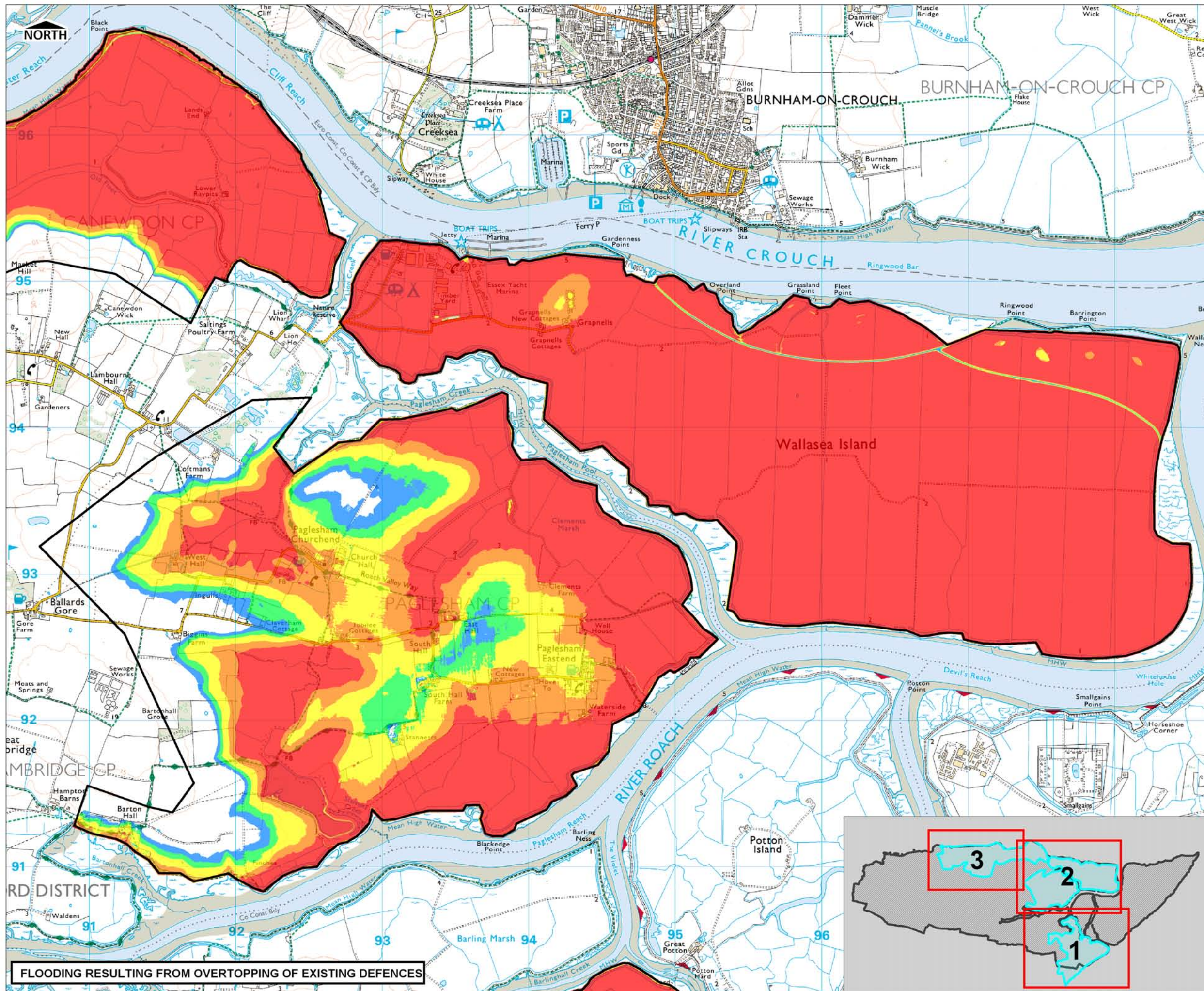
**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**COMPOSITE MAXIMUM FLOOD DEPTH
1000YR (2110)
OVERTOPPING**



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE B-6 (View 1)



KEY

- Flood Cells
- Maximum Flood Depth [m]**
- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

TECHNICAL NOTE
 Hydraulic modelling has been undertaken using 2-D hydraulic modelling software MIKE21-HDFM (ver. 2009), to assess the effect of overtopping of defences. The model simulates 3 tidal cycles with the peak level occurring on the second peak and two slightly smaller peaks either side.

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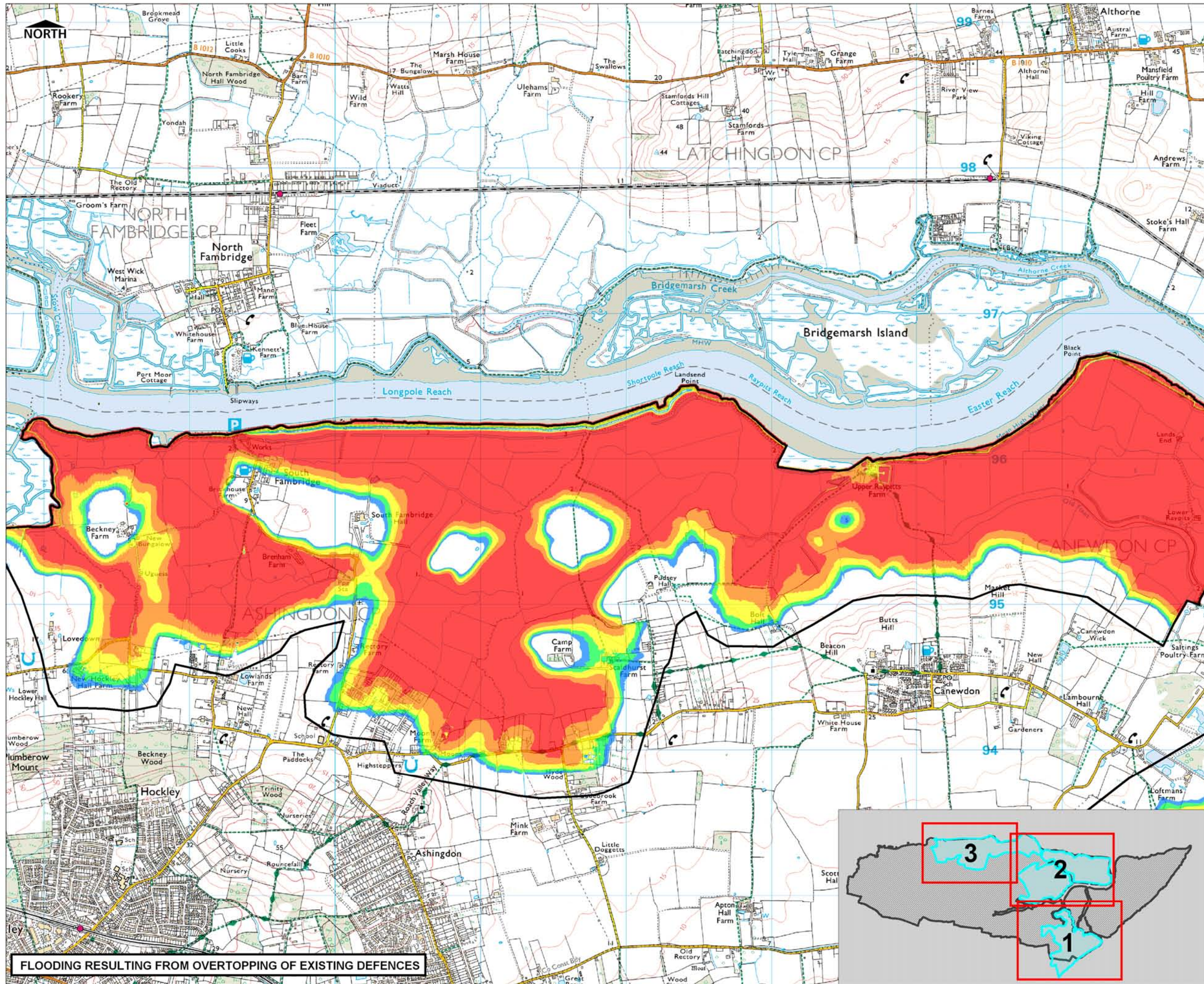
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE MAXIMUM FLOOD DEPTH 1000YR (2110) OVERTOPPING



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FIGURE B-6 (View 2)



FLOODING RESULTING FROM OVERTOPPING OF EXISTING DEFENCES

KEY

- Flood Cells
- Maximum Flood Depth [m]**
- 0.0m to 0.5m
- 0.5m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m and greater

TECHNICAL NOTE
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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE MAXIMUM FLOOD DEPTH 1000YR (2110) OVERTOPPING



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 6-8 Greencoat Place
 London, SW1P 1PL
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FIGURE B-6 (View 3)

Appendix C: Hazard Mapping

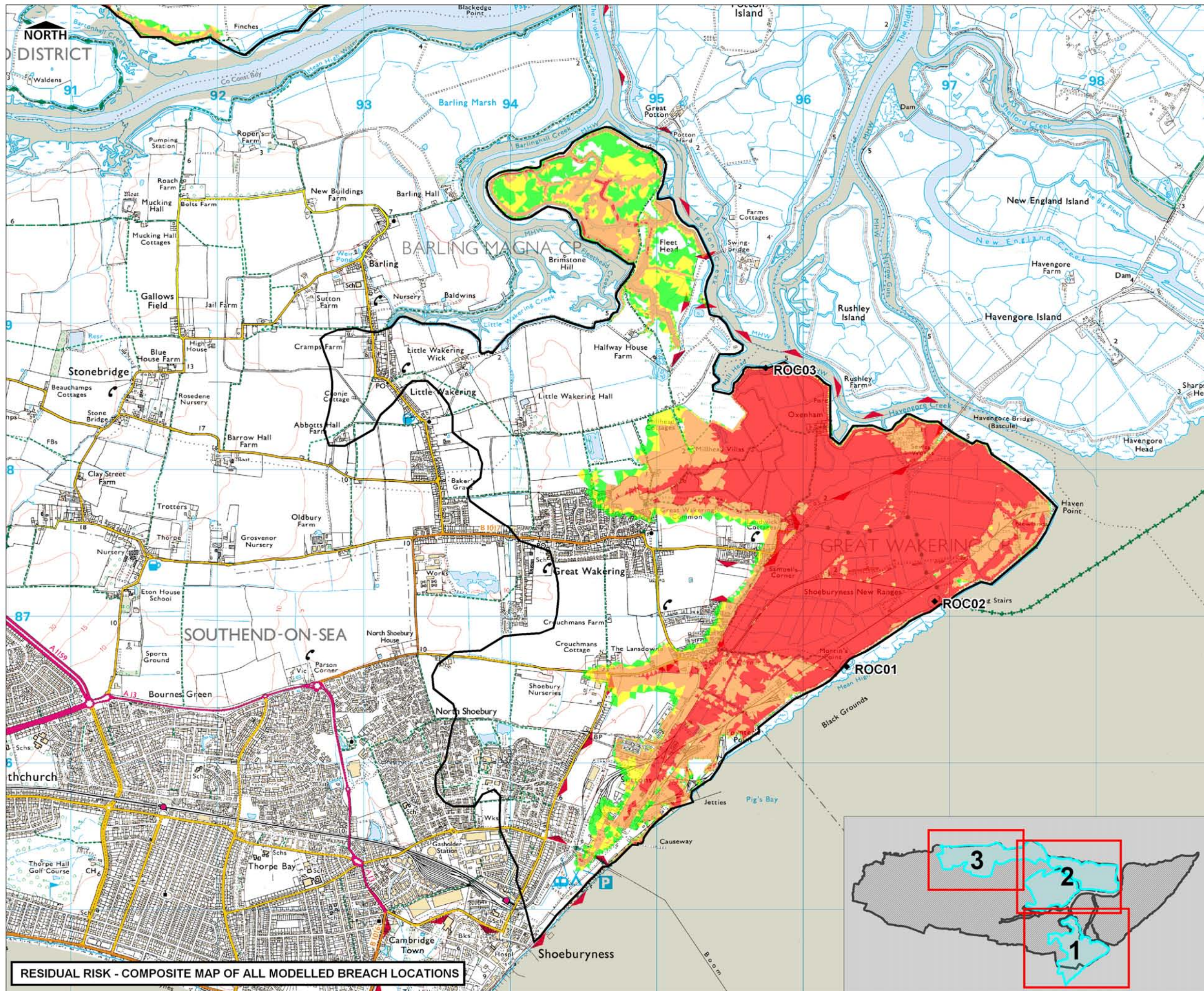
Residual Risk – Composite of Breach Results and Overtopping

(Composite Results for all breaches; ROC01, ROC02, ROC03, ROC04, ROC05, ROC06, ROC07)

- C1 (View 1-3)** Maximum Flood Hazard from Breaches & Overtopping (1 in 0200yr event, 2010)
- C2 (View 1-3)** Maximum Flood Hazard from Breaches & Overtopping (1 in 1000yr event, 2010)
- C3 (View 1-3)** Maximum Flood Hazard from Breaches & Overtopping (1 in 0200yr event, 2110 incl. CC)
- C4 (View 1-3)** Maximum Flood Hazard from Breaches & Overtopping (1 in 1000yr event, 2110 incl. CC)

Potential Impact of Overtopping

- C5 (View 1-3)** Maximum Flood Hazard from Overtopping (1 in 0200yr event, 2110 incl. CC)
- C6 (View 1-3)** Maximum Flood Hazard from Overtopping (1 in 1000yr event, 2110 incl. CC)



KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

Hydraulic modelling has been undertaken using 2-D hydraulic modelling software MIKE21-HDFM (ver. 2009), to assess the effect of breaches at specified points and/or overtopping of defences. The model simulates 3 tidal cycles with the peak level occurring on the second peak and two slightly smaller peaks either side. Breaches in the defence walls are modelled to occur immediately before the peak tidal level to assess the potential impact of rapid inundation of floodwater.

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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE FLOOD HAZARD RATING 0200YR (2010)

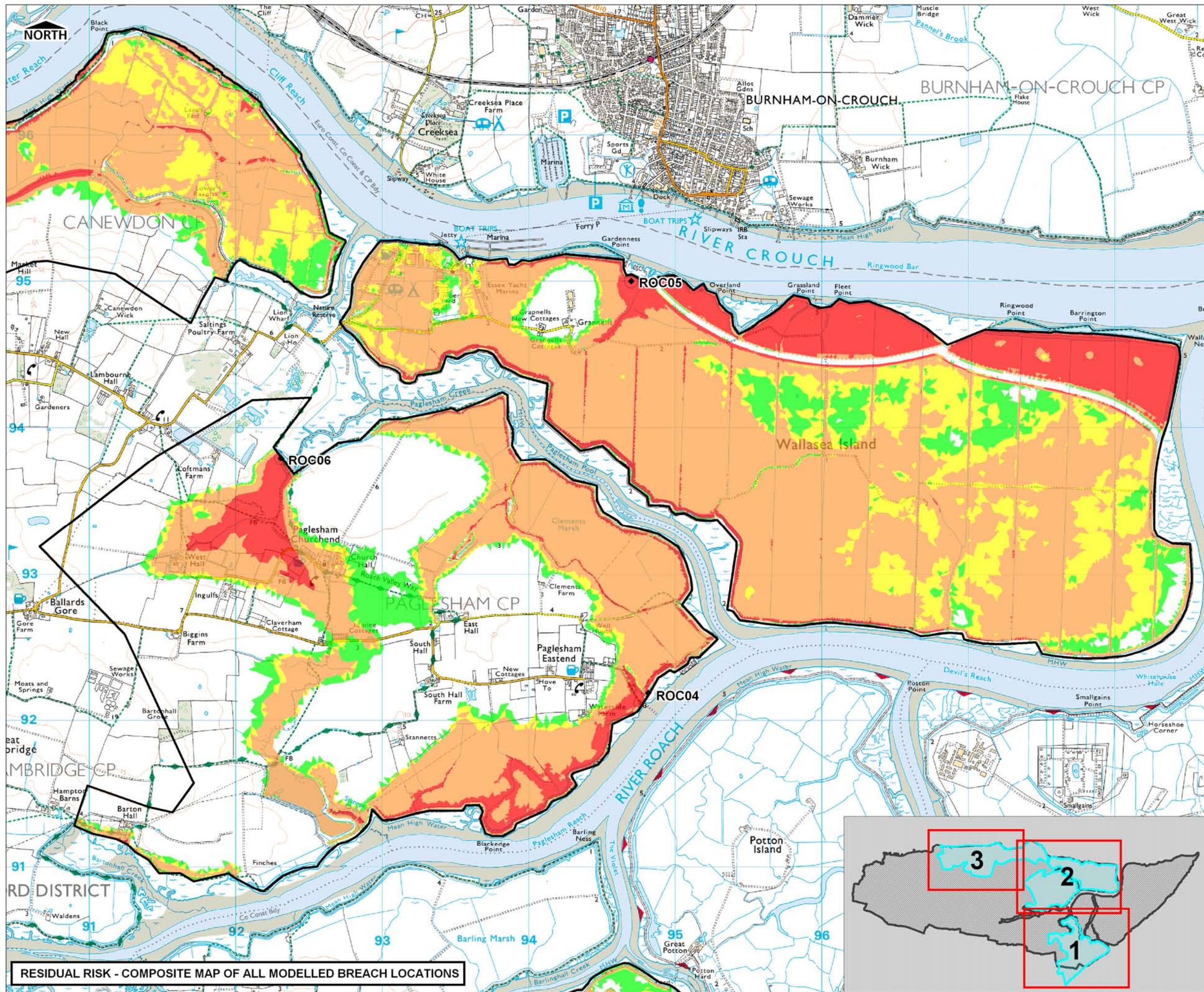
ALL BREACHES (ROC01-ROC07) & OVERTOPPING

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Scott Wilson
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London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER

FIGURE C-1 (View 1)



KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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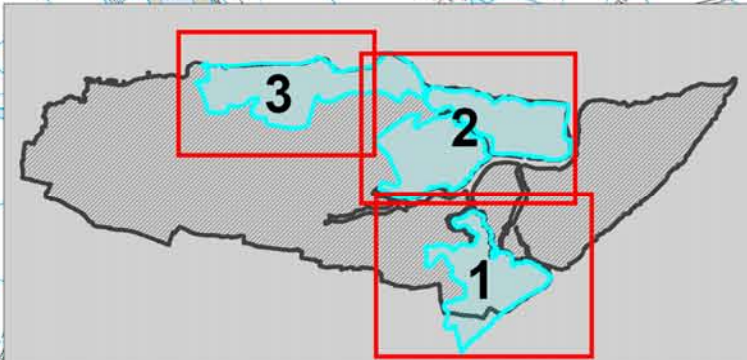
**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**COMPOSITE FLOOD HAZARD RATING
0200YR (2010)
ALL BREACHES (ROC01-ROC07) & OVERTOPPING**

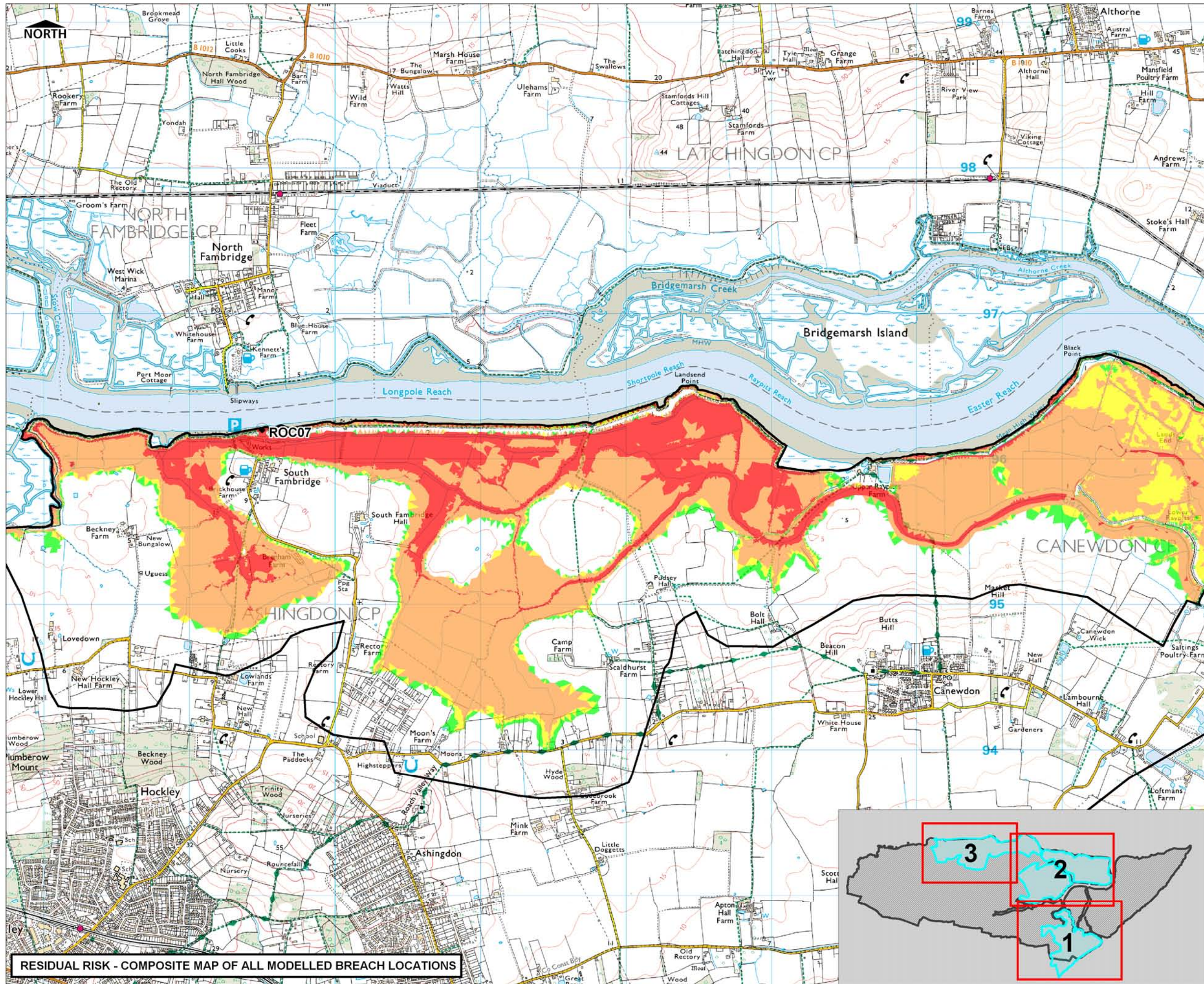


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FIGURE C-1 (View 2)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS

KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
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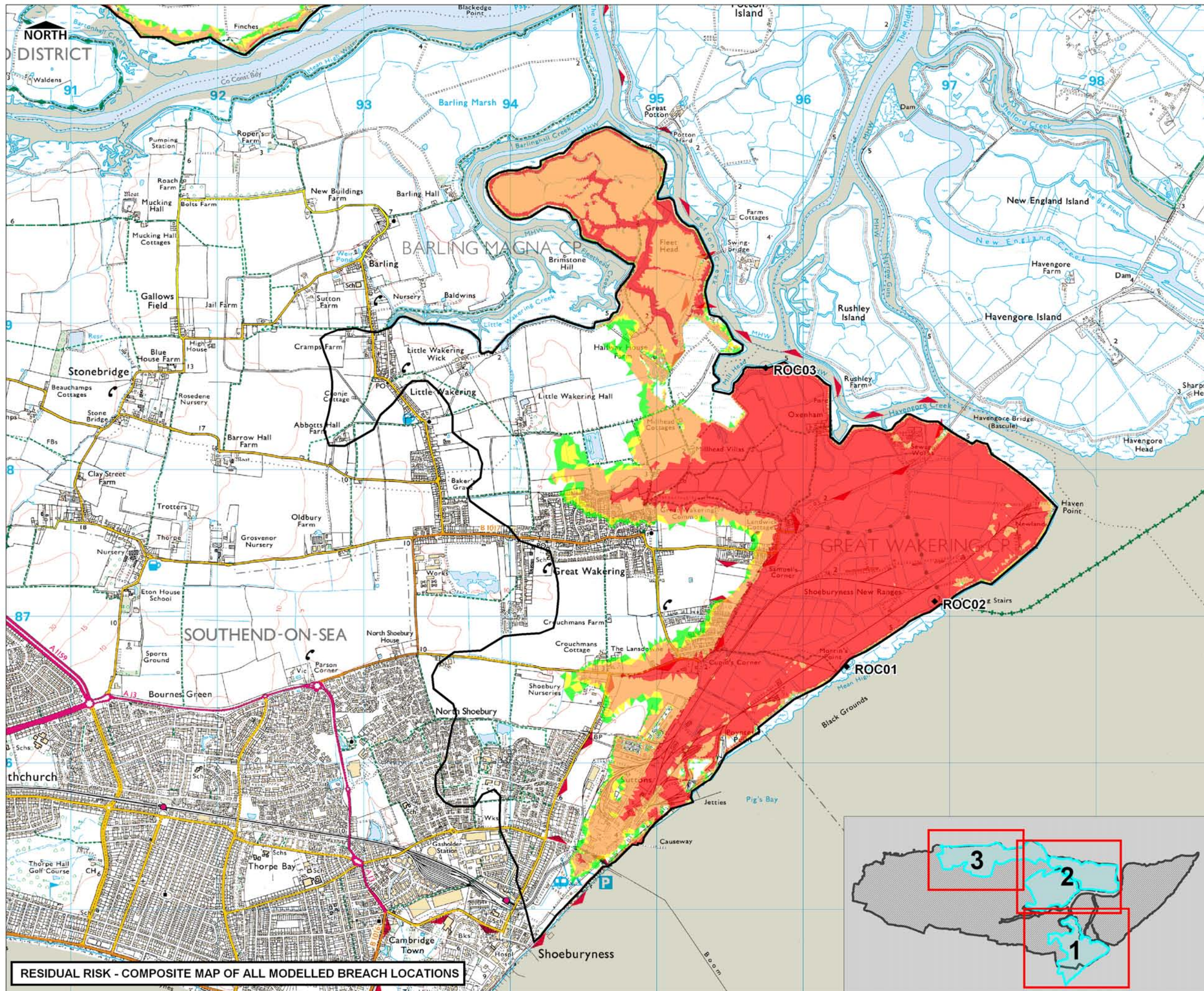
THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE FLOOD HAZARD RATING
0200YR (2010)
ALL BREACHES (ROC01-ROC07) & OVERTOPPING

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Scott Wilson
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London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE C-1 (View 3)



KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

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STRATEGIC FLOOD RISK ASSESSMENT**

**COMPOSITE FLOOD HAZARD RATING
1000YR (2010)**

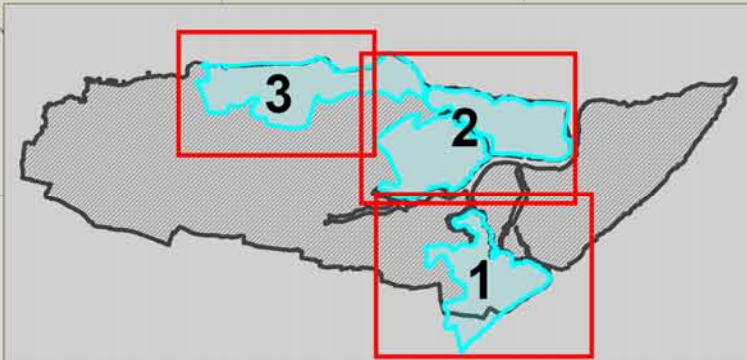
ALL BREACHES (ROC01-ROC07) & OVERTOPPING

Basildon Council castlepoint Rochford District Council

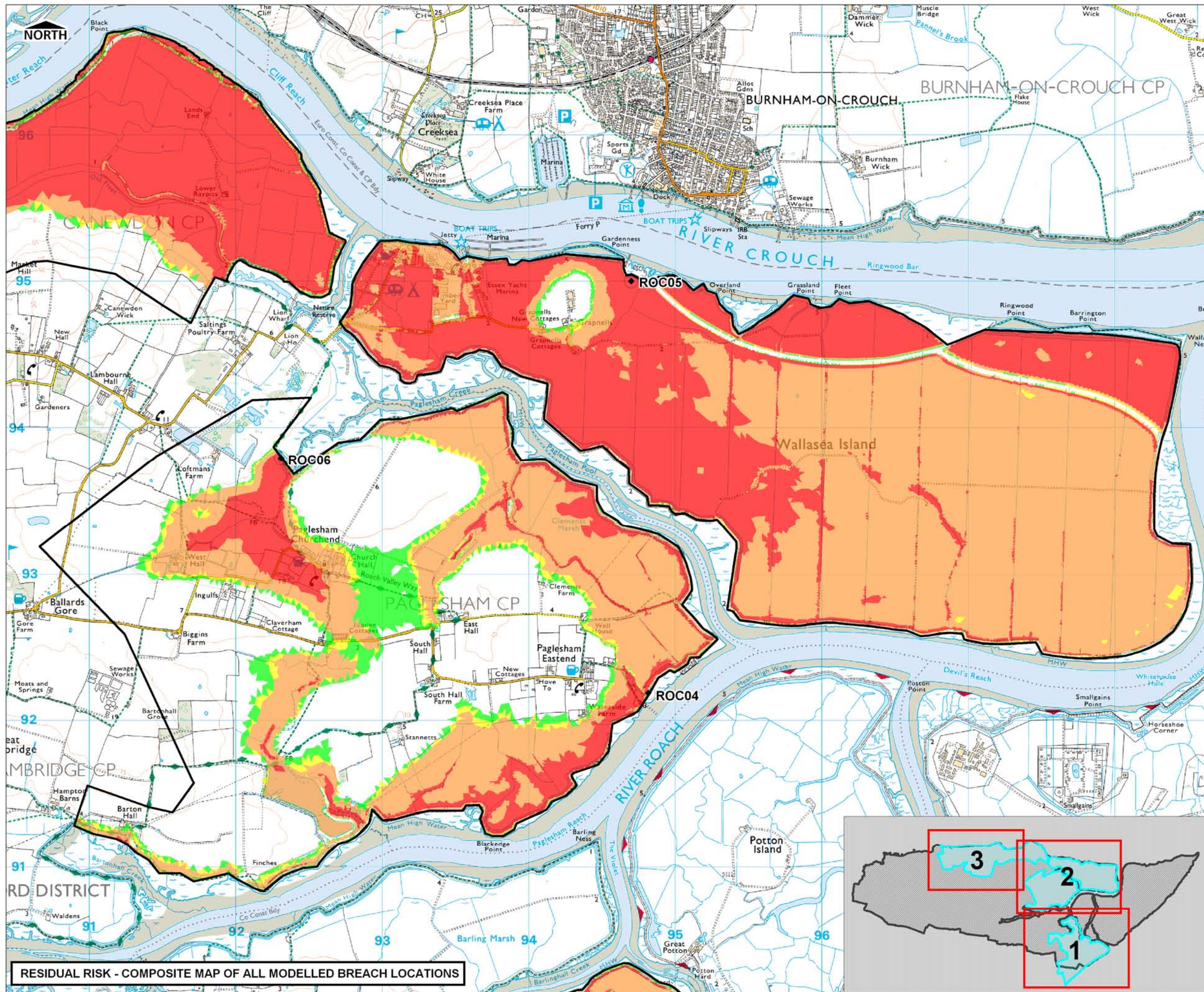
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FIGURE C-2 (View 1)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS



KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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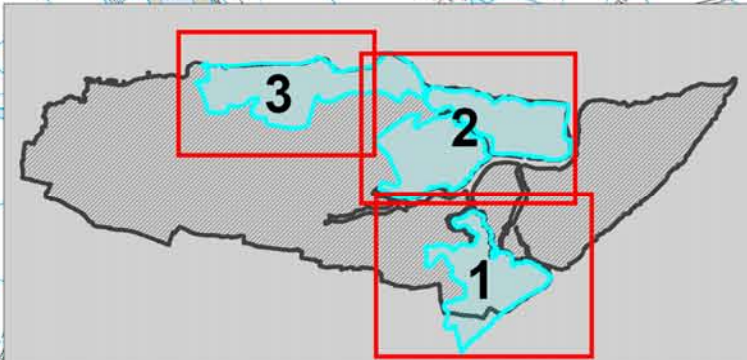
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE FLOOD HAZARD RATING 1000YR (2010)
ALL BREACHES (ROC01-ROC07) & OVERTOPPING

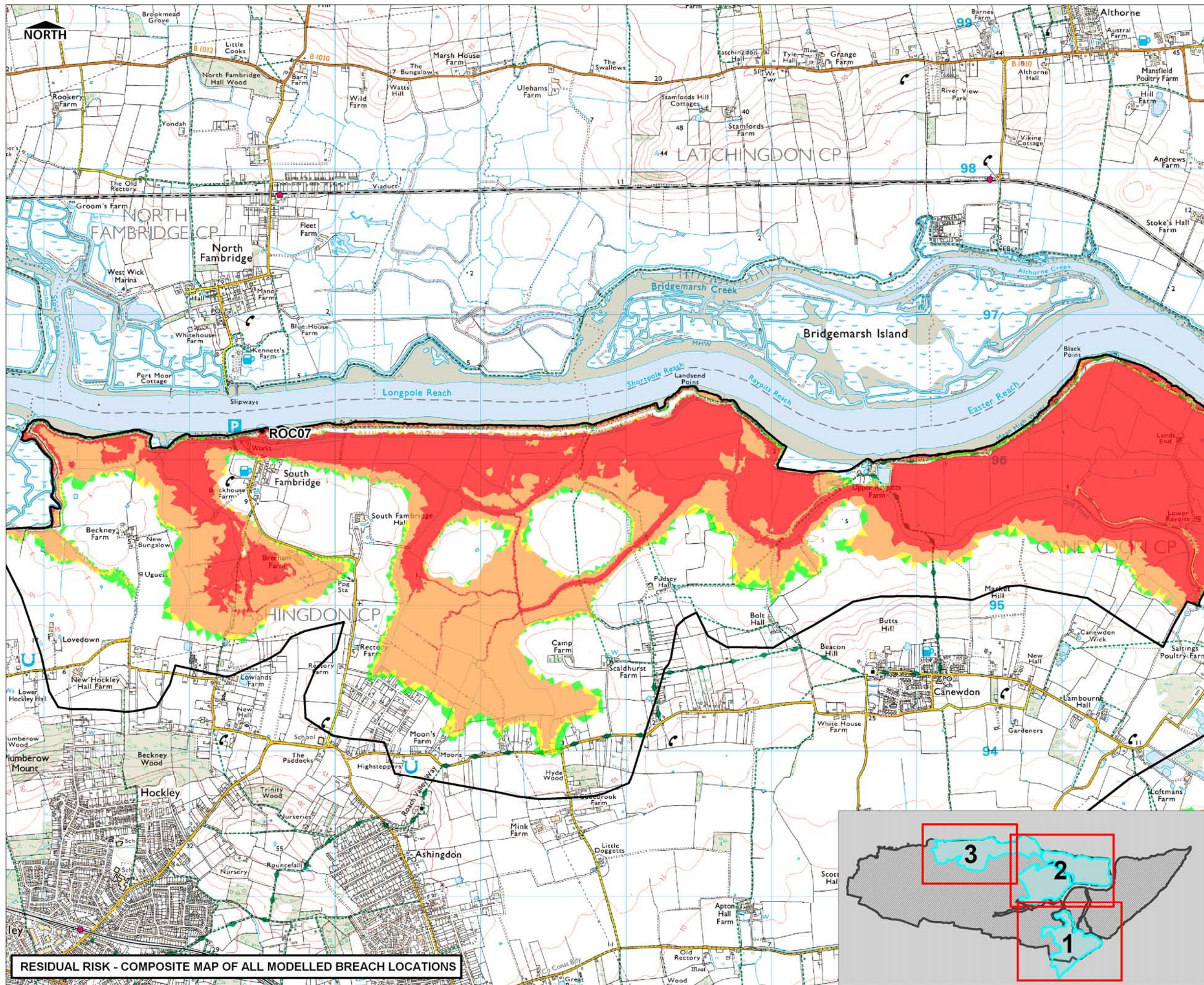


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FIGURE C-2 (View 2)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS



KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

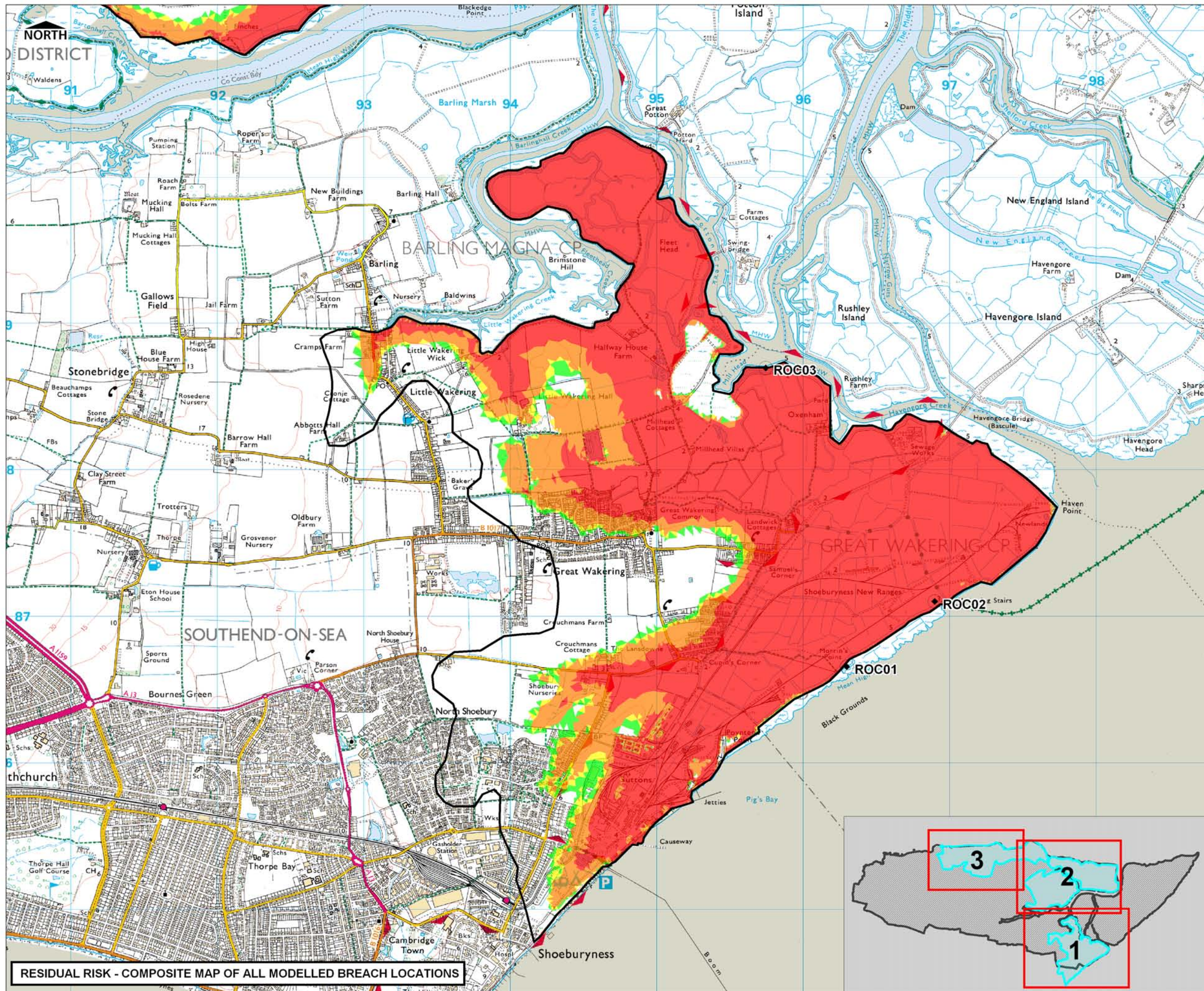
**COMPOSITE FLOOD HAZARD RATING
1000YR (2010)**

ALL BREACHES (ROC01-ROC07) & OVERTOPPING

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FIGURE C-2 (View 3)



KEY

- Flood Cells
- Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE FLOOD HAZARD RATING 0200YR (2110)

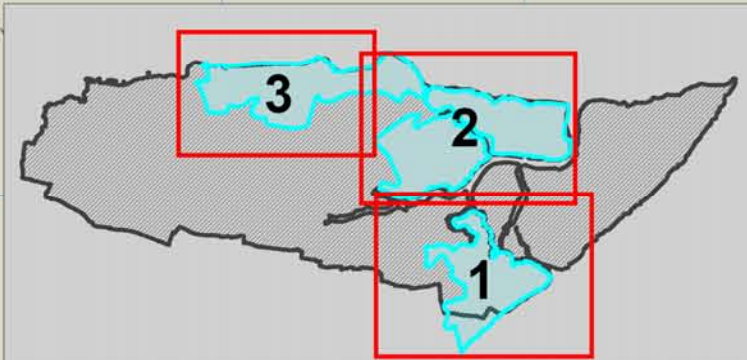
ALL BREACHES (ROC01-ROC07) & OVERTOPPING

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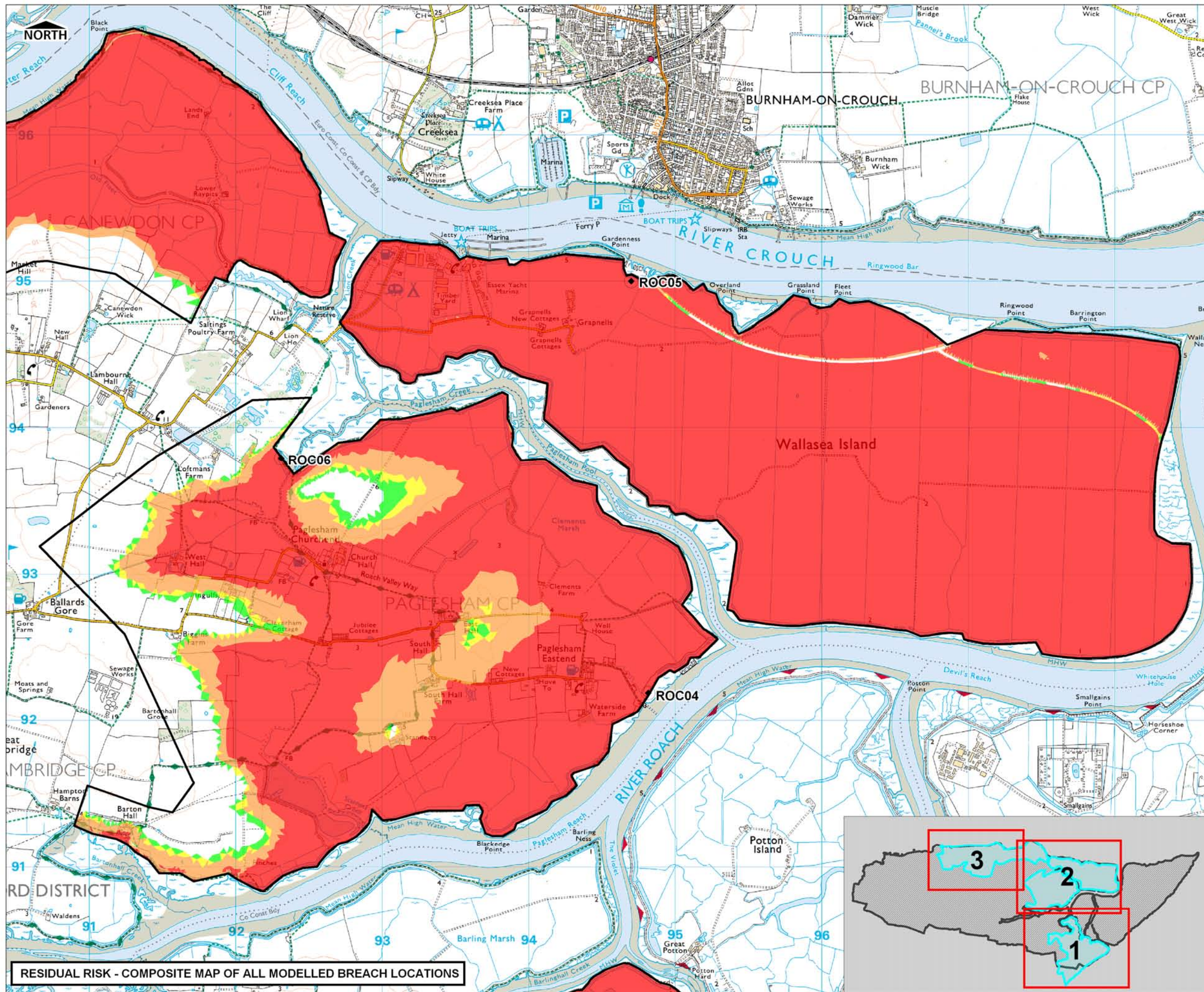
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FIGURE C-3 (View 1)

REV 02



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS



KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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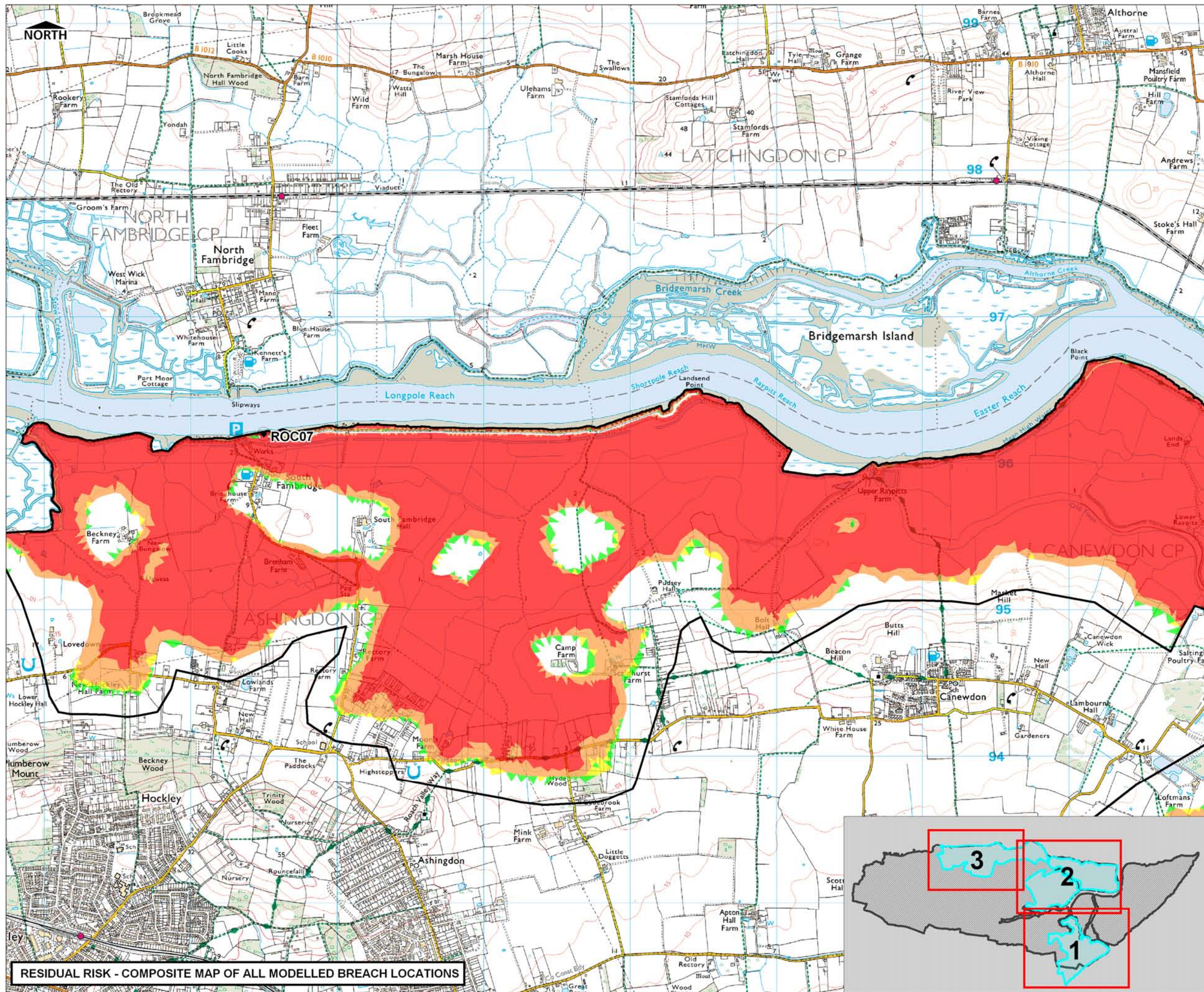
**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**COMPOSITE FLOOD HAZARD RATING
0200YR (2110)
ALL BREACHES (ROC01-ROC07) & OVERTOPPING**



Scott Wilson
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Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE C-3 (View 2)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS

KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT

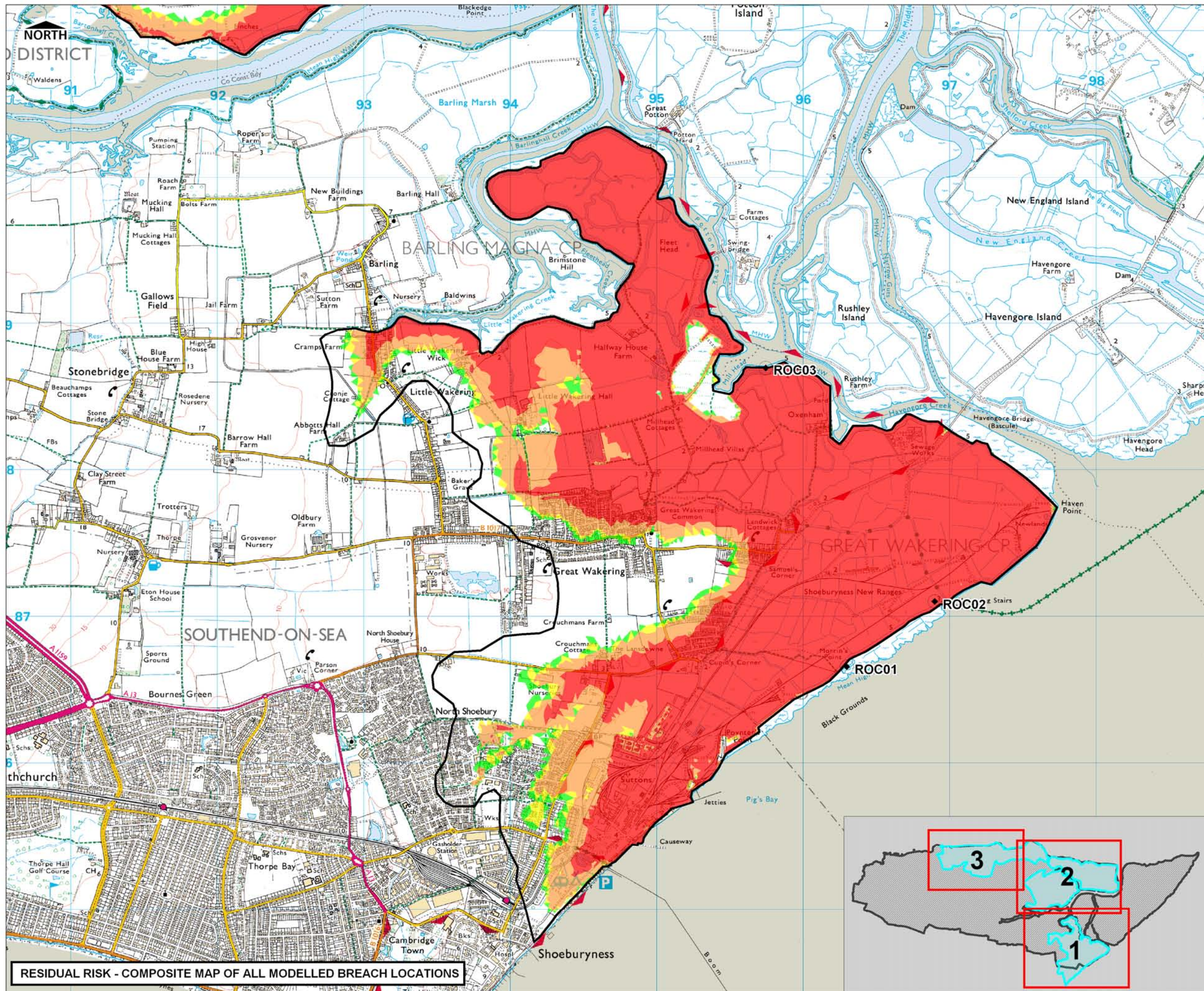
COMPOSITE FLOOD HAZARD RATING
0200YR (2110)
ALL BREACHES (ROC01-ROC07) & OVERTOPPING

Basildon Council castlepoint Rochford District Council

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000



DRAWING NUMBER
FIGURE C-3 (View 3)



KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE FLOOD HAZARD RATING 1000YR (2110)

ALL BREACHES (ROC01-ROC07) & OVERTOPPING

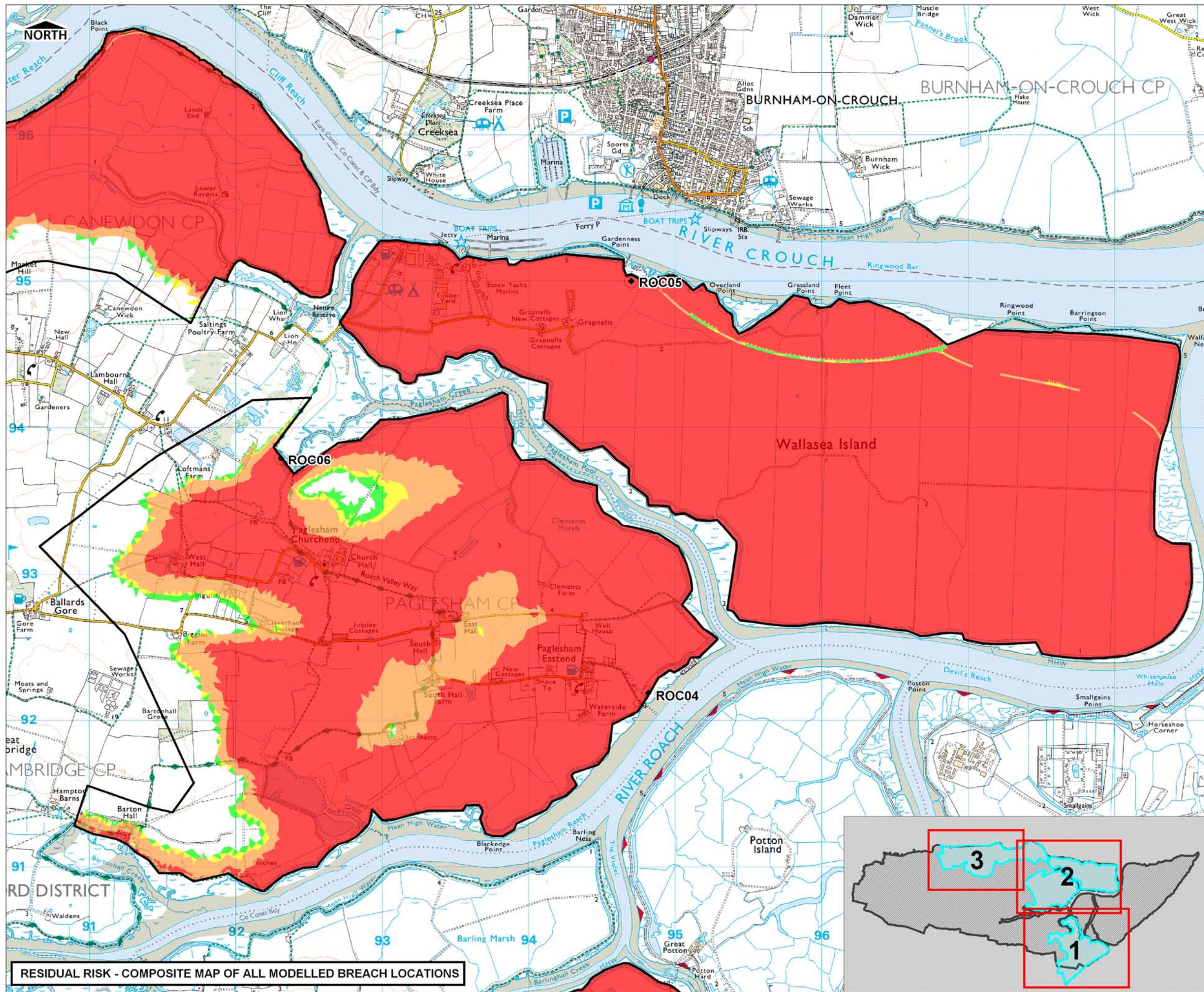
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Scott Wilson
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London, SW1P 1PL
Tel: (020) 7798 5000



DRAWING NUMBER

FIGURE C-4 (View 1)



KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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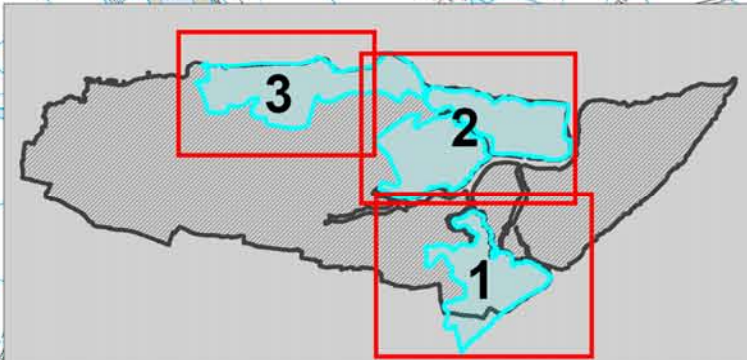
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE FLOOD HAZARD RATING 1000YR (2110) ALL BREACHES (ROC01-ROC07) & OVERTOPPING

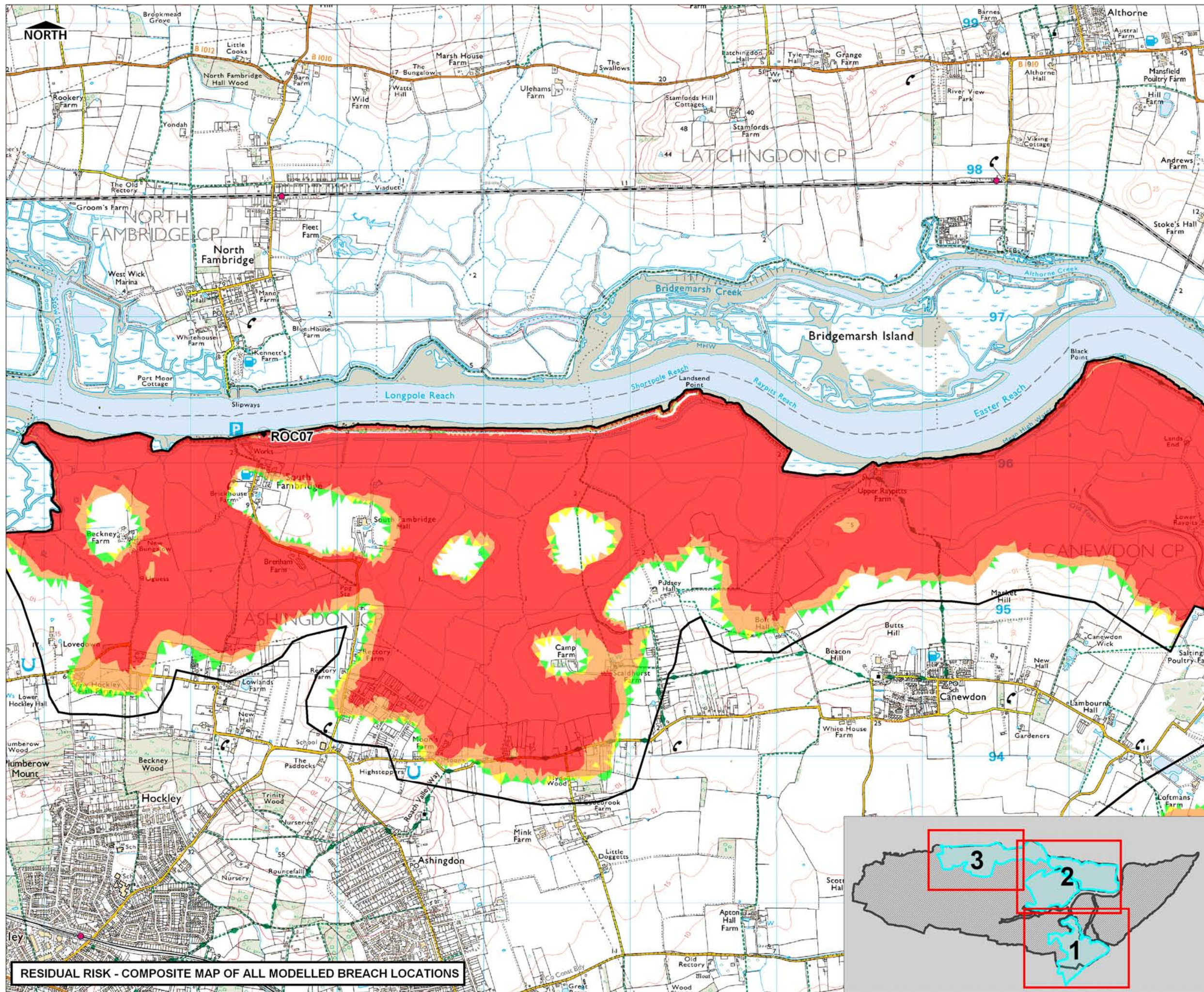


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FIGURE C-4 (View 2)



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS



RESIDUAL RISK - COMPOSITE MAP OF ALL MODELLED BREACH LOCATIONS

KEY

— Flood Cells ◆ Breach Location

Flood Hazard Rating

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THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT

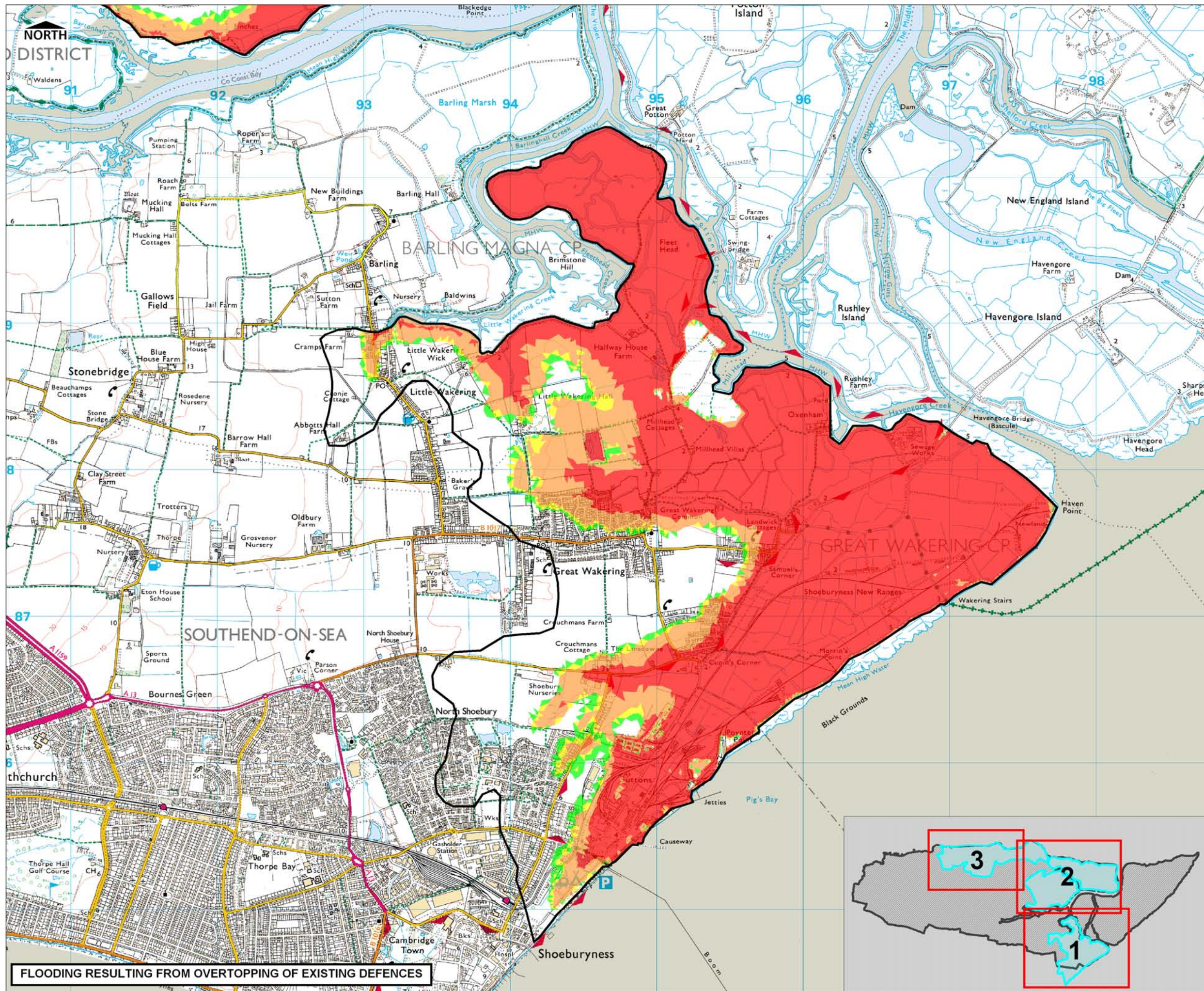
COMPOSITE FLOOD HAZARD RATING
1000YR (2110)

ALL BREACHES (ROC01-ROC07) & OVERTOPPING



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6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE C-4 (View 3)



KEY

— Flood Cells

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**COMPOSITE FLOOD HAZARD RATING
0200YR (2110)
OVERTOPPING**

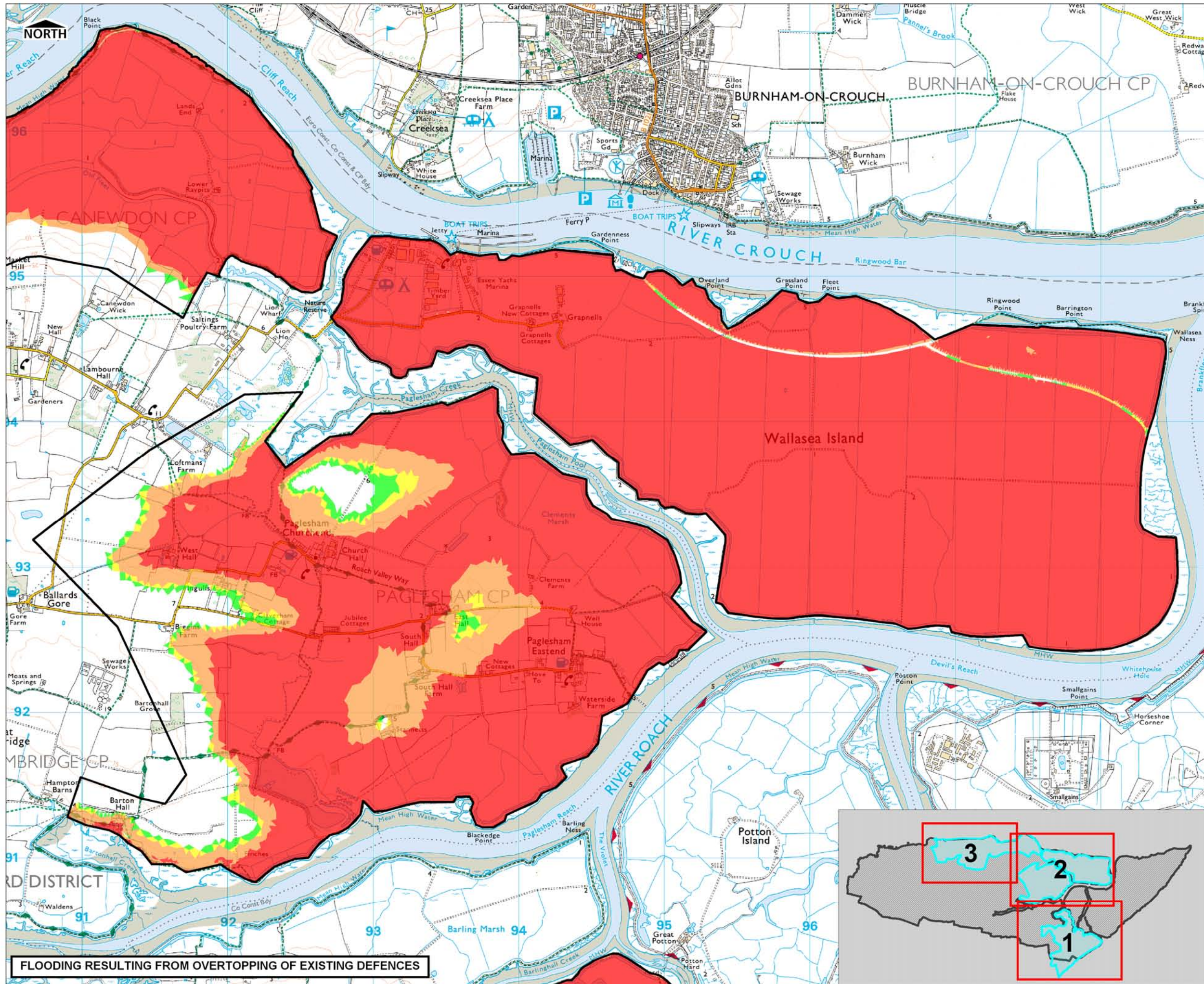


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FIGURE C-5 (View 1)



KEY

- Flood Cells

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

Hydraulic modelling has been undertaken using 2-D hydraulic modelling software MIKE21-HDFM (ver. 2009), to assess the effect of overtopping of defences.

The model simulates 3 tidal cycles with the peak level occurring on the second peak and two slightly smaller peaks either side.

Flood hazard is calculated as a function of the flood depth and flow velocity at a particular point in the floodplain, along with a suitable debris factor. Each element within the model is assigned one of 4 hazard categories based on the methodology from Flood Risks to People FD2320 (DEFRA & EA, 2005). These hazard classifications do not indicate a change in the flood probability.

USER NOTE

This plan has been produced in accordance with Planning Policy Statement 25 - Development and Flood Risk. Because the information is indicative rather than specific, local planning authorities will nevertheless need to consult the Environment Agency on individual applications.

FLOODABLE AREAS NOT SHOWN

Land adjacent to watercourses not included within this study. Areas susceptible to drainage system inadequacies or localised ponding. Areas flooded due to debris blockage unless shown for specific structures. Areas flooded from breaches in flood defences.

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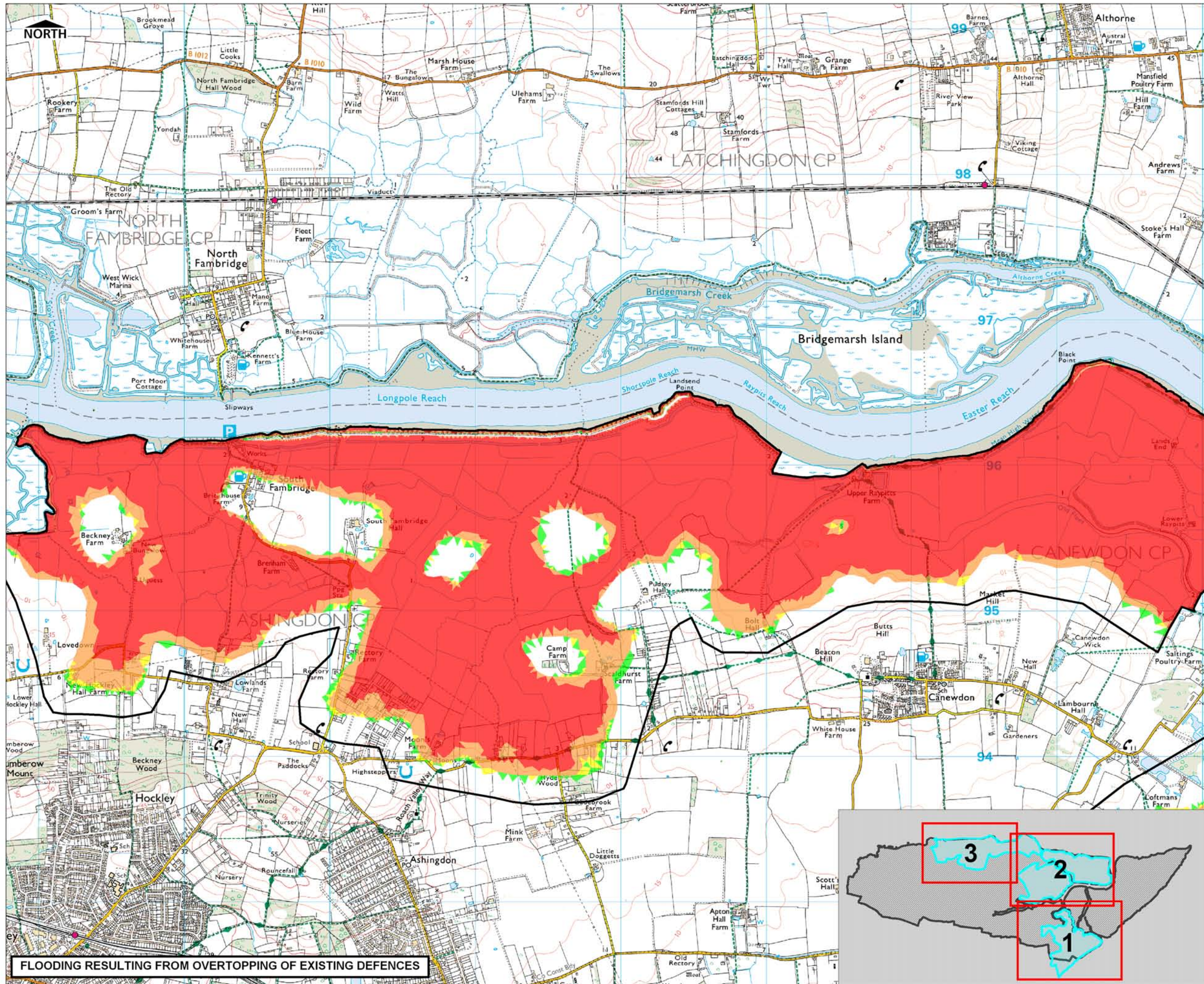
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

COMPOSITE FLOOD HAZARD RATING 0200YR (2110) OVERTOPPING






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DRAWING NUMBER
FIGURE C-5 (View 2)



FLOODING RESULTING FROM OVERTOPPING OF EXISTING DEFENCES

KEY

-  Flood Cells
- Flood Hazard Rating**
-  Low Hazard
-  Moderate Hazard (Danger for Some)
-  Significant Hazard (Danger for Most)
-  Extreme Hazard (Danger for All)

TECHNICAL NOTE

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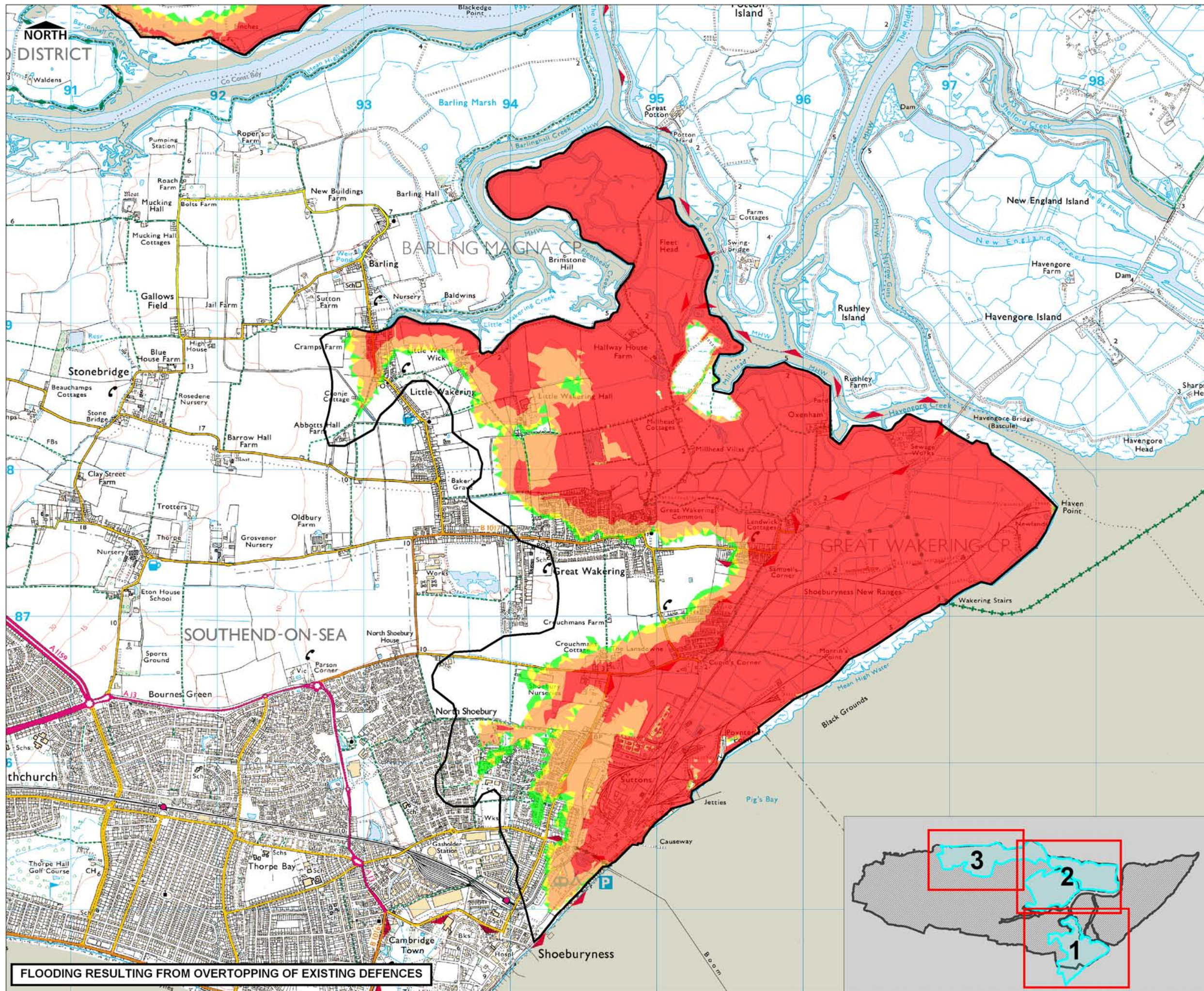
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DRAWING NUMBER
FIGURE C-5 (View 3)



KEY

— Flood Cells

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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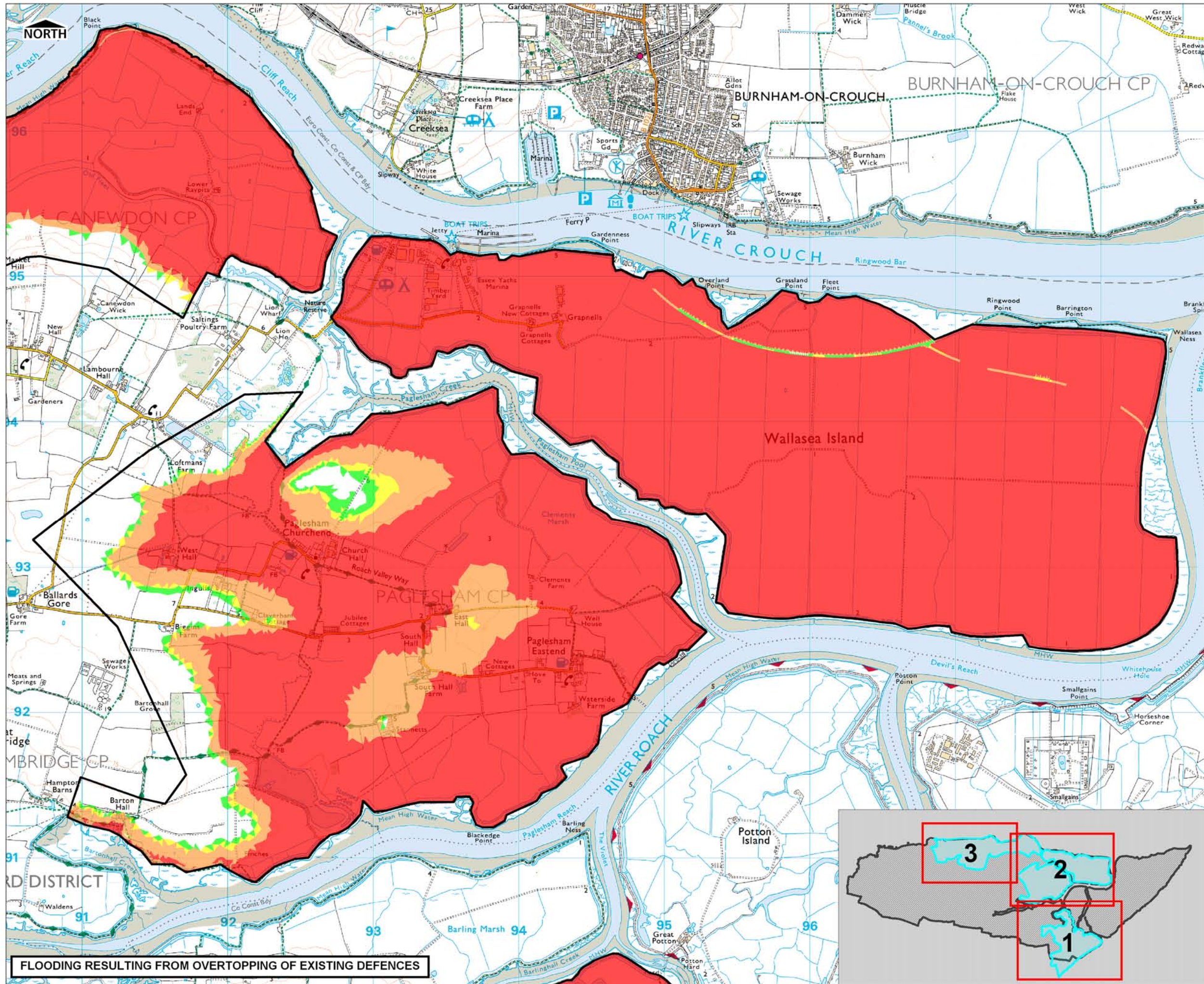
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COMPOSITE FLOOD HAZARD RATING 1000YR (2110) OVERTOPPING



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DRAWING NUMBER
FIGURE C-6 (View 1)



KEY

— Flood Cells

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

TECHNICAL NOTE

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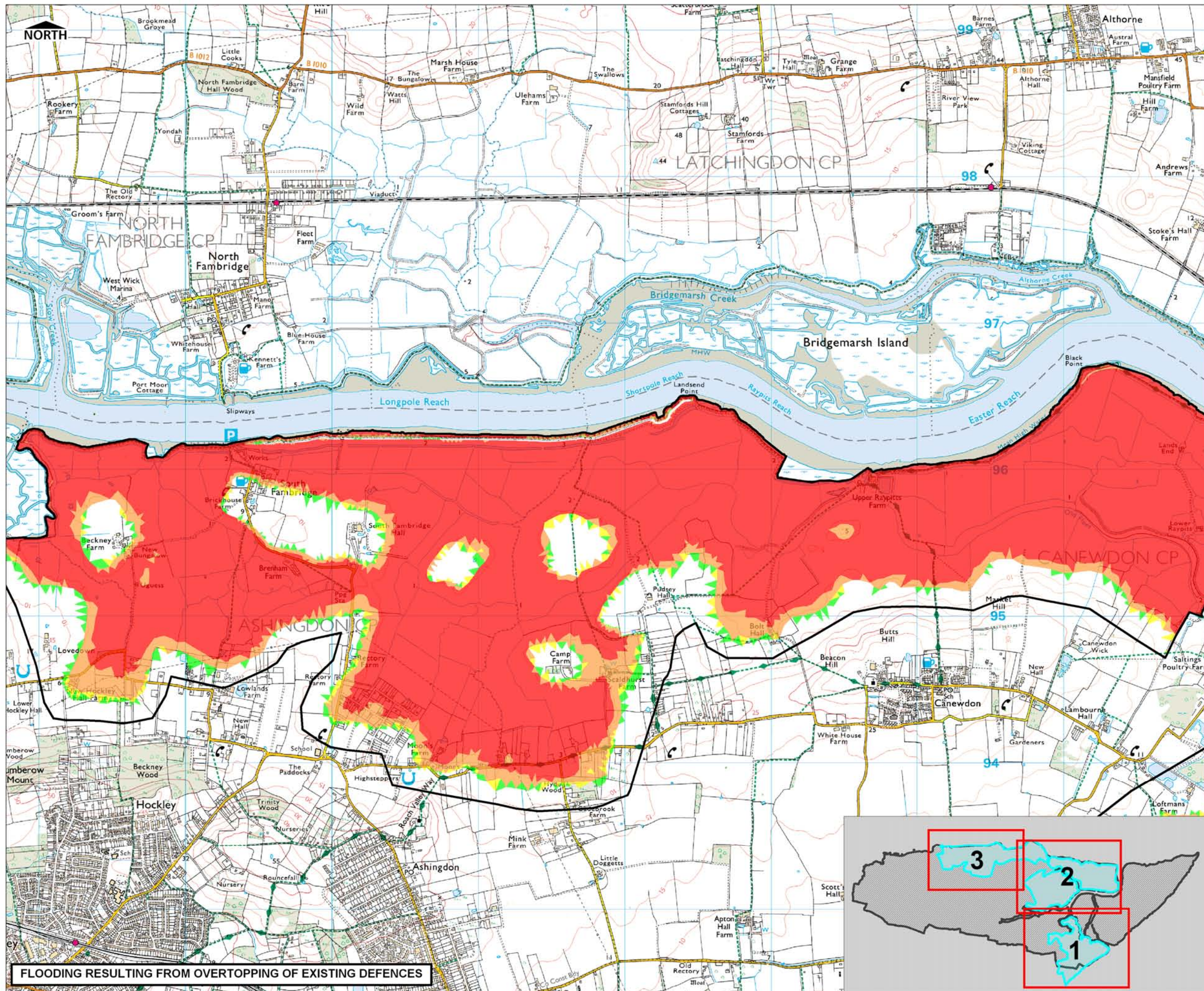
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FIGURE C-6 (View 2)

FLOODING RESULTING FROM OVERTOPPING OF EXISTING DEFENCES



KEY

— Flood Cells

Flood Hazard Rating

- Low Hazard
- Moderate Hazard (Danger for Some)
- Significant Hazard (Danger for Most)
- Extreme Hazard (Danger for All)

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COMPOSITE FLOOD HAZARD RATING 1000YR (2110) OVERTOPPING



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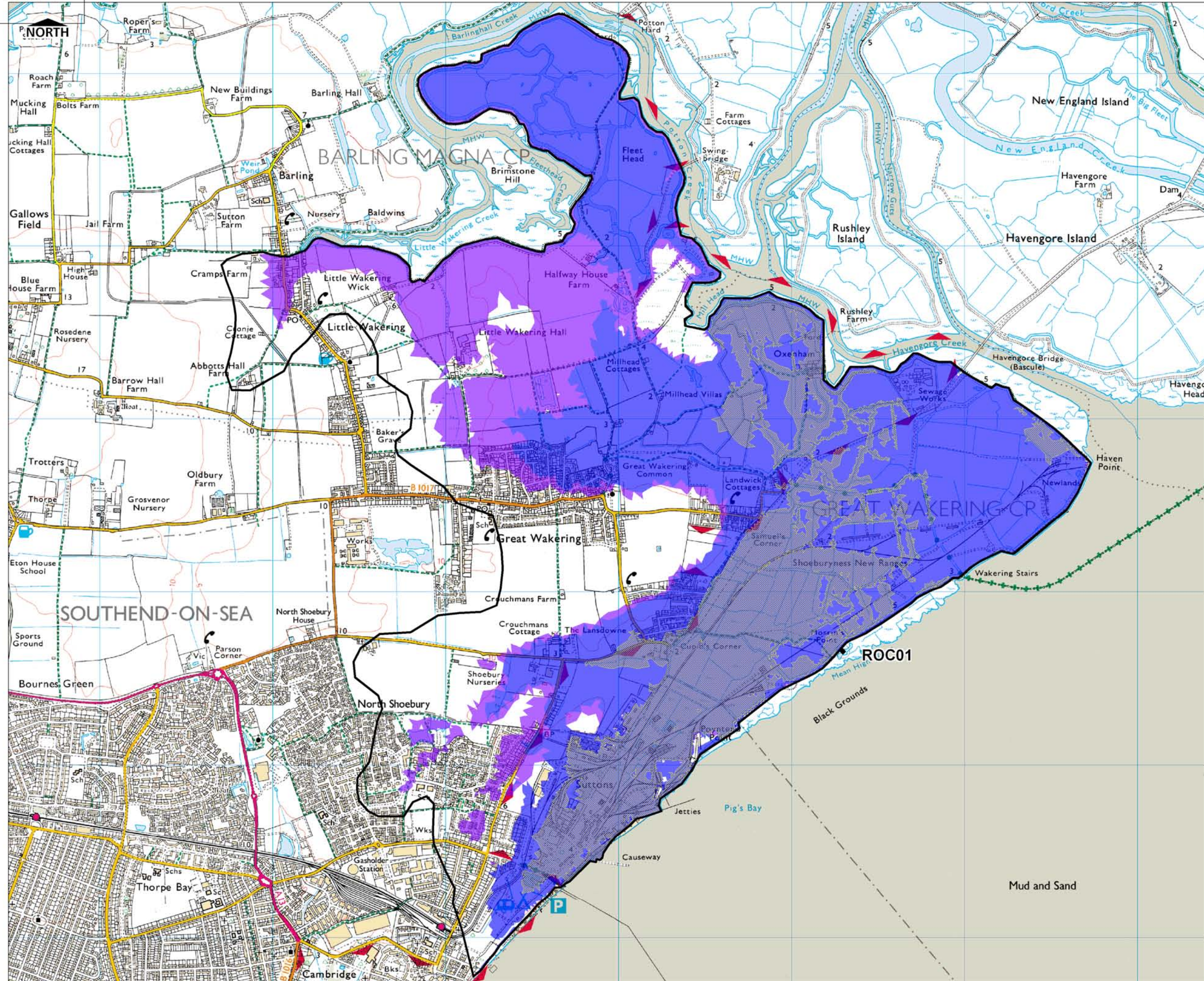
FIGURE C-6 (View 3)

Appendix D: Time to Inundation Mapping

Potential Impact of Breach & Overtopping

D-1	Breach ROC01 Time to Inundation (1 in 1000yr event, 2110 incl. CC)
D-2	Breach ROC02 Time to Inundation (1 in 1000yr event, 2110 incl. CC)
D-3	Breach ROC03 Time to Inundation (1 in 1000yr event, 2110 incl. CC)
D-4	Breach ROC04 Time to Inundation (1 in 1000yr event, 2110 incl. CC)
D-5	Breach ROC05 Time to Inundation (1 in 1000yr event, 2110 incl. CC)
D-6	Breach ROC06 Time to Inundation (1 in 1000yr event, 2110 incl. CC)
D-7	Breach ROC07 Time to Inundation (1 in 1000yr event, 2110 incl. CC)
D-8	Breach ROC01 Time to Inundation (1 in 0200yr event, 2110 incl. CC)
D-9	Breach ROC02 Time to Inundation (1 in 0200yr event, 2110 incl. CC)
D-10	Breach ROC03 Time to Inundation (1 in 0200yr event, 2110 incl. CC)
D-11	Breach ROC04 Time to Inundation (1 in 0200yr event, 2110 incl. CC)
D-12	Breach ROC05 Time to Inundation (1 in 0200yr event, 2110 incl. CC)
D-13	Breach ROC06 Time to Inundation (1 in 0200yr event, 2110 incl. CC)
D-14	Breach ROC07 Time to Inundation (1 in 0200yr event, 2110 incl. CC)
D-15	Breach ROC01 Time to Inundation (1 in 1000yr event, 2010)
D-16	Breach ROC02 Time to Inundation (1 in 1000yr event, 2010)
D-17	Breach ROC03 Time to Inundation (1 in 1000yr event, 2010)
D-18	Breach ROC04 Time to Inundation (1 in 1000yr event, 2010)
D-19	Breach ROC05 Time to Inundation (1 in 1000yr event, 2010)
D-20	Breach ROC06 Time to Inundation (1 in 1000yr event, 2010)
D-21	Breach ROC07 Time to Inundation (1 in 1000yr event, 2010)
D-22	Breach ROC01 Time to Inundation (1 in 0200yr event, 2010)
D-23	Breach ROC02 Time to Inundation (1 in 0200yr event, 2010)
D-24	Breach ROC03 Time to Inundation (1 in 0200yr event, 2010)
D-25	Breach ROC04 Time to Inundation (1 in 0200yr event, 2010)
D-26	Breach ROC05 Time to Inundation (1 in 0200yr event, 2010)
D-27	Breach ROC06 Time to Inundation (1 in 0200yr event, 2010)
D-28	Breach ROC07 Time to Inundation (1 in 0200yr event, 2010)

No Window



KEY

- Flood Cell
 - Breach Location
- Time To Inundation [Hours]**
- < 1 Hour
 - 1 - 4 Hours
 - 4 - 8 Hours
 - 8 - 12 Hours
 - 12 - 16 Hours
 - 16 - 20 Hours
- Inundation from overtopping prior to breach

TECHNICAL NOTE

Hydraulic modelling has been undertaken using 2-D hydraulic modelling software MIKE21-HDFM (ver. 2009), to assess the effect of breaches at specified points and/or overtopping of defences. The model simulates 3 tidal cycles with the peak level occurring on the second peak and two slightly smaller peaks either side. Breaches in the defence walls are modelled to occur immediately before the peak tidal level to assess the potential impact of rapid inundation of floodwater.

In order to map Time to Inundation, time 0 (zero) is designated as the time when tidal water enters the breach. The <1 hour band encompasses all areas that are inundated within the first hour of water passing through the breach and into the flood cell. Subsequent bands have been produced to show inundated cells for each 4 hour interval up to 20 hours. Areas that experience flooding as a result of overtopping of the defences prior to the breach event, are shown as hatched areas.

Time to inundation maps represent the onset of flooding from 1 specified breach. The rate will vary spatially if the breach locations are in different local areas. Changes in inundation extent or rate of onset of flooding are non-linear to changes in breach location. It should be noted that the breach width and depth, though based on EA guidance, are arbitrary and do not necessarily represent the actual dimensions of a potential breach at a given location.

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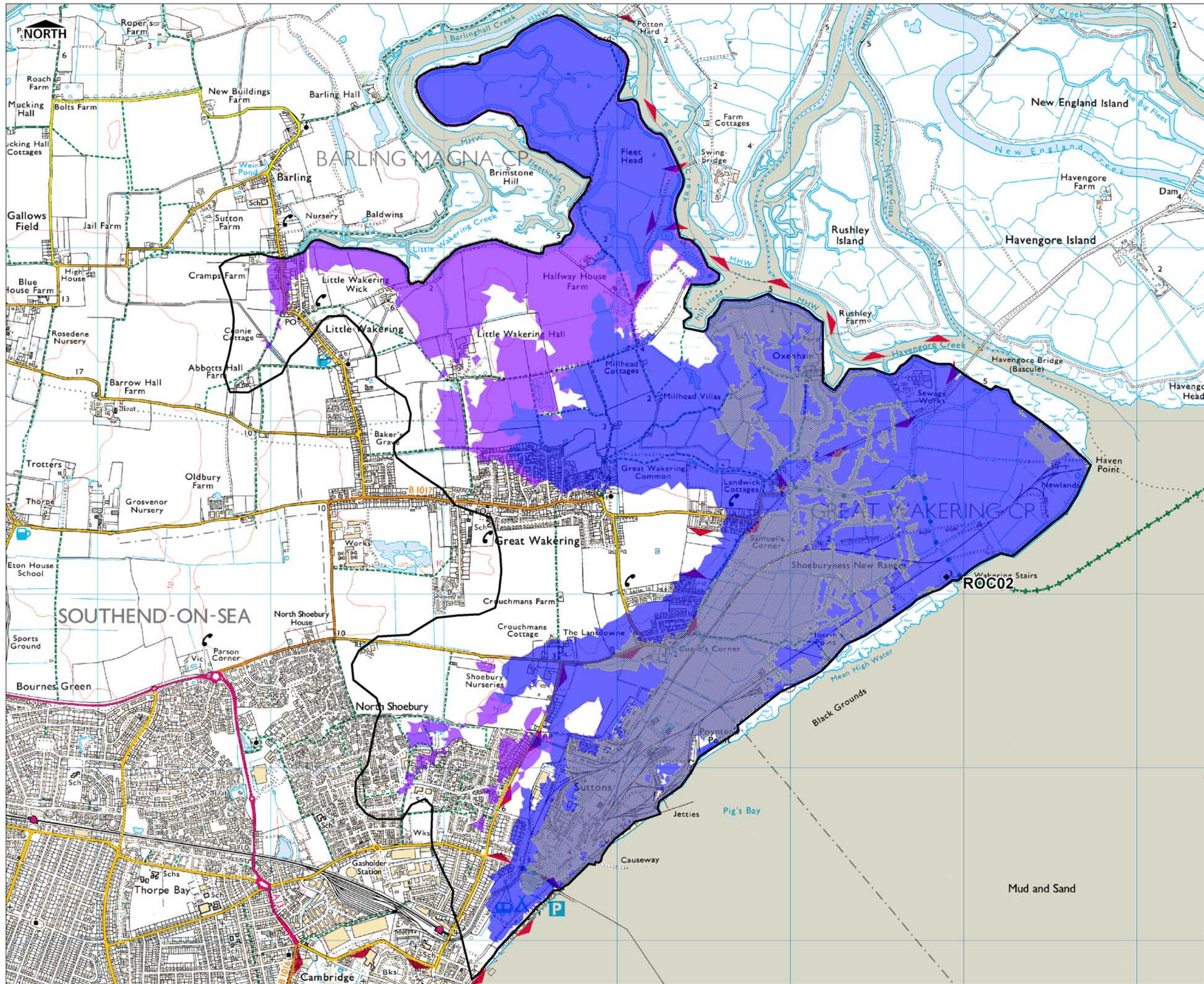
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 1000YR + CC (2110) BREACH ROC01



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DRAWING NUMBER
FIGURE D-1



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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In order to map Time to Inundation, time 0 (zero) is designated as the time when tidal water enters the breach. The <1 hour band encompasses all areas that are inundated within the first hour of water passing through the breach and into the flood cell. Subsequent bands have been produced to show inundated cells for each 4 hour interval up to 20 hours. Areas that experience flooding as a result of overtopping of the defences prior to the breach event, are shown as hatched areas.

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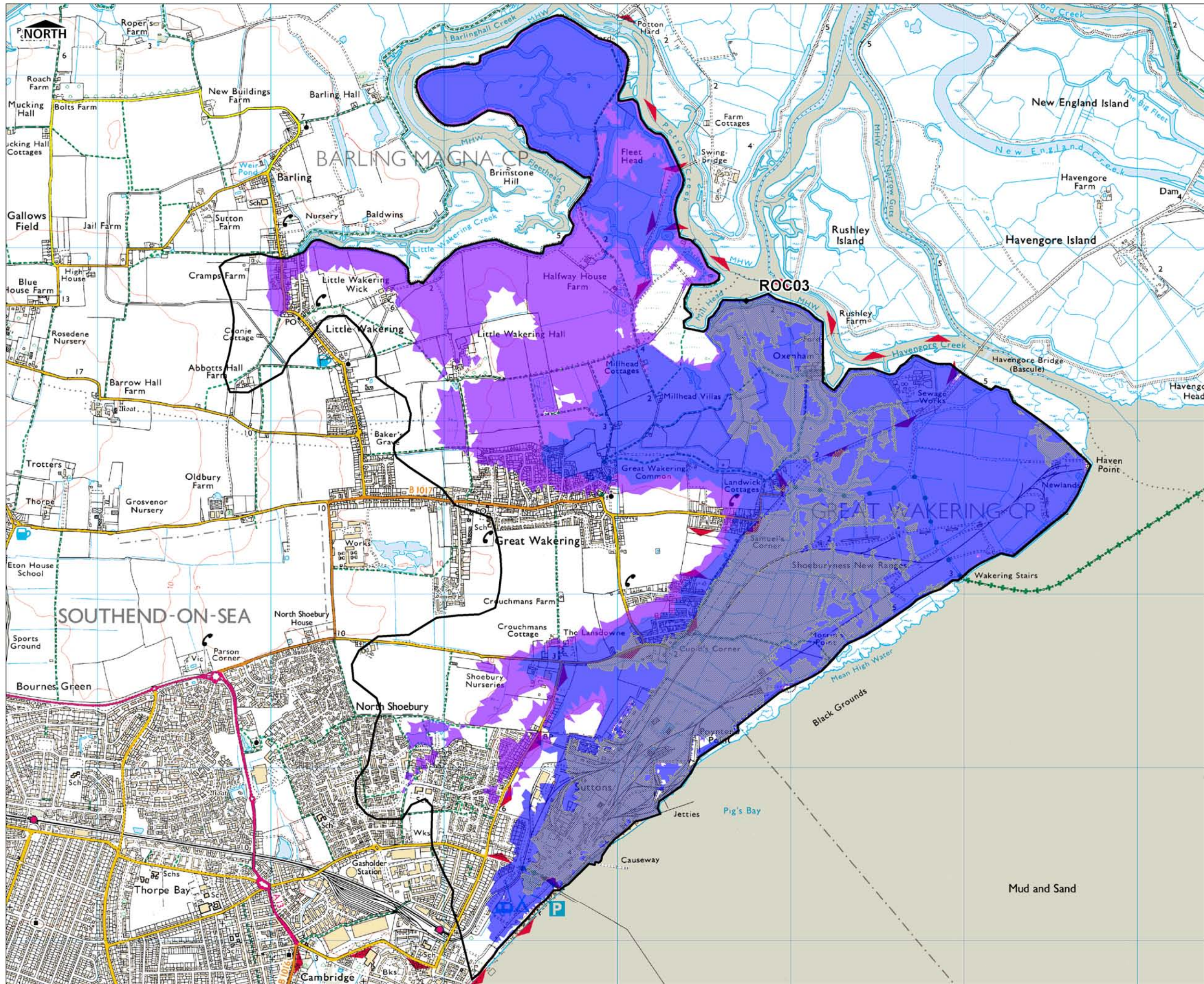
TIME TO INUNDATION 1000YR + CC (2110) BREACH ROC02



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DRAWING NUMBER

FIGURE D-2



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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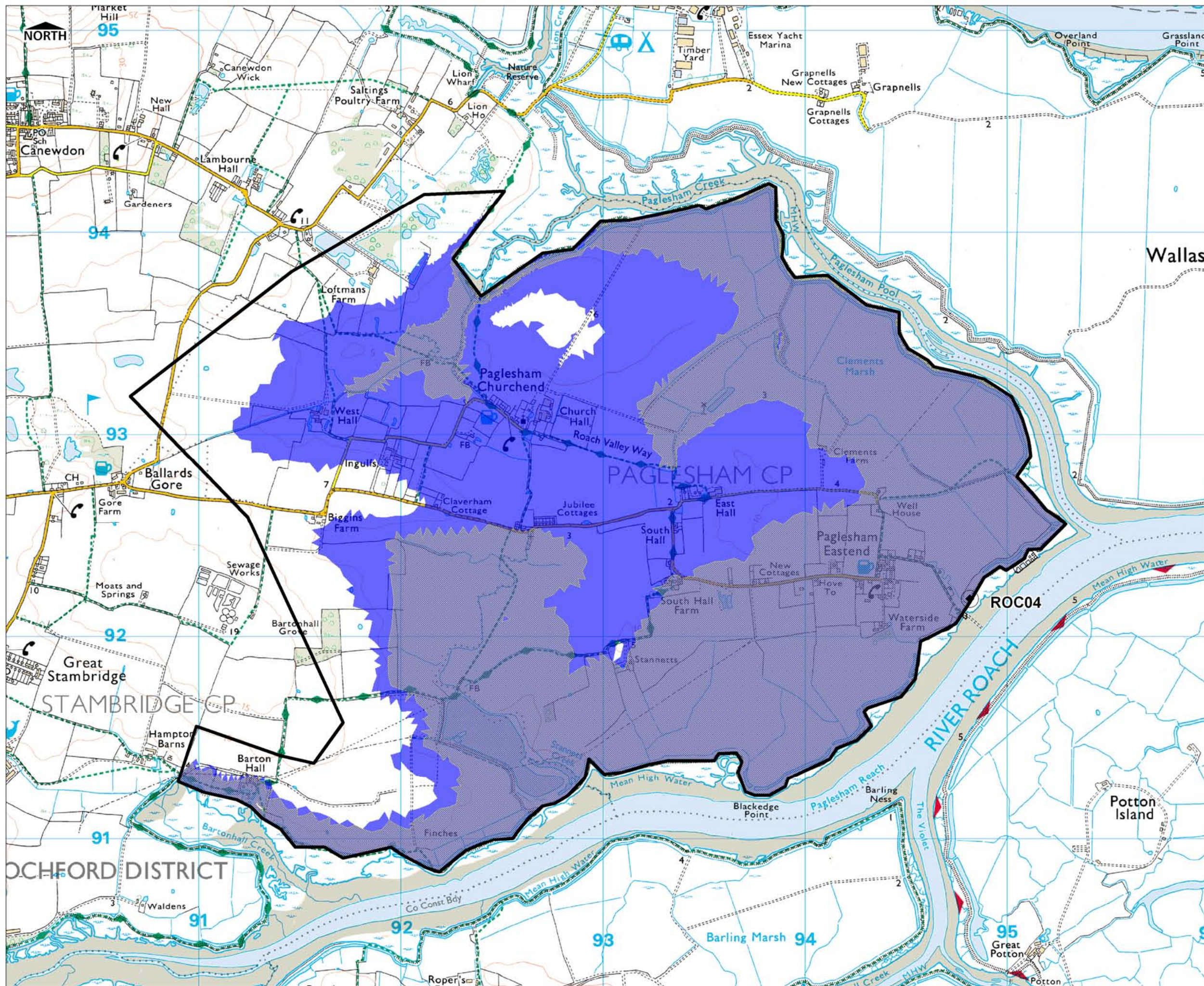
TIME TO INUNDATION 1000YR + CC (2110) BREACH ROC03



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DRAWING NUMBER **FIGURE D-3**



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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FLOODABLE AREAS NOT SHOWN

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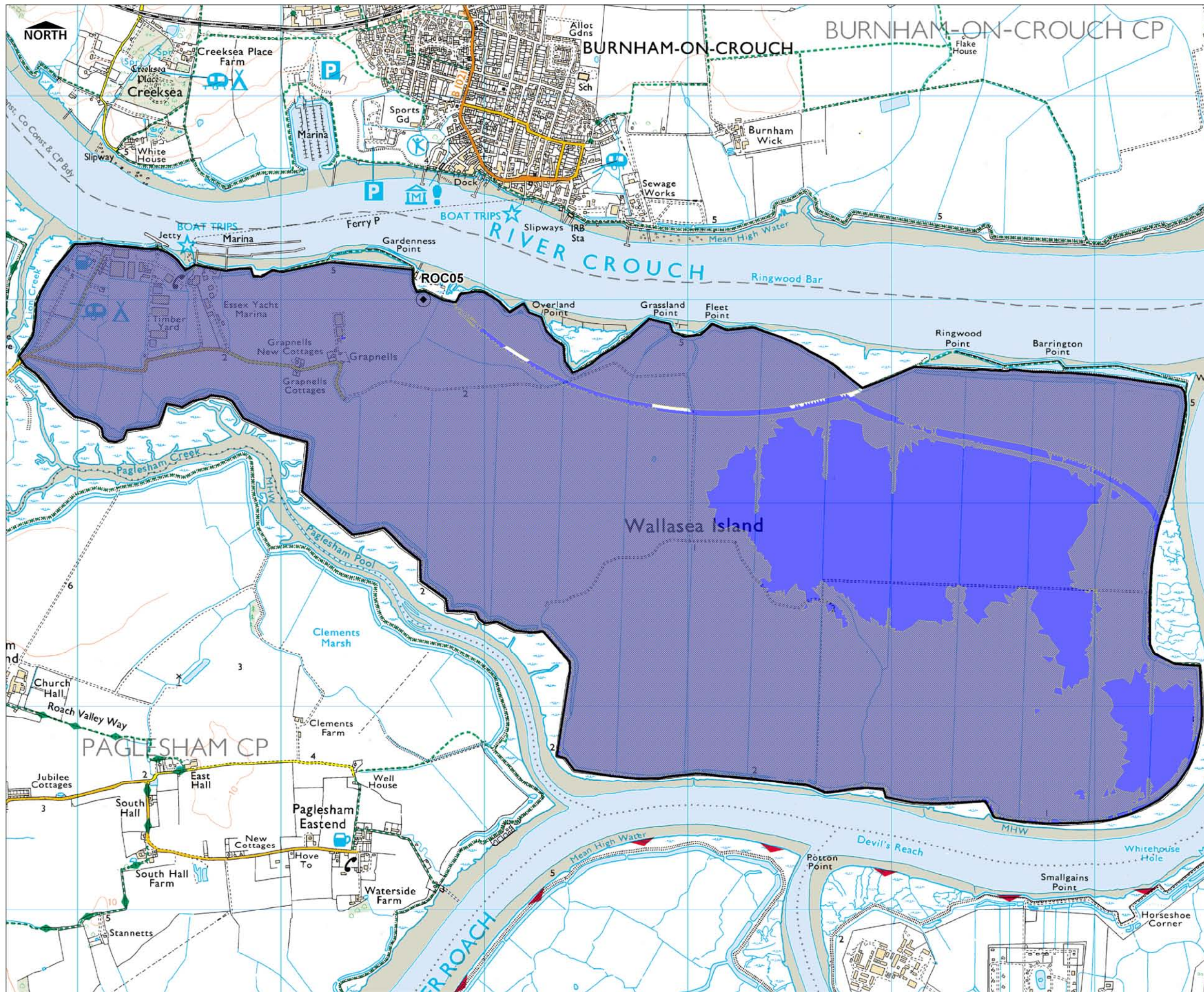
**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**TIME TO INUNDATION
1000YR + CC (2110)
BREACH ROC04**



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE D-4



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

Hydraulic modelling has been undertaken using 2-D hydraulic modelling software MIKE21-HDFM (ver. 2009), to assess the effect of breaches at specified points and/or overtopping of defences. The model simulates 3 tidal cycles with the peak level occurring on the second peak and two slightly smaller peaks either side. Breaches in the defence walls are modelled to occur immediately before the peak tidal level to assess the potential impact of rapid inundation of floodwater.

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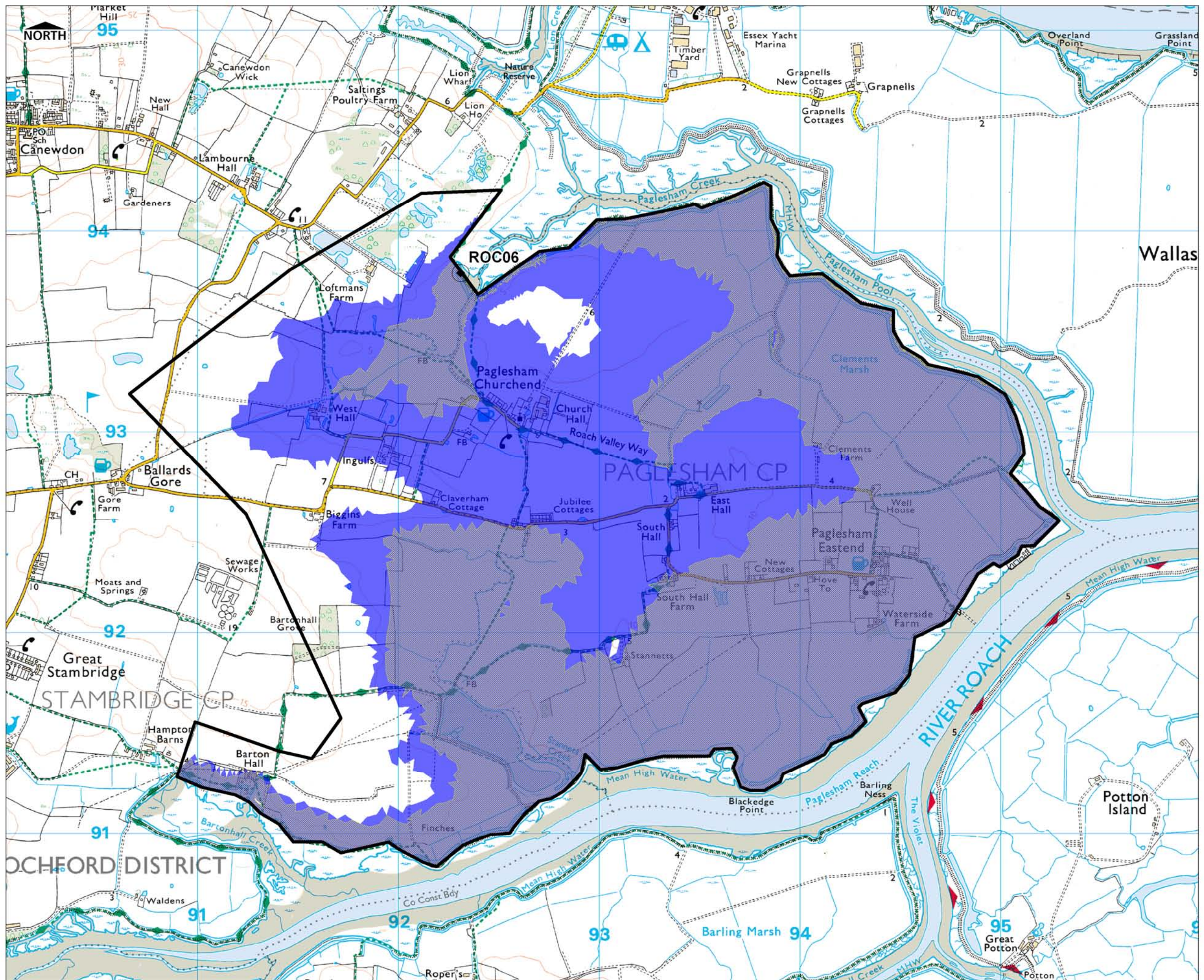
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 1000YR + CC (2110) BREACH ROC05



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER **FIGURE D-5**



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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USER NOTE

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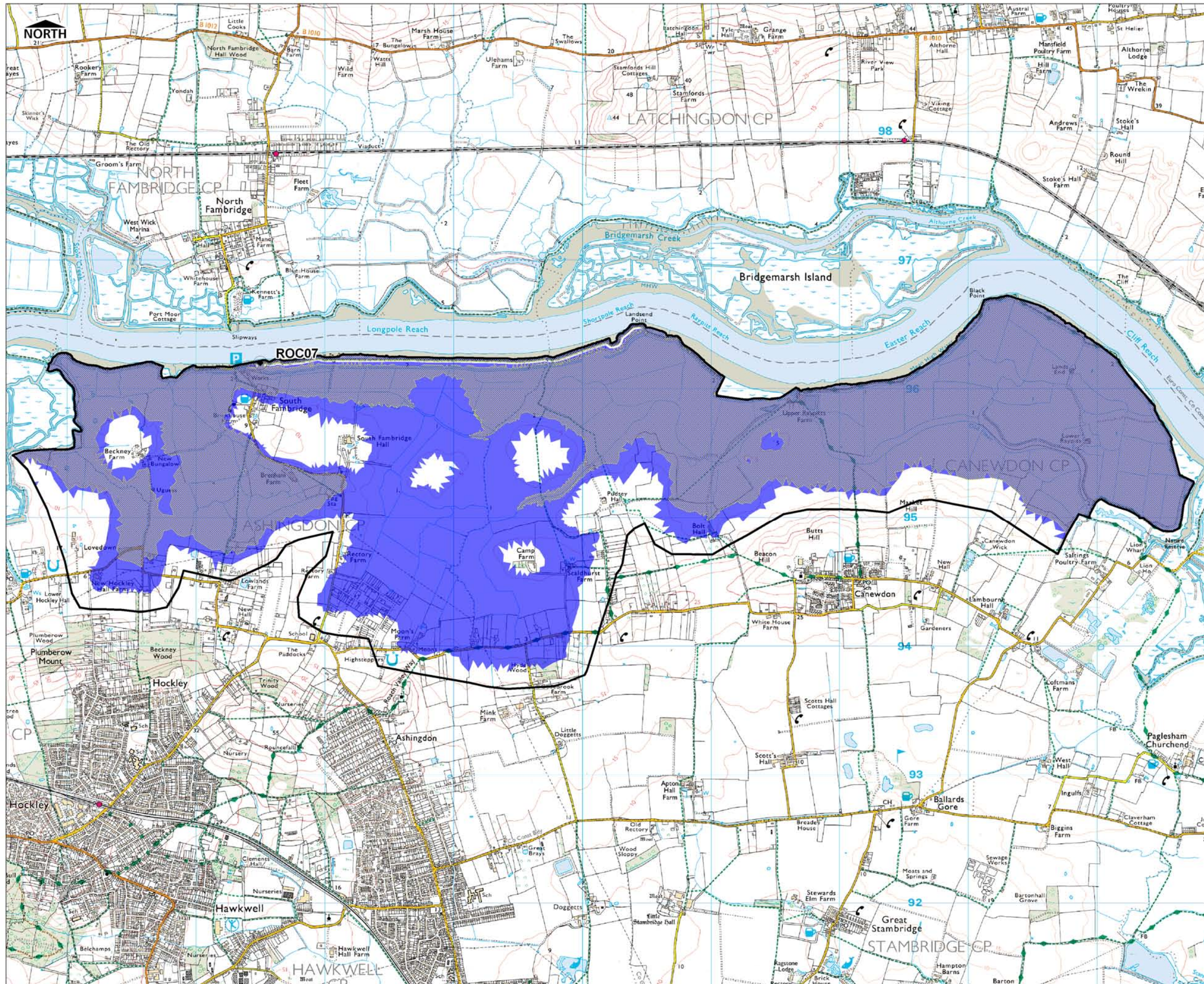
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 1000YR + CC (2110) BREACH ROC06



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER **FIGURE D-6**



KEY

- Flood Cell
- Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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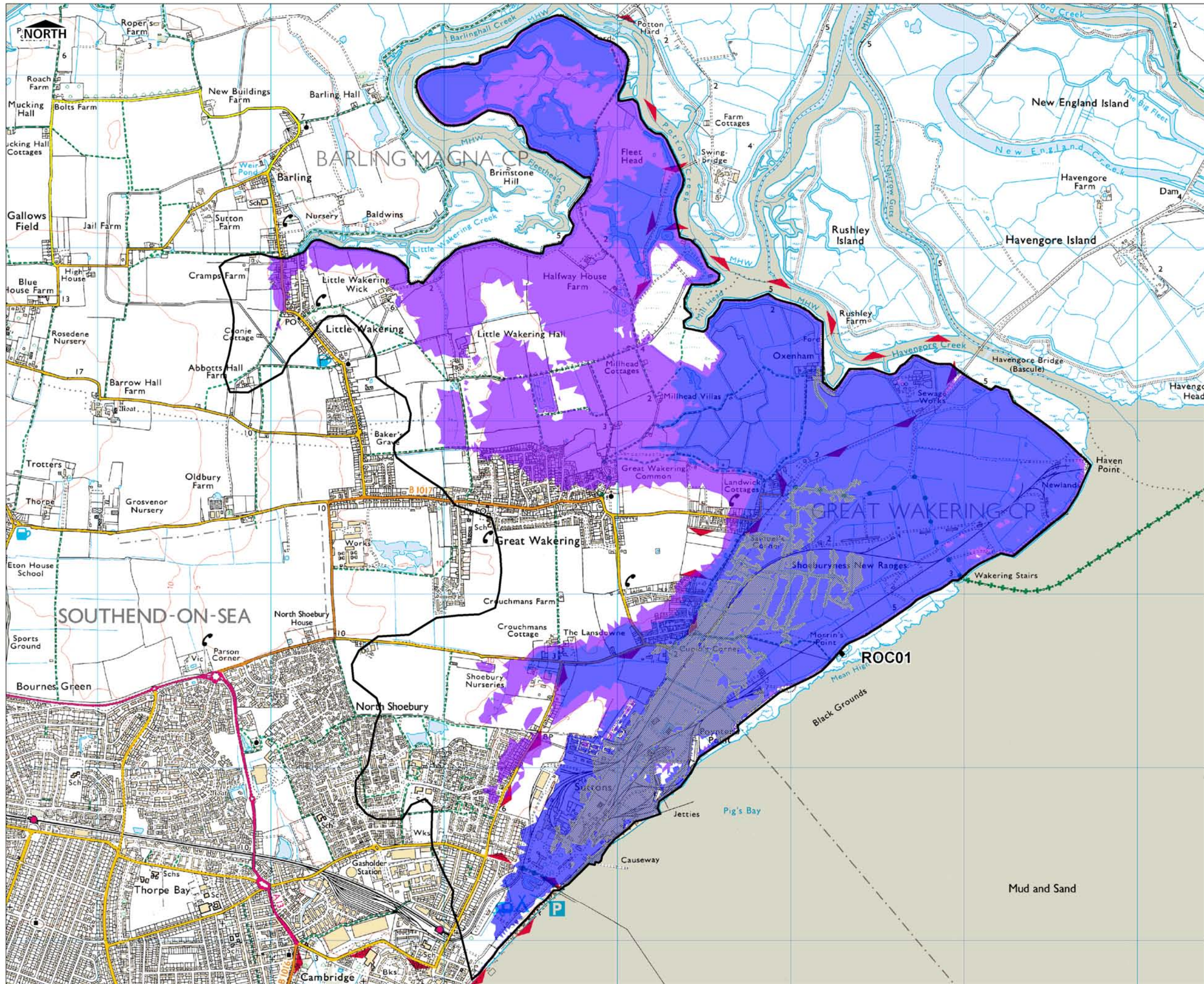
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 1000YR + CC (2110) BREACH ROC07

Basildon Council castlepoint Rochford District Council

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER **FIGURE D-7**



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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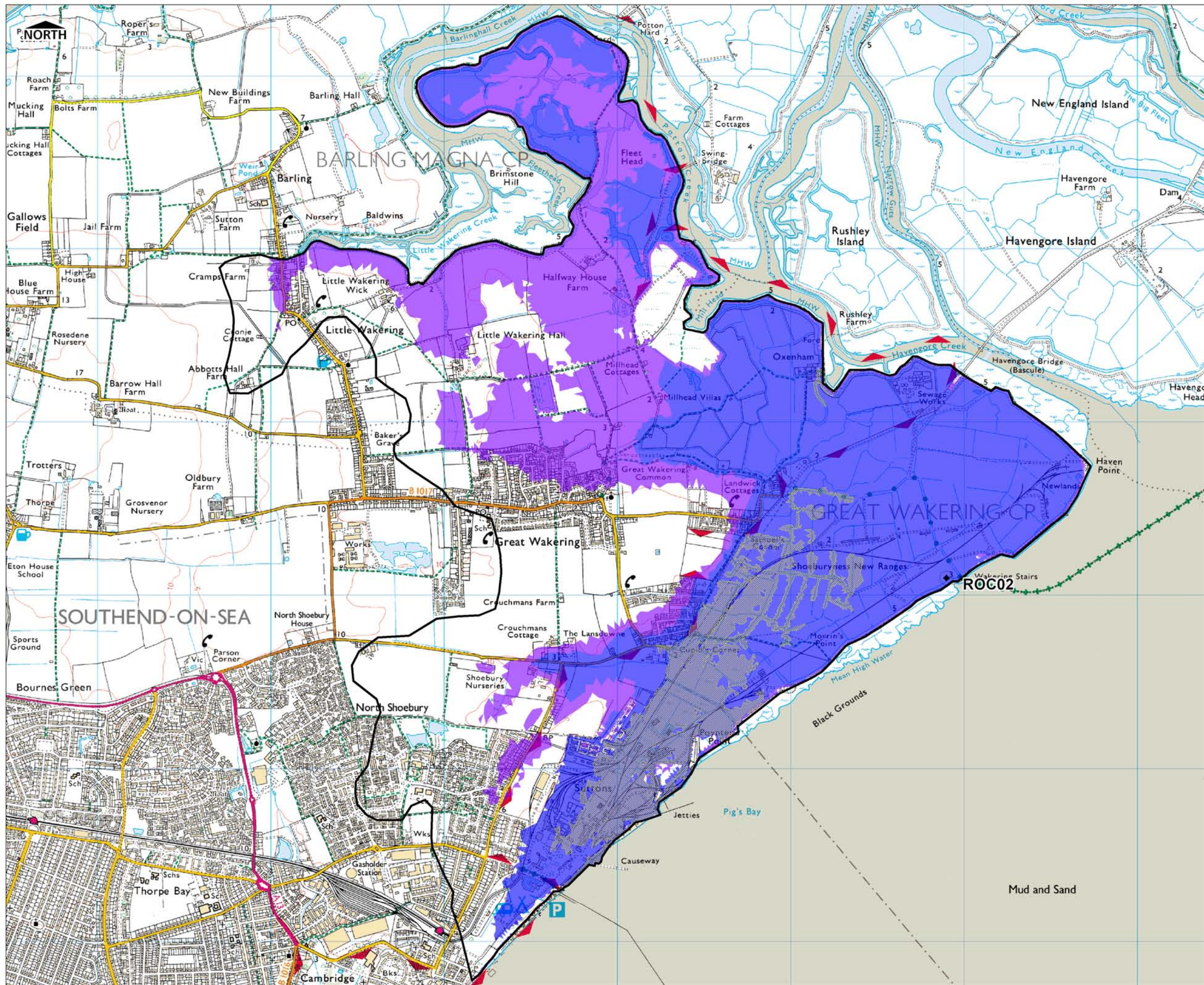
**TIME TO INUNDATION
0200YR + CC (2110)
BREACH ROC01**



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000



DRAWING NUMBER
FIGURE D-8



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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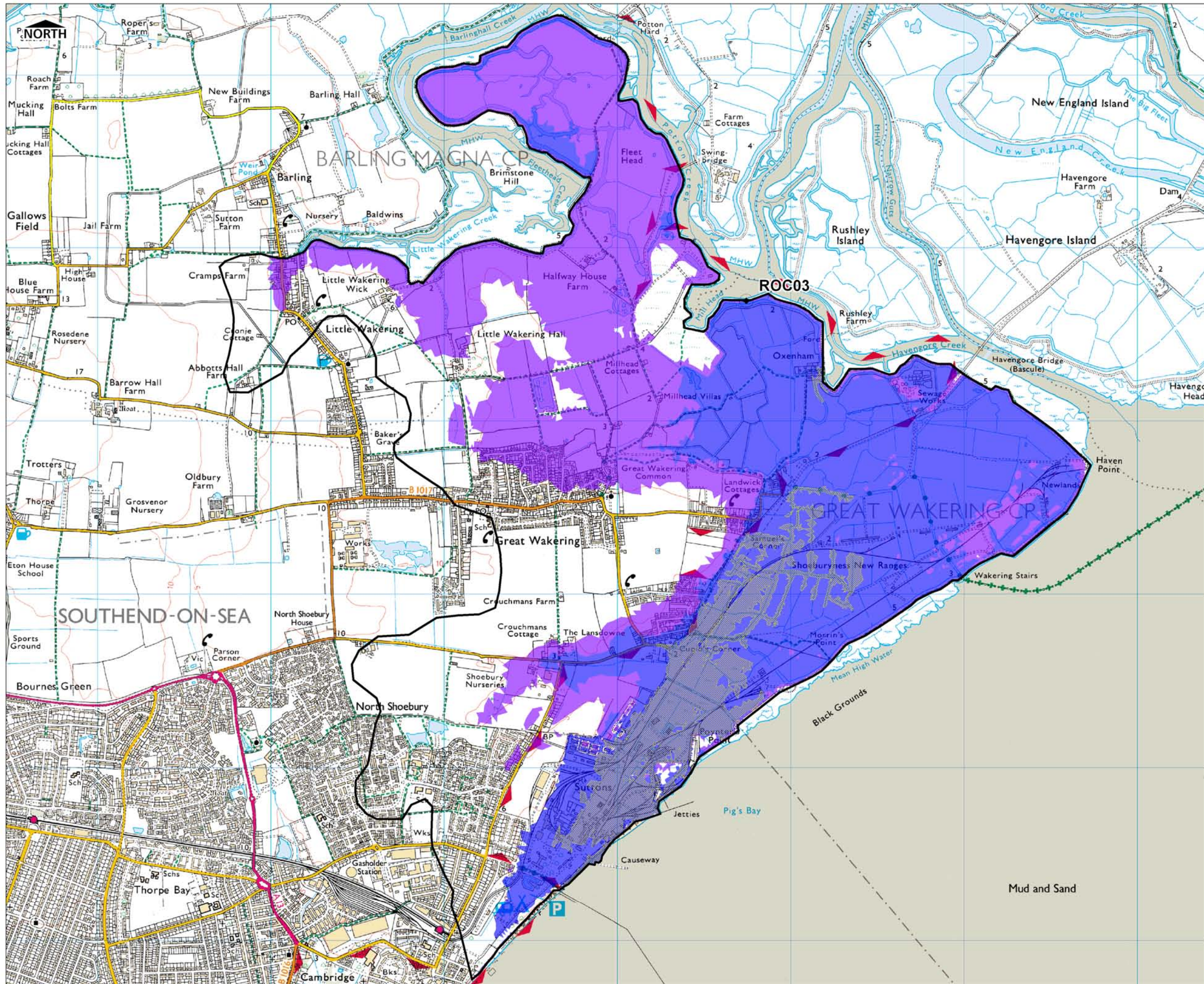
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION
 0200YR + CC (2110)
 BREACH ROC02



Scott Wilson
 6-8 Greencoat Place
 London, SW1P 1PL
 Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE D-9



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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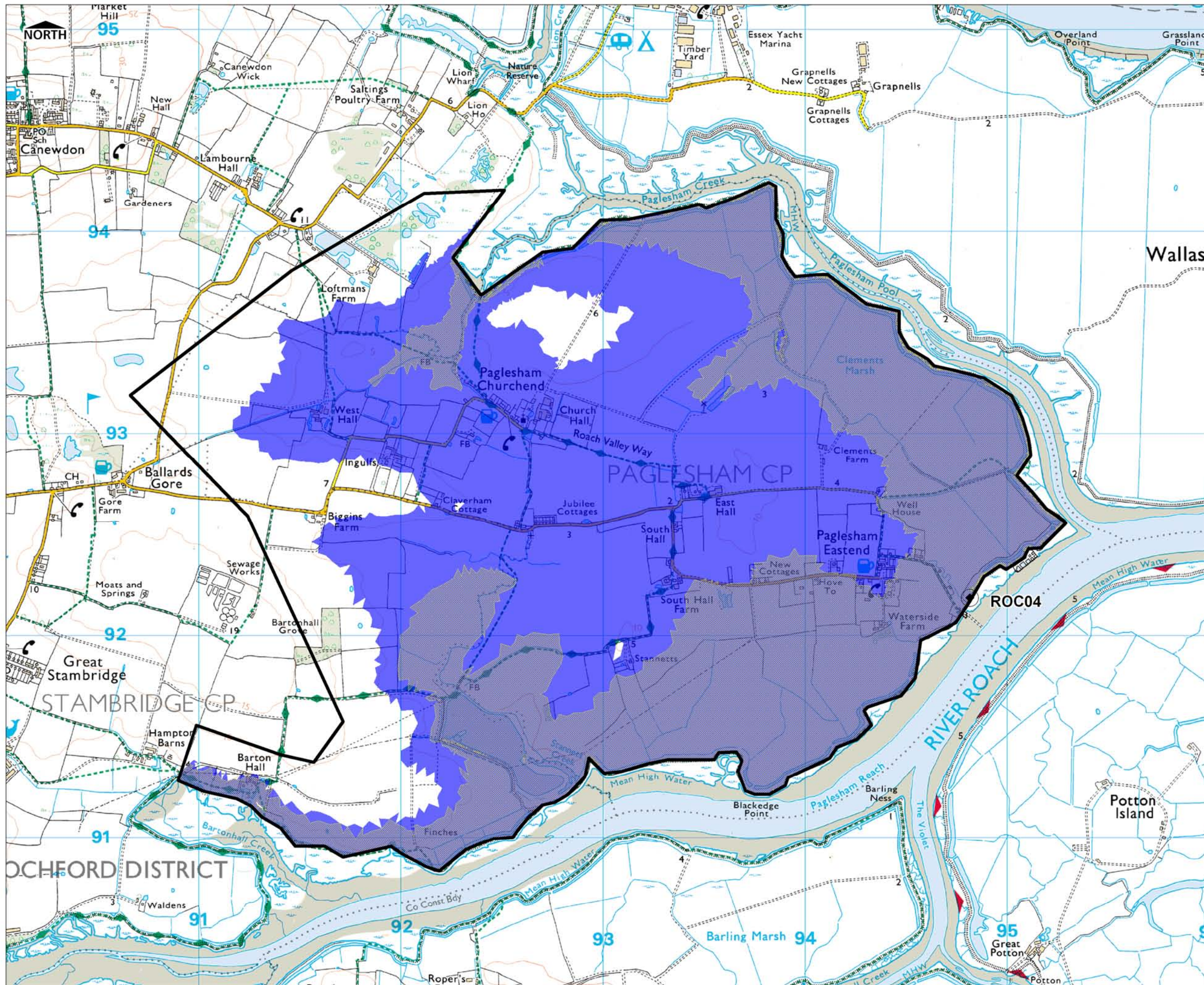
TIME TO INUNDATION
 0200YR + CC (2110)
 BREACH ROC03



Scott Wilson
 6-8 Greencoat Place
 London, SW1P 1PL
 Tel: (020) 7798 5000



DRAWING NUMBER
FIGURE D-10



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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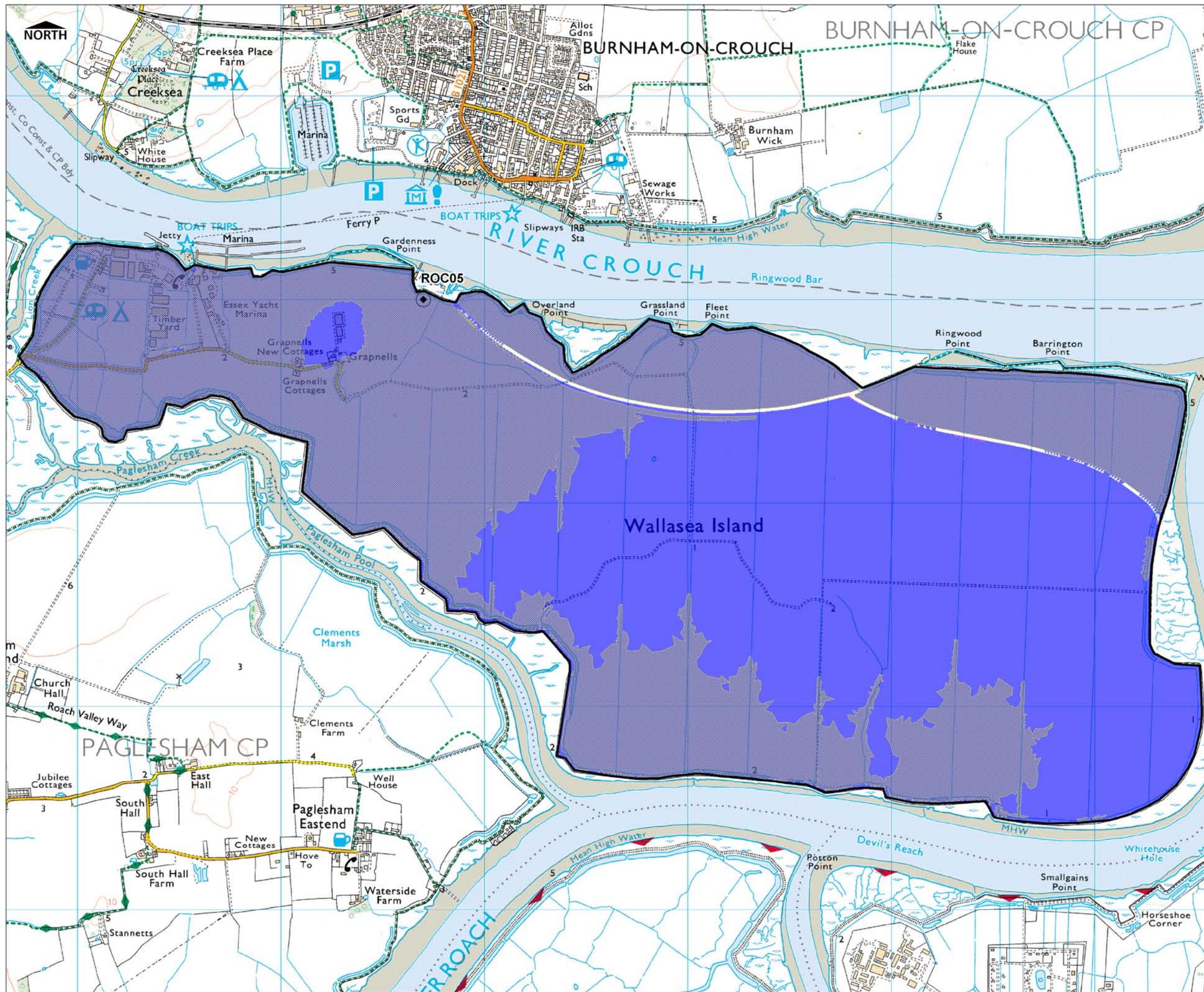
**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**TIME TO INUNDATION
0200YR + CC (2110)
BREACH ROC04**



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE D-11



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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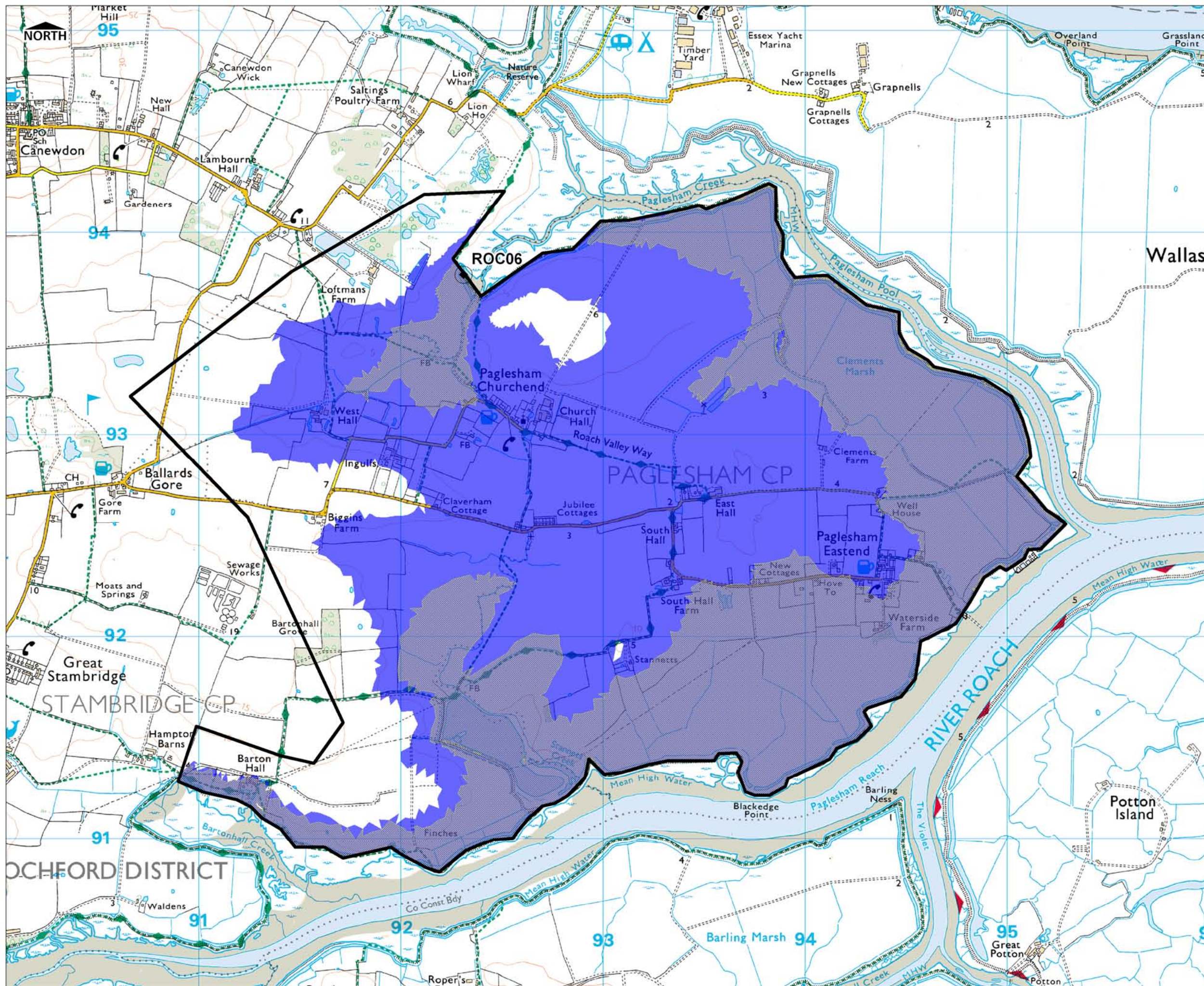
**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**TIME TO INUNDATION
0200YR + CC (2110)
BREACH ROC05**



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE D-12



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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USER NOTE

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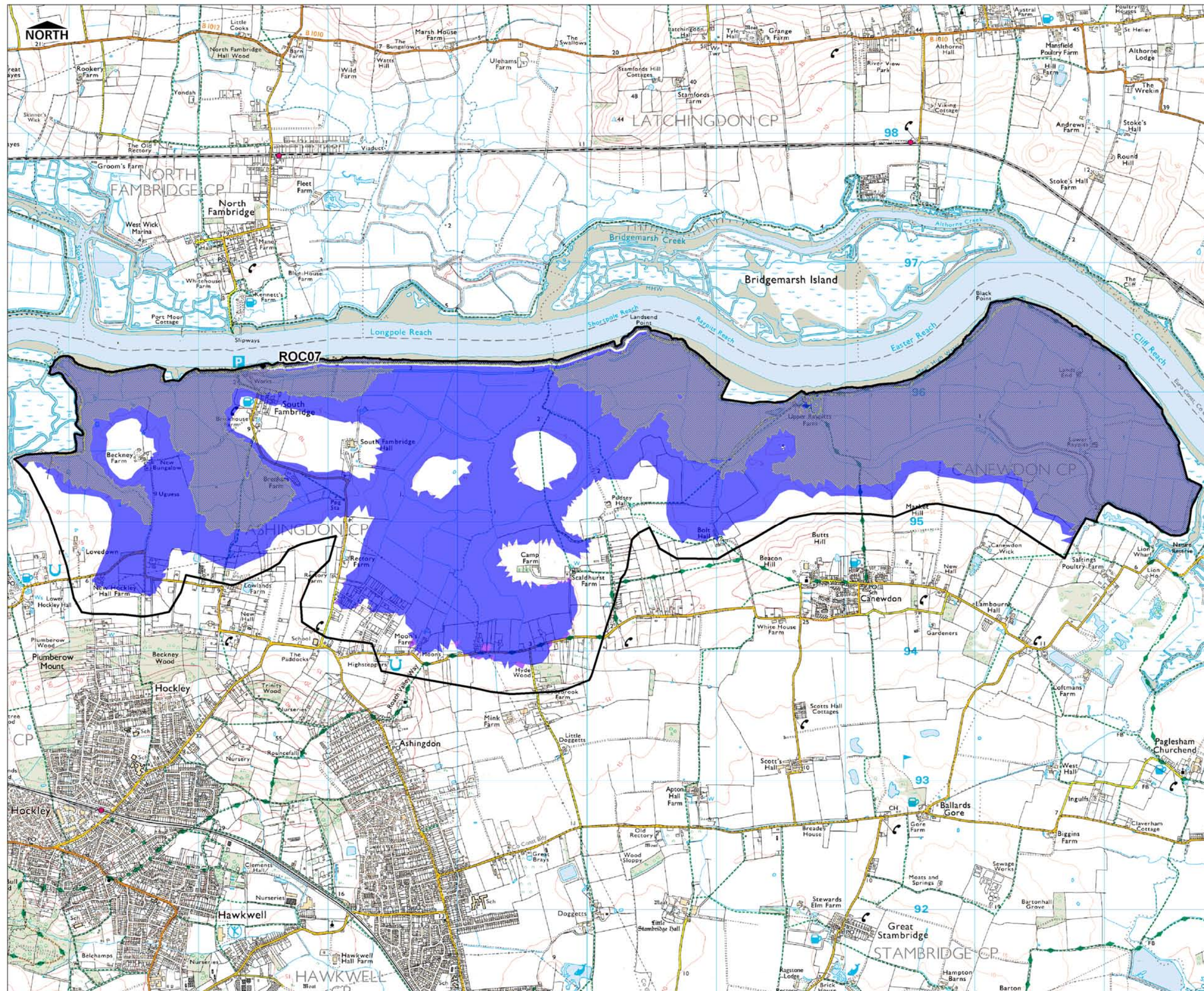
**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**TIME TO INUNDATION
0200YR + CC (2110)
BREACH ROC06**



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER
FIGURE D-13



KEY

- Flood Cell
- Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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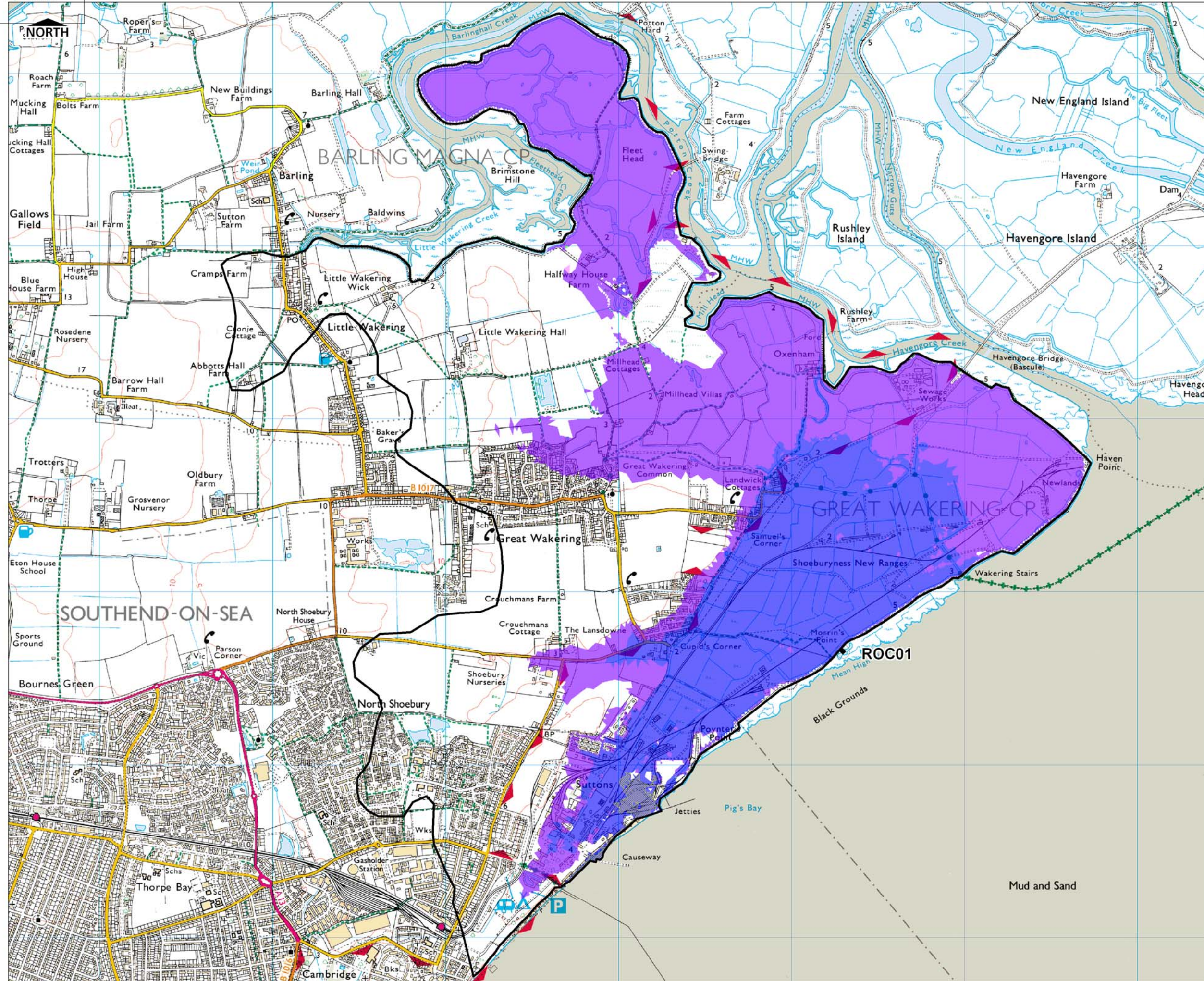
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 0200YR + CC (2110) BREACH ROC07

Basildon Council castlepoint Rochford District Council

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

No Window



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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Time to inundation maps represent the onset of flooding from 1 specified breach. The rate will vary spatially if the breach locations are in different local areas. Changes in inundation extent or rate of onset of flooding are non-linear to changes in breach location. It should be noted that the breach width and depth, though based on EA guidance, are arbitrary and do not necessarily represent the actual dimensions of a potential breach at a given location.

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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

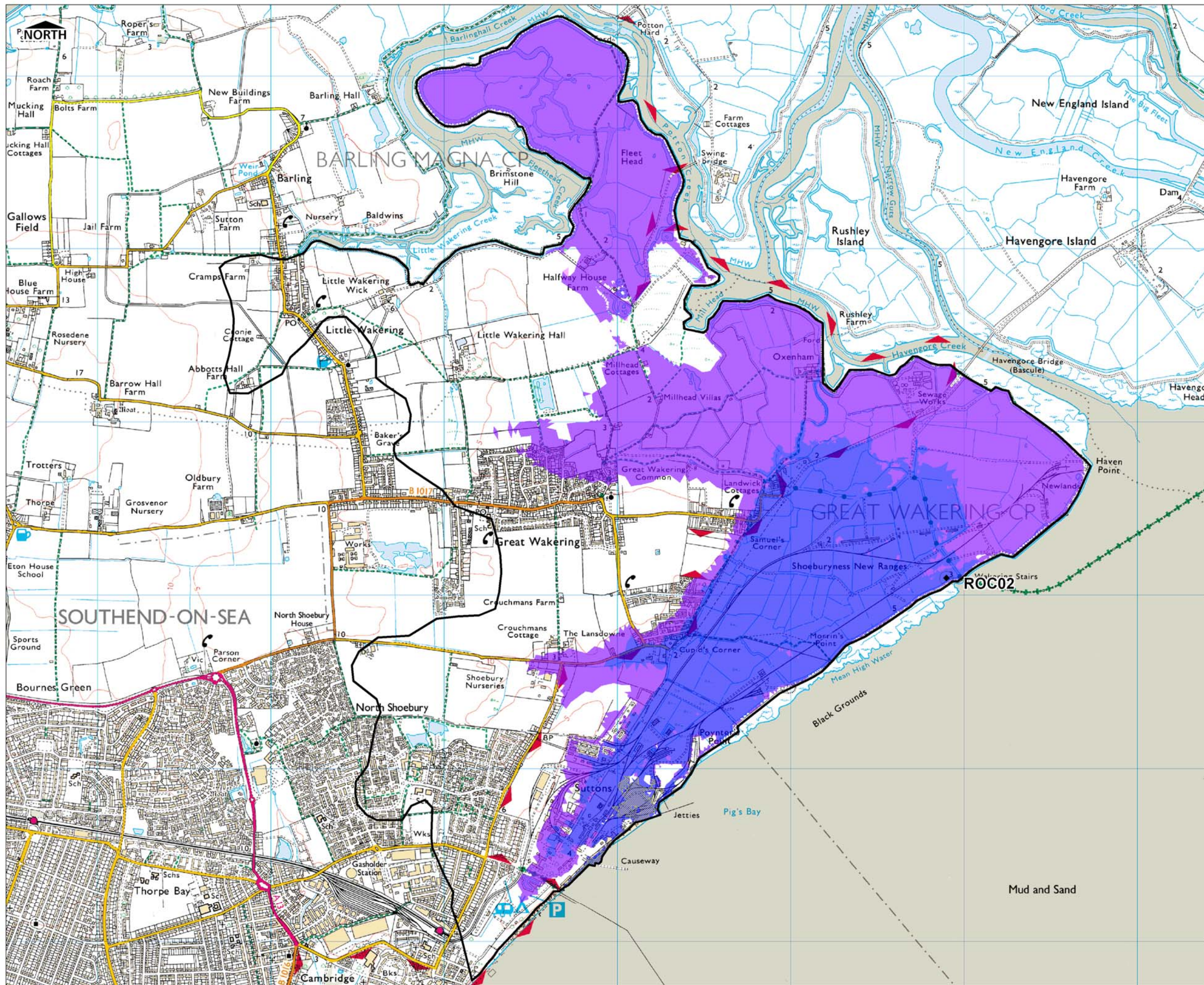
**TIME TO INUNDATION
1000YR (2010)
BREACH ROC01**



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000



DRAWING NUMBER
FIGURE D-15



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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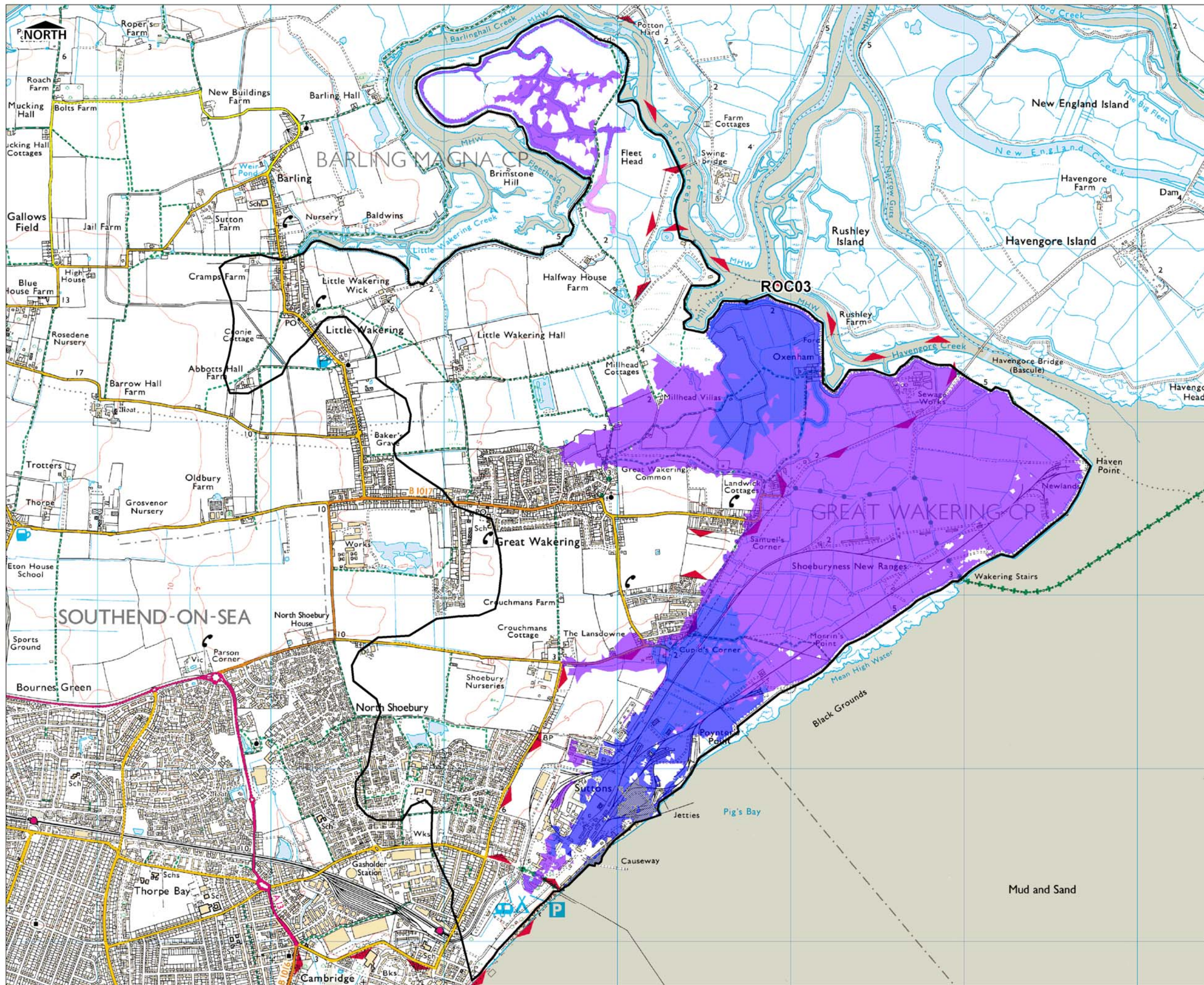
THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 1000YR (2010) BREACH ROC02



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

DRAWING NUMBER **FIGURE D-16**



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 1000YR (2010) BREACH ROC03

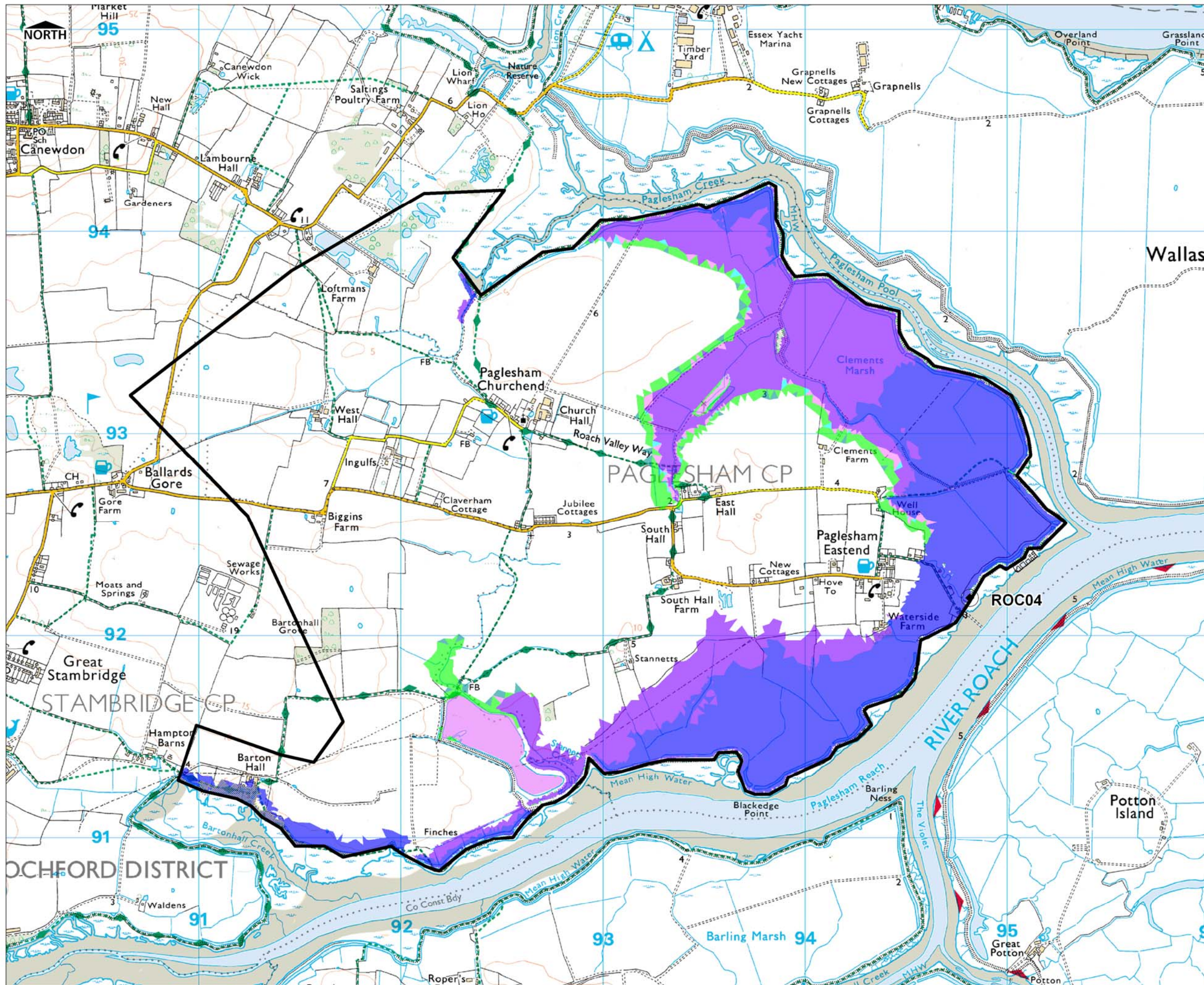


Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000



DRAWING NUMBER

FIGURE D-17



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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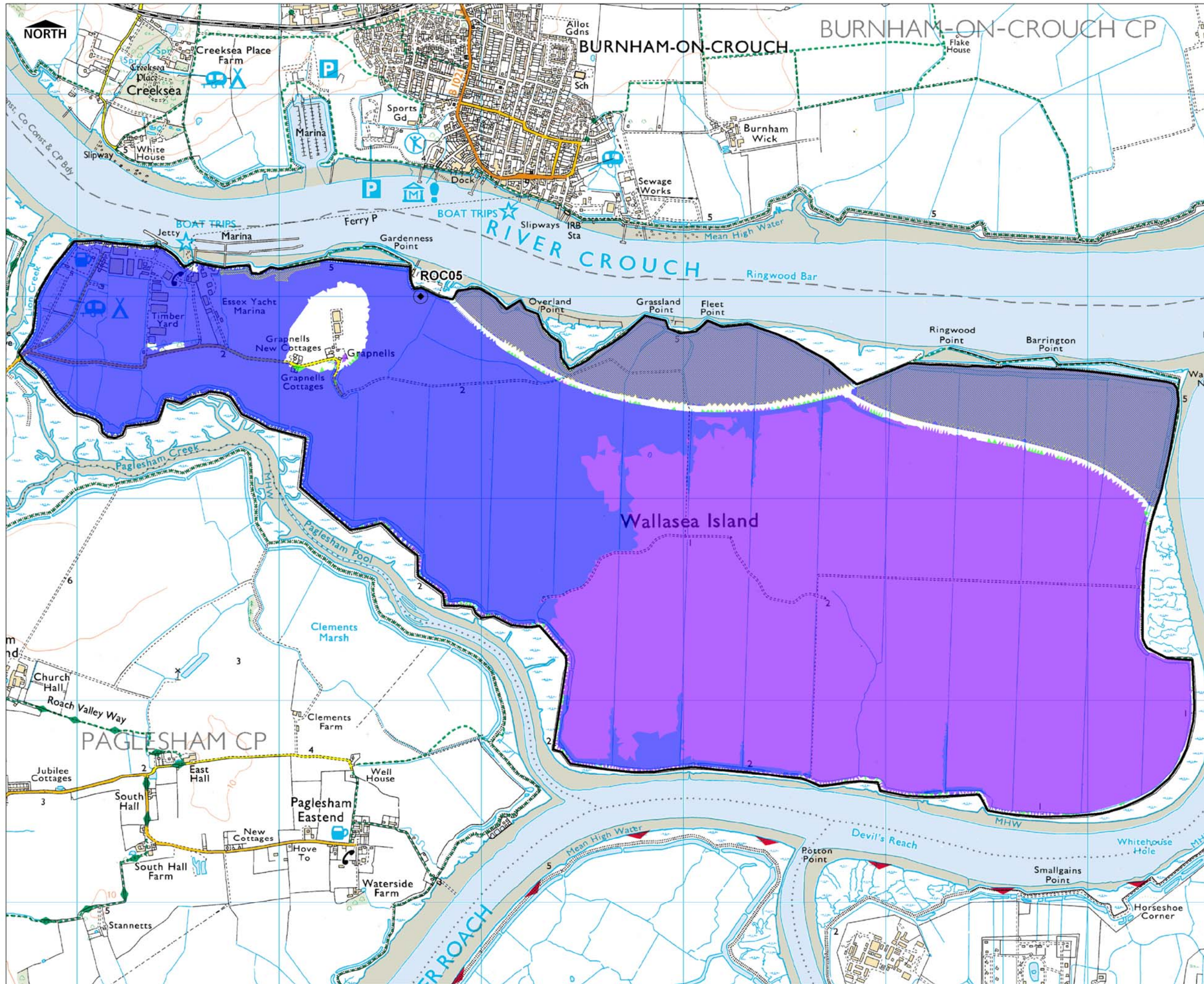
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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 1000YR (2010) BREACH ROC04



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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TIME TO INUNDATION 1000YR (2010) BREACH ROC05

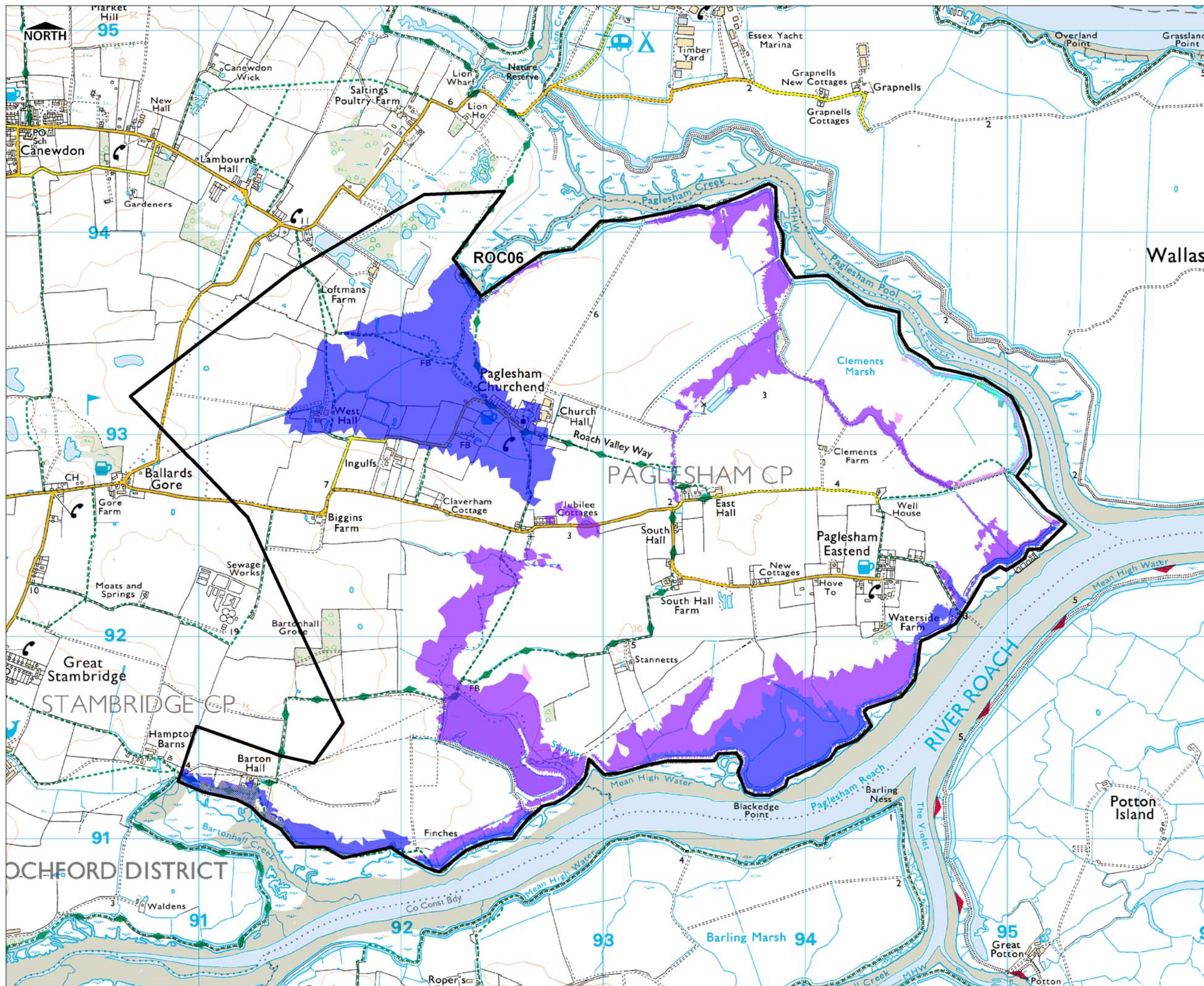


Scott Wilson
 6-8 Greencoat Place
 London, SW1P 1PL
 Tel: (020) 7798 5000



DRAWING NUMBER

FIGURE D-19



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

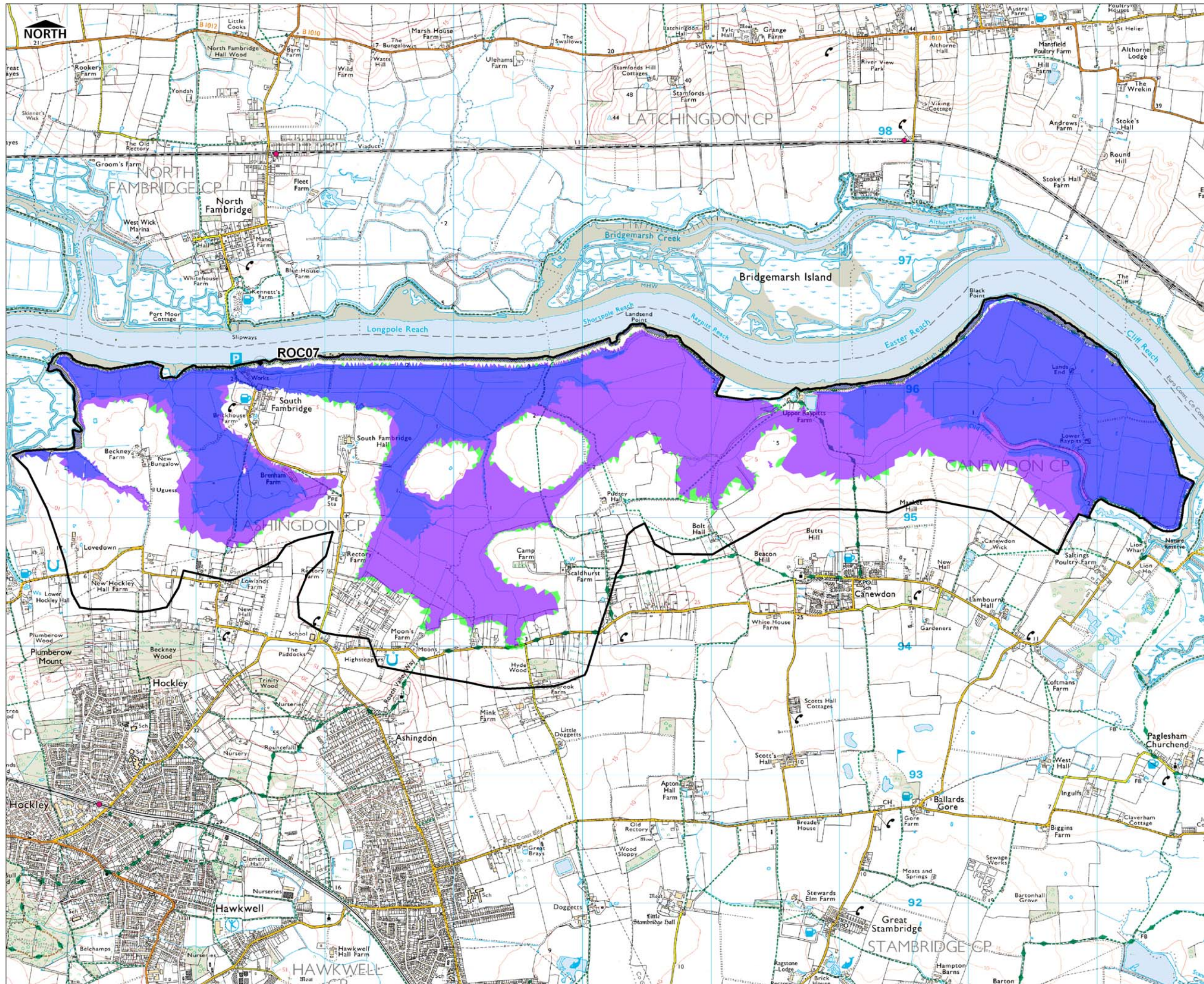
**TIME TO INUNDATION
1000YR (2010)
BREACH ROC06**



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000



DRAWING NUMBER
FIGURE D-20



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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USER NOTE

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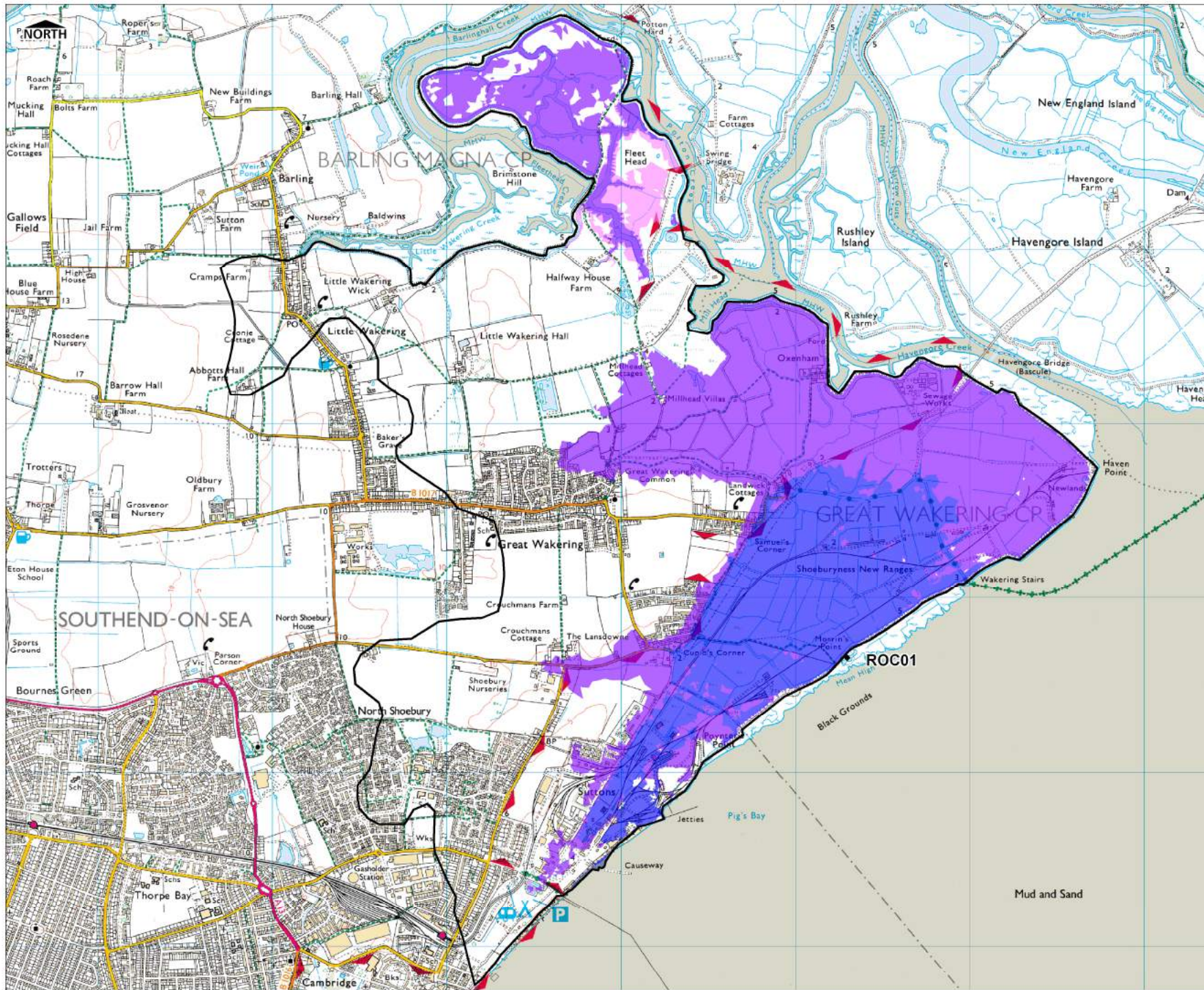
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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**TIME TO INUNDATION
1000YR (2010)
BREACH ROC07**

Basildon Council castlepoint Rochford District Council

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

TECHNICAL NOTE

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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 0200YR (2010)
BREACH ROC01

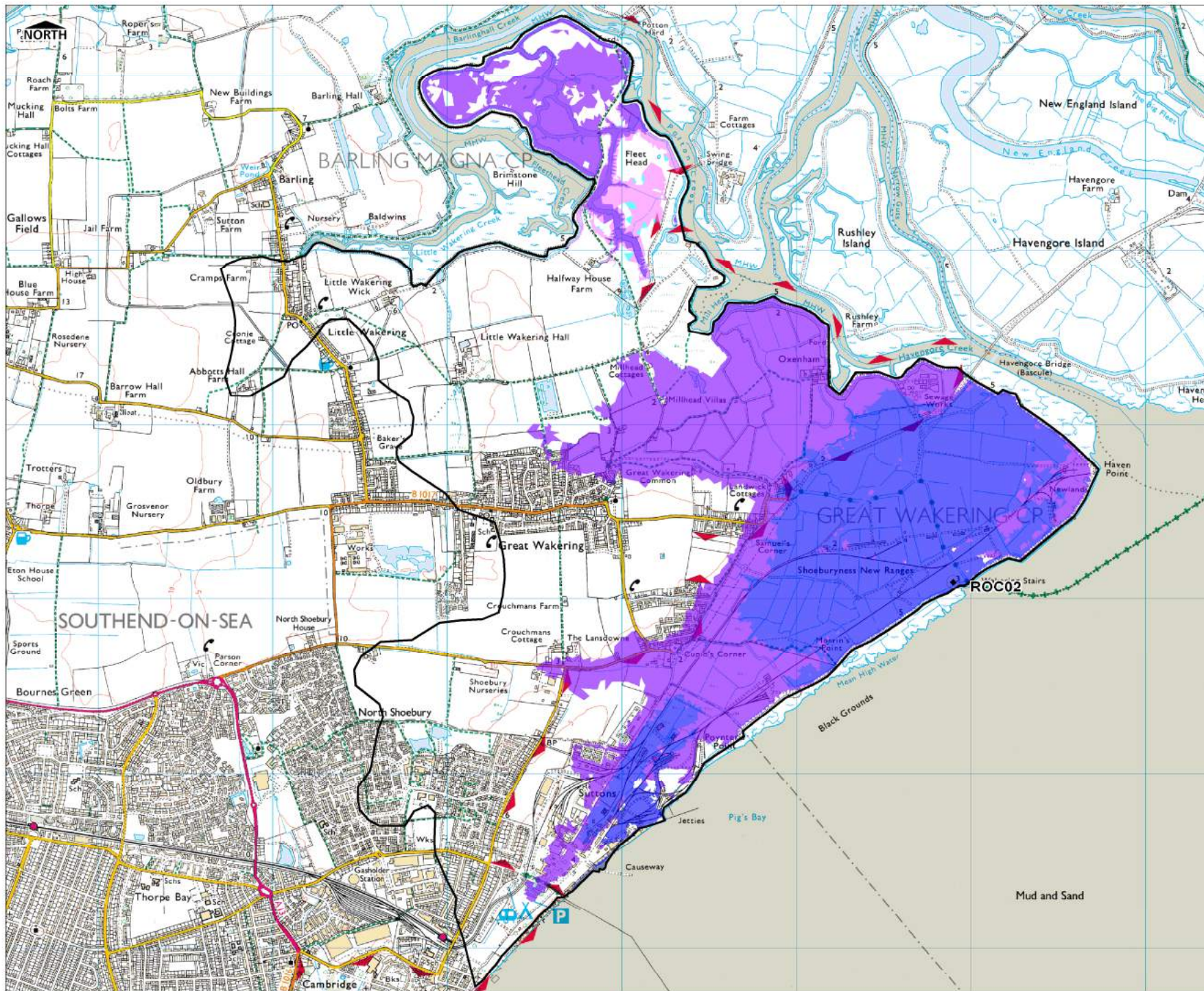
Basildon Council **castlepoint** **Rochford DISTRICT COUNCIL**

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

SCOTT WILSON

DRAWING NUMBER: **FIGURE D-22**

REV 01



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

TECHNICAL NOTE

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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**TIME TO INUNDATION
0200YR (2010)
BREACH ROC02**

Basildon Council
BASILDON DISTRICT COUNCIL

castlepoint
DISTRICT COUNCIL

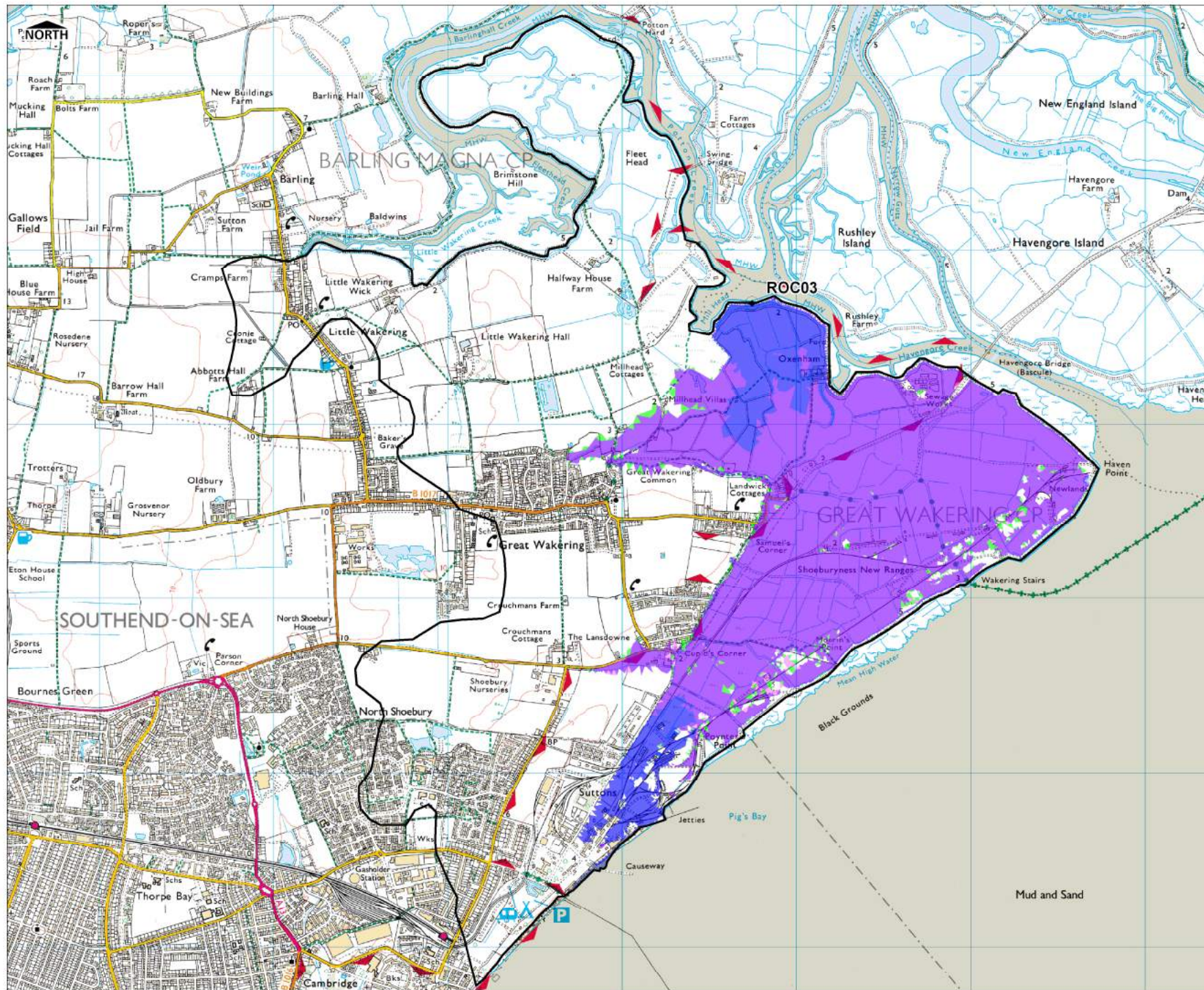
Rochford
DISTRICT COUNCIL

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

Scott Wilson

DRAWING NUMBER
FIGURE D-23

REV 01



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

TECHNICAL NOTE

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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**TIME TO INUNDATION
0200YR (2010)
BREACH ROC03**

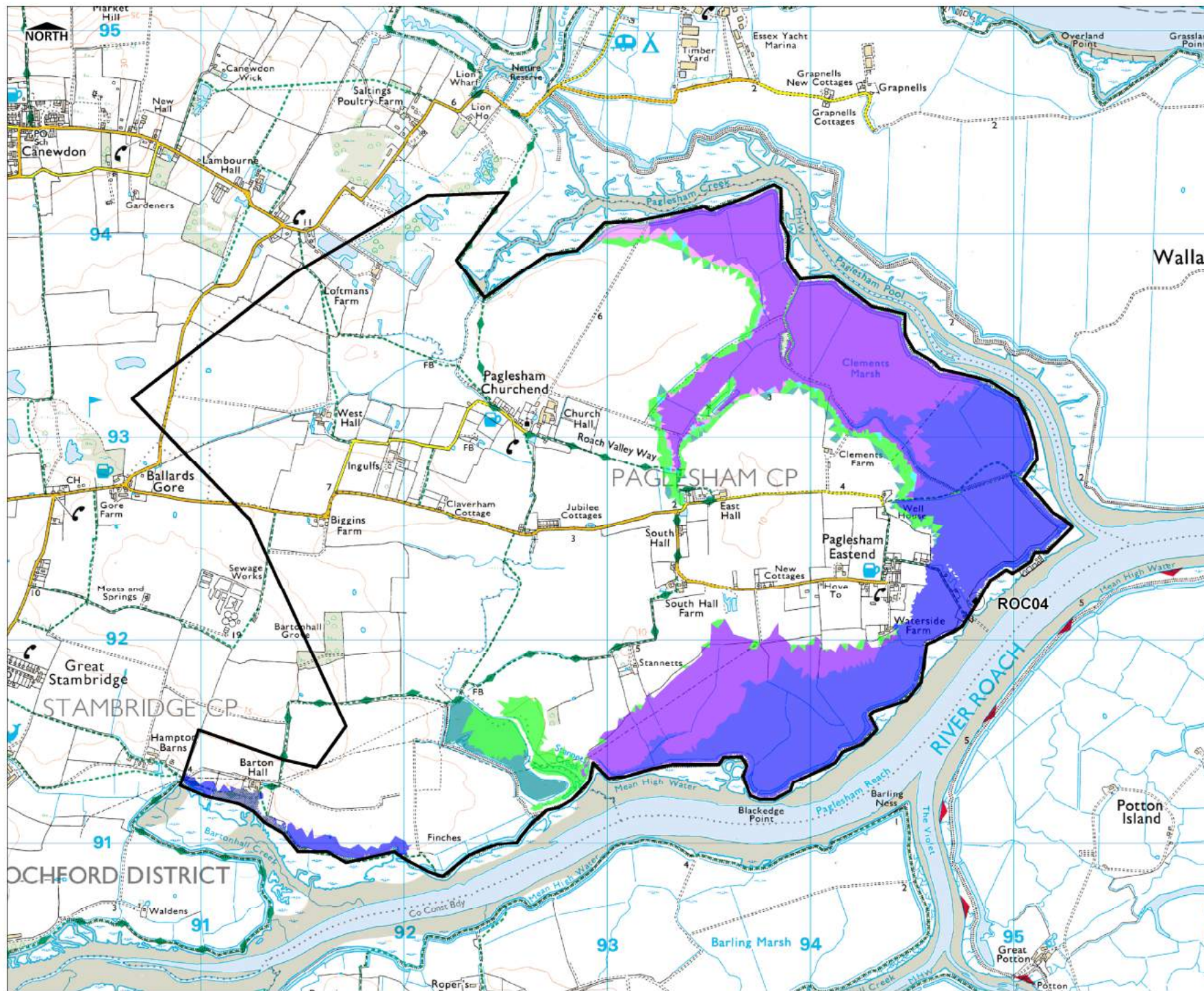
Basildon Council castlepoint Rochford District Council

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

SCOTT WILSON

FIGURE D-24

REV 01



KEY

- Flood Cell
- Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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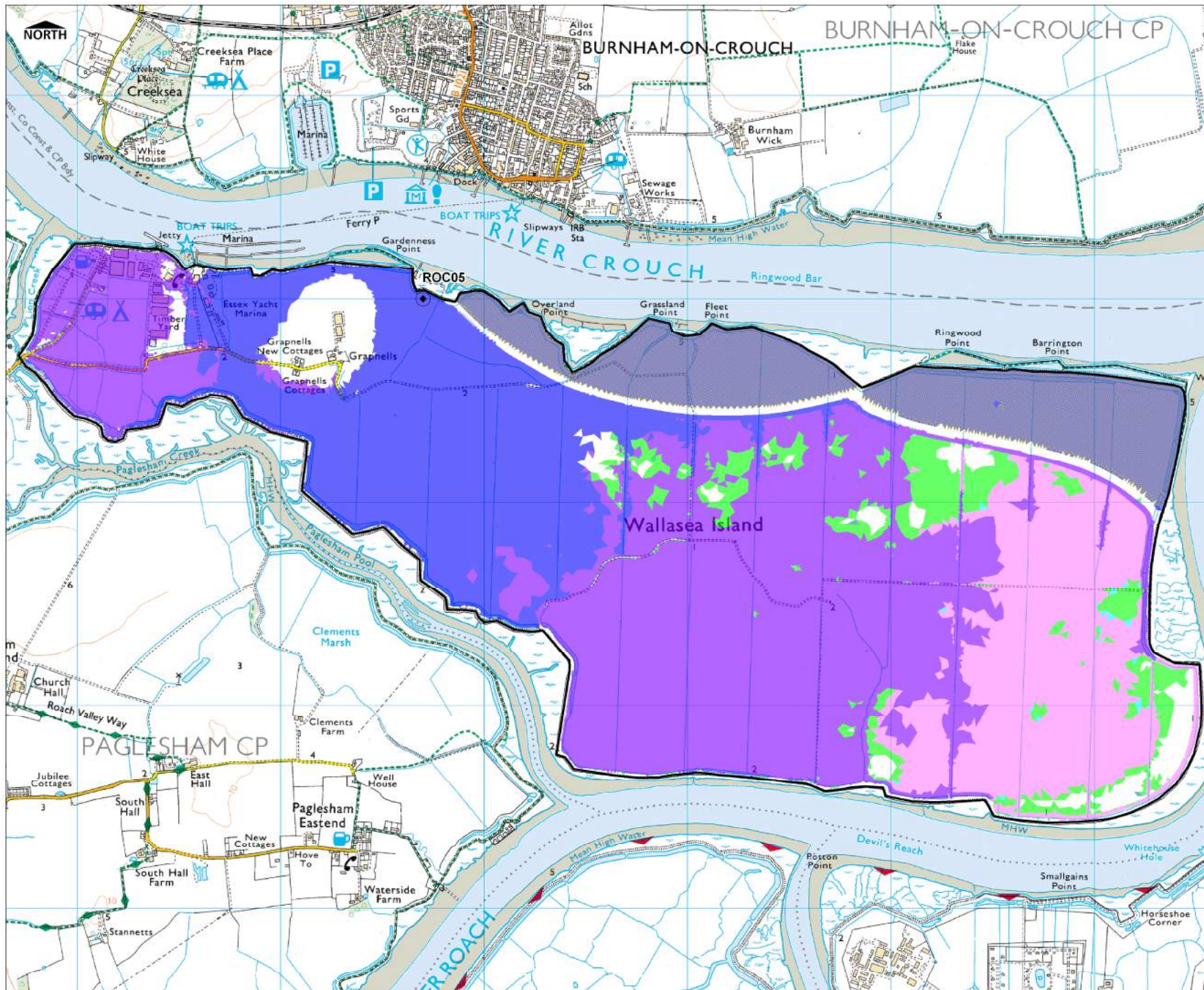
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		London

THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 0200YR (2010)
BREACH ROC04



Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7598 5000



KEY

- Flood Cell
- Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

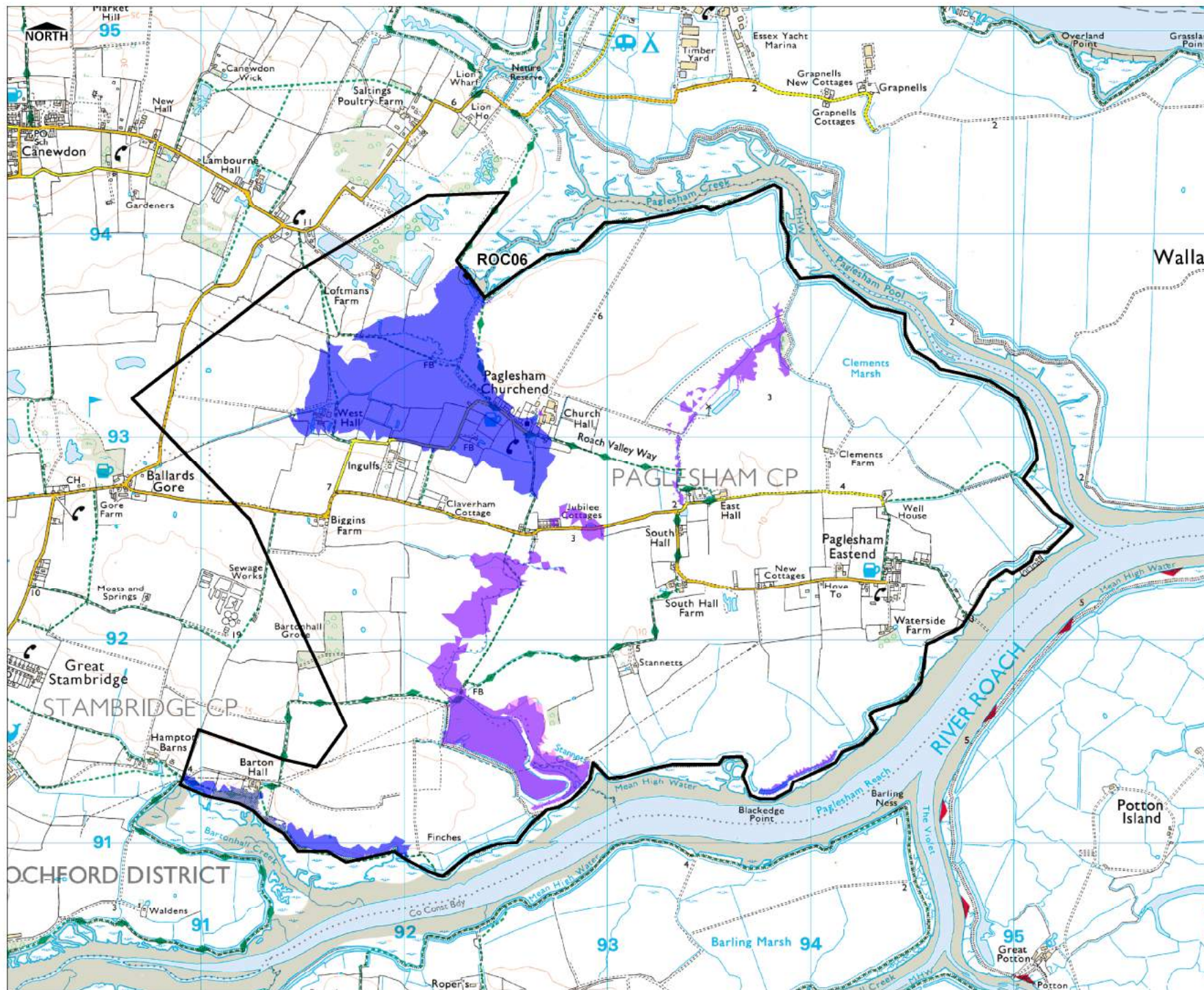
**TIME TO INUNDATION
0200YR (2010)
BREACH ROC05**

Basildon Council
Basildon District Council

castlepoint
Basildon District Council

Rochford
Rochford District Council

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000



KEY

- Flood Cell
- Breach Location

Time To Inundation [Hours]

- < 1 Hour
- 1 - 4 Hours
- 4 - 8 Hours
- 8 - 12 Hours
- 12 - 16 Hours
- 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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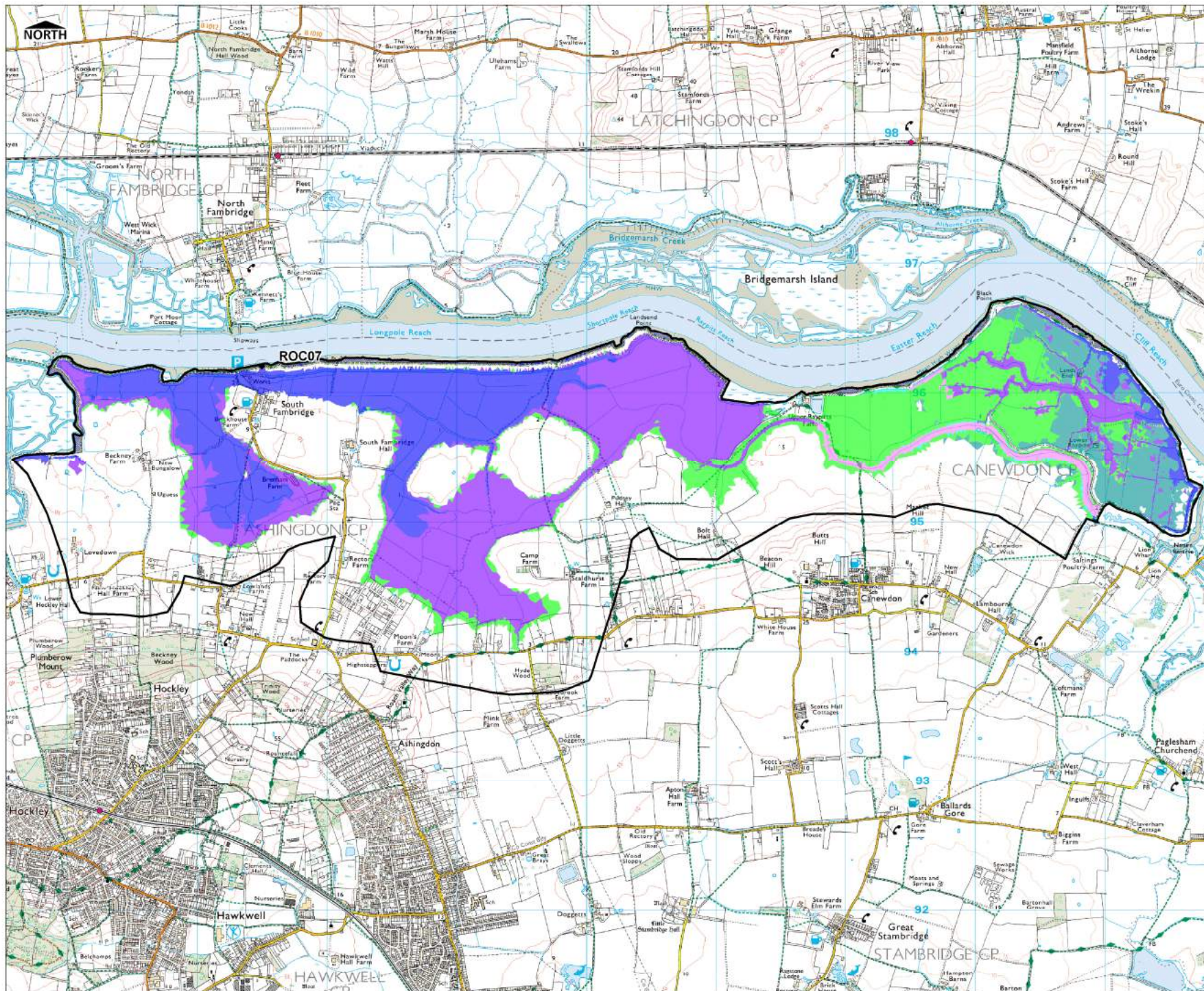
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THAMES GATEWAY SOUTH ESSEX STRATEGIC FLOOD RISK ASSESSMENT

TIME TO INUNDATION 0200YR (2010)
BREACH ROC06

Scott Wilson
 6-8 Greencoat Place
 London, SW1P 1PL
 Tel: (020) 7798 5000



KEY

- Flood Cell
- ◆ Breach Location

Time To Inundation [Hours]

- Blue: < 1 Hour
- Purple: 1 - 4 Hours
- Pink: 4 - 8 Hours
- Cyan: 8 - 12 Hours
- Green: 12 - 16 Hours
- Teal: 16 - 20 Hours

Inundation from overtopping prior to breach

TECHNICAL NOTE

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**THAMES GATEWAY SOUTH ESSEX
STRATEGIC FLOOD RISK ASSESSMENT**

**TIME TO INUNDATION
0200YR (2010)
BREACH ROC07**





Scott Wilson
 6-8 Greencoat Place
 London, SW1P 1PL
 Tel: (020) 7798 5000



Appendix E: Modelling Methodology

Appendix E: Hydrodynamic Breach Modelling Methodology

This appendix presents the methodologies used to develop modelling outputs, including maximum flood depth, hazard rating and time to inundation maps, for the Strategic Flood Risk Assessment.

Rapid Inundation Modelling

The modelling methodology used for this SFRA uses a 'breach at the peak' approach or 'rapid inundation' approach. Rapid inundation modelling simulates breaches that occur suddenly just before the peak tidal level. As the maximum force and volume of water behind the defences will occur at the peak of the simulated water level it was agreed that this modelling scenario would provide the most rapid inundation of the system. A greater volume of water would surge through the breach with more rapid and higher floodwater velocities simulated, particularly in the vicinity of the breaches. This would correspondingly produce the most severe time to inundation results in the area local to the breach position and hazard with velocity playing a large part in the determination of the flood hazard category in certain areas. The results from these scenarios could then be used to determine the minimum time to inundation for vulnerable locations in the flood cell, particularly for the more vulnerable properties located closer to the flood defences.

The total volume of water entering the system will be slightly less compared with a modelled situation where the breach is open throughout the modelled simulation (i.e. open flood gate situation), and inundation will be slightly lower in the outlying areas of the flood cell. The rapid inundation methodology will however more appropriately test the potential flooding in more vulnerable lower lying areas close to the breach. This methodology was agreed with the Environment Agency (EA) prior to the commencement of the project.

The modelling carried out for this SFRA was based on the previous modelling undertaken as part of the Thames Gateway SFRA. It should be noted that although many of these breach locations were previously identified, all of the breach modelling conducted within this study is original and does not use or incorporate any previous modelling; each breach cell has been reconstructed exclusively for this study. In addition, every breach location has been assessed for suitability to this study.

Site Visit

Initially each breach was investigated to determine the location of the breach, the defence type and height, the width of the breach and the invert level of the breach. This was informed by the previous SFRA and validated using aerial photography and topographic data in the form of LiDAR. This information was then sent to the EA for confirmation and comment prior to visiting the site to ensure any points for discussion and further investigation were highlighted prior to the visit.

This database was then confirmed by a site visit where all breach locations, (with the exception of the inaccessible ones: CAS01, ROC01 & ROC02), were visited prior to commencement of the modelling process. This site visit was undertaken to ensure each breach location was positioned sensibly and properly represented within the model, and equally importantly that the wider flood cell was adequately represented with any important features noted.

Topographic Data

A key component in the modelling process is the representation of topography throughout flood prone regions of the study area. For this purpose, a Digital Terrain Model (DTM) was derived for each of the modelled areas. A DTM is a three-dimensional 'playing field' on which the model simulations are run.

The platform used for the generation of the DTM was the GIS software package MapInfo Professional (version 8.5.2) and its daughter package Vertical Mapper (version 3.1).

The DTM is primarily based on filtered LiDAR data provided by the EA. LiDAR (Light Detection And Ranging) is a method of optical remote sensing, similar to the more primitive RADAR (which uses radio waves instead of light). Filtered LiDAR data represents the "bare earth" elevation with buildings, structures (such as bridges) and vegetation removed. In this case, the LiDAR surveys return data at a horizontal resolution of 2 metres, 1 metre and 0.25metres (that is, a unique elevation level is given every two/one/0.25 metres in both the north-south and east-west directions). The LiDAR was provided by the EA for this study and the following information is provided for completeness:

- All of the data is referenced using the British National Grid OSGB36, the Z value is metres above Ordnance Datum Newlyn.
- Data from different, overlapping surveys, at different resolutions, have been merged together. The newest, and highest resolution data, has had precedence in the merging process. If the input data was at a resolution finer than 2 metres, it was re-sampled to 2 metres using the bilinear interpolation method in ESRI's Spatial Analyst software.

During the compilation of the DTM it was realised that there were gaps in the LiDAR coverage. In order to accurately represent each flood cell complete topographic data was needed. Synthetic Aperture Radar or SAR was used to infill the gaps. SAR is generally less accurate and has a lower resolution (approximately 5m compared to the 2m LiDAR) so is used only in areas where LiDAR is not available.

The LiDAR data combined with SAR data was used to create a DTM grid covering the complete study area. In addition to the 2m LiDAR some 25cm LiDAR data was obtained. This is generally available for areas of specific interest only, such as along defences, so is patchy. As 25cm LiDAR is very accurate the files are extremely large. To allow reasonable working times, the 2m LiDAR was used as a basis for the modelling and where 25cm LiDAR was available this was used to override the 2m data. This provided a more accurate representation of the topography within the flood cell.

Flood Cell Definition

Sixteen breach locations have been identified along the northern bank of the River Thames, and the Rivers Crouch and Roach within the Basildon Borough, Castle Point Borough and Rochford District Council administrative areas. Details are provided in Table E-1 and shown in Figure A-1.

Table E-1 Breach Characteristics

Code (TGSE update 2010)	Breach Name (TGSE update 2010)	Previous Code (TGSE SFRA 2006)	Previous Breach Name (TGSE SFRA 2006)	Easting	Northing
BAS01/CAS	Flood barrier, Fobbing Horse, Vange Creek	Cas09	Barrier Vange Creek	574044.7	184305.5
CAS01	Upper Horse	Cas01	Canvey Island 1	575200	183400
CAS02	Canvey Village, Lower Horse	Cas02	Canvey Island 2	577100	182600
CAS03	STW	Cas03	Canvey Island 3	578100	182000
CAS04	Canvey Island Golf Course	Cas04	Canvey Island 4	579437.5	182463
CAS05	Leigh Beck	Cas05	Canvey Island 5	581600	182700
CAS06	Sunken Marsh	Cas06	Canvey Island 6	580900	184300
CAS07	Castle Point Golf Course	Cas07	Canvey Island 7	579008.6	185005
CAS08	Benfleet Creek Flood Barrier	Cas08	Benfleet Marshes	578067.6	185605
ROC01	Morrin's Point	Roc05	Morrin's Point	596298.3	186654.2
ROC02	Waking Stairs	Roc04	Waking Stairs	596900	187100
ROC03	Oxenham Farm	Roc06	Oxenham Farm	595745	188694.5
ROC04	Paglesham Eastend	Roc03	Paglesham East End	594767.5	192116.8
ROC05	Grapnells, Wallasea Island	Roc01	Wallasea Island	594700	195000
ROC06	Loftmans Farm, Paglesham Creek	Roc07	Paglesham Creek	592370.3	193694
ROC07	South Fambridge	Roc02	South Fambridge	585500	196200

Code (TGSE update 2010)	River	River Classification	Defence Type	Breach Width (m)*	Breach Invert Level (m)	Crest Height APPROX (m)
BAS01/CAS	Vange Creek, Thames Estuary - Esturay	Estuary	hard defence - barrier	width of barrier-45	1	6.5
CAS01	Holehaven Creek, Thames Estuary	Estuary	hard defence with earth embankment	20	2.4	6.4
CAS02	Holehaven Creek (mouth), Thames Estuary	Estuary	hard defence with earth embankment	20	2.3	6.5
CAS03	Thames Estuary	Estuary	hard defence with earth embankment	20	2	6.9
CAS04	Thames Estuary	Estuary	hard defence with earth embankment	20	1.7	6.8
CAS05	Thames Estuary	Estuary	hard defence with earth embankment (breach at flood gate)	20	1.5	6.3
CAS06	Benfleet Creek, Thames Estuary	Estuary	hard defence with earth embankment	20	2.7	6.5
CAS07	Benfleet Creek, Thames Estuary	Estuary	hard defence with earth embankment	20	3.2	6.3
CAS08	Benfleet Creek, Thames Estuary	Estuary	hard defence - barrier	width of barrier-50	2.5	7.5
ROC01	Thames Estuary - Open Sea	Open Coast	earth embankment	200	1.7	5.1-5.3
ROC02	Thames Estuary - Open Sea	Open Coast	earth embankment	200	1.7	4.9-5.4
ROC03	The Middleway	Tidal river	earth embankment	50	1.5	4.8
ROC04	River Roach	Tidal river	flood gate	50	2.3	4.5
ROC05	River Crouch	Tidal river	earth embankment	50	1.5	4.4-4.3
ROC06	Paglesham Creek, River Roach	Tidal river	earth embankment	50	1.8	4.6
ROC07	River Crouch - River	Tidal river	earth embankment	50	1.2	5.6

Code (TGSE update 2010)	Source of water level info	200 year	200 year with 100 years of Climate Change allowance	1000 year	100 year with 100 years of Climate Change allowance
BAS01/CAS	Thames Estuary Extreme Water Levels (2008)	5.15	6.25	5.68	6.77
CAS01	Thames Estuary Extreme Water Levels (2008)	5.15	6.25	5.68	6.77
CAS02	Thames Estuary Extreme Water Levels (2008)	5.12	6.22	5.63	6.75
CAS03	Thames Estuary Extreme Water Levels (2008)	5.12	6.22	5.63	6.75
CAS04	Thames Estuary Extreme Water Levels (2008)	5.05	6.14	5.54	6.65
CAS05	Thames Estuary Extreme Water Levels (2008)	5.02	6.12	5.51	6.62
CAS06	Thames Estuary Extreme Water Levels (2008)	4.95	6.05	5.43	6.55
CAS07	Thames Estuary Extreme Water Levels (2008)	4.95	6.05	5.43	6.55
CAS08	Thames Estuary Extreme Water Levels (2008)	4.95	6.05	5.43	6.55
ROC01	Anglian Region Extreme Tide Levels (2007)	4.49	5.54	4.83	5.88
ROC02	Anglian Region Extreme Tide Levels (2007)	4.48	5.53	4.82	5.87
ROC03	Anglian Region Extreme Tide Levels (2007)	4.46	5.51	4.81	5.86
ROC04	Anglian Region Extreme Tide Levels (2007)	4.43	5.48	4.58	5.63
ROC05	Anglian Region Extreme Tide Levels (2007)	4.36	5.41	4.64	5.69
ROC06	Anglian Region Extreme Tide Levels (2007)	4.43	5.48	4.58	5.63
ROC07	Anglian Region Extreme Tide Levels (2007)	4.40	5.45	4.64	5.69

Once the DTM grids and breach locations were obtained and confirmed, the flood cell for each model must be defined. The flood cell is the geographical extent of the model; the area of the overall DTM that will be used in the model. While it would be possible to run each of the breach models using all of the derived DTM topographical data, it is far more sensible and computationally efficient to define a smaller area on which to run each scenario.

Flood cells are typically defined by considering the topography of the area inland of the breach and the peak levels of the tidal events to be tested. MapInfo can be used to show areas of potential flooding by only displaying areas of the DTM that are below the predicted peak inundation levels in the vicinity of the breach, plus a freeboard. Areas of the DTM that are not shown (that is, areas that are well above the tidal levels of interest) do not need to be considered in the model.

Where the local topography does not clearly define an enclosed flood cell it may be necessary to artificially enclose certain parts of the flood cell. This should only be done for areas that are distant from the breach or any important areas of the model, and will typically be outlying or empty areas of the flood cell. For example, estuaries or flat, open fields at the far end of the flood cell. Since the model treats the boundaries of flood cells as 'glass walls' it is vital that any artificial boundaries do not affect levels in the important areas of the flood cell. This is typically not an issue in models where the inflows are based on tidal levels rather than a specific volume, as in this case.

Within this study there were a number of flood cells that had to be artificially constrained (notably ROC05 and ROC07 flood cells). In these cases local features as well as topography were used to inform the decision as to where to terminate the flood cell. In the case of the Rochford flood cells, natural water courses were used as these were thought to provide a natural break in the topography.

Extreme Water Level Derivation

Water levels were taken from *Environment Agency: Thames Tidal Defences Joint Probability Extreme Water Levels 2008, Final Modelling Report, April 2008* preferentially where available and appropriate for particular breach locations. Where this study did not cover particular breach locations *Environment Agency, Anglian Region, Eastern and Central Areas Report on Extreme Tidal Levels, 2007* was used to obtain water level information. Where modelled nodes were present within close proximity to specific breach locations unmodified water levels were used. Where a significant distance was present between the modelled nodes and the breach locations, modelled water levels were factored based on chainage to provide more realistic water levels.

Climate Change

PPS25 recommended contingency allowances have been applied to the extreme water levels obtained from the above studies in order to simulate climate change scenarios (100 years of climate change simulated up to 2110). Where climate change modelled runs were undertaken as part of the above studies, PPS25 allowances were applied to the closest run scenario to obtain 2110 water levels (i.e. for the *Environment Agency: Thames Tidal Defences Joint Probability Extreme Water Levels 2008, Final Modelling Report, April 2008* a model run was undertaken for 2107, so only three years of the appropriate PPS25 climate change contingency need be added).

Breach Modelling

Sixteen breach locations have been identified; eleven along the northern bank of the River Thames, two on the River Crouch and three on the River Roach. These are all located within the TGSE area of Castle Point, Basildon and Rochford administrative areas as shown in Figure A-1 and Table E-1.

To assess flood propagation in events where the flood defences are breached, a hydraulic modelling analysis has been undertaken using the two-dimensional hydraulic modelling software MIKE21-HDFM (Release 2009, Service Pack 4). This section discusses the modelling methodology that has been applied for the hydraulic modelling analysis of the breach events. The choice of model is discussed, the model schematisation is described and the boundary conditions used are presented.

Model and Software Selection

To achieve the study objectives, the model used to estimate the maximum flood conditions was required to:

- Accommodate the effects of a flood flow (propagation of a flood wave and continuous change of water level);
- Simulate the hydraulics of the flow that breach/overtop the flood defences; and
- Generate detailed information on the localised hydraulic conditions over the flooded area in order to evaluate flood hazard.

MIKE21-HDFM was developed by the Danish Hydraulic Institute (DHI) Water and Environment and simulates water level variations and flows for depth-averaged unsteady two-dimensional free-surface flows. Release 2009, Service Pack 3 was used for this study. It is specifically oriented towards establishing flow patterns in complex water systems, such as coastal waters, estuaries and floodplains using a flexible mesh (FM) approach. The flexible mesh model has the advantage that the resolution of the model can be varied across the model area. The model utilises the numerical solution of two-dimensional shallow water equations.

Model Extent and Resolution

Flexible meshes were developed to define the topography of the land within each flood cell, using the MIKE21 program's mesh generator application which creates a mesh of triangular elements covering the defined 'flood cell' - the land that has an elevation below the peak tidal level with the potential to flood (see above).

One of the advantages of the flexible mesh application is that the element size within the mesh can be varied depending upon the complexity of the floodplain, features of interest, and the location of topographic features which are thought to have a significant impact on flood propagation. By adding 'control lines' during the development of the mesh, the triangles or elements are forced to follow the alignment of the features ensuring the elevations of important features are picked up during the mesh generation. For example, control lines would be placed along each side of a road/ditch/topographic feature. In this way, the mesh is 'forced' to follow the features accurately and use level values at very specific points.

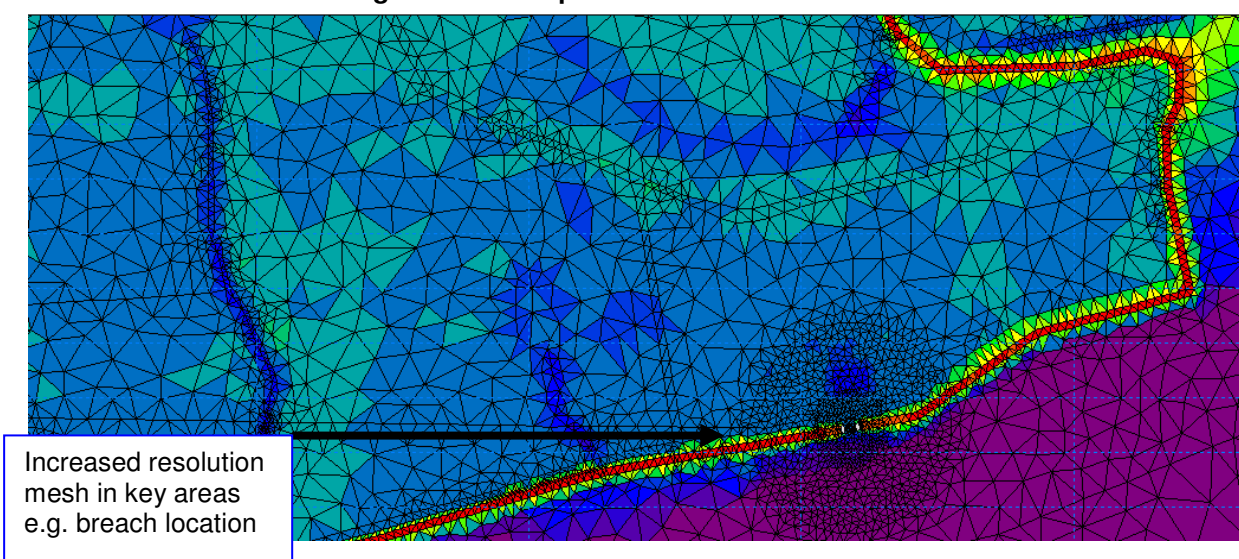
It was decided that considering these models are for strategic and not site specific purposes that small features such as culverts and small drainage ditches will not be included within the mesh. Taking into

account the size of the study areas, the determination of all culverts and small features was outside the scope of the study.

In order to accurately represent the hydraulics around the breach locations a comparatively small element size has been specified in the vicinity of the breaches. The breach itself is represented with a minimum of four elements across its width.

Once the final mesh is developed and the triangles generated, elevation values are imported into the mesh at each triangle vertex from the previously created DTM, utilising the 2m LiDAR data and where available the 25cm LiDAR. This then provides the 3-dimensional 'playing field' for simulating the breach scenario.

Figure E-1 Example of MIKE 21 HD Flexible Mesh



Breach Specifications

The breach width and exposure duration are determined by the type of defences and the nature of the adjacent water body. Flood defences are categorised as either 'Hard Defences'¹ or 'Earth Embankments'. According to EA guidance (Environment Agency SFRA Guidance²), the breach width adopted for the above categories is 20 metres and 50 metres respectively for tidal rivers/estuary and 50 metres and 200 metres respectively for open coast (see Table E-2).

¹ The EA consider revetted clay walls to be a hard defence. For many clay walls, either revetted or not, the main cause of failure is from overtopping and the back of the defence being compromised. Once failure has commenced, the structure will be rapidly washed out regardless of the face of the structure. The resulting gap will, by consequence of the construction, be much wider than a solid structure such as piles or concrete

² Agency Management System Document: Uncontrolled When Printed [10/01/07]

Table E-2 Environment Agency Breach Guidelines

Location	Defence Type	Breach width (m)
Open Coast	Earth bank	200
	Dunes	100
	Hard	50
	Sluice	Sluice width
Estuary	Earth bank	50
	Hard	20
Tidal River	Earth bank	50
	Hard	20
Fluvial River	Earth bank	40
	Hard	20

The land water boundary along Canvey Island, Castle Point and Southend-on-Sea is classified as tidal river/estuary to Shoeburyness point and as open coast to the east of this point. The Rivers Crouch and Roach are considered as river/estuary (Table E-1).

Within this study there are breaches in hard defences, earth embankments and flood barriers/gates.

The repair time required to close a breach is assumed to be 20.5 hours, covering two tidal cycles. In the hydraulic modelling undertaken for this study, the breach in the flood defence wall occurs prior to the peak tidal level occurring on the second peak and remains open for the remainder of the simulation. This total simulation corresponds to approximately three tidal cycles, with two smaller peaks either side of the maximum peak. This allows any potential overtopping to occur on the first tidal cycle prior to the breach and a subsequent tidal cycle after the peak to allow water to enter through the open breach in the second cycle.

Defences

The defences along the coastline are variable in standard. There are lengths of defence that fall below the 1 in 200 year design standard. As such, models including the potential for overtopping as well as breaching have been constructed. These models allow a breach to be forced through a section of chosen defence but also allow overtopping of the defences to occur where the defences are lower than the simulated water level. In addition to this, an overtopping scenario was also run where no breach occurs. This gives a flood water extent from overtopping alone, or 'actual' flood risk.

Defence heights have been determined from the most appropriate and accurate supplied data. In the main this has been LiDAR data, 25cm taking precedence over 2m LiDAR data. On Canvey Island, and stretches of the coastline in Castle Point data was supplied by the EA as points with associated levels. This data was triangulated and used to determine the height of the defences in the areas where available. The EA were also contacted on a number of occasions regarding the height of the defences and for clarification on the supplied levels.

The Easthaven and Benfleet barriers were confirmed to have a crest height of 6.65m AOD with adjacent defence crest heights at 6.6m AOD. The East Haven Barrier tie in defence has a crest height of 6.7m AOD (concrete cap at 6.7m AOD and sheet pile to 6.6m AOD). This information has been used to update the supplied point data where relevant. Ideally, the defence crest heights would have been surveyed and this data used to set crest heights within the model. As this was not available the best supplied data has been used but it should be recognised that this introduces a limitation to the modelling process and results.

Hydraulic Roughness used in Modelling

Hydraulic roughness represents the conveyance capacity of the land or riverbed where flows are occurring. Within the MIKE21 model, hydraulic roughness is defined by the dimensionless Manning's 'n' roughness coefficient.

A number of material roughness classifications have been identified within the study area, for example water - 0.03 (for the river), urbanised - 0.08, rural/non-urbanised land - 0.04, road - 0.02, and rail - 0.03. The distribution of these factors has been defined using aerial photography, OS maps and knowledge gained by the site visit in order to vary the conveyance rates throughout the flood cell domain.

Tidal Model Boundary Conditions

Within the MIKE21 model, tidal water level boundary files (in this case located in the Rivers Thames, Crouch and Roach) are used to provide the important input of water volumes to the mesh. The tidal water level is defined in the river and determines the flow entering the flood cell through the breach.

The water level boundary file consists of real-time tide curves, using the tidal peak levels derived from the report *Environment Agency: Thames Tidal Defences Joint Probability Extreme Water Levels 2008, Final Modelling Report, April 2008* and *Environment Agency, Anglian Region, Eastern and Central Areas Report on Extreme Tidal Levels, 2007* for the present day and with climate change allowances.

Boundary conditions have been applied along the middle of the River Thames, and the opposite banks of the Crouch and Roach. This was simulated to ensure a true representation of the modelled water levels were applied at the breach locations. In locations where smaller watercourses propagate flood water from the main river to the specific breach location, water levels will naturally be modified by the funnelling process of water travelling up a smaller watercourse.

Model Simulations Undertaken

The following flood events were simulated for each breach location;

- A tidal flood event with a return period of 1 in 200 years (present day 2010) breach and overtopping;
- A tidal flood event with a return period of 1 in 200 years (with climate change 2110) breach and overtopping;
- A tidal flood event with a return period of 1 in 200 years (with climate change 2110) overtopping only³;
- A tidal flood event with a return period of 1 in 1000 years (present day 2010) breach and overtopping;
- A tidal flood event with a return period of 1 in 1000 years (with climate change 2110) breach and overtopping;
- A tidal flood event with a return period of 1 in 1000 years (with climate change 2110) overtopping only⁴.

³ In the case of Canvey Island, two overtopping simulations were run: one where the Easthaven and Benfleet Barriers were operational and one where these defences failed

⁴ In the case of Canvey Island, two overtopping simulations were run: one where the Easthaven and Benfleet Barriers were operational and one where these defences failed

Breach Time

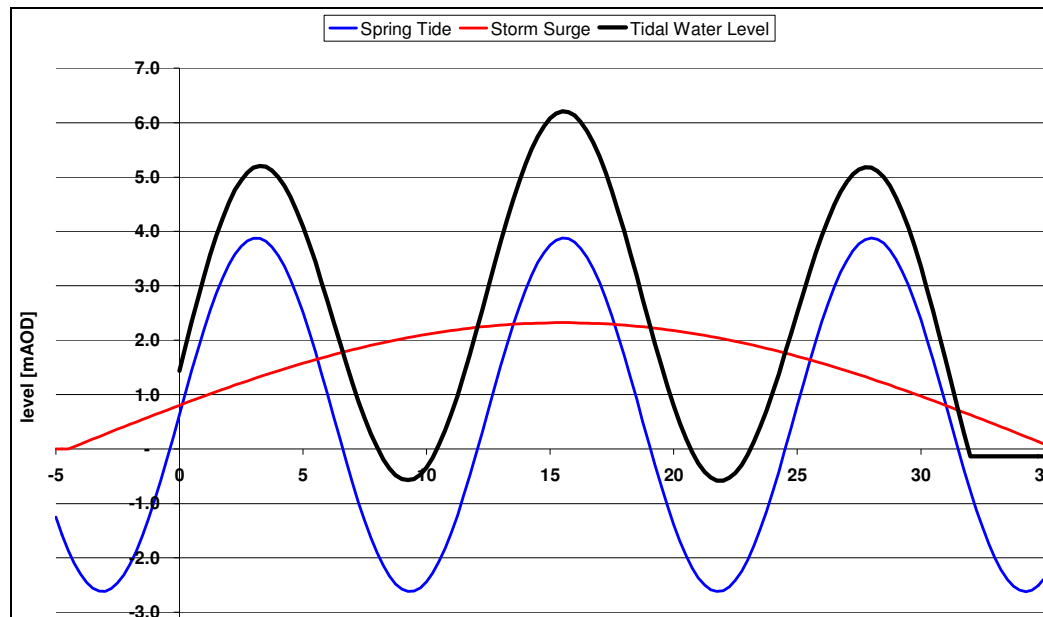
The water levels during a tidal flood event are generated by a summation of the astronomical tide levels and the storm surge residual, as shown in Figure E-2.

In terms of speed and force of floodwaters, the worst time for a breach to occur is when the maximum hydrostatic force has built up behind the flood defences. Therefore, the modelling undertaken for this study was run where the flood defences suddenly breach just before the tidal level acting on the flood defences is at a maximum.

A one hour 'lead-time' prior to the maximum flood level was included to ensure that, once the breach had occurred, the water level continued to rise and the maximum volume of water possible was able to travel through the breach at the maximum water level. This was seen as a compromise between the breach open method and the breach at peak method and the corresponding results.

The models were run for 36 hours. This allowed the potential for overtopping before the breach, during the first tidal cycle and ensured water could enter the model through the breach for the second and third tidal cycles.

Figure E-2 Example of Tidal Curve with Breach Time



Modelling Outputs

Modelling analysis presents data to identify the residual risk and actual risk of flooding from a failure or overtopping of local defences. The mapping of the model outputs as flood depth, flood hazard and time to inundation within the study area provides the three councils with flood risk information to enable more detailed consideration of the risk of flood water inundation, the Sequential Test and PPS25 vulnerability classifications within Flood Zone 3a.

Once the meshes were defined and the models run (by flooding the meshes, through the breaches/overtopping, with the tidal events using the 2D hydrodynamic modelling programme Mike21), the results were processed to produce the above outputs. GIS processing and mapping tasks have been performed using MapInfo Professional (Version 8.5.2) with the Vertical Mapper spatial analysis add-on (Version 3.1).

Maximum Flood Depth

The maximum flood depth is obtained from the water level achieved at each point in the model, minus the LiDAR topographic level at that point. This has been processed for all scenarios run. Composite depth maps were also created taking the maximum depth at each point where breaches coincided.

Hazard Rating

Flood hazard is a function of both flood depth and flow velocity. Due to this dependence on velocity, it is common during tidal flood events for the maximum flood hazard at a certain location to occur before the maximum floodwater level occurs, i.e. while floodwaters are flowing and the velocities are higher.

In order to assess the maximum flood hazard during a flood event, the hazard level at each element of the MIKE21 mesh is assessed at every time step of the model simulation.

Each element within the model is assigned one of four hazard categories 'Extreme Hazard', 'Significant Hazard', 'Moderate Hazard', and 'Low Hazard'.

The derivation of these categories is based on Flood Risks to People FD2320 (DEFRA & EA, 2005), using the following equation:

$$\text{Flood Hazard Rating} = ((v+0.5)*D) + DF \quad \text{Where } v = \text{velocity (m/s)}$$

$$D = \text{depth (m)}$$

$$DF = \text{debris factor}$$

The depth and velocity outputs from the 2D hydrodynamic modelling are used in this equation, along with a suitable debris factor. For this SFRA, a precautionary approach has been adopted inline with FD2320; a debris factor of 0.5 has been used for depths less than and equal to 0.25m, and a debris factor of 1.0 has been used for depths greater than 0.25m.

Table E-3 Hazard categories based on FD2320, DEFRA & Environment Agency 2005

Flood Hazard		Description	
HR < 0.75	Low	Caution – Flood zone with shallow flowing water or deep standing water	
0.75 ≥ HR ≤ 1.25	Moderate	Dangerous for some (i.e. children) – Danger: flood zone with deep or fast flowing water	
1.25 > HR ≤ 2.0	Significant	Dangerous for most people – Danger: flood zone with deep fast flowing water	
HR > 2.0	Extreme	Dangerous for all – Extreme danger: flood zone with deep fast flowing water	

A flood hazard rating grid was created for each of the breach locations for all flooding scenarios. A composite grid was then created for appropriate overlapping areas by extracting the maximum flood hazard rating value (where applicable) for each point, considering all relevant model output grids.

Time to Inundation

As previously stated, a breach was simulated in the models one hour before the peak tidal level. Flows then tended to pass through the breach, inundating the flood cell, for approximately five to six hours, after which the tide level had again retreated well below the breach invert. After another six hours (11 to 12 hours after the breach) the next high tide would again push water through the breach causing further flooding for a further five to six hours.

From examining the results it was decided that the vast majority of land that was inundated by the model was inundated within six hours of the breach occurring. Some of the outlying areas (some distance from the breach) were affected by the second peak.

The MIKE21 application 'Data Extraction FM' was used to extract 'snapshots' of the model results. Time 0 is set to the time when tidal water enters the breach. This means that the <1 hour band encompasses all areas that are inundated (wet) within the first hour of water travelling through the breach and into the flood cell. Further bands have been produced to show wet cells at: 1-4 hours, 4-8 hours, 8-12 hours, 12-16 hours and 16-20. Where overtopping occurred prior to the opening of the breach, this has been classified as such using a hatching.

For each model run, a mesh of polygons was derived in GIS (in this case, MapInfo format), each containing the approximate time of inundation for each triangular element composing the model mesh. All empty (zero) elements were then deleted and a 3-dimensional grid file (using the time of inundation as the vertical z-value) was created to define the time to inundation for each model simulation.

These grid files could be used as the final output of the time to inundation process. However, the results are 'patchy' and complicated in places, mainly due to a finite number of breach locations being used (sixteen in this case). Ideally, a very high number of breach locations would have been used in the modelling (for example every few hundred metres or more) but this is impractical considering the computing power and time that would be required. This should be noted by the reader for all output results, i.e. results are from a discrete number of breach locations and therefore may be subject to change if the breach location were to change.

As overtopping is possible at any point where the defences are below the water level (due to the variable defence standard), some overtopping will be classified within the time to inundation bands from the breach event. This is particularly noticeable in areas a significant distance from the breach that are shown as inundated within the first hour of the breach event (i.e. water would not have time to flow from the breach to these locations within the first hour). This should be considered by the user.

Appendix F: Data Register

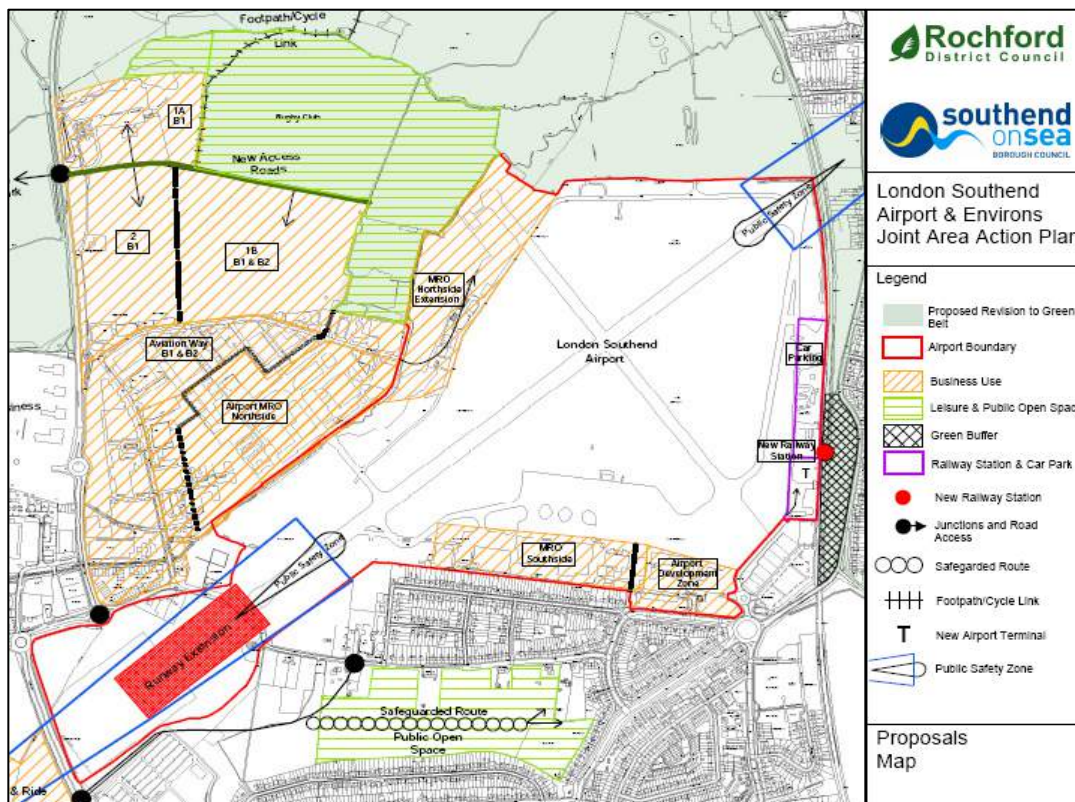
Appendix F - Data Register

Project Type	Project		Supply Project			
SFRA Review	Thames Gateway South Essex Strategic Flood Risk Assessment Review (Level 1 or 2)		Sheet Number	1		
Date updated	08/10/2010		Job Number	D130256		
Filename	Description	To - Name	From - Name	Medium	Confidence	Date of Issue
council_extnt_rochford.tab	Rochford District Boundary	Emily Blanco (SW)	Sam Hollingworth (RDC)	CD		1-Jun-10
nat_floodzone2_v3_14.shp	GIS outline of Flood Zone 2	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
nat_floodzone3_v3_14.shp	GIS outline of Flood Zone 3	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Prittle_20yr.shp	GIS outline of 1 in 20yr return period for Prittle Brook	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Prittle_100yr.shp	GIS outline of 1 in 100yr return period for Prittle Brook	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Prittle_100yrCC.shp	GIS outline of 1 in 100yr return period including allowances for climate change for Prittle Brook	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Prittle_1000yr.shp	GIS outline of 1 in 1000 year return period for Prittle Brook	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Eastwood_20yr.shp	GIS outline of 1 in 20yr return period for Eastwood Brook	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Eastwood_75yr.shp	GIS outline of 1 in 75yr return period for Eastwood Brook	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Eastwood_100yr.shp	GIS outline of 1 in 100yr return period for Eastwood Brook	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Eastwood_100yrCC.shp	GIS outline of 1 in 20yr return period for Eastwood Brook	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Eastwood_1000yr.shp	GIS outline of 1 in 100yr return period for Eastwood Brook	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Eastwood_nodes.shp	GIS layer of nodes along Eastwood Brook model	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Defence_01_polyline.shp	Extract from the National Flood and Coastal Defence Database for the study area	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
20100406 Rochford DC multi-agency flood plan.doc	Flood plan for Rochford DC	Emily Blanco (SW)	Sam Hollingworth (RDC)	Project Space		1-Jun-10
625k_V5_BEDROCK_Geology_Polygons.shp	GIS layer of Bedrock geology across study area (1:625,000 Mapping)	Emily Blanco (SW)	British Geological Survey	Downloaded freely from BGS website		1-Jun-10
625k_V5_DYKES_Geology_Polygons.shp	GIS layer of dykes across study area (1:625,000 Mapping)	Emily Blanco (SW)	British Geological Survey	Downloaded freely from BGS website		1-Jun-10
625k_V5_FAULT_Geology_Lines.shp	GIS layer of geological faults across study area (1:625,000 Mapping)	Emily Blanco (SW)	British Geological Survey	Downloaded freely from BGS website		1-Jun-10
UK_625k_SUPERFICIAL_Geology_Polygons.shp	GIS layer of Superficial geology across study area (1:625,000 Mapping)	Emily Blanco (SW)	British Geological Survey	Downloaded freely from BGS website		1-Jun-10
OS_1_50_000_scale_colour_raster_108849_139928.tif	1:50,000 Ordnance Survey Mapping of study area	Sarah Littlewood (SW)	EmapSite	Downloaded freely from Emap website		1-Jun-10
TQ68.TIF and similar...	1:25,000 Ordnance Survey Mapping of study area	Emily Blanco (SW)	Sam Hollingworth (RDC)	CD		1-Jun-10
Less susceptible to surface flooding.shp	Areas Susceptible to Surface Water Flooding Dataset: GIS layer of areas LESS susceptible	Emily Blanco (SW)	Environment Agency	CD		1-Jun-10
Medium susceptibility to surface flooding.shp	Areas Susceptible to Surface Water Flooding Dataset: GIS layer of areas with MEDIUM susceptibility	Emily Blanco (SW)	Environment Agency	CD		1-Jun-10
More susceptible to surface flooding.shp	Areas Susceptible to Surface Water Flooding Dataset: GIS layer of areas MORE susceptible	Emily Blanco (SW)	Environment Agency	CD		1-Jun-10
connecting_cows.shp	GIS layer of connecting critical ordinary watercourses	Emily Blanco (SW)	Environment Agency	CD		1-Jun-10
cows.shp	GIS layer of critical ordinary watercourses	Emily Blanco (SW)	Environment Agency	CD		1-Jun-10
Main_Rivers.shp	GIS layer of Environment Agency Main Rivers	Emily Blanco (SW)	Environment Agency	CD		1-Jun-10
South_Benfleet_Location_Map.pdf	Map showing the extent of the South Benfleet Flood Storage Area (FSA)	Emily Blanco (SW)	Environment Agency	CD		1-Jun-10
South Essex CFMP.pdf	South Essex Catchment Flood Management Plan	Emily Blanco (SW)	Environment Agency	CD		1-Jun-10
Anglian RBMP.pdf	River Basin Management Plan for the Anglian River Basin District	Emily Blanco (SW)	Environment Agency	CD		1-Jun-10
DG5 Register postcodes Essex (Anglian Water).xls	Database of recorded incidents of sewer flooding across the study area	Sarah Littlewood (SW)	Anglian Water	Email		1-Jun-10
051FWCDV4D1.zip	GIS layer of Environment Agency Flood Warning Areas (FWAs)	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
051FWCDV4D2.zip	GIS layer of Environment Agency Flood Warning Areas (FWAs)	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
051FWCDV4D3.zip	GIS layer of Environment Agency Flood Warning Areas (FWAs)	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
051FWCDV4D5.zip	GIS layer of Environment Agency Flood Warning Areas (FWAs)	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
051FWCDV4D6.zip	GIS layer of Environment Agency Flood Warning Areas (FWAs)	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
051FWCDV5A1.zip	GIS layer of Environment Agency Flood Warning Areas (FWAs)	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
051FWCDV5B2.zip	GIS layer of Environment Agency Flood Warning Areas (FWAs)	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
051FWCDV5B3.zip	GIS layer of Environment Agency Flood Warning Areas (FWAs)	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
051FWFEF7B.zip	GIS layer of Environment Agency Flood Warning Areas (FWAs)	Sarah Littlewood (SW)	Environment Agency	CD		1-Jun-10
Crouch_20yr.shp	GIS outline of 1 in 20yr return period for fluvial part of the River Crouch.	Sarah Littlewood (SW)	Environment Agency	CD		1-Oct-10
Crouch_100yr.shp	GIS outline of 1 in 100yr return period for fluvial part of the River Crouch.	Sarah Littlewood (SW)	Environment Agency	CD		1-Oct-10
Crouch_100yr_CC.shp	GIS outline of 1 in 100yr return period including allowances for Climate Change for fluvial part of the River Crouch.	Sarah Littlewood (SW)	Environment Agency	CD		1-Oct-10
Crouch_1000yr.shp	GIS outline of 1 in 1000yr return period for fluvial part of the River Crouch.	Sarah Littlewood (SW)	Environment Agency	CD		1-Oct-10
Roach_20yr.shp	GIS outline of 1 in 20yr return period for fluvial part of the River Roach.	Sarah Littlewood (SW)	Environment Agency	CD		1-Oct-10
Roach_100yr.shp	GIS outline of 1 in 100yr return period for fluvial part of the River Roach.	Sarah Littlewood (SW)	Environment Agency	CD		1-Oct-10
Roach_100yr_CC.shp	GIS outline of 1 in 100yr return period including allowances for Climate Change for fluvial part of the River Roach	Sarah Littlewood (SW)	Environment Agency	CD		1-Oct-10
Roach_1000yr.shp	GIS outline of 1 in 1000yr return period for fluvial part of the River Roach.	Sarah Littlewood (SW)	Environment Agency	CD		1-Oct-10
RDC Core Strategy Submission FINAL.pdf	Core Strategy Document	Emily Blanco (SW)	Sam Hollingworth (RDC)	Project Space		1-Jun-10

Appendix G: London Southend Airport & Environs JAAP

Southend-on-Sea Borough Council and Rochford District Council are in the process of preparing a planning framework to guide development at the proposed London Southend Airport and the neighbouring employment areas. This planning framework is known as the Joint Area Action Plan (JAAP) and is illustrated in Figure G-1 below. The two Councils have published their 'Preferred Option' for development which has been used as a basis to make a strategic assessment of flood risk which is described below.

Figure G-1 London Southend Airport JAAP



Fluvial Flood Risk

Environment Agency Flood Zones

The Eastwood Brook is a Main River which flows in a south west to north east direction to the north west of the Southend Airport JAAP area as illustrated in Figure G-2 below.

The JAAP outlines development for business uses to the north west of the airport adjacent to the Eastwood Brook (MRO Northside Extension). This area is currently shown to lie within Flood Zone 3b associated with the Eastwood Brook. Flood Zone 3b is defined as the functional floodplain and only water-compatible (mainly water-based) uses and essential infrastructure, as defined by Table D2 of PPS25, are considered appropriate in this location.

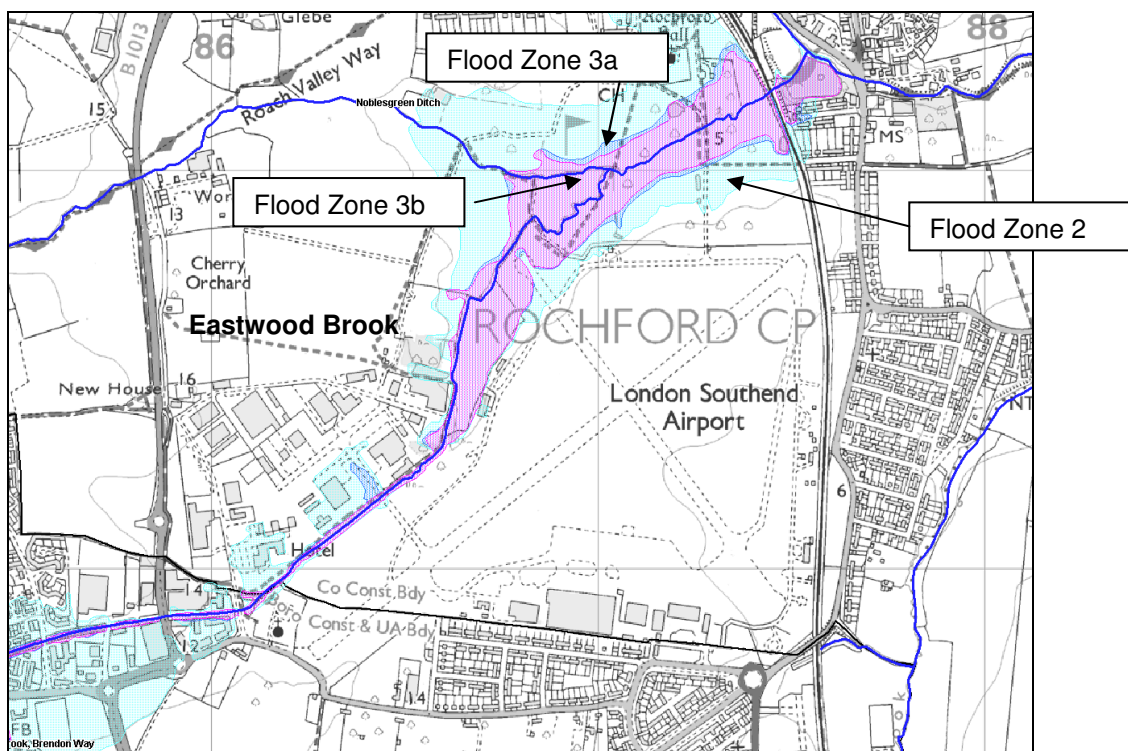
Airport MRO Northside is also proposed for business use. A small section of the potential development area adjacent to the Eastwood Brook is located in Flood Zone 3b, with small pockets of Flood Zone 3a and Flood Zone 2. A sequential approach to the development layout would have to be applied in this location to ensure

that no development is located in Flood Zone 3b, and less vulnerable uses are located in Flood Zone 3a and Flood Zone 2.

The northern half of Aviation Way B1 and B2 is located within Flood Zone 1. However, the southern half of this plot, adjacent to the Eastwood Brook contains some small pockets of Flood Zone 2, 3a and 3b. A sequential approach to the development layout would have to be applied in order to steer development into the lower areas of flood risk.

A detailed FRA will be required for all development located in Flood Zone 2, 3a or 3b including Aviation Way, Airport MRO Northside and MRO Northside Extension.

Figure G-2 Environment Agency modelled Flood Outlines – Eastwood Brook.



Environment Agency Modelled Fluvial Flood Depths

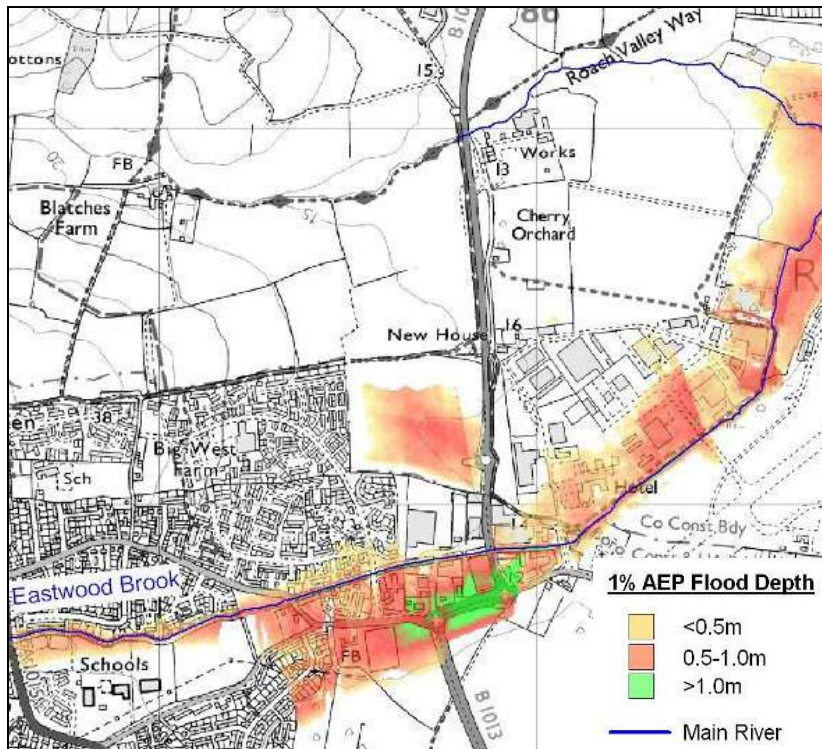
The Environment Agency has recently completed a flood risk study for the Eastwood Brook. The flooding mechanism for this watercourse is described as *'overtopping of river banks leading to low velocity flooding in most areas with flood depths ranging between 0.3m and 0.5m'* (Table 3.17 included in the Catchment Flood Management Plan).

The Environment Agency has assigned this watercourse a 'high priority' natural channel maintenance regime and they provide flood warning with a 2 hour lead time.

With reference to the fluvial flood depth map for Eastwood reproduced in Figure G-3 below and Figure G-1 Development Layout, it can be seen that flood depths may reach 1.0m within the proposed 'Airport MRO Northside' development area. Depth modelling is not included in the CFMP for the northern extent of the JAAP but Figure G-3 suggests that depths may also be greater than 1.0m in the area identified for the 'MRO Northside Extension'.

It should be noted that the airport has previously experienced flooding from the Eastwood Brook including in 1981 when the brook burst its banks leading to flooding of the airport hanger.

Figure G-3 Fluvial flood extent and depth for Eastwood (1% or 1 in 100 year probability)



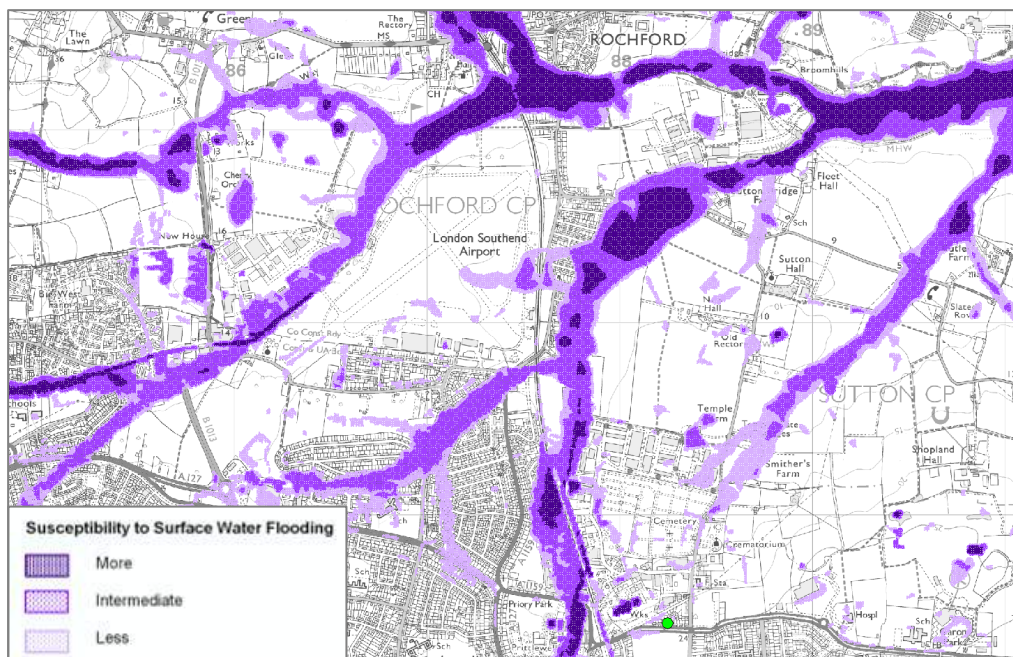
(Source South Essex CFMP – Final Plan August 2008, EA.)

Surface Water Flood Risk

The Environment Agency published maps to illustrate ‘Areas Susceptible to Surface Water Flooding’ in July 2009. This data has been created to provide an overview to where the potential for flooding from surface water needs particular assessment.

The Environment Agency Areas Susceptible to Flood Risk maps (extract included in Figure G-4) highlight that surface water flooding may be an issue to the north west of the JAAP including the proposed development at Aviation Way, Airport MRO Northside and MRO Northside Extension. The surface water flood maps use ground levels in the modelling, therefore, areas of potential surface water flooding often follow river corridors. This is the case at the airport JAAP where the Eastwood Brook and Prittle Brook corridor is highlighted as being at surface water flood risk. In addition, there are smaller pockets of potential risk illustrated to the east of the runway, local to the proposed new railway station building.

Figure G-4 Environment Agency Areas Susceptible to Surface Water Flooding



(Source Southend-on-Sea BC Level 1 SFRA, September 2010)

Tidal Flood Risk

Detailed breach and overtopping modelling has been considered for tidal sources at 9 locations along the Southend seafront and 7 locations along the Rochford frontage. These identify the flood risks associated with a failure in the flood defence, through a breach and by overtopping. Modelling at all locations has highlighted that the London Southend Airport site is not at risk of tidal flooding from the Thames Estuary or North Sea.

Groundwater Flood Risk

The South Essex Catchment Flood Management Plan states that groundwater flooding is not a major issue in this area. The presence of London clay reduces the risk of groundwater flooding as it creates an impermeable barrier between the ground surface and the underlying aquifer (where present).

The Southend Airport JAAP is underlain by river terrace deposits of silt and clay, with sand and gravel river terrace deposits following the Eastwood Brook corridor to the west of the JAAP. There have been no groundwater flooding incidents reported to the Environment Agency or the Council within the Southend Airport JAAP area.

There is little recorded information currently available on groundwater flooding. The proposed Phase 2, 3 and 4 Surface Water Management Plan (anticipated in Spring 2011) may provide a greater level of detail and should be referred to as part of a site-specific FRA.

Flood Risk Assessment Guidance – Southend Airport JAAP

A site-specific FRA should include details of the proposed surface water drainage system including storm water storage. As the Eastwood Brook is adjacent to the proposed development area in the north west, it seems logical that surface water drainage be discharged to this watercourse. It should be noted that there is potential that if a rainfall event co-insides with the Eastwood Brook being in flood, the outfall for the

development drainage system may become surcharged. This could cause surface water to back up into the development site causing surface water flooding.

Any discharge to a main river watercourse will require consent from the Environment Agency and will require attenuation to discharge at a flow rate to be confirmed with the Environment Agency (potentially Greenfield runoff rate).

As part of a site-specific FRA, historic flood records where available should be referred to in order to verify the potential surface water flood risk. A site visit should also be used to assess and ground truth the data.