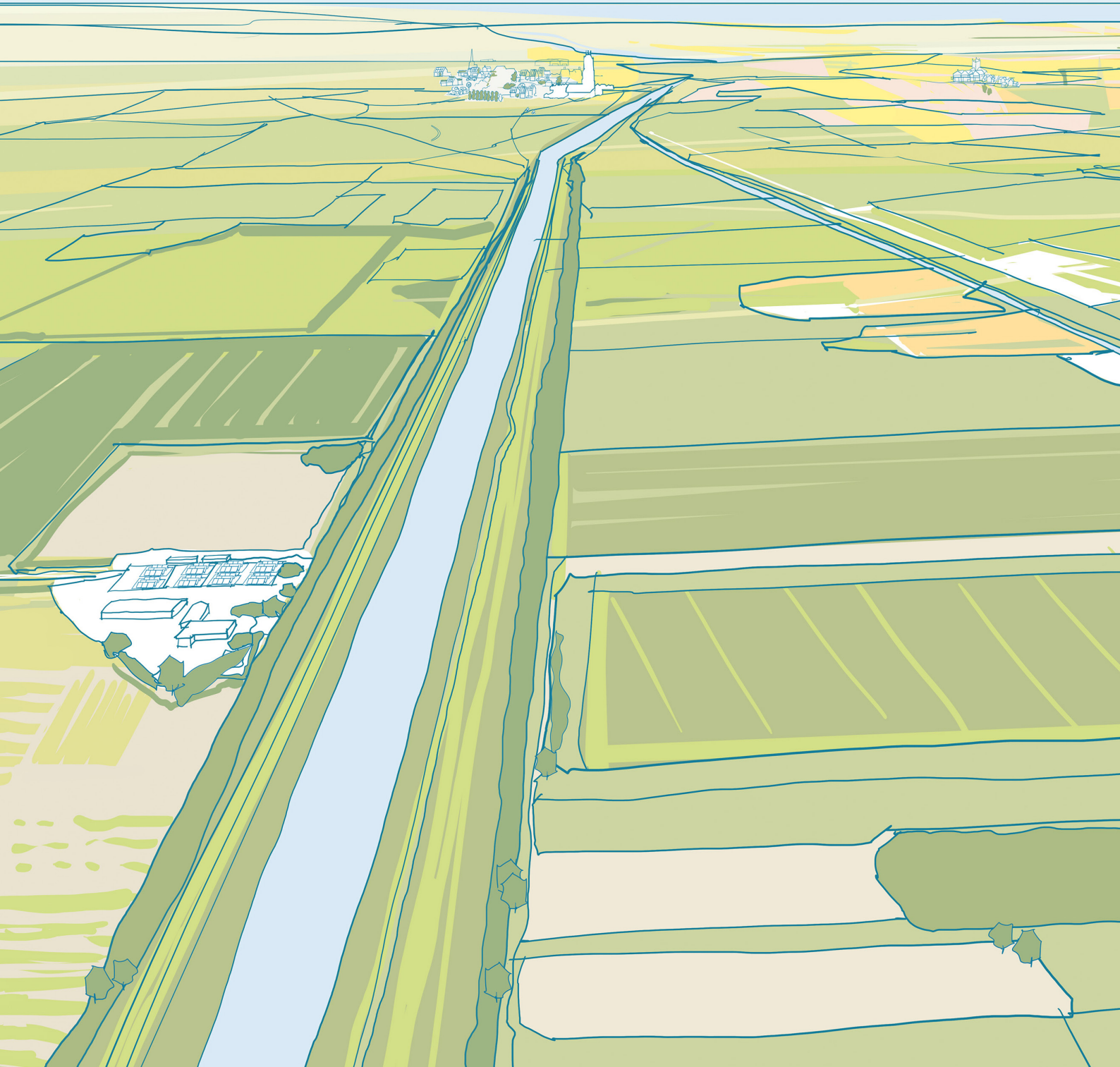


Witham South Forty Foot Drain

Flood risk baseline

2025



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Glossary of Terms

- **AIMS** – Asset Information System - An Environment Agency hosted database of information on Environment Agency assets, as well as some other key RMA assets.
- **AOD** – Above Ordnance Datum - Referring to an altitude above a localised mean sea level.
- **BRC** - Below Required Condition.
- **Cumecs** – is the SI unit of volumetric flow rate and are equivalent to cubic meters per second (m^3/s).
- **FCERM** – Flood and Coastal Erosion Risk Management.
- **The Fens** – In the context of Fens 2100+, the combined catchments of the Witham, Lower Welland, Lower Nene, Great Ouse and Steeping, including land with an elevation at or below 6m AOD.
- **Flood risk** - A combination of the probability and the potential consequences of flooding. This includes risks from various sources such as rivers, the sea, direct rainfall, rising groundwater, overwhelmed sewers, and reservoirs
- **IDB** - Internal Drainage Board - A public body that manages water levels in an area, known as an internal drainage district.
- **LLFA** – Lead Local Flood Authority, bodies with a statutory responsibility for taking the lead operational role in managing the risk of flooding.
- **MEICA** - Mechanical, Electrical, Instrumentation, Control and Automation assets, in the context of this report relating to flood and coastal risk management (FCRM) assets.
- **NFM** – Natural Flood Management, the practice of using natural processes to reduce the risk of flooding.
- **Resilience**: The capacity of people and places to plan for, protect, respond to, and recover from flooding and coastal change. Resilience has been considered in the context of Fens 2100+ as follows:
 - Anticipate and adapt: Taking action to prepare for and adjust to both the current effects of climate change and the predicted impacts in the future, while responding to local place-based needs and ambitions.
 - Protect: Reducing the risk of flooding and coastal erosion to enhance the safety of communities and places (through investment in physical grey and green infrastructure).
 - Maintain: Co-ordinated activity to realise the whole life value from flood risk infrastructure through inspection, operational management, repair, replacement, renewal and decommissioning.
 - Respond: The ability of places and people to prepare for and react to flooding and coastal erosion in a way that results in minimal impacts to property, the natural environment and health and wellbeing.

- Recover: The ability of places and people to rebound from flooding and coastal erosion with minimal impacts to property, the natural environment, and health and wellbeing.
- Transform: To change and improve the way FCERM infrastructure is planned, delivered and operated to be more efficient, sustainable and resilient.
- **RMA** - Risk Management Authority - an organisation responsible by statute for flood and coastal erosion risk management.
- **RNAG** – Reasons for Not Achieving Good.
- **SoP** – Standard of Protection - The severity of flooding that something is designed to withstand, represented by the percentage chance of a certain level of flooding occurring in that year.
- **Telemetry** – is technology that enables an asset to operate without manual interaction.
- **WFD** – Water Framework Directive.
- **WLCS** – Water Level Control Structures

1. Introduction

1.1 Aim and purpose of this document

This document presents a catchment-scale assessment of current and future flood risk for the South Forty Foot Drain catchment. Using the best available data, it presents an overview of current and future flood risk and is intended to support future choices, investments and actions for the Fens 2100+ programme (hereafter referred to as “Fens 2100+”).

1.2 Usage statement

The purpose of the document is to support strategic decision making for the Fens 2100+. This document should be read alongside the South Forty Foot Drain baseline evidence report and is intended to provide a strategic current and future flood risk baseline which will inform the development of a future asset management strategy for the Fens 2100+. This document provides a proportionate level of detail required for a strategic catchment-scale baseline. It is anticipated that specific interventions will need to be supported by a more detailed study.

1.3 The Fens 2100+ study area

Fens 2100+ comprises the seven catchments of the Steeping, Lower Welland, East and West Fens, Lower Witham Fens, South Forty Foot Drain, Lower Nene and Great Ouse (see Figure 1).

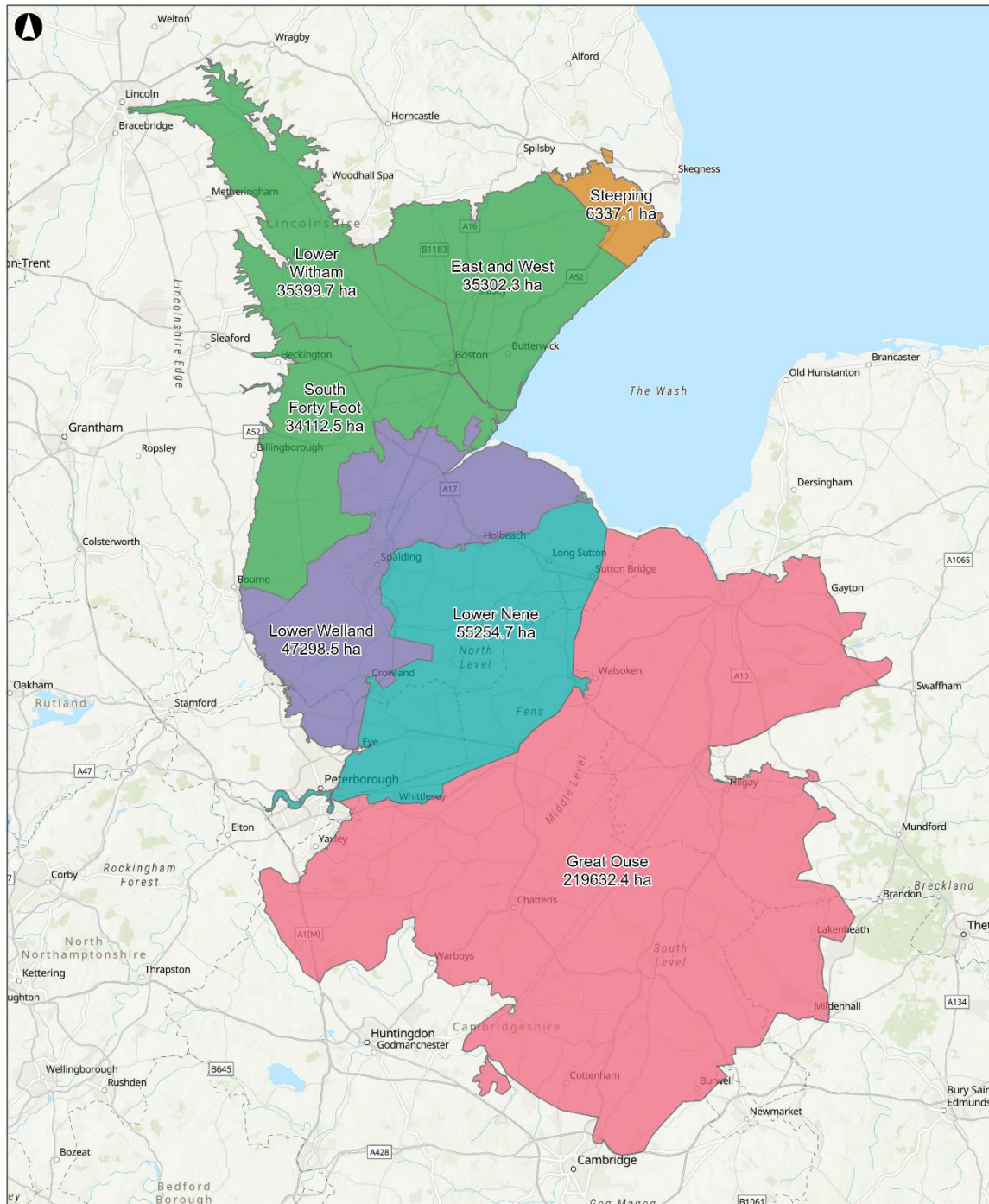


Figure 1: Fens 2100+ study area

1.4 South Forty Foot Drain catchment

The South Forty Foot Drain catchment (hereafter referred to as “the catchment”) covers an area of approximately 341.1km² (34,110ha), located in southeastern Lincolnshire, in the middle of the Fens 2100+ study area. It is a sub catchment of the River Witham. It is bounded by the Lincolnshire Wolds to the west, the River Welland catchment to the south and east and the ‘East and West Fens’ catchment to the north.

The South Forty Foot Drain is a man-made channel, it’s water flows from a number of more natural streams and watercourses in the catchment, with their sources to the west of the Fens. It flows in a general northerly direction towards Swineshead, then flows east

towards Boston. It then discharges into the tidally influenced section of the River Witham known as The Haven, at the Black Sluice, in Boston.

The catchment topography is low-lying and flat, with slightly elevated land along the far west of the catchment and near the communities of Swineshead, Bicker and Donington in the centre of the catchment. The lowest point of the South Forty Foot Drain catchment lies below sea level at -2.7m AOD, in the south-western corner of the catchment.

It has a wide coastal plain partially consisting of drained saltmarsh and priority habitats such as coastal and floodplain grazing marsh and coastal saltmarsh. The catchment is dominated by highly fertile farmland, with 96% classified as Grade 1 or Grade 2 agricultural land.

Figure 2 shows a typical image of a drain in the South Forty Foot Drain catchment.



Figure 2: A typical image of the South Forty Foot Drain catchment © Arup

It is acknowledged that the catchment is not strictly a hydrological catchment, as there are movements of water both into and out of the area defined, that are not being considered in this report. However, the term 'catchment' has been used throughout the dialogue with the Environment Agency during establishment of the study areas and these areas are being defined for water management purposes. Therefore, the term catchment is used to describe the study area.

1.5 Catchment context

The other Main Rivers within the catchment comprise Rippingdale Running Dike, Billingborough Lode, Ouse Mere Lode, Swaton Eau, Helpringham Eau, Helpringham South Beck and Skerth Drain (Figure 3). These Main River watercourses represent a high-

level carrier system that accepts water from the more elevated land to the west and conveys this water by gravity to the South Forty Foot Drain.

The Black Sluice Internal Drainage Board (BSIDB) operates 37 low-lying sub catchments. These all drain into the South Forty Foot Drain via approximately 600km of drains and ditches. The majority of the sub catchments are able to drain by gravity, with the pumps improving the flow rate. There are a number of pumping stations within the catchment which lift water into the South Forty Foot Drain, including Donington North Ings, Swineshead and Chain Bridge pumping stations. In total 34 of the catchments are pumped.

The Main Rivers in the catchment are shown in Figure 3.

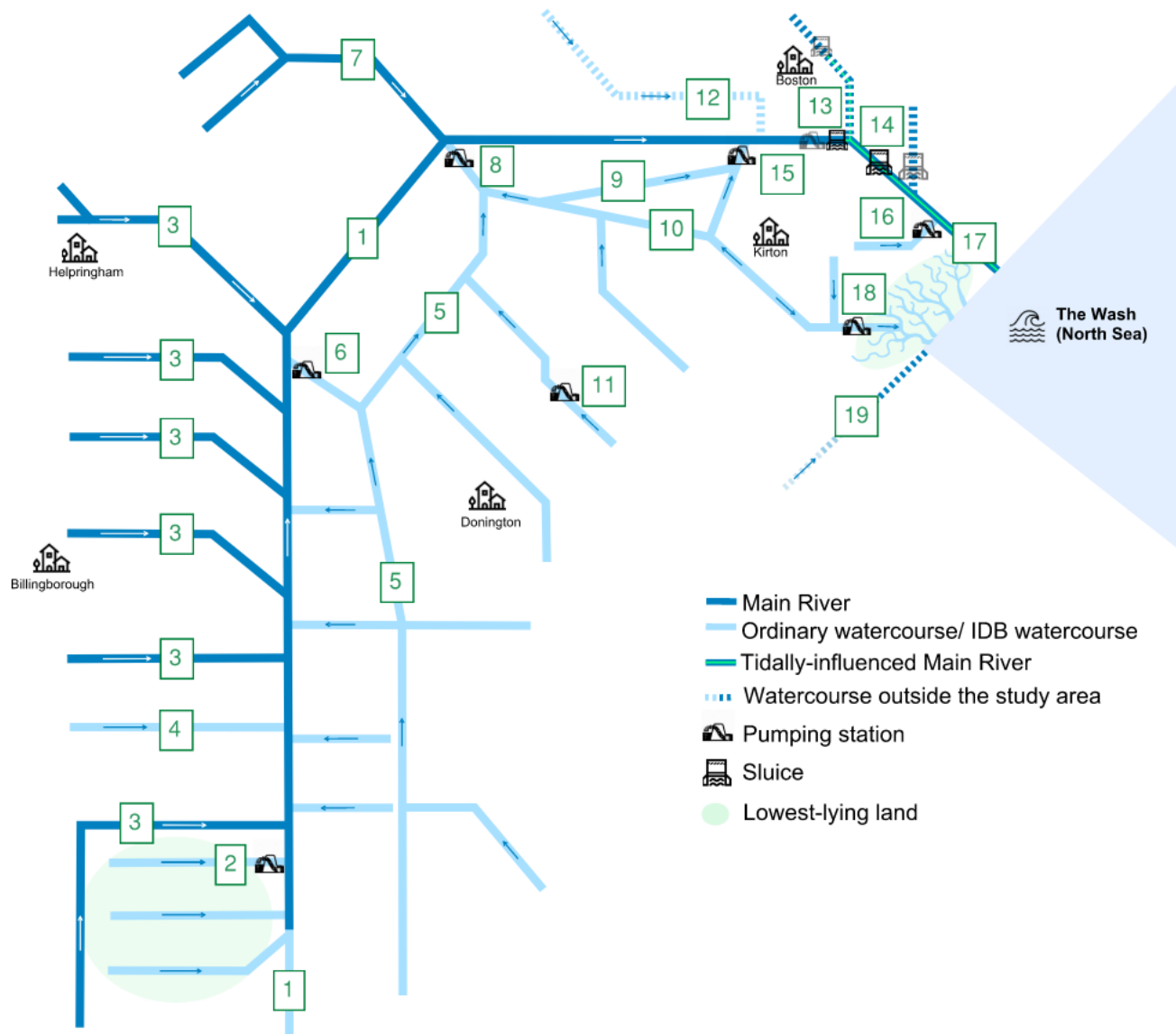


Figure 4: South Forty Foot Drain catchment overview

- 1

South Forty Foot Drain
Main River

Almost all water entering the catchment is directed into the South Forty Foot Drain, either via gravity or by pumping. The drain discharges into the tidal Boston Haven.
- 2

Black Hole Drove Pumping Station
Black Sluice IDB

One of 22 pumping stations lifting water into the South Forty Foot Drain along its length. In total, Black Sluice IDB own 34 pumping stations within the catchment.
- 3

Main River Highland Carrier Drains
Main River

All of the Main River highland carrier drains to the west carry flows from the higher ground of the Southern Lincolnshire Uplands to the South Forty Foot Drain (SFFD). There are no structures controlling these 'junctions' so water enters the SFFD freely by gravity. From north to South, they are the Helpringham Eau, Helpringham South Beck, Swaton Eau, Ousemere Lode, Billingborough Lode, and the Rippingale Running Dike.
- 4

Pointon Lode
Black Sluice IDB

Previously designated as Main River, it was re-designated as an Ordinary Watercourse in 2018, giving Black Sluice IDB permissive powers for channel maintenance.
- 5

Hammond Beck
Black Sluice IDB

Receives flows from the wider Black Sluice IDB drainage network and allows water to flow parallel to the South Forty Foot Drain.
- 6

Donington North Ings Pumping Station
Black Sluice IDB

Lifts water into the South Forty Foot Drain. It can relieve pressure on Swineshead Pumping Station downstream by pulling water southwards down the Hammond Beck.
- 7

Skerth Drain
Main River

Four IDB pumping stations discharge water into this watercourse, which enters the South Forty Foot Drain uncontrolled by gravity.
- 8

Swineshead Pumping Station
Black Sluice IDB

The most powerful pumping station managed by BSIDB. It pulls water from the Hammond Beck and Old Hammond Beck and lifts it into the South Forty Foot Drain.
- 9

New Hammond Beck
Black Sluice IDB

A straightened channel carrying water to Chain Bridge Pumping Station.
- 10

Old Hammond Beck
Black Sluice IDB

Water in this drain can move in either direction, depending on the relative power of the pumping stations at Swineshead and Chain Bridge.
- 11

Bicker Eau Pumping Station
Black Sluice IDB

One of four booster stations owned by Black Sluice IDB which help to convey water from inland areas towards other pumping stations where it is pumped for a second time into the Main River system.
- 12

North Forty Foot Drain
Black Sluice IDB

One of several Black Sluice IDB drains bringing water to the South Forty Foot Drain from Holland Fen outside the catchment area to the north. This additional water means that IDB pumps downstream have to work harder to move water into the Main River.
- 13

Black Sluice Complex
Environment Agency

The site consists of a decommissioned pumping station, and two tidal sluices (one of which operates as a navigational lock) that allow water from the South Forty Foot Drain to flow out into the Boston Haven during low tide.
- 14

Boston Barrier
Environment Agency

Completed in 2020, the Boston Barrier protects over 13,000 homes and businesses in the town.
- 15

Chain Bridge Pumping Station
Black Sluice IDB

Lifts water from Old Hammond Beck and New Hammond Beck into the South Forty Foot Drain. It can be used to relieve pressure on Swineshead Pumping Station upstream.
- 16

Wyberton Marsh Pumping Station
Black Sluice IDB

Pumps water out into the Boston Haven.
- 17

Boston Haven
Main River

The tidal section of the River Witham.
- 18

Kirton Marsh Pumping Station
Black Sluice IDB

Pumps water from Kirton Drain out into the coastal saltmarsh, where it can drain into The Wash.
- 19

River Welland
Main River

The River Welland's tributary the River Glen forms the southern boundary of the catchment further inland. All water falling on land north of the River Glen (even very close to it) is diverted northwards via the South Forty Foot Drain, and the Black Sluice IDB network.

1.6.1 Sluices

Black Sluice is a key asset in the catchment managed by the Environment Agency. It consists of two tidal sluices which allow the South Forty Foot Drain to discharge into the tidally influenced section of the River Witham, known as The Haven, in Boston. One of the tidal sluices acts as a lock at this location enables navigation from South Forty Foot Drain into The Haven.

At the Black Sluice site, there is also a pumping station that is no longer in use. The pumping station was infrequently used between 1946 and 2013 to pump high fluvial flows from the SFFD during tide locked periods. Following studies looking at the effectiveness of the pumping station, it was concluded that the small additional benefit of using the station could not be outweighed by the costs of refurbishing and running the site. In 2018, a collective decision was taken by all risk management and local authorities for the area, to decommission the pumping station and use gravity discharge at all times to evacuate water to The Haven.



Figure 5 shows Black Sluice. The decommissioned pumping station in the building on the left, and the two tidal sluices are on the right-hand side of the photograph. Figure 6 shows the view from Black Sluice looking upstream.



Figure 5: Black Sluice looking downstream © Arup



Figure 6: View from Black Sluice looking upstream © Arup

1.6.2 Tidal barrier

Since 2020, Boston has been protected from tidal flooding by the Boston Barrier. This Environment Agency owned and operated asset is located just downstream of Black Sluice.

1.6.3 Pumping stations

Large areas of the South Forty Foot Drain catchment are reliant on pumping stations to pull water up from low-lying areas into large rivers and drains. Networks of smaller drains will lead to a pumping station which pulls water out of that catchment into a larger drain to the sea. There are 34 IDB pumping stations, the majority pump water into the SFFD drain catchment, however some do discharge into the Kyme Eau or other watercourses.

Black Hole Drove Pumping Station is operated and maintained by Black Sluice IDB. It lifts water into South Footy Foot Drain. The pumping station is shown in Figure 7.



Figure 7: Black Hole Drove Pumping Station © Alex McGregor and licensed for reuse under the Creative Commons Licence.

Donnington North Ings Pumping Station is operated and maintained by Black Sluice IDB. It lifts water into South Footy Foot Drain. It can relieve pressure on Swineshead pumping station downstream by pulling water southwards down the Hammond Beck.

Swineshead Pumping Station is operated and maintained by Black Sluice IDB. It is the most powerful of the pumping stations in the catchment. It pulls water from the Hammond Beck and Old Hammond Beck and lifts it into South Footy Foot Drain.

(Wyberton) Chain Bridge Pumping Station is operated and maintained by Black Sluice IDB. It lifts water from Old Hammond Beck into South Footy Foot Drain. It can be used to relieve pressure on Swineshead Pumping Station upstream.

1.6.4 Embankments

Embankments are constructed features designed to contain water and are ideally constructed of a solid clay core surrounded by piled material, and finally a layer of grass/vegetation. The use of geotextiles is now often being implemented in newly constructed embankments to better stabilise the slope and help improve the strength of utilised soil. However, the majority of embankments within the catchment are not built to modern standards due to their age. Often lacking a clay core, most are comprised of locally won materials, and include less desirable and structurally stable sands, gravels and peats. Making them subject to settlement, erosion and sometimes complete failure in the form of a breach. In some instances, there are operational safety concerns related to access or crest width. When crest widths are narrow or uneven, this severely limits the availability of plant, whether this be plant needed for vegetation maintenance or for accessing repairs.

Embankments in the catchment represent a vulnerability, as maintenance of these assets is costly and difficult to justify. Damage caused by burrowing animals, such as badgers, pose a risk as burrowing can affect the stability of the embankment and therefore the rate of deterioration. Badgers are a protected species and when a sett needs to be relocated an alternative artificial sett needs to be established first. Also toe erosion caused by over-deepening of the bed and/or rapid draw down of levels following high flows causes damage and degradation. Some of the Environment Agency embankments are tenanted, with tenants often using grazing as a form of maintenance. However, the damage thought to be caused by grazing is not necessarily covered by the income from the tenants and is not regularly repaired.

The defence embankments in the South Forty Foot Drain catchment are shown in Figure 8.

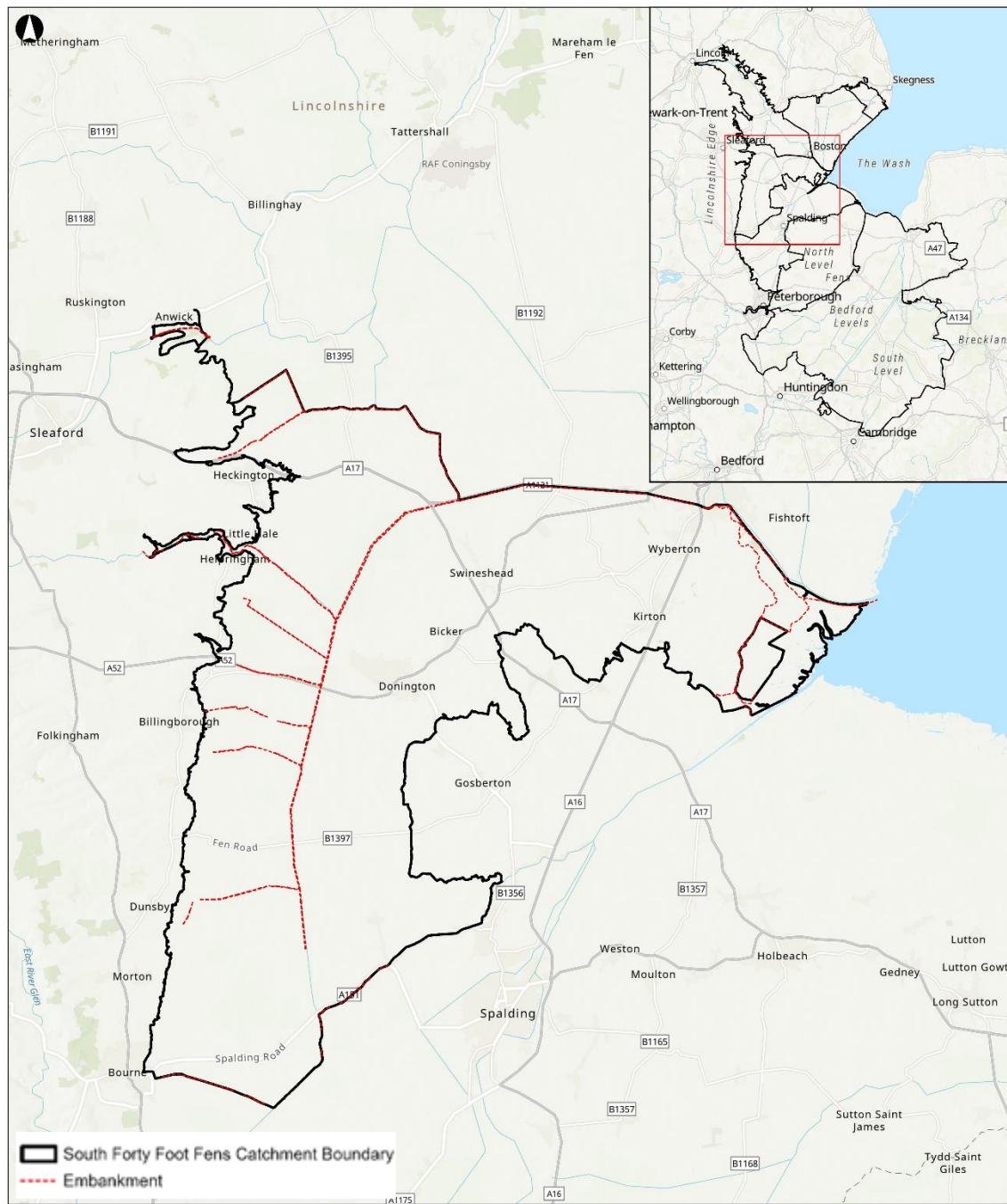


Figure 8: Environment Agency embankments in the Great Ouse catchment

2. Notable flood history

A number of flood events have impacted the South Forty Foot Drain catchment. These events have been summarised in the proceeding sections.

Information on flood history has come in the form of:

- Flood outlines (GIS files) recorded by the Environment Agency;
- Records/emails from Environment Agency staff detailing number of properties impacted;
- Section 191 reports from Local Authorities; and
- News articles from reputable news organisations, such as the BBC and local newspapers.

2.1 October 1763

The 'Great Flood' of Lincolnshire on 7th October 1763 caused by continual rains² that inundated 237km² to the south and west of Boston. This resulted in the Black Sluice Drainage Acts (1765 and 1770). Under these Acts the Black Sluice Commissioners were created, a replacement Black Sluice was constructed, and another 21km of the South Forty Foot Drain was cut. In addition, the Boston Port Act (1766), created the Boston Harbour Commissioners who undertook works to improve navigation within The Haven.

2.2 1810

An extreme tidal event in 1810 resulted in raising of the existing sea banks to two feet (0.6 m) above the 1810 level (19.33 feet (5.89 mAOD) in and around Boston.

2.3 January 1953

On the 31st of January 1953, the greatest storm surge, within records held for the North Sea, caused extensive tidal flooding along the coast. However, the existing defences in Boston safeguarded the majority of the South Forty Foot Drain catchment from inundation during the major tidal surge. There is no Environment Agency recorded flood extent in this catchment.

2.4 2012

Swaton residents were impacted by floods four times in 2012³. A flood warning was in place on 24th/25th November 2012 caused by heavy rain. Swaton was flooded in July 2012.

The BBC reported that the A52 east of Boston was affected by surface water flooding on 25th November 2012⁴

¹ Under the Flood and Water Management Act 2010, Lead Local Flood Authority are required to investigate significant flood incidents, and produce reports known as Section 19 reports.

² [Chronology of British Hydrological Events \(CBHE\)](#)

³ [Swaton residents hit by floods four times in a year - BBC News](#)

⁴ [Lincolnshire storm: Roads closed after heavy rain - BBC News](#)

2.5 December 2013

In 2013 a major tidal flood event damaged Black Sluice pumping station and caused flooding of 800 properties and 55 streets within Boston (Figure 9). However, it would appear that most flooding in the South Forty Foot catchment occurred from The Haven, not the South Forty Foot Drain, and impacted commercial properties and roads on the right hand floodplain of the Haven.

As a result of this event, the Environment Agency undertook a review of the pumping station's performance. This resulted in the Black Sluice Pumping Station being decommissioned. Water levels are now managed using the gravity sluice only. The damage caused by the 2013 flood event resulted in formation of Boston Combined Strategy, which then lead to the construction of the Boston Barrier and a significant length of raised embankments along The Haven, to protect Boston from the risk of tidal inundation. Construction of the barrier was completed in 2020.

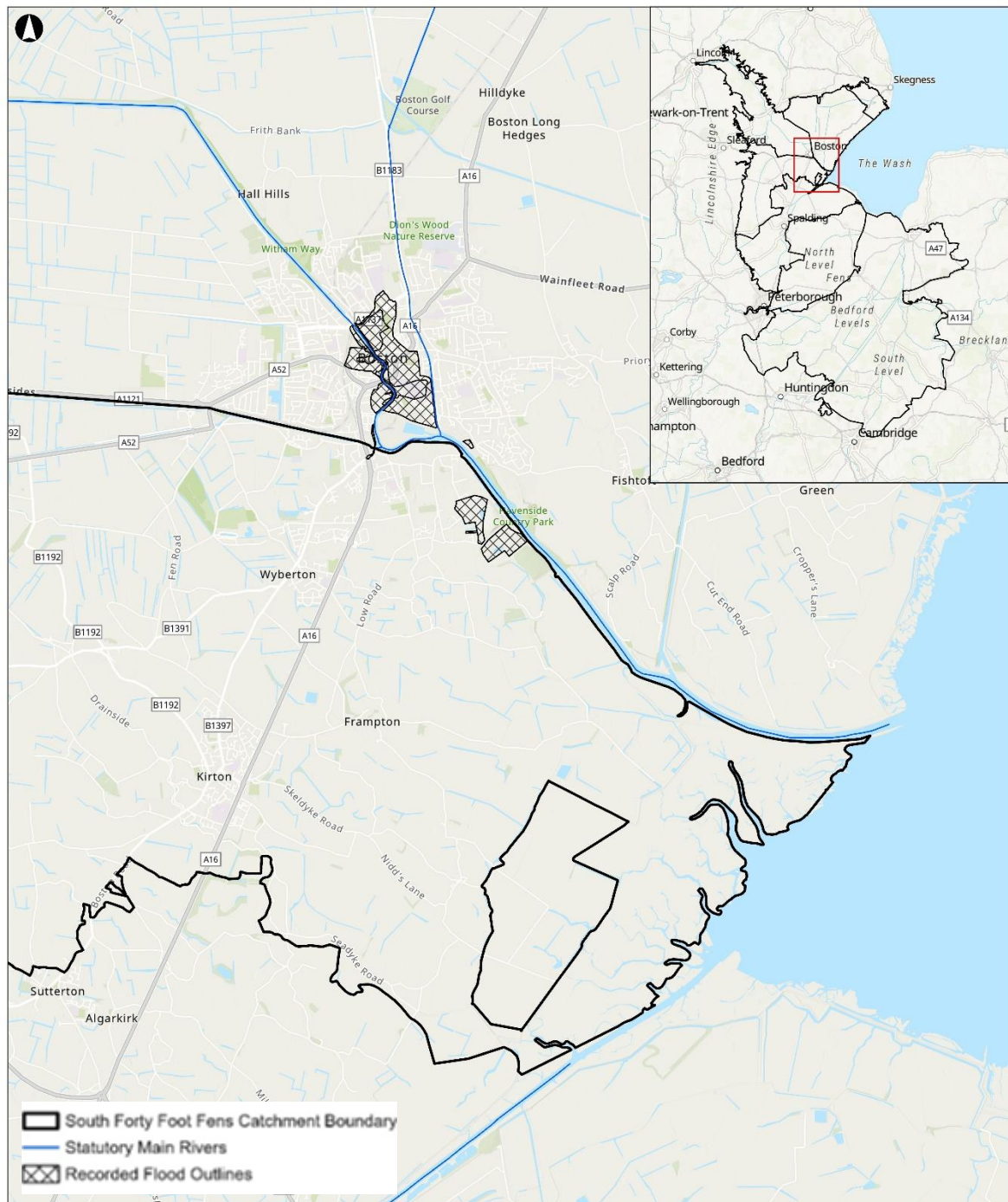


Figure 9: Flood outlines in Boston during the 2013 tidal event

2.6 January 2021

A flood warning was issued for Swaton Eau in Swaton village on 14th January 2021 where heavy rain led to rising river levels causing flooding of low-lying land and roads in Swaton⁵. Whilst Swaton lies on the western periphery of the South Forty Foot Drain catchment, the Swaton Eau watercourse drains in an easterly direction into the catchment, and

⁵ [Flood warning in village near Sleaford](#)

newspaper reports “heavy rain fell on the South Forty Foot catchment for over 12 hours” which implies that this event may have caused more flooding across the catchment⁶.

Flood alerts were also in place during this event for minor watercourses of the South Forty Foot Drain, meaning that flooding was possible, and it is advised to be prepared for flooding. However, no further reports of flooding were recorded.

2.7 Winter 2023/2024 (Storm Babet/Storm Henk)

The winter storms of 2023/2024 saw widespread fluvial flooding across Lincolnshire and the East Midlands. This put tremendous pressure on the entire drainage system, as well as the Black Sluice IDB staff and their budget.

⁶ Flood warning in village near Sleaford

On 20th October 2023 during Storm Babet, 23 properties flooded and on 2nd January 2024 during Storm Henk, 56 properties were flooded⁷ in the catchment (Figure 10)

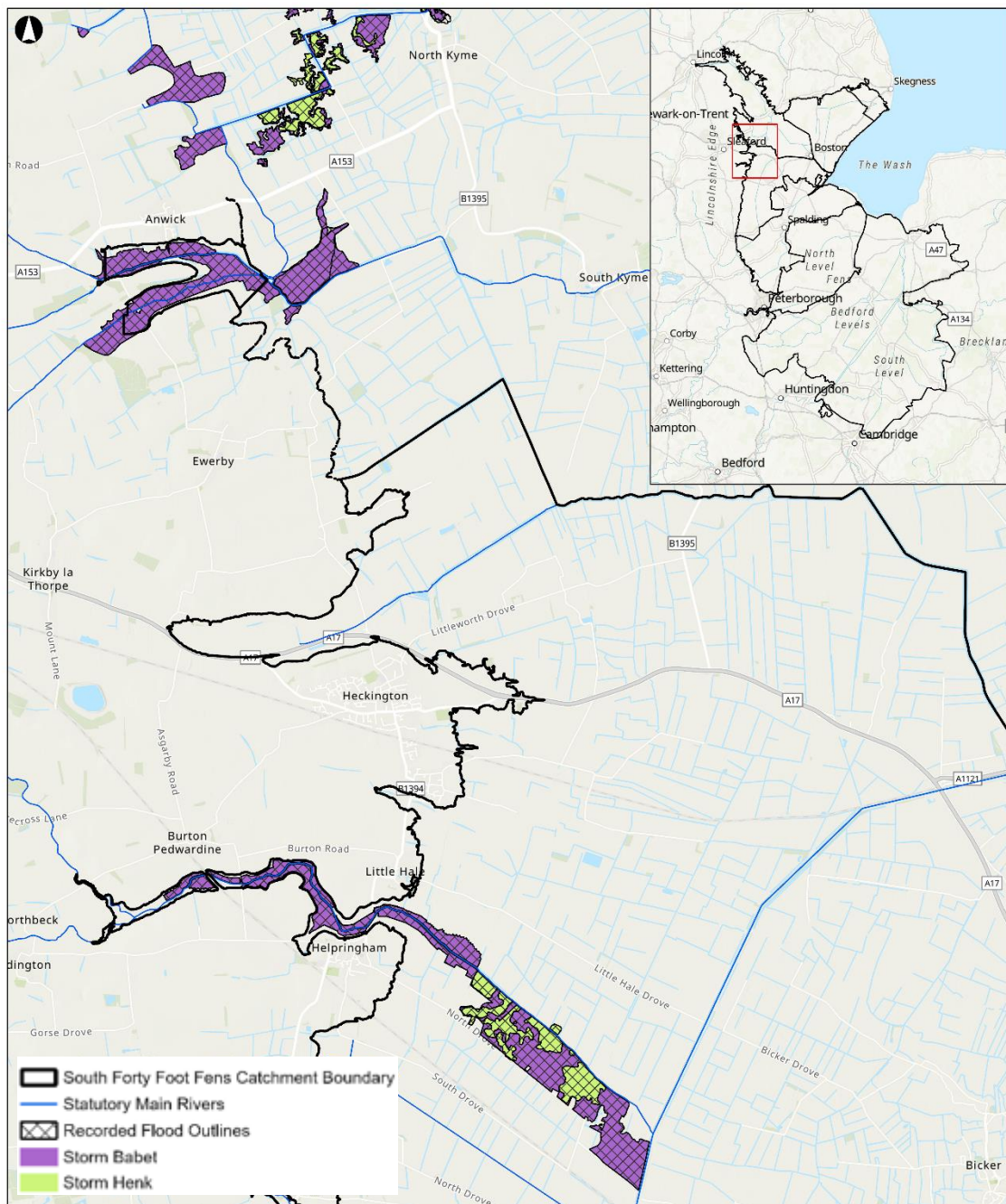


Figure 10: Flood outlines during Storm Babet and Storm Henk

2.8 January 2025

A flood warning was in place on 6th January 2025 in the Boston area and was removed three days later. 34 residential properties flooded on Wyberton West Road in Boston from overtopping and seepage of the South Forty Foot Drain. River levels were the highest ever recorded. Flooding was likely exacerbated by the high tide occurring at the same time. There was flooding of properties and roads at Pointon and Billingborough. It is evident that

⁷ Pers comms with the Environment Agency July 2024

several areas on the right bank of the Helpringham Eau experienced flooding during this event, similarly to their experience during Storm Babet.

2.9 Other events

The flood events detailed in the preceding sections detail the flood history of the catchment where records have been found. Recorded flood history is likely to be biased towards flooding that impacts properties.

It is expected that there will be more instances of flooding of agricultural land that have not been recorded.

2.10 Discussion

The flood history indicates that the main flooding mechanism that has occurred in the catchment is from fluvial flooding, as demonstrated by the most recent events in 2023, 2024 and 2025.

Whilst there were tidal events in the early 1800s that have caused damage within the catchment, these were before 1846, when the Black Sluice was constructed. The fact that the 1953 and 2013 storm surge had minimal impact on this catchment suggests that this catchment is well protected from tidal events. However, there is a risk of overtopping of the defences downstream of Black Sluice, which occurred during the 2013 event.

3. Methodology and data review

3.1 Methodology

The methodology used in this assessment is to use best available information (i.e. no new modelling work has been undertaken for this study) to document both current and future flood risk and has been agreed with the Environment Agency. This assessment has been informed by a review of the existing hydraulic modelling and engagement with the relevant Environment Agency teams.

The proceeding sections detail the existing datasets used to determine the baseline flood risk in the South Forty Foot Drain catchment.

3.2 Detailed hydraulic modelling

A review of all detailed models in the Fens 2100+ study area was undertaken. The review found that in the South Forty Foot catchment, there were two suitable models that could be used to describe flood risk and which a number of metrics could be extracted from:

- 2017 Black Sluice Catchment hydraulic model.
- 2010 Northern Area Tidal Modelling.

These models are described in more detail in the proceeding sections.

3.2.1 2017 Black Sluice Catchment Model

The Black Sluice Catchment Model was developed by Mott MacDonald, on behalf of the Environment Agency in 2017 as part of the Black Sluice Project Appraisal Report (PAR).

The model is a fluvial, 1D only Infoworks RS model, converted from a 2016 ISIS model (now known as Flood Modeller Pro). The model extent is shown in Figure 11, as well as a comparison of the 2016 and 2017 model maximum extent for the 1% AEP event. The 2017 model showed a slightly larger maximum flood extent, though these increases are isolated to few locations across the model boundary. The model included representation of the Black Sluice Pumping Station at the downstream boundary of the model and flood embankments. No tidal scenarios have been undertaken as part of this study.

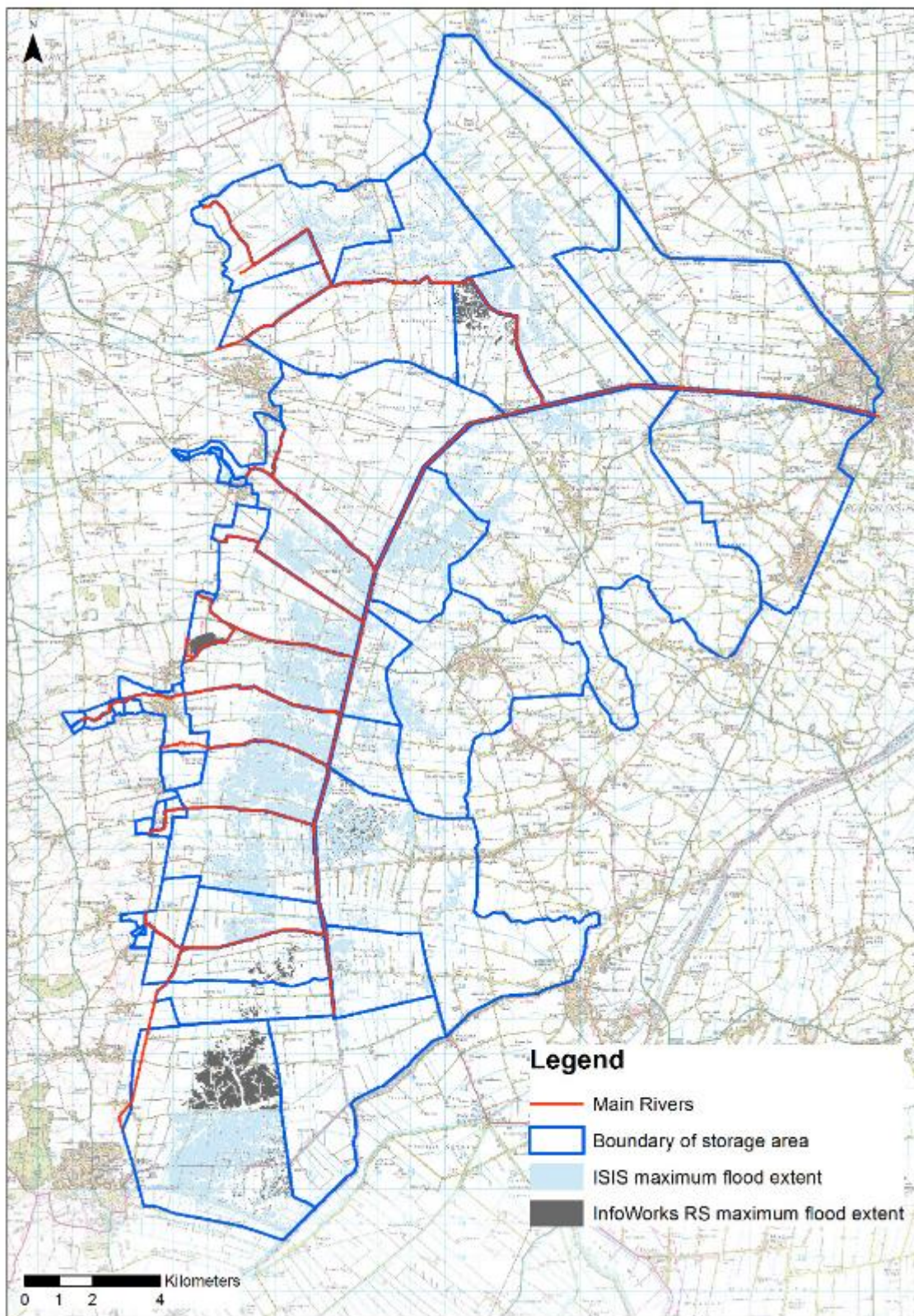


Figure 11: 2017 Black Sluice catchment model extent

3.2.2 Northern Area Tidal Modelling

In 2010, Mott MacDonald, on behalf of the Environment Agency undertook tide, surge and wave analysis of the coastline from the Humber to The Wash.

The results from this analysis were then input into a 2D TUFLOW model of the same area to understand the flood risk. The study area for the modelling is shown in Figure 12.

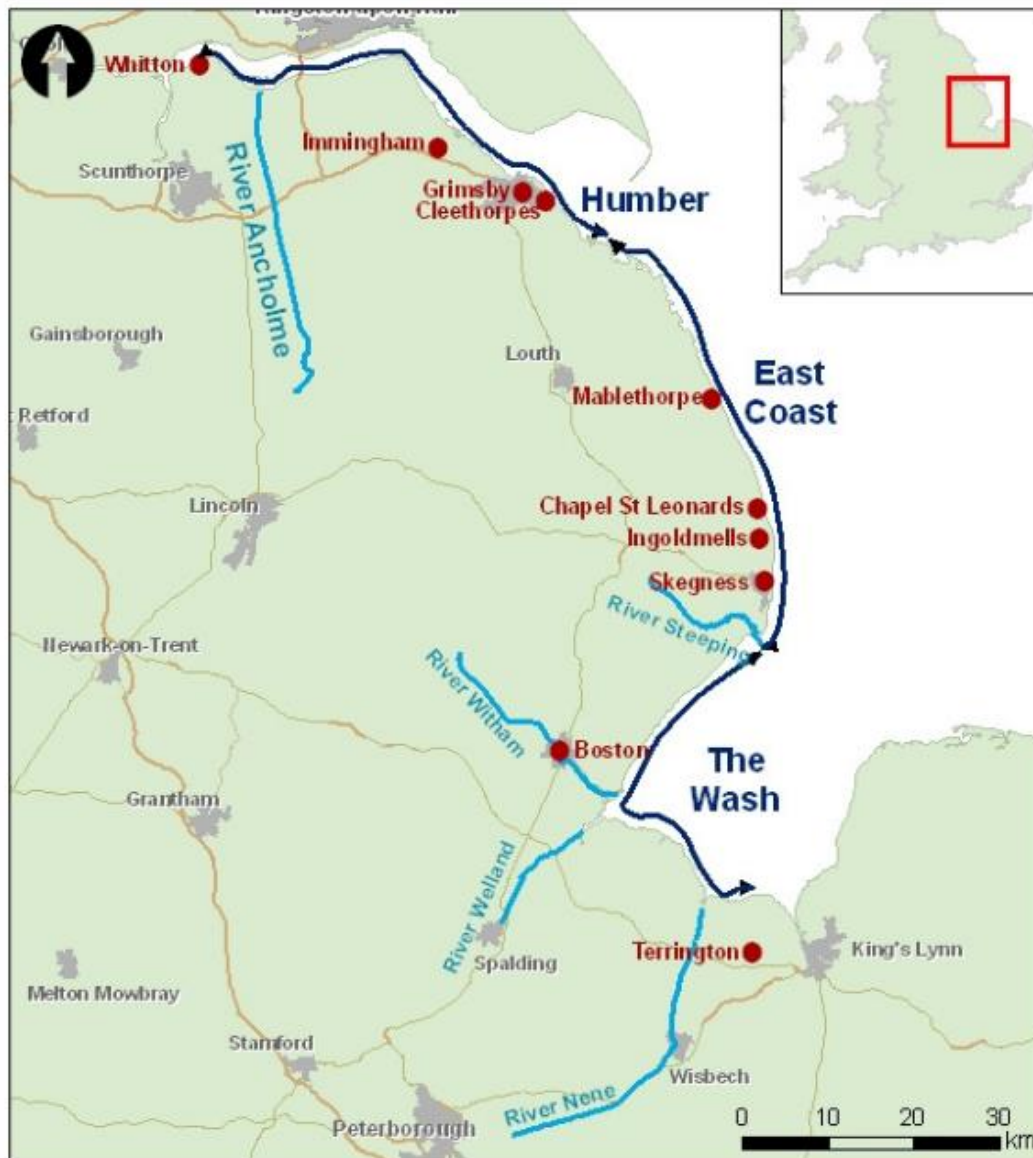


Figure 12: Northern Area Tidal Modelling study area, extracted from the Northern Area Tidal Modelling report © Environment Agency

As part of the inundation modelling, defended and undefended scenarios were undertaken.

The modelling only assessed tidal flood risk – no representation of fluvial flooding was undertaken as part of this modelling study.

A detailed analysis of the wind and wave conditions in the study area were undertaken. This established the 1 in 1 year wave conditions (wave overtopping that would be expected every year) and used in the TUFLOW inundation modelling. For the climate

change scenarios, a 10% uplift was applied to wave inflows. Figure 13 details the events undertaken as part of the Northern Area Tidal Modelling study.

Water Level - Event Scenario	Water Level - Annual Exceedance Probability	Wave Condition	Present Day (2006)	Climate Change (2115)
1 in 10	10%	1 in 1 annual chance	Humber and East Coast models and for internal use only.	x
1 in 75	1.3%	1 in 1 annual chance	√	x
1 in 100	1%	1 in 1 annual chance	√	x
1 in 150	0.7%	1 in 1 annual chance	√	x
1 in 200	0.5%	1 in 1 annual chance	√	√
1 in 1000	0.1%	1 in 1 annual chance	√	√

Figure 13: Events modelled as part of the 2010 Northern Area Tidal Modelling © Environment Agency

An update of the coastal modelling is currently in progress and is due to be delivered in March 2026.

3.2.3 Limitations

The following limitations are associated with the data:

- Both models were developed for Environment Agency – therefore are focussed on flooding from tidal and Main River sources, as such the representation of flooding from drainage ditches is likely to be simplistic or not represented at all.
- 2010 model does not include any fluvial elements;
- The 2010 model used tidal boundary data that is now 15 years old – these levels will have changed.
- The 2010 and 2017 model uses LIDAR data and has been superseded by finer resolution data.
- The 2017 model is 1D only, therefore out of bank flood mapping will not be as accurate as a 1D-2D approach, as it will project 1D levels across available LIDAR.
- Hydrological inflows used in the 2017 model will have changed due to changes in existing methodologies and new data.
- Channel survey used to define the 1D geometry, is at least 10 years old and will not reflect any changes to the watercourse.
- No tidal scenarios were undertaken as part of the 2017 model.
- The 2017 model does not include an assessment of joint probability for fluvial and tidal variables. The 2017 modelling assumes that fluvial is dominant mechanism.

3.3 Other data sources

3.3.1 National Flood Risk Assessment

The National Flood Risk Assessment (NaFRA) consists of a number of different products, including:

Risk of Flooding from Rivers and Sea - A geospatial dataset the floodplain split into 50m x 50m cells and each allocated one of four flood risk likelihood categories.

Reduction in Risk of Flooding from Rivers and Sea Due to Defences - Produced using the defended scenario of flood risk in the Risk of Flooding from Rivers and Sea dataset and an undefended scenario of flood risk from rivers and sea.

Risk of Flooding from Surface Water (RoFSW) - A geospatial dataset the floodplain split into 2m x 2m cells and each allocated one of four flood risk likelihood categories.

Risk of Flooding from Multiple Sources (RoFMS) - A geospatial dataset combining data from RoFRS & RoFSW. The RoFMS inherits the appearance of the input datasets. When both RoFRS and RoFSW indicate a risk in the same area, the RoFSW (surface water flood risk) will be the more prominent feature, indicating the potential for flooding from surface water in that specific location (see Figure 14).

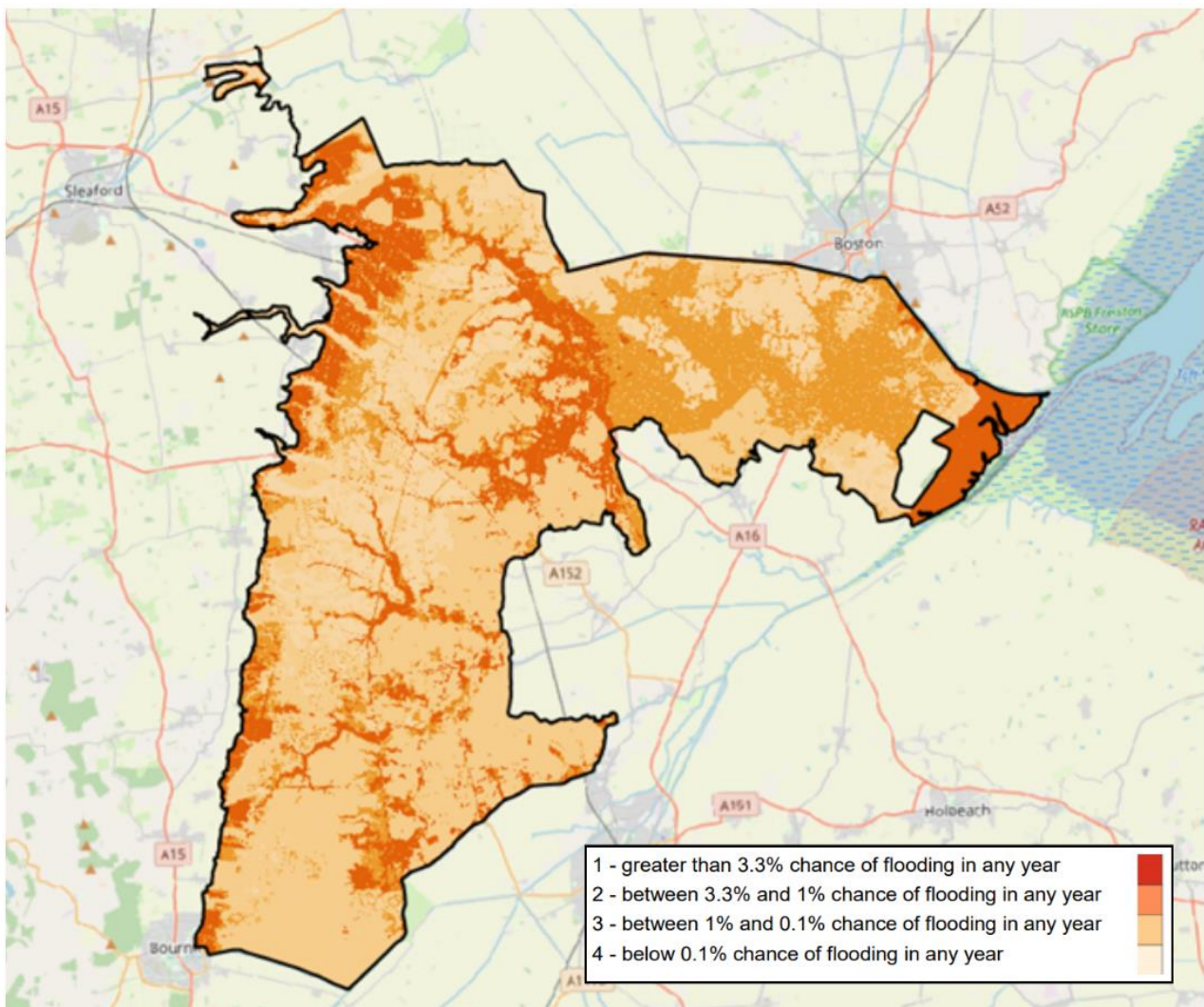


Figure 14: Risk of flooding from multiple sources (Environment Agency, 2025)

Reduction in Risk of Flooding from Rivers and Sea Due to Defences - Produced using the defended scenario of flood risk in the Risk of Flooding from Rivers and Sea dataset and an undefended scenario of flood risk from rivers and sea.

Reduction in Risk of Flooding from Rivers and Sea Due to Defences - Produced using the defended scenario of flood risk in the Risk of Flooding from Rivers and Sea dataset and an undefended scenario of flood risk from rivers and sea.

Flood Zone 2 - It is the best estimate of the areas of land at risk of flooding, when the presence of flood defences is ignored and covers land between Flood Zone 3 and the extent of the flooding from rivers or the sea with a 0.1% AEP of flooding each year.

Flood Zone 3 - It is the best estimate of the areas of land at risk of flooding, when the presence of flood defences is ignored and covers land with a 1% AEP or greater chance of flooding each year from Rivers; or with a 0.5% AEP or greater chance of flooding each year from the Sea.

The datasets listed above, have been developed using an ‘undefended’ approach – i.e. the tidal and fluvial flood defences have been removed. Given the low-lying nature of the majority of the catchment and the reliance on flood defence assets, this will inevitably result in an over-prediction of current flood risk. Conversely the undefended fluvial extents in low-lying pumped catchments will under-predict flood extents. The dataset does not include any allowance for climate change. It will also not represent flood risk accurately in a heavily pumped catchment such as the South Forty Foot Drain catchment.

As this catchment has detailed models for both fluvial and tidal flood risk, NaFRA has not been used in this assessment.

3.3.2 National Flood Risk Assessment 2

National Flood Risk Assessment 2 (NaFRA2) includes:

- NaFRA2 software system: a web-based IT solution for Environment Agency staff; and
- New National Modelling (NNM): provides hazard outputs for rivers, sea, and surface water for various scenarios.

For NaFRA2, the focus is on using local modelling, though limited detailed local models are available within the catchment. The NNM will be used throughout most of the catchment and features:

- Models using JFlow GPU software;
- A 2m model grid based on the Environment Agency’s Integrated Height Model 2019 and Defra Marine DEM;
- Outputs including maximum depth, level, etc.; and
- Present day and climate change scenarios.

However, a specific Fens model developed for NaFRA2 is not available for this project, as it is not currently approved for use locally.

3.3.3 Internal drainage board models

We have not been made aware of any models produced by the Internal Drainage Board for this catchment.

3.4 Other sources of information

3.4.1 Joint Lincolnshire Flood Risk and Drainage Management Strategy (2019-2050)

The Strategy provides a framework for flood risk management across Lincolnshire linking all the RMAs.

3.4.2 Anglian River Basin District River Basin Management Plan

This policy tackles the challenges affecting the water environment in the Anglian River Basin District. Developed under the Water Framework Directive, it outlines actions to mitigate these pressures.

3.4.3 Anglian River Basin District Flood Risk Management Plan (2021-2027)

This plan encourages a partnership to explore the resilience measures that will help the river basin district be more resilient and informs the delivery of existing flood programmes.

3.4.4 South East Lincolnshire Strategic Flood Risk Assessment (2017)

This outlines how development should consider flood risk at every stage of the development process. It includes a standard advice appendix which describes the assessment and mitigation measures required, based on Flood Zones and vulnerability to flood risk. No modelling was undertaken as part of the SFRA.

3.4.5 Boston Combined Strategy (2013)

The Strategy seeks to reduce the risk of tidal flooding to the town over the next 100 years. This strategy includes the construction Boston Barrier, completed in 2020 and the raising of flood banks along The Haven.

3.4.6 The Wash Shoreline Management Plan 2 (2010) Section Gibraltar Point to Old Hunstanton

This plan outlines a strategic approach to managing flood and coastal erosion risks along the English coastline through to 2105. The Policy Development Zone (PDZ) of relevance to the South Forty Foot Drain is PDZ1 Gibraltar Point to Wolfreton Creek, where the intention is to maintain the position and function of existing coastal flood defences. In the medium and longer term, managed realignment may be required depending on the potential loss of foreshore.

3.4.7 Witham Catchment Flood Management Plan (2009)

This plan guides the Environment Agency and its partners in planning and determining the most effective strategies for managing future flood risks. The key policy relevant to the catchment is Policy 4 which describes how further actions may be required to address the changes caused by climate change in areas that are prone to flood risk and are heavily managed, such as the Fens. Although this document has not been withdrawn, the publication of the 2021 - 2027 River Basin Flood Risk Management Plan has diminished its weight in decision making.

3.5 Key receptors

3.5.1 Settlements

Key settlements in the catchment include Billingbrough, Donington, Gosberton Helprington, Kirton, Quadring Swineshead and Wyberton, and also encompasses the southern portion of the market town of Boston. These settlements are served by the A151, A16, A17 and A52 roads which are strategic transport routes through the catchment area. In addition, there is a local rail service with stations at Hubberts Bridge and Swineshead linking to Boston.

3.5.2 Agriculture

The Fens is an area of national agricultural importance due to its rich peaty soils. Farms across the catchment are mainly focused on the production of arable and grassland crops.

Across the catchment, around 323km² (95%) of land is classified as ALC Grade 1 and 2 land, with the majority being classified as Grade 2 land. Table 1 and Figure 15 present an overview of ALC classification in the catchment.

Table 1: Overview of ALC classification within the catchment

	Grade 1	Grade 2	Grade 3	Grade 4	Non-agricultural
Area (km ²)	145.06km ² (14,506 ha)	178.17km ² (17,817ha)	7.48km ² (748ha)	0km ² (0ha)	6.62km ² (662ha)
Percentage of catchment (%)	42.6	52.9	2.2	0	1.9

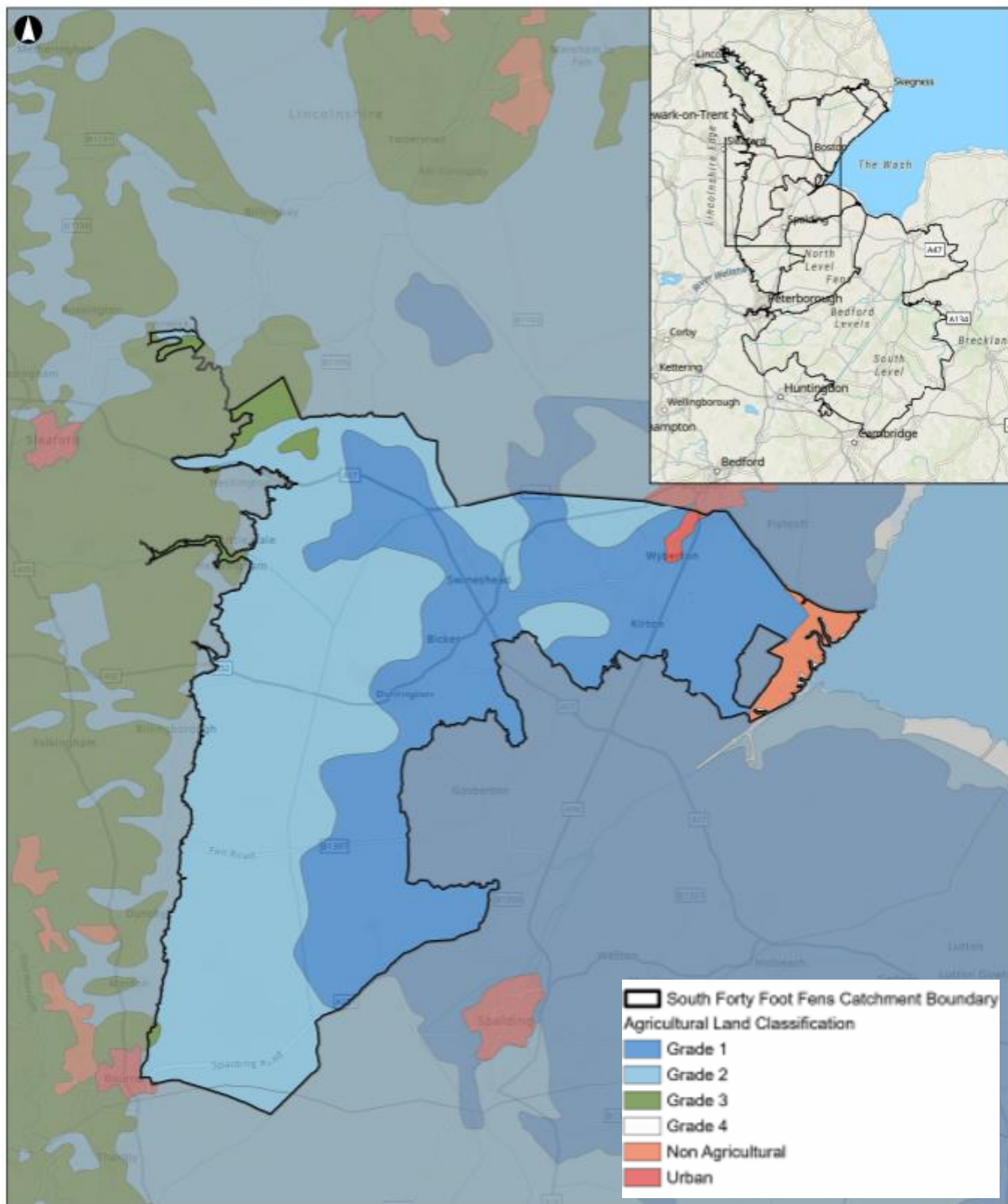


Figure 15: Land classification across the catchment

Approximately 294km² (86%) of land across the South Forty Food Drain catchment is currently farmed.

It is estimated that the agricultural value of the crops grown on this land (based on 2023 data) is as follows:

- Cereal production – c.£20.8 million;
- Other arable– c.£15.8 million; and
- Fruit and vegetables – c.£54.2 million.

Grassland does not directly create economic value but instead supports the grazing of sheep and cattle, or the production of livestock feed. The estimated overall economic output of crops and livestock is in the region of £120.4 million, highlighting the importance of the agricultural sector.

4. Climate change

The impact of climate change has been represented in both models used in this assessment to understand future tidal and fluvial impacts. The approach to climate change in each of the models is described in the proceeding sections.

4.1 Tidal climate change

Climate change (CC) has been assessed as part of the Northern Area Tidal Modelling up to 2115, calculated rates of sea level rise used in this study are shown in Figure 16.

Years	Net Sea Level Rise (mm/yr)	Calculated Sea Level Rise (m)
2006 - 2025	4	0.08
2025 - 2055	8.5	0.26
2055 - 2085	12	0.36
2085 - 2115	15	0.45
Calculated Total Sea Level Rise (2006 – 2115)		1.14

Figure 16: Sea level rise used in 2010 Northern Area Tidal Modelling

The sea level rise applied to the design peak water levels generates a level of **6.17mAOD** at Burgh Sluice for the 0.5% AEP event.

Since the study was completed in 2010, sea level rise estimates have been revised. Current Environment Agency guidance recommends assessing against two scenarios; Higher Central and Upper End. The allowances for sea level rise are shown in Table 2.

Table 2: Sea level allowances for each epoch

Area of England	Allowance	2000 to 2035 (mm/yr)	2036 to 2065 (mm/yr)	2036 to 2065 (mm/yr)	2066 to 2095 (mm/yr)	Cumulative rise 2000 to 2125 (metres)
2025 Anglian	Higher central	5.8	8.7	11.6	13	1.20
	Upper end	7	11.3	15.8	18.1	1.60

For flood risk assessments and strategic flood risk assessments both the higher central and upper end allowances will need to be assessed.

Flood and Coastal Erosion Risk Management (FCERM) schemes are typically assessed against the higher central. Given the long-term nature of the Fens 2100+ project, the 2080s epoch with the higher central allowance is most applicable to this study.

These estimates have been compared to those applied in the 2010 modelling, shown in Figure 17. This shows that the estimates used in the 2010 study lie between the Higher Central and Upper End. Given that FCERM schemes typically assessed against the higher central it is considered that the climate change estimates used in the 2010 modelling are appropriate for use in this study.

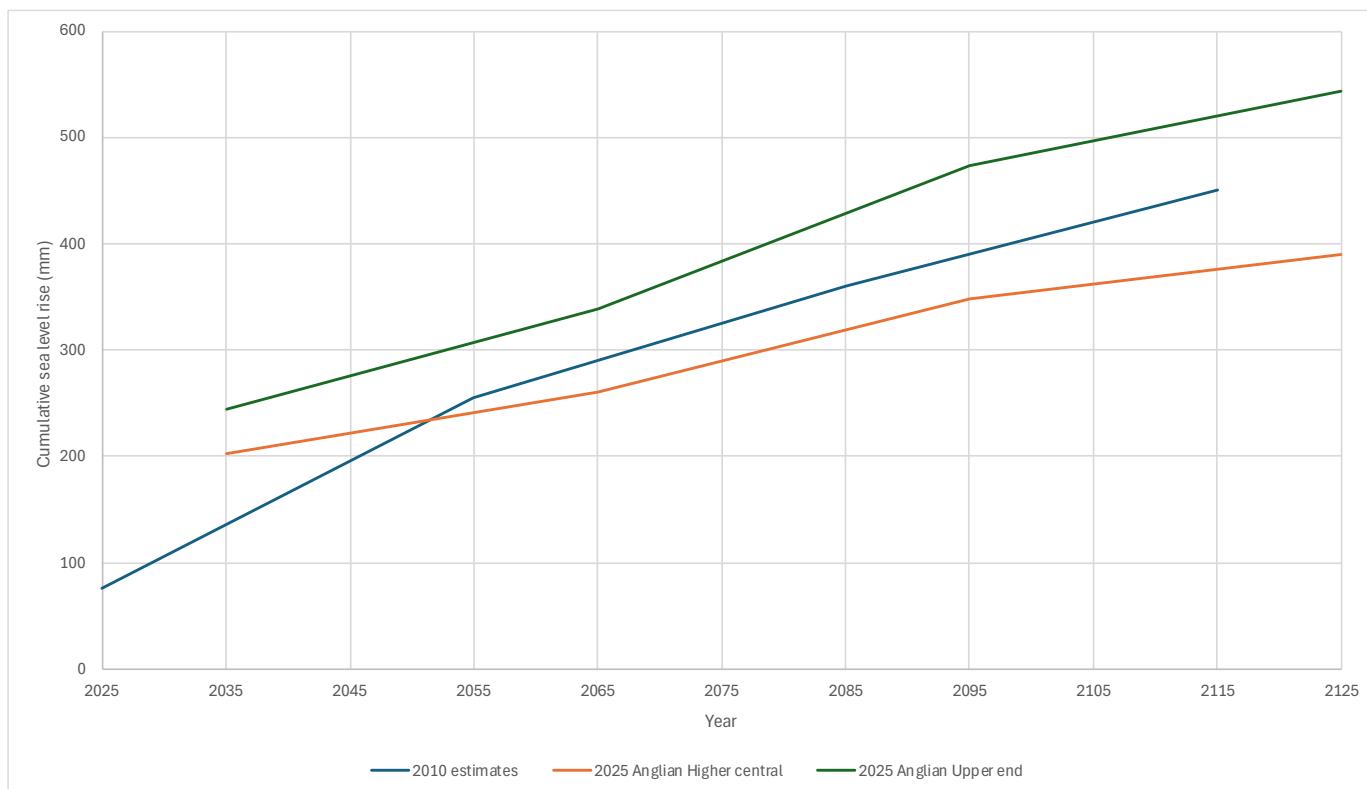


Figure 17: Comparison of sea level rise estimates

4.2 H++ scenario

The Fens 2100+ programme is a long term adaptive plan for the landscape as such the H++ is a useful sensitivity test. Current Environment Agency guidance states that a value of 1.9m up to 2100 should be used (There is no H++ value for sea level rise beyond 2100).

None of the available modelling for the South Forty Foot Drain catchment includes an assessment of the H++ scenario. The most extreme value for climate change used within the 2010 modelling (as detailed in Figure 16) is 1.14m – this is considerably smaller than the value if 1.9m. We can therefore infer that the H++ scenario would show more flooding (depth and extent) than the results presented in the proceeding sections.

4.3 Fluvial climate change

The 2017 Black Sluice Catchment model has applied climate change uplifts to the 1% and 0.1% AEP events. The model uses climate change allowances in accordance with National Planning Policy Framework (NPPF) guidance which was current at the time of the model build which was plus 20% to model inflows.

Latest climate change guidance for the Witham Catchment (where the South Forty Foot Drain catchment is located), is provided in Table 3. This indicates that an increase of fluvial flows by 20% is similar to the Central estimate for the 2080 epoch.

Table 3: Witham Management Catchment peak river flow allowances

	Central	Higher	Upper
2020s	9%	14%	27%
2050s	8%	15%	32%
2080s	21%	32%	57%

For Flood Risk Assessments and Strategic Flood Risk Assessments the following are used:

- Flood zones 2 or 3a:
 - essential infrastructure – higher central allowance;
 - highly vulnerable – central allowance (development should not be permitted in flood zone 3a);
 - more vulnerable – the central allowance;
 - less vulnerable – the central allowance;
 - water compatible – the central allowance;
- Flood zone 3b:
 - essential infrastructure – use the higher central allowance;
 - highly vulnerable – development should not be permitted;
 - more vulnerable – development should not be permitted;
 - less vulnerable – development should not be permitted;
 - water compatible – use the central allowance.
- For FCERM schemes, the following are used:
 - Central allowance as the design allowance;
 - Higher central allowance to test the impacts of higher scenarios of climate change and any extra mitigation;
 - Extreme allowance to test the option under more extreme climate change and exceedance events; and
 - 2080s epoch allowances for changes beyond the 2080s epoch and up to 2115.

This guidance suggests that the climate change uplift applied to the 2017 model is similar to that required for FCERM schemes, and for more vulnerable, less vulnerable and water compatible development (central allowance) in Flood Zone 3a.

5. Tidal flood risk

5.1 Current tidal flood risk

The South Forty Foot Drain catchment is protected by significant tidal defences along the coast (as shown in

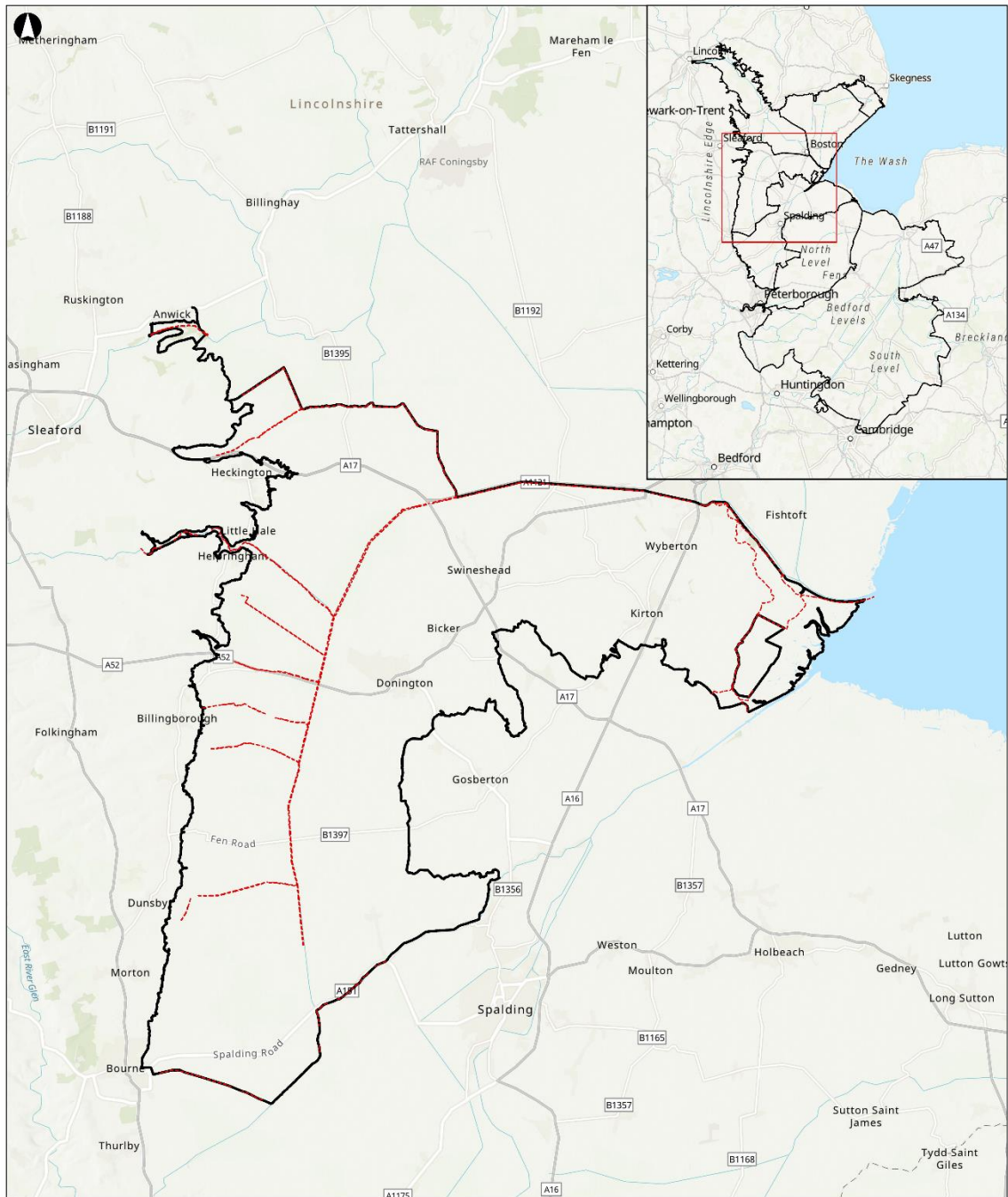


Figure 8: Environment Agency embankments in the Great Ouse catchment

), these provide a high level of protection and are only overtopped during an extreme flood event.

The 2010 Northern Area Tidal Modelling shows that the tidal flood risk in the catchment is located close to the coastline on the right-hand bank of The Haven downstream of Boston as shown in Figure 18. This suggests that there may be a few isolated properties at risk from tidal flooding from the 0.5% and the 0.1% tidal event. The largest area at risk from tidal flooding in this catchment is the Frampton Marsh Nature Reserve, which is a RSPB nature reserve which supports freshwater wetlands, reedbeds, wet grasslands and large shallow pools (scrapes)⁸. The flooding is caused by overtopping at low points in the existing embankment.

Though no properties are at risk, it is notable that only Grade 1 agricultural land is at risk of flooding in both the present day 0.5% and 0.1% AEP events.

⁸ Frampton Marsh Nature Reserve, Lincolnshire

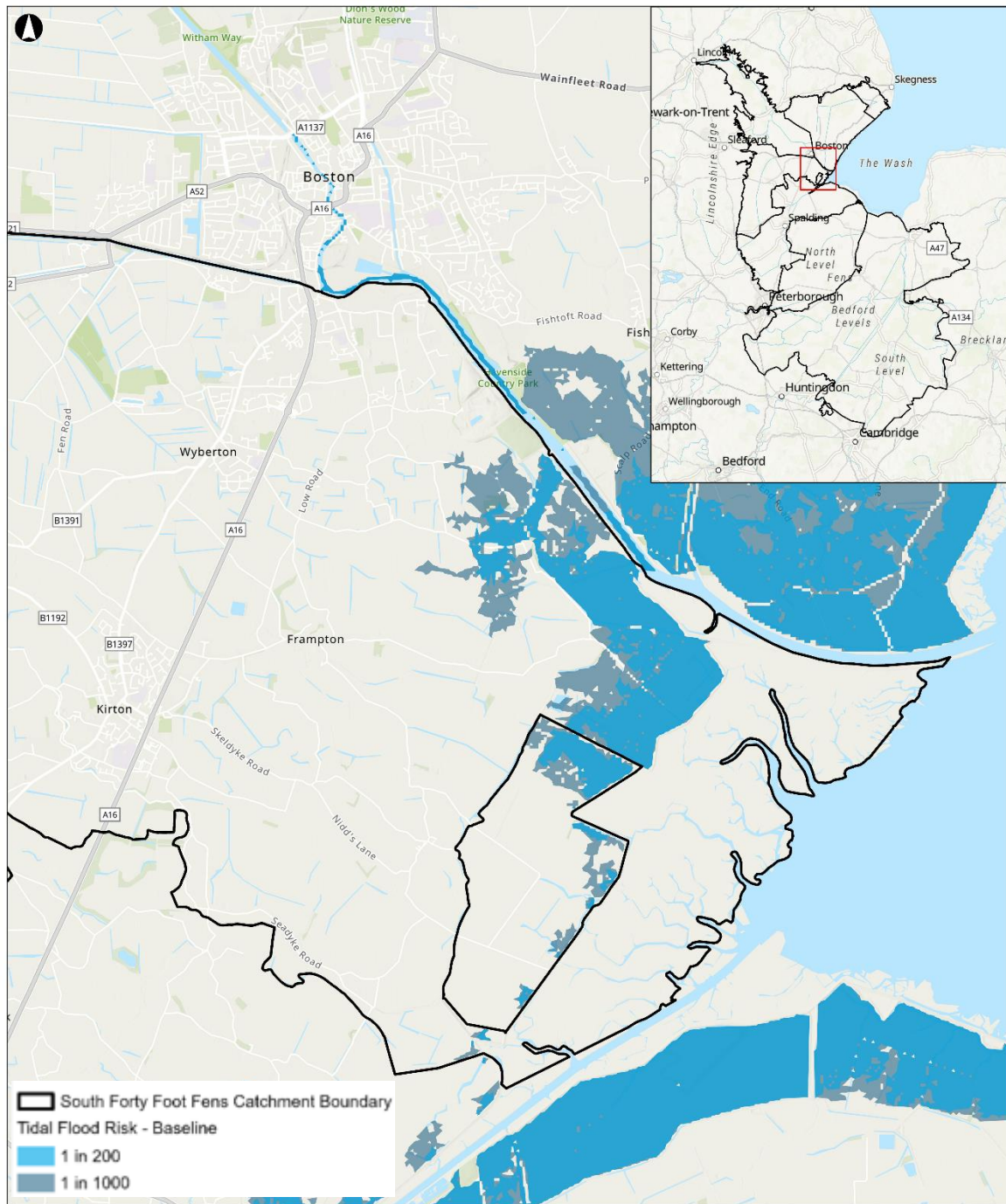


Figure 18: 0.5% AEP event and 0.1% AEP event current tidal flood risk in the catchment

5.2 Future tidal flood risk

Tidal climate change has been assessed using the 2010 Northern Area Tidal modelling for the 0.5% AEP event up to 2115.

Results from the modelling showed a significant increase in flood risk in comparison to the present day with large areas of the South Forty Foot catchment predicted to inundate, including the Wyberton area of Boston on the right bank of the South Forty Foot drain, as shown in Figure 19.

The modelling showed flooding due to overtopping of embankments downstream of the Boston Tidal Barrier, as such the fact that the Boston Barrier is not represented in the 2010 modelling will have a minimal impact on flood risk to the catchment as the Boston Barrier provides protection to properties upstream (i.e. within the urban area of Boston).

In addition to the flooding of areas of Boston, large areas of Grade 1 farm land are predicted to inundate for this event.

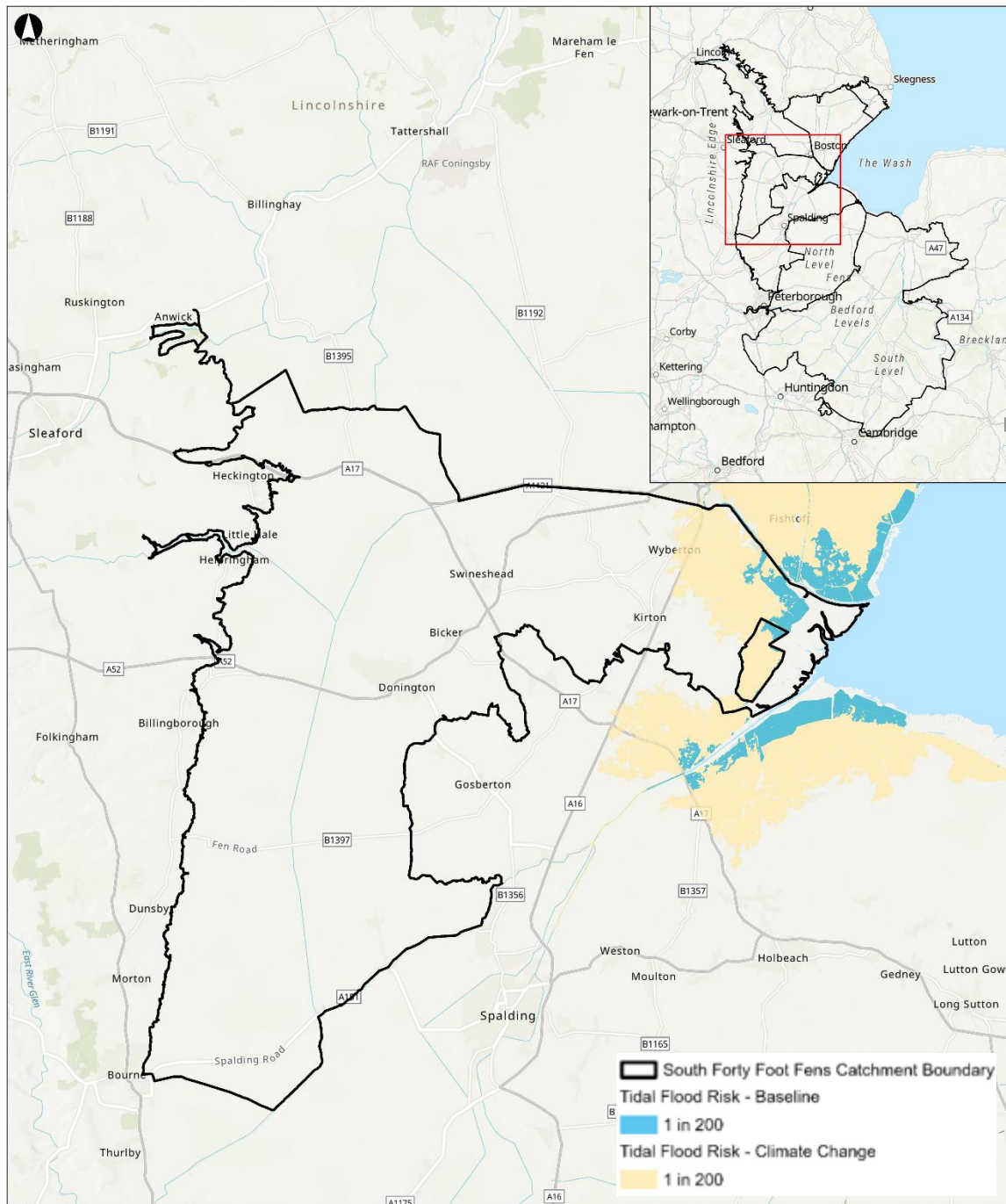


Figure 19: Comparison between 0.5% present day and 0.5% with climate change applied up to 2115

5.3 Key metrics

5.3.1 Total area

The total area to be at risk of tidal flood risk in the 2010 model within the South Forty Foot Drain catchment was:

- Current 0.5% AEP event – 2.24km² (224ha) – 0.66% of total catchment area;
- Future 0.5% AEP event with allowance for climate change – 17.18km² (1,718ha) – 5.0% of total catchment area;

- Current 0.1% AEP event – 3.57km² (357ha) – 1.05% of total catchment area.

5.3.2 Grades of agricultural land

The agricultural land within the South Forty Foot Drain catchment area is assessed for tidal flood risk based on different grades, this has been summarised in Table 4.

Table 4: Agricultural land grading at risk of tidal flooding

Agricultural Grade	0.5% AEP (km ²)	0.5% with an allowance for climate change AEP (km ²)	0.1% AEP (km ²)
Grade 1	2.24km ² (224ha)	16.35km ² (1,635ha)	3.57km ² (357ha)
Grade 2	0	0	0
Grade 3	0	0	0
Grade 4	0	0	0
Grade 5	0	0	0
Total	2.24km ² (224ha)	16.35km ² (1,635ha)	3.57km ² (357ha)

5.3.3 Percentage area over 30cm flood depth

The area that floods over 30cm for each event is as follows:

- Current 0.5% AEP event – 0.94km² (94ha) – 0.27% of total catchment area.
- Future 0.5% AEP event with allowance for climate change – 16.4km² (164ha) – 4.7% of total catchment area.
- Current 0.1% AEP event – 1.68km² (168ha) – 0.49% of total catchment area.

5.3.4 Discussion

As a percentage of the total catchment area, the land at risk of flooding from tidal sources is small. However, it should be noted that the flood risk to agricultural land is isolated to Grade 1 land, even during the 0.5% AEP event with allowance for climate change. Though there may only be isolated properties at risk during the present day, a large part of Boston is predicted to inundate when climate change up to 2115 is applied to the 0.5% AEP event, highlighting the vulnerability of the South Forty Foot catchment to climate change.

The tidal flood risk predicted by the 2010 modelling, is downstream of where overtopping occurred in 2013, though this may be due to the limitations of the 2010 modelling and age of input data such as LIDAR.

6. Fluvial flood risk

6.1 Current fluvial flood risk

The flood history suggests the main source of flood risk to the South Forty Foot Drain catchment is fluvial flooding from the South Forty Foot Drain and its tributaries upstream of Boston.

Results from the 2017 model for the Black Sluice catchment show that there is extensive fluvial flooding in the 1% AEP event and in the 0.1% AEP event (Figure 20). The increase in modelled flood extent between the 1% AEP and the 0.1% AEP event is relatively small.

The present day fluvial flood risk impacts large areas of high grade agricultural land, with Grade 2 agricultural land making up the vast majority of land at risk from present day fluvial flooding.

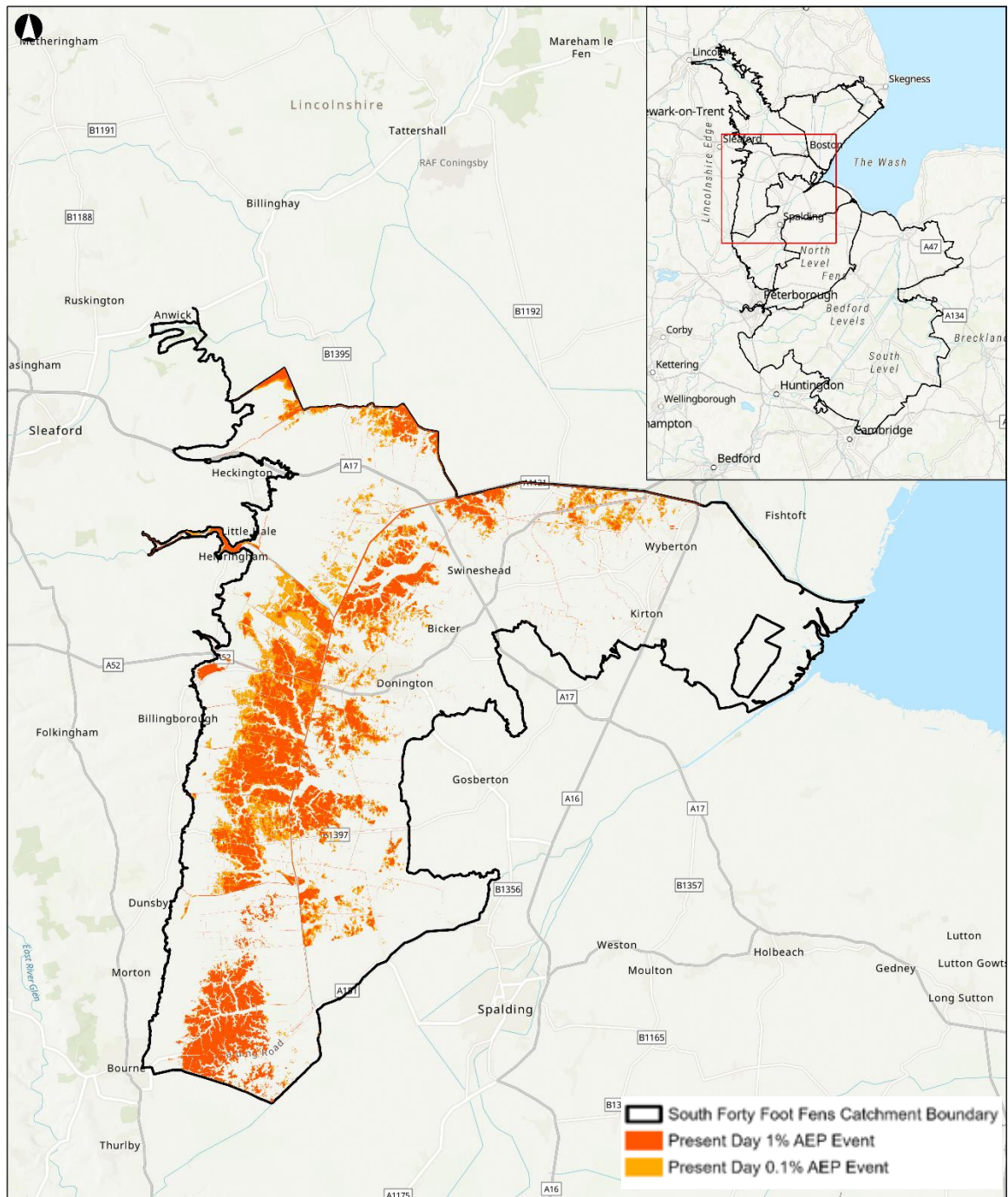


Figure 20: The 1% AEP event and the 0.1% AEP event current fluvial flood risk in the catchment

6.2 Future fluvial flood risk

The 2017 model applies one climate change scenario using a flow uplift of +20%, this is very close to the Central allowance in the 2080s epoch.

Despite fluvial flows being increased by 20%, there is only a small increase in fluvial flood risk predicted by the 2017 modelling, as shown in Figure 21.

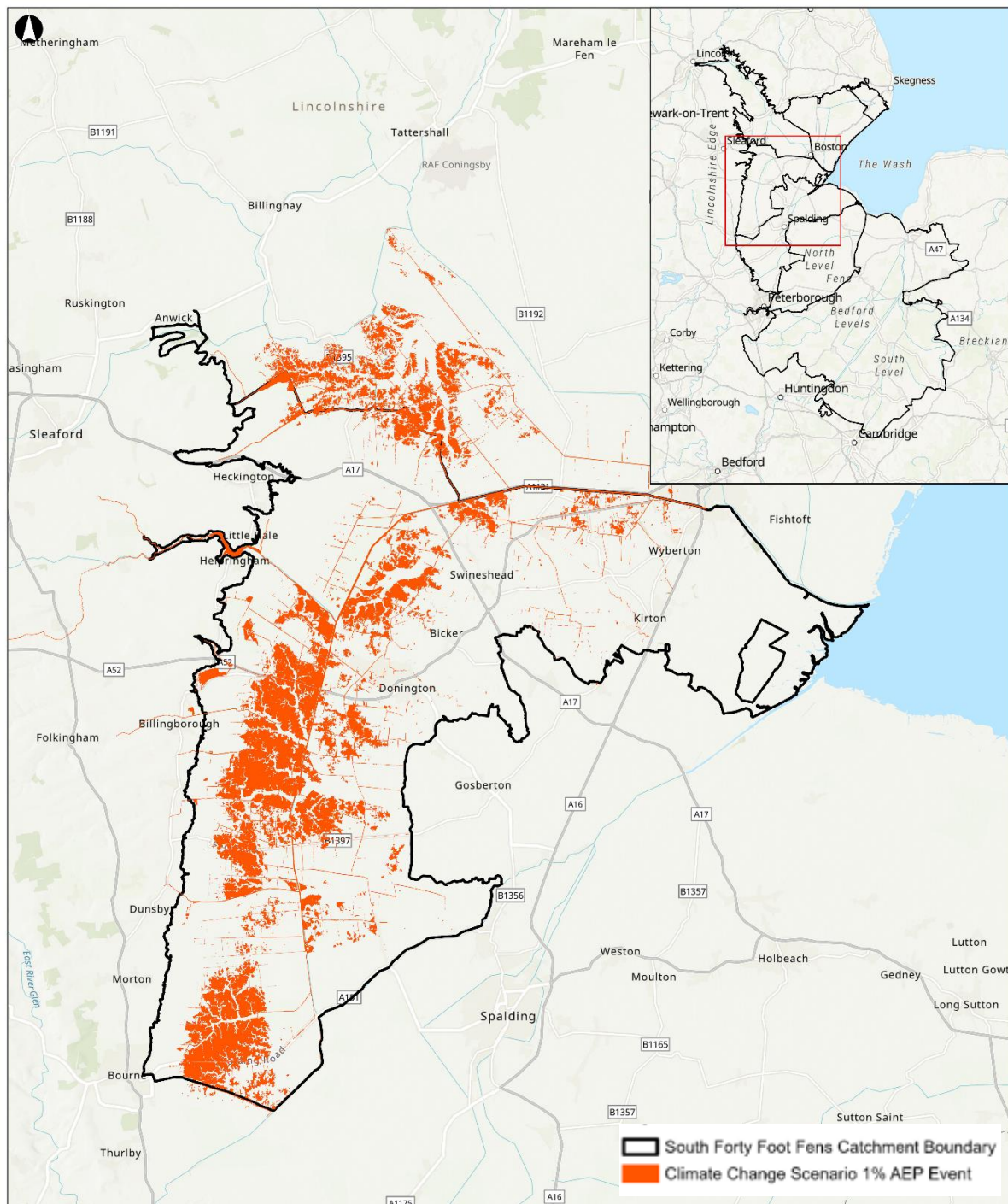


Figure 21: South Forty Foot catchment 1% AEP event climate change scenario

6.3 Key metrics

6.3.1 Total area

The total area at risk of fluvial flood risk within the South Forty Foot Drain catchment is as follows:

- Current 1% AEP event – 41.69km² (4,169ha) – 12.23% of total catchment area.
- Future 1% AEP event with allowance for climate change – 45.58km² (4,558ha) – 13.37% of total catchment area.

- Current 0.1% AEP event – 67.76km² (6,776ha) – 19.87% of total catchment area.

6.3.2 Grades of agricultural land

The agricultural land within the South Forty Foot Drain catchment area is assessed for fluvial flood risk based on different grades, this has been summarised in Table 5. The greatest proportion of agricultural land at risk of fluvial flooding is Grade 2 agricultural land.

Table 5: Agricultural land grading at risk of fluvial flooding

Agricultural Grade	1% AEP (km ²)	1% AEP with an allowance for climate change (km ²)	0.1% AEP (km ²)
Grade 1	3.22km ² (322ha)	3.44km ² (344ha)	7.74km ² (774ha)
Grade 2	37.66km ² (3,766ha)	41.29km ² (4,129ha)	58.78km ² (5,878ha)
Grade 3	0.78km ² (78ha)	0.82km ² (82ha)	1.20km ² (120ha)
Grade 4	0	0	0
Grade 5	0	0	0
Total	41.69km² (4,169ha)	45.58km² (4,558ha)	67.76km² (6,776ha)

6.3.3 Percentage area over 30cm flood depth

The 2017 Black Sluice Catchment model is a 1D only model – as such no depth grids were produced for this study.

6.4 Discussion

Current and future fluvial flooding is almost exclusively to high grade (mainly Grade 2) agricultural land in the South Forty Foot catchment and there is limited flooding of properties.

The increase in flood risk within the South Forty Foot catchment as a result of climate change, is limited, with only a small increase in flooding to agricultural land predicted.

7. Other sources of flooding

Aside from fluvial and tidal, other sources of flooding include surface water, groundwater, and reservoirs. These sources can be the sole cause of flood events or compound the effects of flooding from fluvial or tidal sources. This section sets out these other sources of flood risk, and potential impacts from these sources. It will also consider historical events in the catchment which highlight these issues. This information is intended to provide a high-level summary of the risk of flooding from these wider sources.

7.1 Surface water

Surface water flooding, also known as pluvial flooding, occurs when intense rainfall results in an excess of overland flow before it can reach a watercourse or drainage network. This type of flooding can also happen when rainwater is unable to drain away through the usual drainage systems or soak into the ground. Contributing factors may include insufficient system capacity, saturated ground, or failures in the drainage system due to blockages or culvert collapses. Presence of sandy or gravel soils can mean increased susceptibility to movement of groundwater and flooding from this source.

While surface water flooding is typically caused by high-intensity rainfall, it can also occur during lower-intensity rainfall if the land has low permeability. Permeability can be reduced by factors such as development, frozen ground, or already saturated soil. Additionally, flooding can occur if the drainage network is already at capacity, preventing efficient water drainage to the intended watercourse or sewer.

The Environment Agency's long term flood risk service⁹ provides mapping of surface water flood risk. It shows that flood risk from surface water is generally highly localised, with dense but small and isolated patches where surface water flooding is likely. However, there are larger areas of surface water flood risk concentrated in a band along the western margin of the catchment along the 'springline' villages at the foot of the Southern Lincolnshire Edge. Areas near Dowsby, Rippingdale, Pointon, and Swaton see the largest extents of surface water flooding, with a high chance (more than 3.3%) of flooding each year.

7.1.1 Surface water flood event at Kirton 4th January 2024¹⁰

Based on the available evidence, it is understood that the cause of flooding was the capacity of the public foul water sewer, under King Street, being exceeded. As a result, combined foul and surface water surcharged out of a manhole, located at a low point in this system. Then, in line with local topography, foul water pooled on the road before flowing north to flood one property internally and a further four properties externally.

7.2 Groundwater

Groundwater flooding occurs when the water table, the level of the water within the land, rises above the ground surface. This type of flooding typically follows extended periods of sustained rainfall. Groundwater flooding can persist for a prolonged duration, often lasting longer than other types of flooding. Throughout the year, the water table naturally

⁹ Environment Agency (2024) Check the long term flood risk for an area in England. Available at: [Information for planning - Check your long term flood risk - GOV.UK](#). Accessed 04/04/2025.

¹⁰ Lincolnshire County Council (2024). Section 19 – Flood Investigations Reporting. Available at: [Microsoft Power BI](#). Accessed 14/04/2025.

fluctuates in response to seasonal rainfall. Groundwater flooding is most common in spring, following prolonged rainfall during the preceding autumn. Presence of sandy or gravel soils can mean increased susceptibility to movement of groundwater and flooding from this source.

Across the South Forty Foot catchment, the land is low-lying, which can contribute to a higher risk of groundwater flooding through the water table being at a shallow depth. There is also a risk that flooding will not recede for long periods of time due to the flat nature of the catchment and the reliance on pumping for drainage. The SFRA for South East Lincolnshire¹¹ identifies no recorded incidents of flooding in the South Forty Foot catchment, although it is possible that high groundwater levels contributed to flooding in a number of historic flood events caused by other sources.

7.3 Reservoir

Reservoir flooding is very rare but occurs when there is a failure of reservoir impounding structures such as raised embankments. In the South Forty Foot catchment, there are several on-farm reservoirs, but these are small and do not pose a significant flood risk. Mapping of reservoir flood risk across the UK¹² reservoir flooding is concentrated to west of Donington, Bicker and Swineshead in the west of the catchment. Although reservoir flooding is only predicted to be a risk for these areas when there is simultaneously flooding from rivers.

Proposals for a new Lincolnshire Reservoir just west of the catchment boundary near Helpringham have been submitted by Anglian Water. Under the current proposals, the embankment crest height will be up to 15m above the surrounding ground level, but with a shallower gradient than is required. This will make the embankments far more resilient to a breach event, and the flood risk as a result of the scheme will likely be very low considering the high level of protection offered by the Reservoir Act.

¹¹South East Lincolnshire Joint Strategic Planning Committee (2017). South East Lincolnshire Strategic Flood Risk Assessment. Available at: [SE-Lincolnshire-SFRA-2017-v6-24th-Jan-2018.pdf](#). Accessed 08/04/2025.

¹² Environment Agency (2024) Check your long-term flood risk. Available at: [Technical map - Check your long-term flood risk - GOV.UK](#). [Accessed 07/04/2025].

8. Summary and recommendations

8.1 Tidal flood risk

Based on the available modelling information, there is limited present day tidal flood risk in the catchment. This is due to the South Forty Foot Drain catchment being protected by significant tidal defences, such as tidal embankments and the Black Sluice which prevents tidal water entering the freshwater South Forty Foot River. However, there is a risk to agriculture and areas of Boston to overtopping of the right bank of The Haven during tidal flood events. This is confirmed, as flooding at this location occurred in 2013. This flooding is downstream of the Boston Barrier and so would occur whether it was in place or not.

As expected, the tidal flood risk is predicted to increase in the future. The modelling showed overtopping of embankments would result in large portions of Boston, as well as large areas of Grade 1 agricultural land, becoming inundated – 16.35km² (1,635ha) in the future 0.5% AEP event.

It was particularly notable in the South Forty Foot catchment where only the highest grade of agricultural land was found to be at risk of flooding.

8.2 Fluvial flood risk

The 2017 modelling showed that fluvial flooding results in a greater area at risk in the South Forty Foot Drain catchment than that of tidal flooding. Modelling shows large areas of Grade 1 agricultural land at risk of flooding in both the 1% AEP and 0.1% AEP events, amounting to 12.23% of the total catchment area in the 1% AEP event. Risk to residential or commercial properties is relatively limited.

When climate change is applied, the modelling showed a limited increase in fluvial flood risk.

8.3 Summary

Due to the presence of flood defences such as tidal embankments, modelled present day tidal flood risk is low, however when climate change is applied, large areas of Grade 1 agricultural land and residential and commercial properties are at risk of flooding.

Current fluvial flood risk within the catchment is high – modelled results show large areas of high grade agricultural land at flood risk; however, the future fluvial flood risk increase is relatively small.