

Steeping River

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 (m³/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 Steeping River 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 Steeping River 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, Witham (incorporating the Lower Witham, East and West Fens and South Forty Foot Drain), Lower Nene and Great Ouse (see Figure 1).

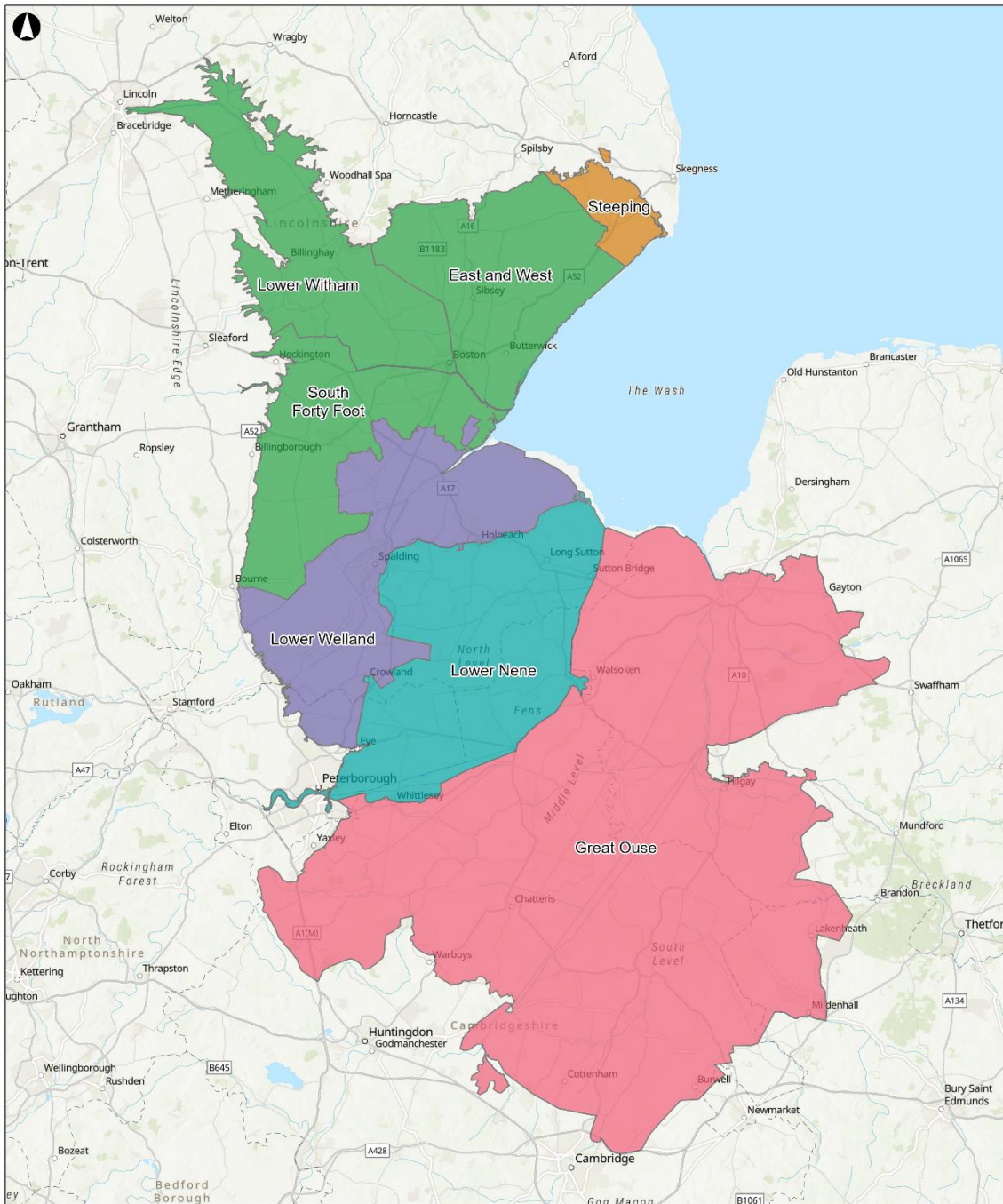


Figure 1: Fens 2100+ study area

1.4 Steeping catchment

The Steeping River catchment (hereafter referred to as “the catchment”) covers an area of approximately 63.4km² (6,340ha) of east Lincolnshire, located at the far north-east of the Fens 2100+ study area.

It spans from the base of the chalk hills of the Lincolnshire Wolds, to the Lincolnshire Marshes, where the River outfalls at Burgh Sluice into The Wash near Gibraltar Point. To the south-east it is bounded by the 'East and West Fens' catchment.

The catchment lies only slightly above sea level (approximately 3m – 9m AOD) and is predominately artificially drained through a complex network of low-lying drains which are pumped into the Steeping River.

It has a wide coastal plain partially consisting of drained salt marsh and priority habitats such as coastal and floodplain grazing marsh and coastal saltmarsh. It is a highly productive agricultural area with over one-third of the land classified as Grade 1 agricultural land.



Figure 2: Aerial image of Wainfleet St Mary © Chris and licenced for reuse under Creative Commons Licence

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 Main Rivers within the catchment comprise the Steeping River, Lady Wath's Beck, Wainfleet Relief Channel, Cowcroft Drain and The River Lymn (see Figure 3). The Steeping River and Wainfleet relief channel reconnect just upstream of Havenhouse.

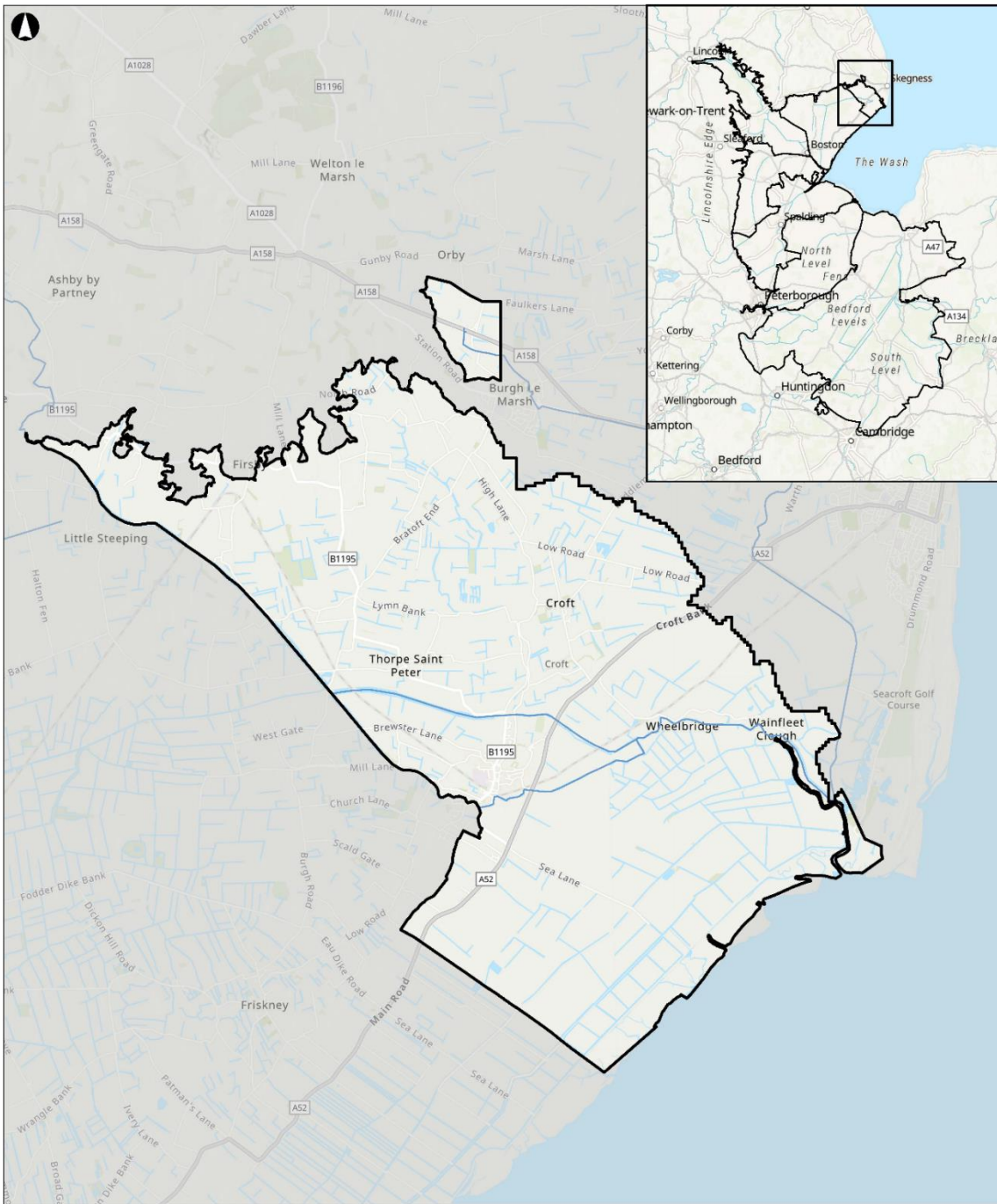
The Steeping River has its source in the Lincolnshire Wolds and has a hydrological catchment area of almost 200km². In the upstream reaches, the river is known as the River Lymn and becomes the Steeping River downstream of the village of Great Steeping where it is joined by Lady Wath's Beck (located in the northern extent of the catchment). The Steeping River flows in a straightened, north-west to south-easterly direction through the catchment and outfalls to The Wash at Wainfleet Clough and Burgh Sluice.

Downstream of Thorpe Culvert the Wainfleet Relief Channel diverts water to the North of Wainfleet All Saints, before eventually reconnecting with the Steeping River at Havenhouse.

The Steeping River then discharges into The Wash and on into the North Sea through Burgh Sluice. Downstream of the Burgh Sluice the Steeping River is known as the Wainfleet Haven or in some literature it is referred to as The Haven.

The Wainfleet Relief Channel was constructed in the 1970s to take high-flows around Wainfleet All Saints. The channel splits from the Steeping River at Thorpe Culvert and flows in a fairly linear, south-easterly, direction to the north of Wainfleet All Saints before rejoining the Steeping River at Havenhouse. The old course of the Lymn leaves the Steeping River main channel at Cloughs Bridge and is understood to be maintained as a drainage ditch by the Internal Drainage Board (IDB). The Lymn joins Cowcroft Drain at Lymn Bank. Cowcroft Drain flows in a general southerly direction through the centre of the catchment and discharges as The Lymn into the relief channel via Croft Lane pumping station. The Main Rivers in the catchment are shown in Figure 3.

The catchment covers the upland gravity fed catchments and the low lying pumped catchments. There is a distinct point of change at Havenhouse Sluice where the river transitions from the higher ground of the Lincolnshire Wolds to the low-lying coastal floodplains.



F  Steeping Catchment Boundary  WFD River Waterbodies **the Steeping catchment**

1.6 Key assets

The Steeping catchment contains a network of sluices, pumping stations, embankments and flood defences which work together to drain the catchment and prevent flooding.

Figure 4 gives an overview of the locations of some of the key assets. For clarity, not all assets have been included.

The proceeding sections give further details of some of these key assets. Refer to the Assets Technical Baseline Appendix for further information.

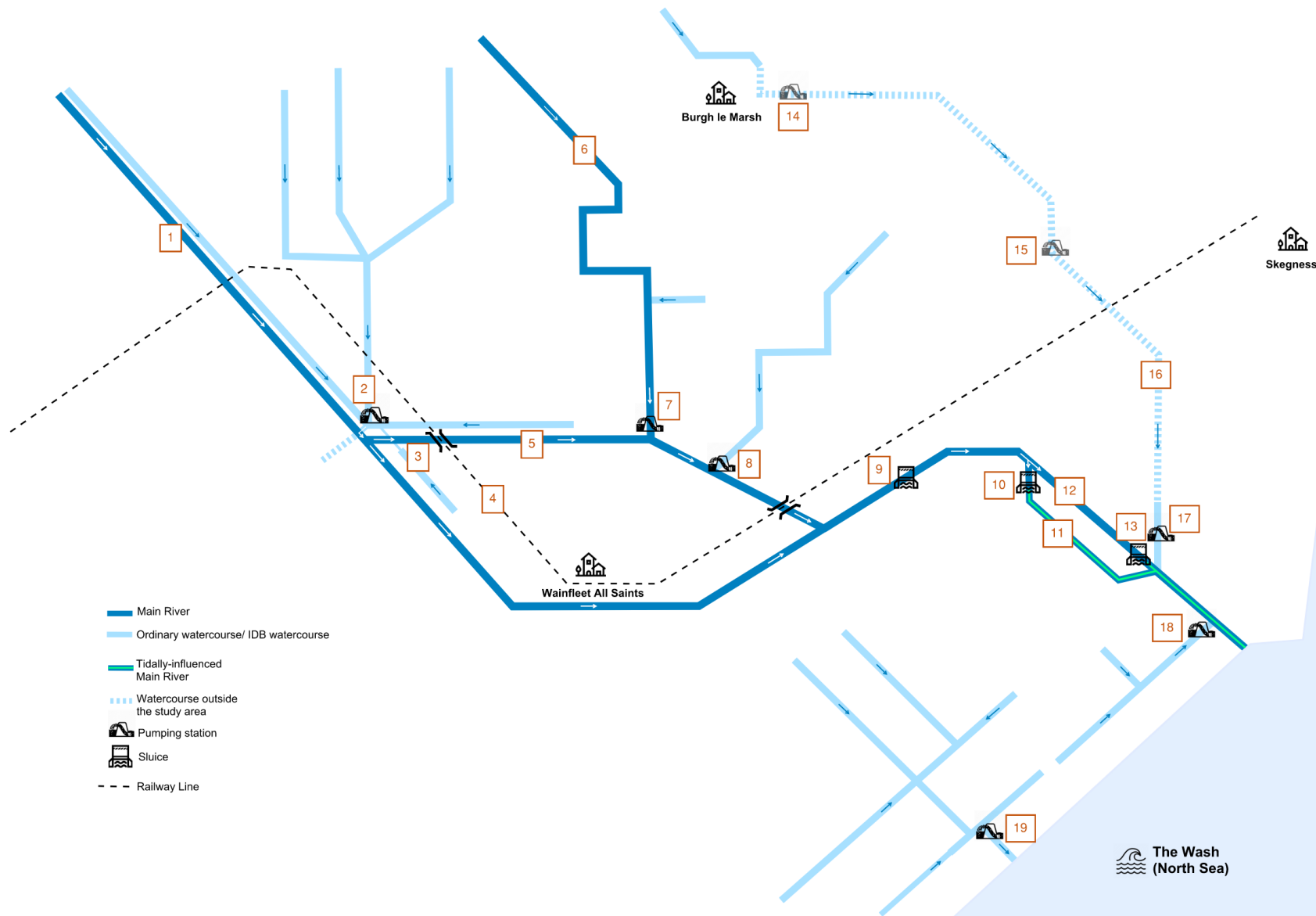


Figure 4: Steeping catchment overview

1 Steeping River

Main River

Much of its lower course has been straightened and earthen embankments contain the channel on both sides.

2 Thorpe Culvert Pumping Station

Lindsey Marsh Drainage Board

Pumps water upwards into the Steeping River. In the past, culverts at this location acted as a route to transfer water from the Steeping catchment into the neighbouring catchment drained by Witham Fourth District IDB. The three culverts carried water beneath the river channel. There is no longer a formal connection between the two catchments, and all water is now pumped into the Steeping River at Thorpe Culvert.

3 Thorpe Culvert Syphons

Lindsey Marsh Drainage Board

Syphons beneath the Wainfleet Relief Channel allow lowland water to flow northwards to be pumped into the Steeping River at Thorpe Culvert.

4 Boston to Skegness Railway Line

There are multiple crossing points where the Wainfleet Relief Channel is conveyed beneath road and railway bridges, via inverted syphons, including under the Boston to Skegness Railway Line. These locations represent low points where the river overflows during extreme flood events.

5 Wainfleet Relief Channel

Main River

Diverts part of the flow of the Steeping River away from the town of Wainfleet All Saints. Earthen embankments contain the channel on both sides.

6 Cowcroft Drain

Main River

Carries water from the northern catchment to Croft Lane Pumping Station.

7 Croft Lane Pumping Station

Environment Agency

Pumps water from the Cowcroft Drain into the Wainfleet Relief Channel.

8 Crown Farm Pumping Station

Lindsey Marsh Drainage Board

Pumps water into the Wainfleet Relief Channel.

9 Haven House Sluice

Environment Agency

Manages water levels upstream. The water level set in Summer enables local abstractors to comply with their abstraction licences.

10 Wainfleet Clough

Environment Agency

This was the original outfall from the River Steeping. It discharges into the Wainfleet Haven.

11 Wainfleet Haven

Main River

The name of the tidal lower course of the Steeping River system.

12 Burgh Sluice Relief Channel

Main River

A wide straightened channel running parallel to the Wainfleet Haven. It conveys the majority of the Steeping River's flow in its lower reach, outfalling at Burgh Sluice.

13 Burgh Sluice

Environment Agency

The main outfall of the Steeping River, located on the Burgh Sluice Relief Channel. Pointing doors also prevent ingress of the tide.

14 Burgh le Marsh Pumping Station

Lindsey Marsh Drainage Board

Pumps water away from the village of Burgh le Marsh.

15 Gotts Pumping Station

Lindsey Marsh Drainage Board

Pumps water upwards from the Main Drain into Cow Bank Drain.

16 Cow Bank Drain

Lindsey Marsh Drainage Board

Located outside of the Steeping catchment boundary but is an important route for water from Skegness to the Wainfleet Haven outfall.

17 Burgh Sluice Pumping Station

Lindsey Marsh Drainage Board

Pumps most of the water coming from Skegness via the Cowcroft Drain into the Wainfleet Haven.

18 Gibraltar Point Pumping Station

Lindsey Marsh Drainage Board

Pumps water out into the outfall of the Wainfleet Haven at Gibraltar Point.

19 Wainfleet Sea Lane Pumping Station

Lindsey Marsh Drainage Board

Drains water from the southern portion of the catchment by pumping water directly into The Wash.

1.6.1 Sluices

Haven House, Wainfleet Clough and Burgh sluice are operated and maintained by the Environment Agency.

Haven House is a control gate sluice which sits just downstream of the point at which the Wainfleet Relief Channel rejoins the Steeping River. This sluice allows the Environment Agency to control levels through the Steeping River, and is telemetry enabled¹. The sluice maintains upstream levels in the summer to 2.48m AOD and 2.7m AOD in winter to provide additional storage. If resources allow, the sluices are opened early to potentially reduce the risk of flooding in the catchment.



Figure 5: Burgh Sluice © Arup

Wainfleet Clough was the old tidal outfall within the system. The outfall has a very low cill level, is subject to siltation and requires intensive maintenance to be operational. Burgh sluice was built in the 1970's to overcome the siltation and tide lock issues of Wainfleet Clough. Due to the issues with Wainfleet Clough, the Burgh Sluice has become the default outfall. However, there is a desire from the local community to keep Wainfleet Clough operational.

Burgh Sluice (shown Figure 5) is a critical asset as its the main outfall for the Steeping River. Burgh Sluice consists of two channels, one through which water is pumped and the other being gravity fed. The pump is owned by Lindsay Marsh IDB and drains a separate catchment to the Steeping. The sluice has pointing doors that will close to prevent inflow of water, however in reality the doors only close during periods of very high tide. The sluice maintains levels to 2.35m AOD. Silt agitators and pumps are installed behind the doors.

¹ Arup (n.d.), Lived experience report – Steeping [Unpublished]

1.6.2 Pumping stations

Large areas of Steeping River 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.

Thorpe Culvert Pumping Station is owned by Lindsey Marsh IDB. The original pumping station was built in 1938. Behind this original structure is the new pumping station, built in 1984 with 4 electric pumps providing 4.2 cumecs capacity. When the new pumping structure was constructed the management of the asset was transferred to the Skegness Internal Drainage Board, their function was replaced by the Lindsey Marsh IDB in 2000 following amalgamation with Alford and Louth Drainage Boards.

The original asset mostly exists as a heritage asset. It can and has been used to provide additional capacity during flood events. However, the diesel pump house is at a lower elevation so more at risk of inundation. The pumping station pumps water upwards into the Steeping River. In the past, three brick culverts at this location acted as a route to transfer water from the Steeping catchment into the neighbouring catchment drained by Witham Fourth District Internal Drainage Board. The culverts are still in place, but they are no longer operational. As a result, there is no longer a formal connection between the two catchments and instead all water is now pumped into the Steeping River.

Croft Lane Pumping Station is owned by the Environment Agency. It is the pumped outfall for the Cowcroft Drain. It is the only means for the Little River Lymn/ Croft system to be able to drain as there is no gravity outfall into the Wainfleet Relief Channel. There are two pumps at this station, one smaller and one larger, both pumps have an operational role but, depending on flows reaching the pumps, they may operate in isolation or together.

Burgh Sluice Pumping Station is owned by Lindsey Marsh IDB. This was constructed in 1986 to replace the original pumping station. The management of the site was transferred to the Lindsey Marsh IDB's predecessor (Skegness Internal Drainage Board) in 1992. It consists of three pumps providing 4.7 cumecs capacity and drains most of the water from Skegness by discharging water from the Cow Bank Drain into the Wainfleet Haven. There are three sub-catchments which are drained from this site, each with their own pumping stations (Gotts Pumping Station (PS), Burgh le Marsh PS and Burgh Sluice PS). Therefore, some of the water discharging at Burgh Sluice PS has been triple pumped.

Although Gotts Lane and Burgh Le Marsh pumping stations are within the Steeping catchment, they not within the study area boundary being used in the Fens 2100+ programme. To avoid double counting the benefits with the East Coast Strategy project they are therefore not discussed in detail in this report. They do however, pump water towards Burgh Sluice Pumping Station, which in turn pumps this water into the Wainfleet Haven.

Crown Farm Pumping Station is owned by Lindsey Marsh IDB. It was constructed in 1972 with two pumps providing 1.7 cumecs capacity. It pumps water into the Wainfleet Relief Channel, from the land lying to the north.

Gibraltar Point Pumping Station is owned by Lindsey Marsh IDB. It pumps water to the outfall of the Wainfleet Haven at Gibraltar Point.

Wainfleet Sea Lane Pumping Station is owned by Lindsey Marsh IDB. It drains water from the southern portion of the catchment by pumping water directly into The Wash.

Crown Farm Pumping Station is owned by Lindsay Marsh IDB. It discharges into the Wainfleet Relief Channel.

1.6.3 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 embankments to better stabilise the slope and help improve the strength of utilised soils.

There are a significant number of embankments across the Steeping catchment. A large proportion of embankment assets are over 125 years old and anecdotal evidence suggests many have been constructed without a clay core which could represent a vulnerability in the system. The embankments in the catchment are shown in Figure 6. Note that the tidal defences north of Gibraltar Point are part of the East Coast Strategy project and are not considered as part of this project.

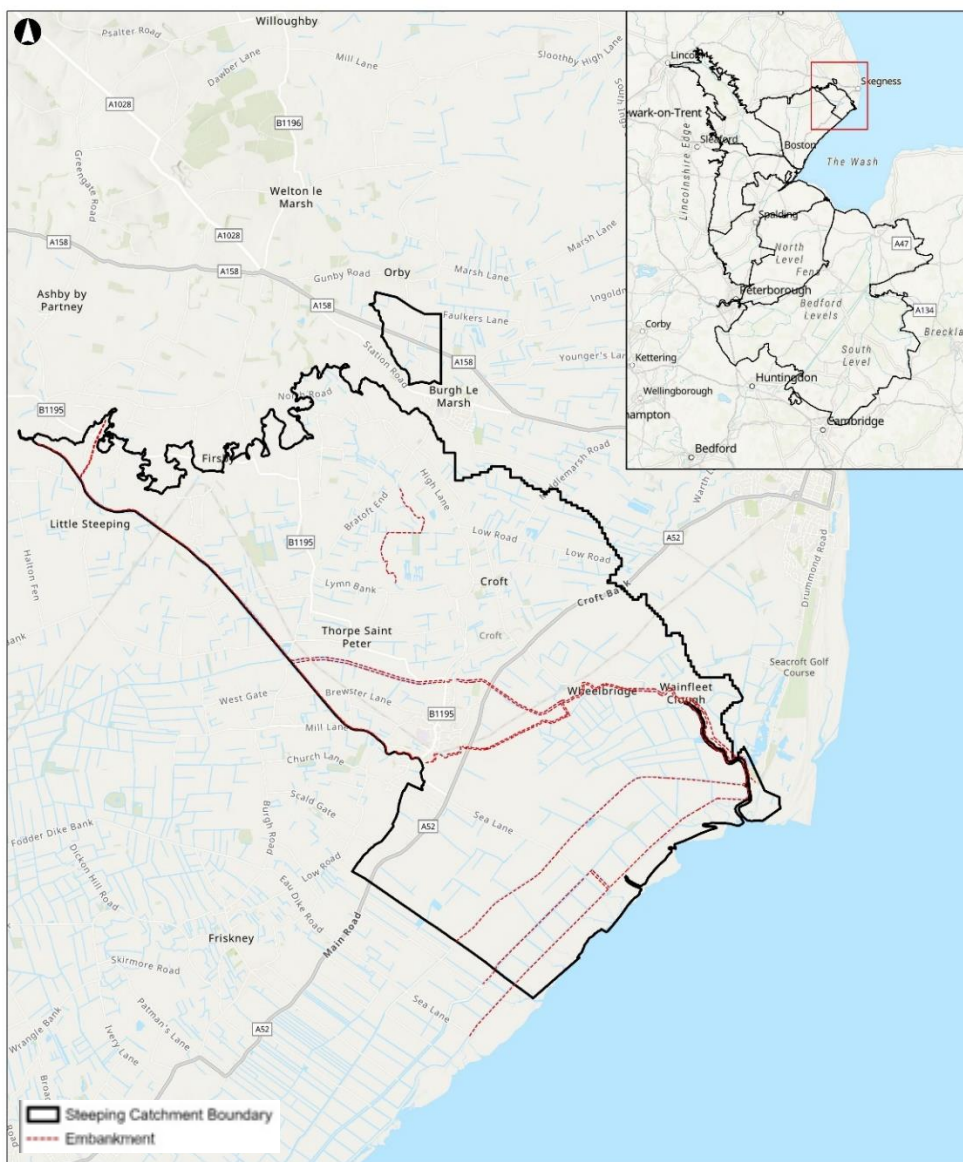


Figure 6: Environment Agency embankments in the Steeping catchment

The **Wainfleet Relief Channel** was constructed in the 1970s following flooding in 1968². It splits the flow of the Steeping River, rather than acting as an overflow, and rejoins it

² Lincolnshire County Council (2020) Investigation into the flooding in Wainfleet in June 2019 Available at: <https://www.lincolnshire.gov.uk/downloads/file/3483/wainfleet-flood-investigation-report> Accessed: November 2024

downstream of Wainfleet. It was constructed from the arisings excavated during construction and does not offer the same protection as a formal, modern flood embankment.

2. Notable flood history

A number of flood events have impacted the Steeping catchment. These events have been summarised in the proceeding sections.

Information on flood history has largely come from the Environment Agency, in the form of:

- Recorded flood outlines (GIS files);
- PDF maps with commentary on mechanism/properties impacted; and
- Emails from Environment Agency staff detailing number of properties impacted.

Other sources of information have come from Section 19³ reports as well as news articles from reputable news organisations, such as the BBC.

2.1 April 1947

The winter of 1946/1947 saw extremely low temperatures and heavy snowfall. A rapid thaw led to significant flooding across the United Kingdom, however there are no records that this event has a significant impact on the Steeping catchment. There is only a brief mention of “flooding from the Steeping River” in 1947, found in the 2019 flood investigation report⁴.

2.2 January 1953

The greatest storm surge on record for the North Sea caused extensive tidal flooding along the coast at Wainfleet Clough via overtopping of existing defences on the 31st January 1953 which inundated primarily agricultural land. The flood extent for this event is shown in Figure 7; whilst the flood extent for this event is large, there is no record of extensive flooding to properties or infrastructure in the Steeping catchment for this event.

³ 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.

⁴ Lincolnshire County Council (2020) Investigation into the flooding in Wainfleet in June 2019 Available at: <https://www.lincolnshire.gov.uk/downloads/file/3483/wainfleet-flood-investigation-report> Accessed: November 2024

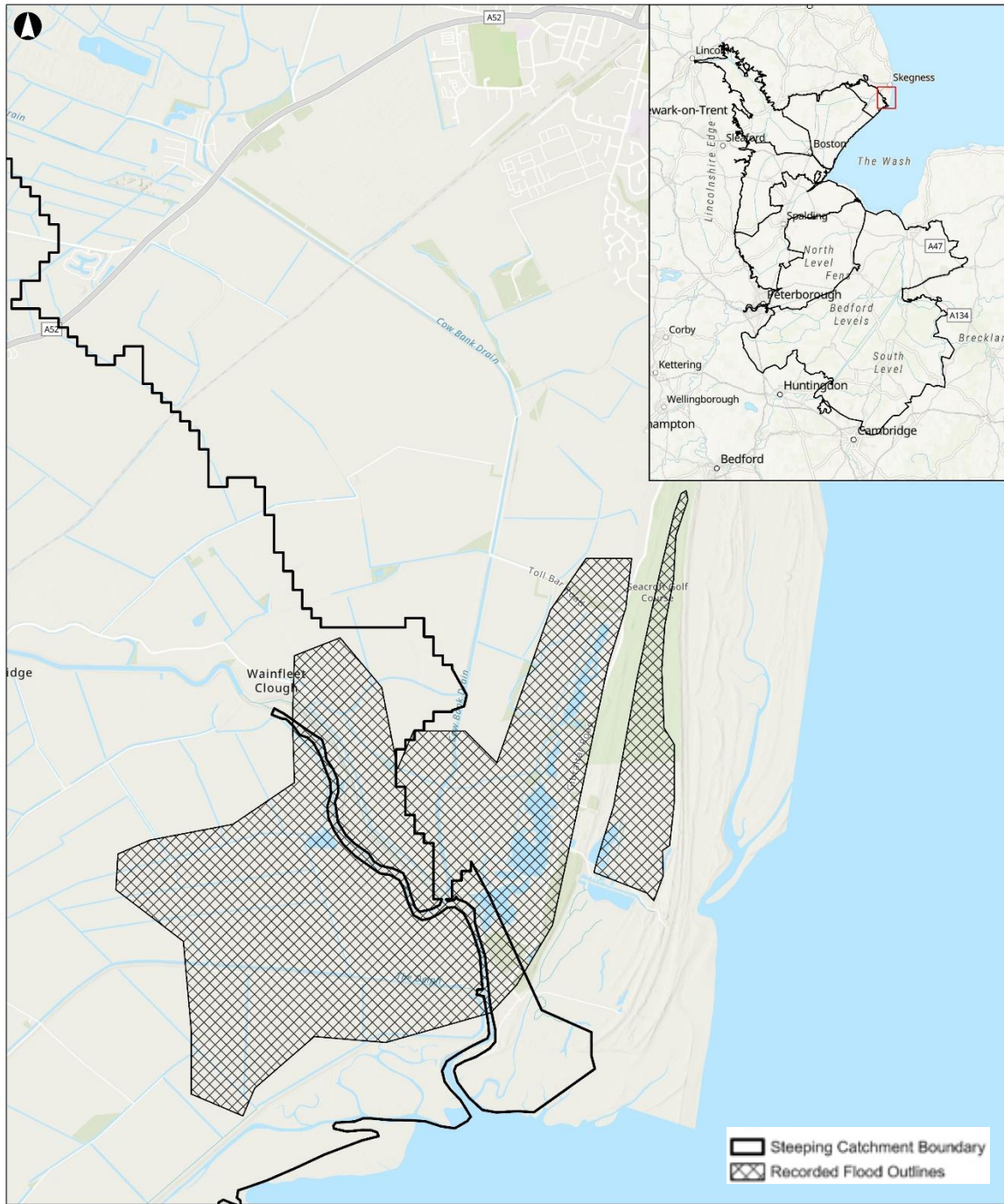


Figure 7: 1953 flood extent

2.3 1968

Flooding in 1968 from the Steeping River led to the construction of the Wainfleet Relief Channel⁵.

⁵ Lincolnshire County Council (2020) Investigation into the flooding in Wainfleet in June 2019 Available at: <https://www.lincolnshire.gov.uk/downloads/file/3483/wainfleet-flood-investigation-report> Accessed: November 2024

2.4 June 2007

Flooding occurred across the Steeping catchment as a result of heavy rainfall in June 2007, with approximately 42.6mm of rain falling in one day⁶. The 2017 East Lindsey Strategic Flood Risk Assessment identified the cause of the flooding as a low spot in the defences⁷.

Following the flooding, various works were carried out to reduce flood risk⁸, including:

- raising localised low spots in the banks;
- improving the operation of sluice gates at the outfall; and
- removal of silt in the channel upstream of Wainfleet.

The recorded flooding locations are shown in Figure 8. Each location is discussed in the proceeding sections.

⁶ Lincolnshire County Council (2020) Investigation into the flooding in Wainfleet in June 2019 Available at: <https://www.lincolnshire.gov.uk/downloads/file/3483/wainfleet-flood-investigation-report> Accessed: November 2024

⁷ East Lindsey District Council (2017) East Lindsey Strategic Flood Risk Assessment. Available at: <https://www.e-lindsey.gov.uk/article/6200/Strategic-Flood-Risk-Assessment> Accessed: June 2025

⁸ Lincolnshire County Council (2020) Investigation into the flooding in Wainfleet in June 2019 Available at: Wainfleet flooding report – Lincolnshire County Council (<https://www.lincolnshire.gov.uk/>) Accessed: November 2024

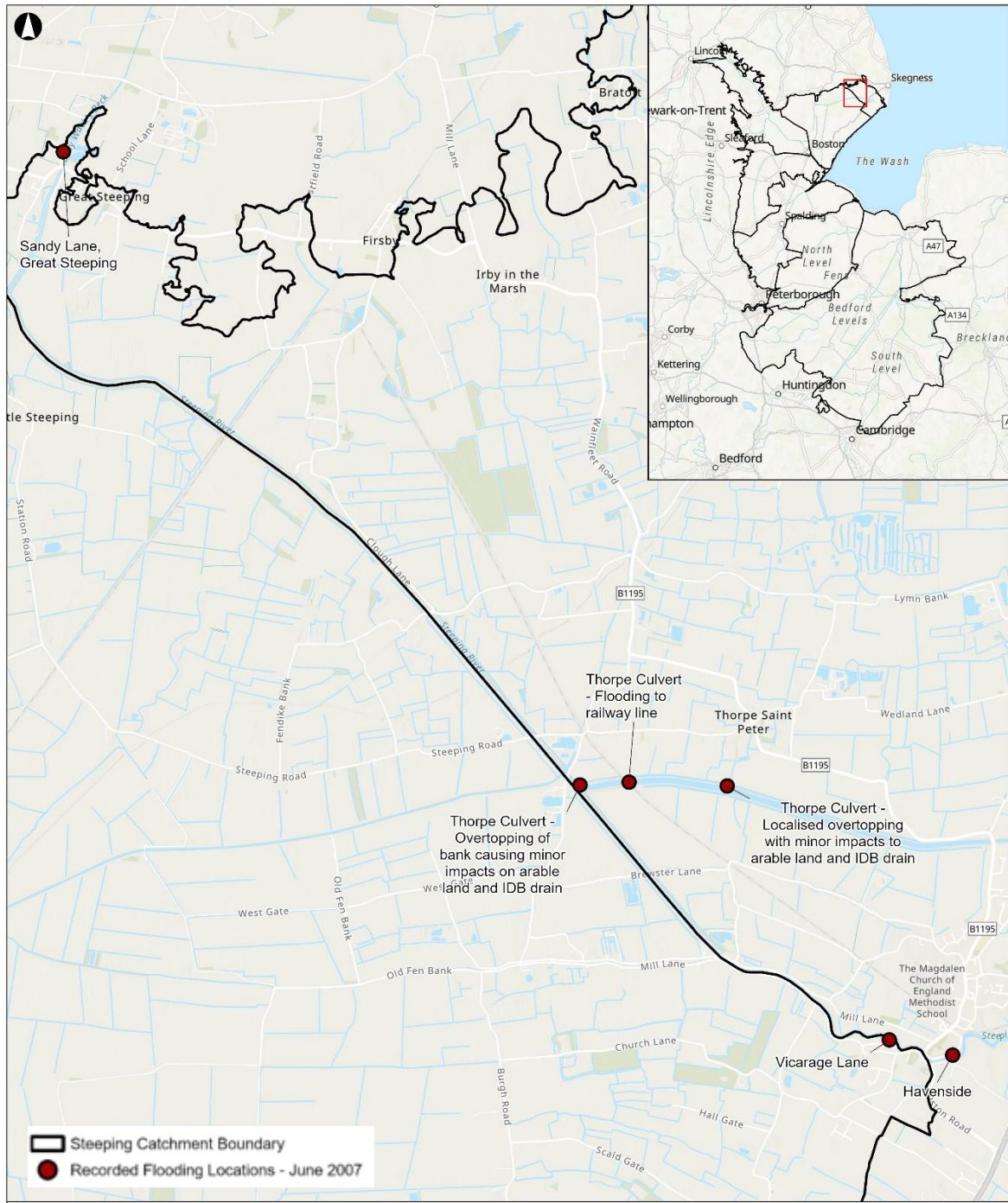


Figure 8: June 2007 recorded flooding locations

2.4.1 Vicarage Lane, Wainfleet

At Vicarage Lane in Wainfleet St Mary, 10 properties were flooded from the Steeping River. Information from the Environment Agency states that this was due to a 3rd party developer lowering the existing embankment at this location.

2.4.2 Thorpe Culvert

Information received from the Environment Agency states that during the June 2007 event; there was overtopping of the left bank of the Wainfleet Relief Channel at a number of locations as shown in Figure 9. The overtopping did not result in flooding of properties – though arable land was inundated.

There was also flooding to the railway line, however there is uncertainty as to whether this was from overtopping, or from seepage (or a combination of the two).

Wainfleet Relief Channel
June 2007



TF 4822 6035



Figure 9: Images showing overtopping of the relief channel © Environment Agency

2.4.3 Sandy Lane

There was flooding to properties on Sandy Lane from the overtopping of the right bank of the Great Steeping – however information from the Environment Agency suggests that there was also a surface water element to this flooding.

2.4.4 Havenside

At Havenside, in Wainfleet, information from the Environment Agency indicates that there may have been flooding of two properties from the Steeping River. However, there is uncertainty whether there was a surface element to this flooding.

2.5 July 2008

Three properties flooded from Lady Wath's Beck⁹.

2.6 December 2013

On the 5th of December 2013 a tidal surge resulted in overtopping of the wall at Burgh Sluice. Following this, Lindsay Marsh IDB raised the wall.

2.7 June 2019

A Met Office yellow weather warning was issued for Northeast Lincolnshire on the 9th of June 2019. The 10th of June 2019 ranked as the wettest day in Wainfleet ever recorded. Wainfleet saw 74.6mm in one day, more than the average rainfall for the whole month (53.13mm). Overall, more than two and half times the monthly average rainfall (138mm¹⁰) fell in just three days.

Flood warnings were subsequently issued for Wainfleet All Saints (11th June) and Great Steeping (12th June). A number of pumping stations in the area struggled to cope, and 1000 people were evacuated from their homes.

On the 12th June around midday, a breach formed in the south bank of the Relief channel (Figure 10 & Figure 11) to the south of Thorpe St Peter, leading to extensive flooding in Wainfleet All Saints (Figure 12). The railway line between Boston and Skegness was also flooded¹¹.

Three RAF helicopters¹² dropped 340 tonnes of material, finally sealing the breach by midnight 14th June (Figure 13). This cost of this was estimated to be up to £1m¹³. Further overtopping occurred on the 15th, but there was no further breach¹⁴.

Lindsey Marsh IDB Pumping Station was also nearly flooded, with flood water found to be entering the substructure of the station on 15th June, putting its electrics at risk. Efforts by the drainage board, emergency services and locals meant it remained operational. It shifted around five million cubic meters of water from the flooded area over 11 days and its loss would have likely resulted in more severe flooding in Wainfleet¹⁵.

⁹ Lincolnshire County Council (2020) Investigation into the flooding in Wainfleet in June 2019 Available at: <https://www.lincolnshire.gov.uk/downloads/file/3483/wainfleet-flood-investigation-report> Accessed: November 2024

¹⁰ ADA (2019) Wainfleet flooding. Available at: <https://www.ada.org.uk/2019/06/wainfleet-flooding/> Accessed: June 2025

¹¹ ADA (2019) Wainfleet flooding. Available at: <https://www.ada.org.uk/2019/06/wainfleet-flooding/> Accessed: June 2025

¹² BBC (2019) Wainfleet flooding: RAF helps to stem River Steeping breach. Available at: <https://www.bbc.co.uk/news/uk-england-lincolnshire-48633669> Accessed: June 2025

¹³ BBC (2019) Wainfleet flooding: RAF ballast drop to cost up to £1m. Available at: <https://www.bbc.co.uk/news/uk-england-lincolnshire-48805485> Accessed: June 2025

¹⁴ Lincolnshire County Council (2020) Investigation into the flooding in Wainfleet in June 2019 Available at: <https://www.lincolnshire.gov.uk/downloads/file/3483/wainfleet-flood-investigation-report> Accessed: November 2024

¹⁵ ADA (2019) Wainfleet flooding. Available at: <https://www.ada.org.uk/2019/06/wainfleet-flooding/> Accessed: June 2025

A total of 88 properties were internally flooded¹⁶ including:

- Wainfleet All Saints: 45 properties (see Figure 14);
- Thorpe St Peter, Thorpe Culvert and Firsby: 18 properties (see Figure 15); and
- Great Steeping: 13 properties (see Figure 16).

More than 2000 acres of agricultural land was also flooded, just as many crops were about to be harvested¹⁷ (see Figure 17 & Figure 18).

The cause of flooding was primarily main river flooding, though there were a number of cases of surface water flooding, ordinary watercourse flooding or multiple sources – see Figure 14, Figure 15 and Figure 16 for further details. Whilst the rainfall levels were unusual, the breach in the main river is considered to have had the most significant impact. The banks have not been known to breach before.

Before the breach occurred, surface water flooding affected 14 properties due to the drainage system capacity being exceeded¹⁸.

The Lincolnshire County Council investigation into the flooding, mentioned a number of factors that may have exacerbated the main river flooding:

- Tide locking and other constrictions such as syphons leading to siltation in channel. The reduced capacity in channel was identified as a potential contributory factor;
- High initial water levels in the summer to allow for water abstraction;
- Cattle grazing damaging banks; and
- Surcharge of surface water and foul drainage systems.

There was speculation that burrowing badgers may have been a factor. However, the Environment Agency confirmed that whilst badgers had been present along the banks in previous years, this was not a factor in this case. Badgers are a protected species, and the badger sett was relocated to an artificial sett from the flood bank a year before. The embankment was repaired with steel piles in August 2019¹⁹.

¹⁶ Lincolnshire County Council (2020) Investigation into the flooding in Wainfleet in June 2019 Available at: Wainfleet flooding report – Lincolnshire County Council (<https://www.lincolnshire.gov.uk/>) Accessed: November 2024

¹⁷ Steeping Catchment Action Plan (2020) Available at: https://www.e-lindsey.gov.uk/media/16099/2020-Steeping-Catchment-Action-Plan/pdf/2020_Steeping_Catchment_Action_Plan.pdf?m=637233152581030000 Accessed: June 2025

¹⁸ Lincolnshire County Council (2020) Report to Flood and Water Management Scrutiny Committee. Available at: <https://lincolnshire.moderngov.co.uk/documents/s31669/Wainfleet%20Section%2019%20Investigation.pdf> Accessed: June 2025

¹⁹ Lincolnshire Live (2020) Could it happen again? Fear and anger in Wainfleet one year after floods ripped through the town. Available at: <https://www.lincolnshirelive.co.uk/news/local-news/wainfleet-floods-one-year-on-4196573> Accessed: June 2025

A year on, the Environment Agency said it had carried out routine maintenance and was looking to strengthen the defences and carry out targeted dredging later in the year²⁰. An action plan was also drawn up²¹ proposing various actions including:

- Weed management;
- Lowering river levels in advance of high-water events;
- Investigating how to make banks more resilient;
- Investigating and delivering a project to reduce flood risk from Lady Wath's Beck;
- Investigating the possible use of Natural Flood Management (NFM) in the upper catchment; and
- Investigating provision of possible flood water storage areas.



Figure 10: Breach in Relief Channel²²

²⁰ BBC (2020) Wainfleet flooding: Residents 'living in fear'. Available at: <https://www.bbc.co.uk/news/uk-england-lincolnshire-53007854> Accessed: June 2025

²¹ Steeping Catchment Action Plan (2020) Available at: https://www.e-lindsey.gov.uk/media/16099/2020-Steeping-Catchment-Action-Plan/pdf/2020_Steeping_Catchment_Action_Plan.pdf?m=637233152581030000 Accessed: June 2025

²² BBC (2019) Wainfleet flooding: RAF helps to stem River Steeping breach. Available at: <https://www.bbc.co.uk/news/uk-england-lincolnshire-48633669> Accessed: June 2025



Figure 11: Drone footage of Wainfleet flooding²³



Figure 12: Flooding at Wainfleet (c) Lincolnshire Community Council

²³ Lincolnshire Live (2019) Flooded out - images reveal aftermath of terrible weather in Wainfleet as crews continue the battle to stop the floods. Available at: <https://www.lincolnshirelive.co.uk/news/local-news/gallery/flooded-out-images-reveal-aftermath-2980011> Accessed: June 2025



Figure 13: RAF helicopter dropping ballast to plug the breach²⁴

²⁴ BBC (2020) Wainfleet flooding: Residents 'living in fear'. Available at: <https://www.bbc.co.uk/news/uk-england-lincolnshire-53007854> Accessed: June 2025

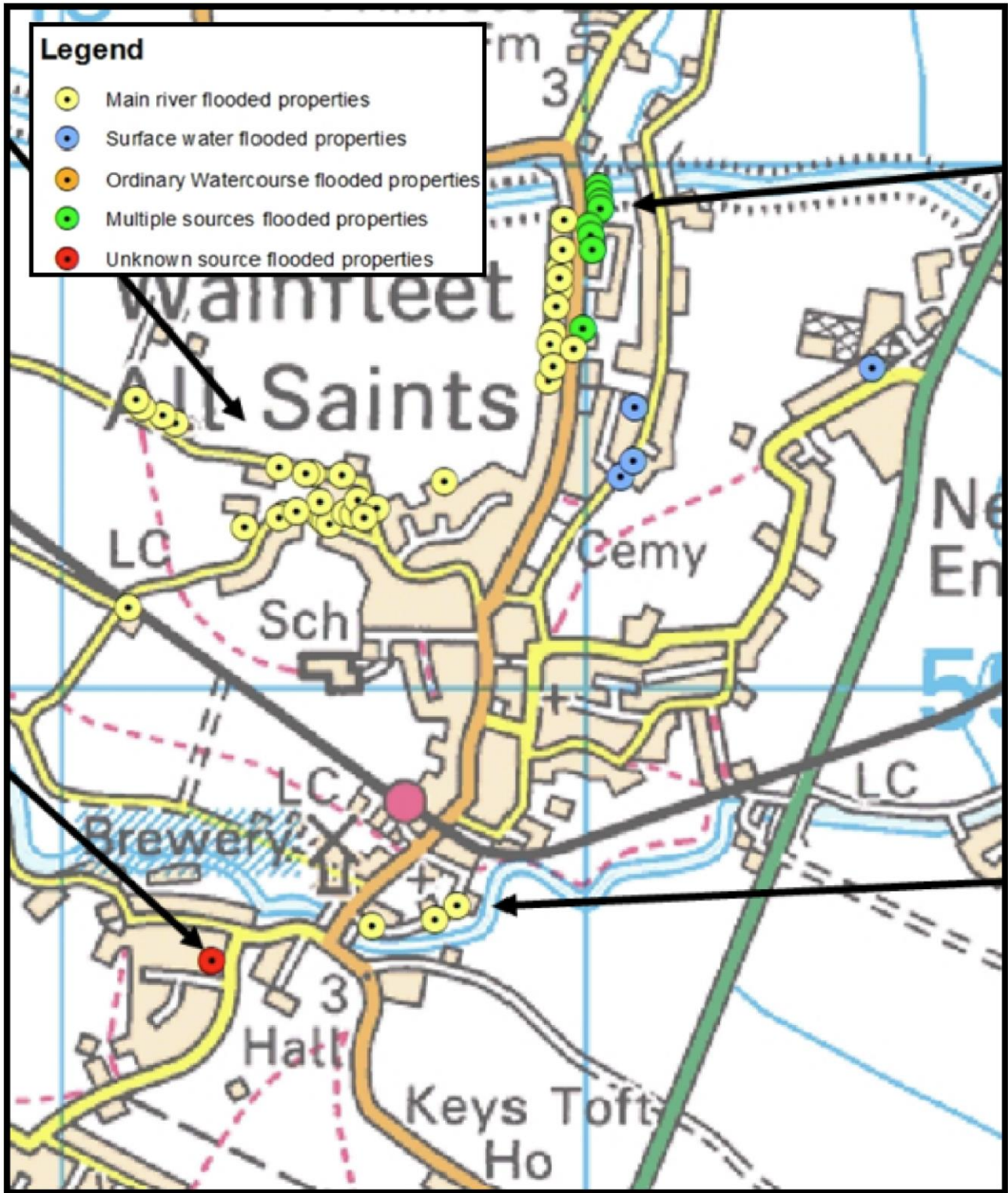


Figure 14: Flooding in Wainfleet All Saints extracted from the 'Investigation into the flooding in Wainfleet in June 2019' report © Lincolnshire Community Council

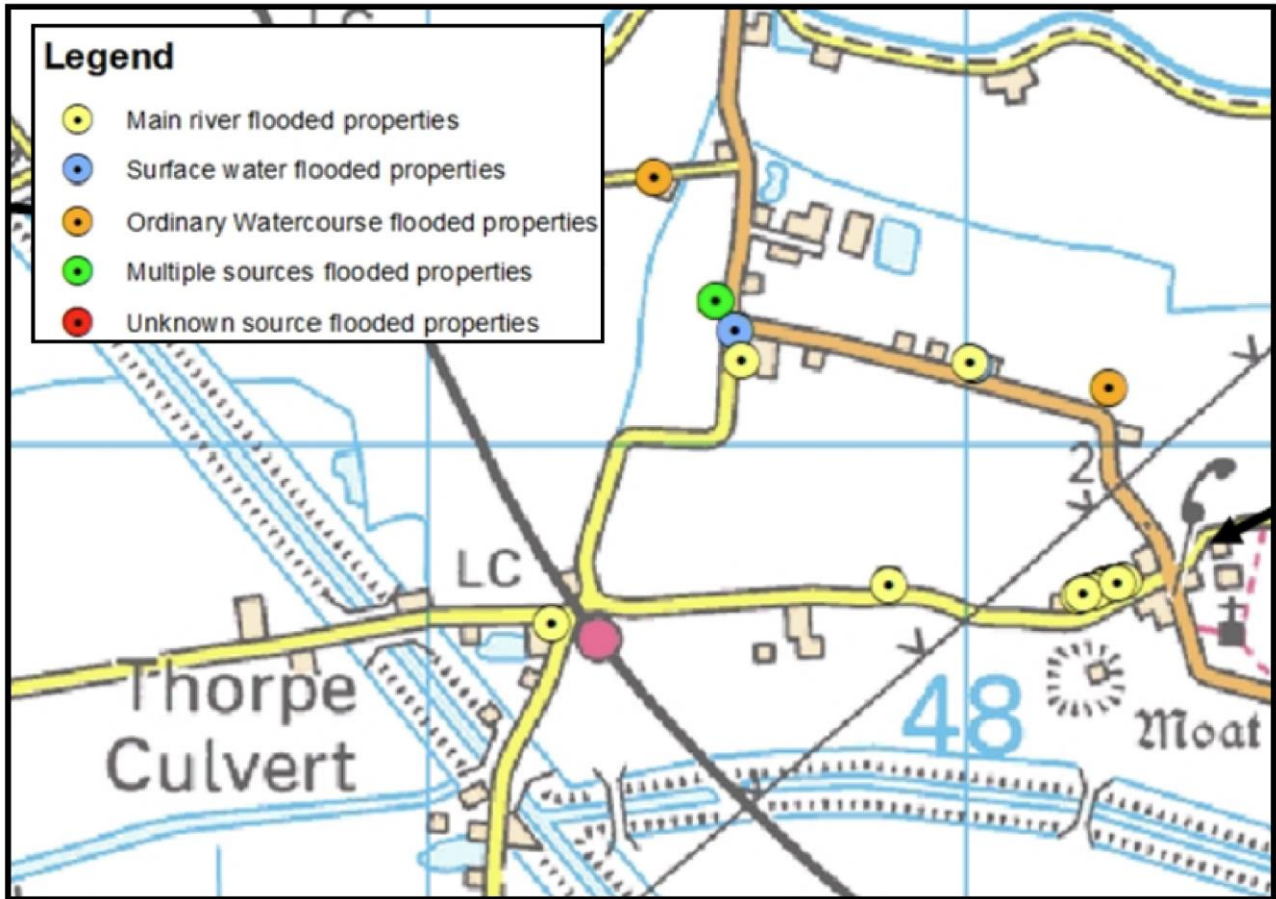


Figure 15: Flooding in Thorpe St Peter extracted from the ‘Investigation into the flooding in Wainfleet in June 2019’ report © Lincolnshire Community Council

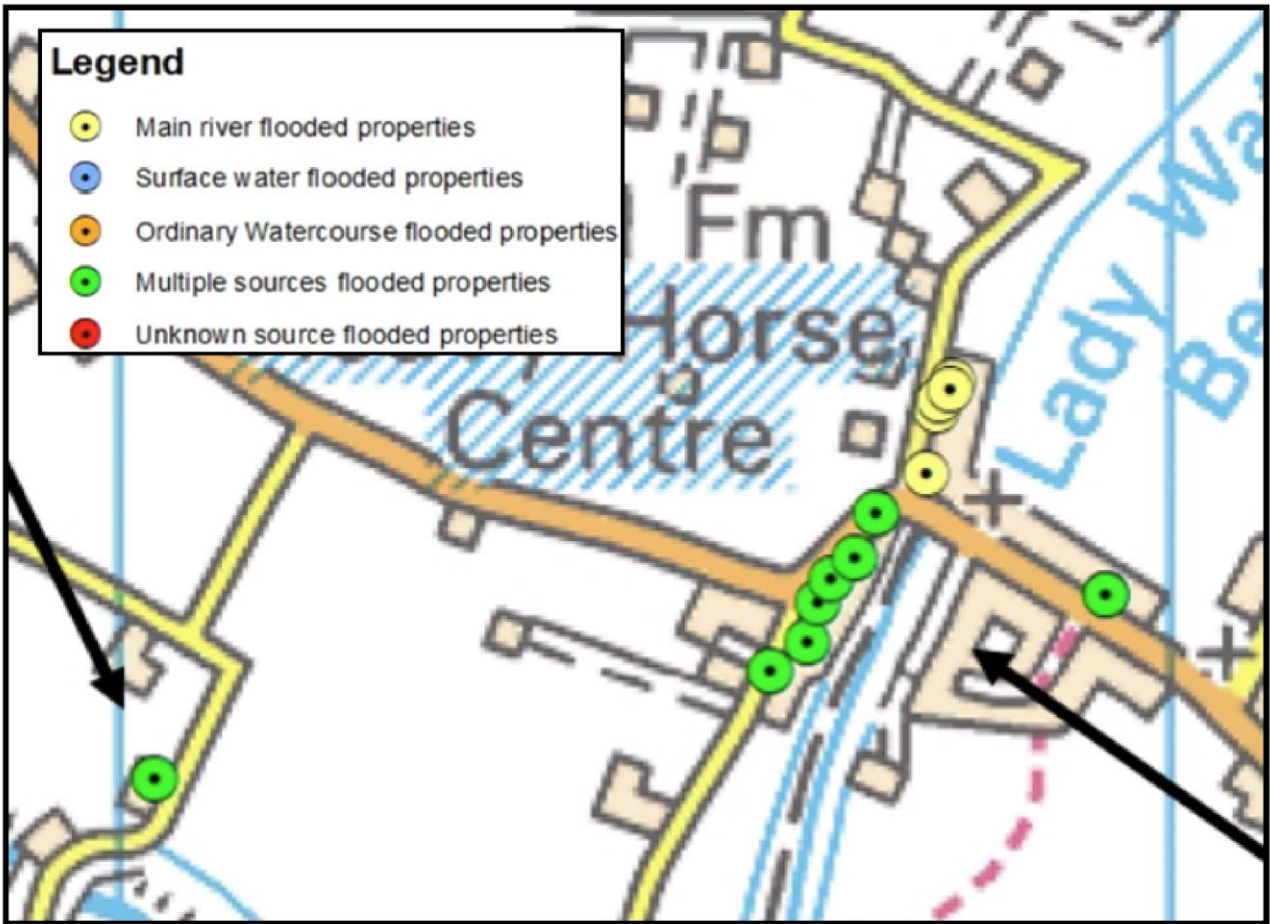


Figure 16: Flooding in Great Steeping extracted from the 'Investigation into the flooding in Wainfleet in June 2019' report © Lincolnshire Community Council

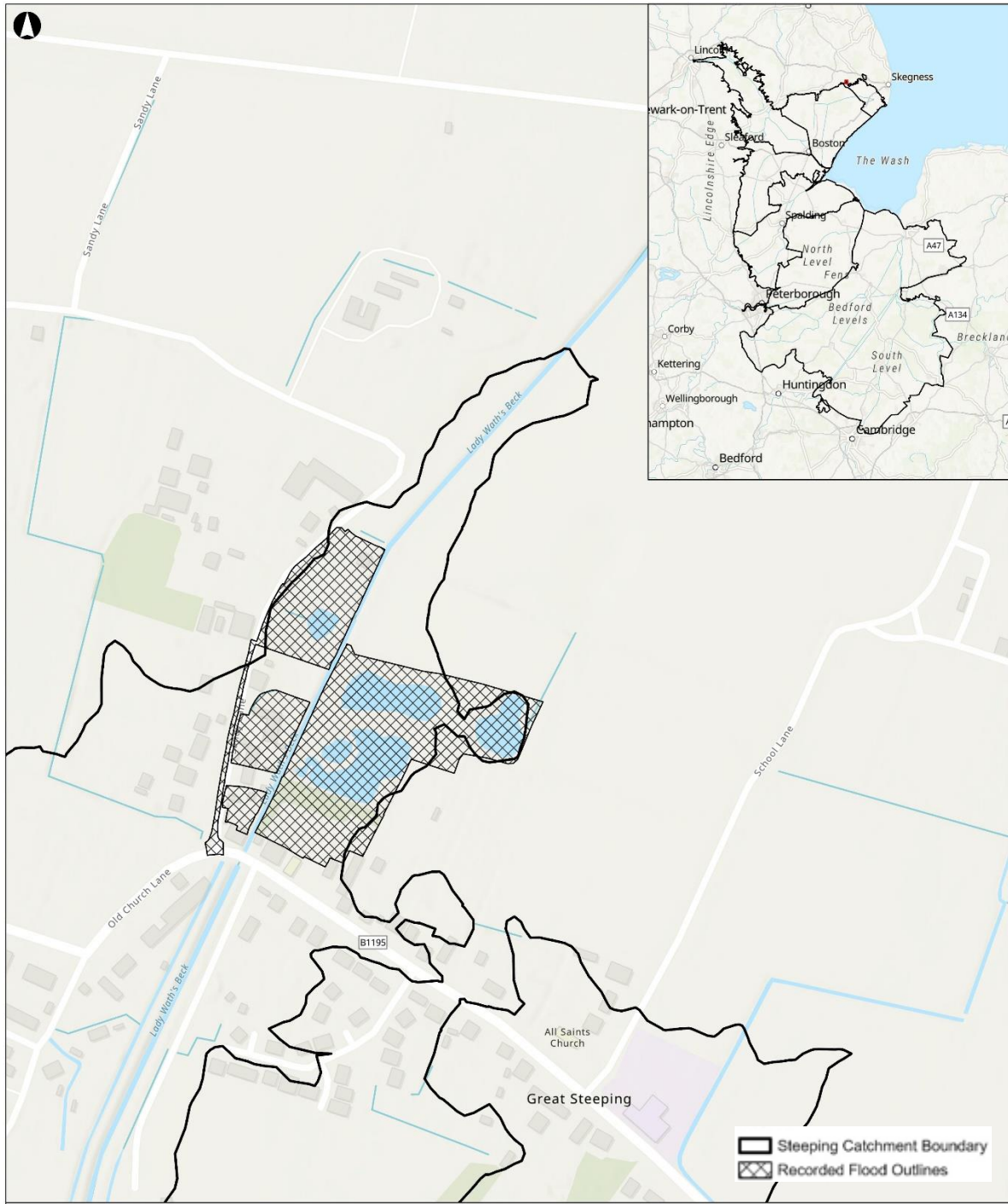


Figure 17: Recorded flood extent at Great Steeping

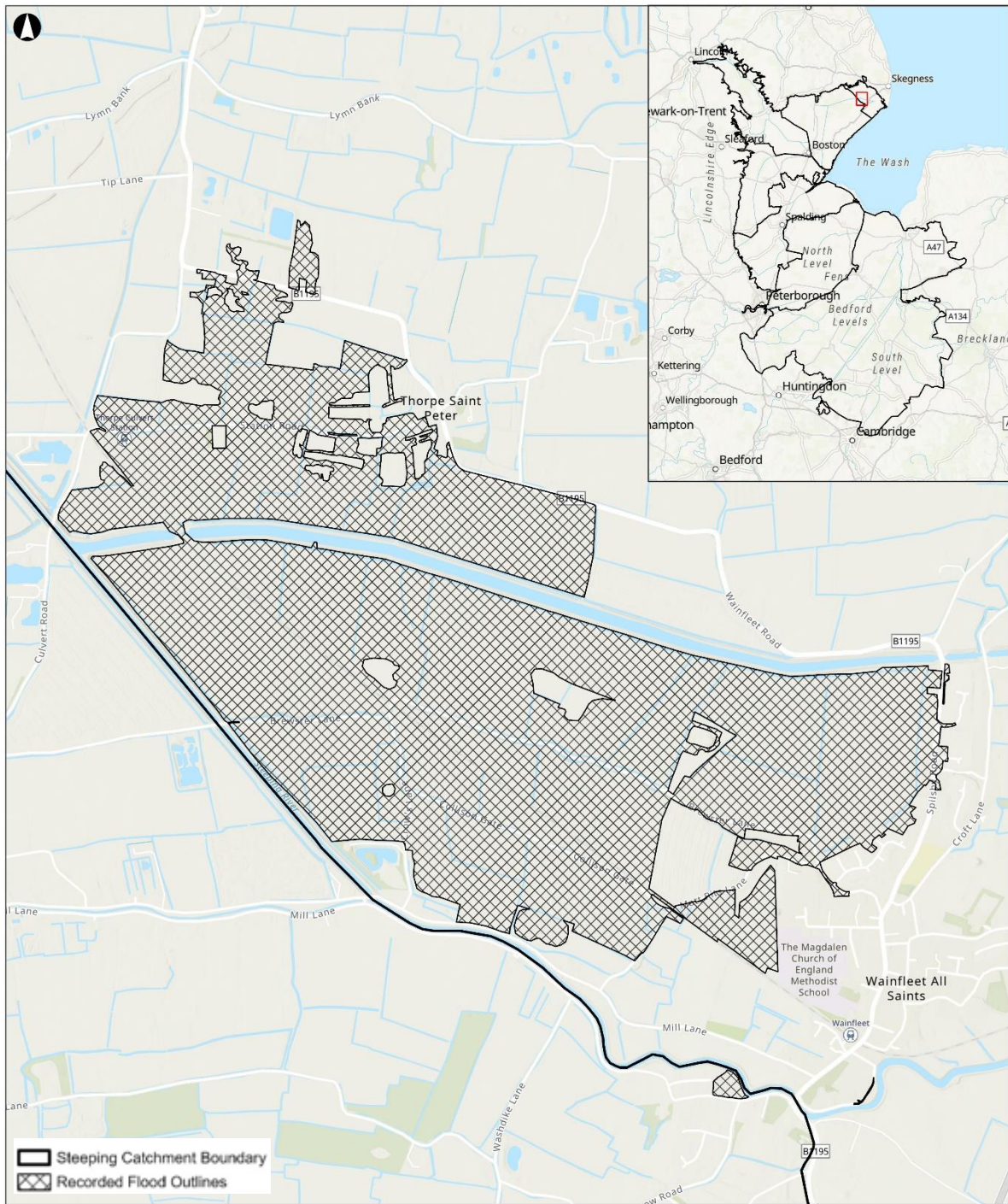


Figure 18: Recorded flood extent at Wainfleet All Saints

2.8 October 2023

Storm Babet brought persistent frontal rain to large parts of the UK between the 19th and 21st of October. Across the hydrological catchment of the River Lymn/River Steeping rain gauge data maximum totals were up to 120mm across the rainfall event.

The peak level recorded at the Wainfleet gauge was the highest on record.

Reporting from the BBC states that 10 properties were affected due to overtopping of the Steeping River²⁵. It is not known if these properties experienced internal flooding, or whether it was flooding of the property boundary.

Evidence from online sources²⁵, appears to suggest that it was overtopping of the Wainfleet Relief channel (as shown in Figure 20), rather than the Steeping River itself that was cause of flooding. No breaches of the embankments occurred during this event.

Evidence from the Environment Agency shows that there was flooding at the railway line crossing Wainfleet Relief channel, as well as overtopping at Spilsby Road – as shown in Figure 19.

Lady Wraths Beck also overtopped – the location and mechanism of this overtopping is still being investigated as part of Section 19 reports, as such a full understanding of flooding at from this watercourse from this event is unknown.



Figure 19: Overtopping at Spilsby Road

²⁵ Shoesmith K, Bell, N. (2023) Lincolnshire flooding: Storm Babet affects more than 150 homes, BBC 21, October. Available at: <https://www.bbc.co.uk/news/uk-england-lincolnshire-67176154> Accessed: (June 2025)



Figure 20: Overtopping of Steeping River relief channel

2.9 January 2024

Storm Henk brought heavy rainfall, following a long period unsettled weather (including Storm Babet) to the Steeping hydrological catchment. No flooding was reported to the Environment Agency, though it is likely that there would be agricultural flooding across the Steeping catchment.

Lady Wraths Beck overtopped during this – the location and mechanism of this overtopping is still being investigated as part of Section 19 reports, as such a full understanding of flooding at from this watercourse from this event is unknown.

2.10 January 2025

On the 6th of January, the UK received two inches of rainfall in two hours. The Steeping River overtopped, but it was not deemed a major incident²⁶. At least two properties were flooded in Wainfleet²⁷. There was also some overtopping of the Wainfleet Relief Channel.

2.11 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.

²⁶ Lincsonline (2025) More than 150 homes in Lincolnshire flooded as county council chief reflects on impact of extreme weather. Available at: <https://www.lincsonline.co.uk/bourne/news/more-than-150-homes-flooded-as-boss-vows-that-we-must-plan-f-9398984/> Accessed: June 2025

²⁷ BBC (2025) Floods update: Scores of homes hit after heavy rain. Available at: <https://www.bbc.co.uk/news/articles/cn8g038jj99o> Accessed: June 2025

2.12 Discussion

Tidal flooding occurred during the 1953 East Coast surge event – there was no evidence to suggest significant property flooding occurred during this event within the Steeping catchment. A tidal surge event in 2013 also caused flooding at Burgh Sluice, again there was no evidence of property flooding other than the Gibraltar Point Nature Reserve Visitor Centre occurred during this event.

The fluvial flood history suggests that there are two high flood risk locations; these are:

1. The Wainfleet Relief Channel.
2. Lady Wath's Beck at Great Steeping.

2.12.1 Wainfleet Relief Channel

The flood history has shown that the banks of the Wainfleet Relief Channel at its western extent have been overtopped in four events; 2007, 2019, 2023 and 2024. In the case of the 2019 event, overtopping caused a breach on the right bank that flooded a significant number of properties.

2.12.2 Lady Wath's Beck at Great Steeping

Flooding to properties at Sandy Lane, Great Steeping have occurred from overtopping of Lady Wath's Beck in five events; 2007, 2008, 2019, 2024 and 2025 – though there is some uncertainty about contribution of surface water flooding in these events.

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 was agreed with the Environment Agency. This assessment was informed by a review of the existing hydraulic modelling and engagement with the relevant Environment Agency teams.

Flooding does not come from one source in the Steeping catchment –there is risk from a range of sources, including tidal, fluvial and surface water – an understanding of all of these (and their limitations) is required to fully understand the issues in the catchment.

The proceeding sections detail the existing datasets used to determine the baseline flood risk in the Steeping 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 Steeping catchment, there were two models that could be used to describe flood risk from which a number of metrics could be extracted from:

- 2025 Steeping hydraulic model.
- 2010 Northern Area Tidal Modelling.

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

3.2.1 2025 Steeping hydraulic model

In September 2020, AECOM were commissioned by the Environment Agency to model the Steeping catchment under the Environment Agency's modelling and mapping framework to enable improved flood forecasting. The model was completed in March 2025.

The model is 1D-2D using Flood Modeller and TUFLOW. The extent of the model is shown in Figure 21. The IDB drains were not explicitly modelled but each represented as a storage area fed by a rainfall-runoff hydrograph and the resulting flood level used to determine the operation of the relevant pumping station.

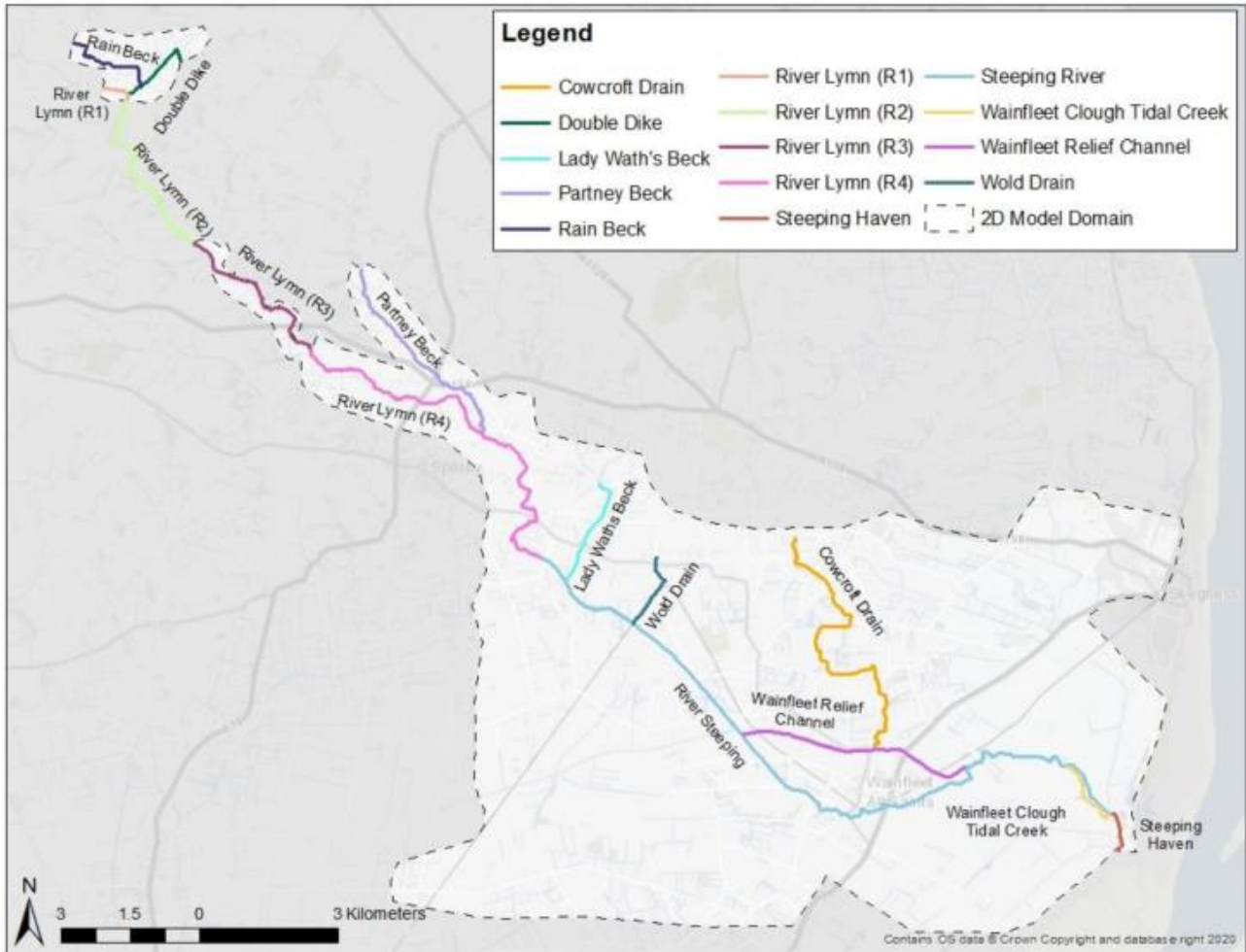


Figure 21: 2025 Steeping hydraulic model extent, extracted from the ‘Steeping Catchment Model User Report © Environment Agency

A number of AEP events were modelled: 50%; 20%; 10%; 5%; 3.3%; 2%; 1.33%; 1%; 0.5%; and 0.1%. The model also includes a tidal boundary for the Fluvial-Tidal joint probability scenarios shown in Table 1.

Table 1: Combined AEP of fluvial and extreme sea level events

Combined Event AEP (%)	Fluvial Event AEP (%)	Extreme Sea Level Event AEP (%)
1	10	50
1	50	10
0.2	10	5
0.2	5	10
0.2	50	1

An allowance for climate change was included for the 1% AEP and 0.1% AEP events for both defended and undefended scenarios, in line with the Environment Agency’s Minimum Technical Requirements as shown in Table 2.

Table 2: Modelled Climate Change Scenarios

AEP Event	Climate Change Scenario	Fluvial Climate Change Allowance	Sea Level Rise Allowance
1%	Epoch 3, Central	21%	597mm
	Epoch 3, Higher Central	32%	597mm
	Epoch 3, Upper End	57%	781mm
0.1%	Epoch 3, Central	21%	597mm

Breach modelling was also included for 30 locations on the River Steeping and Wainfleet Relief Channel (see Figure 22) for the 1 and 0.1% AEP scenarios, with and without a fluvial climate change allowance of 21%. It is noted that the model boundary differs from the Steeping catchment boundary shown in Figure 3, reflecting local hydraulic considerations.

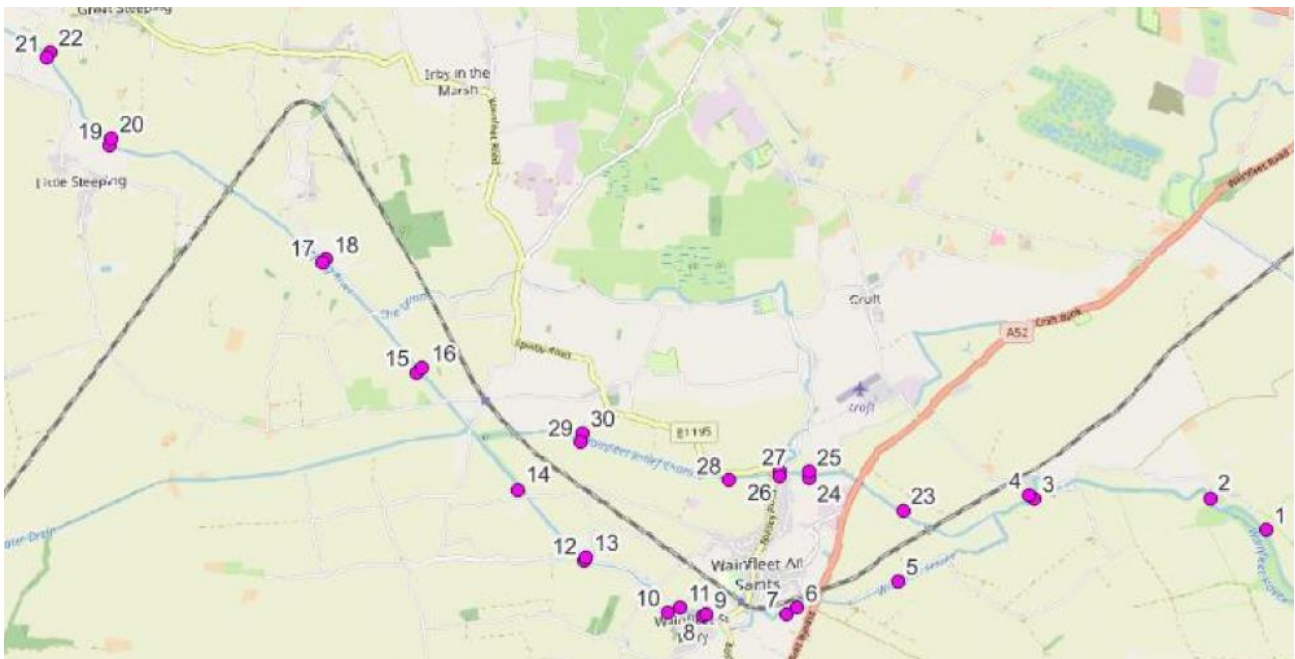


Figure 22: Steeping hydraulic model breach locations, extracted from the ‘Steeping Catchment Model User Report © Environment Agency

A meeting with the Environment Agency revealed that the model calibrated well to three events initially tested, however underpredicted flooding when calibrated against Storm Babet. No further testing was undertaken to achieve a closer fit to observed / recorded peak levels; however, an improved fit could be achieved with changes to key model input parameters.

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 23.

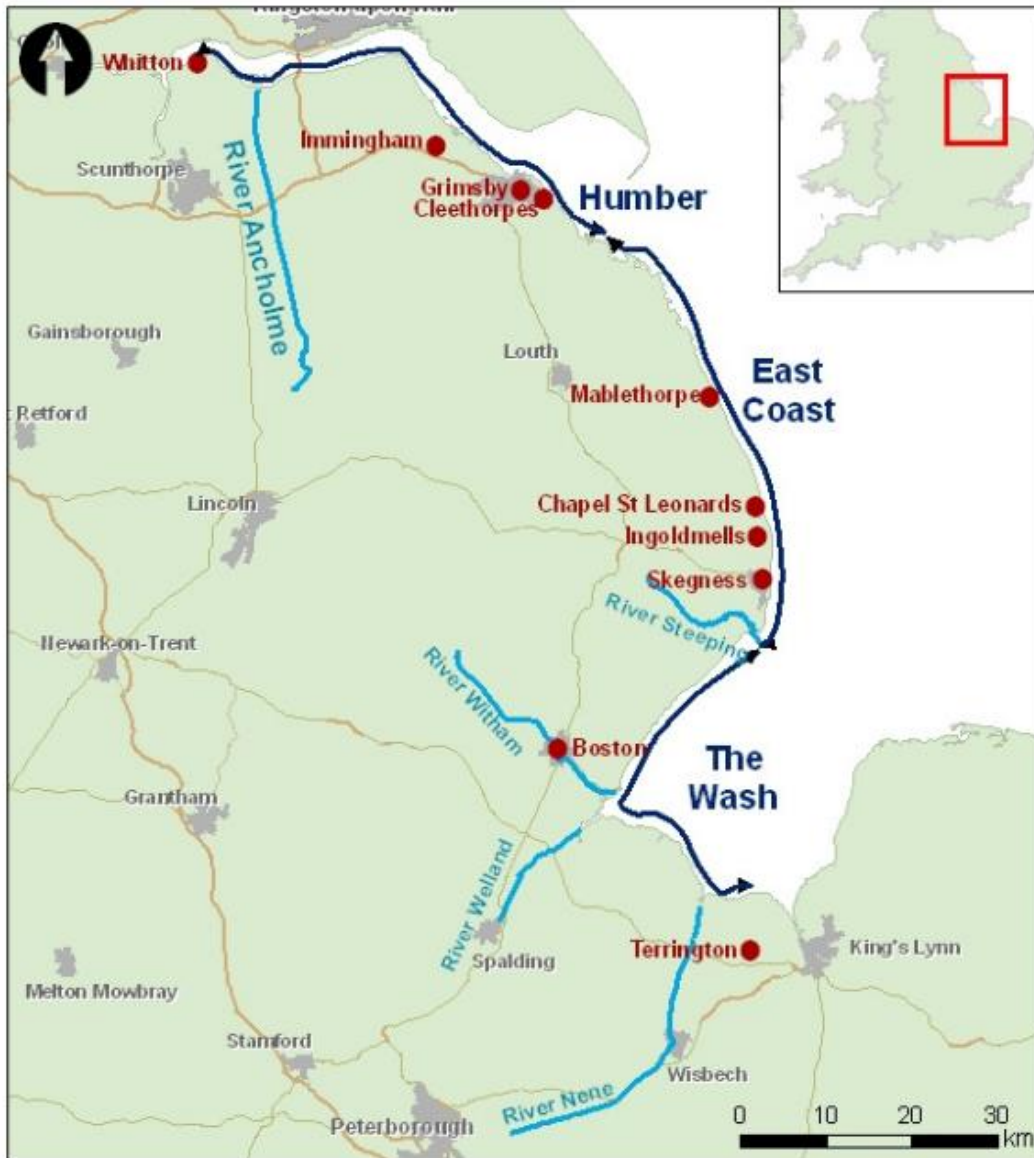


Figure 23: Northern Area Tidal Modelling study area, extracted from the Northern Area Tidal Modelling report © Environment Agency

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

The modelling only assesses tidal flood risk - no representation of fluvial flooding has been undertaken as part of this modelling study.

A detailed analysis of the wind and wave conditions in the study area have been undertaken. This established the 1 in 1 year wave conditions used in the TUFLOW

inundation modelling. For the climate change scenarios, a 10% uplift has been applied to wave overtopping inflows.

Figure 24 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 24: 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:

- Whilst it is acknowledged by the Environment Agency that the Steeping model does not appear to be replicating known flood mechanisms, the 2025 model is the best representation of current and future flooding currently available and as such has been used in this assessment.
- Both the 2025 and 2010 models are primarily interested in flooding from tidal and Main Rivers as they are part of Environment Agency project. As such the representation of flooding from IDB systems is likely to be simplistic or not represented at all (though the 2025 Steeping model does use the pump inflows and drainage network to inform the 2D flow routes).
- The 2010 model does not include a representation of the Burgh Sluice – as such tidal flooding upstream of this asset is likely to be overestimated as tidal flood waters will be able to propagate further up the channel.
- The 2010 model uses tidal boundary data that is now 15 years old – tidal boundary conditions, including sea levels and climate change allowances have been updated since this modelling was undertaken.
- The 2010 model uses LIDAR data that will have been superseded by finer resolution data.

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 which divides the floodplain 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 25).

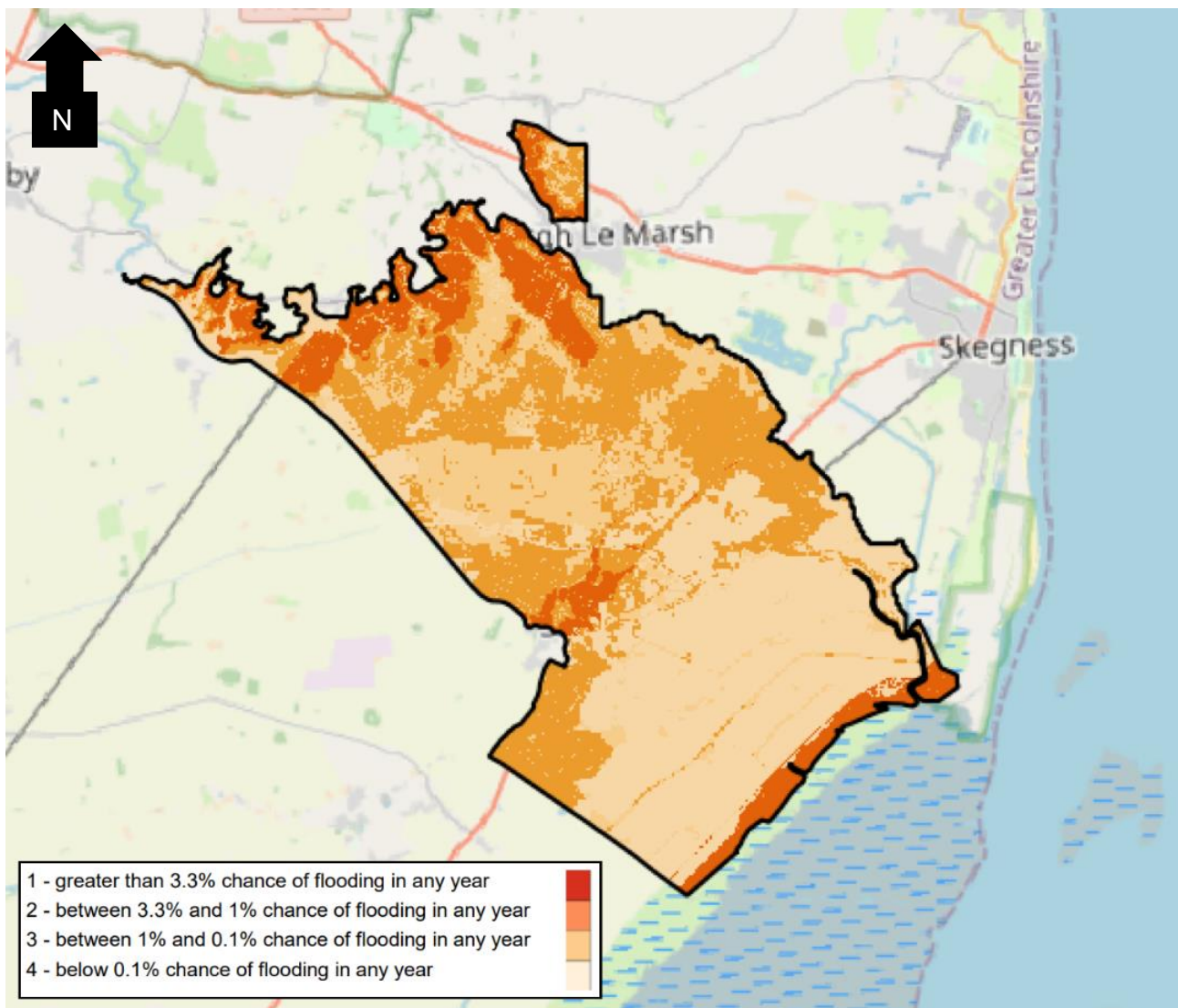


Figure 25: Risk of flooding from multiple sources ©Environment Agency, 2025

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.

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 Zone 3 and the extent of the flooding from rivers or the sea with a 0.1% AEP chance 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. 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 Steeping catchment.

As the Steeping 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:

- Outputs including maximum depth, level, etc.;
- 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 due to Environment Agency. Results from the 2025 Steeping catchment model are currently being processed for input in NaFRA2.

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. There are Environment Agency models for both fluvial and tidal flood risk as detailed in Section 3.2 and the 2025 Steeping model can be used to show how flows route across the lowland drainage system.

3.4 Other sources of information

3.4.1 East Lindsay Strategic Flood Risk Assessment (2017)

East Lindsay Strategic Flood Risk Assessment (SFRA) was completed in 2017 and provides an assessment of flood risk to inform the Council's strategy for delivering sustainable development. No new modelling was undertaken as part of the SFRA, therefore the outputs from this study have not been used in this assessment.

3.4.2 Lincolnshire County Council (2020) Investigation into the flooding in Wainfleet in June 2019

In June 2019, 88 properties were flooded across the East Lindsey District, when a breach formed in the Wainfleet Relief Channel, following heavy rain. Norfolk County Council on behalf of Lincolnshire County Council carried out an investigation into the causes of the flooding and provided strategic level options to reduce the risk of future flooding.

3.4.3 Steeping Catchment Action Plan (2020)

Following the June 2019 flooding, a steering group and subgroups were formed by the Lincolnshire Flood Risk and Water Management Partnership Strategy Group to produce an action plan to reduce the risk of future flooding.

3.5 Key receptors

3.5.1 Settlements

Key settlements include the historic market town of Wainfleet All Saints, located near the western boundary of the catchment, and the village of Wainfleet St Marys. There are several other linear settlements spread along minor roads and lanes in the north of the catchment area. Major transportation routes, such as the A52 and the Boston-Skegness Railway Line, provide vital links between the catchment and the surrounding areas.

3.5.2 Agriculture

The '*Steeping River: Environment and Agriculture Appendix*' produced as part of this project has defined the Fens as 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. Smaller areas of more water-intensive, and higher value crops, such as potatoes and sugar beet are present, particularly in the south of the catchment fed by irrigation reservoirs.

Across the catchment, around 33.5km² (56%) of land is classified as Agricultural Land Classification (ALC) Grade 1 and Grade 2 land. The majority of the Grade 1 land located within the area south-east of Wainfleet All Saints. Table 3 and Figure 26 present an overview of ALC classification in the catchment.

Data to inform the ALC classification has been sourced from the Provisional Land Agricultural Classification (ALC), published by Natural England.

Table 3: Overview of ALC classification within the catchment

	Grade 1	Grade 2	Grade 3	Grade 4	Non-agricultural
Area (km ²)	22.49 km ² (2,249ha)	11.09 km ² (1,109ha)	24.71 km ² (2,471ha)	1.46 km ² (146ha)	0.18 km ² (18ha)
Percentage of catchment (%)	37.5	18.5	41.2	2.4	0.3

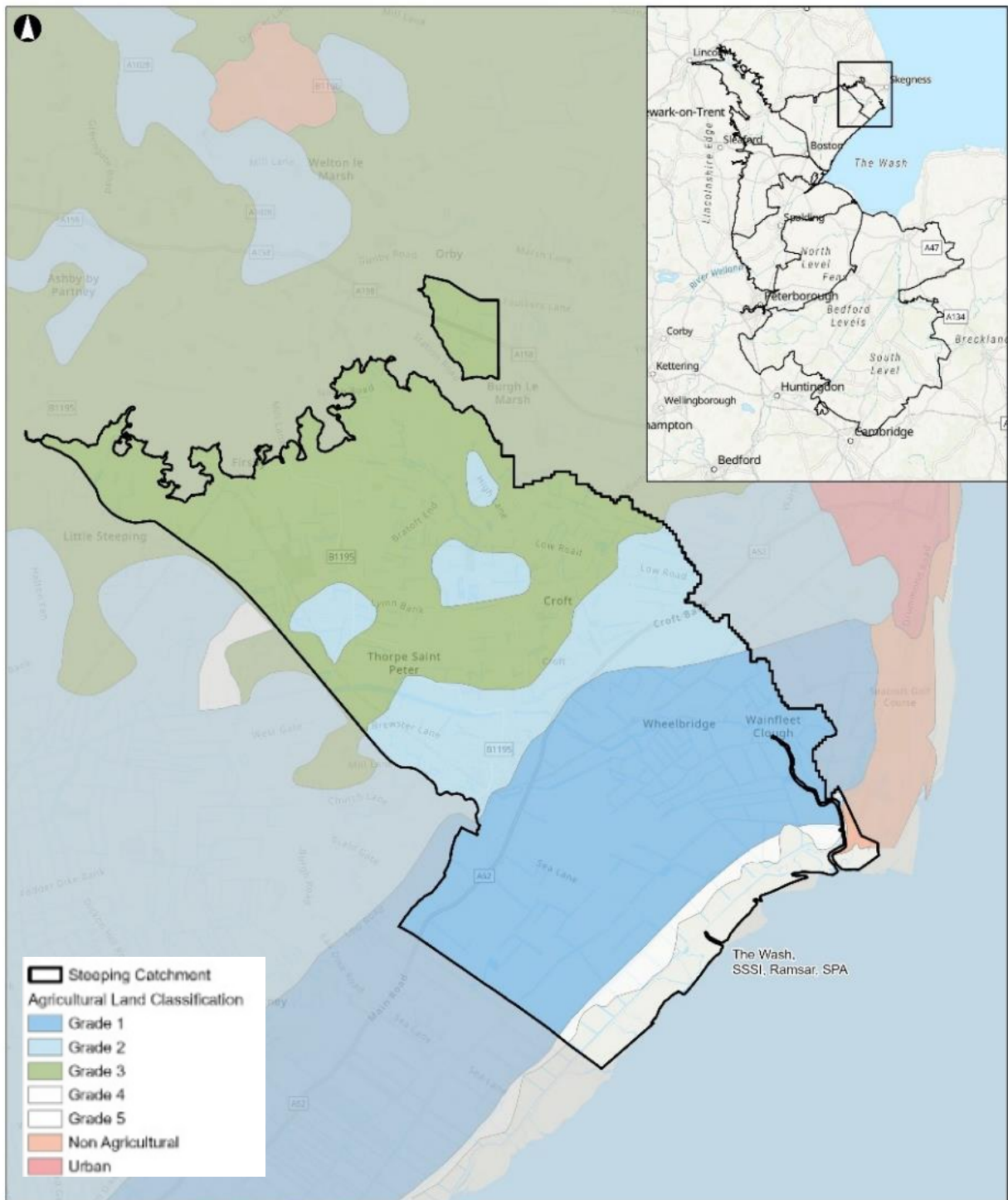


Figure 26: Land classification across the catchment

Approximately 49.37 km² (78%) of land across the Steeping catchment is currently farmed.

It is estimated that the agricultural value of the crops grown on this land (based on 2021 data) is as follows:

- Cereal production – c. £3.67 million;
- Other arable – c.£2.49 million; and
- Fruit and vegetables – c.£2.87 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 £10 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. The approach to climate change in each of the models is described in the preceding sections.

4.1 Tidal Climate Change

Climate change has been assessed as part of the Northern Area Tidal Modelling up to 2115 by an allowance for calculated rates of sea level rise over time. The increases used in this study are shown in Figure 27.

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 27: Sea level rise used in 2010 Northern Area Tidal Modelling © Environment Agency

The sea level rise applied to the design peak water levels generates a level of **6.17m AOD** at Burgh Sluice.

Since the study, which 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 4.

Table 4: Sea level allowances for each epoch

Area of England	Allowance	2000 to 2035 (mm)	2036 to 2065 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	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. To test sensitivity to severe climate change and to understand any required mitigation the Upper End allowance should be tested for sensitivity for both tidal and fluvial flooding.

These estimates have been compared to those applied in the 2010 modelling, shown in Figure 28. 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.

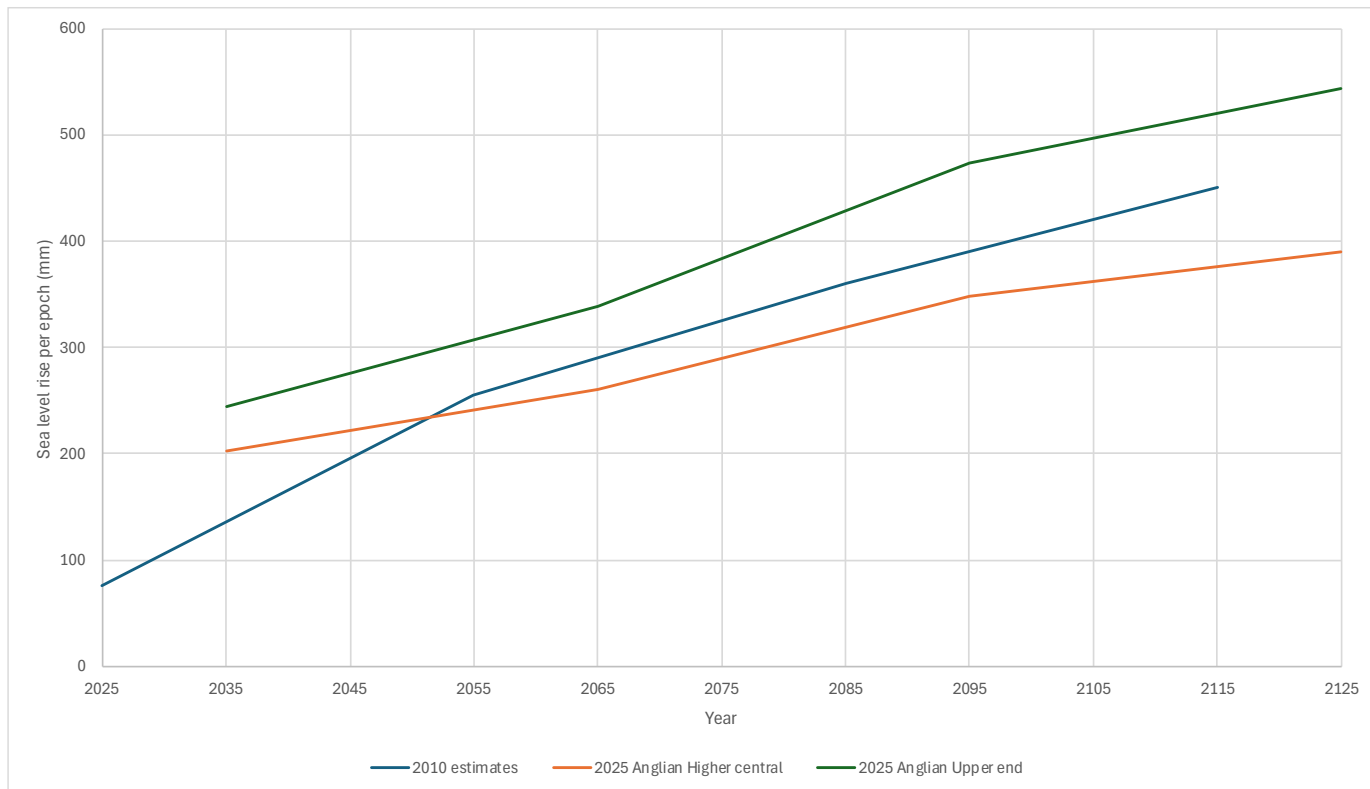


Figure 28: Comparison of sea level rise estimates (Environment Agency guidance)

4.1 H++ scenario

The Fens 2100+ project 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 Steeping catchment included an assessment of the H++ scenario. The most extreme value for climate change used within the 2010 modelling (as detailed in Figure 27) is 1.14m – this is considerably smaller than the H++ value of 1.9m. We can therefore infer that the H++ scenario would show significantly more flooding (depth and extent) than the results presented in the proceeding sections.

4.2 Fluvial climate change

The 2025 Steeping model has assessed three climate change scenarios for the 1% AEP event and one for the 0.1% event:

Table 5: Modelled Climate Change Scenarios

AEP Event	Climate Change Scenario	Fluvial Climate Change Allowance	Sea Level Rise Allowance
1%	Epoch 3, Central	21%	597mm
	Epoch 3, Higher Central	32%	597mm
	Epoch 3, Upper End	57%	781mm
0.1%	Epoch 3, Central	21%	597mm

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

Typically, 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.

4.3 Conclusion

Both the 2010 Northern Area Tidal Model and the 2025 Steeping Model represent climate change. The 2025 Steeping Model uses the latest climate change guidance, therefore there are no caveats to using this information in this study. The 2010 Northern Area Tidal Modelling study inevitably uses older sea level rise estimates. A review of the data suggests that these estimates will be between the Higher Central and Upper End

scenarios in the current guidance. Whilst not exact, the sea level rise estimates in the 2010 model are broadly comparable to current estimates, as such are considered suitable for assessing future flood risk at a strategy scale.

5. Tidal flood risk

5.1 Current tidal flood risk

The Steeping catchment is protected by significant coastal defences, these provide a high level of protection and are only overtopped during a rare flood event, such as the 1953 East Coast tidal surge. Even during the 1953 east coast tidal surge, available evidence does not suggest widespread flooding to properties within the Steeping catchment, though agricultural land was affected (see Section 2).

The 2010 Northern Area Tidal Modelling shows that current tidal flood risk in the 0.5% AEP would impact the agricultural areas close to the coastline. During the 0.5% AEP event no properties are predicted to flood. Flood depths for this event reach a maximum depth of approximately 0.6m towards the boundary with the East and West Fens catchment.

Inspection of model results shows that to the west of the Steeping River, the defences are not overtopped during the 0.5% AEP event, rather the flooding is as a result of wave overtopping.

To the east of the Steeping River, the flooding mechanism is from the tidal water level overtopping the existing embankments, close to the Burgh Sluice.

For the 0.1% AEP event, there is not a significant change in modelled flood extents (see Figure 29), though flood extents do get close to properties in the village at Wainfleet Clough. Flood depths are increased in comparison to the 0.5% AEP event, with depths of up to approximately 1m towards the boundary with the East and West Fens Catchment.

Closer inspection of the model results suggests that in addition to wave overtopping, defences are overtopped during the 0.1% AEP event.

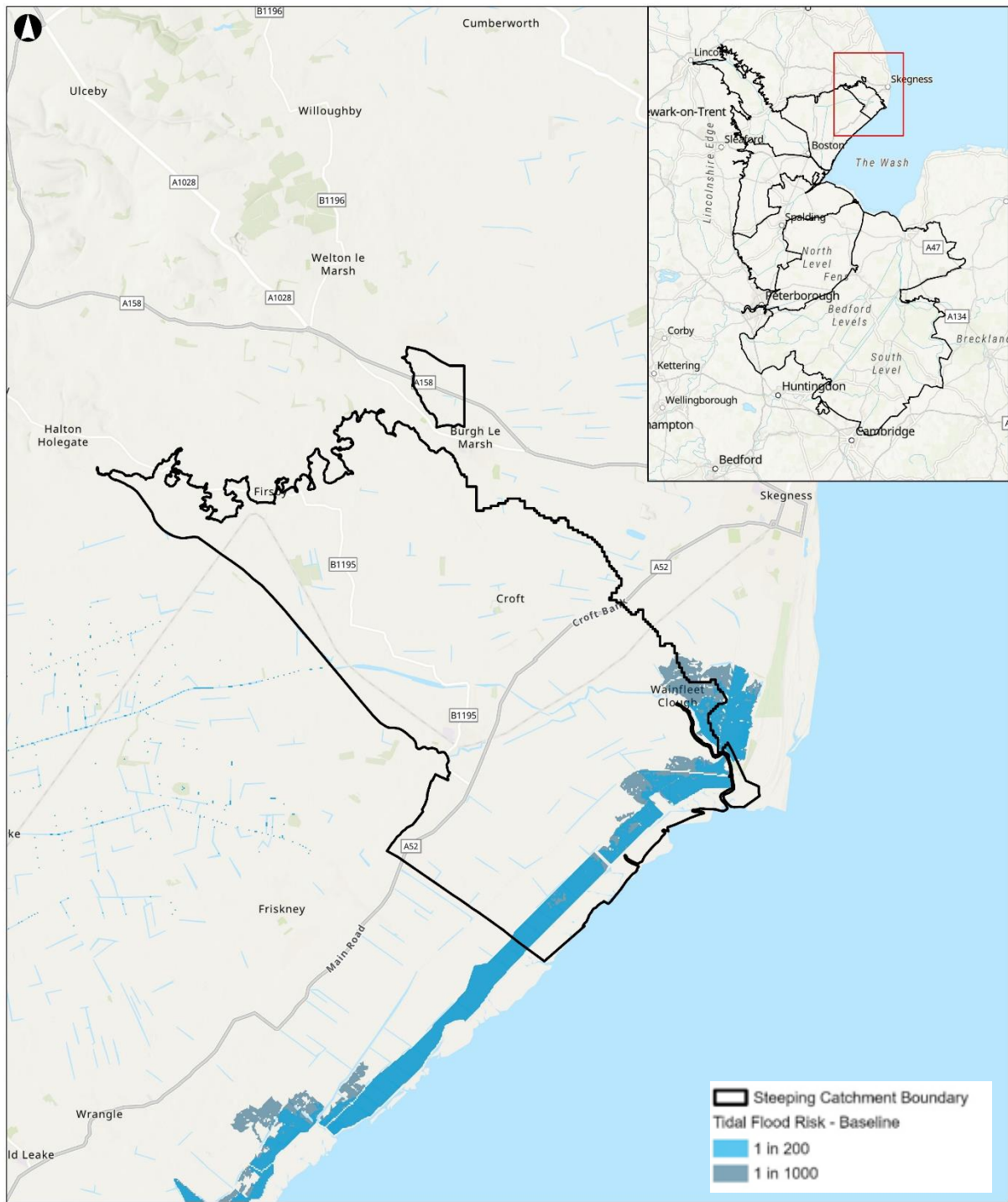


Figure 29: 0.5% and 0.1% AEP tidal AEP events maximum flood extent

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 (see Figure 30).

Results from the modelling show a significant increase in flood risk in comparison to present day with large areas of the Steeping catchment predicted to inundate, including the settlements of Wainfleet Cough, Wainfleet All Saints and Croft.

The main mechanism is still water overtopping of the existing flood embankments, as the sea level for the 0.5% AEP is higher than many of the existing embankments, this results in significant flooding across the Steeping catchment.

In contrast to current flood risk, for the 0.5% AEP a number of settlements are at flood risk, these include:

- Wainfleet All Saints;
- Croft;
- Wainfleet Clough; and
- Havenhouse.

It is also notable that the railway line between Wainfleet All Saints and Skegness is predicted to inundate in the 0.5% AEP.

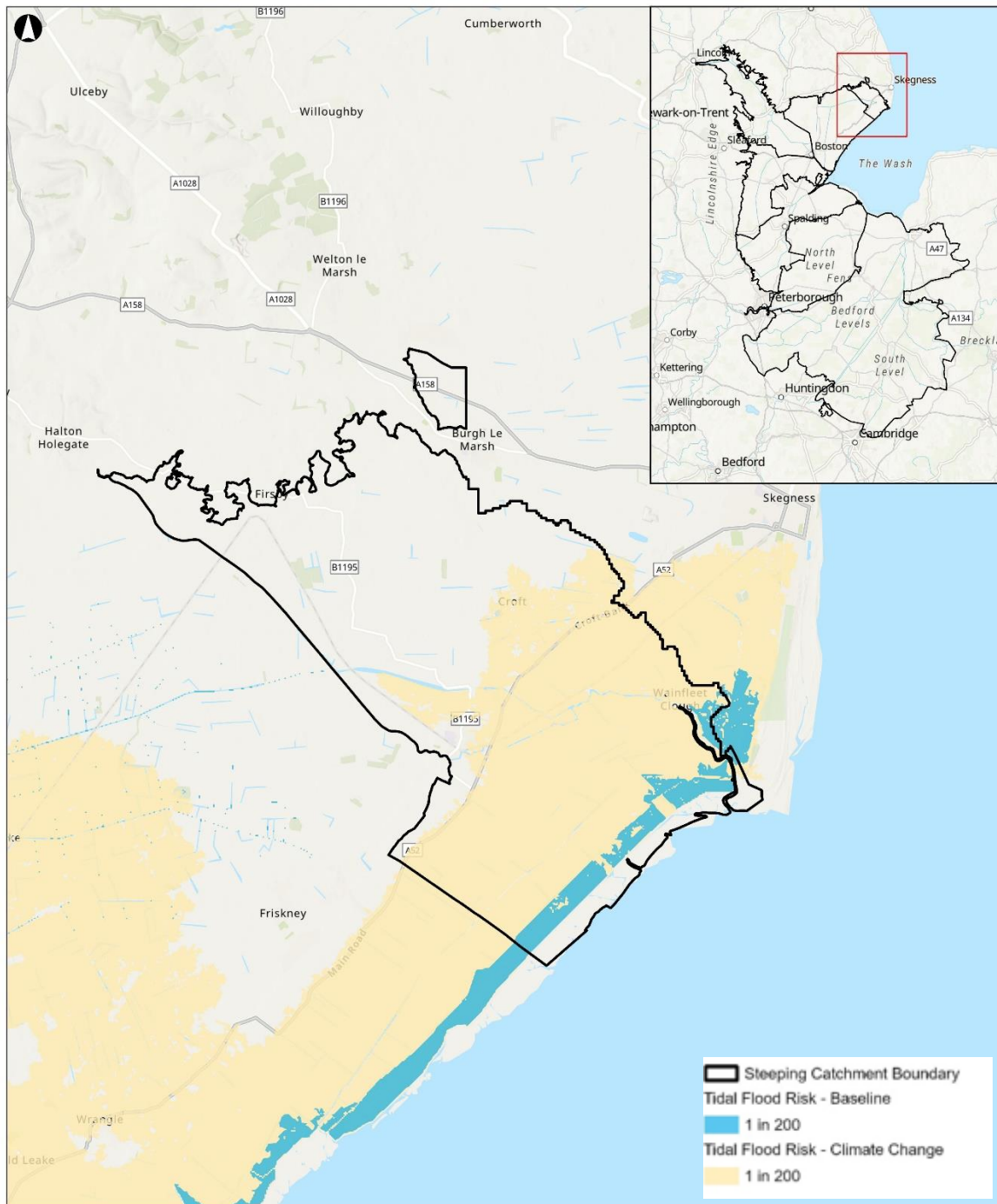


Figure 30: Comparison between 0.5% present day and 0.5% with climate change applied up to 2115

5.3 Key metrics

5.3.1 Total area

The total area modelled to be at risk of tidal flood risk in the 2010 model within the Steeping catchment was:

- Current 0.5% AEP event – 2.66km² (266ha) – **4.2%** of total catchment area.

- Future 0.5% AEP with sea level rise up to 2115 – 30.16km² (3,016ha) – **48%** of the total catchment area.
- Current 0.1% AEP event – 3.93km² (393ha) - **6.2%** of total catchment area.

5.3.2 Grades of agricultural land

The agricultural land within the Steeping catchment area is assessed for flood risk based on different grades, this has been summarised in Table 3.

Table 6: Agricultural land grading at risk of current 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	0.64 km ² (64ha)	20.95 km ² (2,095ha)	1.71 km ² (171ha)
Grade 2	0 km ²	5.50 km ² (550ha)	0 km ²
Grade 3	0 km ²	1.09 km ² (109ha)	0 km ²
Grade 4	1.06 km ² (106ha)	1.40 km ² (140ha)	1.20 km ² (120ha)
Grade 5	0 km ²	0 km ²	0 km ²
Total agricultural land flooded	2.10 km² (210ha)	28.94 km² (2,894ha)	2.91 km² (291ha)

5.3.3 Percentage area over 30cm

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

- 0.5% AEP event - 0.7km² (70ha) – **1.2%** of total catchment area.
- 0.5% AEP with sea level rise up to 2115 event - 26.7km² (2,670ha)– **42%** of total catchment area.
- 0.1% AEP event – 1.00km² (100ha) – **1.5%** of total catchment area.

5.4 Discussion

The significant increase in flood risk for the 0.5% AEP event when climate change is included shows how vulnerable the Steeping Catchment is to sea level rise. A present day 0.5% AEP event results in minimal flooding (and none to any settlements). When climate change is applied to the same event, the flood extent is considerably greater, with a number of settlements predicted to be at flood risk.

6. Fluvial flood risk

6.1 Current fluvial flood risk

The flood history suggests the main source of flood risk to the Steeping catchment is fluvial flooding from the Steeping River, in particular from the Wainfleet Relief channel. The flooding that occurred during the 2007, 2019 and 2013 came via the relief channel (though flooding in 2019 was exacerbated by a breach on the right embankment).

Results from the 2025 Steeping model show that there is limited fluvial flooding, even in extreme events such as the 0.1% AEP event.

Results from the model shows that the Willow Lake Holiday Park, on the right bank of the Cowcroft Drain is at risk from flooding in events greater than and including the 3.33% AEP event.

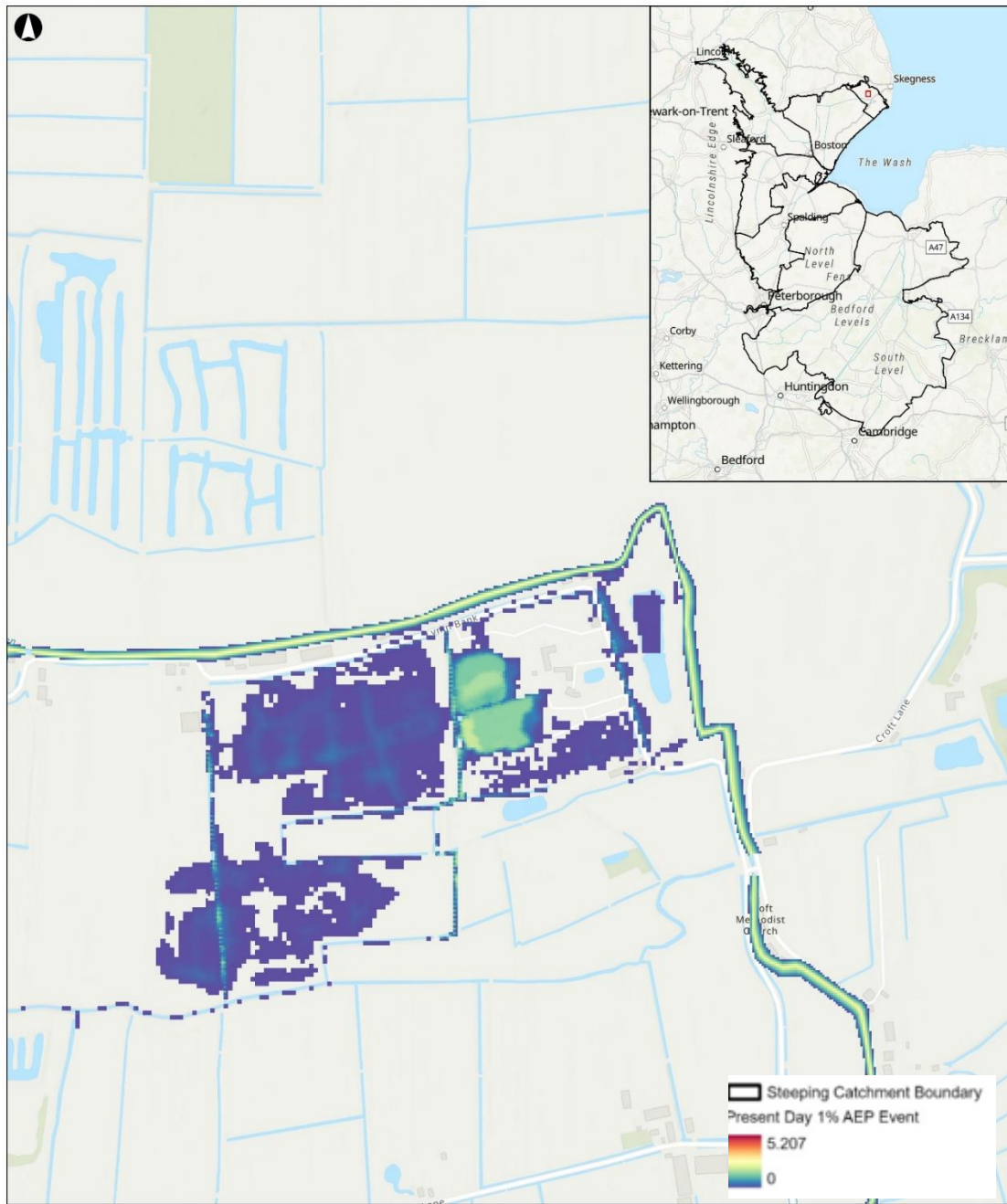


Figure 31: Willow Lake Holiday Park

In the modelled 1% AEP event, there is some inundation of fields near White House Farm on the left bank of the Steeping River and at Croft House on the left bank of the Cowcroft Drain.

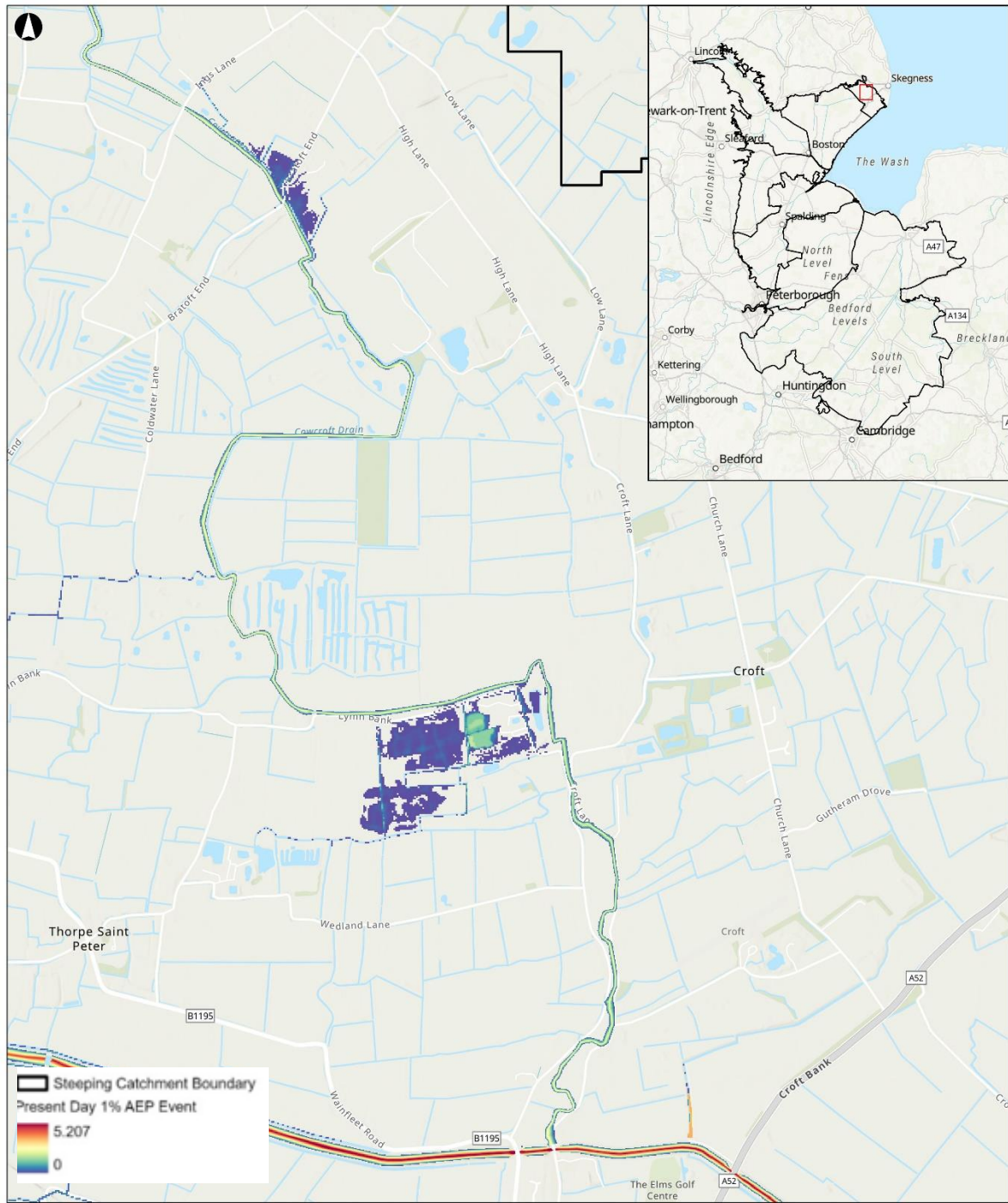


Figure 32: 1% AEP event

There is a significant increase in flood extent between the 1% AEP and the 0.1% AEP event. During the 0.1% AEP event the villages of Great Steeping and Thorpe Culvert are at flood risk, there is also significant flooding of agricultural land in the western portion of the catchment, with particularly high depths shown to the fields to the north of Thorpe Culvert, as shown in Figure 33.

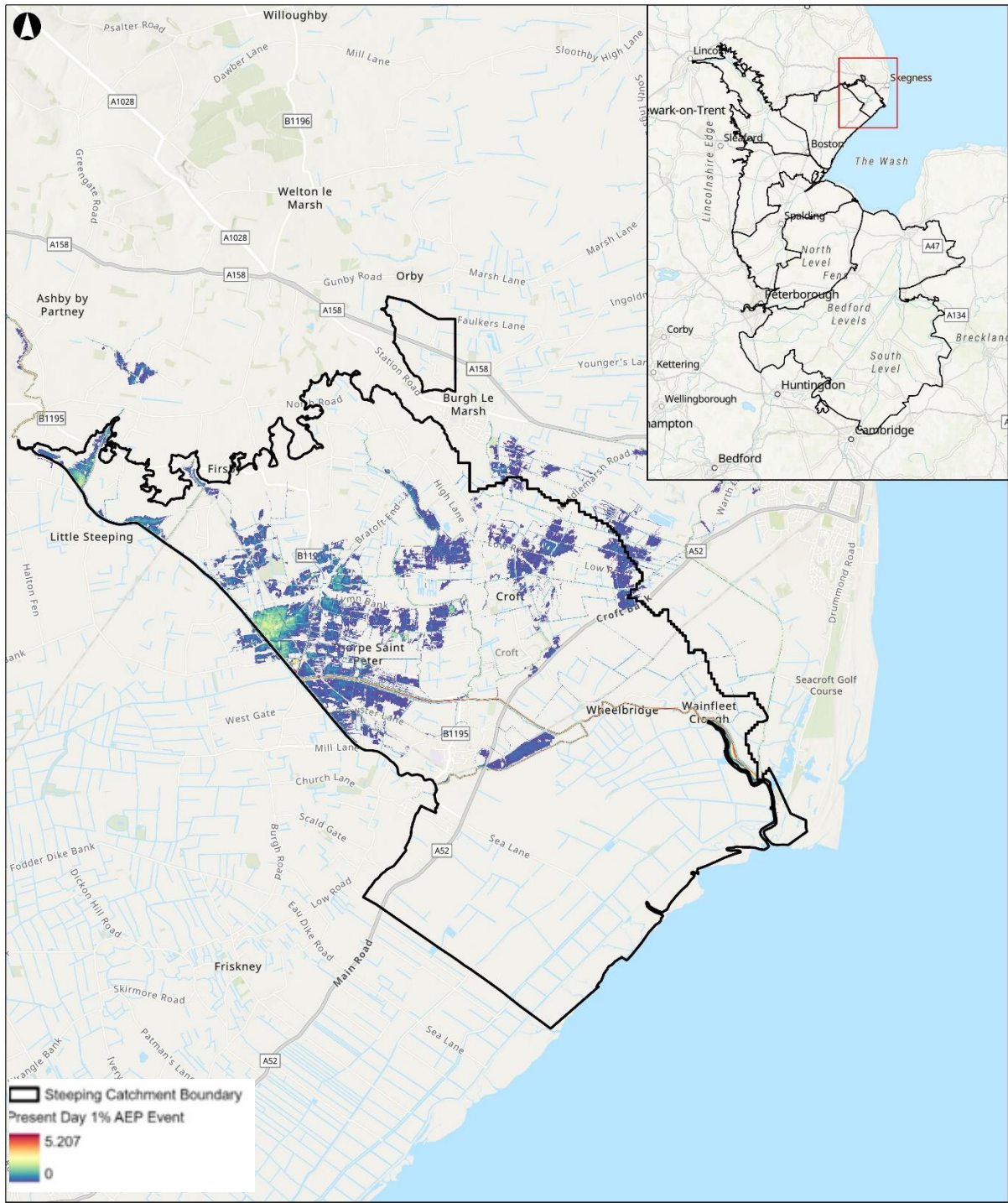


Figure 33: 0.1% AEP event

6.2 Future fluvial flood risk

The 2025 Steeping model has assessed three climate change scenarios on the 1% AEP event:

1. Uplift in fluvial flows of 21% - this is the Upper End allowance for the 2020s epoch;
2. Uplift in fluvial flows of 32% - this is the Higher Central allowance for the 2080s epoch; and
3. Uplift in fluvial flows of 57% - this is the Upper End allowance for the 2080s epoch.

As expected, the uplift in fluvial inflows results in an increase in flood risk across the catchment. As discussed in Section 6, there is limited flooding in the present day 1% event.

For all climate change scenarios, there is an increase in flooding across the catchment as shown in Figure 34. Climate change results in significantly more agricultural land flooding, particularly around Thorpe Culvert and Wainfleet All Saints. However, there is limited additional flooding to settlements, even when the Upper allowance for the 2080s epoch is applied to the model.

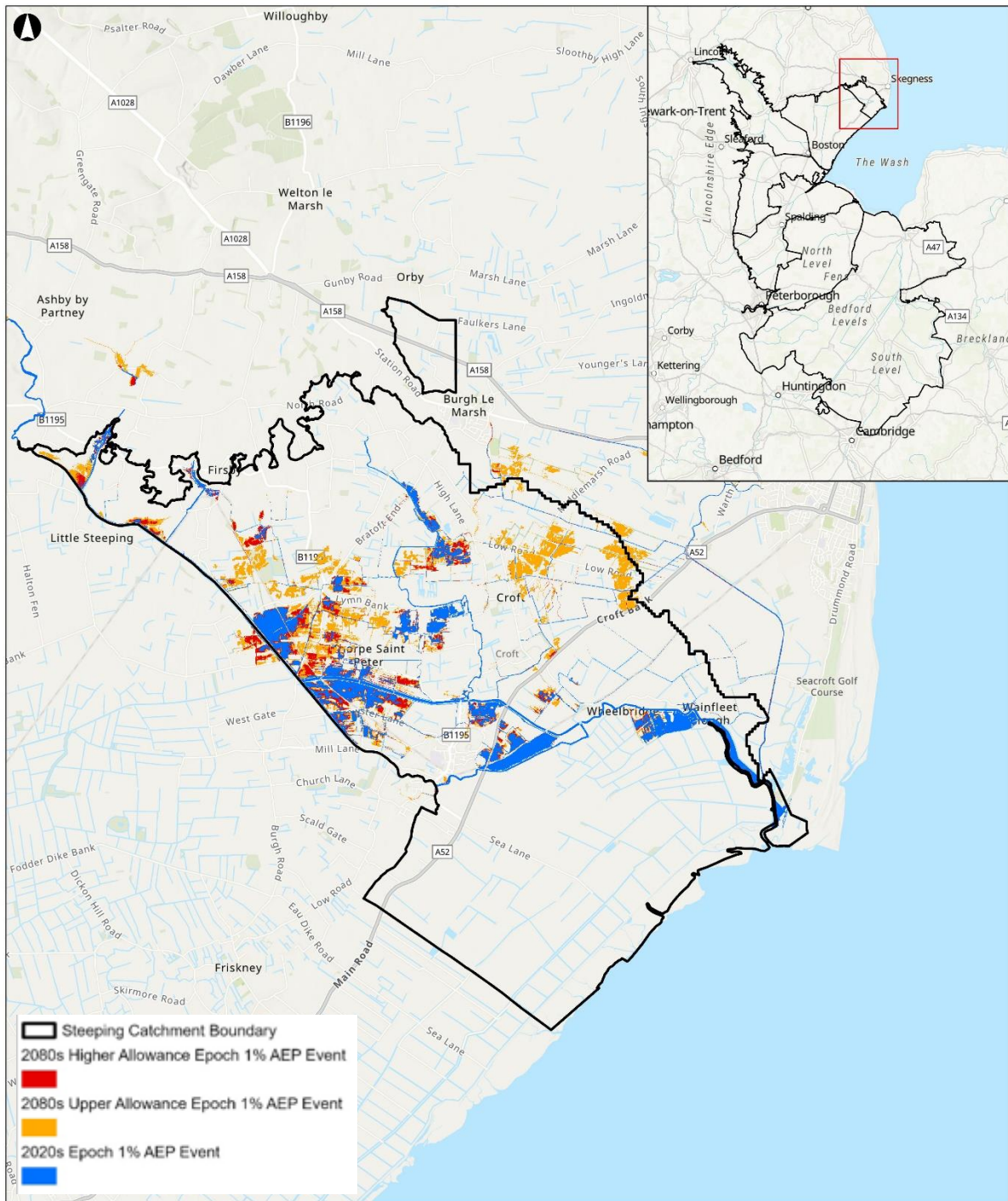


Figure 34: Steeping catchment 1% AEP event climate change scenarios

6.3 Key metrics

6.3.1 Total area

The total area at risk of fluvial flood risk within the Steeping catchment based on the 2025 model is as follows:

- 1% AEP event – 1.16km² (116ha) – **1.84%** of total catchment area.
- 1% AEP event with 21% fluvial uplift – 3.74km² (374ha) – **5.93%** of total catchment area.

- 1% AEP event with 32% fluvial uplift – 4.69km² (469ha) – **7.44%** of total catchment area.
- 1% AEP event with 57% fluvial uplift – 7.44km² (744ha) – **11.8%** of total catchment area.
- 0.1% AEP event – 7.10km² (710ha) - **11.2%** of total catchment area.

6.3.2 Grades of agricultural land

The agricultural land within the Steeping catchment area is assessed for flood risk based on different grades and has been summarised in Table 7.

Table 7: Agricultural land grading at risk of fluvial flooding

Agricultural Grade	1% AEP (km ²)	1% AEP event with 21% fluvial uplift (km ²)	1% AEP event with 32% fluvial uplift (km ²)	1% AEP event with 57% fluvial uplift (km ²)	0.1% AEP (km ²)
Grade 1	0.41km ² (41ha)	1.15km ² (115ha)	1.22km ² (122ha)	1.34km ² (134ha)	0.68km ² (68ha)
Grade 2	0.21km ² (21ha)	0.98km ² (98ha)	1.33km ² (133ha)	2.31km ² (231ha)	2.25km ² (225ha)
Grade 3	0.54km ² (54ha)	1.55km ² (155ha)	2.07km ² (207ha)	3.72km ² (372ha)	4.41km ² (441ha)
Grade 4	0	0	0	0	0
Grade 5	0	0	0	0	0
Total agricultural land	1.16km² (116ha)	3.68km² (368ha)	4.62km² (462ha)	7.30 km² (730ha)	7.34km² (734ha)

6.3.3 Percentage area flooded over 30cm

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

- 1% AEP event - 0.83km² (83ha) – **1.31%** of total catchment area.
- 1% AEP event with 21% fluvial uplift – 3.85km² (385ha) – **6.1%** of total catchment area.
- 1% AEP event with 32% fluvial uplift – 4.44km² (444ha) – **7.04%** of total catchment area.
- 1% AEP event with 57% fluvial uplift – 5.69km² (569ha) – **9.03%** of total catchment area.
- 0.1% AEP event – 2.40km² (240ha) – **3.80%** of the total catchment area.

6.4 Discussion

Up to the 0.1% AEP event, fluvial flood risk across the catchment is low, with only small areas shown to be at fluvial flood risk.

Based on the outputs from the 2025 Steeping model, fluvial flood risk across the catchment is limited up to and including the 1% AEP event. There is a large increase in flood risk between the 1% AEP event and the 0.1% AEP event.

The application of climate change to fluvial flows results in a significant increase in flood risk across the Steeping catchment – however there is a limited increase in flood risk to settlements. The increase in flood risk is largely to agricultural land.

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 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 water from draining efficiently to the intended watercourse or sewer.

The Environment Agency's long term flood risk service²⁸ 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. A few properties are shown to be at risk in Wainfleet All Saints and Wainfleet St Mary. There is a slight increase in density of the localised patches of flood risk towards the north (upstream) end of the catchment.

7.1.1 June 2019

As mentioned in Section 2.7, on June 10th, 2019, heavy rainfall led to a breach in the Relief Channel causing flooding in Wainfleet All Saints. Prior to the breach, surface water flooding was also reported in Wainfleet All Saints, affecting 14 properties due to the drainage capacity being exceeded²⁹.

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 fluctuates in response to seasonal rainfall. Groundwater flooding is most common in

²⁸ 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.

²⁹ Lincolnshire County Council (2020) Report to Flood and Water Management Scrutiny Committee. Available at: <https://lincolnshire.moderngov.co.uk/documents/s31669/Wainfleet%20Section%2019%20Investigation.pdf> Accessed: June 2025

spring, following prolonged rainfall during the preceding autumn. The presence of sandy or gravel soils can mean increased susceptibility to movement of groundwater and flooding from this source.

Across the Steeping 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. No incidents of groundwater flooding have been found in the literature review.

7.3 Reservoir

Reservoir flooding is very rare but occurs when there is a failure of reservoir impounding structures such as raised embankments. There are no reservoirs in the Steeping catchment.

8. Summary and recommendations

8.1 Tidal flood risk

Current tidal flood risk is predicted to impact Grade 1 and Grade 4 agricultural land near the coast. Overtopping of the existing embankments only occurs in the most extreme event modelled – the 0.1% AEP event. Flooding in the 0.5% AEP event is caused by wave overtopping, rather than the tide level being higher than the existing embankments.

In the future, the modelled flood risk indicated that future flood risk would increase significantly due to sea level rise, up to the year 2115. Modelling has shown that for the 0.5% AEP event when sea level rise has been considered, the total area flooded covers approximately 48% of the Steeping catchment (in comparison to 4.2% in a present day scenario). This includes predicted flooding to 20.95km² (2,095ha) of Grade 1 agricultural land – in comparison to 0.64km² (64ha) in a present day 0.5% AEP event. Future tidal flood risk modelling indicates flooding of a number of settlements within the Steeping catchment, including Wainfleet All Saints.

Overall, the current tidal flood risk to the Steeping catchment is low, however this increases significantly when climate change is applied, resulting in flooding of half the catchment during the 0.5% AEP event. Whilst it can be considered that current flood risk is low, this assumes the existing embankments do not fail during an event. A breach in the tidal defences is likely to result in significant flooding of the Steeping catchment – in particular to Grade 1 agricultural land.

8.2 Fluvial flood risk

The flood history of the Steeping catchment showed that there have been a number of fluvial flood events that have impacted properties and agricultural land throughout the record. Two locations appear to be a high risk; Great Steeping and the right and left banks of the western end of the Wainfleet Relief channel, though it is clear that other locations have experienced fluvial flooding. This is not observed in the existing model, which indicates that the current fluvial flood risk is up to the 0.1% AEP event, with limited flooding of agricultural land – a total of 11.6km² (116ha). This figure increases to 11.60km² (1,160ha) for the current 0.1% AEP event.

There is an increase in flooding when climate change is applied to the 1% AEP event, though in the Upper allowance scenario, only 7.44km² (744ha) of agricultural land is inundated – a relatively small proportion of the overall catchment.

However, given the 2025 Steeping model's inability to replicate previous flooding seen in the catchment, the results of the modelling should be treated with caution – and may underpredict the existing flood risk.

The modelling assumes that there are no breaches in the existing embankment – however the flood history shows that flooding in the Steeping catchment has been exacerbated, particularly at Wainfleet All Saints, by a breach to the Wainfleet Relief channel.

8.3 Conclusions

Modelled present day tidal and fluvial flood risk to the Steeping catchment is low. The presence of significant tidal and fluvial embankments, as well as assets such as the Burgh Sluice provides protection to the catchment from both fluvial and tidal sources. However, where current tidal and fluvial flood risk is predicted, it is usually to high grade agricultural land.

Modelling predicts that the Steeping catchment is vulnerable to future tidal flooding due to sea level rise as a result of climate change. For the tidal 0.5% AEP event, almost half the catchment is predicted to inundate, even allowing for the presence of the tidal embankments.

Although there is an increase in future fluvial flood risk as a result of climate change, it is the future tidal flood risk that will impact a greater proportion of the catchment.

