Fens 2100+

Lower Welland

Baseline evidence report

2025

Find out more

Summary baseline evidence report

Discover key findings from across the Fens.

Catchment baseline evidence reports

View the full suite of reports, for more detail on each catchment.

Technical appendices

Explore the evidence, detailed in technical appendices for each catchment report:

- Flood risk baseline
- Baseline economic appraisal report
- Assets baseline report
- Environmental and agricultural baseline
- Natural capital register and account

For more information contact:

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This document has been produced by Arup in collaboration with the Environment Agency, Rivelin Bridge and the Fens 2100+ Partners as part of a wider programme of work, drawing from engagement across the area and sector.

The report in context

A robust evidence base

This report provides, for the first time, a comprehensive picture of flood risk and asset performance across the Lower Welland catchment.

This report was compiled in collaboration with Internal Drainage Boards (IDBs) and local partners.

It forms part of a suite of catchment reports offering a robust evidence base to support the Fens 2100+ Partnership in transforming the approach to investing in flood and coastal resilience, including:

- Maintaining and managing critical assets, which are ageing and under increasing pressure from climate change.
- Addressing how the area will function in the future, balancing flood risk, water supply, sustainability and economic growth.

Each report brings together data and insights from key Risk Management Authorities (RMAs) on their experience of managing the catchment. Information includes the historical and environmental context, the function of flood risk assets and their economic impact, current and future flood risks and investment challenges and opportunities.

Securing the future of the Fens

Located in eastern England, the Fens is one of the UK's most distinctive landscapes. Significantly influenced by human activity, it has evolved over centuries from marshland into fertile farmland through drainage systems, embankments and pumping stations. Today, it is a vital region for food production and manufacturing and environmental value, contributing significantly to the UK economy.

Lying largely at or below sea level, this highly vulnerable region faces increasing risks from rising sea and river levels driven by climate change and land subsidence caused by drying peat soils.

Without constant water management, large areas of the Fens would become uninhabitable, with the lives and livelihoods of over 600,000 being impacted by flooding from the rivers and the sea.

Yet, many of the 17,000 flood risk management assets that sustain the region are being affected by reliability and performance issues caused by their age. Many were built in the post-war period, with some dating back to the 1600s.

If these critical assets fail, the consequences would be catastrophic, risking lives, land, businesses and infrastructure.

Lower Welland

Total catchment area
473km^2

93%
of land classified as Grade 1 & 2 agricultural land

20km
of coastline

Estimated total population
75,443

23 pumping stations

3 Internal Drainage Boards

26 Scheduled Monuments

9 Conservation Areas

76,080
tonnes of CO_2 equivalent emitted by degraded peatland in the catchment each year

12 designated sites for nature conservation

£43.9 million
total annual value from natural capital

84% Environment Agency maintenance expenditure spent on embankments

Total length of embankments managed by the Environment Agency 149km

£8.9bn
economic benefits of current flood defences

Introduction

The evidence is clear: without urgent investment to maintain and upgrade flood risk assets across the Lower Welland catchment, £9.3 billion of damages could be sustained to land, homes and livelihoods.

A landscape worth protecting

Spanning 473km^2 (47,300ha) of south-east Lincolnshire and part of Peterborough, Lower Welland catchment is an area of national agricultural importance. Its healthy agricultural economy contributes £183.6 million a year to the UK economy.

There are 12 designated nature conservation sites, including Baston and Thurlby Fens. In addition there are a number of important heritage sites including historic embankments, channels and medieval salt workings.

Natural capital delivers £43.9 million of benefits a year, including food production, flood risk management, carbon sequestration, clean water and recreation. Around 10% of land is underlain by rich peat deposits.

What's the challenge?

Continuous land drainage and flood defences are all that protect low-lying areas from permanent inundation. 405km^2 (40,500ha) of land and 24,870 homes are at risk. Yet, 94% of flood risk assets are being affected by reliability and performance issues caused by their age and 31% have already expired.

Approximately 28% of assets are rated 'Poor', 'Very Poor' or 'Unknown', including key structures such as outfalls and control gates. This complex system of assets requires significant resources and collaboration between RMAs.

Repeated flooding events highlight the catchment's vulnerability, including at Cowbit, Crowland and Surfleet in 2024. Climate change would intensify this risk, even if current defences are maintained.

What's needed?

£540-£860 million

of investment

to sustain the current Standard of Service for 100 years

To maintain

£8.9 billion

of benefits

through reduction of damages to properties, agriculture, transport and the environment

Catchment overview map

The river in context

The Lower Welland catchment covers 473km² (47,300ha) of primarily rural, highly productive agricultural land. Most of the catchment is situated within Lincolnshire, although the southern corner lies within the City of Peterborough.

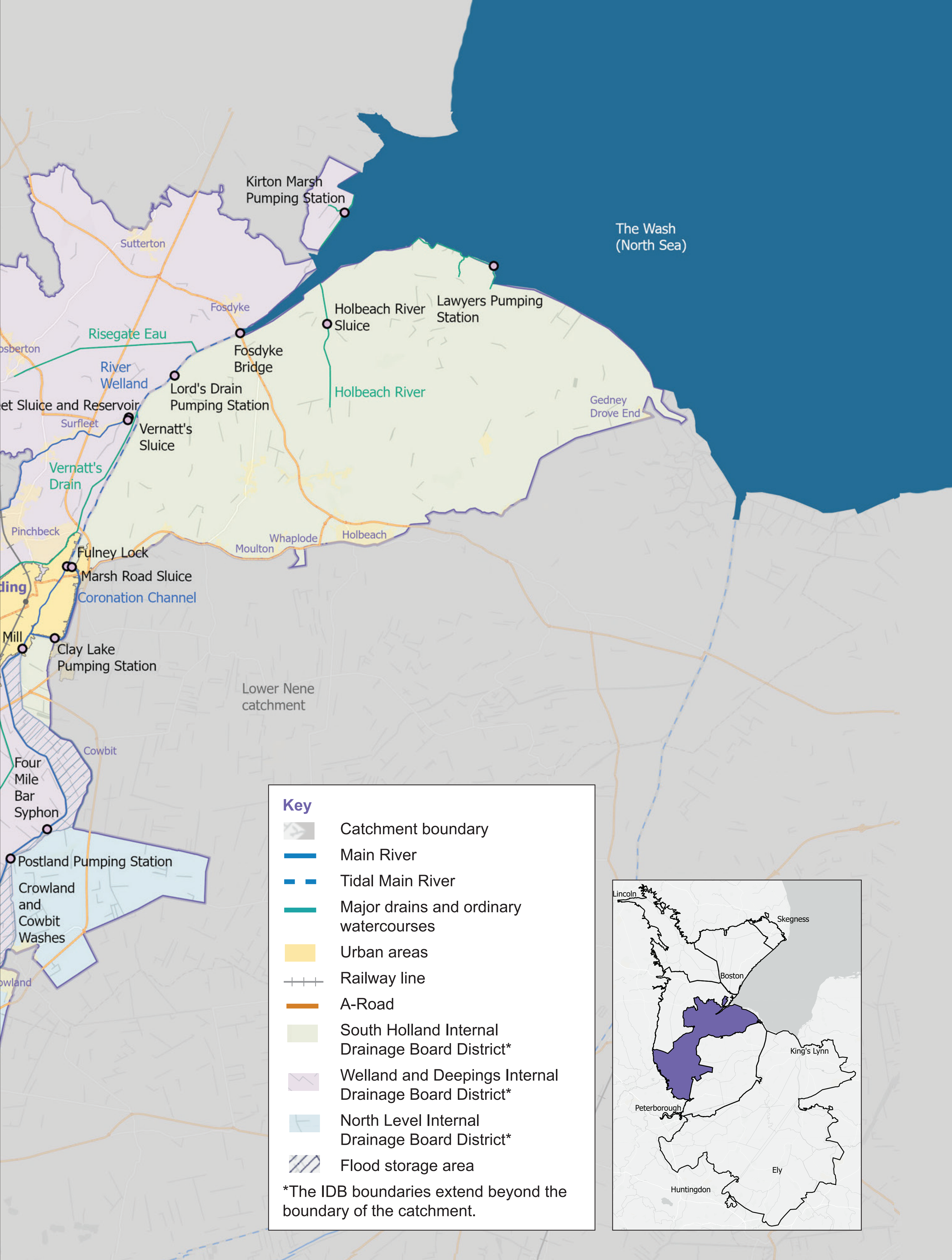
The catchment spans from Market Deeping in the south-west, to the outfall of the River Welland into The Wash at Fosdyke. It is bordered by the Lower Nene catchment to the south and the South Forty Foot Drain catchment to the north.

Within the catchment, the watercourse network is comprised of two drainage systems: a Main River network managed by the Environment Agency, and a network of drains managed by the Welland and Deepings, South Holland, and North Level District IDBs. The three IDBs mainly discharge water from their districts into the Main Rivers, although water from some coastal areas is discharged directly into The Wash.

The Lower Welland catchment covers approximately

473km²

of south-east Lincolnshire and part of the Peterborough district.


Kirton Marsh Pumping Station
The Wash (North Sea)
Sutterton
Fosdyke
Risegate Eau
River Welland
Fosdyke Bridge
Holbeach River Sluice
Lawyers Pumping Station
Lord's Drain Pumping Station
Holbeach River
et Sluice and Reservoir
Surfleet
Vernatt's Sluice
Gedney Drove End
Vernatt's Drain
Pinchbeck
Whaplode
Holbeach
Moulton
Fulney Lock
Marsh Road Sluice
Coronation Channel
Mill
Clay Lake Pumping Station
Lower Nene catchment
Cowbit
Four Mile Bar Syphon
Postland Pumping Station
Crowland and Cowbit Washes
Key
Catchment boundary
Main River
Tidal Main River
Major drains and ordinary watercourses
Urban areas
Railway line
A-Road
South Holland Internal Drainage Board District*
Welland and Deepings Internal Drainage Board District*
North Level Internal Drainage Board District*
Flood storage area
*The IDB boundaries extend beyond the boundary of the catchment.
Lincoln
Skegness
Boston
King's Lynn
Peterborough
Ely
Huntingdon

Catchment overview

Major flood defence works occurred on the River Welland following the floods of 1947, including diversions and new channels which are still operational today.

Many elements of the current Lower Welland Main River system were put in place as part of the Major Improvements Scheme following severe flooding across the region in 1947. Upstream of the study area a diversion channel, the Greatford Cut, was constructed to take some flow from the River Glen to the River Welland. Likewise, upstream of Deeping St James the River Welland was partially diverted through the straightened Maxey Cut.

Upstream of Spalding, the Crowland and Cowbit Washes provide a large capacity for flood storage, but have seldom operated for this purpose since the Major Improvement Scheme was implemented in 1947 due to major flooding. There have been several uncontrolled breaches of the Crowland and Cowbit Washes' banks, causing flooding to and from the Crowland and Cowbit Washes.

At Spalding, the artificial Coronation Channel diverts a large proportion of the River Welland's flow around the east of Spalding, rejoining downstream of Fulney Lock and Marsh Road Sluice. These structures also mark the tidal limit on the two watercourses.

Downstream of Spalding, the River Welland continues to its confluence with the River Glen at Surfleet, and then to its outflow into The Wash approximately 20km downstream of Spalding. Several significant tributaries connect to the River Welland in its tidal reach, including the River Glen and the Holbeach River which discharges by gravity.

The catchment is also drained by an extensive network of man-made drains managed by three IDBs: the Welland and Deepings IDB, South Holland IDB and the North Level District IDB. All of the land north of the River Welland is drained by Welland and Deepings IDB. They manage the Counter Drain, North Drove Drain, and South Drove Drain which all carry water from the low-lying Deeping Fen area to Pode Hole. From there it is pumped up to Vernatt's Drain before discharging to the River Welland at Surfleet.

The catchment's low-lying terrain is typical of the wider Fens with most of the land in the southern catchment lying less than 2m above sea level. 51.3% of the catchment is highly productive Grade 1 agricultural land.

There are several small settlements within the catchment including Pinchbeck, Surfleet, Deeping St Nicholas, Gosberton and Fosdyke. The larger market town of Spalding sits centrally in the catchment. Connectivity within the catchment is supported by key transport routes, such as the A17, A16, A151 and the A1175, and the railway station at Spalding which links it to Peterborough and Sleaford. The catchment has an estimated total population of 75,443.

Vernatt's Sluice

Flood management system

1 **River Welland**
Main River
Primary watercourse running the full length of the catchment, with a tidal boundary at Marsh Road Sluice.

2 **Maxey Cut**
Environment Agency
Upstream of the study area this channel diverts a proportion of the River Welland's flow, rejoining upstream of Crowland and Cowbit Washes.

3 **Peakirk Pumping Station**
Environment Agency
Controls the flow entering the River Welland from the Folly River, which carries water from Peterborough to the south. It marked the previous/natural tidal limit of the River Welland.

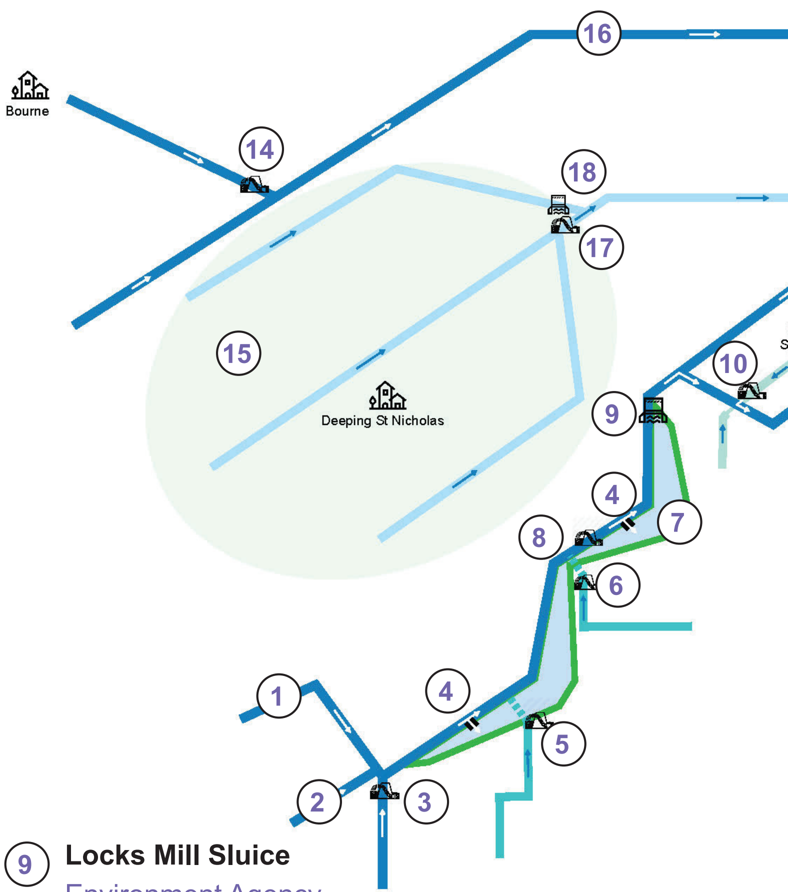
4 **Cradge Bank Syphons**
Environment Agency
Newborough Syphon (upstream) and Four Mile Bar Syphon (downstream) were designed as the main inlets for water from the River Welland into the Crowland and Cowbit Washes.

5 **Newborough Pumping Station**
North Level IDB
Drains land to the south by pumping water 140m across the Washes through discharge pipelines into the River Welland.

6 **Postland Pumping Station**
North Level IDB
Drains Crowland and land to the south by pumping water 90m across the Washes through discharge pipelines into the River Welland.

7 **Crowland and Cowbit Washes**
Environment Agency and partners
Registered under the Reservoirs Act 1975, the Washes function as a flood storage area, with the Environment Agency acting as caretaker. If flows in the River Welland are exceptionally high, water can overtop the Cradge Bank and spill into the Washes, which are contained on the outer edge by the Barrier Bank.

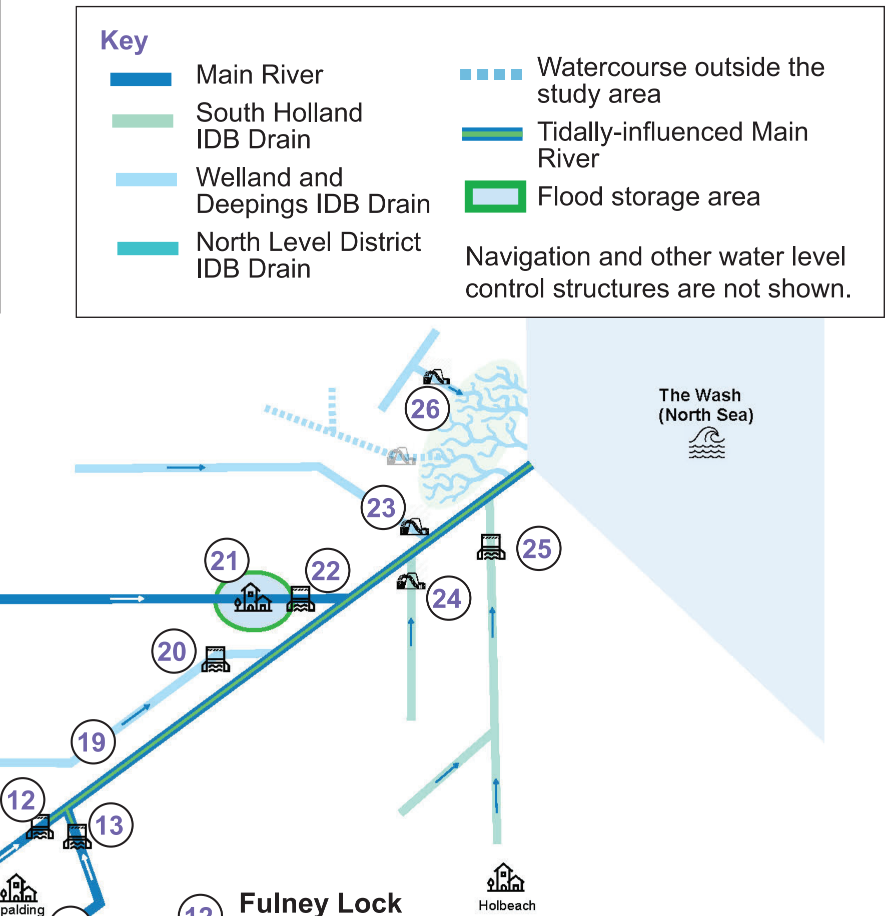
8 **Crowland and Cowbit Pumping Station**
Welland and Deepings IDB
Lifts water from drainage channels in the Washes back into the River Welland.



9 **Locks Mill Sluice**
Environment Agency
If the Washes are filled with water, this sluice allows water to flow back into the River Welland once river levels have lowered.

10 **Clay Lake Pumping Station**
South Holland IDB
Pumps water from Spalding and an area to the south into the Coronation Channel.

11 **Coronation Channel**
Main River
This bypass channel conveys the majority of the River Welland's flow around the southern edge of Spalding.



(12) Fulney Lock

Environment Agency

Sets the tidal limit of the River Welland. It also allows navigation but is rarely used for this purpose.

(13) Marsh Road Sluice

Environment Agency

Sets the tidal limit of the River Welland.

(14) Bourne Eau Pumping Station

Environment Agency

Lifts water coming from Bourne via the Bourne Eau upwards into the River Glen.

(15) Deeping Fen drainage system

Welland and Deepings IDB

The particularly low-lying area in the south-west of the catchment is drained by North Drove, South Drove and Counter Drain IDB.

(16) River Glen

Main River

Between its confluence with the Bourne Eau and the village of Surfleet, it marks the northern boundary of the Lower Welland catchment.

(17) Pode Hole Pumping Stations

Welland and Deepings IDB

Deeping St Nicholas Pumping Station and Adventurers Pumping Station lift water from the North Drove Drain and South Drove Drain into Vernatt's Drain.

(18) Pode Hole Pointing Doors

Welland and Deepings IDB

Prevent water which has been pumped through Pode Hole Pumping Station from flowing back up the Counter Drain towards Market Deeping.

(19) Vernatt's Drain

Welland and Deepings IDB

Carries water from Deeping Fen towards its outfall at Surfleet Sluice.

(20) Vernatt's Sluice

Welland and Deepings IDB

Marks the tidal limit of the Vernatt's Drain, and allows water to flow out of the drain into the River Welland at low tide.

(21) Surfleet Reservoir

Environment Agency

The reservoir was originally constructed to store water to flush silt accumulating at Surfleet Sluice. The embankments prevent flooding of surrounding fenland. The reservoir is unusual in that there are now residential properties situated within the storage area.

(22) Surfleet Sluice

Environment Agency

Marks the tidal limit of the River Glen and allows navigation.

(23) Risegate Eau

Welland and Deepings IDB

Carries water from Gosberton to the River Welland. It is pumped into the Main River by Risegate Eau Pumping Station.

(24) Lord's Drain Pumping Station

South Holland IDB

Pumps water from Lord's Drain into the River Welland.

(25) Holbeach River Sluice

South Holland IDB

Sets the tidal limit of the Holbeach River and controls the discharge of water into the River Welland.

(26) Kirton and Frampton Marsh Pumping Station

Welland and Deepings IDB

Pumps water from the isolated section of the catchment into the coastal saltmarsh, where it can drain into The Wash.

History of the catchment

Significant modifications to the catchment took place in the 1600s, with the construction of the Crowland and Cowbit Washes, and the cutting of Vernatt's Drain.

One of the earliest efforts to manage water in the Lower Welland catchment was the Roman construction of earth banks between Long Sutton and the early settlement at Spalding.

In the 1600s, there was a burst of drainage activity as a group of entrepreneurs known as 'The Adventurers' sought to make improvements to river navigation. The River Welland was widened and deepened by 12.2m and 1.8m respectively, from Deeping St James to the outfall at Fosdyke.

The Adventurers also reclaimed approximately 100km^2 (10,000ha) of land on The Wash coast, now part of the South Holland IDB district. In order to effectively drain the southern half of the catchment, known as Deeping Fen, a drain was cut in 1642 to allow water from the fen to flow into the River Welland downstream of Spalding. The drain was called the Vernatt's Drain, named after one of the Adventurers, Sir Philibert Vernatti. In 1664, the Crowland and Cowbit Washes were constructed as a temporary flood storage area for the protection of Spalding, a function which they still fulfil today.

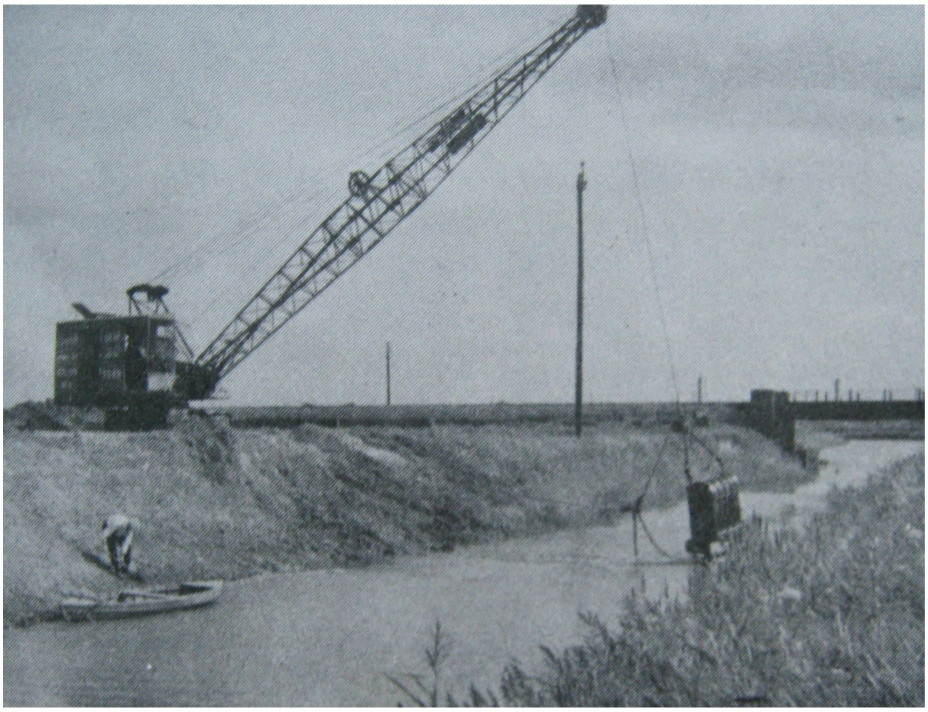
By 1763 the land to the south of Spalding in Deeping Fen was drained by 50 windmills, lifting water into 160km of drains. Spalding was by then a flourishing port, trading coal and agricultural produce which grew on the rich fenland soil. In 1793 a significant achievement was made with the construction of the 24km long South Holland Embankment, running parallel to the coast from the west of Holbeach to the River Nene.

The mid 1900s was another key period of drainage activity. During World War 2, almost all of Deeping Fen was used for agricultural purposes, and drainage had to keep pace with the extra demand. In 1947 major flooding occurred when the southern barrier bank of the Crowland and Cowbit Washes was breached following heavy rainfall. If the breach had occurred in the west bank of the River Welland, the result would have been disastrous to Deeping Fen and Spalding.

The 1947 flood prompted the River Welland Major Improvement Scheme, which overhauled the drainage system over the next ten years. This included the widening of 20km of the River Welland between Peakirk and Spalding; the construction of the Coronation Channel and Marsh Road Sluice to protect the town of Spalding; the construction of Maxey Cut and Greatford Cut; and the installation of powerful new diesel pumps at Pode Hole in 1956 to draw more water from Deeping Fen into the Vernatt's Drain.

Growing concerns about flooding and the environment led to the founding of the Welland Rivers Trust in 2009 (now East Mercia Rivers Trust), which in 2011 joined with other groups to form the Welland Valley Partnership. This partnership guides a unified strategy for future management and improvement of the catchment.

Intense storms in recent years have caused a series of significant flood events, in 2018, 2020, 2021 and most recently in 2024 when heavy rainfall led to the breaches at Crowland and Cowbit Washes.



Improvement works on the Vernatt's Drain in 1942
© Heritage South Holland

Crowland and Cowbit Washes
© Historic England

History timeline

Pre-1800s

Circa 1043
The ‘Roman Bank’ was constructed to protect the Fens from tidal inundation, with drainage outlets to facilitate drainage through the bank.

1086
The Domesday Book outlined a cultivated area between Long Sutton and Spalding, protected by the Roman Bank and local parish embankments. At this point, Surfleet was approximately 3km from the coast, and had a flourishing salt making industry.

1632-1634
The River Welland was widened by 12m and deepened by 1.8m, from Deeping St James to its outfall at Fosdyke, cut by hand by 600 men. The Counter Drain was also cut to ease the River Glen.

1642
Vernatt’s Drain was cut from Pode Hole to the River Welland.

1664
Crowland and Cowbit Washes were created to store surplus water from the Welland during high flow periods.

1738
The Deeping Fen Act initiated a programme of repairs to the Deeping Bank which ran for 19km along the south-eastern edge of the Fen, protecting it against flooding from the River Welland.

1739
Surfleet Reservoir and Sluice were built, to enable a rush of water to be released and scour the channel downstream. The pointing doors created a tidal limit.

1741
Two large scoop wheels, powered by windmills, were erected to lift water off Deeping Fen into Vernatt’s Drain.

1767
Much of Deeping Fen was flooded for two years.

1774
The Vernatt’s Drain was extended and the original Vernatt’s Sluice constructed.

1793
South Holland Embankment was constructed, extending west of Holbeach to the River Nene.

1800s

1827
Two steam-powered pumps were installed at Pode Hole to accelerate the drainage of Deeping Fen.

1842
The Vernatt’s Sluice was destroyed when water forced its way through the foundations. It was replaced 15 years later, with a lower sill level to encourage the flow of water.

1847
An Act of Parliament stipulated that the Cradge Bank (which separates the River Welland from the Crowland and Cowbit Washes) should be maintained to a minimum level of 4.42m AOD.

1867
The Welland Outfall Trustees were established to maintain the navigability of the river.

1879
Surfleet Sluice was rebuilt.

1882
The River Glen banks were breached by high flows, flooding Deeping Fen.


© Deeping Fen, Spalding and Pinchbeck IDB 1965


© Wikimedia Commons

1900s

1930

The Land Drainage Act established catchment boards across England, including the Welland Catchment Board. This was incorporated into the Welland and Deepings Internal Drainage Board in 1973.

1947

Heavy rain caused a breach of the Crowland and Cowbit Washes Barrier Bank, leading to severe and sudden flooding. The south bank of the River Glen was also breached, flooding Deeping Fen to a depth of 1.5m. The River Welland Major Improvement Scheme was initiated by the catchment board as a result.

1947-1957

The Coronation Channel was constructed to divert water around Spalding, and Marsh Road Sluice was constructed to move the tidal limit of the Welland downstream of the town.

1973

The Welland and Deepings Internal Drainage Board was formed by the amalgamation of four smaller Boards.

1975

The Crowland and Cowbit Washes were classed as a reservoir under the Reservoirs Act.

1989

The Water Act of 1989 privatised the water industry.

1994

In February 1994, high water levels at Surfleet Reservoir affected several properties.

1998

Overtopping of the River Welland occurred between Crowland and Cowbit.

2000s

2009

The Welland Rivers Trust was founded due to environmental concerns.

2011

The Welland Valley Partnership (WVP) was formed from the Welland Rivers Trust and other organisations to identify pressures on the entire catchment.

2013

The WVP published the Welland Valley Improvement Plan.

2021

In January 2021, many of the properties within Surfleet Reservoir were flooded due to a combination of high river levels and tide-locking of the Surfleet Sluice.

2022

The WVP published the Five Year Catchment Plan to set priorities for the catchment until 2027. The top priorities include improving biodiversity and water quality, and supporting landowners with new agri-environmental policies.

The Lincolnshire and Welland Rivers Trusts combined to form the East Mercia Rivers Trust.

2024

Storm Henk caused severe flooding across the catchment, as rain fell on already-saturated ground. The River Welland breached its banks near Crowland and Cowbit and properties in Surfleet were flooded.

Managing flood risk

Across the Lower Welland catchment, flood risk is managed by multiple organisations.

Roles and responsibilities

The Environment Agency have permissive powers to carry out flood and coastal risk management activities and regulate activities on Main Rivers.

The Welland and Deepings, North Level District, and South Holland IDBs are responsible for managing the complex network of drainage channels and pumping stations which drain the land within their districts. They also regulate water levels on ordinary watercourses (non-Main Rivers).

Riparian Landowners have the main legal responsibility for maintaining all watercourses.

Lincolnshire County Council (LCC) acts as both the Lead Local Flood Authority (LLFA) and the local Highway Authority. The Highways department is responsible for maintaining highway drainage assets, while the LLFA has overall responsibility for local flood risk matters. Lincolnshire was one of the first areas in England to publish and implement a Local Flood Risk Management Strategy, and was forward-looking in the way all the relevant risk management authorities were involved.

South Holland District Council, Boston Borough Council, South Kesteven District Council and Peterborough City Council have a responsibility to promote sustainable development in their role as the Local Planning Authority. They have responsibilities under the Land Drainage Act (1991) to undertake flood risk management works on ordinary watercourses outside IDB areas.

Anglian Water is the main water company within the Lower Welland catchment and have a role in managing the risk of flooding posed by public drainage infrastructure.

Legislation

The roles and responsibilities of these RMAs are set out in the Flood and Water Management Act (2010). This national legislation developed in response to the widespread flooding experienced across England in 2007. The Act re-established the roles and responsibilities of the risk management authorities related to flood risk. This Act is supported by local policies and plans that outline the management of local issues.

Local groups and partnerships

Under the FMWA (2010), Regional Flood and Coastal Committees (RFCCs) were established by the Environment Agency. RFCCs guide flood and coastal erosion risk management within their river catchments and coastlines. The Lower Welland catchment is within the Anglian (Northern) RFCC boundary.

The Welland Valley Partnership (established 2011) brings together government agencies, local authorities, private businesses and charities to identify and collaboratively address challenges facing the River Welland catchment.

Future Fens Integrated Adaptation (FFIA) is a strategic partnership initiative, with the aim of working together across sectors to determine the actions that partners involved in managing water across the landscape can jointly take to secure a vibrant future for the Fens.

National strategies

In 2020, the Environment Agency published the latest National Flood and Coastal Erosion Risk Management Strategy. It contains ‘Measure 1.5.4’, which requires development of a long-term plan for managing future flood risk in the Fens.

Local policies, strategies and plans

The key local policies, strategies and plans that directly influence how flood risk management is undertaken within the Lower Welland catchment are outlined below:

Welland Valley Partnership: Five Year Catchment Plan 2022-2027

This plan outlines the vision for the catchment over the next five years. A key focus will be on developing sustainable and collaborative management practices among all stakeholders whose activities impact the catchment, ensuring that flood risk is effectively mitigated.

Anglian River Basin District Flood Risk Management Plan 2021-2027

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

Joint Lincolnshire Flood Risk and Drainage Management Strategy 2019-2050

This provides a framework for flood risk management across Lincolnshire, linking all the RMAs.

Joint Lincolnshire Strategic Flood Risk Assessment (2017)

This outlines how development should consider flood risk at every stage of the development process including assessment and mitigation measures, based on Flood Zones and vulnerability to flood risk.

Gibraltar Point to Hunstanton Shoreline Management Plan 4 (2010)

This plan outlines a strategic approach to managing flood and coastal erosion risks through to 2105. The Policy Development Zone (PDZ) of particular relevance to the Lower Welland catchment is Gibraltar Point to Wolferton 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.

River Welland: Catchment Flood Management Plan (2009)

The CFMP aims to develop long-term policies for sustainable flood risk management. These policies guide the Environment Agency and its partners in planning and determining the most effective strategies for managing future flood risks. Policy 4 of the management plan defines the Lower Welland catchment as an area where flood risk is already being managed but where climate change is expected to lead to significant increases in flood risk.

The role of critical infrastructure

Only the continuous operation of flood risk assets can protect the low-lying areas of the catchment from severe and long-term flooding.

Before human intervention, much of the Lower Welland catchment was a waterlogged landscape, covered by freshwater and intertidal marsh. Over centuries, huge effort and investment has enabled the transformation of the area into a habitable and productive landscape. If flood risk assets were abandoned, and constant management of water levels were to cease, then the landscape would soon be inundated, becoming an uninhabitable inland salt lake.

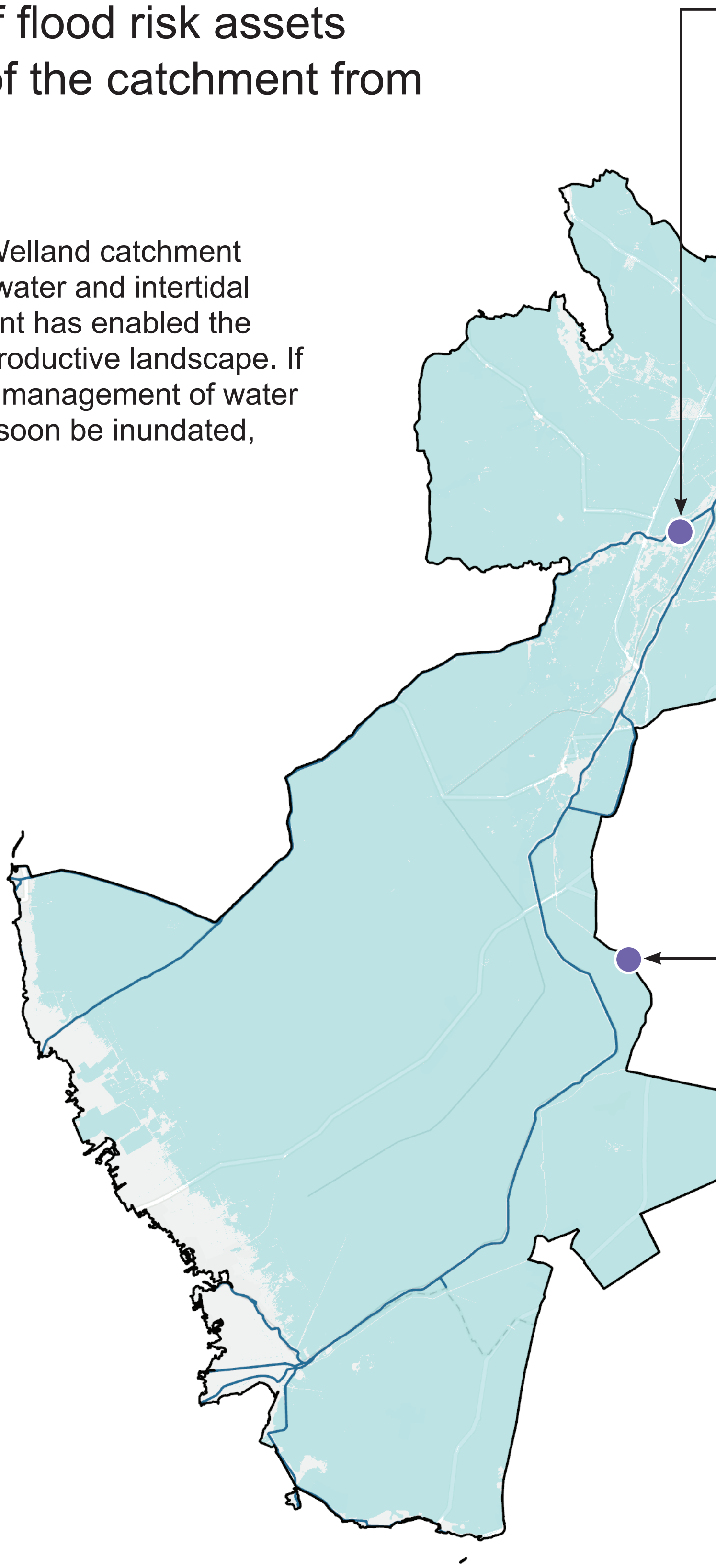
To demonstrate the existential risk of flooding to the catchment in the absence of defences, the map of tidal inundation from the Mean High Water Spring (MHWS) tide shows the tidal inundation that would occur on a regular basis in the absence of tidal flood defences. In this scenario, the tide would inundate the land to a level of 3.9m AOD. Whilst some areas of the catchment would drain as the tide recedes, the frequency of tidal inundation would mean the land was essentially uninhabitable.

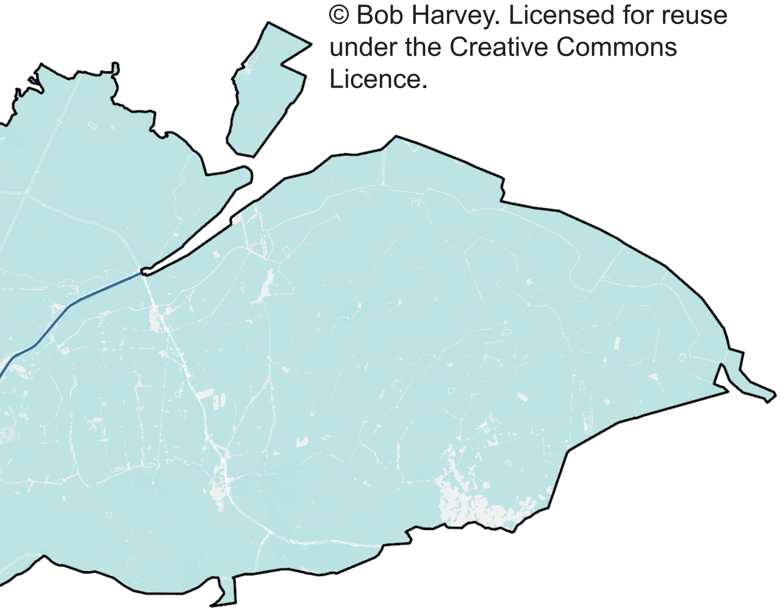
A low-lying catchment

The catchment topography is low lying and flat, with the higher ground bordering the catchment to the south-west, and silt deposits at the coast sitting higher than the peaty soils of Deeping Fen further inland.

The lowest point of the Lower Welland catchment would be flooded to a depth of 4.1m in the MHWS tidal event. Ground within the catchment is slowly lowering, largely as a result of the shrinkage of peat soils through drainage.

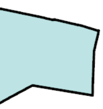
The topography makes it difficult for water to drain naturally from these lower-lying areas. Whenever flooding occurs, the lack of gradient allows floodwaters to spread over a large area.





Surfleet Sluice

The Barrrier Bank of Crowland Wash



Key

Main River

Areas below 3.9m AOD (MHWS)

Reliance on flood risk assets

Protection of land from tidal inundation relies on the presence of defences along the coastline and the tidal reaches of the River Welland. The effective drainage of floodwater from the catchment is reliant on the operation of pumping stations to lift water from IDB watercourses into Main Rivers or The Wash.

Embankments are critical for containing flow within Main Rivers and the Crowland and Cowbit Washes. Without effective containment, the Main River system could contribute additional water to the IDB networks, and place greater pressure on pumping station capacity. Sluices and other water management assets are monitored and adjusted all year round to maintain water levels in both the IDB and Main River systems. Without these assets, water levels would rise rapidly and exceed watercourse capacity, leading to widespread flooding.

If any of these assets were not present, or if existing defences were allowed to deteriorate through age or lack of maintenance, extreme events would severely compromise drainage and would result in the inundation scenario depicted on the map, leading to uninhabitable conditions over a short timeframe.

Extreme events

Even with current flood risk assets in place, tidal and fluvial flooding poses a significant risk to the catchment, as evidenced by flood events in 1994, 1998, 2018, 2020, 2021 and 2024. A number of events have arisen from fluvial flooding of the River Welland in the vicinity of the Crowland and Cowbit Washes, and also from the River Glen when levels have risen in Surfleet Reservoir and flooded properties.

Current flood risk

The impact of permanent inundation is mitigated by the operation of flood risk management assets.

Hydraulic modelling is used to understand the risk of flooding in an area. The hydraulic models used to assess flood risk are the 2010 Northern Area Tidal Model representing tidal events. The 2016 Bourne Eau model and 2016 Welland-Glen model depict fluvial events on the Main Rivers but not on the IDB system. These models include existing flood defences and assume that all assets are fully functional and maintained at their current Standard of Service. The flood map opposite is used to highlight areas of residual risk where flood events would exceed the protection offered by the defences. This might include the risk of overtopping. The models used herein do not include breaching (failure) of the embankments.

Tidal

Model results show that with existing defences, current tidal flood risk for a 0.5% AEP event would impact approximately 7.5km^2 (747ha) of the total catchment area. Waves overtopping the defences would lead to flooding of 7.4km^2 (740ha) of Grade 1 and 2 agricultural land at the coast, to a predicted maximum depth of 2m AOD. Properties in Fosdyke are predicted to be at risk of flooding in this scenario, with the potential maximum flood depth reaching around 1m in the village.

Fluvial

Flood risk maps from the 2016 Bourne Eau model and the 2016 Welland-Glen model show that with existing river defences, river flows during a 1% AEP event would be largely contained within the Crowland and Cowbit Washes flood storage areas which are intended for this purpose.

Even in an extreme 0.1% AEP event, flood waters would be largely contained within the outer embankments of the Washes.

Outside the Washes, flooding of agricultural land is expected in the area between Deeping St James and Peakirk beyond the 1.3% AEP event, but a more extreme 0.5% AEP event is required for properties in this area to be put at risk.

There is also evidence of repeated use of Surfleet Reservoir for flood storage, which continues today.

Other sources

Other sources of flood risk not included in the hydraulic models include;

Surface water flooding. This describes when the volume and intensity of rainfall overwhelms local drainage systems. The risk of this is likely to increase across the catchment if settlements continue to expand.

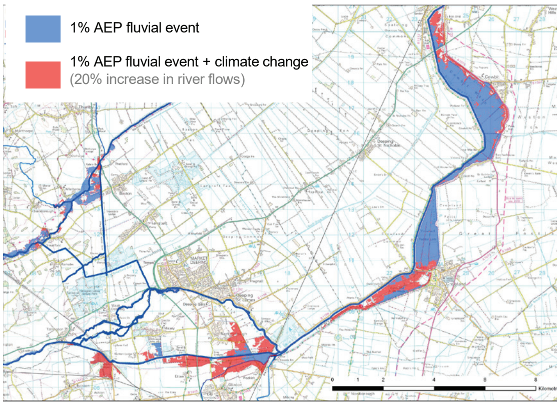
Groundwater flooding. This occurs when the water table rises to meet the ground surface. This is not identified as a high-risk flood source in the Strategic Flood Risk Assessments for the four Local Authority Districts which intersect with the catchment, with no recorded instances of groundwater flooding in the catchment.

Reservoir flooding. This is rare and happens when a reservoir’s impounding structure fails. Although the Crowland and Cowbit Washes breached in 1947, the current likelihood of a reservoir breach is very low due to the provisions of the Reservoirs Act (1975).

7.5km²

(747ha) of the catchment is at risk of flooding under a present-day 0.5% AEP tidal event including existing flood defences. This includes 2.1km² (210ha) of Grade 1 agricultural land.

Area calculated based on the model flooded area in comparison to the area represented within catchment boundary.



Fluvial

An excerpt of the 2016 Welland-Glen model is shown above (as model results were not available to include within the tidal flood map). This includes current and future flood risk. The majority of the Crowland and Cowbit Washes are at risk of flooding during a 1% AEP event, along with a small area south-west of the Washes near Peakirk. With a 20% increase in river flows under climate change, flood risk is still largely contained within the Washes, but the area at risk of flooding further south between Deeping St James and Peakirk increases in size.

Case study: Embankment breach

The modelling results presented do not fully reflect the flood risk facing the catchment. In particular, they do not account for embankment breaches, which can occur suddenly and are difficult to predict. Such breaches can release vast volumes of water in a short time and repairing them is often time consuming and costly. Significant breaches occurred in the Lower Welland catchment in January 1947. Following heavy rainfall and rapid snowmelt, the River Glen was the first to breach. Waters from the River Welland were largely contained in the Crowland and Cowbit Washes until a catastrophic breach 45m wide formed in the North Level Barrier Bank. Severe and sudden flooding followed in land to the south and east, and Crowland was almost entirely cut off by floodwaters.

AEP = Annual Exceedance Probability.
The probability of a certain sized flood event being equalled or exceeded in a given year.

Future flood risk

Tidal and fluvial flood risk is expected to increase over the next 100 years, even if defences are maintained to the current level of protection.

Future tidal and fluvial flood risk will rise due to the increasing height and frequency of tidal surges and river flows driven by climate change. These changes pose a growing threat to agricultural land and residential properties, with more frequent and severe overtopping events and failure of defences becoming more likely.

Tidal

Tidal flood risk will increase significantly over the next 100 years as sea levels rise in response to climate change. Modelling assumes that sea levels will rise by 1.1m up to 2115. Under this scenario, even with existing flood defences in place approximately 52.7km^2 (5,265ha) of the catchment would be at risk of inundation, a six-fold increase compared to the current flood risk. This includes 41.7km^2 (4,170ha) of Grade 1 agricultural land and 10.7km^2 (1,070ha) of Grade 2 agricultural land, which can be damaged by extended periods of saltwater inundation. Several villages would be at risk of flooding, including Gedney Drove End, Fosdyke, and the business park outside Holbeach St Marks.

Since the modelling was undertaken in 2010, sea level rise estimates have been revised upwards, and under the UK government's upper end allowance, sea level would rise by between 1.2m and 1.6m by 2125. This means that flood risk could be even greater than the model predicts in the future.

Higher sea levels will increase the risk of tide-locking at key outfalls such as Surfleet Sluice and Marsh Road Sluice. Tide-lock means that water cannot be discharged from the river system during periods of high tide, causing it to back-up in the catchment. The impacts of this would be particularly acute at Surfleet, which is already at risk of flooding during periods of tide-lock.

Fluvial

Modelling predicts an increase in fluvial flooding when a climate change allowance of 20% is applied to the 1% AEP event, even with current flood defences still in place. Under this climate change scenario, flooding around Crowland remains largely contained within the Crowland and Cowbit Washes flood storage area. Upstream in the region of Deeping St James, flooding increases – with a larger area of agricultural land at risk, as well as a small number of additional properties in Peakirk. Since this modelling, climate change allowances have been revised upwards to a 53% uplift to the 2080s, meaning the flood risk could be even greater than the model predicts in the future.

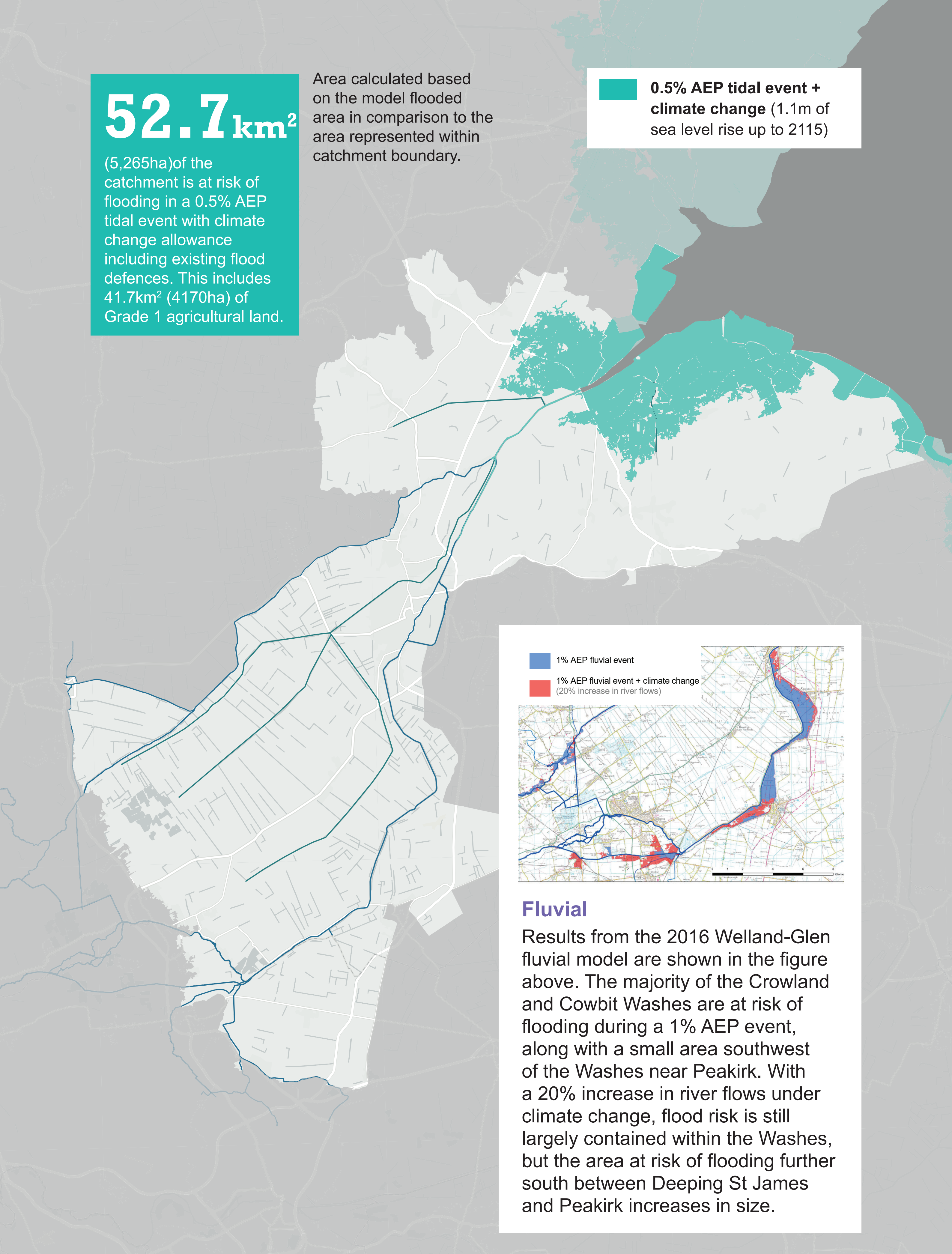
Climate change

Assessment of climate change scenarios are based on government guidance and best available data at the time of writing, or model production. This guidance is revised as climate change projections are revised. Irrespective of the predicted magnitude of change, climate change will increase the frequency and severity of flood events over time. Longer term climate change scenarios have been considered within a Fens Climate Change Risk Assessment undertaken by FFIA.

52.7km²

(5,265ha)of the catchment is at risk of flooding in a 0.5% AEP tidal event with climate change allowance including existing flood defences. This includes 41.7km² (4170ha) of Grade 1 agricultural land.

Area calculated based on the model flooded area in comparison to the area represented within catchment boundary.



Fluvial

Results from the 2016 Welland-Glen fluvial model are shown in the figure above. The majority of the Crowland and Cowbit Washes are at risk of flooding during a 1% AEP event, along with a small area southwest of the Washes near Peakirk. With a 20% increase in river flows under climate change, flood risk is still largely contained within the Washes, but the area at risk of flooding further south between Deeping St James and Peakirk increases in size.

Flood risk management assets

Site visits and workshops were undertaken with asset owners and operators, alongside data analysis, to understand key asset challenges.

Key catchment challenges

Assets are ageing

A large group of assets (60%) have a foreseeable design life of 16-30 years, and a further 31% have zero years foreseeable design life. This means a significant burst of investment may be required in the short term, and again in the medium term.

Pumping station challenges

IDB pumping stations in the catchment often work close to or at capacity.

Risk to people and property

Much of the highly populated town of Spalding relies on pumping. In Deeping Fen, communities are vulnerable to flooding if Pode Hole Pumping Station is unable to move enough water. At Surfleet Reservoir 40 properties are located within the flood embankments.

System dependencies

Tide-locking at Holbeach River Sluice and the Environment Agency's Surfleet Sluice is becoming more frequent.

Investment needs

There are several planned refurbishments of pumping stations in the catchment. However these works will not significantly increase system capacity, which is increasingly becoming an issue in the catchment, exacerbated by climate change.

Embankment vulnerability

There are over 16km of embankment assets in the catchment. Their condition profile in the Environment Agency's Asset Information and Maintenance dataset (AIMS) is relatively good. However, anecdotal evidence indicates they have a high number of defects and require the majority of maintenance expenditure.

Channel risk

The Vernatt's Drain and the drains upstream of Bourne South Fen Pumping Station often experience excess weed growth in summer which is difficult and expensive to manage. Siltation is a known issue at Marsh Road Sluice, further reducing flow capacity.

Data availability and quality

Data analysis is based on an export of the Environment Agency's Asset Information and Maintenance dataset (AIMS) from October 2024. This includes other RMA assets, but not all. The Environment Agency has advised that some data within AIMS may be outdated, potentially underestimating the number of assets currently under stress.

Additional data and insights have been collated through site visits and workshops with IDBs.

Asset ownership

Within AIMS, the Environment Agency own 46% of assets, 27% reported to be of 'Unknown' ownership and the remainder is owned by other RMAs.

Asset age profile

A large proportion of the assets in the catchment were installed between 1950 and 1999. The majority of these are embankments. Around 31% of assets within the catchment are recorded as having zero years of foreseeable design life.

A further 60% of assets have a foreseeable design life of 16-30 years, which may present an investment challenge in the future as they reach the end of their foreseeable design life at a similar time.

Asset condition profile

Approximately 28% of assets have a current condition score of 'Poor', 'Very Poor' or 'Unknown' in the Environment Agency's AIMS. Despite their age, 81% of the 536 embankment assets recorded in AIMS are in 'Fair' or 'Good' condition. Assets including natural high ground, control gates and outfalls have a relatively high proportion 'Below Required Condition'. The key assets within this catchment have been noted to be in an acceptable condition, with investment in refurbishment of pumping stations and water level control structures in recent years.

Mouth Lane Pumping Station © Jonathan Billinger. Licensed for reuse under the Creative Commons Licence.

Foul Anchor Sluice © J.Hannan-Briggs. Licensed for reuse under the Creative Commons Licence.

Tydd Pumping Station © Arup 2024.

Cowbit Wash, with the Barrier Bank visible on the right © Hugh Venables. Licensed for reuse under the Creative Commons Licence.

Pumping Stations at Pode Hole © Bob Harvey. Licensed for reuse under the Creative Commons Licence.

Surfleet Sluice © Bob Harvey. Licensed for reuse under the Creative Commons Licence.

Operating challenges

Bourne South Fen Pumping Station has problems with excessive weed growth which can restrict pumping. It has a gravity outfall, but this cannot be used when levels in the River Glen are elevated, hence pumping is required.

Crowland and Cowbit Washes are limited in terms of the rate at which water can be removed from them through Locks Mill Sluice. The sluice operates through gravity discharge, and mobile pumps are sometimes required. The siphons which act to fill the reservoirs do not currently operate as designed, meaning the Washes operate infrequently.

Pode Hole Pumping Station works at maximum capacity during periods of high flow. This is typically around 21 days per year.

Vernatt's Drain has ongoing issues with weed growth, which can force water back up the Counter Drain.

At Fulney Lock some leakage of water has been noted. Additionally, the tidal surge in 2013 nearly reached the top of the structure, highlighting its vulnerability to extreme events.

Surfleet Sluice marks the tidal limit of the River Glen and allows navigation. It is increasingly prone to tide-locking. Surfleet Reservoir was originally built to store water during periods of tide-lock, but properties have since been built in the reservoir and are at risk of flooding.

At Holbeach River Sluice, rising sea levels will exacerbate tide-locking issues, and a new pumping station may be required at this site in the future.

There are some known current and future performance risks in this catchment. Assets in the North Level District and Welland and Deepings IDB systems have been close to operating at capacity during recent years. This will be exacerbated by issues such as climate change, weed growth and siltation.

Current asset maintenance

Based on analysis of Environment Agency revenue programme dataset:

Environment Agency maintenance expenditure

£4.9M was spent on embankment maintenance between 2022 and 2024. This makes up 84% of all maintenance expenditure in the catchment, reflecting their volume and criticality.

£540k was spent on open channels between 2022 and 2024, 75% of which is spent on weed control.

IDB maintenance and expenditure

Across the three IDBs, maintenance expenditure on drains is greater than on Water Level Control Structures (WLCS). Drain expenditure is relatively stable, slightly increasing overtime, with WLCS costs increasing more rapidly. South Holland IDB typically spend the same amount on each of their pumping stations, except Lawyers Pumping Station, which costs five times more than the average of the others.

Maintenance expenditure for all three IDBs has been consistent between financial years 2017-2022, £1.07 million for North Level IDB, £1.49 million for South Holland IDB and £1.82 million for the Welland and Deepings IDB.

Across all RMAs, substantial investment in capital and maintenance will be required to ensure all assets are in 'Fair' condition or better, as well as enabling new construction schemes to improve the area's resilience. Funding requirements will increase as climate hazards place greater strain on asset systems.

Bourne South Fen Pumping Station © Rodney Burton. Licensed for reuse under the Creative Commons Licence.

Vernatt's Sluice © Arup 2024.

Holbeach River Sluice © Mat Fascione. Licensed for reuse under the Creative Commons Licence.

Environment

Mapping shows environmental features such as areas of permanent pasture in the south-west of the catchment supporting many species, and the centre of Spalding as a heritage conservation area.

The market town of Spalding is the largest settlement within the catchment.

There are several smaller settlements situated within the catchment including Holbeach, Pinchbeck, Crowland, Surfleet, Deeping St Nicholas, Gosberton and Fosdyke.

There are 12 statutory designated nature conservation sites within the catchment, some overlap entirely or partially with other designations.

The Baston and Thurlby Fens is a designated Site of Special Scientific Interest (SSSI). The washland habitat features flooded borrow pits and marshes, supporting diverse wetland plant communities.

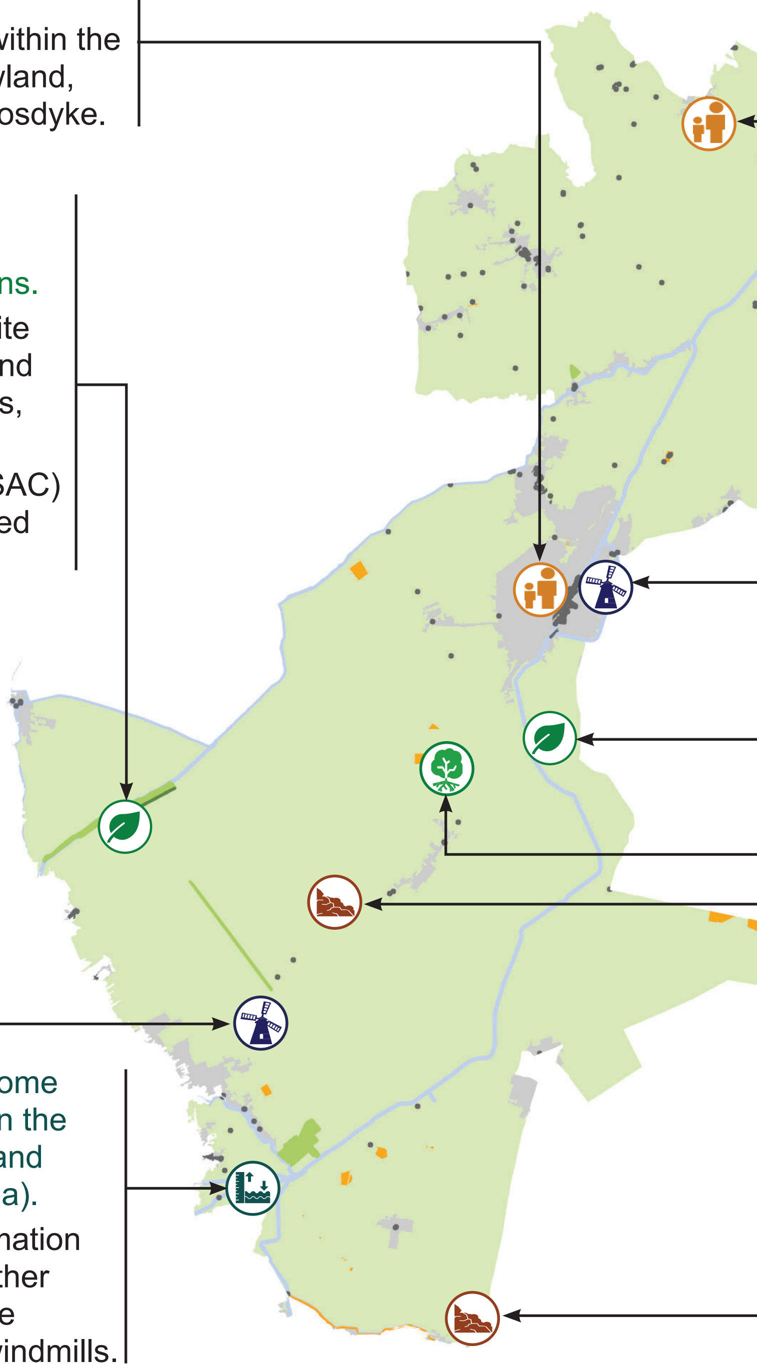
Baston Fen is a Special Area of Conservation (SAC) as an area of permanent pasture, which is flooded in winter and attracts large numbers of wildfowl.

There are 26 Scheduled Monuments within the catchment.

This includes an Iron Age saltern (medieval salt workings) on Hall Meadow and settlement of Iron Age and Roman date. Artefacts including pottery and fired clay, characteristic of the salt extraction process have been found locally. Monuments reflect the agricultural and building practices specific to the Fens.

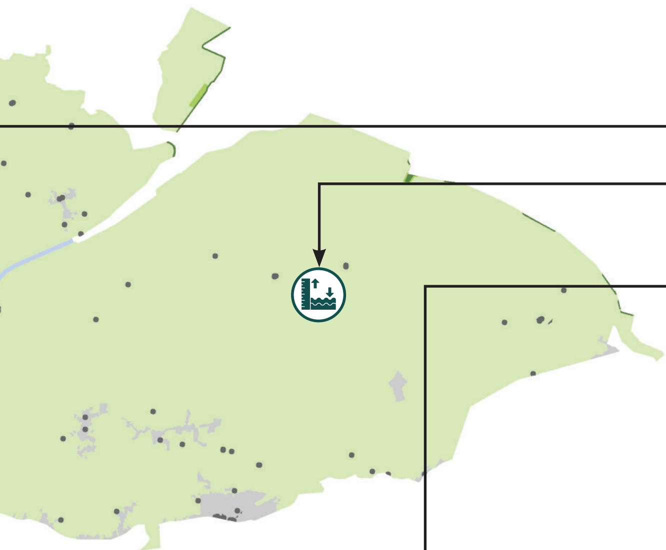
The drainage channels and embankments are some of the most notable historic landscape features in the catchment. The embankments of the Crowland and Cowbit Washes contain an area of 9.5km² (950ha).

These features represent the complete transformation of this landscape in the post-medieval period. Other structures associated with this drained landscape include bridges, sluices, pumping stations and windmills.



Key

- Biodiversity
- Landscape
- Population and Health
- Water Environment
- Heritage
- Ground Conditions
- Listed Buildings
- Scheduled Monuments
- Internationally Designated Sites



Coastal communities within the catchment are amongst the most deprived areas in England.

The Lower-layer Super Output Area (LSOA) of Boston 007A which includes Sutterton and Algakirk is within the top 30% of most deprived neighbourhoods nationally in terms of overall deprivation. This considers domains such as income, employment, education, health, crime, barriers to housing and services, and living environment.

The Vernatt's Drain and the Welland are classified as heavily modified water bodies under the Water Environment Regulations / Water Framework Directive.

Vernatt's Drain is an artificial water body and the Welland has been physically modified for flood protection purposes and is impacted by rural and waste water pollution.

There are nine Conservation Areas within the catchment including a large area of Spalding.

Conservation Areas possess special architectural or historic interest. The town of Spalding has been occupied since the Roman times.

The Cowbit Wash is a SSSI designated for its geological significance.

It provides valuable data on post-glacial sea level changes through the analysis of marine clastic and freshwater peat layers.

The catchment is largely located within The Fens National Character Area (NCA) – these are areas of distinct and recognisable character.

The Fens NCA is notable for its large-scale, flat, open topography with extensive vistas to level horizons. Small areas of the south-western edge of the catchment are located within the Bedfordshire and Cambridgeshire Claylands NCA and the Kesteven Uplands NCA described as gently rolling, mixed farmland. The Historic Landscape Character Areas include The Southern Cliff, The Fens, The Wash and Peterborough.

Roddons (paleochannels), such as those documented in the Peterborough district, are an influential feature within the catchment.

Roddons are former river channels, typically filled with silt, which now sit proud of the land and potentially funnel surface waters. Due to their composition, they may impact structures and assets through differential settlement, compaction and peat wastage.

Peaty soils cover 10.2% of the catchment area.

They are concentrated in the south of the catchment, between Deeping St Nicholas and Bourne.

Agriculture

The Lower Welland catchment contains the most important area for double-cropping in the UK, producing vegetables, salad and ornamental crops.

Soilscape

The majority of the catchment contains loamy and clayey soils of coastal flats with naturally high groundwater which can support a range of cropping. The soil enables crops to be planted at any time of year and is one of the most important areas in the UK for enabling more than one crop to be grown each year.

Agricultural Land Classification (ALC)

Approximately 93% of land in the Lower Welland catchment is classified as Grade 1 and 2. Grade 1 land comprises over half the catchment area and is predominately located to the north of the catchment. This is high-yielding land with little or no limitations for agricultural use.

Water availability

The Welland Catchment Abstraction Licensing Strategy notes restricted water availability across the catchment during higher flows. These are the flows equalled or exceeded at least 50% of the time, with water restricted or not available at other times.

Abstraction is therefore only available over a limited period of the year. To ensure that high value crops can be irrigated, many farms throughout the catchment have their own reservoirs to store water for summer irrigation use.

Value of agriculture in the catchment

Land use within the catchment is primarily agricultural, predominantly arable agriculture and higher value horticulture due to the high quality of farmland throughout the catchment. A small proportion of the agricultural land is used for the grazing of livestock, with several farms producing beef cattle and/or sheep on grazed areas. The catchment also has a range of intensive agricultural operations, including poultry, glasshouse and controlled agriculture enterprises.

The whole agri-food chain employs people at different stages of food production, from agriculture to food processing, packing and retail. The estimated overall economic output of farm crop and livestock within the catchment is in the region of £183.6 million annually (in 2023 values).

	Area (km^2)	Area (ha)	Percentage of farmed land (%)	Estimated annual value* (£)
Cereals	209.6	20960	50.4%	£30.1 million
Arable crops (excluding cereals)	107.8	10780	25.9%	£25.2 million
Grassland	26.9	2690	6.5%	Grassland does not directly create economic value, but instead supports the grazing of sheep and cattle, or the production of livestock feed.
Fruit and vegetables	39.3	3930	9.4%	£75.1 million

Key land use, crop areas and livestock populations on commercial agricultural holdings and estimated annual value (£) for the Lower Welland catchment. Data provided by Collinson & Associates. Based on 2023 land and livestock data available from Defra.

Environmental stewardship

There are a number of active middle-tier stewardship agreements covering over a quarter of the catchment. These agreements are managed under government funded agreements such as the recently introduced Countryside Stewardship scheme (part of Defra Environmental Land Management schemes), or the historic Entry Level Stewardship scheme.

Climate change

Climate change will increase the risks of fluvial and coastal flooding, as well as drought. Flooding and drought events can restrict the ability to establish new crops, reduce crop yields and quality, or destroy crops once ready for harvest leading to direct agricultural damages and wider economic consequences for landowners.

Examples of agricultural stakeholders and businesses

Holiday parks, including fishing lakes, and caravan parks are distributed across the catchment, especially along the A16.

There are several businesses in Sutterton supplying farmers and horticulturalists with farm equipment and allium (onions, shallots etc.) seeds.

A farming business, based in Wykeham, produces cereals, sugar beet, potatoes and vegetables across 65km^2 (6,500ha) of land across south Lincolnshire.

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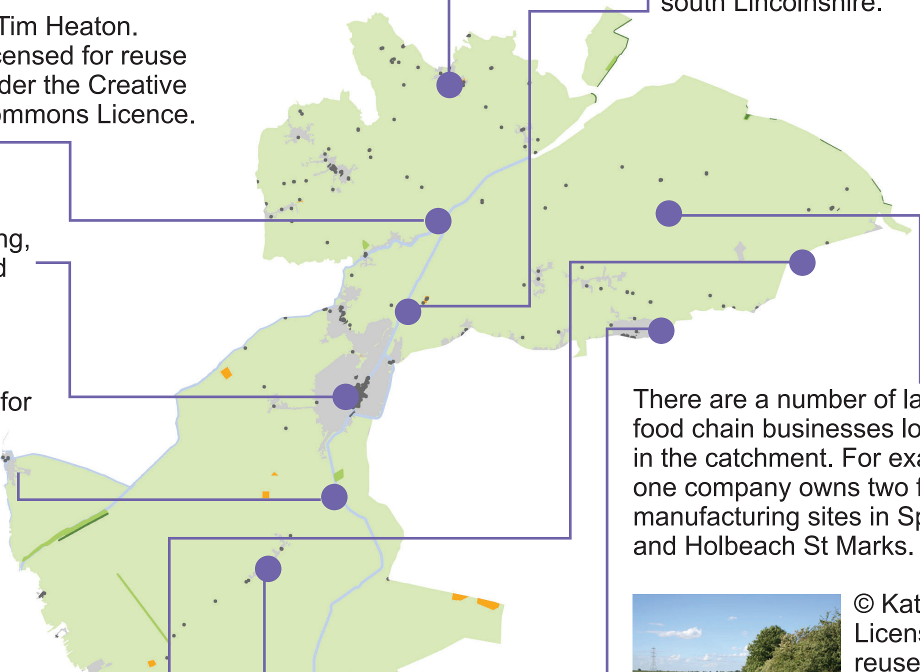

A farming business, headquartered in Spalding, produces leaf salads and onions across 1200ha.

Crowland and Cowbit Washes provide a large volume of flood storage for river flows on Grade 2 and 3 agricultural land.

There are a number of large food chain businesses located in the catchment. For example, one company owns two food manufacturing sites in Spalding and Holbeach St Marks.

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There are several solar parks in operation across the catchment, with developments located at Gedney Marsh, Deeping St Nicholas and Crowland.

Similar to other areas across the Fens, farmers and landowners are diversifying to invest in renewable energy projects. The catchment is home to a number of farm-fed anaerobic digestion plants.

Natural capital

Natural capital refers to elements of the natural environment that provide valuable goods and services to people, underpinning wellbeing and economic prosperity.

The benefits provided by natural capital assets such as freshwater, soils, air, and species of plants and animals are known as 'ecosystem services'.

These ecosystem services are vitally important for human wellbeing, and include provision of raw materials, food production, carbon sequestration, temperature regulation, crop pollination, as well as enabling recreation and cultural activities. Some of the services provided by nature do not directly benefit humans, but support the provision other ecosystem services, for example in the case of water and nutrient cycling, and soil formation.

Together these services provide many benefits to society and the economy including improved physical and mental health through recreation; temperature regulation; flood protection; and provision of clean water.

The monetary value of benefits provided from ecosystem services can be estimated using information about the quantity, quality and location of natural capital assets, as well as societal use. Values may be underestimated due to lack of information, or complexity in assigning a monetary value. Key ecosystem services that are difficult to quantify include biodiversity; pollination and seed dispersal; soil quality; and cultural benefits from education, volunteering, amenity, aesthetics and a sense of place. The financial value of these services is difficult to quantify but they are nevertheless vitally important for underpinning our economy, society and the natural world.

Natural capital in the Lower Welland catchment has an annual value of

£43.9 million

Climate regulation

In some cases, the poor condition of the environment can compromise the benefits that it would otherwise provide. For example, peaty soils in healthy condition can continue to form peat and therefore sequester carbon, but when degraded they start to release carbon back to the atmosphere.

Enclosed farmland, woodland and saltmarsh within the catchment sequesters a total of 6,872 tonnes of CO_2 equivalent per year. However, this is far outweighed by the 82,956 tonnes of CO_2 emitted by the degraded peatland in the catchment, making the land a net source of carbon.

The impact of climate change driven by this process gives a negative value (or cost) for climate regulation.*

Overall, the net release of CO_2 equivalent across the catchment has an annual **cost** of

£20.8 million

*This assessment only takes account of land-based emissions, and therefore excludes emissions from industry, transport or other sources.

£10.4 million
Recreation

The welfare value of approximately 2.7 million visits by adults each year to publicly accessible green spaces within the catchment. The welfare value of a further 690,000 visits made by children each year cannot be quantified but is likely to be significant.

£2.6 million
Physical health

£2.55 million in healthcare treatment costs can be avoided every year due to improved physical health through approximately 1.39 million active visits to publicly accessible green spaces in the catchment. Active visits involve at least 30 minutes of exercise.

£41.2 million
Agriculture

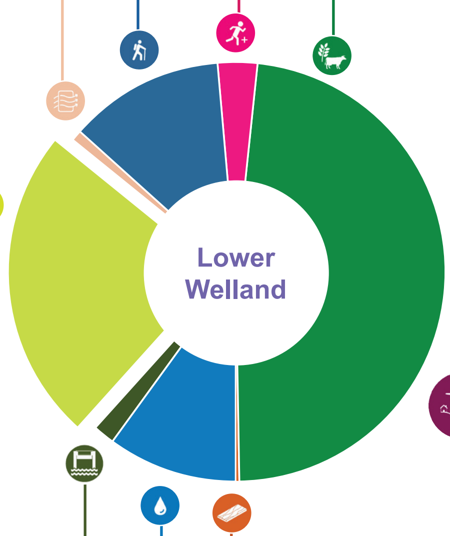
The 437.5km^2 (43,745ha) of enclosed farmland in the catchment provide several ecosystem services, but the service with the largest annual value is food production. Arable and livestock yields from the catchment have a combined annual value of £41.2 million.

£0.6 million
Air Quality

The removal of approximately 2,500 tonnes of air pollutants by vegetation in the catchment avoids the costs of damages to health. This has an annual value of £626,000 per year.

£0.01 million
Water quality

The Kirton Marsh Drain is the only river waterbody within the catchment with 'Good' water quality. Based on a willingness-to-pay approach, the 0.2km of this watercourse within the catchment is worth approximately £10,400, as an alternative to having poorer water quality.



£-20.8 million
Climate regulation

The value of climate change regulation in the catchment is negative because the habitats across the catchment release more carbon than they sequester overall. Each year, approximately 76,080 tonnes of CO_2 equivalent are released overall, costing around £20.8 million per year through the detrimental effects of climate change.

£0.0 million
Hazard regulation

The assessment does not provide a monetary value for this benefit. However, in the catchment an estimated 47,800m^3 of floodwater is temporarily stored in areas of woodland.

£1.5 million
Renewable energy

An estimated 107,500MWh of renewable energy, predominantly from wind and solar, is generated each year within the catchment. This has an annual value of approximately £1.46 million.

£8.4 million
Water supply

The annual value of approximately 3.0 million m^3 of water which is abstracted from the catchment each year, for public water supply and other uses such as irrigation.

£0.04 million
Timber

National data can be applied to the Lower Welland catchment to estimate a yearly timber production volume of 1,250m^3, which is valued at approximately £41,100 per year.

Flood economic damage scenarios

To understand the potential economic impact of flooding over the next 100 years, two scenarios have been explored which describe different approaches to managing flood risk assets. These are the 'Maintain' and 'Do Nothing' scenarios.

Maintain

The 'Maintain' scenario represents the continued maintenance of the existing flood defences. This assumes sufficient investment to maintain the existing flood defences for 100 years. All flood defences would continue to provide the same level of service that they currently offer. There is no allowance for increasing the Standard of Protection offered by existing assets or for climate change adaptation, such as increasing the height and resilience of flood defences or increasing the capacity or performance of pumping stations.

In a 'Maintain' scenario, flooding would occur in events which exceed the height of existing flood defences or the capacity of pumping stations. The resulting damage to properties and infrastructure has been used to determine the scale of economic losses which might be expected over the next 100 years. Due to limitations of the 2016 Welland-Glen model for use in the economic analysis, flood risk in this scenario is represented with the modelling results from the nationally available Risk of Flooding from Multiple Sources (RoFMS) dataset.

£8.9 billion

the economic benefits of current flood risk management activities

Do Nothing

The 'Do Nothing' scenario is a hypothetical scenario, used to understand the benefits of investment in flood defences by considering the consequences of investment being withdrawn. In this scenario, all flood risk management activities would stop, including pumping and maintenance of existing flood defences. Sluices on the Main Rivers would no longer operate, increasing the risk of flooding as river water backs up. Without pumped outfalls to the Main Rivers and The Wash, water would be unable to drain from the land.

For the purpose of the economic scenario, the catchment is assumed to act as a basin, filling with water to the limiting level (the maximum level that the catchment would be able to fill with water).

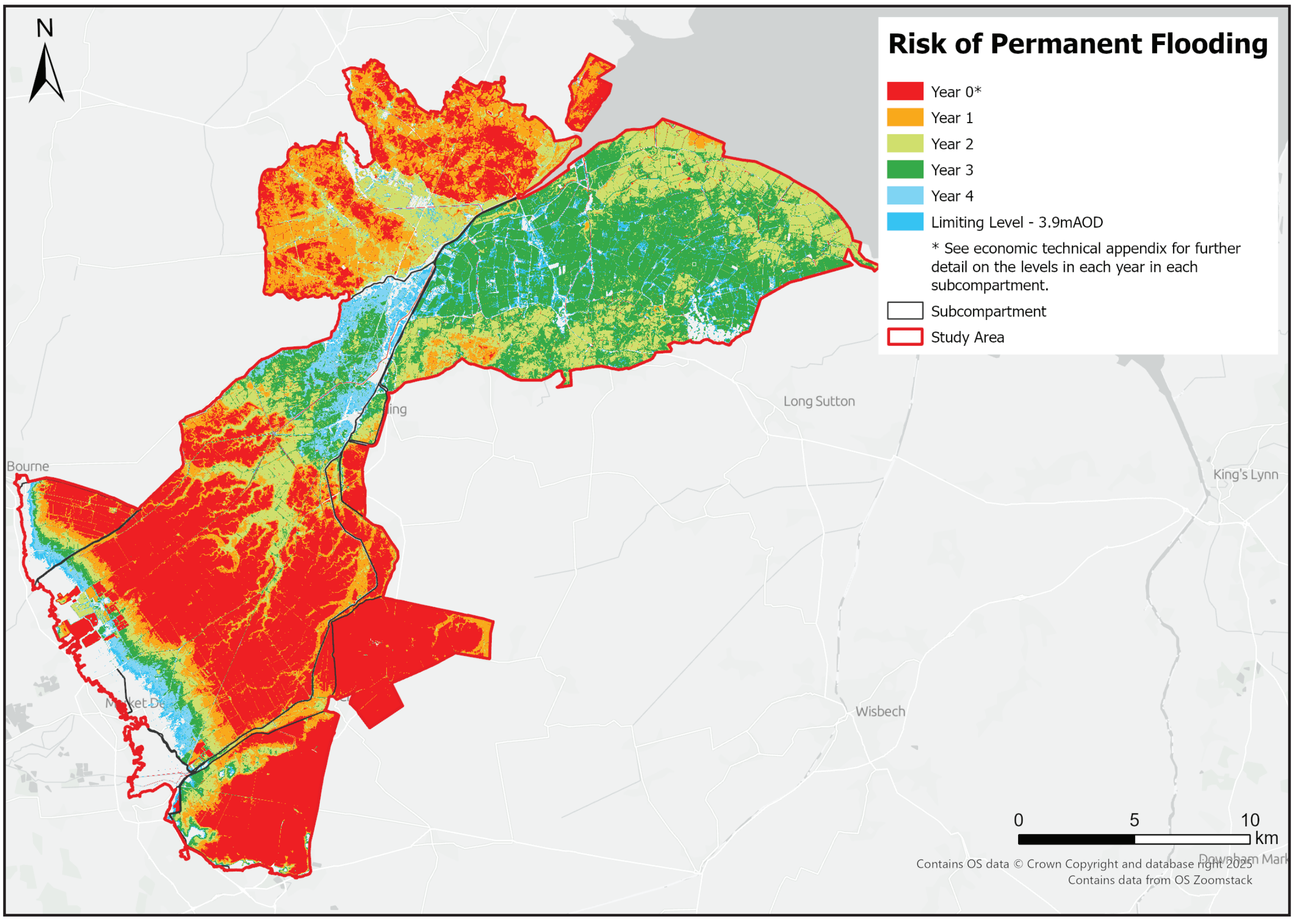
This has been set at 3.9m, based on mean high tide level. Water is assumed to rise towards this limiting level at a rate of 0.5m per year, based on rainfall estimates. Whilst there would be some loss of water over summer due to evaporation and transpiration, the water levels would be expected to rise steadily over a few years filling the catchment.

The resulting damages are used to determine the economic losses over the next 100 years, if all flood risk management activities ceased.

The economic analysis estimates the damages that would be expected to occur in each of the 'Do Nothing' and 'Maintain' scenarios. The economic benefit of maintaining the existing flood defences is the damages avoided in the 'Maintain' scenario, compared to 'Do Nothing'.

The Total Impact framework to the left shows the range of damages considered.

The results of the assessment show that there is a total of £9.3 billion of economic damages in a 'Do Nothing' scenario (excluding losses to the local economy), compared to only £381 million of economic damages in a 'Maintain' scenario. As such, the economic benefits of current flood risk management activities are valued at approximately £8.9 billion.



Risk of permanent flooding over time, in a 'Do Nothing' scenario

Economic damages and benefits of flood protection

If all flood risk management activities ceased ('Do Nothing'), total damages in the catchment over the next 100 years would exceed £9.3 billion, with £9.0 billion of this in the first ten years.

£1.1 billion

Agriculture

Flooding to farmland will lead to immediate and long-term crop losses. Damages capture loss of crops and livestock and associated loss of profits.

404.9km² (40,491ha)
of agricultural land written off in the 'Do Nothing' scenario

£6.4 billion

Properties

Captures the impacts of flooding on residential and non-residential buildings, through damage to building fabric and structure.

24,870 residential properties written off in the 'Do Nothing' scenario, costing **£5.3 billion**	**3,124** non-residential properties written off in the 'Do Nothing' scenario, costing **£1.1 billion**

£118.9 million

Environment and recreation

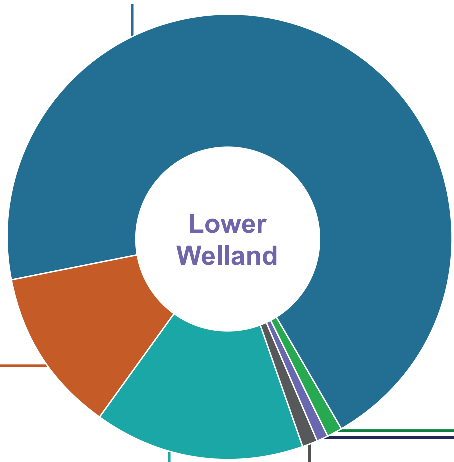
Loss of 1.3km² (129ha) of designated environmental sites across the catchment, will lead to losses of ecosystem services such as carbon sequestration, flood regulation, biodiversity, recreation and non-use values.

Recreational damage would arise through loss of 1.3km² (134ha) of recreational sites and 139km of Public Rights of Way.

£42.5 million

Heritage

The cost of the loss or damage of 136 heritage assets as a result of flooding. The catchment contains 344 Listed Buildings and 28 Scheduled Monuments, concentrated in the southern half of the catchment.



£131 million

Utilities

Captures the impacts of flooding to power, water supply, and gas networks. This includes damage to 878 substations, 4,000 pole towers and 23km of underground gas pipelines.

£6.4 billion

Losses to the local economy

Losses to the local economy have been considered in terms of Gross Value Added (GVA). This considers the cost to the local economy of 29,413 jobs being lost across the catchment under a 'Do Nothing' scenario. GVA is a local / regional benefit so cannot be included in application for Grant in Aid funding.

£1.4 billion

Transport

The cost of the loss of road infrastructure, and railway network as a result of permanent flooding.

Loss of **47.2km** of road infrastructure, costing **£1.2 billion**	Loss of **19.6km** of rail infrastructure, costing **£110.5 million**

£121.8 million

Isolated land

The consideration of isolated land and properties is unique to the 'Do Nothing' scenario which considers permanent inundation of the catchment, rather than infrequent extreme flood events. It accounts for areas of land which may not be directly flooded, but are abandoned because flood waters cut-off the area from the existing road network.

Lower Welland	Do Nothing Damages	Maintain Damages	Maintain Benefits
Damages to properties and associated indirect damages	£6.4 billion	£359 million	£6 billion
Agricultural losses	£1.1 billion	£16.4 million	£1.1 billion
Environment and recreational losses	£118.9 million	£74,000	£118.9 million
Heritage losses	£42.5 million	£132,000	£42.4 million
Transport damages	£1.4 billion	-	£1.4 billion
Utilities damages	£131 million	£5 million	£126 million
Land lost due to isolation	£121.8 million	-	£121.8 million
TOTAL Excluding losses to the local economy	£9.3 billion	£381 million	£8.9 billion
Losses to the local economy	£6.4 billion	£6 million	£6.4 billion

£8.9 billion

total benefits of maintaining current flood defences for the next 100 years

Total investment needed:

£540-£860 million

to sustain the current Standard of Service for 100 years (excluding the impact of climate change).

The investment needed to sustain the existing flood defences has been estimated with no allowance for improvements in protection or adaption to the impacts of climate change. These investment needs have been developed based on three types of assumed costs:

- Ongoing and routine maintenance and operational costs;
- Infrequent asset refurbishment costs; and
- End of life asset replacement costs.

The costs have been developed based on data for various assets across the wider Fens 2100+ study area, collated from the Environment Agency and IDBs.

All damages and benefits are shown for a 100-year period, except for GVA, which is for 10 years.

These have been used to determine the average costs for each type of asset, including for maintenance, operation and asset replacement. Asset refurbishment costs are only included where these have been provided for specific assets. The range of costs reflects the uncertainty in the assumptions made at this stage.

The flood risk, asset condition, economic and total investment analyses given within this baseline report demonstrate the critical importance of a strategic plan for the future of flood risk management within the Lower Welland catchment. Future stages of the Fens 2100+ Partnership will build on this evidence to set out an investment strategy for the region.

Details of the assessment of economic damages and benefits are provided in the technical appendix.

Glossary of terms and acronyms

Agricultural land Grades 1 and 2

Land classified as Grade 1, using the UK's Agricultural Land Classification (ALC), has little or no limitations and will consistently achieve high yields for most crops. Grade 2 has reduced flexibility compared to Grade 1 and yields are generally high but can be more variable compared to Grade 1.

Agri-environmental schemes

Agri-environment schemes provide funding to farmers and land managers to farm in a way that supports biodiversity, enhances the landscape, and improves the quality of water, air and soil.

Annual Exceedance Probability (AEP)

This is the probability of a certain sized flood event occurring in a single year.

Asset Information Management System (AIMS)

A database with information about flood defence assets currently owned, managed and inspected by the Environment Agency.

Benefits

The positive quantifiable and unquantifiable changes that a flood risk management scheme is expected to produce, i.e. damages avoided.

Capital funding

Funding secured for the creation of new assets or the major refurbishment of existing assets to maintain or increase current standards of protection.

Carbon sequestration

The process of capturing and storing greenhouse gases from the atmosphere. In the context of natural systems this is via plant vegetation and soil processes.

Catchment

For the purposes of the Fens programme, the catchment study area has been defined by land at or below the 6m AOD contour, which may differ slightly from the hydrological catchment.

Climate mitigation

Actions taken to limit the effects of climate changes by reducing carbon emissions or enhancing carbon sinks.

Damages

The value of negative social, economic and environmental impacts caused by flooding.

Ecosystem services

Services provided by the natural environment which benefit people. They provide outcomes that provide positive benefits to human wellbeing.

Flood risk management assets

In the context of this report this refers to a structure built and maintained specifically for flood risk management purposes, for example embankments, flood defence walls and pumps.

Main River

A statutory designation of watercourse, usually applied to larger streams and rivers. The Environment Agency have permissive powers to carry out maintenance, improvement and construction works on these watercourses, although usually the main responsibility for these lies with the riparian owner.

Maintenance funding

Funding secured for maintenance activities to existing assets to sustain the existing standard of protection. Sometimes this is referred to as revenue funding.

Maladaptation

Actions or strategies that, while intended to address a problem, ultimately increase vulnerability or harm, either in the short or long term.

Mean High Water Spring (MHWS)

The average height of high-water level during spring tides, placing this area at risk of permanent inundation.

Natural capital

Refers to elements of the natural environment that provide valuable goods and services to people, underpinning wellbeing and economic prosperity.

Ordinary watercourse

Any watercourse which is not designated as a Main River. Within the Fens the IDBs manage these watercourses on behalf of the riparian owners.

Ordnance Datum (OD)

The Ordnance Datum is the basis for all the land heights that appear on Ordnance Survey maps. It is essentially the mean sea level at Newlyn in Cornwall, and is sometimes called Ordnance Datum Newlyn (ODN).

Resilience

The capacity for people and places to plan for, protect, respond to and positively recover from flooding and coastal change.

Risk Management Authorities (RMAs)

Refers to the authorities which take a strategic lead on the management of flooding and have permissive powers to carry out the works. These authorities include the Environment Agency, LLFAs, district councils, IDBs, highway authorities and water companies.

Soilscape

A classification used to describe the broad regional differences in soil types and their distribution across a landscape.

Standard of Protection (SoP)

At a given point in time, the AEP of a flood event which an asset is able to withstand. SoP will vary over time.

Standard of Service (SoS)

Defined physical characteristics that a flood risk infrastructure asset is required to achieve. For example, the height of a protective barrier or throughput of a pump.

Fens 2100+