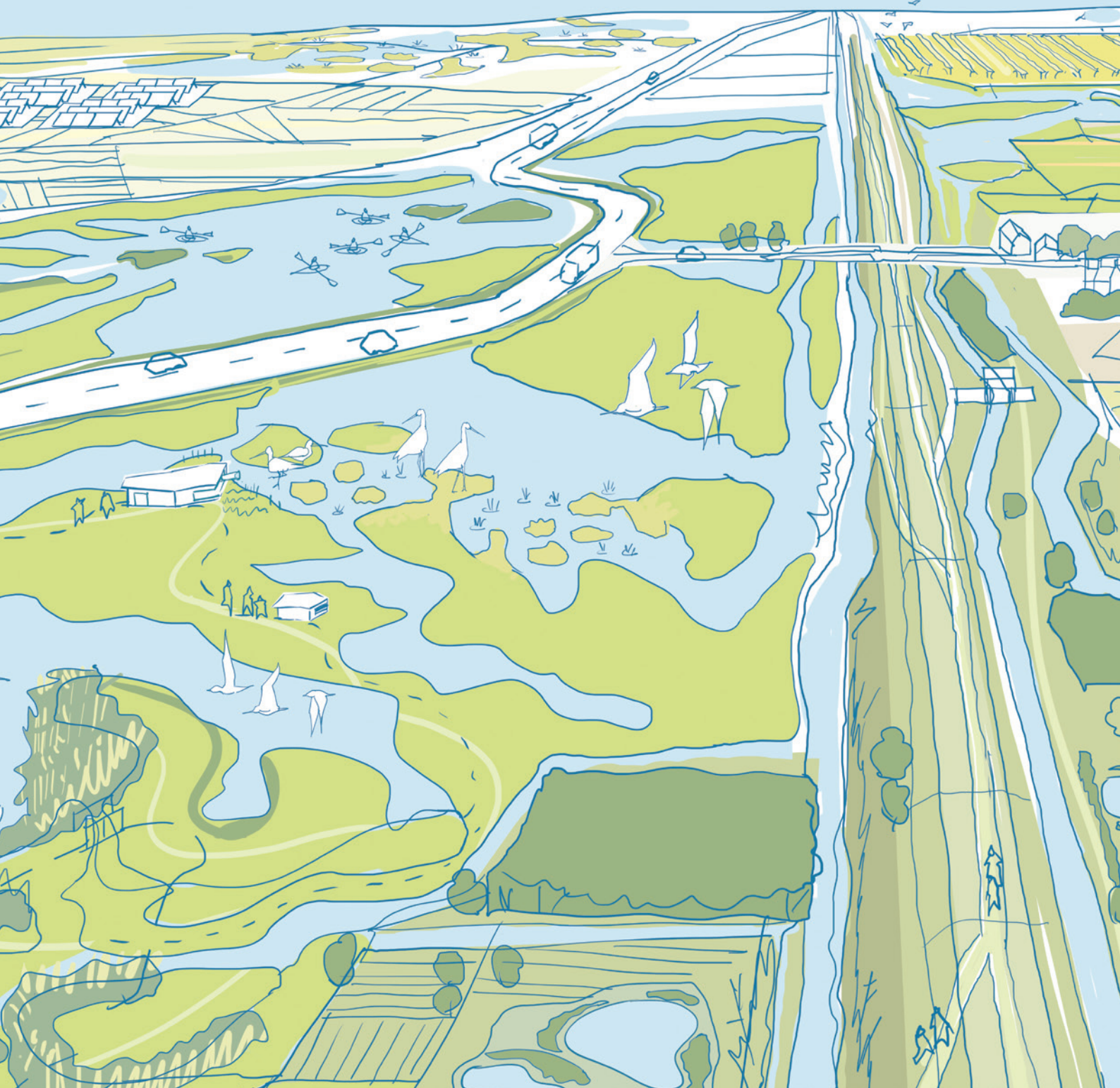


Fens 2100+ summary baseline report

Enabling partnership investment in critical coastal,
flood and water management infrastructure

March 2026





Foreword



Paul Learoyd
Chair of Anglian Northern Regional
Flood and Coastal Committee



Brian Stewart OBE
Chair of Anglian Great Ouse Regional
Flood and Coastal Committee

A solid base for future action

The Fens is a man-made and constantly managed landscape, unlike any other. Without management, there is no landscape. Our evidence is clear: there is no business-as-usual approach that can keep the Fens safe and productive.

This suite of baseline reports represents the first time that all partners have had a unified evidence base of the whole flood risk management system, to support a shared understanding of the issues and challenges, and a shared story of the value this management brings.

Fens 2100+ is driving forward a transformative new approach to investing in the critical Flood and Coastal Risk Management infrastructure that underpins the Fens. By collectively developing a long-term, landscape-scale flood resilience programme, we can all support a climate-resilient, vibrant, and sustainable future for the Fens region.

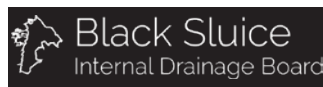
The catchment baseline reports, and this summary report, provide a clear, shared evidence base that can be drawn upon by all partners to plan, fund and deliver investments to support both our place-keeping and place-making missions. This evidence was built in partnership to secure the future of this unique region.

Our Partnership

This partnership report is written for and on behalf of the Fens 2100+ Partnership, including regional leadership and representation from:



middle level
commissioners



This document draws upon the individual catchment baseline reports and technical appendices including baselines for flood risk, economics, environment and agriculture, and natural capital.

For more information contact:

Fens2100@environment-agency.gov.uk

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 to inform decision making

For the first time, we have a collective set of robust evidence and key insights about flood risk and asset performance across the Fens, equipping decision-makers to shape the future of the Fens with confidence and clarity.

This report summarises findings from a suite of catchment baseline reports, bringing together data and insights from key Risk Management Authorities (RMAs) on their experience of managing flood risk assets.

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.

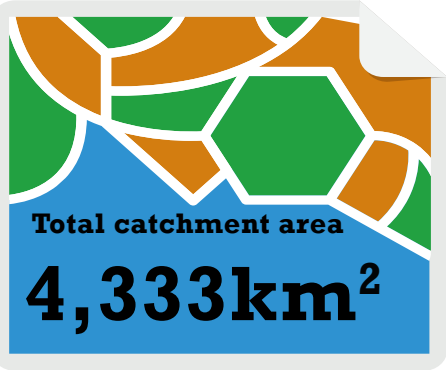
This offers a collective evidence base to support the Fens 2100+ Partnership in transforming the approach to investing in flood and coastal resilience, including:

- Making decisions about the maintenance, management, and investment prioritisation of critical assets, which are ageing and under increasing pressure from climate change.
- Supporting the preparation and successful delivery of future FCERM business cases, and partnership working to secure future funding and finance.
- Addressing how the area will function in the future, balancing flood risk, water supply, sustainability and economic growth.



The Ouses Washes as the sun begins to set
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The Fens



58
Internal
Drainage Boards



87%
of the Fens is below
the level of a Spring tide

6.5m
Holme Fen is
below the level
of a Spring tide.

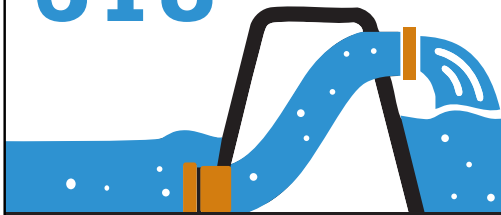


Estimated population
of more than

600,000



318 pumping stations



More than **17,000**
flood risk management and water
level management assets.



48%

of England's Grade 1
agricultural land

1/3

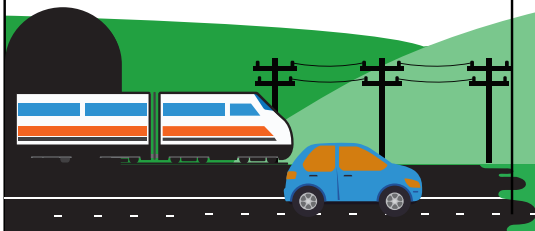
of England's
vegetables
grown in the Fens



1,288km
of A and B roads

277km
of rail infrastructure

4,921km
of power cables



259 Scheduled Monuments

102 Conservation Areas

3,825 Listed Buildings



Approximately

£500
million

total annual value
from natural capital



35% of assets are owned
and managed by the
Environment Agency

65% are the responsibility
of other RMAs or
riparian owners.

89km

of coastline

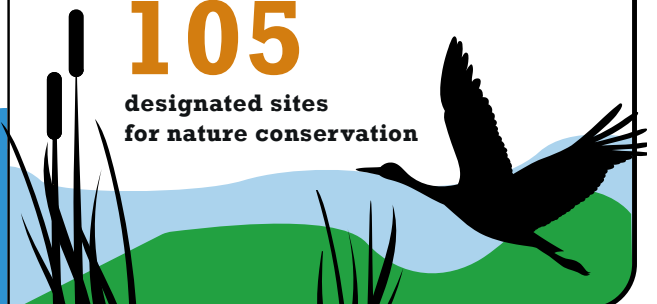


4,500km
of watercourse



105

designated sites
for nature conservation



Introduction

The evidence is clear: without urgent, sustained investment to maintain and upgrade critical flood risk management infrastructure, we risk being the generation that failed to protect the future of the Fens.

A landscape worth protecting

The Fens supports a concentration of agricultural output which could not be replicated anywhere else in the UK. The Fens contains 48% of England's Grade 1 (best and most versatile) agricultural land and its thriving agricultural economy supports 80,000 jobs.

There are 105 designated sites for nature conservation, including internationally important sites such as The Wash and Gibraltar Point, which provide habitats for many key species. Natural capital delivers £500 million in annual benefits, including food production, flood risk management, clean water and recreation.

With a rich cultural heritage dating back to the Iron Age and Roman times, the area contains over 4,000 designated heritage assets.

Flood risk management assets in the Fens protect critical transport infrastructure and essential power and water supply utilities from damage and disruption worth £8.1 billion and £5.1 billion respectively. Through this they underpin wider economic growth across eastern England.

What is the challenge?

Continuous land drainage and flood defences are all that protect low-lying areas from permanent inundation. The lives and livelihoods of over 600,000 people who live in the Fens would be put at risk without these critical assets, and flood damages would exceed £60 billion over the next 100 years.

Yet around 31% of flood risk assets in the Fens will reach the end of their foreseeable design life within 15 years, including critical embankments, pumps, and control gates. By 2075, the proportion of assets which will reach or be beyond their foreseeable design life will be 89%.

Many of the 17,000 flood risk assets that sustain the region were built in the post-war decades, which was the last period of mass investment in drainage infrastructure. Maintaining and managing such a complex system of assets requires significant resources and collaboration between RMAs.

Repeated flooding events highlight the region's vulnerability. Climate change will intensify this risk, even if current defences are maintained.

The Fens: context and overview

The Fens is a landscape of national importance, combining exceptionally productive agriculture, internationally significant sites for biodiversity, and a rich cultural heritage.

The Fens 2100+ study area covers 4,333km² (433,300ha) of the Lincolnshire and Cambridgeshire Fens. The four largest rivers, the Witham, Welland, Nene, and Great Ouse, drain water from 12% of England through the Fens into The Wash.

Large areas of the Fens lie below sea level. Inland, it is bordered by the Lincolnshire Wolds, the Southern Lincolnshire Edge and the higher ground of Cambridgeshire and East Anglia. A low ridge of silt and sediment along the coast of The Wash forms a bowl, with the lowest areas further from the coast. The UK's lowest point, 2.75m below sea level, is in Holme Fen, south of Whittlesey in the Great Ouse catchment.

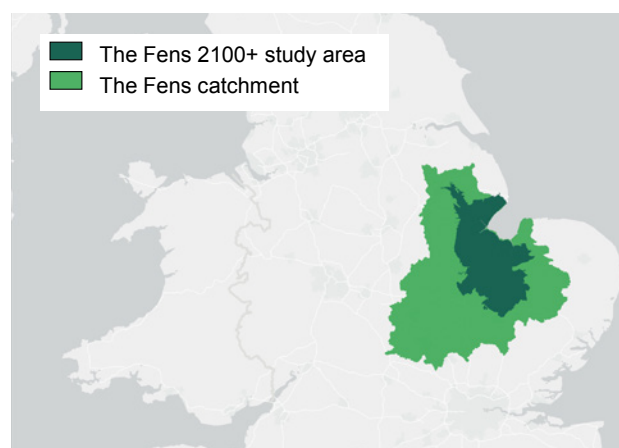
Due to its flat and low-lying topography, the Fens can only be kept dry by a complex system of flood risk management assets. Constant management of water and the rich peaty soils left behind by the drainage enable the region to support incredibly productive agriculture. The Fens contains around half of the UK's Grade 1 agricultural land and contributes over 7% to the UK's total agricultural production.

Once a waterlogged landscape periodically inundated by rivers and the sea, the Fens has been dramatically transformed. Over the last thousand years, humans have constructed an extensive network of drainage channels, embankments, and pumping stations, which aim to keep the area flood free and well drained.

Without active management 365 days per year, the region would be flooded from rivers and the sea. Centuries of land subsidence due to the shrinking

of drained peat as it dries and oxidises have left many rivers elevated above their floodplains. They are contained by artificial earthen embankments, which were raised as land levels fell. Pumping water upwards into these rivers and maintaining the embankments has since been vital to prevent inundation and keep the area habitable and productive.

Climate change is expected to increase the frequency and severity of fluvial and tidal flooding as well as drought. Ongoing drainage and intensive agriculture continue to accelerate peat subsidence, which further lowers ground levels, releases stored carbon and erodes the most fertile soils. Climate change is also expected to accelerate the rate of asset deterioration, demanding more frequent maintenance, and shorter periods between renewals. Maintaining current defences is expected to cost £6 - £9.4 billion, not including the upgrades that will be required to make the asset system resilient to climate change.



Outline of the Fens 2100+ study area and its catchment, demonstrating how much of the east of England drains into and through the Fens



The Fens has an estimated total population of more than

600,000



80%

of land in the Fens is classified as Grade 1 or 2 agricultural land.



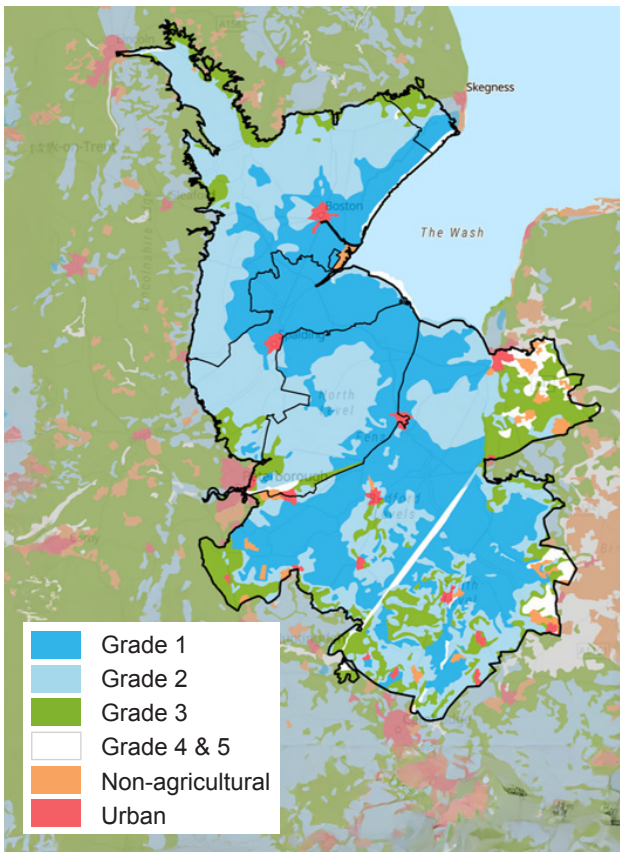
The River Nene © Steven Trehwella, used with permission.

Agriculture

Almost half of the best quality agricultural land in England is located within the Fens. This land produces a fifth of England's crops and a third of its vegetables. The area supports a high value food processing and logistics hub, which is supported by academic institutions to create innovation and add value. The agricultural land supports approximately 80,000 jobs across the food supply chain.

Agricultural success here depends on managing flood risk and water levels—ensuring enough water for irrigation in dry summers and protection from flooding and waterlogging in wetter conditions and during extreme weather events.

The impacts of drought and flood events on agriculture can be severe. Even after floodwaters have receded, salinisation (caused by tidal flooding or groundwater leaching) can have long-term impacts on soil health and productivity.



Agricultural Land Classification in the Fens



1/3

of England's vegetables are grown in the Fens.



48%

of England's Grade 1 agricultural land is within the Fens

Human environment

The Fens has a rich cultural heritage dating back to the Iron Age and Roman periods. It possesses over 4,000 designated heritage assets, including 3,825 Listed Buildings, 259 Scheduled Monuments, and 102 Conservation Areas. Peat soils may preserve many more as yet undiscovered archaeological remains.

Culturally there has been a strong connectedness with water across the Fens, from the 'Adventurers' who undertook the major drainage works of the 1600s, to the wildfowling who depended on natural wetland resources for subsistence and trade. This connection has diminished over recent history.

Although only 3% of the area is urban, the Fens' population is growing faster than the national average. Boston Borough's population is projected to grow by 9.1% between 2025 and 2041, compared to 6% for England.

However, there is stark inequality. Some areas face deprivation, with low life expectancy, poor health, and limited access to green space and skills development. Parts of the region rank in the bottom 1% nationally for education, skills, and training.

The strong growth ambitions of the region are dependent on critical flood, coastal and water management infrastructure.

Natural environment

Biodiversity

Less than 1% of original fen habitats survive, yet the region still supports rare plants, insects, and over 170 bird species. There are 105 sites across the Fens which have been designated for their national or international importance for biodiversity.

The Whittlesey (Nene) Washes flood storage area is designated as a Special Protected Area (SPA), Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC) and a Ramsar Site. Intermittent flooding supports diverse wildlife and preserves peaty soils through the high water table.

Water environment

The condition of waterbodies is described by their Water Environment Regulations (WER) / Water Framework Directive (WFD) status. Most water bodies in the Fens are heavily modified or artificial. They are affected by pollution from rural areas and wastewater, and by physical modifications associated with flood defence structures, land drainage operations and uniform channel geometry.

Landscape

The study area is mainly within The Fens National Character Area, notable for its flat, open landscape and wide views. The network of rivers, drains and ditches forms a distinctive geometric field pattern, and level horizons contribute to a strong sense of isolation and tranquillity.

Soils

Peaty soils cover 18% of the Fens. They are deepest in washlands such as the Whittlesey (Nene) Washes, and across much of the South Level in the Great Ouse catchment. Much of the remnant lowland peat present across the Fens is likely to be degraded due to long-term agricultural use and drainage. There is significant potential for enhanced carbon sequestration.

18% of the Fens is covered by peaty soils.



The Whittlesey (Nene) Washes © Richard Humphrey. Licensed for reuse under the Creative Commons Licence.

Natural capital

Natural capital refers to elements of the natural environment that provide valuable goods and services to people. Benefits provided by natural capital assets such as freshwater, soils, air, plants and animals are known as 'ecosystem services'.

These ecosystem services support human wellbeing and the economy by supplying raw materials, food, clean water, carbon storage, temperature regulation, pollination, and opportunities for recreation.

Their value can be estimated using data on the quantity, quality, location, and use of natural assets.

Almost £500 million of natural capital has been identified across the Fens. This value may be underestimated due to data gaps or the complexity of assigning monetary value.

The majority of natural capital value in the Fens derives from agriculture (£376m) and water supply (£382m).

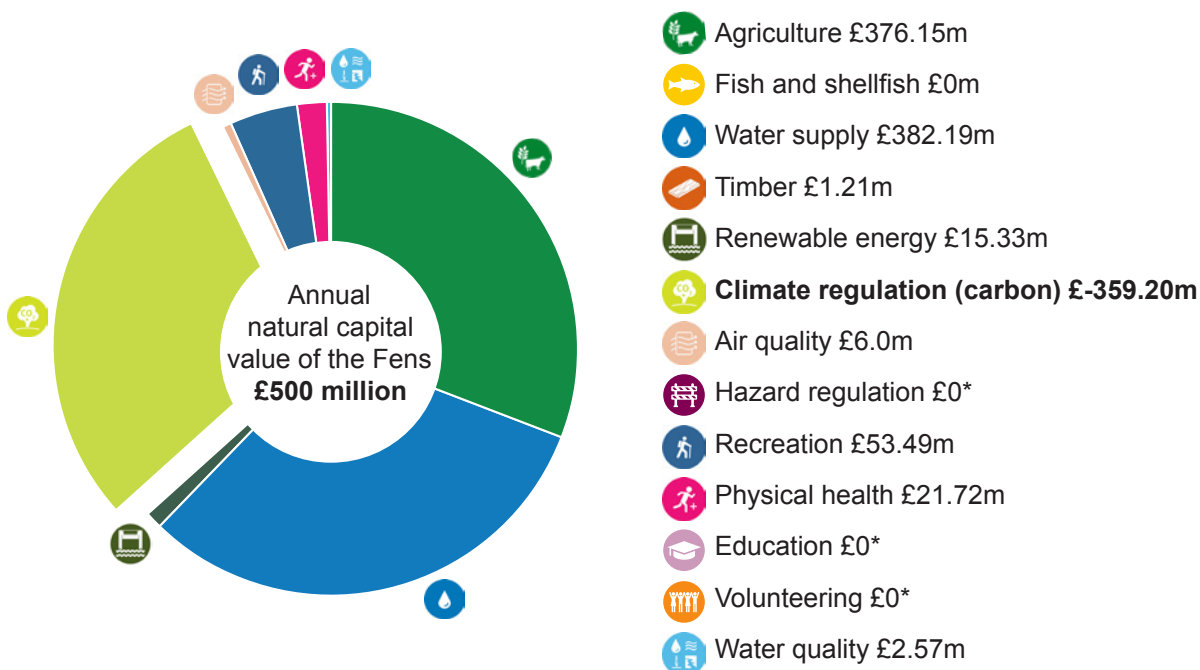
The way that water is managed across the landscape is not always joined up, and there are significant opportunities to unlock wider natural capital value in both of these areas through future flood risk management approaches.

Across the Fens, natural capital value is suppressed due to high carbon emissions. Healthy peat soils store carbon, but degraded peat soils release it, worsening climate change and reducing peatland value. All Fens 2100+ catchments (except the Steeping River catchment) emit more carbon than they absorb, costing £359 million annually.

Even accounting for the cost of carbon emissions, the natural capital across the Fens provides services with a total annual value of approximately

£500 million

Annual value of natural capital across the Fens



*The value of education, volunteering and hazard regulation is greater than £0, however there is currently insufficient data available to provide a monetary value.

History of the Fens

Change has been a constant feature of the Fens landscape. From the earliest human settlements, and particularly since the 1600s, people have actively managed the flow of water across the region.

Natural wetlands and early settlement

Remains of ancient oak trees, or 'bog oaks', found in fenland peat are evidence of a once densely forested landscape. Around 5,000 years ago, rising sea levels created wetlands, burying and preserving the trees. Tidal rivers deposited silt, often blocking flow and causing frequent floods that formed inland lakes, or 'meres'.

Human settlement in the Fens dates back to the Neolithic period. By the end of Roman rule (AD 43–410), early flood defences and navigation improvements had begun, including construction of the Carr Dyke and the raised Fen Causeway between Peterborough and Denver.

Salt production was among the earliest industries. Waste silt from this process formed 'salterns', or elevated coastal areas where villages developed.

Local drainage and monastic influence

During the Saxon period (AD 410–1066), settlements and monastic foundations were created on some of the raised Fen 'islands' such as Crowland, Ely, Thorney, and Ramsey. Communities farmed, fished, hunted, harvested reeds, and produced salt. In the 1100s, some of the first dykes were dug by monks for transporting goods.

The ports of King's Lynn, Boston, and Wainfleet thrived through the medieval period (1066–1485), from the trade of wool and fenland resources. Drainage efforts were mainly limited to small flood embankments, raised by local landowners.

The 'Great Draining'

In the 1600s, draining the peat-rich Fens was seen as a way to create profitable farmland. In 1630, the Fourth Earl of Bedford and a group of investors, known as the 'Adventurers', appointed Dutch engineer Cornelius Vermuyden to lead major drainage works in the Great Ouse and Lower Nene catchments. His approach focused on straightening rivers to speed up the flow of water to the sea. Navigation and river trading were also important drivers for investment at this time.

Further north, the Earl of Lindsey attempted to drain the South Forty Foot Drain catchment in 1635–1638. These changes angered locals who relied on the Fens for fishing and hunting. In protest, they sabotaged the new works and became known as the 'Fen Tigers'.

The emergence of pumping

Although drainage schemes produced results initially, it became apparent that the peaty soils were shrinking as the land began to dry, impeding the natural flow of water along the new channels. Windmills transformed drainage by allowing water to be moved upwards from the land into the embanked watercourses above.

Large undrained areas remained until steam pumps were introduced in the mid-1800s. These pumped eight times more water than windmills and could run continuously, revolutionising drainage and boosting agricultural production.

Post-war investment

The outbreak of World Wars and the associated periods of food rationing in the 1900s raised the importance of national food security. In the Fens this prompted a renewed wave of investment in drainage, supported by the 1930 Land Drainage Act which created many of the organisations that we see today.

In the interwar period, the first investments in more intensive modern drainage began. Tydd Pumping Station was commissioned to intensify drainage of the North Level, and the first electrical pumps were installed at Pode Hole in 1937.

Major flood events in 1947 and 1953 renewed the focus on flood protection. New relief channels were dug, and Main Rivers were straightened and embanked. In the 1950s and 1960s, a wave of new diesel and electric pumps were built across the Fens. These post-war assets are now coming to the end of their foreseeable design life.

Modern investment

Since the 1980s the level of investment in the Fens has dropped as flood defence spending has focused on protection of properties rather than agricultural land. The globalisation of food markets has also made food security less of a priority.

Since the 2010s, budgets for maintenance of flood risk management assets have also been reduced, with funding bids often under-resourced.

Climate change impacts are now evident. Tidal breaches in 2013, a prolonged wet winter in 2023/24, and a dry summer in 2025 have strained drainage systems, exposing several weaknesses.



Windmill at Wicken Fen © Sarah Charlesworth.
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Horse-powered scoop wheel in Bourne South Fen, 1904 © Heritage South Holland.

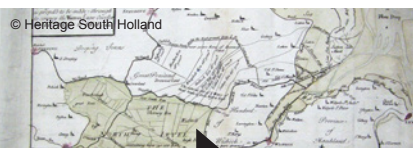


Interior of the newly built Adventurer's Pumping Station at Pode Hole in 1957 © Heritage South Holland.



Breach of the Crowland and Cowbit Washes in 1947 © Peterborough Images Archive.

History timeline



Natural wetlands and early settlement

Pre-10,000 BC

The area was forested.

43-410 AD

Romans constructed the first artificial channels and the raised Fen Causeway.

600-1000 AD

Monastic foundations were created on some of the raised fen 'islands'.

Local drainage and monastic influence

1287

A disastrous tidal surge affected Boston and South Holland. Spalding Monastery was destroyed.

1530s

New laws were passed supporting sewerage and draining, which led to the cutting of new drains.

Water which had once flowed into the Steeping River from the East Fen was now diverted towards the River Witham.

'The Great Draining'

1600

Windmills started to be used to drain the Fens.

1630s

The River Welland was widened and deepened to improve navigation and drainage.

1630

Cornelius Vermuyden designed a scheme to drain the Lower Nene and Great Ouse catchments.

1632

Approximately 100km² of land in South Holland was reclaimed from the sea for agriculture.

1664

Crowland and Cowbit Washes were constructed.

1700s

Drainage of Deeping Fen began, and the River Witham was straightened to improve navigation.

1799

Drainage of the East and West Fens begins.

Emergence of pumping

1820s

Steam powered engines began to replace windmills.

1851

Whittlesey Mere finally vanished due to drainage. It had once been the largest lowland lake in England.

1899

Wicken Fen became the National Trust's first nature reserve.

1930

The Land Drainage Act created IDBs and Catchment Boards.

1934

The first St. German's Pumping Station was constructed, after it was realised that gravity alone was insufficient for draining the Middle Level.



Post-war investment

1937

Dog-in-a-Doublet Sluice constructed.

1940s

Following severe flooding on the River Welland in 1947, construction of the new Coronation Channel began.

1953

The North Sea tidal surge was the UK's worst natural disaster of the 20th Century.

1956-1957

Large pumping stations were commissioned at Pode Hole and Hobhole to boost drainage of Deeping Fen and the East and West Fens.

1960s - 1970s

Embankments were raised along highland carrier drains, and relief channels were constructed in the Steeping River catchment to increase the capacity of the river network.

1973-1993

Further investment in diesel and electric pumps. Ten new diesel and electric pumping stations were constructed in the North Level District.

Modernisation

1990s-2000s

A new telemetry system was installed in the East and West Fens, enabling remote monitoring of water levels and automated adjustment of assets.

1998

Following heavy rainfall, St. German's Pumping Station ran continuously for 12 days. This prompted construction of a new pumping station in 2010 – the largest pumping station in England.

2013

A tidal surge breached embanked defences at Wrangle and Boston, and damaged Black Sluice Pumping Station, which led to its closure.

2018

5.8km of sea defences at Wrangle were raised to a height of 7.2m.

2020

Construction of Boston Barrier completed to provide tidal surge protection for the town, with allowance for sea level rise.

Now and next

2020

FCERM national strategy measure 1.5.4 led to the Fens 2100+ Partnership.

2023-2024

The wettest winter on record for the UK pushed flood risk assets in the Fens to their limits and beyond.

January 2025

Water levels in the South Forty Foot Drain were the highest ever recorded.

2040

31% of flood risk assets in the Fens will come to the end of their foreseeable design life. By 2075, this rises to 89%.

2080s

Peak flows in rivers across the Fens could be between 4% and 21% higher than those recorded currently.

2125

1.2-1.6m of sea level rise projected under the UK Government's 'Upper End' allowance.

The role of critical infrastructure

Without critical flood risk management assets, the Fens would quickly flood and become uninhabitable.

A changing landscape

Before human intervention, the Fens was a rich wetland, with meres, bogs, woodland, and salt marshes. Natural islands supported drier habitats.

Over centuries, major effort and investment has transformed the area into a habitable and productive landscape. Without ongoing management and flood defences, the Fens would quickly flood from rivers and the sea and become uninhabitable.

Importance of the flood risk management asset system

Effective drainage in the Fens depends on pumping stations and well-maintained river and tidal embankments. Sluices and control structures help manage water levels to prevent breaches.

These flood defences are actively managed year-round. Without them, or if they were neglected, the Fens would quickly flood. If all pumps stopped, the area would become uninhabitable within less than a decade.

Legacy investment

The flood risk management system we have today was inherited from previous generations and made possible by substantial investment. Many of the largest drainage features such as channels and embankments were dug by hand, at huge financial and human cost. Projects of this scale are unlikely to be feasible under current conditions; at the time, they required several Acts of Parliament to proceed. In today's terms, replicating a similar system from nothing would cost in the region of £25-£30 billion.



Hobhole Diesel Pumping Station, showing the difference in water level between the Hobhole Drain (left) and the Boston Haven (right) into which water must be pumped © Witham Fourth District IDB.

Extent of permanent inundation

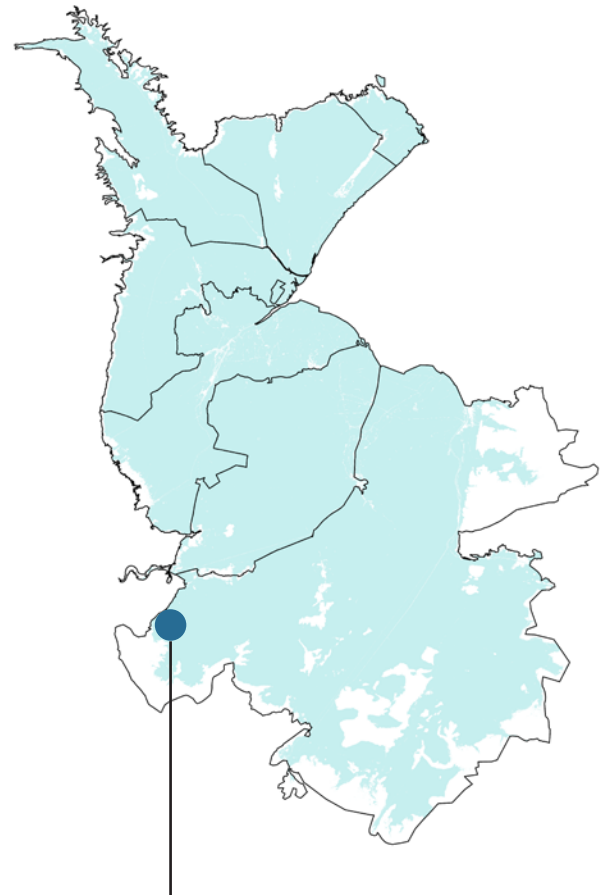
The map to the right shows the tidal flood risk in the Fens without flood defences. Much of the land lies below the mean high spring tide (MHWS) level of 3.9m AOD, making it highly vulnerable to tidal inundation. The Fens has a bowl-shaped topography with lower ground inland of the elevated coastal areas. This traps water, preventing natural drainage. The UK's lowest point lies 2.75m below AOD at Holme Fen. During a high spring tide (MHWS), the sea level is more than 6.5m above the land surface at Holme Fen — equivalent in height to a two-storey building. Tidal embankments are the only defence against this flooding being realised with each spring tide.

Why is the Fens landscape a bowl?

One of the reasons that the Fens today is vulnerable to flooding is its distinctive bowl-shaped topography. As water has been removed from the peaty soils further inland, the ground has shrunk and subsided significantly. As a result, it now sits below the natural ridges of silt nearer to the coast, where the earliest settlements were established. In the mid-1800s, the peat at Holme Fen was over 6.5m deep, but in the past 175 years the ground level there has dropped by around 4m.

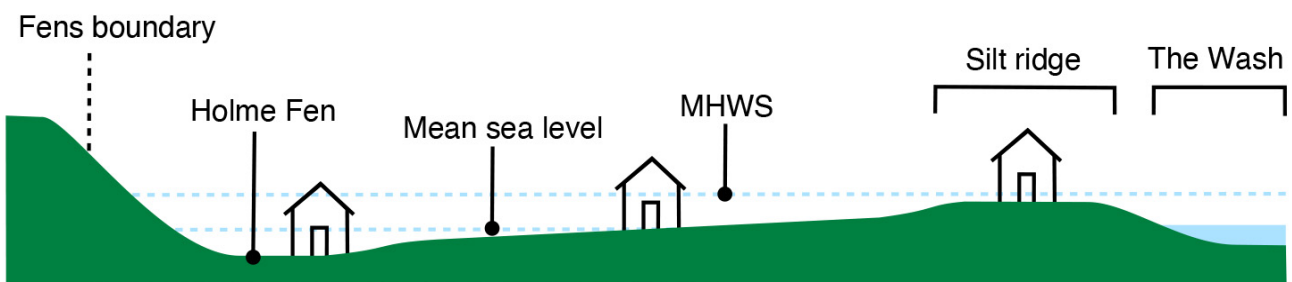
This creates a striking paradox: the more the land is drained, the more the peat soil shrinks, creating a cycle which has made the Fens increasingly dependent on pumped drainage to move water upwards against gravity, towards The Wash.

Area below 3.9m AOD (MHWS) and at risk of permanent inundation if we walked away.



Holme Fen is the lowest point in the UK, at 2.75m below mean sea level (AOD), located approximately 47km from the sea.

87% of the Fens is below 3.9m AOD (MHWS) and at risk of permanent inundation if we walked away



Illustrative diagram showing the cross sections of the Fens from Holme Fen to The Wash. NOT TO SCALE.

Flood risk asset system

Given the scale and complexity of the asset system, spanning more than 17,000 interconnected assets, systems thinking is central to the future of the Fens. No single organisation can solve the challenge alone.

This schematisation illustrates key flood risk management assets which protect the Fens from flooding. Thousands more assets exist to support flood risk reduction, navigation and the maintenance of water resources.

Responsibilities for different assets are split across multiple organisations with varying priorities. Approximately 35% of assets are owned and managed by the Environment Agency, with 65% the responsibility of other RMAs or riparian owners.

① Coastal defences

Walls and embankments are in place along the coast and tidal rivers to prevent coastal flooding. These defences are stressed by the daily cycles of the tides and are increasingly under pressure from sea level rise. They can be very high to provide protection for regular spring (higher) tides, as well as tidal surges potentially caused by storms. At Wrangle, the embankments are up to 7m tall.

② Main River defences

Main Rivers often sit above surrounding land due to subsidence. Embankments contain these elevated 'highland carrier' channels. Catchwater drains intercept runoff from higher ground before it reaches low-lying areas.

Sluices manage water levels in Main Rivers by releasing water before floods and retaining it during dry spells. They also support navigation and aquatic habitats.

③ Flood storage areas

Flood storage areas, or washlands, are a prominent feature of the Fens and are present in four of the seven catchments. They are usually dry and are managed for wildlife and used for grazing, or other types of agriculture. But when river levels are high, they can be used to store excess water, which is kept within the storage area by earthen embankments.

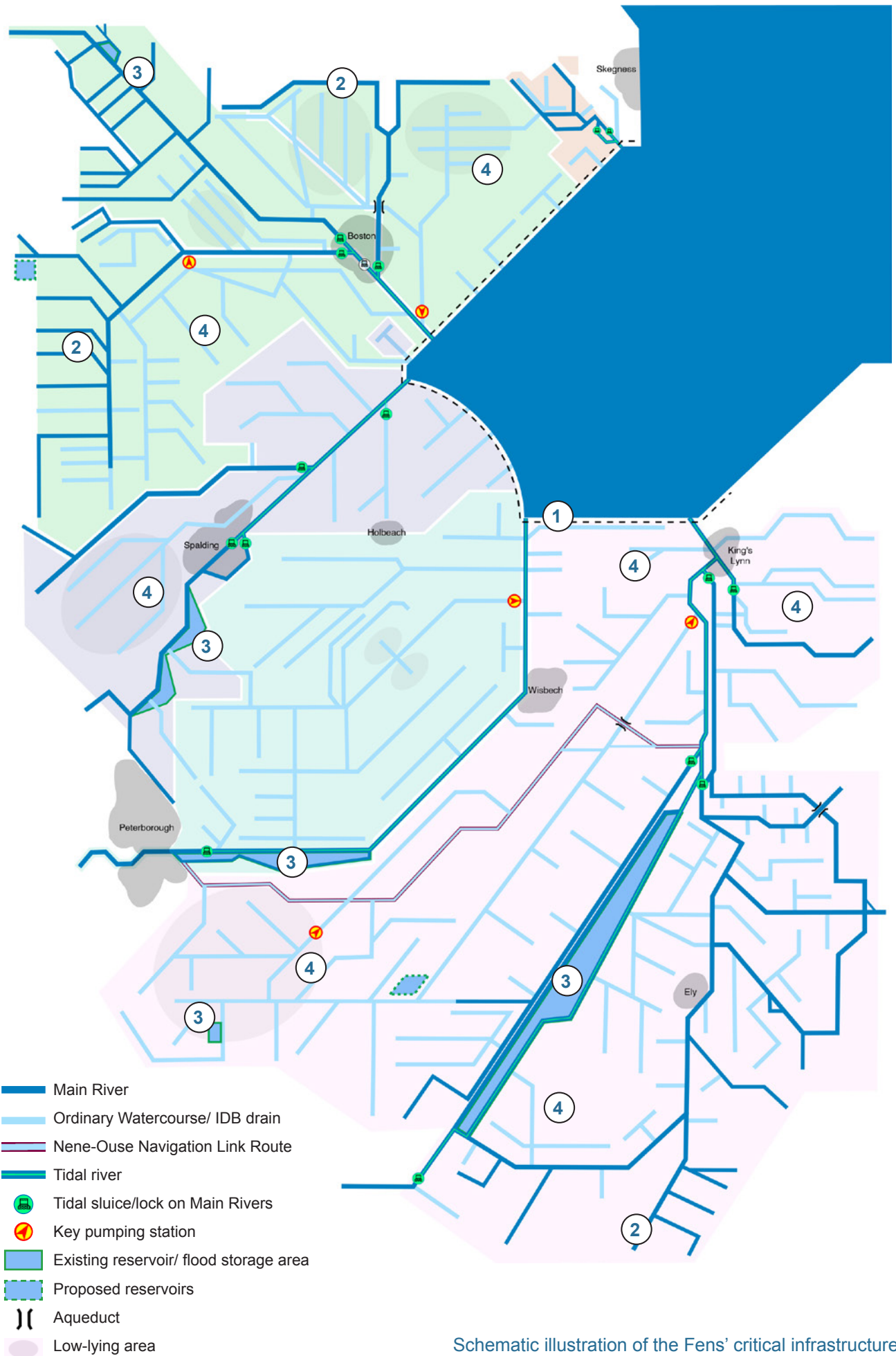
④ Pumped and gravity drainage systems

Due to peat shrinkage and the flatness of the landscape, many watercourses in the Fens lack the natural gradient typical of rivers elsewhere, and water must sometimes move 'uphill' to enter the Main River system or the sea. The movement of water off the land is therefore largely reliant on pumping stations.

Some sub-catchments with suitable topography are able to be sufficiently drained through gravity sluices alone. However, as sea levels rise, and land continues to subside, gravity drainage is becoming increasingly unreliable.

Dual-purpose assets

Many assets serve a dual purpose, alongside managing flood risk. For example, several sluice structures can manage water levels for flood risk reduction, navigation, environmental protection, and water supply for homes and agriculture. Competing objectives make the management of these assets particularly complicated.



Schematic illustration of the Fens' critical infrastructure

Asset condition and performance

Consulting asset owners and operators was central to the baseline reports, capturing real-world management experience. Combined with the Environment Agency's Asset Information and Maintenance dataset (AIMS) data, this revealed shared challenges for RMAs and underscored the need for ongoing collaboration and investment in asset condition.

Despite its vital role in protecting the Fens, the flood risk management system faces growing challenges. Ageing infrastructure, operational complexity, and competing demands are creating vulnerabilities that hinder efforts to safeguard people, property, and the environment.

The asset system is complex

Flood risk assets in the Fens form an interconnected network. One asset alone seldom provides complete defence of an area against flooding.

Decisions taken at one site – such as increasing pumping rate, or lowering water levels – can affect other assets downstream, shifting the demand for water management between assets and sometimes organisations.

Seasonal extremes add further complexity; winter rainfall demands rapid drainage, while summer requires water retention to support navigation and irrigation. The Fens is one of the driest areas in the country overall, but drains the rainfall from a much larger area, covering 12% of England. These extremes of wet and dry are projected to worsen with climate change.

People and skills are vital

Specialist skills are essential to manage these assets. During floods, key sites like Hobhole Pumping Station and Denver Sluice require 24/7 staffing, limiting the Environment Agency and IDBs' ability to respond to issues elsewhere. Recruiting and retaining skilled staff is difficult, and these RMAs stress the need to preserve institutional knowledge before it disappears.

Assets are ageing

Many critical assets in the Fens are ageing, with some exceeding their foreseeable design life. This raises the risk of failure, increases maintenance costs, and reduces efficiency. By 2040, 31% of flood risk management assets will reach the end of their foreseeable design life, and by 2075, this will increase to 89%.

In areas where many assets were built at the same time, the risks around ageing assets are compounded, as one failure could cascade onto a neighbouring asset of similar vulnerability. Extending asset life may ease short-term investment pressures but will not remove the eventual need for large investments in asset replacement.

35:65 split of asset ownership
Environment Agency and other Risk Management Authorities

31% of assets across the Fens will reach or be beyond their foreseeable design life by 2040.

Case study: Ageing components at Dog-in-a-Doublet Sluice

Built in 1937, Dog-in-a-Doublet Sluice is nearly 90 years old and forms the upstream limit of tidal defences on the River Nene, controlling levels for navigation, water supply, and agriculture. It suffers frequent mechanical failures from constant telemetry adjustments, and sourcing parts is costly and difficult. Planned renewal could extend its life by 20 years, but full replacement will eventually be required.



Dog-in-a-Doublet Sluice and Lock © Richard Humphrey. Licensed for reuse under the Creative Commons Licence.

Pumped systems are at capacity

Many Fens pumping stations are outdated and operating at capacity, having been designed for lower peak flows. Each was built to reflect the technology of their time, without standardisation. The bespoke designs and mismatched components of different assets makes repairs difficult and reliant on a small pool of very skilled individuals.

Long lead times for parts often leave pumps offline or underperforming, reducing system capacity and increasing flood risk in local sub-catchments during outages.

Gravity discharge is becoming more difficult

Many Fens sub-catchments rely on gravity-controlled drainage, which depends on low tide levels to let water flow out to sea.

However, gravity discharge is now much harder than when these systems were built. Sinking of the land over time due to peat shrinkage has flattened the natural slope of watercourses, making it harder for water to move. At the same time, rising sea levels reduce the time available for discharge at low tide, creating longer periods of 'tide-lock' when no discharge is possible. In addition, silt can build up near outfall sluices, further blocking the flow and contributing to increased flood risk due to water backing up in the catchment.

Case study: Future loss of gravity discharge at Sutton Bridge Sluice

The South Holland Main Drain in the Lower Nene catchment is the main route for water discharge from an area of 185km² (18,513ha) which contains over 10,000 residential properties.

Discharge from the South Holland Main Drain into the River Nene currently relies on gravity discharge through Sutton Bridge Sluice. However, as discharge is only possible at low tide, there are periods of 'tide-lock' when no discharge is possible. Future sea level rise driven by climate change could restrict gravity discharge even further, and it will become necessary to add a new pumping station at this site.



Sutton Bridge Sluice © Hugh Venables. Licensed for reuse under the Creative Commons Licence.

Embankments are vulnerable

Many embankments in the Fens were built centuries ago before modern engineering standards, and are formed of variable materials, unsuitable by modern standards. This makes them prone to deformation, seepage, and failure. Risks are intensified by burrowing animals, peat shrinkage, groundwater variations, and unstable clay, all of which threaten the long-term stability of these vital flood defences.

Embankments are vulnerable to climate change, particularly due to the impact of wetting and drying cycles and changes to vegetation. This is expected to accelerate asset deterioration and increase costs through the need for more frequent inspection and maintenance.



Overtopping of the Wainfleet Relief Channel in October 2023. The relative water level compared to the property visible on the right shows how critical these embankments are © Environment Agency

Case study: Lower Witham Flood Resilience Project (2025)

Many of the 300km of embankments in the Lower Witham catchment are over 200 years old and prone to failure. Barlings Eau has breached six times since 1878, most recently in 2019 and January 2024. Storms in winter 2023-24 caused slips at Fiskerton and a breach on the River Bain.

The Lower Witham Flood Resilience Project aims to improve the resilience of embankments for example through bank re-profiling and the filling of low-spots.

Better data about asset condition is needed

The AIMS database is an important record of most Environment Agency assets. It includes some other RMA assets, but not all, leaving key gaps in understanding. Even for the assets that are included, data users have raised concerns with how current this data is, potentially under-representing the number of assets currently under stress.

18% of assets across the Fens have no data about their condition.

Strategic co-ordination and governance is essential

Managing assets in the Fens depends on strong collaboration between organisations such as the Environment Agency and IDBs. While coordination and sharing of personnel and resources during flood events is effective, fragmented responsibilities and misaligned priorities threaten long-term, joined-up solutions.

Assets are carbon intensive

The operation of pumping stations (diesel and electric) is one of the most carbon intensive activities. In the Great Ouse catchment, the most recent (2021) annual estimate of emissions from maintenance and electricity usage suggested over 80% of emissions were associated with grid electricity usage at pumping stations.

High energy demand makes asset operation vulnerable to fluctuations in energy markets. While many modern stations use electric pumps, many older stations still run on diesel, and many sites run a combination of the two to add resilience in case electricity is cut off during flood events. Rising energy costs and increasing focus on carbon highlight the need for a carbon reduction strategy.

Climate change will exacerbate asset vulnerability

The deterioration of assets can be driven by multiple climate hazards, including more intense and frequent extreme weather events, high temperatures, drought and heatwaves. These hazards may also compound to exacerbate asset vulnerability. Assets are designed to provide a certain Standard of Service, but increased exposure to climate hazards will accelerate the deterioration of ageing infrastructure. This will change the frequency, cost, and nature of maintenance activities.

There are gaps in investment

Investment gaps are leaving the Fens' flood risk management system increasingly vulnerable. High-cost, high-risk assets such as pumping stations and embankments often remain underfunded, with maintenance driven by budget constraints rather than actual need.

Maintenance investment is prioritised for assets that pose the highest potential consequences if they fail. Assets that fall below the required condition but have minimal direct impact, particularly in terms of immediate risk to life and property, are given lower priority.

The current 'fix-on-fail' approach limits strategic renewal and rationalisation, preventing improvements that would strengthen long-term resilience. As key assets near the end of their foreseeable design life and climate change intensifies pressures, maintenance costs will rise, putting increasing pressure on limited resources.

Without a shift toward proactive investment in asset renewal and replacement, the system's ability to protect the region will continue to erode.

Multifunctional assets present an operational challenge

Alongside all of the vulnerabilities and complexities of the flood risk management system, there are other drivers which must be considered.

Flood risk management assets in the Fens are not only vital for protecting people and property from flooding. They also serve multiple, sometimes competing, functions. Many structures, such as sluices and embankments, must balance flood protection with navigation, environmental quality, and water supply.

This creates complex operational decisions: for example, lowering water levels before a storm can reduce flood risk, but may render channels unnavigable for boats or disrupt habitats that depend on certain water levels. As climate change intensifies seasonal extremes, asset managers face growing pressure to adapt quickly—removing excess water in wet winters, yet conserving it during increasingly dry summers.



Denver Sluice © Mike Todd. Licensed for reuse under the Creative Commons Licence.

Current and future flood risk

The risk of fluvial and tidal flooding is currently managed well, but is set to increase significantly as sea levels and river flows increase.

The Fens is currently well protected from severe flooding by its flood risk management system. This network of assets—including coastal and Main River defences, flood storage areas, and pumped and gravity drainage systems—work together to keep flood risk in the region remarkably low.

In the decades immediately after the significant investments of the 1950s and 60s, flood events were generally infrequent and impacted smaller areas with limited impact on people and property.

However, the climate is changing. In recent years, the system has faced unprecedented stress from increasingly extreme weather. Long wet winters, dry summers and severe storm events have tested the system to its limits, and at times to breaking point.

The continued effectiveness of the flood defence system relies on seamless interaction between assets, which can only be sustained with urgent maintenance investment.

When assets are overwhelmed by exceptional events or breaches, vulnerabilities are exposed. The consequences can be severe, including injury and loss of life, and damage to property, infrastructure, natural habitats and cultural heritage sites.

AEP = Annual Exceedance Probability.

The probability of a certain sized flood event being equalled or exceeded in a given year.

Different mechanisms such as rising sea levels, more intense rainfall, and land subsidence are amplifying flood risks. These challenges manifest as loss of gravity drainage, increased river flows, and increasing risk of salination. As climate related pressures increase, the risk of cascading failures also increases, exacerbating and compounding flood risk.

Each catchment is vulnerable in different ways, but overall it is clear that across the Fens, existing approaches to asset investment, maintenance and renewal are not going to work in the future.

Fluvial flood risk

At present, the Fens benefits from a remarkably low risk of fluvial flooding. This is the direct result of the extensive system of embankments, sluices, and—most critically—washlands and flood storage areas such as the Ouse Washes and Whittlesey (Nene) Washes. These storage areas act as buffers, absorbing excess water during periods of high river flow and preventing rivers from overtopping their banks.

Looking ahead, more extreme rainfall under climate change is expected to increase peak river flows in all catchments across the Fens. According to projections from the UK Centre for Ecology and Hydrology and Defra, by the 2080s, central estimates suggest that peak flows could increase by:

- Witham: 21%
- Welland: 17%
- Nene: 4%
- Great Ouse: 6-19%

As river flows increase, the existing washlands and flood storage areas may no longer be sufficient to manage the higher volumes of water. This means that it may be necessary to create additional water storage areas or expand the capacity of existing ones.

Pumping capacity will also need to be upgraded, which could include adding new or more powerful pumps at existing stations, or introducing additional pumping capability in catchments where water currently drains by gravity. This will have significant operational cost and carbon implications.

Which areas are particularly at risk of fluvial flooding?

The South Forty Foot Drain catchment has the greatest area currently at risk of fluvial flooding. Under a present day 1% AEP event, 41.7km² (41,700ha) is at risk, of which 40.9km² (40,900ha) is Grade 1 and 2 agricultural land. Peak flows in the South Forty Foot Drain will increase 20% by the 2080s, with the area at risk increasing 9%.

Flows in the Main Rivers of the East and West Fens catchment are assumed to increase much more, by 65% over the same period. The East and West Fens catchment is therefore predicted to see the greatest increase in the area at risk of fluvial flooding under climate change, with an additional 15km² (1,500ha) at risk, of which 13.7km² (1,370ha) is Grade 1 and 2 agricultural land.



Branston Island flood storage reservoir on the River Witham © Simon Tomson.

Risk of embankment breach

What existing fluvial models do not account for is the risk of embankment breach, which is a key vulnerability across the Fens due to the age and structural instability of many earthen embankments. Fluvial flooding from embankment breach can occur suddenly and is difficult to predict. Such breaches can release vast volumes of water in a short time, presenting a risk to life and property, with full repairs often being time consuming and costly.

Case study: Failure of the Wainfleet Relief Channel embankment

In June 2019, Wainfleet All Saints saw its wettest day on record. Rising water in the Steeping River breached the embankment, of the Wainfleet Relief Channel, flooding 8.1km² of farmland just before harvest. 88 properties and the Boston–Skegness railway line were affected. It took over 48 hours and 340 tonnes of material dropped by RAF helicopters to seal the breach, costing around £1 million.



Fluvial Flooding at Wainfleet All Saints in June 2019 © Lincolnshire County Council



Flooding from the Steeping River in June 2019 © Richard Hardesty



High flows in the River Nene in November 2012
© Peterborough Images Archive



Overtopping of the Wainfleet Relief Channel during Storm Babet in October 2023 © BBC 2023



Heavy rainfall in Autumn 2023 caused overtopping of drains in the South Forty Foot Drain catchment © Black Sluice IDB



Overtopping of the Wainfleet Relief Channel in October 2023 threatened the operability of Thorpe Culvert Pumping Station © Environment Agency

Tidal flood risk

Tidal flooding is caused by high tides, storm surges and wave action. Current tidal flood risk in the Fens is limited to the most extreme events and to land near the coast. Under a present day 0.5% AEP event, a total of 39.9km² (3,990ha) is at risk of flooding, including 13.2km² (1,320ha) of Grade 1 agricultural land. Protection against more severe tidal flooding is provided by the 271km of embankments along the coast and tidal rivers, and the sluice structures which prevent tides moving further upstream.

However, tidal flood risk is expected to increase significantly over the next 100 years due to sea level rise. The 2010 Northern Area Tidal Model assumes that sea level will rise by 1.1m up to 2115. When this climate change allowance is added to the 0.5% AEP event with existing flood defences in place, the area at risk of tidal flooding across the Fens increases to 382km² (38,200ha) – representing more than an eight-fold increase. The area of Grade 1 land at risk in this scenario is 209km² (20,900ha), representing more than a fourteen-fold increase against the present-day scenario. This demonstrates that tidal flooding will disproportionately affect area of the best and most versatile agricultural land.

Under the Environment Agency's more recent 'Higher Central' and 'Upper End' allowances for climate change, sea level could rise by between 1.2m and 1.6m by 2125. This suggests that flood risk will be significantly higher in the future than the model predicts.

Higher sea levels will increase the risk of tide-locking at key outfalls such as Dog-in-a-Doublet Sluice and Grand Sluice. Tide-locking means that water cannot be discharged from the rivers and places increasing pressure on embankments upstream which must contain greater volumes of water for longer periods.

Managing the increasing risk of tidal flooding in the Fens in a way that is sustainable and adaptable to future sea level rise will require a coordinated approach that aligns with the Shoreline Management Plan (SMP).

Which areas are particularly at risk of tidal flooding?

Changes to tidal flood risk are not the same across catchments. Under a current 0.5% AEP event, the Great Ouse catchment has the greatest area at risk of tidal flooding, at 14.6km² (1,456ha). This includes 0.6km² (60ha) of Grade 1 agricultural land. Under climate change, this area roughly doubles, to a total of 31.3km² (3,130ha) at risk.

This increase is significant, but it is dwarfed by the increase in tidal flood risk predicted for the East and West Fens catchment. Modelling shows that this catchment has the greatest projected increase in tidal flood risk during a 0.5% AEP event with existing defences in place. Under the present-day scenario, 12km² (1,200ha) is at risk in the East and West Fens catchment, but when 1.1m of sea level rise under climate change is applied, the area increases twenty-fold to 230km² (23,000ha). This is greater than the area at risk in the all of the other Fens 2100+ catchments combined, under the same scenario.



Tidal flooding of agricultural land near Wrangle in December 2013 © Environment Agency

The total area at risk of tidal flooding across the Fens when climate change is applied to the 0.5% AEP event, even with current defences in place, is

382km²

Compared to the present-day, this represents an

8.5 fold increase

60%

of the total area at risk of tidal flooding with climate change applied is located within the East and West Fens catchment.



Evacuation of homes in Boston during the 2013 tidal surge © BBC 2023

Salinisation risk

Tidal inundation of agricultural land, exacerbated by seepage of saltwater from rising groundwater, can increase the concentrations of salt within the soil. Salt is an essential mineral for crop growth, but at high concentrations can degrade soil quality—slowing growth, reducing yields, and even causing crop failure. This can have long lasting impacts on productivity of the land.

Case study: 2013 tidal surge

On the 5th December 2013, a 6m tidal surge along the east coast of England devastated coastal communities. Over 800 properties were flooded in Boston across 55 streets after the tide overtopped defences along The Haven. The earthen coastal defences at Wrangle, known as the Wrangle Sea Banks were also breached by the surge.

The event prompted several improvements to the tidal defences. In 2018, 6km of the Wrangle Sea Banks were raised to a height of 7.2m, improving the protection of 438 properties and 34km² (3,400ha) of prime farmland against tidal inundation.

To safeguard Boston, the Boston Barrier was completed in 2020. The 28m-wide, 11m-high rising sector gate now protects over 14,000 properties.



The Boston Barrier © Environment Agency

Groundwater flood risk

Groundwater flooding happens when the water table reaches the ground surface. It is often overlooked because it typically coincides with fluvial and surface water flooding, but it can significantly worsen flood impacts. Across the Fens, groundwater flood risk is generally low.

Waterlogged soils can reduce crop production and if prolonged, waterlogging can lead to soil erosion, salinisation, and loss of soil structure.

Surface water flood risk

Surface water flooding happens when heavy or prolonged rainfall creates runoff that overwhelms drains, sewers, or watercourses. It also occurs when drainage systems are blocked, saturated, or lack capacity. In the Fens, many localised areas are at risk, as shown in the Environment Agency's 'Risk of Flooding from Surface Water' dataset.

Climate change is expected to increase rainfall intensity, raising the risk of surface water flooding. Low-permeability land is especially vulnerable, so urban development is likely to make the problem worse. In pumped drainage catchments, this can clash with the ambition for short, efficient pumping cycles to control energy use and costs.



Surface water flooding of East Fen during Storm Babet in October 2023

© Witham Fourth District IDB



Surface water flooding in Pinchbeck following heavy rainfall in August 2022

© Lincolnshire Online

Reservoir flood risk

Historically, parts of the Fens have been affected by reservoir flooding. In March 1947, the North Level barrier bank of the Crowland and Cowbit Washes failed, flooding more than 40km² (4,000ha) of the North Level.

The Reservoirs Act (1975) now requires reservoirs and associated structures to be maintained to the highest standards, meaning the risk of reservoir flooding through failure is now very low.

Currently the risk of reservoir flooding in the Fens relates primarily to reservoirs upstream of the Fens boundary, but within the Fens the flood storage areas which pose a risk (albeit a very low one) include the Whittlesey (Nene) Washes, the Ouse Washes, and the Crowland and Cowbit Washes.

Two additional reservoirs in the Fens have been proposed by Anglian Water. These will be built to the highest modern standards and are therefore expected to present very low risk.



Breach of the Crowland and Cowbit Washes in 1947 © Peterborough Images Archive.

Historic flood events timeline

1947

Following rapid snow-melt, high flows in the River Welland caused a breach of the South Barrier Bank of Crowland Wash, causing sudden flooding of 85km² (8,500ha) of prime agricultural land.

1953

A severe North Sea tidal surge killed many people along the East Coast, including 15 people in King's Lynn.

1978

On 11th January, a tidal surge reached 5.6m AOD, causing a 40m section of flood defence wall in Boston to collapse, flooding 180 properties.

1998

The Easter floods of 1998 devastated the Fens, after a month's rain fell in a day on already wet ground.

2007

Heavy rainfall led to high river flows across the country. The Steeping River overtopped at several locations.

2013

On 5th December, a 6m tidal surge breached embanked defences in Boston, damaged rare freshwater habitats at Gibraltar Point. Three pumps at Black Sluice Pumping Station were damaged.

2019

A breach of the Steeping River caused 88 properties to be internally flooded.

2023

Storm Babet brought persistent rain, causing fluvial and surface water flooding across the Fens. The Steeping River overtopped at several locations.

2024 and 2025

Heavy rainfall on top of storm events led to highest ever recorded levels, and fluvial flooding in January of both years. In 2024, 56 properties were flooded, then in 2025 over 30 properties were flooded in the South Forty Foot Drain catchment.

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 Service 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.

Under this ‘Maintain’ scenario, damages caused by extreme flood events (which exceed the Standard of Service offered by current defences) are

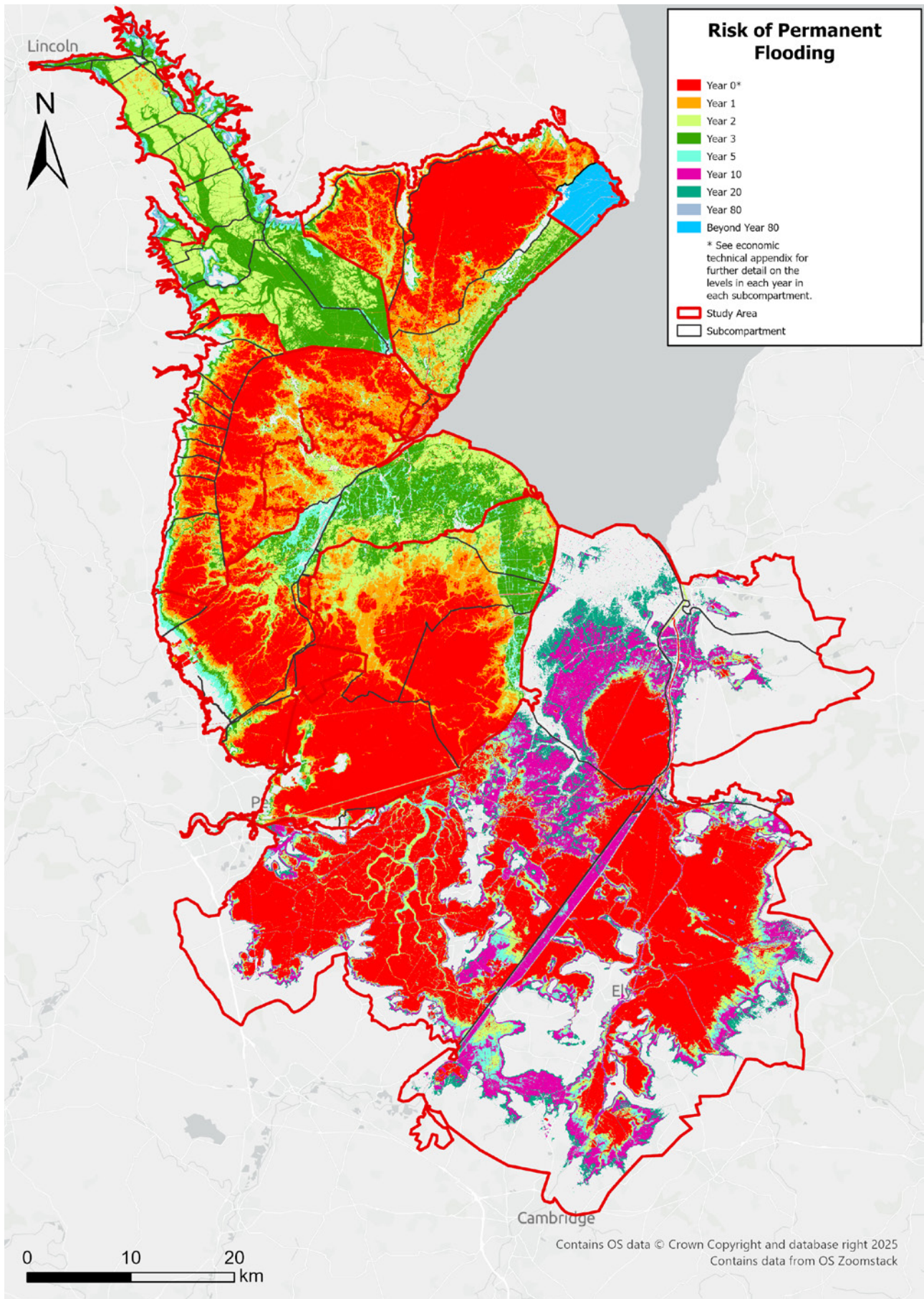
£2.1 billion

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. As a result, much of the Fens would be flooded within the first ten years.

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).

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



This map represents the 'Do Nothing' Scenario, illustrating land at risk of permanent inundation if we stopped pumping and maintenance.

Damages avoided by investment

If all flood risk management activities ceased ('Do Nothing'), flood damages across the Fens over the next 100 years would exceed £60 billion, with £56.9 billion of this in the first ten years*.

£7.9 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.

Over 2,020km² (202,073ha)

of arable land written off in the 'Do Nothing' scenario

£36.6 billion

Properties

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

Over 99,000

residential properties written off in the 'Do Nothing' scenario, costing **£28.4 billion**

Over 29,000

non-residential properties written off in the 'Do Nothing' scenario, costing **£8.1 billion**

£905.3 million

Environment & recreation

Loss of over 37km² (3,700ha) of environmentally designated sites across the Fens 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 over 22km² (2,200ha) of recreational sites and over 500km of public rights of way.

£217.5 million

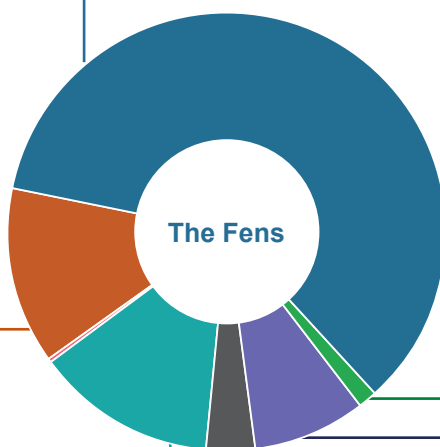
Heritage

Cost of the loss or damage of over 400 heritage assets as a result of flooding. The catchment contains over 1,200 Listed Buildings and 100 Scheduled Monuments.

£35.5 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 over 188,000 jobs being lost across the Fens under a 'Do Nothing' scenario. GVA is a local/ regional benefit so cannot be included in application for Grant in Aid funding.



£5 billion

Utilities

Captures the impacts of flooding to power, water supply, and gas networks. This includes damage to more than 6,700 substations, 22,000 pole towers, 100km of underground gas pipelines, and 450km of power cables.

£8.1 billion

Transport

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

Loss of over **260km** of road infrastructure, costing **£6.6 billion**

Loss of over **150km** of rail infrastructure, costing **£1.5 billion**

£2.2 billion

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.

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

The benefits of investment

Current flood risk management assets maintain £58.8 billion of benefits, including protecting properties, agriculture, and transport networks.

What is the economic benefit of the current flood risk management assets?

Living and working in the Fens is only possible because of the flood risk management and water level management assets, such as pumping stations and embanked defences. These assets provide £58.8 billion of benefits through avoided flood damages to agriculture, property, transport infrastructure and utilities. They also deliver indirect benefits through avoided losses to the local economy and to secure the rich natural capital assets across the Fens, worth £500 million.

The investment needed to sustain the existing flood defences has been estimated at £6-£9.4 billion. This does not include the investment needed to upgrade assets to increase their resilience to 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. 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 report demonstrate the critical importance of a strategic plan for the future of flood risk management within the Fens.

£6-£9.4 billion

The total investment needed to sustain the current Standard of Service for 100 years. This does not include the investment needed to upgrade assets to increase their resilience to climate change.

50% of this investment is needed within **40 years**

The costs, impacts and management approach are illustrative of the scale and complexity of the investment challenge within the Fens. They provide a starting point for business cases and Partnership development of future programmes and projects.

What is the evidence telling us?

Value built on legacy

The Fens landscape has been transformed by human influence. The scale of change has been so significant it required several Acts of Parliament. The legacy asset system we have today reflects past approaches to land drainage and flood risk management, which has been very successful in creating and maintaining a highly productive agricultural landscape and keeping people safe. The concentration of Grade 1 land means the agricultural value created here could not be offset somewhere else in the UK.

Critical infrastructure under pressure

This landscape value is enabled by more than 17,000 interconnected assets, managed by different organisations for many purposes. This means collaboration and shared understanding of the system is essential.

Many assets are outdated, built before modern engineering standards, and working at the limits of their capacity. Maintenance is often reactive and does not address increasing demands of future climate and land-use change. RMAs currently make difficult decisions about which maintenance activities to prioritise.

High-cost, high-risk assets remain underfunded. Budget constraints are preventing the kind of strategic renewal or rationalisation that could improve performance and reduce long-term costs.

Climate change will increase future risk. Loss of gravity drainage and compounding risks from sea level rise and more frequent extreme weather events will place pressure on flood risk management assets to deliver the same Standard of Service. Increased rainfall and storm events are expected to increase river flows by 4-21% by the 2080s, and 1.1m of sea level rise is expected to cause an 8.5-fold increase in the area at risk of tidal flooding by 2125.

If essential flood risk assets fail, the consequences will be catastrophic, risking lives, land, businesses and infrastructure. Vast areas would become permanently inundated. Business as usual cannot support effective flood risk management.

Urgency

We must invest in asset maintenance and renewal now to secure the legacy value we already have. We need to plan for assets across the system which are nearing or have exceeded their foreseeable design life. The risk of cascading failures is growing as these assets degrade in parallel. By 2040, 31% of flood risk management assets will be beyond their foreseeable design life, reaching 89% by 2075. Around £6-9 billion of public and private investment is needed to sustain the current system for 100 years.

And while we are investing to secure our existing assets, we must do so with the forethought of what is needed to upgrade systems to meet growing climate change risks, or to unlock transformation across the landscape, including aligning with the SMP.

Considerations for each catchment

The catchment baseline reports reveal shared challenges, but indicate that effective solutions must take into account the distinct characteristics of each catchment.

Steeping

- The area at risk of tidal flooding will increase ten-fold under climate change.
- The embankments of the Wainfleet Relief Channel are vulnerable to overtopping during periods of high flow.

East and West Fens

- The area at risk of tidal flooding will grow seventeen-fold under climate change, affecting over 55% of the catchment, across prime Grade 1 and 2 agricultural land.
- Management of the increasing risk of tidal flooding should align with the SMP.

Lower Witham

- Projected increase in peak river flows of 21% by the 2080s, without plans for additional flood storage in place.
- 300km of embankment assets have medium to very high risk of failure, with 7% at very high risk of failure.

South Forty Foot Drain

- The catchment is divided into more than 25 pumped sub-catchments, with the smallest covering just 4km² (400ha). There is potential to rationalise the number of pumping stations to reduce the number of assets which need to be inspected and maintained.

Lower Welland

- Peak river flows are projected to increase 17% by the 2080s.
- The Crowland and Cowbit Washes are currently under-utilised. There is potential to unlock greater volumes of flood storage to alleviate fluvial flood risk.

Lower Nene

- The current risk of tidal flooding is low, but a thirty-fold increase in area at risk is projected under climate change.
- A decision about the future of Dog-in-a-Doublet Sluice is required now. The choice of location for the tidal limit will affect the wider asset system.

Great Ouse

- The Denver Sluice complex is critical for controlling water across the catchment and affects the security of King's Lynn. All structures at the site need to be modernised, with better capability to monitor what is happening across the catchment in real time.

Glossary of terms and acronyms

Above Ordnance Datum (AOD)

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).

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.

Assets

In the context of this report, assets refers to a structure built or created within the landscape and maintained specifically for water management purposes, for example embankments, sea walls, pumps and flood storage areas.

Asset Information Management System (AIMS)

A dataset 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.

Damages

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

Design life

Describes the original life expectancy of an asset at the time of its original design. This will be based on the standard of design applied to the asset.

Ecosystem services

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

Fens 2100+ study area

For the purposes of the Fens 2100+ Programme, the study area has been defined by land at or below the 6m AOD contour, which may differ slightly from the hydrological catchment.

Flood risk management assets

In the context of this report this refers to a structure built or created within the landscape and maintained specifically for water management purposes, for example embankments, sea walls, pumps, flood storage areas.

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.

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.

Resilience

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

Shoreline Management Plan (SMP)

Shoreline Management Plans (SMPs) outline a strategic approach to managing flood and coastal erosion risks through to 2105. The Policy Development Zone (PDZ) of particular relevance to the Fens is PDZ1 Gibraltar Point to Wolfreton Creek, where the intention is to hold the position and function of existing coastal flood defences. In the medium and longer term, managed realignment may be required.

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.

