Fens 2100+

Lower Welland

Baseline economic appraisal report

2025

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1. Executive Summary

As part of the Environment Agency collaborative delivery framework (CDF), Ove Arup and Partners Ltd (Arup) have been commissioned to present an economic baseline for the Lower Welland catchment, with reference to current and future flood risk management. This report presents an evaluation of key receptors at risk of flooding across the catchment and focuses on defining broad economic impacts. The project focuses on the extents of the Lower Welland catchment. The catchment is situated in East Lincolnshire at the centre of the wider Fens 2100+ study area, bordering the Lower Nene and South Forty Foot catchments. The catchment is protected by flood risk assets predominantly operated by the Environment Agency; Welland and Deepings, North Level District and South Holland Internal Drainage Boards (IDBs); and other risk management authorities.

This economic assessment has focused on quantitively defining high-level impacts to a series of the key receptors at risk, including:

- Residential Properties;
- Non-residential Properties;
- Agriculture;
- Environment & recreational sites;
- Heritage;
- Highways;
- Rail;
- Gas;
- Electricity;
- Isolated Properties;
- Mental Health;
- Emergency Service costs;
- Risk to life;
- Evacuation and temporary accommodation costs;
- Vehicle damages;
- Health service disruption;
- Educational disruption;
- Intangible impacts to human health;
- Utilities disruption; and,
- Local losses to the economy as Gross Value Added.

The Do-Nothing baseline scenario identifies present value damages of up to £9,313 million across the catchment extents over a 100-year period. This is compared to the residual damages estimated to occur with existing flood risk management arrangements of £381

million. Based upon the analysis, the present FRM arrangements and activities across the catchment are estimated to afford a benefit of £8,932 million to the Lower Welland catchment. Without these activities to reduce flood risk and manage water levels in the catchment, the study area is at risk of permanent inundation – impacting across the natural, social, economic, human, intellectual and manufacturing capitals. The analysis demonstrates that there is a case for flood risk management in the long term, but the optimal flood risk management regime has not yet been determined. With a benefit cost ratio of 13.59, maintaining the existing flood defences within the Lower Welland catchment has a Partnership Funding score of 83% and is eligible for £544 million in Grant in Aid, which leaves a funding gap of £113 million.

1.1 Glossary

Table 1-1: Glossary of economic terminology

Terminology	Summary Definition
Scenario	A scenario is defined as a representation of what flood risk could be based on an explicit set of assumptions. This can include multiple flood mechanisms. For example, in a Do Nothing scenario all risk management authorities would walk away from operation and maintenance of their flood risk management assets leading to more extensive flooding of communities beyond the status quo. This could be made up of a combination of overtopping of defences, breach, or other flood mechanisms.
Standard of Protection (SoP)	At a given point in time, the Annual Exceedance Probability (AEP) of a flood event which an asset is able to withstand. SoP will vary over time.
Standard of Service	The physical attributes or output of an FCERM asset or service usually set out in a design specification. For example, the height of a wall or barrier, the pumping capacity of a pump, the scale, extent and frequency of a service. The standard of service does not change over time as a result of impacts such as climate change whereas the SoP does.
Receptor	A receptor is defined as something that is affected by a flood. For example, a residential property in the floodplain would be a receptor.
Appraisal period	The appraisal period is the length of time where damages, benefits, and costs are calculated for a particular intervention.
Discounting	Discounting is a method of converting future costs and benefits with different time spans to a common “present value” basis using a discount rate. HM Treasury discount rates are used, which adjust for social time preference, defined as the value society attaches to present, as opposed to future consumption. The rates are based on comparisons of utility across different points in time or different generations.
Present Value	Values expressed in today’s terms following relevant discounting.
Cash	Values expressed in today’s terms not discounted.
Damages	The value of negative social, economic and environmental impacts caused by flooding.
Benefits	The positive quantifiable and unquantifiable changes that a flood risk management scheme is expected to produce, i.e. damages avoided
Write off	Write-off is losses to an asset deemed unrecoverable

2. Introduction

2.1 Aim and purpose of this document

This document presents a catchment-scale economic baseline for the Lower Welland catchment as part of the Fens 2100+ Project 3 baselining, with reference to the current flood risk management regime. This report details the baseline scenarios assessed, the methodology utilised in the economic appraisal, costs associated with maintaining the status quo within the catchment, as well as a summary of the results.

The appraisal approach follows the principles developed as part of the previous work undertaken on the Great Ouse[1] but utilising latest available data and with changes to approach following subsequent reviews and work on the Lower Witham[2]. Details of methodologies have been consulted on and agreed with key stakeholders.

Along with the suite of Fens 2100+ documents, this report aims to build the evidence required to support investment certainty in the short term, clarity of actions in the medium term, and shared confidence for the long term. This will support RMAs and partners in securing the essential national and regional investment to ensure future flood resilience through delivery of the right projects, in the right places, at the right time.

This project has sought only to produce a baseline economic appraisal. At this stage, no Do Something options have been considered.

2.2 Catchment context

The Lower Welland catchment (hereafter referred to as “the catchment”) covers an area of approximately 473km^2 of primarily rural, highly productive agricultural land. The catchment is situated in east Lincolnshire at the centre of the wider Fens 2100+ study area, bordering the Lower Nene catchment to the south and the South Forty Foot catchment to the north, with The Wash to the north-east. It is noted that this is not necessarily a hydrological catchment but is defined as a catchment for the purposes of the Fens 2100+ work.

The catchment’s low-lying terrain is typical of the wider Fens with most of the land lying just approximately 3m above sea level Much of the catchment area consists of reclaimed wetlands and peatlands dominated by highly productive agricultural land.

The market town of Spalding sits centrally in the catchment. There are also several smaller settlements within the catchment including Pinchbeck, Surfleet, Deeping Saint Nicholas, Gosberton and Holbeach. Connectivity within the catchment is supported by key transport routes, such as the A17, A16, A151 and A1175, and the railway station at Spalding which links the town to Peterborough and Sleaford.

The catchment area has a total population of approximately 75,443.

[1] Environment Agency (May 2020). Future Fens Flood Risk Management Economic Appraisal Report

[2] Arup (September 2024). Lower Witham Flood Resilience Project Economic Appraisal Baseline Report

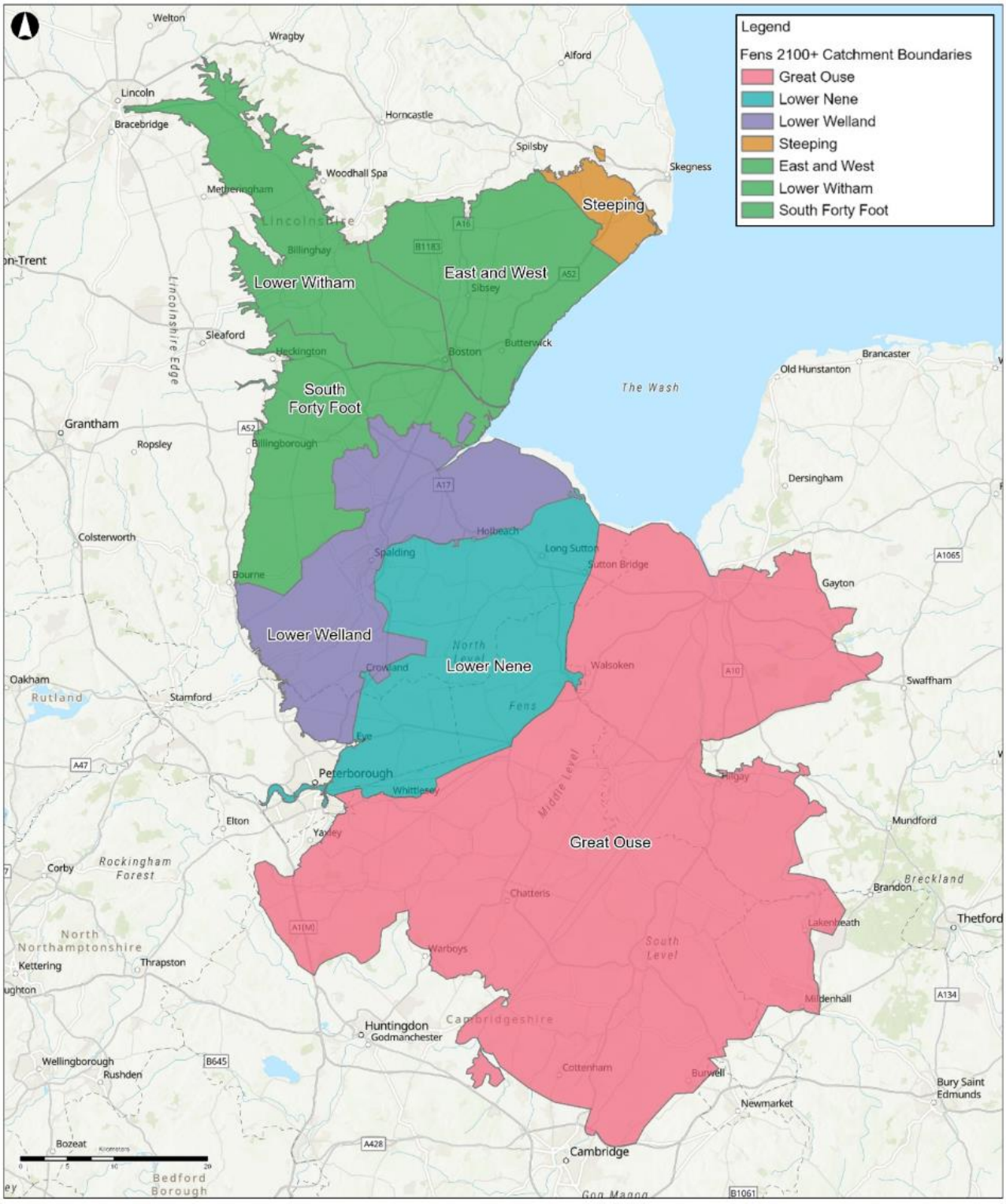

Figure 1: Catchments covered within the Fens 2100+ economic appraisal

2.2.1 Drainage network

The catchment relies on a complex network of watercourses, pumping stations and sluices to protect the land from flooding.

The River Welland and River Glen are both designated as Main Rivers, giving the Environment Agency permissive powers to carry out maintenance works and regulate

activities to reduce flood risk arising from these watercourses. The primary watercourse within the catchment is the River Welland, rising in the Hothorpe Hills of Northamptonshire. The Welland collects urban run-off from northern Peterborough before flowing north-eastwards to Spalding. Here, the artificial Coronation Channel (also a Main River) diverts all of the flow of the Welland around the town, and the structures of Fulney Lock and Marsh Road Sluice mark the tidal limit on the two channels. It is noted that Fulney Lock does not allow gravity outfall. The river eventually discharges into The Wash a further 20km downstream of Spalding.

The Environment Agency undertake a rolling programme of maintenance to protect and maintain the condition of the existing defences, including embankment strengthening and restoration.

Alongside the Main Rivers, there is a much more extensive network of drainage watercourses managed by the Welland and Deepings IDB, South Holland IDB and North Level District IDB. Welland and Deepings IDB district is almost entirely within the Lower Welland catchment. Around a quarter (the north-western portion) of the area covered by South Holland IDB sits within the Lower Welland catchment. Only a small portion of the area covered by North Level District IDB sits within the Lower Welland catchment.

The three IDBs each own and operate a drainage system that sits either fully or partially within the Lower Welland catchment. These drainage systems consist of a network of assets including watercourses and their accompanying culverts and embankments, along with sluices and pumping stations. The main IDB watercourses include the Vernatts Drain, North Drove Drain, and South Drove Drain, which all carry water to the River Welland from the south-west portion of the catchment, known as Deeping Fen. Each of these watercourses is managed by Welland and Deepings IDB.

The IDB systems are maintained to ensure drainage of the study area. A number of on-going operation and maintenance activities are undertaken by IDBs, including pumping station operation/maintenance, channel dredging/clearance, and reinstatement of embankments.

2.2.2 Asset schematisation

A graphical schematisation of the catchment has been produced to provide additional context to this section. This is shown on Figure 2.

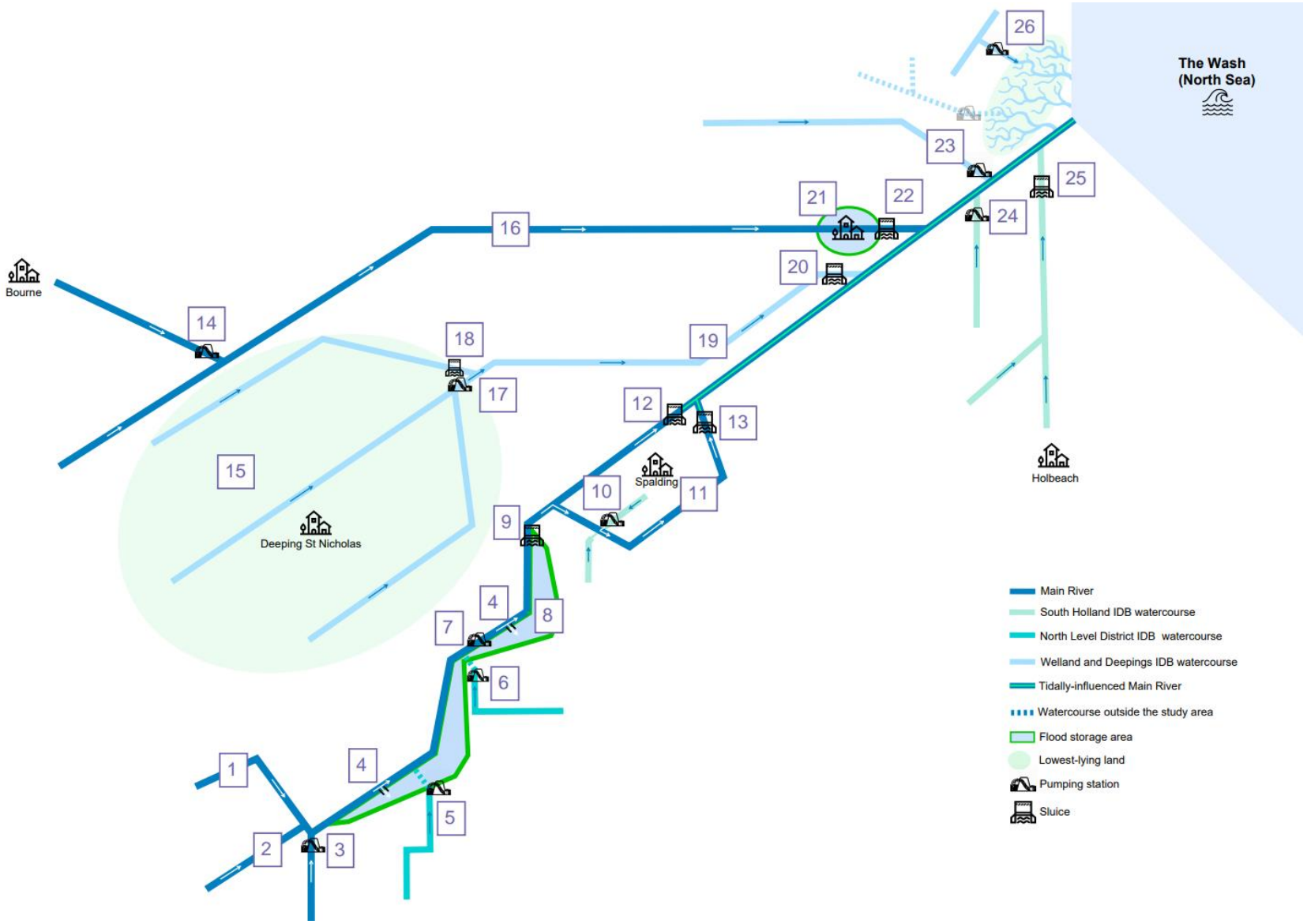

Figure 2: Schematisation of the flood risk assets in the Lower Welland catchment

1 **River Welland**
Main River
Tidal as far inland as Marsh Road Sluice.

2 **Maxey Cut**
Main River
Upstream of the study area, it diverts a proportion of the River Welland's Flow, rejoining the River Welland upstream of the 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 approximate natural tidal limit of the River Welland before Marsh Road Sluice was constructed.

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

8 **Crowland and Cowbit Washes**
Environment Agency & Partners
Registered under the Reservoirs Act 1975, the Washes function as a flood storage area, with the EA acting as Undertaker. 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.

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 Coronation Channel.

14 **Bourne Eau Pumping Station**
Environment Agency
Lifts water coming from Bourne via the Bourne Eau upwards into the River Glen.

15 **Deeping Fen**
A particularly low-lying area in the south-west of the catchment.

16 **River Glen**
Main River
Between its confluence with the Bourne Eau and the village of Surfleet, it marks the northern boundary of the Welland catchment.

17 **Pode Hole Pumping Stations**
Welland and Deepings IDB
Deeping St Nicholas Pumping Station and Adventurers Pumping Station lift water from from the North Drove Drain and South Drove Drain into the Vernatts 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 **Vernatts Drain**
Welland and Deepings IDB
Carries water from Deeping Fen towards its outfall at Surfleet Sluice.

20 **Vernatts Sluice**
Welland and Deepings IDB
Marks the tidal limit of the Vernatts Drain, and allows water to flow out of the drain into the 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 River Welland 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.

2.3 Study context

The catchment is heavily engineered with flood defence embankments and flood defence walls, in addition to the assets including pumping stations, which are essential to the water level management across large areas of the catchment. Drainage works and embanked watercourses perched above the surrounding land have enabled highly productive arable land to be farmed and communities to be established in the area. The farmland is some of the highest-grade agricultural land in the country with around one-third of land classified as Grade 1.

Figure 3: Deeping St Nicholas Pumping Station at Pode Hole

2.4 Description of flood risks

Flood risks in the Lower Welland catchment are influenced by a complex interplay of assets and water flows between catchments, making prediction and management challenging.

The key sources of flooding in the area include river flooding from the River Welland and Nene during periods of heavy rainfall, as well as tidal and coastal flooding. South Holland IDB relies heavily on sea bank protection and has transitioned from gravity led drainage to pumping systems due to siltation in the marsh. Maintenance activities, such as cutting channels for water conveyance, are crucial, and recent refurbishments have included fish-

friendly pumps. Flood water storage on Grade 1 agricultural land is not feasible, and salinity in drains poses a threat to agriculture, necessitating regular monitoring.

2.5 Historic flooding

There is a history of significant flood events across the Fens 2100+ study extents. Prior to the 1600s, the wider Fens were formed of low-lying marshland with conurbations on islands of higher land. Historic flood events, within living memory, are outlined in Table 2-1. These events highlight the catchment's vulnerability in the absence of effective performance and operation of assets.

Table 2-1: Historic flood events

Date	Source of flooding	Details
1947	Fluvial	"The winter of 1946/47 was one of the coldest in living memory with long periods of freezing temperatures. This was accompanied by the worst snowfall for seventy years. Then in the second half of March came a rapid thaw and widespread flooding. The combined effect of melting snow and rain amounted to up to 4.5 inches (~115mm) - the equivalent of a 24 hour long heavy thunderstorm3. The first breach occurred on the River Glen near the old Counter Drain station and flooded the Tongue End washes. It is not clear where the Tongue end washes are, however, there is a settlement called Tongue End on the right bank of the River Glen on Counter Drain Drove, and it is assumed that this breach occurred near this location. Two days later, a 50-yard-wide breach formed in the North Level Barrier Bank on the side of the Cowbit Wash between Brotherhouse Bar and Crowland, leading to severe and sudden flooding4. The subsequent flood water surrounded Crowland. The River Welland Major Improvement Scheme was initiated by the catchment board as a result.
February 1994	Fluvial	In February 1994 there was out-of-bank flooding of the River Glen at Surfleet Reservoir. Several properties on the left bank experienced flooding.
April 1998	Coastal / tidal	Overtopping of the River Welland occurred between Crowland and Cowbit in Easter of 1998, flooding areas of farmland. Localised flooding was also recorded at Surfleet Reservoir, impacting a number of properties.
April 2018	Fluvial	Heavy rainfall over the River Glen catchment and high tides led to the flooding of the gardens of some properties at the Surfleet Reservoir.
2020	Fluvial	An IDB representative observed flooding which overtopped and seeped through the Cradge Bank and the Crowland and Cowbit Washes. Some water overtopped the siphons, but they did not fully prime. Agricultural land was flooded, but there was no flooding to property.

[3] South Holland Heritage (2023) Floods couldn't defeat South Holland's Spirit – Memories of 1947 Flood. Available at: https://www.heritagesouthholland.co.uk/article/floods-couldnt-defeat-south-hollands-spirit-memories-1947-flood/ Accessed: March 2025

[4] South Holland Heritage. 1947 Floods. Available at: https://www.heritagesouthholland.co.uk/article/1947-floods/. Accessed: March 2025

January 2021	Fluvial	In January 2021, a number of properties were flooded at Surfleet Reservoir due to a combination of high tides and pumped water from the Bourne Eau system.
January 2024	Fluvial	Storm Henk caused severe flooding in the catchment, as rain fell on already-saturated ground. The River Welland breached its banks near Crowland and Cowbit. This resulted in the flooding of agricultural land in the catchment.
February 2024	Fluvial	High flows occurred on the River Glen, coinciding with high tides, and led to flooding in Surfleet

2.6 Existing flood risk assets, operation, and maintenance

The defences are essential, highly engineered assets which are of critical importance to the sustainability of the economy of the catchment and the people that reside within the catchment. Without these defences and the IDB assets (including pumping stations which drain large areas of land), much of the area would be marshland, regularly inundated by the sea.

Water levels are effectively managed through a network of pumping stations, sluices, and flood storage areas to manage navigation and mitigate flood risk. Some structures such as Surfleet Sluice serve a dual purpose, controlling flows whilst also allowing recreational vessels to pass through. The River Welland is navigable 36km inland of The Wash, and the River Glen is navigable up to Tongue End, although the locks in the catchment can only be opened at certain tide levels.

The Environment Agency undertake a rolling programme of maintenance to protect and maintain the condition of the existing defences, including embankment strengthening and restoration. The IDB systems are maintained to ensure drainage of the study area. A number of ongoing operation and maintenance activities are undertaken by the IDBs, including pumping station operation/maintenance, channel dredging/clearance, and reinstatement of embankments.

Within the catchment, Welland and Deepings IDB own and operate fourteen pumping stations, North Level District IDB own and operate three next to the Crowland and Cowbit and Crowland Washes, and South Holland IDB own and operate six.

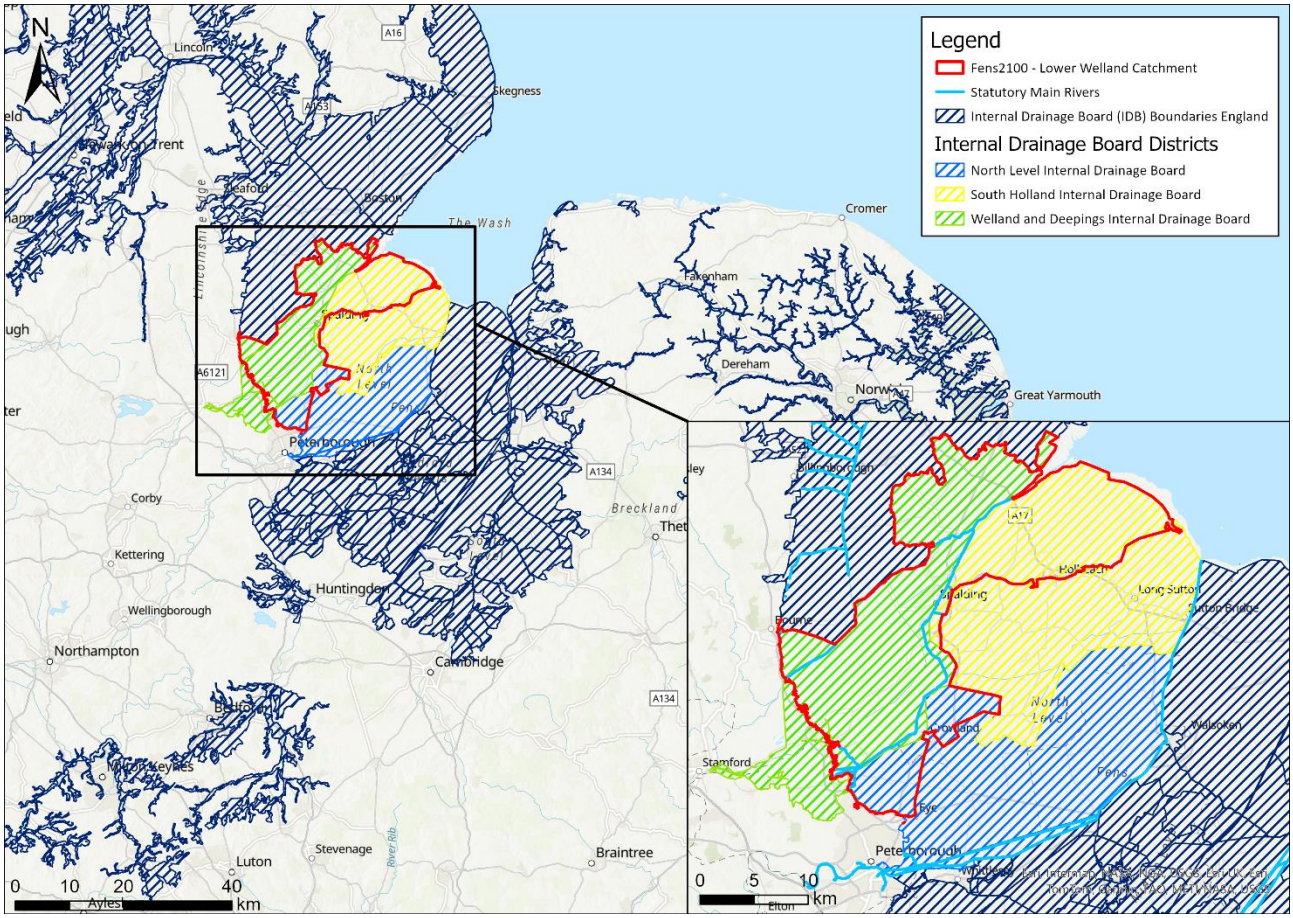

Figure 4: Internal Drainage Boards in the Lower Welland catchment

3. Economic Appraisal Baseline Scenarios

The objective of this economic assessment is to provide a broad assessment of key receptors at risk for the Lower Welland catchment. The economic baseline is identified as the Do-Nothing scenario. Further analysis of the present flood risk management arrangements (the Maintain scenario) is undertaken to evaluate the existing protection and residual risk with the current flood mitigation measures in place, and the benefits of continuing to maintain the existing asset base. The scenarios to be utilised within this appraisal are described within the following sections.

3.1 Do-Nothing scenario

3.1.1 Definition

Due to interdependent activities in managing flood risk across pumped catchments, the cessation of Flood Risk Management activities will lead to relatively rapid inundation of the catchment from water which is unable to drain to the River Glen or the River Welland.

Under the Do Nothing scenario the pumping stations would cease operating resulting in water being unable to drain and the rainfall would start to fill the catchment. In addition, the sluices on the main rivers would cease to operate and cause the rivers to back-up. Extreme flood events on the rivers will cause additional flooding that cannot drain away. There will be some loss of water over summer due to evaporation and transpiration, however the water levels would rise steadily over a few years. Sea defences are assumed to be robust and unlikely to fail in the short term. When the water levels in the catchment are high enough they would spill over the sluices and embankments into neighbouring catchments or main rivers.

A rate of catchment fill of 0.5m per year is applied for the Lower Welland catchment. This has been taken from the Lower Witham study[1]. This rate was estimated based on the average rainfall minus an allowance for evapotranspiration and infiltration. It is assumed that water levels in the catchment will increase by the net rainfall per year, and will be unable to drain, therefore, resulting in permanent inundation of land, properties, and infrastructure.

The limiting level to which the Lower Welland catchment fills is defined at an individual catchment level, based on the level of Mean High Water Springs (MHWS) because there is a tidal influence and high ground and main river embankments are above this level. An illustration of the limiting level for the Lower Welland catchment is shown in Figure 5.

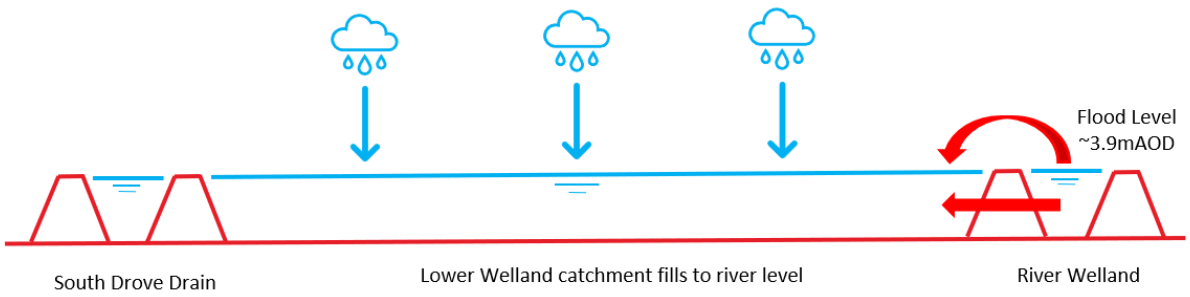

Figure 5: Illustration of the Do-Nothing scenario limiting levels for the Lower Welland catchment

3.1.2 Key assumptions

For the purpose of the baseline economic appraisal, the Lower Welland is assumed to be frequently or permanently inundated to the water levels defined by the limiting level, with the rate at which this is achieved based on the rainfall estimates for the catchment. Before properties, land, and infrastructure fall below these water levels, they will be subject to risk from extreme events. This risk is represented using the best available data for the catchment.

A local model is not available and, thus, a Weighted Annual Average Damages approach is applied for assessment of damages outside of the permanently flooded area. This approach is defined in the Multi-Coloured Manual[2].

The median ground level across each sub-compartment is taken from LiDAR DTM data to determine a suitable starting point from which water can be assumed to fill the catchment. The starting points to be used are assessed for each sub-compartment individually. The rounded starting levels for each sub-compartment and subsequent fill over time to each of their limiting levels can be seen in Table 3-1.

The limiting levels will vary over time. Initially the limiting levels will be determined by the height of the banks on the main rivers; this is the level which the flood water will need to reach before it can spill back into the main rivers and be carried away to The Wash. However, under the Do Nothing these barrier banks on the main rivers will not be maintained and therefore over time will breach, removing this initial limiting level. Once the main river barrier banks breach the limiting level will effectively revert to being the tidal level. Whilst the timing of the failure of the main river barrier banks under the Do Nothing approach with no further maintenance or repairs will vary between locations it is likely to occur in the short to medium term.

To simplify the assessment a limiting level based on MHWS has been used which is much less than the height of the barrier banks and the 33.33% AEP event tidal level. The tidal limiting level of 3.9m AOD has been applied throughout the appraisal period. This assumption is reasonable as the limiting level is likely to be reached within 5-10 years. This 3.9m AOD MHWS level was derived specifically for The Wash using tidal levels from Boston as part of 2020 updates to the Tidal River Nene model[5].

[5] Arup (April 2020). River Nene Modelling Update – Derivation of Updated Tide Curve

Increases of flow and rainfall as a result of climate change have not been considered due a lack of modelling data to inform the assessment at this stage. Whilst it is acknowledged that sea level rise will lead to an increase in tide locking periods preventing fluvial discharge to the sea, no allowance has been made for sea level rise in this assessment. Due to the nature of the Do Nothing scenario, it is considered the impact on the damages assessment would be marginal if climate change were incorporated. Sensitivity analyses have been undertaken to test key assumptions around fill rates and maximum water levels to give confidence in this approach.

These assumptions follow the method statement[6] agreed with the Fens teams and were communicated to key stakeholders.

3.1.3 Flood extents

Based on the assumptions described above, indicative flood extents are generated for the Lower Welland by GIS analysis. This involves the use of LiDAR data to define a series of flood extents for specific flooded water levels, i.e., elevation levels (m AOD). The flood extents represent the catchment gradually filling up over time. Figure 6 shows the permanent inundation levels based on this method for the Lower Welland catchment. The defined permanent inundation levels for each sub-compartment are present in Table 3-1.

Table 3-1: Do Nothing Scenario assumptions regarding water level over time

Appraisal Year [yr]	Water Level [m AOD]					
	North Level (A) North Level (B) Welland & Deepings (B) South Holland A) South Holland (B) South Holland (C)	Welland & Deepings (C) Welland & Deepings (D) North Level (C)	Welland & Deepings (A)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)
Year 0: Environment Agency and IDB cease maintenance of assets (incl. pumping); fluvial water begins to pond across the catchment.						
0	2.19	3.59	1.67	1.48	2.76	3.21
1	2.69	3.90	2.17	1.98	3.26	3.71
2	3.19	3.90	2.67	2.48	3.76	3.90
3	3.69	3.90	3.17	2.98	3.90	3.90
4	3.90	3.90	3.67	3.48	3.90	3.90
5	3.90	3.90	3.90	3.90	3.90	3.90
19	3.90	3.90	3.90	3.90	3.90	3.90
99	3.90	3.90	3.90	3.90	3.90	3.90

[6] Arup (February 2025). Fens 2100+ Proposed Economic Baseline Assumptions: Lower Welland

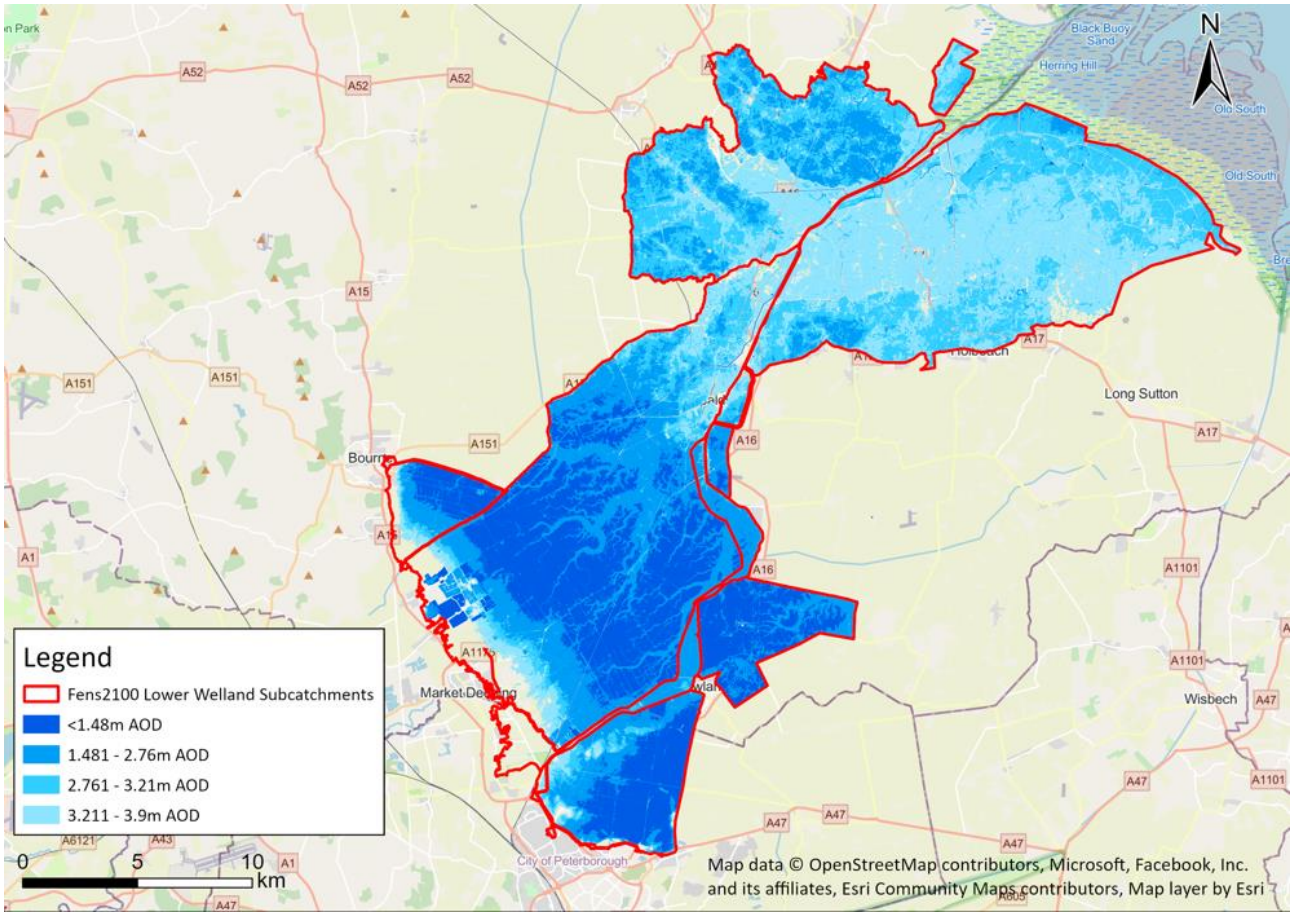

Figure 6: Do Nothing permanent flood extents for the Lower Welland catchment

3.1.4 Additional information

It is recognised that under a true Do Nothing scenario, it is likely that localised flood events would result from blockages in watercourses and flood risk management assets, and failure of coastal defences. However, this appraisal is focused on valuing broad economic damages using a simplified approach to the generation of the flood extents. For this reason, localised flood events from degrading assets, blockages of tidal defences are not included in this analysis. It is also anticipated that, due to the speed with which the catchment is assumed to fill, these events would have relatively minor impacts on the total damages in the Do Nothing scenario.

Before write-off of land, properties, and infrastructure occurs, these receptors are subject to risk from infrequent extreme storm and tidal events. This risk is represented using the 'Risk of Flooding from Multiple Sources' (RoFMS) dataset. To ensure no double counting of damages occurs, this residual risk associated with infrequent extreme events is recalculated for the assets at risk above each water level tabulated in Table 3-1, such that the damages associated with this risk reduce as the permanent water levels in the Do Nothing scenario rise.

3.1.5 Sensitivity test

Sensitivity testing of the Do Nothing scenario focuses on the rate of inundation of low-lying areas. The rate of inundation has been varied from 0.25m (lower estimate) to 0.75m (upper estimate) every year in order to better understand the potential impacts of inundation being less/more rapid than expected. In addition, an extreme scenario has been tested for potential damages if the catchment were to fill to 6m AOD.

3.2 Maintain scenario

3.2.1 Definition

This baseline economic appraisal also considers a Maintain scenario. This scenario represents the benefits of existing assets being maintained to continue to provide their existing Standard of Service. There is no allowance for adaptation to climate change. In a maintain scenario, the study area remains at risk from infrequent flooding in events exceeding the design standard of the existing Flood Risk Management assets.

3.2.2 Description

The Maintain scenario relates to the present business as usual (BAU) approach to fluvial and coastal flood mitigation for the Lower Welland catchment. This scenario is based on the best available flood risk data, which indicates the flood risk associated with exceedance of the existing flood risk management assets. In this scenario it is assumed that the existing flood risk management assts are maintained in serviceable condition and embankments are maintained to their present crest level.

This scenario will be based on nationally available 'Risk of Flooding from Multiple Sources' (RoFMS) dataset which indicates the flood risk associated with exceedance of the existing flood risk management assets, including from tidal, fluvial and surface water sources.

3.2.3 Flood extents

National RoFMS data will be used to inform a weighted annual average damage (WAAD) assessment as defined in the Multi-Coloured Manual. The RoFMS high risk category in the dataset is assumed to be representative of the 3.33% AEP event; the medium risk category in RoFMS is assumed to be equivalent to the 1% AEP event; and the low risk category is assumed to be equivalent to a 0.1% AEP event. Table 4.6 in the MCH will be used to determine the number of properties at risk in more frequent events than the 3.33% AEP event (10% AEP and 20% AEP).

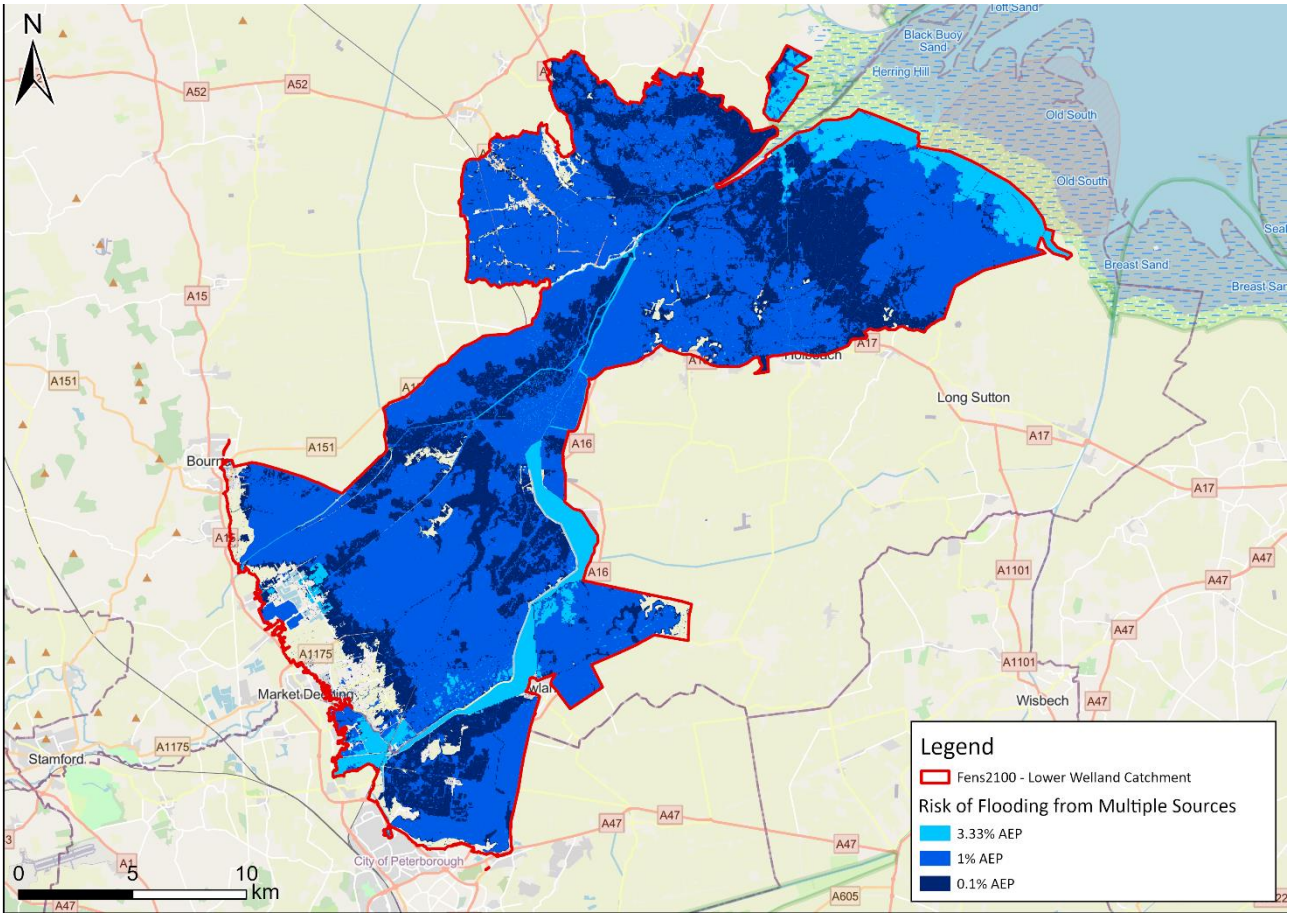

Figure 7: Risk of Flooding from Multiple Sources for the Lower Welland

4. Appraisal Receptors

4.1 Economic appraisal receptors

The Total Impact Framework in Figure 8 identifies a series of common receptors across catchments loosely mapped across the wider determinants of health. The Framework demonstrates that the flood risk across the Lower Welland catchment has the potential to significantly impact the social, cultural, political, economic, commercial and environmental factors that shape the environment in which the local communities live, work and thrive.

Receptors bordered in red are those considered as part of this economic assessment.

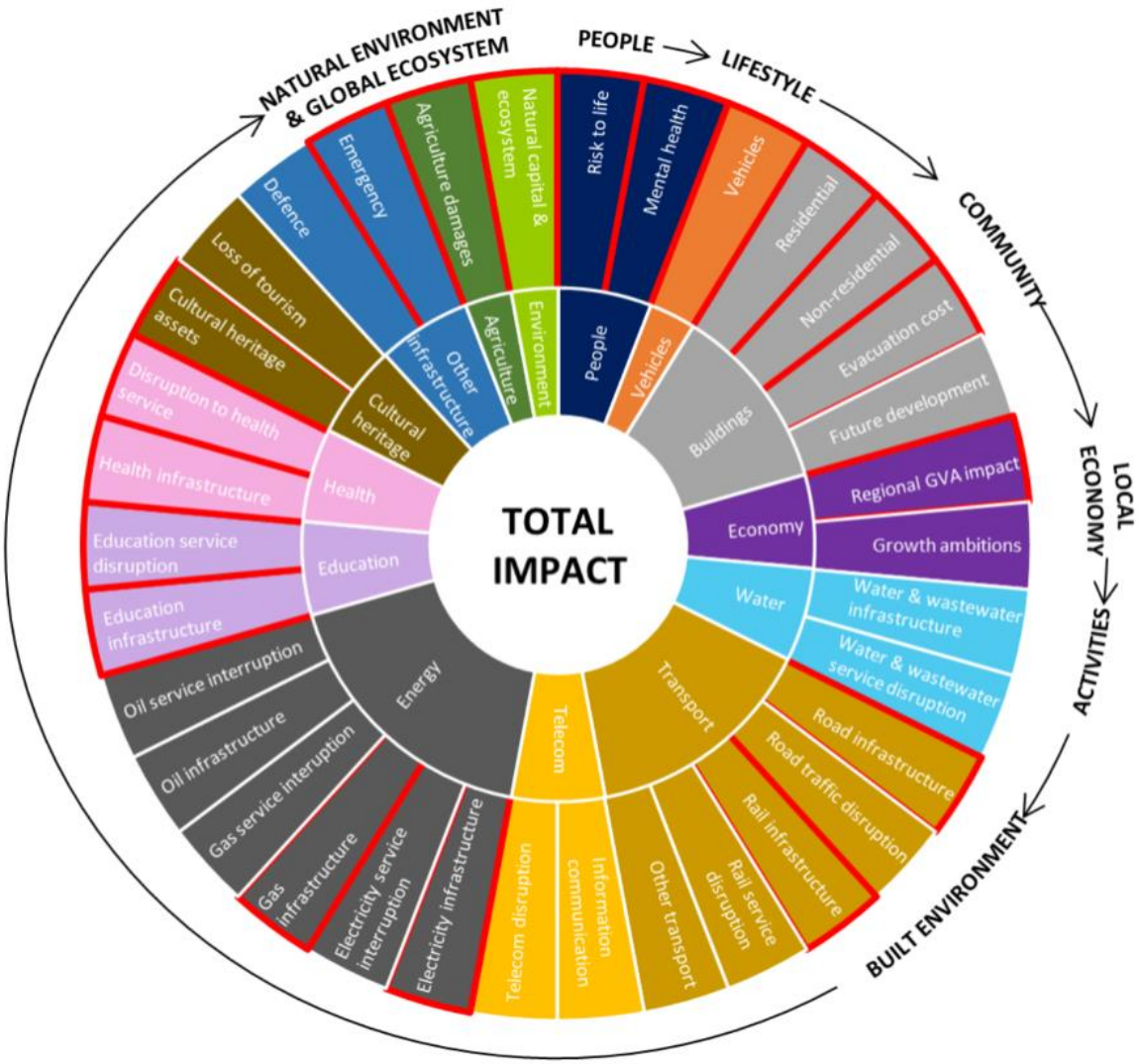

Figure 8: Total Impact Framework

5. Baseline Damages Appraisal

The baseline FCERM economic damages to the nation have been calculated in line with the standard guidance (FCERM Appraisal Guidance[7] (AG) (2022), and HM Treasury Green Book[8] (2022)) and using the Flood Hazard Research Centre's Multi Coloured Manual (MCM) (2013) methodology supplemented by the Multi Coloured Handbook (MCH) and data (2024). A 100-year appraisal period has been assessed, with results also presented for a 20-year appraisal period to inform any development of tactical plans and sustain projects ahead of more strategic long-term decisions being made.

Due to the nature of the project, the economic approach has focused towards defining 'broad-brush' economic damages for key receptors. Further detailed analysis could be undertaken in-line with the needs and requirements of any future stages of the project development and for individual investment business cases.

The following damage streams have been assessed and are described in detail in Sections as indicated:

Section 5.1	Residential and non-residential property damages
Section 5.2	Agricultural losses
Section 5.3	Environmental and recreational losses
Section 5.4	Heritage losses
Section 5.5 - 5.7	Infrastructure (transport & utilities) damages
Section 5.8	Isolated properties and land
Section 5.9	Mental health costs
Section 5.10	Intangible impacts to human health
Section 5.11	Emergency service costs
Section 5.12	Risk to life
Section 5.13	Evacuation and temporary accommodation costs
Section 5.14	Vehicle damages
Section 5.15	Utilities disruption
Section 5.16	Health service disruption
Section 5.17	Educational disruption
Section 5.18	Losses to the local economy (as GVA)

All damages have been presented in a 2025 price base, using latest available GDP data from December 2024[9]. Where historic data has been used, this has been uplifted to a 2025 price base using GDP Deflator data.

[7] FCERM appraisal technical guidance - GOV.UK

[8] The Green Book: appraisal and evaluation in central government - GOV.UK

[9] GDP deflators at market prices, and money GDP December 2024 (Quarterly National Accounts) - GOV.UK

5.1 Direct residential and non-residential property damages

Across the Lower Welland catchment, there are several small settlements benefitting from the existing FRM activities including, but not limited to, Pinchbeck, Surfleet, Deeping Saint Nicholas, Gosberton and Fosdyke. Some of these communities already suffer from regular flooding despite the FRM activities. Flooding to these rural communities can cause severe disruption to residents and damage to properties, with large financial costs in response and recovery activities and personal expenditure. This remains an area of significant concern for the government and the local communities at risk.

Figure 9: River Glen at Surfleet Seas End

Direct residential and non-residential property damages are the losses to property owners and residents because of the direct inundation of their property from a flood event and considers damage to building fabric and structure. Properties at risk have been identified using the National Receptor Dataset (NRD). Noting that the refreshed 2023 NRD data contains far fewer unknown ‘999’ data points, a sensitivity analysis has been undertaken for these catchments to show the potential impact on benefits should these points be appropriate to include in the damages assessment, as described in Section 5.1.6.

5.1.1 Do Nothing scenario approach

Write off of property is assumed to occur at the point at which the water level in the catchment exceeds the level of the property such that it becomes permanently inundated

or becomes un-inhabitable due to frequency of flooding; the property is written off in the year in which this is assumed to occur, as per specific assumptions made per catchment. The value of that property was taken as the loss and discounted to Present Value using HM Treasury discount rates. Residential properties have been valued based on the regional property valuations for the East Midlands from the MCM Chapter 4 Table 5.9. Non-residential property has been valued based on MCM Chapter 5 Table 5.4 and Chapter 3 Table 3.4 taking rateable values for the East Midlands and using floor areas from NRD; where no floor area is available in NRD data, MasterMap building polygons have been used to determine an appropriate floor area.

Where properties have not been written off, they may be at risk of flooding due to extreme storm and tidal events, in exceedance of the Standard of Service of existing FRM assets. This risk has been assessed using the flood risk data set out in Figure 7**.**

A local model is not available and, thus, a Weighted Annual Average Damages approach is applied for assessment of damages outside of the permanently flooded area. This approach is defined in the Multi-Coloured Manual[2].

Residential property damages are capped at average market value for the property type. Non-Residential properties are capped based on the rateable value for the property type multiplied by the rental yield factor, and the floor area for the property. Where properties have no floor area, they have been excluded from the analysis – this is recommended as an area for further development as part of any future more detailed appraisals. Damages due to extreme storm events cease to accrue following write-off of the property due to permanent or frequent inundation.

WAAD has been reassessed at each flood level as permanent flood levels within the catchment rise to ensure that damages are not double counted, i.e. properties which have been written off by permanent flooding are no longer assessed for WAAD. The WAAD value has then been forecast across the appraisal period and discounted to understand Present Value (PV) damages to properties.

5.1.2 Maintain scenario approach

For the Maintain scenario, properties are at risk from flooding due to extreme storm and tidal events in exceedance of the Standard of Service for existing FRM assets. Residential and non-residential property damages have been calculated based on the approach to calculating WAAD as detailed in Section 5.1 with no reduction in WAAD over time given that there is no permanent inundation assumed in the Maintain scenario. It has been assumed that there is a flood warning for this assessment. The WAAD value has been forecast across the appraisal period and discounted to understand PV damages to properties.

5.1.3 Key assumptions

Table 5-1: Residential and non-residential property data and assumptions

Key assumptions:

Residential property values

Property Type	Market Value (£)
Detached	361,975
Semi-detached	231,449
Terraced	189,400
Flat	140,557
Bungalow	140,557

Source: MCM Handbook. (2024). Chapter 4, Table 4.9 Regional Residential House Prices (2024). East Midlands

Non-residential property values

Type		Market Value £/m^2
Retail		1,787
Offices		1,171
Distribution / logistics		598
Leisure		1,093
Playing fields		1,093
Sports centre		1,093
Marina		1,093
Sports Stadium		1,093
Public buildings		1,093
Industry		683
Car Park		1,093
Electricity sub-station	Excluded to avoid double counting with electricity damages	
Unknown (999 and 9)	Excluded	
Source: Based on MCM Table 5.4 for East Midlands; Savills Research		

Key datasets:

- Lower Welland model results
- National receptor database
- OS MasterMap
- LIDAR DTM
- MCH Chapter 3, 4, 5 data and tables.

5.1.4 Do-Nothing scenario outcomes

Table 5-2: Do Nothing Write-off – number of residential properties impacted (cumulative)

Appraisal year (Year)	Number of residential properties						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	260	1,055	0	2	0	5	313
1	364	1,391	0	8	325	27	798
2	379	1,558	0	632	1,737	68	1,664
3	385	1,643	0	3,540	3,140	113	5,199
4	386	1,670	0	4,229	3,406	135	10,122
5	386	1,670	0	4,229	3,406	135	11,366
99	386	1,670	0	4,229	3,406	135	11,366

Appraisal year (Year)	Number of residential properties						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	3	313	0	
1	0	0	0	6	1,922	4	
2	0	0	0	16	3,430	4	
3	0	0	0	25	3,637	4	
4	0	0	0	33	3,637	4	
5	0	0	0	37	3,637	4	
99	0	0	0	37	3,637	4	

Table 5-3: Do Nothing Write-off – PV residential property losses (cumulative) (£k)

Appraisal year (Year)	PV property losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	60,157	244,099	0	880	332	£1,173	73,454
1	83,405	319,214	0	2,619	73,275	6,103	182,841
2	86,645	355,284	0	137,719	378,401	14,967	371,356
3	87,897	373,022	0	744,622	671,212	24,362	1,108,985
4	88,098	378,465	0	883,572	724,873	28,800	2,101,741
5	88,098	378,466	0	883,613	724,905	28,803	2,344,223
99	88,098	378,486	0	884,786	725,826	28,893	2,348,357

Appraisal year (Year)	PV property losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	43	0	696	72,650	3	
1	0	84	0	1,368	432,439	897	
2	0	124	0	3,528	758,143	897	
3	0	163	0	5,406	801,344	897	
4	0	200	0	7,019	801,352	897	
5	0	236	0	7,800	801,360	897	
99	0	1,278	0	7,808	801,576	897	

Table 5-4: Do Nothing Write-off – number of non-residential properties impacted (cumulative)

Appraisal year (Year)	Number of non-residential properties						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	36	120	1	48	1	10	80
1	59	179	1	63	18	15	180
2	66	226	1	145	121	18	316
3	67	250	1	524	175	20	643
4	67	260	1	656	191	20	1,160
5	67	260	1	656	191	20	1,314
99	67	260	1	656	191	20	1,314

Appraisal year (Year)	Number of non-residential properties						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	1	1	0	0	111	0	
1	2	3	0	1	339	2	
2	3	3	0	9	548	3	
3	8	3	0	10	584	3	
4	8	3	0	11	584	3	
5	8	3	0	17	584	3	
99	8	3	0	17	584	3	

Table 5-5: Do Nothing Write-off –PV non-residential property losses (cumulative) (£k)

Appraisal year (Year)	PV non-residential property losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	15,975	25,149	0	357	76	£698	21,819
1	19,840	29,212	0	2,901	949	2,689	52,492
2	20,092	33,178	0	25,014	40,845	10,300	101,761
3	20,187	40,371	0	250,003	45,590	10,442	202,384
4	20,187	43,572	0	298,474	48,072	10,442	437,559
5	20,187	43,574	0	298,571	48,094	10,443	481,901
99	20,187	43,614	0	301,364	48,729	10,453	490,443

Appraisal year (Year)	PV non-residential property losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	72	114	0	7	12,804	43	
1	142	224	0	1,738	80,553	1,442	
2	209	331	0	6,902	143,724	1,442	
3	6,002	434	0	6,910	148,581	1,442	
4	6,002	533	0	6,910	148,584	1,442	
5	6,002	630	0	8,347	148,588	1,442	
99	6,002	3,403	0	8,356	148,686	1,442	

A total of 24,870 residential and 3,124 non-residential properties are written-off due to inundation in the Do Nothing. This amounts to a total of £5,266,006k and £1,082,679k of residential and non-residential property losses respectively over both the 100-year and 20-year appraisal period.

5.1.5 Maintain scenario outcomes

Table 5-6: Maintain scenario – number of residential properties impacted (cumulative)

Annual Exceedance Probability	Residential properties Impacted						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
20%	1	0	0	10	0	0	9
10%	2	0	0	20	0	0	18
3.33%	6	1	0	48	1	1	46
2%	19	3	0	154	3	3	147
1%	149	607	0	2,456	3,663	158	9,218
0.5%	160	653	0	2,641	3,663	161	9,912
0.1%	303	965	0	4,608	3,663	164	12,288

Annual Exceedance Probability	Residential properties Impacted						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
20%	0	2	0	0	4	0	
10%	0	4	0	0	8	1	
3.33%	0	10	0	0	21	2	
2%	0	32	0	0	67	2	
1%	0	216	0	20	1,846	4	
0.5%	0	232	0	22	1,985	4	
0.1%	0	279	0	24	2,995	4	

Table 5-7: Maintain scenario – Associated cash residential property damages (£k)

Annual Exceedance Probability	Cash Property Damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
20%	4	1	0	33	1	1	32
10%	2	0	0	17	0	0	16
3.33%	3	1	0	24	1	1	23
2%	5	1	0	37	1	1	36
1%	120	54	0	205	326	14	807
0.5%	1	2	0	8	0	0	31
0.1%	6	14	0	87	0	0	105

Annual Exceedance Probability	Cash Property Damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
20%	0	7	0	0	14	1	
10%	0	4	0	0	7	1	
3.33%	0	5	0	0	11	1	
2%	0	8	0	0	16	0	
1%	0	16	0	2	158	0	
0.5%	0	1	0	0	6	0	
0.1%	0	2	0	0	44	0	

Table 5-8: Maintain scenario – number of non-residential properties impacted (cumulative)

Annual Exceedance Probability	Non-residential properties impacted						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
20%	29	6	0	916	23	0	1,292
10%	58	13	0	1,831	47	0	2,583
3.33%	145	32	0	4,578	117	0	6,458
2%	378	102	0	14,648	374	0	20,667
1%	9,851	9,191	0	95,432	35,973	1,331	242,068
0.5%	10,081	9,715	0	102,554	35,973	1,371	257,240
0.1%	10,926	14,993	0	140,934	35,973	1,632	394,643

Annual Exceedance Probability	Non-residential properties impacted						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
20%	0	32	0	0	15	268	
10%	0	63	0	0	30	536	
3.33%	0	158	0	0	76	1,341	
2%	0	158	0	0	212	1,341	
1%	0	740	0	2,050	31,800	1,341	
0.5%	0	740	0	2,105	54,453	1,341	
0.1%	0	740	0	2,342	54,453	1,341	

Table 5-9: Maintain scenario – Non-residential cash property damages (£k)

Annual Exceedance Probability	Non-residential cash property damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
20%	5	0	0	12	1	0	17
10%	4	0	0	8	0	0	13
3.33%	6	0	0	13	1	0	19
2%	8	0	0	21	1	0	32
1%	16	14	0	118	46	1	360
0.5%	0	1	0	9	0	0	23
0.1%	0	2	0	36	0	0	132

Annual Exceedance Probability	Non-residential cash property damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
20%	0	0	0	0	2	15	
10%	0	0	0	0	1	11	
3.33%	0	0	0	0	2	17	
2%	0	0	0	0	1	0	
1%	0	1	0	3	46	0	
0.5%	0	0	0	0	3	0	
0.1%	0	0	0	0	14	0	

Table 5-10: Maintain scenario – Cash indirect commercial losses (£k)

Annual Exceedance Probability	Non-residential cash indirect commercial losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
20%	0.2	0	0	0	0	0	0.5
10%	0.1	0	0	0	0	0	0.4
3.33%	0.2	0	0	0	0	0	0.6
2%	0.2	0	0	1	0	0	1
1%	0.5	0	0	4	1	0	11
0.5%	0	0	0	0	0	0	0.7
0.1%	0	0	0	1	0	0	4

Annual Exceedance Probability	Non-residential cash indirect commercial losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
20%	0	0	0	0	0	0	
10%	0	0	0	0	0	0	
3.33%	0	0	0	0	0	1	
2%	0	0	0	0	0	0	
1%	0	0	0	0	1	0	
0.5%	0	0	0	0	0	0	
0.1%	0	0	0	0	0	0	

A total of £65,999k and £30,924k is accrued in residential and non-residential PV damages respectively when discounted over the full 100-year appraisal period. In addition, £928k of PV indirect commercial losses is accumulated over the same period of time.

5.1.6 Sensitivity testing

Sensitivity analysis has been undertaken to assess the impact of NRD 999 (classified as unknown receptors) on damages. These have been excluded from the baseline analysis, but for the sensitivity analysis have been included assuming damages equivalent to the non-residential sector average values. This provides an indication of the potential additional damages which could be included if these 999 points were reclassified based on local knowledge, aerial photography or similar, to a more appropriate classification.

Table 5-11: Do Nothing – number of non-residential properties including NRD 999 impacted (cumulative)

Appraisal year (Year)	Number of non-residential properties						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	106	301	1	49	1	19	297
1	171	445	2	75	19	85	713
2	190	614	2	260	133	109	1,182
3	192	712	2	1,202	214	120	1,970
4	192	741	2	1,622	235	124	2,922
5	192	741	2	1,622	235	124	3,186
99	192	741	2	1,622	235	124	3,186

Appraisal year (Year)	Number of non-residential properties						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	2	1	0	8	217	190	
1	3	3	0	31	984	236	
2	4	3	0	70	1,672	240	
3	9	3	0	84	1,798	240	
4	9	3	0	99	1,798	240	
5	9	3	0	119	1,798	240	
99	9	3	0	119	1,798	240	

Table 5-12: Do Nothing – non-residential property losses including NRD 999 (cumulative) (£k)

Appraisal year (Year)	PV Property losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	36,572	59,180	0	1,646	86	£4,723	118,192
1	48,112	75,696	67	6,186	1,014	22,803	215,911
2	49,697	94,408	67	62,377	41,457	33,262	330,187
3	49,922	111,151	67	486,151	47,456	35,386	510,704
4	49,922	116,703	67	637,099	50,111	35,889	848,336
5	49,922	116,706	67	637,518	50,135	35,890	908,780
99	49,922	116,813	68	649,599	50,852	35,926	919,994

Appraisal year (Year)	PV Property losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	173	128	0	1,124	36,744	317	
1	243	252	0	13,665	193,772	6,476	
2	310	372	0	35,376	346,513	7,931	
3	6,103	487	0	37,426	372,085	7,931	
4	6,103	599	0	39,145	372,098	7,931	
5	6,103	707	0	42,479	372,111	7,931	
99	6,103	3,822	0	42,690	372,475	7,931	

Table 5-13: Maintain scenario – number of non-residential properties including NRD 999 impacted (cumulative)

Annual Exceedance Probability	Non-residential properties impacted						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
20%	29	6	11	3,866	30	10	1,770
10%	58	13	23	7,731	61	20	3,539
3.33%	145	32	57	19,328	152	49	8,848
2%	378	102	57	61,849	488	158	28,314
1%	26,247	39,249	57	269,426	39,255	19,262	495,993
0.5%	27,712	42,036	62	289,644	39,255	20,651	530,279
0.1%	34,856	69,756	100	491,179	39,255	24,091	790,123

Annual Exceedance Probability	Non-residential properties impacted						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
20%	17	72	0	0	134	1,246	
10%	34	144	0	0	268	2,492	
3.33%	86	361	0	0	669	6,230	
2%	86	361	0	0	2,020	6,587	
1%	86	4,058	0	16,988	142,372	6,587	
0.5%	86	4,308	0	18,167	152,213	6,747	
0.1%	86	4,443	0	34,845	238,658	7,111	

Table 5-14: Maintain scenario - non-residential properties including NRD 999 associated cash property damages (£k)

Annual Exceedance Probability	Cash property damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
20%	5	0	1	165	1	1	42
10%	4	0	0	121	1	0	31
3.33%	6	0	1	191	1	1	48
2%	8	0	0	318	2	1	80
1%	56	86	0	422	54	43	951
0.5%	3	6	0	41	0	3	69
0.1%	8	29	0	232	0	4	279

Annual Exceedance Probability	Cash property damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
20%	1	2	0	0	8	66	
10%	1	2	0	0	6	48	
3.33%	1	3	0	0	9	76	
2%	0	0	0	0	13	3	
1%	0	8	0	39	307	0	
0.5%	0	1	0	3	23	0	
0.1%	0	0	0	20	93	0	

Table 5-15: Maintain scenario – non-residential properties including NRD 999 cash indirect commercial losses (£k)

Annual Exceedance Probability	Cash indirect commercial losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
20%	0	0	0	5	0	0	1
10%	0	0	0	4	0	0	1
3.33%	0	0	0	6	0	0	1
2%	0	0	0	10	0	0	2
1%	1	3	0	13	2	1	29
0.5%	0	0	0	1	0	0	2
0.1%	0	1	0	7	0	0	8

Annual Exceedance Probability	Cash indirect commercial losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
20%	0	0	0	0	0	2	
10%	0	0	0	0	0	1	
3.33%	0	0	0	0	0	2	
2%	0	0	0	0	0	0	
1%	0	0	0	1	9	0	
0.5%	0	0	0	0	1	0	
0.1%	0	0	0	1	3	0	

5.2 Agricultural losses

The Lower Welland and wider Fens 2100+ study area, which is a region of national agricultural importance due to its fertile soils. The Fens account for around half of the most productive (termed “grade 1”) agricultural land in England, which supports a nationally important agricultural industry. With a significant proportion of agricultural land across the catchment benefitting from the present FRM activities, frequent flooding or long-term inundation of the catchment would have a significant impact on regional and national food production.

“Although it covers less than 4% of England’s farmed area, the Fens produces more than 7% of England’s total agricultural production, worth a staggering £1.23 billion. The whole food chain, from farm to fork employs 80,000 people – equivalent to the population of Peterborough – and generates more than £3 billion a year for the Fens’ economy” (NFU, Farming Food in the Fens, 2020)

Figure 10: Potato field south-west of Spalding

5.2.1 Do-Nothing scenario approach

Flooding of farmland can lead to immediate, as well as long term, crop losses. The scale of impacts is likely to be a function of inundation depth, duration and seasonality. From a tidal perspective, even as flood waters recede, salt deposition from sea water establishes a legacy of soil salinity, negatively affecting the growth of many crops with long-term impacts on soil structure.

Due to the nature of the flooding in the Do-Nothing scenario, it is assumed agricultural land below Do-Nothing ‘write off level’ will be abandoned/written off. Where write off of agricultural land occurs, the valuation of this land has been based on survey data from Knight Frank. It has been conservatively assumed that the valuation of land can be equated to that of average arable and

average pastureland from this survey, depending on the classification of the land use taken from CEH Land Cover Plus Crops data. A value of £600 has been removed from this valuation to account for farming subsidies; whilst the payment of subsidies to farmers from the EU have ceased, the UK government has replaced them with the Environmental Land Management Scheme (ELMS). ELMS is not yet considered mature enough to determine an appropriate alternative subsidy value to use and therefore £600 has been applied as a proxy for ELMS payments.

Where agricultural land is written off, it is recognised that the conversion of land use to an area which is frequently or permanently flooded may result in alternative ecosystem services benefits being provided to the food production benefits provided when in agricultural use. However, permanent inundation is also likely to create contamination issues within the area from increasing salinity, historical land use sources and other sources such as active and disused landfill sites. Over the longer-term, there is uncertainty over whether the area would become a “naturally functioning” system due to the absence of fresh sand supply and the presence of man-made structures within the flooded area. Therefore, these benefits have not been assessed for agricultural areas at this stage. Losses and benefits generated from ecosystem services at existing environmental sites are assessed as part of the Environmental Damages and Benefits assessment (Section 5.3).

Alongside write off, there is risk owing to extreme storm and tidal events in exceedance of the Standard of Service of the current FRM assets, as represented by the flood risk data noted in Section 3.2.3. Recognising the importance of agriculture within the Fens, a more detailed methodology to calculate agricultural flood damage due to these events has been used, as opposed to the standard agricultural losses detailed within the MCM (Table 9.20 in the MCM 2013; Tables 9.7 and 9.8 in MCH 2024). The approach is in-line with the detailed scheme appraisal level noted in Chapter 9 of the MCM and was developed as part of the Future Fens (Great Ouse) Economic Appraisal (2020). The approach considered land use and crop types across the catchment and the loss in crop/livestock output and associated loss of value-added (profits) due to flooding and a reduction in agricultural drainage conditions. This approach draws on techniques and analysis undertaken for the Future Fens (Great Ouse) appraisal.

The analysis utilised the CEH Land Cover plus Crops dataset which is a geographical agricultural land dataset to define land use. This dataset contains information on 11 crop types including a category for ‘other’ crops. The areas (ha) of agricultural land by crop type which are impacted by flooding in the Do-Nothing scenario were interrogated from this dataset and were averaged across three years of recent CEH data to reflect crop rotation activities.

Estimates of annual per hectare gross output, gross margin and net margin were produced for the main crop types following reviews of key datasets and engagement with key stakeholders and farmers across the Witham and Great Ouse catchments. The values derived for the Witham catchment have been used as proxies for the remaining catchments, except for the Great Ouse catchment which has its own estimates to account for the higher value of ‘other’ CEH category crops produced in this area. The annual Net Margins (per ha) were multiplied by the areas impacted by flooding in order to determine losses.

Damages due to extreme storm events cease to accrue following write off of agricultural land due to permanent or frequent inundation. Therefore, damages from extreme storm events have been recalculated for the area above each permanent flood level defined in the Do-Nothing scenario such that these decrease over time and there is no double counting of damages.

Appropriate soil saturation is required to successfully yield crops; for instance, if soil is too dry or wet it can result in poor conditions for crops to grow and a field’s yield can be severely reduced. Recognising agricultural productivity is critically dependent on standards of land drainage and field water level control, the assessment considered the impact of poor drainage across the catchment due to the gradual filling up of the catchment under the Do-Nothing scenario. By applying a drainage freeboard above the permanent flood level, the area with sub optimal drainage conditions could be calculated. Three categories of freeboard were applied to agricultural land, as described in Table 5-16. Due to the suitability of each drainage class to different agricultural uses, the

productivity of land within each drainage class is different (as highlighted in Table 5-17). The annual losses are defined by a move in land categorisation from good to bad or very bad drainage, or permanent inundation.

As the catchments are assumed to be gradually inundated in the Do-Nothing scenario, the freeboard was also assumed to rise over time relative to the assumed permanently inundated water level. This results in increasing levels of reduced productivity across the catchment.

Where land falls into the very bad drainage category, or where it is in the bad drainage category for more than five years, the land is assumed to be written off. As a result, there is a change in land use with associated potential for alternative ecosystem services to be provided. These potential benefits have been calculated as part of a sensitivity analysis due to uncertainty in the time and viability for naturally functioning habitats to develop (Section 5.3.6.3).

Table 5-16: Agricultural land drainage assumptions

Category	Freeboard	Assumptions
Permanent inundation	Water level	Agricultural activity ceases due to permanent inundation, as a result of the catchment being unable to appropriately drain.
Very bad drainage	0 – 0.5m above water level	Due to the severity of the very bad drainage conditions, it is assumed for land within this category conventional farming is not viable. Therefore, write off is also assumed for ground levels up to 0.5m above permanent water levels.
Bad drainage	0.5 – 1.5 m above water level	It is assumed that farming activities continue in bad drainage conditions – as in the short-term it is assumed farmers can cover the direct costs of production with the support of the current farm income support. Bad Drainage conditions result in negative margins (£/ha) due to the fact that low yields mean that farmers would fail to recover full costs on areas subject to Bad Drainage. Therefore, for most crops it is not considered a sustainable practice to continue farming in the longer term – as a result, farming activities are assumed to only continue for a period of five years beyond which activities cease and the land is written off.
Good drainage	+1.5m above water level	It is assumed agricultural land 1.5m above permanent water levels is not impacted.

5.2.2 Maintain scenario approach

The modelled data indicates the extents of the catchment impacted by extreme storm and tidal flood events. To define the impacts associated with these events, the losses from short term infrequent flood events for each crop type have been applied to the extents of the agricultural land impacted for each return period modelled. This has followed the same approach detailed for the Do-Nothing scenario based on Annual Net Margins for each crop type impacted. All agricultural land is assumed to have good drainage conditions in the Maintain scenario.

5.2.3 Key assumptions

Table 5-17: Agricultural assumptions

Key assumptions:

Annual Net Margin per ha by Crop Type (£ / ha)

Estimates of net margins for main crops identified in Land cover plus, including high value 'other' (vegetable). These are 'economic' values to the economy rather than financial values to farmers, expressed in 2024 prices.

(£/ha)	Good Drainage	Bad Drainage	Very Bad Drainage
Winter wheat	440	22	-396
Spring wheat	305	145	-14
Winter barley	279	-40	-359
Spring barley	264	123	-17
Field beans	272	147	22
Oilseed Rape	464	280	97
Maize	368	213	57
Beet	571	22	-14
Potatoes	3,167	22	-14
Other Crops	2,601	22	-14
Grass	129	-111	-37

Source: Analysis draws on the CEH Land Cover Plus data, Defra Farming Statistics 2010 and 2016, AgCensus 2010, and Eastern Regional Farm Business Surveys 2013/14 to 2017/18. Estimates of financial performance by crop and livestock type were expressed in 2024 values and adjusted to represent economic values.

Agricultural land valuations

(£/ha)

Crop Type	Assumed Typology	Market Value (£/ha)
Winter wheat	Arable	26,087
Spring wheat	Arable	26,087
Winter barley	Arable	26,087
Spring barley	Arable	26,087
Field beans	Arable	26,087
Oilseed Rape	Arable	26,087
Maize	Arable	26,087
Beet	Arable	26,087
Potatoes	Arable	26,087
Other Crops	Arable	26,087
Grass	Pasture	18,028

Source: Knights Frank, 2021 – Farmland Market Values for Lincolnshire

https://www.fwi.co.uk/business/markets-and-trends/land-markets/find-out-average-farmland-prices-where-you-live

Key assumptions:

Annual Agricultural Losses per Hectare for Short Term Infrequent Flooding (£)

Agricultural Losses per Hectare for Short Term Infrequent Flooding (£) – it is assumed good drainage is available throughout the catchment during the existing maintain scenario.

Crop Type	Floods over 2 weeks (£/ha) - Good Drainage conditions
Winter wheat	440
Spring wheat	305
Winter barley	279
Spring barley	264
Field beans	272
Oilseed Rape	464
Maize	368
Beet	571
Potatoes	3,167
Other Crops	2,601
Grass	129

Source: Analysis draws on the CEH Land Cover Plus data, Defra Farming Statistics 2010 and 2016, AgCensus 2010, and Eastern Regional Farm Business Surveys 2013/14 to 2017/18. Estimates of financial performance by crop and livestock type were expressed in 2022 values (uplifted to 2024) and adjusted to represent economic values.

Key datasets:

- Flood risk data used
- CEH Land Cover plus Crops

5.2.4 Do-Nothing scenario outcomes

Table 5-18: Do Nothing – Area of agricultural write off for the Do Nothing scenario (ha) (cumulative)

Appraisal year (Year)	Area of agricultural write-off (ha)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	2,030	2,330	23	458	4	222	8,919
1	2,040	2,605	31	4,207	9	227	10,602
2	2,041	2,735	31	11,379	10	229	11,657
3	2,042	2,785	31	12,628	10	230	12,344
4	2,043	2,820	31	13,060	10	230	12,837
5	2,043	2,820	31	13,060	10	230	13,171
99	2,043	2,820	31	13,060	10	230	13,171

Appraisal year (Year)	Area of agricultural write-off (ha)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	703	10	0	611	5,037	338	
1	805	39	0	715	6,474	347	
2	828	39	0	796	6,732	353	
3	842	39	0	867	6,899	353	
4	852	39	0	934	6,899	353	
5	852	39	0	983	6,899	353	
99	852	39	0	983	6,899	353	

Table 5-19: Do Nothing – Agricultural write off PV damages for the Do Nothing scenario with basin fill (£k) (cumulative)

Appraisal year (Year)	Agricultural write-off damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	56,768	64,703	644	23,360	70	5,985	250,404
1	57,039	71,851	870	132,844	181	6,109	297,205
2	57,081	75,045	873	320,838	197	6,144	325,297
3	57,105	76,177	875	352,415	197	6,164	342,726
4	57,125	76,930	878	362,967	198	6,180	354,624
5	57,125	76,930	878	362,967	198	6,180	362,418
99	57,145	77,401	1,048	366,222	198	6,196	369,038

Appraisal year (Year)	Agricultural write-off damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	19,506	298	8	17,032	141,142	9,355	
1	22,185	1,071	14	19,876	180,128	9,605	
2	22,758	1,174	15	22,080	186,906	9,762	
3	23,082	1,273	15	23,923	191,137	9,763	
4	23,319	1,369	16	25,579	191,236	9,763	
5	23,319	1,398	16	26,788	191,236	9,763	
99	23,523	6,218	45	28,543	192,922	9,781	

Table 5-20: Do Nothing – Residual agricultural PV damages in Steeping model extents with basin fill (£k) (cumulative)

Appraisal year (Year)	Residual agricultural PV damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	<1	<1	-	41	-	<1	28
1	1	1	-	52	-	<1	42
2	1	1	-	58	-	<1	51
3	1	1	-	63	-	<1	57
4	1	1	-	66	-	<1	61
5	1	1	-	68	-	<1	64
99	2	4	-	117	-	1	119

Appraisal year (Year)	Residual agricultural PV damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	4	26	-	2	1	-	
1	6	44	-	3	2	-	
2	7	55	-	4	3	-	
3	8	64	-	4	3	-	
4	9	73	-	5	4	-	
5	9	82	-	5	4	-	
99	20	327	-	6	13	-	

Table 5-21: Do Nothing – Total PV Damages (£k)

Sub-compartment	Total agriculture PV damages (£k)
North Level (A)	57,147
North Level (B)	77,405
North Level (C)	1,048
South Holland (A)	366,339
South Holland (B)	198
South Holland (C)	6,197
Welland & Deepings (A)	369,157
Welland & Deepings (B)	23,543
Welland & Deepings (C)	6,545
Welland & Deepings (D)	45
Welland & Deepings (E)	28,550
Welland & Deepings (F)	192,935
Welland & Deepings (G)	9,781
Total	1,138,889

5.2.5 Maintain scenario outcomes

Table 5-22: Maintain scenario – Area of agricultural land flooded (cumulative) (ha)

Annual Exceedance Probability	Area of agricultural flooding (ha)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
20%	37	3	0	417	0	0	57
10%	73	4	1	834	0	0	113
3.33%	183	11	3	2,086	0	1	282
2%	585	34	3	6,675	1	5	902
1%	2,303	2,096	3	12,836	12	198	11,107
0.5%	2,476	2,254	3	13,856	12	213	11,955
0.1%	2,513	3,677	4	17,954	12	268	16,214

Annual Exceedance Probability	Area of agricultural flooding (ha)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
20%	221	59	0	0	16	57	
10%	441	119	0	0	32	122	
3.33%	1,104	297	0	1	79	305	
2%	1,105	464	0	3	252	418	
1%	1,105	464	0	967	3,945	418	
0.5%	1,107	499	0	1,039	7,468	449	
0.1%	1,107	504	0	1,087	9,382	449	

Table 5-23: Maintain scenario – Total agricultural cash damages (cumulative) (£k)

Annual Exceedance Probability	Total agricultural cash damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
20%	14	1	<1	265	<1	<1	37
10%	28	2	<1	531	<1	<1	75
3.33%	69	6	<1	1,326	<1	<1	187
2%	220	18	<1	4,244	<1	3	598
1%	990	1,161	<1	11,896	1	86	6,677
0.5%	1,064	1,248	<1	2,791	1	93	7,179
0.1%	1,097	2,017	<1	16,800	1	132	10,022

Annual Exceedance Probability	Total agricultural cash damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
20%	126	25	0	<1	16	56	
10%	253	50	0	<1	32	113	
3.33%	631	126	0	<1	79	282	
2%	632	200	0	2	252	386	
1%	632	200	0	637	6,996	386	
0.5%	633	215	0	685	7,523	415	
0.1%	633	216	<1	717	9,381	455	

Table 5-24: Maintain scenario – Total PV Damages (£k)

Sub-compartment	Total agriculture PV damages (£k)
North Level (A)	727
North Level (B)	623
North Level (C)	2
South Holland (A)	10,967
South Holland (B)	0
South Holland (C)	47
Welland & Deepings (A)	4,049
Welland & Deepings (B)	18
Welland & Deepings (C)	9
Welland & Deepings (D)	0
Welland & Deepings (E)	1
Welland & Deepings (F)	14
Welland & Deepings (G)	4
Total	16,461

5.2.6 Sensitivity testing

5.2.6.1 Write off method

An alternative method for valuing agricultural write off was tested based on the approach used in the Great Ouse Fens project. Rather than writing off the land below the Do-Nothing 'write off level' based on land market valuations, agricultural land is valued based on lost productivity of the land at a field scale. The value of losses if the land is written off is assumed to be the lost productivity of the land for the remainder of the appraisal period rather than the land valuation from Knight Frank or similar. This approach was utilised in the Great Ouse following consultation with the NFU and farmers, where it was found that the process of write off was considered to undervalue the land and did not account for the significance of the agricultural sector in the Fens for national food security. The losses accrued beyond write off of land were based on net margins for good drainage conditions.

Table 5-25: Do Nothing – Total PV damages for the Do Nothing scenario using a lost productivity approach (£k)

Sub-compartment	Total agriculture PV damages (£k)
North Level (A)	31,543
North Level (B)	52,513
North Level (C)	494
South Holland (A)	409,707
South Holland (B)	40
South Holland (C)	3,574
Welland & Deepings (A)	268,844
Welland & Deepings (B)	16,939
Welland & Deepings (C)	3,894
Welland & Deepings (D)	22
Welland & Deepings (E)	21,392
Welland & Deepings (F)	239,193
Welland & Deepings (G)	11,291
Total	1,059,445

5.2.6.2 *Subsidy payments*

Agricultural land valuations used in the assessment have been reduced by £600 to account for the ELMS payments (which have replaced EU subsidies) received from the UK Government. A sensitivity analysis has been undertaken to consider the removal of this subsidy from the assessment and thus taking the full land valuation. Further to this, an assessment of an increase in the subsidy to £1,200 has been undertaken, given the uncertainty in ELMS payment rates. This helps to assess the impact of any potential future changes in subsidies and provides a range of possible agricultural damages based on changing understanding of ELMS payment rates.

Table 5-26: Do Nothing – Total PV damages for the Do Nothing scenario with no subsidy or increased subsidy (£1200) (£k) (cumulative)

Sub-compartment	Subsidy total of £0 (£k)	Subsidy total of £1,200 (£k)
North Level (A)	58,373	55,930
North Level (B)	79,092	76,256
North Level (C)	1,070	1,025
South Holland (A)	373,778	357,662
South Holland (B)	204	332
South Holland (C)	6,336	6,120
Welland & Deepings (A)	377,023	361,976
Welland & Deepings (B)	24,054	23,467
Welland & Deepings (C)	6,675	6,415
Welland & Deepings (D)	45	44
Welland & Deepings (E)	29,159	28,219
Welland & Deepings (F)	197,061	191,783
Welland & Deepings (G)	9,993	9,601
Total	1,162,864	1,118,831

5.2.6.3 *Land subject to bad drainage conditions converting to pasture*

The assessment has assumed that land subject to bad drainage conditions will be written off after five years of these conditions (see Table 5-17). This assumption aligns with those made for the Great Ouse and Witham economic baseline assessments undertaken previously. A sensitivity test has been undertaken to assess the impact on agricultural damages should this land be used as pasture rather than written off, and therefore the loss has been assessed based on the reduction in land market valuations from arable to pasture land (as per the values in Table 5-17).

Table 5-27: Do Nothing – Total PV damages for the Do Nothing scenario with land subject to bad drainage converting to pasture land (£k)

Sub-compartment	Total agriculture PV damages (£k)
North Level (A)	57,131
North Level (B)	77,047
North Level (C)	927
South Holland (A)	367,015
South Holland (B)	198
South Holland (C)	6,184
Welland & Deepings (A)	364,379
Welland & Deepings (B)	23,380
Welland & Deepings (C)	3,087
Welland & Deepings (D)	25
Welland & Deepings (E)	27,316
Welland & Deepings (F)	191,738
Welland & Deepings (G)	9,768
Total	1,125,195

5.2.6.4 *Land use change – ecosystem service gains*

Where permanent flooding occurs, there is the potential for the change in land use to result in alternative ecosystem services being generated. This is aligned to the assessment for environmental damages as described in Section 5.3. There is uncertainty in the viability and timescale for land to become a fully functioning natural habitat after land use change. A period of 50 years has been assumed for transition, after which, agricultural land is assumed to have converted to fully functioning Coastal habitat with ecosystem service benefits valued as per Table 5-17. The total area of agricultural land inundated is therefore multiplied by the value for coastal habitat to determine the annual benefits and is assumed to accrue for the remainder of the appraisal period from a point 50 years after the maximum water level is reached.

Table 5-28: Do Nothing – Total PV benefits as a result of habitat created in the Do Nothing scenario (£k)

Sub-compartment	Total agriculture PV benefits (£k)
North Level (A)	79,006
North Level (B)	114,525
North Level (C)	620
South Holland (A)	507,856
South Holland (B)	355
South Holland (C)	7,889
Welland & Deepings (A)	471,786
Welland & Deepings (B)	32,111
Welland & Deepings (C)	288
Welland & Deepings (D)	6
Welland & Deepings (E)	33,743
Welland & Deepings (F)	287,298
Welland & Deepings (G)	14,650
Total	1,550,133

5.3 Environment and recreational losses

The Lower Welland is a distinct, historic, and human-influenced wetland landscape lying to the south of The Wash Estuary, a large intertidal bay with ecologically important estuarine mudflats, sandbanks, and saltmarshes. The catchment is notable for its large, flat, and open topography, with drainage ditches and dykes draining towards the River Welland, which flows into The Wash Estuary. This area includes several environmental designations such as local nature reserves and SSSIs, including The Wash, which covers a significant portion of the Lower Welland catchment coastline. Permanent inundation could lead to the loss of these habitats and the associated Natural Capital benefits they provide. Additionally, these sites, along with Public Rights of Way and other open spaces, offer significant wellbeing value to local communities and visitors.

It should be noted that the damages and benefits calculated for environmentally designated sites in this section differ from the valuation of ecosystem service presented in the Natural Capital reporting in the baseline report. This is because the Natural Capital reporting provides a total value of ecosystem services currently estimated to be provided across the catchment, whilst this analysis focuses on estimating the impacts and losses of these services, and only for designated sites.

Figure 11. Willow Tree Fen Nature Reserve, west of Spalding

5.3.1 Do-Nothing scenario approach

Damages as a result of the loss of environmentally designated habitats, local nature reserves, Public Rights of Way (PRoW) and other open spaces have been calculated for the Do-Nothing scenario. It is assumed damages associated with the majority of the remaining rural landscape have been captured as part of the agricultural analysis.

Environmental sites have been identified through the Natural Capital baselining work, with geospatial outputs from that work used to inform this assessment. This captured environmentally designated sites (including Natura 2000, SSSIs, RAMSAR, Local & National Nature Reserves, Special Protection Areas and WTT) for each catchment. In addition, PRoWs and other open spaces have been captured based on data in the ORVal tool (University of Exeter)[10].

Comparison with CEH Land Cover plus Crops data was undertaken to remove any areas included within the agricultural damages assessment and remove the possibility of double counting of damages. However, where agricultural land is written off, an assessment of potential benefits generated through provision of alternative ecosystem services has been undertaken as a sensitivity analysis under the agricultural damages assessment (see section 5.2.6.4).

Estimates of quantified ecosystem service benefits were calculated within the Natural Capital Baselining work using the NCRAT tool (with data informing this primarily from the DEFRA ENCA services data-book[11] and ORVal tool[10]). The areas identified as providing ecosystem benefits from this work were compared with the areas of permanent inundation to determine which sites would be lost, and as a result which ecosystem services would be lost. This builds on the work undertaken for the Great Ouse which valued only the most prominent ecosystem services afforded by the designated sites, which are considered to be:

- Carbon – i.e. the sequestration of carbon dioxide from the atmosphere. This varies between types of broad habitats.
- Flood regulation – i.e. some habitats can offer flood risk management benefits by regulating water flow through the retention and slowing of water.
- Recreation – i.e. environmental settings providing recreational use. The analysis is based on reported visitor numbers and Willingness to Pay (WTP) (£/visit) from the University of Exeter Outdoor Recreation Valuation Tool[10] (ORVal: Version 2.0) for specific site locations, aligned with other WTP for nature conservation sites.
- Biodiversity – i.e. providing habitats to support variability among living organisms, that supports the provision of environmental goods and services to people.
- Non-use value – i.e. the benefit of individuals knowing that an aspect of the environment exists and is being, or will be, maintained.

The percentage of the total area of each site lost in each Do-Nothing permanent flood level has been used to determine the loss of ecosystem services based on the total ecosystem services the sites are calculated to provide within the Natural Capital baseline.

The land use will change to coastal habitat, as per the broad definitions used in the Natural Capital baselining, though existing coastal habitats will change to marine habitats. However, no ecosystem service gains are included initially for the area permanently or frequently flooded, as it is considered that this inundation is also likely to create contamination issues within the area, from increasing salinity, historical land use sources and other sources such as active and disused landfill sites. Over the longer-term, there is

[10] Day, B. H., and G. Smith (2018). Outdoor Recreation Valuation (ORVal) User Guide: Version 2.0, Land, Environment, Economics and Policy (LEEP) Institute, Business School, University of Exeter. Available online at: https://www.leep.exeter.ac.uk/orval/.

uncertainty over whether the area may become a “naturally functioning” system due to the absence of fresh sand supply and the presence of man-made structures within the flooded area, potentially limiting the quality of the habitat and the ecosystem services provided. However, it has been assumed that 50 years after the maximum water level is achieved, the change of land use will result in a naturally functioning habitat that will start to deliver ecosystem service benefits.

Table 5-29: Habitat designation type and sites impacted

Habitat Designation	Sites
Coastal	• The Wash
Semi-natural grassland	• Baston and Thurlby Fens SSSI • Cross Drain SSSI • Surfleet Lows SSSI • Vernatts LNR
Enclosed farmland	• Cowbit Wash SSSI
Wetlands/freshwater	• Deeping Gravel Pits SSSI

For recreational losses, wellbeing values associated with the PRoWs and open spaces identified in ORVal[10] have been used to determine potential losses. A displacement factor, representing the number of visitors who would go to an alternative site, has been calculated for each site independently. However, for the Do Nothing scenario with write off across many sites and PRoWs, an average value for displacement has been taken across the entire catchment, as it is considered some of the alternative sites to which it could be assumed visitors would go will also have been lost.

5.3.2 Maintain scenario approach

Losses of ecosystem services in a Maintain scenario are considered likely to occur where flooding is sufficiently frequent that it would impair the ability of the site to deliver these services. It can reasonably be assumed that a site would therefore need to be impacted in a 50% Annual Exceedance Probability (AEP) event, or more frequently, for a habitat to be impacted in this way.

Of the catchments being considered as part of the Fens 2100+ work, only the Steeping catchment has data to inform risk in a 50% AEP event. The other catchments have insufficient evidence to determine areas which may be affected. Therefore, no losses as a result of environmentally designated site damages in the Maintain scenario are being considered as part of this appraisal.

For wellbeing, losses have been estimated for sites which are shown to be impacted by flood risk. It has been assumed that wellbeing value is lost for a period of disruption to the site, assumed to be one week. The losses have been converted into an Annual Average Damage based on probability of events occurring and total loss of wellbeing value as a result.

5.3.3 Key assumptions

Table 5-30: Environmental assumptions

Key assumptions:	
Environmental benefit valuations (DEFRA NCRAT, ENCA[11], ORVal[10])	Economic values drawn from research literature and the ENCA Services data book[11] created by DEFRA indicates economic values associated with a range of factors including carbon storage and residual flood storage. They include selected quantified benefits only and use cautious rates for estimating. Values for recreational benefits are based on the Welfare values taken from the ORVal tool (University of Exeter)[10].
Environmental assumptions	It is recognised that whilst habitats may be lost, permanent inundation may result in the development of new habitats (e.g. wetlands) offering additional benefits. However, inundation is also likely to create contamination issues within the area from increasing salinity, historical land use sources and any other sources such as active and disused landfill sites. Over the longer-term, there is uncertainty over whether the area may become a "naturally functioning" system due to the absence of fresh sand supply and the presence of man-made structures within the flooded area. A conservative estimate of 50 years from maximum water level being reached has been used to determine when a new land use type may start to deliver ecosystem service benefits.

Existing Habitat Type	Total Impact Value (2025) (£)	New Habitat	Change in Total Impact Value (2025) (£)
Wetlands / Freshwater	1,976	Coastal	+5,069
Woodland	2,036	Coastal	+5,010
Semi-natural grassland	462.31	Coastal	+6,583
Urban	-269	Coastal	+7,314
Enclosed farmland	576	Coastal	+6,470
Marine	874	Marine	-
Coastal	7,045	Marine	-6,171
Mountain, moor and heath	651	Coastal	+6,394

Recreational Asset	Displacement Factor (%)	Maintain Flood Duration (days)
Parks and other recreational sites	35	7
Public rights of way	30	7

Key datasets:

- Natural Capital Baseline assessment
- National Nature Reserves in England
- Local Nature Reserves in England

[11] Department for Environment, Food and Rural Affairs (2025) *Enabling a Natural Capital Approach*. Available online at: https://www.data.gov.uk/dataset/3930b9ca-26c3-489f-900f-6b9eec2602c6/enabling-a-natural-capital-approach.

Key assumptions:
• Site of Special Scientific Interest (SSSI) • ORVal Valuation Data (University of Exeter)[10] • DEFRA ENCA[11] • OS Greenspaces Sites[12] • Rowmaps: Public Rights of Way[13]

5.3.4 Do-Nothing scenario outcomes

The total areas impacted in hectares for the environmental and recreational sites, as well as the lengths of public rights of way, can be seen in Table 5-31, Table 5-33, and Table 5-35 respectively.

[12] https://www.ordnancesurvey.co.uk/products/os-mastermap-greenspace-layer

[13] Cornelius, B. (no year). Rowmaps: Maps, KML and GPX showing rights of way. Retrieved from: https://www.rowmaps.com/

Table 5-31: Do Nothing - area of environmental sites impacted (cumulative) (ha)

Appraisal year (Year)	Environmental sites impacted (ha)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	0	0	0	0	0	25
1	0	0	0	0	0	0	65
2	0	0	0	0	0	0	74
3	0	0	0	1	0	0	91
4	0	0	0	2	0	0	94
5	0	0	0	3	0	0	96
99	0	0	0	3	0	0	96

Appraisal year (Year)	Environmental sites impacted (ha)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	2	0	0	0	3	11	
1	4	0	0	0	3	12	
2	8	0	0	0	3	12	
3	9	0	0	3	3	12	
4	9	0	0	5	3	12	
5	9	0	0	6	3	12	
99	9	0	0	6	3	12	

Table 5-32: Do Nothing - PV losses from environmental sites (cumulative) (£k)

Appraisal year (Year)	PV Environmental losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	0	0	1	0	0	53
1	0	0	0	4	0	0	189
2	0	0	0	23	0	0	351
3	0	0	0	55	0	0	599
4	0	0	0	88	0	0	855
5	0	0	0	121	0	0	1,110
99	0	0	0	1,060	0	0	6,042

Appraisal year (Year)	PV Environmental losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	4	0	0	0	56	80	
1	12	0	0	0	111	171	
2	28	0	0	0	165	260	
3	43	0	0	3	217	346	
4	57	0	0	6	267	429	
5	72	0	0	10	316	510	
99	216	0	0	-43	1,605	2,827	

Table 5-33: Do Nothing – area of recreational sites impacted (cumulative) (ha)

Appraisal year (Year)	Recreational sites impacted (ha)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0.03	7.05	0	0	0.01	8.25	0.81
1	0.12	7.40	0	0.02	0.19	9.04	1.55
2	0.13	7.43	0	4.27	3.77	9.04	5.36
3	0.13	7.61	0	21.39	6.74	9.05	22.53
4	0.13	7.74	0	22.40	7.75	9.05	54.73
5	0.13	7.74	0	22.40	7.75	9.05	67.95
99	0.13	7.74	0	22.40	7.75	9.05	67.95

Appraisal year (Year)	Recreational sites impacted (ha)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	2.87	0	
1	0	0	0	0.05	7.73	0	
2	0	0	0	1.68	16.79	0	
3	0	0	0	1.84	17.55	0	
4	0	0	0	1.84	17.55	0	
5	0	0	0	1.84	17.55	0	
99	0	0	0	1.84	17.55	0	

Table 5-34: Do Nothing – PV damages to recreational sites (cumulative) (£k)

Appraisal year (Year)	PV Recreation damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	18	0	0	0	21	2
1	0	37	0	0	1	45	6
2	1	56	0	11	10	67	20
3	1	75	0	64	27	90	76
4	1	94	0	119	46	112	210
5	2	113	0	173	65	134	374
99	18	1,091	0	3,005	1,044	1,278	8,963

Appraisal year (Year)	PV Recreation damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	7	0	
1	0	0	0	0	27	0	
2	0	0	0	4	70	0	
3	0	0	0	9	113	0	
4	0	0	0	13	156	0	
5	0	0	0	18	199	0	
99	0	0	0	251	2,417	0	

Table 5-35: Do Nothing – length of public rights of way impacted (cumulative) (m)

Appraisal year (Year)	Public rights of way impacted (m)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	7,485	3,851	0	13,202	0	0	7,636
1	7,485	3,851	0	15,123	373	0	8,012
2	7,672	3,922	0	26,264	919	0	13,329
3	7,672	3,922	0	29,912	1,571	238	23,343
4	7,672	3,922	0	33,730	1,653	238	32,242
5	7,672	3,922	0	33,730	1,653	238	38,862
99	7,672	3,922	0	33,730	1,653	238	38,862

Appraisal year (Year)	Public rights of way impacted (m)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	11,007	1,064	0	0	11,556	0	
1	18,774	1,094	0	0	15,027	203	
2	21,589	1,094	0	0	19,750	3,786	
3	25,209	1,094	0	0	19,758	3,786	
4	28,075	1,094	0	0	19,758	3,786	
5	28,075	1,094	0	0	19,758	3,786	
99	28,075	1,094	0	0	19,758	3,786	

Table 5-36: Do Nothing – PV damages to public rights of way (cumulative) (£k)

Appraisal year (Year)	PV Recreation (PRoW) damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	85	44	0	15	0	0	87
1	169	87	0	319	4	0	176
2	253	130	0	609	14	0	323
3	337	173	0	934	31	3	577
4	419	215	0	1,295	49	5	922
5	500	256	0	1,651	67	8	1,332
99	4,734	2,420	0	20,264	979	139	22,778
Appraisal year (Year)	PV Recreation (PRoW) damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	125	12	0	0	131	0	
1	335	24	0	0	299	2	
2	573	36	0	0	517	44	
3	847	48	0	0	732	85	
4	1,148	60	0	0	943	126	
5	1,444	72	0	0	1,152	166	
99	16,937	675	0	0	12,055	2,255	

The losses associated with impacted environmental and recreational sites as well as public rights of way result in total damages of £118,919k by the end of the 100-year appraisal period.

5.3.5 Maintain scenario outcomes

Table 5-37: Maintain scenario - area of recreational sites impacted (cumulative) (ha)

Annual Exceedance Probability	Recreational sites impacted (ha)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	0	0.22	0	0.20	0.31	0	2.17
1%	0	4.83	0	15.66	11.65	9.05	84.35
0.1%	0.03	8.01	0	23.84	11.65	9.07	103.25
Annual Exceedance Probability	**Recreational sites impacted (ha)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	0	0	0	0	0.10	0	
1%	0	1.80	0	0.75	12.05	0	
0.1%	0	1.94	0	1.78	16.17	0	

Table 5-38: Maintain scenario - recreational sites associated cash damages (£)

Annual Exceedance Probability	Cash damages (£)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	0	11	0	10	16	0	109
1%	0	208	0	780	597	451	4,270
0.1%	1	364	0	1184	597	452	5,197
Appraisal year (Year)	**Cash damages (£)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	0	0	0	0	5	0	
1%	0	90	0	21	616	0	
0.1%	0	97	0	50	825	0	

Table 5-39: Maintain scenario - length of public rights of way impacted (cumulative) (m)

Annual Exceedance Probability	Public rights of way impacted (m)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	5,480	1,698	-	40,360	480	-	25,518
1%	7,466	4,549	-	59,984	1,657	238	38,093
0.1%	7,485	4,549	-	60,282	1,657	238	47,272
Annual Exceedance Probability)	Public rights of way impacted (m)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	31,461	5,256	-	951	17,456	203	
1%	31,461	6,246	-	1,268	28,347	3,786	
0.1%	31,461	6,276	-	1,268	28,901	5,716	

Table 5-40: Maintain scenario - public rights of way cash damages (£k)

Annual Exceedance Probability	Cash damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	1	0.4	0	9	0.1	0	6
1%	2	1	0	13	0.4	0	8
0.1%	2	1	0	13	0.4	0	10
Annual Exceedance Probability	Cash damages (£)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	7	1	0	0.2	4	0	
1%	7	1	0	0.2	6	0.8	
0.1%	7	1	0	0.2	6	1	

These cash damages produce AAD losses of just £1.4k. This gives PV losses of £74k when discounted across the 100-year appraisal period and £24k when discounted across the 20-year tactical plan period.

5.3.6 Sensitivity testing

5.3.6.1 Reduction in valuations used in defining ecosystem services

A sensitivity test has been undertaken to test a reduction in the level of ecosystem service benefits provided by each habitat type. This test has been used to account for potential for:

- double counting of benefits across different ecosystem service types
- uncertainty in the level of ecosystem services a site can provide.

The test has assessed a 25% and 50% reduction in the value of ecosystem service benefits for all habitat types.

Table 5-41: Do Nothing - PV losses from environmental sites (cumulative) (£k) with a 25% reduction in ecosystem service benefits for all habitat types

Appraisal year (Year)	PV Environmental losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	0	0	0	0	0	43
1	0	0	0	3	0	0	159
2	0	0	0	21	0	0	300
3	0	0	0	49	0	0	521
4	0	0	0	79	0	0	750
5	0	0	0	108	0	0	978
99	0	0	0	938	0	0	5,142

Appraisal year (Year)	PV Environmental losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	4	0	0	0	56	61	
1	12	0	0	0	111	132	
2	25	0	0	0	164	200	
3	40	0	0	2	215	266	
4	53	0	0	5	265	330	
5	66	0	0	9	313	392	
99	180	0	0	-61	1,593	2,175	

Note: negative losses are due to ecosystem service gains associated with long term land use change

Table 5-42: Do Nothing - PV losses from environmental sites (cumulative) (£k) with a 50% reduction in ecosystem service benefits for all habitat types

Appraisal year (Year)	PV Environmental losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	0	0	0	0	0	32
1	0	0	0	3	0	0	129
2	0	0	0	19	0	0	249
3	0	0	0	44	0	0	443
4	0	0	0	70	0	0	645
5	0	0	0	95	0	0	846
99	0	0	0	816	0	0	4,242

Appraisal year (Year)	PV Environmental losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	4	0	0	0	55	43	
1	11	0	0	0	110	92	
2	23	0	0	0	163	140	
3	36	0	0	2	214	186	
4	49	0	0	4	263	231	
5	61	0	0	7	311	274	
99	144	0	0	-80	1,580	1,523	

Note: negative losses are due to ecosystem service gains associated with long term land use change

5.3.6.2 Changes in displacement of visitors making use of alternative sites

A sensitivity test has been undertaken to determine the impact of lower or higher displacement of visitors to environmental sites for both the Do Nothing and Maintain scenarios. This has tested a change in displacement by ten and 20 percentage points, both as an increase and a decrease.

Table 5-43: Do Nothing – PV damages to welfare values of recreational sites when the displacement factor is increased by 20 percentage points (£k)

Appraisal year (Year)	PV damages (£k): +20 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	13	0	0	0	15	1
1	0	26	0	0	0	32	4
2	1	40	0	8	7	48	14
3	1	53	0	45	19	64	53
4	1	66	0	84	32	79	148
5	1	80	0	122	46	95	264
99	13	770	0	2,121	737	902	6,327

Appraisal year (Year)	PV damages (£k): +20 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	5	0	
1	0	0	0	0	19	0	
2	0	0	0	3	49	0	
3	0	0	0	6	80	0	
4	0	0	0	10	110	0	
5	0	0	0	13	140	0	
99	0	0	0	177	1,706	0	

Table 5-44: Do Nothing – PV damages to welfare values of recreational sites when the displacement factor is decreased by 20 percentage points (£k)

Appraisal year (Year)	PV damages (£k): -20 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	24	0	0	0	28	3
1	1	48	0	0	1	58	8
2	1	73	0	14	13	87	25
3	1	97	0	83	35	116	98
4	2	122	0	154	59	145	272
5	2	146	0	224	83	173	484
99	23	1,411	0	3,888	1,351	1,654	11,599

Appraisal year (Year)	PV damages (£k): -20 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	10	0	
1	0	0	0	0	35	0	
2	0	0	0	6	90	0	
3	0	0	0	12	147	0	
4	0	0	0	17	202	0	
5	0	0	0	23	257	0	
99	0	0	0	325	3,128	0	

Table 5-45: Do Nothing – PV damages to welfare values of public rights of way when the displacement factor is increased by 20 percentage points (£k)

Appraisal year (Year)	PV damages (£k): +20 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	61	31	0	107	0	0	62
1	121	62	0	228	3	0	126
2	181	93	0	435	10	0	231
3	241	123	0	667	22	2	412
4	299	153	0	925	35	4	659
5	357	183	0	1,179	48	5	951
99	3,381	1,729	0	14,474	699	99	16,270

Appraisal year (Year)	PV damages (£k): +20 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	89	9	0	0	94	0	
1	239	17	0	0	214	2	
2	409	26	0	0	369	31	
3	605	34	0	0	523	61	
4	820	43	0	0	674	90	
5	1,031	51	0	0	823	118	
99	12,098	482	0	0	8,611	146	

Table 5-46: Do Nothing – PV damages to welfare values of public rights of way when the displacement factor is decreased by 20 percentage points (£k)

Appraisal year (Year)	PV damages (£k): -20 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	109	56	0	193	0	0	112
1	217	112	0	410	5	0	227
2	326	167	0	783	18	0	416
3	433	222	0	1,201	40	3	742
4	539	276	0	1,665	63	7	1,186
5	643	329	0	2,122	86	10	1,713
99	6,086	3,112	0	26,054	1,258	178	29,286

Appraisal year (Year)	PV damages (£k-): -20 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	161	16	0	0	169	0	
1	431	31	0	0	385	3	
2	737	47	0	0	665	57	
3	1,089	62	0	0	941	110	
4	1,476	77	0	0	1,213	162	
5	1,856	92	0	0	1,481	213	
99	21,776	868	0	0	15,500	2,899	

Table 5-47: Do Nothing – PV damages to welfare values of recreational sites when the displacement factor is increased by 10 percentage points (£k)

Appraisal year (Year)	PV damages (£k): +10 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	16	0	0	0	18	2
1	0	32	0	0	0	38	5
2	1	48	0	9	9	58	17
3	1	64	0	55	23	77	65
4	1	80	0	101	39	96	179
5	1	96	0	148	55	114	319
99	15	930	0	2,563	890	1,090	7,645

Appraisal year (Year)	PV damages (£k): +10 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	6	0	
1	0	0	0	0	23	0	
2	0	0	0	4	59	0	
3	0	0	0	8	97	0	
4	0	0	0	11	133	0	
5	0	0	0	15	170	0	
99	0	0	0	214	2,062	0	

Table 5-48: Do Nothing – PV damages to welfare values of recreational sites when the displacement factor is decreased by 10 percentage points (£k)

Appraisal year (Year)	PV damages (£k): -10 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	21	0	0	0	7	2
1	0	43	0	0	1	10	7
2	1	64	0	12	12	14	22
3	1	86	0	73	31	21	87
4	2	108	0	136	53	24	241
5	2	129	0	199	74	28	429
99	21	1,251	0	3,446	1,197	1,466	10,281

Appraisal year (Year)	PV damages (£k): -10 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	9	0	
1	0	0	0	0	31	0	
2	0	0	0	5	80	0	
3	0	0	0	10	130	0	
4	0	0	0	15	179	0	
5	0	0	0	21	228	0	
99	0	0	0	288	2,773	0	

Table 5-49: Do Nothing – PV damages to welfare values of public rights of way when the displacement factor is increased by 10 percentage points (£k)

Appraisal year (Year)	PV damages (£k): +10 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	73	38	0	129	0	0	74
1	145	74	0	274	4	0	151
2	217	112	0	522	12	0	277
3	289	148	0	800	27	2	495
4	359	184	0	1,110	42	4	790
5	428	219	0	1,415	57	7	1,142
99	4,057	2,074	0	17,369	839	119	19,524

Appraisal year (Year)	PV damages (£k): +10 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	107	10	0	0	113	0	
1	287	21	0	0	257	2	
2	491	31	0	0	443	38	
3	726	41	0	0	627	73	
4	984	51	0	0	809	108	
5	1,238	61	0	0	987	142	
99	14,517	579	0	0	10,333	1,933	

Table 5-50: Do Nothing – PV damages to welfare values of public rights of way when the displacement factor is decreased by 10 percentage points (£k)

Appraisal year (Year)	PV damages (£): -10 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	97	50	0	171	0	0	99
1	193	99	0	365	5	0	202
2	290	149	0	696	16	0	370
3	385	197	0	1,067	36	3	659
4	479	245	0	1,480	56	6	1,054
5	571	293	0	1,886	76	9	1,522
99	5,410	2,766	0	23,159	1,119	159	26,032

Appraisal year (Year)	PV damages (£): -10 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	143	14	0	0	150	0	
1	383	28	0	0	342	3	
2	655	42	0	0	591	50	
3	968	55	0	0	837	97	
4	1,312	69	0	0	1,078	144	
5	1,650	82	0	0	1,316	189	
99	19,356	772	0	0	13,777	2,577	

Changing the displacement factor by ten percentage points results in the Do Nothing PV recreational damages over the 100-year appraisal period to change by 14 percent, that is an increase to £115,850k and a decrease to £86,753k from £101,300k. Considering the sensitivity test, which adjusts the displacement factor by 20 percentage points, the PV recreational damages change by 29 percent, which results in an increase of damages to £130,396k and a decrease to £70,742k.

Table 5-51: Maintain – Cash damages to welfare values of recreational sites when the displacement factor is increased by 20 percentage points (£k)

Annual Exceedance Probability	Cash damages (£): +20 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	0	9	0	6	4	0	77
1%	0	137	0	530	394	319	3,032
0.1%	0	247	0	813	394	319	3,682
Annual Exceedance Probability)	Cash damages (£): +20 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	0	0	0	0	4	0	
1%	0	63	0	10	436	0	
0.1%	0	68	0	24	580	0	

Table 5-52: Maintain – Cash damages to welfare values of recreational sites when the displacement factor is decreased by 20 percentage points (£k)

Annual Exceedance Probability	Cash damages (£): -20 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	0	15	0	13	20	0	141
1%	0	137	0	1,011	768	584	5,104
0.1%	2	247	0	1,535	768	586	6,309
Annual Exceedance Probability)	Cash damages (£): -20 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	0	0	0	0	7	0	
1%	0	116	0	32	793	0	
0.1%	0	125	0	76	1,062	0	

Table 5-53: Maintain – Cash damages to welfare values of public rights of way when the displacement factor is increased by 20 percentage points (£k)

Annual Exceedance Probability	Cash damages (£): +20 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	853	262	0	6,281	75	0	7,860
1%	1,162	422	0	9,335	258	37	10,960
0.1%	1,165	422	0	9,382	258	37	13,786
Annual Exceedance Probability	Cash damages (£): +20 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	9,793	1,636	0	296	3,433	63	
1%	9,793	1,944	0	395	8,823	1,179	
0.1%	9,793	1,944	0	395	8,995	1,779	

Table 5-54: Maintain – Cash damages to welfare values of public rights of way when the displacement factor is decreased by 20 percentage points (£k)

Annual Exceedance Probability	Cash damages (£): -20 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	1,535	476	0	11,306	11,306	134	6,999
1%	2,091	759	0	16,804	16,804	464	9,082
0.1%	2,097	759	0	16,887	16,887	464	11,599
Annual Exceedance Probability)	Cash damages (£): -20 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	8,813	1,472	0	267	4,890	60	
1%	8,813	1,750	0	355	7,941	1,061	
0.1%	8,813	1,758	0	355	8,096	1,601	

Table 5-55: Maintain – Cash damages to welfare values of recreational sites when the displacement factor is increased by 10 percentage points (£k)

Annual Exceedance Probability	Cash damages (£): +10 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	0	10	0	9	14	0	8
1%	0	172	0	666	511	385	454
0.1%	1	305	0	1,010	511	386	518
Annual Exceedance Probability	Cash damages (£): +10 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	0	0	0	0	4	0	
1%	0	76	0	16	446	0	
0.1%	0	83	0	37	621	0	

Table 5-56: Maintain – Cash damages to welfare values of recreational sites when the displacement factor is decreased by 10 percentage points (£k)

Annual Exceedance Probability	Cash damages (£): -10 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	0	12	0	0	2	0	0
1%	0	64	0	2	63	518	17
0.1%	2	201	0	20	63	519	37
Annual Exceedance Probability	Cash damages (£): -10 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	0	0	0	0	0	-	
1%	0	103	0	27	42	-	
0.1%	0	111	0	63	43	-	

Table 5-57: Maintain – Cash damages to welfare values of public rights of way when the displacement factor is increased by 10 percentage points (£k)

Annual Exceedance Probability	Cash damages (£): +10 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	1,023	317	0	7,537	90	0	4,666
1%	1,394	850	0	11,202	309	44	6,055
0.1%	1,398	850	0	11,258	309	44	7,733
Annual Exceedance Probability	Cash damages (£): +10 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	5,876	982	0	178	3,260	38	
1%	5,876	1,167	0	237	5,294	707	
0.1%	5,876	1,172	0	237	5,398	1,068	

Table 5-58: Maintain – Cash damages to welfare values of public rights of way when the displacement factor is decreased by 10 percentage points (£k)

Annual Exceedance Probability	Cash damages (£): -10 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	1,365	423	0	10,050	119	0	6,354
1%	1,859	674	0	14,937	412	59	9,486
0.1%	1,864	674	0	15,011	412	59	11,771
Annual Exceedance Probability	Cash damages (£): -10 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	7,834	1,309	0	237	4,347	51	
1%	7,834	1,555	0	316	7,028	943	
0.1%	7,834	1,563	0	316	7,166	1,423	

5.3.6.3 Land use change in the Do Nothing resulting in alternative habitat type

A sensitivity analysis has been undertaken to determine the impact of a change in the habitat type resulting from a change in land use in the Do Nothing. The baseline assessment assumes all areas will become coastal habitat, with existing coastal habitat becoming marine habitat. This sensitivity test assesses the impact on losses or benefits as a result of land use changing to wetlands/freshwater habitat instead, though coastal habitat will still change to marine habitat as previously.

Table 5-59: Do Nothing - PV losses from environmental sites (cumulative) (£k) where non-coastal/marine habitats shift to wetlands/freshwater habitat

Appraisal year (Year)	PV Environmental losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	-	-	-	<1	-	-	11
1	-	-	-	2	-	-	69
2	-	-	-	15	-	-	147
3	-	-	-	33	-	-	287
4	-	-	-	51	-	-	435
5	-	-	-	68	-	-	583
99	-	-	-	572	-	-	4,849

Appraisal year (Year)	PV Environmental losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	4	-	-	-	54	6	
1	12	-	-	<1	108	13	
2	28	-	-	<1	160	20	
3	43	-	-	1	211	26	
4	57	-	-	3	260	33	
5	72	-	-	4	307	39	
99	426	-	-	57	1,665	219	

As shown in Table 5-59, changing the habitat type from coastal to wetlands/freshwater after 50 years of reaching the maximum contour level per subcompartment, there is an increase in losses associated with ecosystem service benefits.

5.4 Heritage losses

The Lower Welland catchment contains several heritage sites at risk of flooding. The catchment area has 344 listed buildings, 14 are listed as grade 1, 307 listed are as grade 2 and 23 are listed as grade 2*. These structures often include elements of timber construction that might be considered more susceptible to flood conditions. Also within the Lower Welland catchment are 28 scheduled monuments and 1 registered park.

Figure 12: Ayscoughfee Hall, Spalding, is a Grade I listed building

Figure 13 shows that there are a total of 28 scheduled monuments in the Lower Welland catchment area. The 28 scheduled monuments are:

- Shrunken medieval village;
- Pinchbeck engine;
- Settlement S of Bank House;
- Settlement NE of Whitebread Farm;
- Settlement W of Cate's Cove Corner;
- Settlement N of The Parks;
- Settlement SW of The Parks;
- Roman site, Priors Meadow;
- Elloe Stone;

- Kenulph's stone;
- St Guthlac's Cross;
- Duck decoy;
- Earthwork enclosure at Peakirk Moor;
- Village cross and lock-up, Deeping St James;
- Medieval field system 250m north of Church End Farm;
- Medieval boundary earthworks at Queen's Bank, 100m south east of Providence House;
- Iron Age and Roman settlement including a saltern on Hall Meadow;
- Churchyard cross, All Saints' churchyard;
- Churchyard cross, St Mary's churchyard;
- Wykeham Chapel: a moated monastic grange and retreat house;
- Medieval moated site and post-medieval gardens at Cressy Hall;
- Section of the Car Dyke canal, fishponds and barrows 250m north west of the Old Rectory;
- Section of the Car Dyke between Whitepost Road and Fen Bridge;
- Four bowl barrows 690m and 550m ESE of The Willows;
- Bowl barrow immediately south of Long Meadow Farm;
- Bowl barrow 130m south west of Gaylands, Milking Nook;
- Three bowl barrows 390m north west of The Firs; and,
- Three bowl barrows and a ring ditch 590m and 500m north west of The Four Winds.

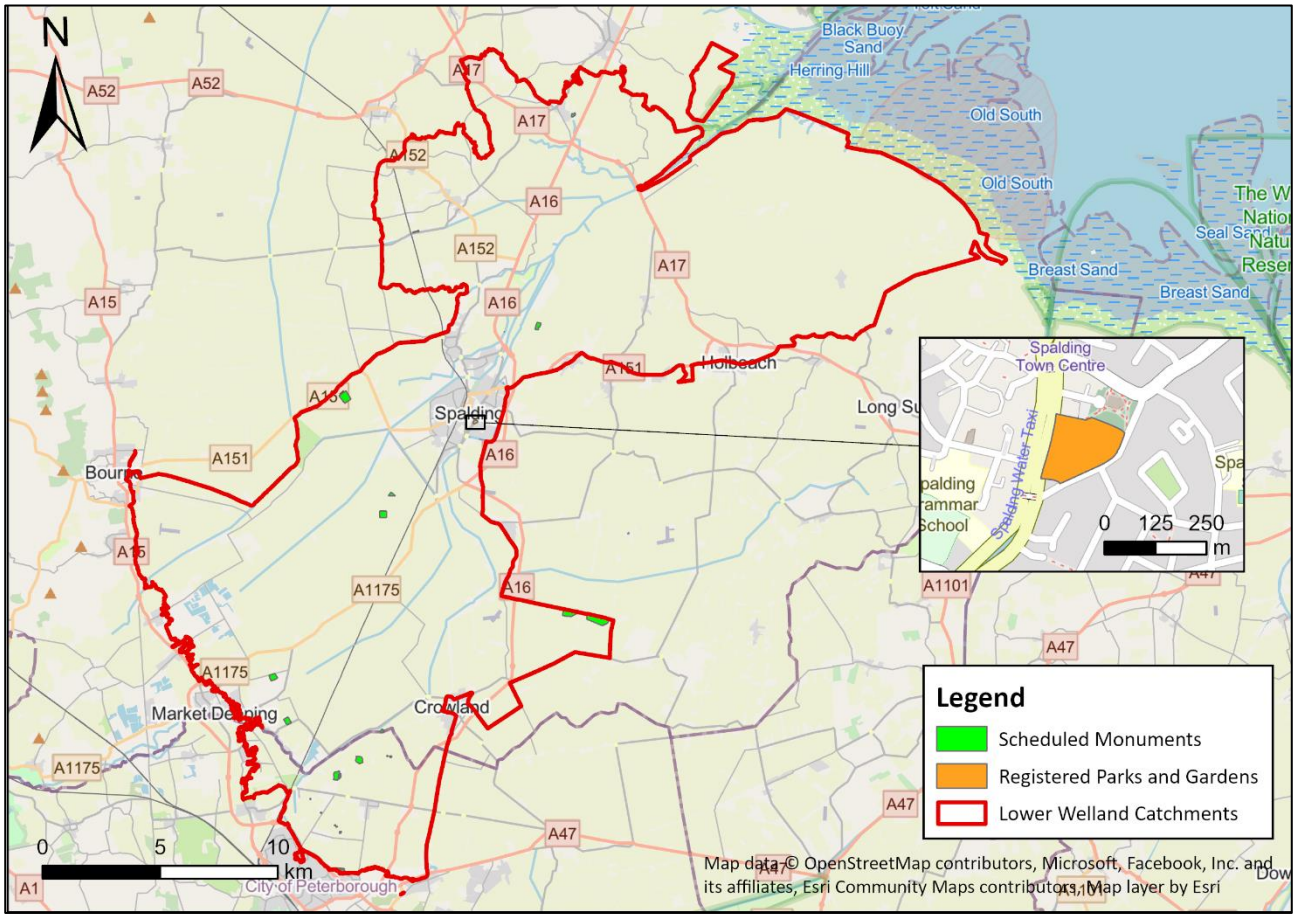

Figure 13: Location of scheduled monuments in the Lower Welland catchment area

5.4.1 Do-Nothing scenario approach

Heritage assets at risk of flooding in the catchment area are identified using a range of data sources, which are outlined in Table 5-60. The value of these heritage assets will be calculated using the DCMS Culture and Heritage Capital Evidence Bank[14]. This valuation approach aligns with the Social Cost Benefit Analysis methods in the HM Treasury Green Book Guidance (2020).

Heritage assets are split into broad categories and Willingness-to-pay values are used to define the benefit. These benefits are split into user benefits, for those who visit and use an asset, and non-user benefits which accounts for the value an asset provides to those in the local community who are aware of its existence, and value this, but do not necessarily visit it.

In the Do Nothing scenario write-off damages at each site will be calculated based on the total annual value of heritage capital lost for the area that is permanently inundated, forecast and discounted across the remainder of the appraisal period from the point at which it is lost. Residual AAD will not continue to be accrued for the assets that has been written off.

[14] Rapid Evidence Assessment: Culture and Heritage Valuation Studies - GOV.UK (www.gov.uk)

5.4.2 Maintain scenario approach

For the Maintain scenario the Willingness-to-pay valuations of assets are used along with estimated periods of disruption due to flood risk to determine a disruption cost for the asset being unavailable for a short period of time.

5.4.3 Key assumptions

Table 5-60: Key assumptions for heritage losses

Key assumptions			
DCMS Asset Types and Valuations	**Cultural or Heritage Asset Type**	**Mean Low Willingness to Pay (£, 2025)**	**Mean High Willingness to Pay (£, 2025)**
	Archaeological asset	8	17
	Built heritage	14	25
	Library	233	338
	Museum	36	73
Disruption time in the Maintain scenario	The valuation of heritage assets for this economic appraisal relies on a Willingness to Pay value which is assumed to be an annual value. This brings some limitations with it as some heritage assets may take a year to be fully dried and back in use, whilst others may only need months or weeks, and so when valuing disruption, there may be discrepancies in how much of the Willingness to Pay value is lost due to disruption. A single assumption of 1 year of value is used for simplicity in the assessment given the broad range of potential receptors covered.		
Key datasets: • Department for Digital, Culture, Media and Sport. (2022). Culture and Heritage Capital Evidence Bank. • Historic England. (2023). Listed Buildings. • Historic England. (2023). Scheduled Monuments. • Office for National Statistics. (2024). Lower layer Super Output Area population estimates.			

5.4.4 Do-Nothing scenario outcomes

Table 5-61: Do Nothing - number of heritage assets impacted (cumulative)

Appraisal year (Year)	Heritage assets impacted						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	3	8	0	1	0	0	3
1	3	8	1	1	0	0	5
2	5	9	1	1	2	0	9
3	5	10	1	15	7	0	14
4	5	10	1	27	8	0	19
5	5	10	1	27	8	0	28
99	5	10	1	27	8	0	28

Appraisal year (Year)	Heritage assets impacted						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	1	1	0	0	4	0	
1	2	2	0	0	12	0	
2	2	2	0	0	44	0	
3	2	2	0	0	53	0	
4	2	2	0	0	53	0	
5	2	2	0	0	53	0	
99	2	2	0	0	53	0	

Table 5-62: Do Nothing - PV heritage losses (cumulative) (£k)

Appraisal year (Year)	PV heritage losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	27	63	0	6	0	0	26
1	53	124	9	11	0	0	66
2	104	191	18	17	13	0	134
3	154	268	26	165	83	0	248
4	202	343	34	431	164	0	404
5	249	415	42	689	242	0	646
99	1,592	2,503	266	8,118	2,495	0	7,646

Appraisal year (Year)	PV heritage losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	9	7	0	0	35	0	0
1	25	27	0	0	152	0	0
2	42	45	0	0	655	0	0
3	57	63	0	0	1,263	0	0
4	73	80	0	0	1,851	0	0
5	87	97	0	0	2,419	0	0
99	511	579	0	0	18,808	0	0

The losses associated with impacted heritage assets in the Do Nothing are shown in Table 5-62. Approximately 136 heritage assets are impacted resulting in total damages of £42,518k by the end of the appraisal period.

5.4.5 Maintain scenario outcomes

Table 5-63: Maintain scenario - number of heritage assets impacted (cumulative)

Annual Exceedance Probability	Heritage assets impacted						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	0	0	0	3	3	0	7
1%	0	3	0	20	50	0	118
0.1%	3	8	1	42	50	0	128
Annual Exceedance Probability	Heritage assets impacted						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	2	2	0	0	1	0	
1%	2	8	0	0	13	0	
0.1%	2	15	0	0	45	0	

Table 5-64: Maintain scenario - heritage cash damages (£k)

Annual Exceedance Probability	Cash losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	0	0	0	1	1	0	3
1%	0	1	0	10	21	0	57
0.1%	1	3	0.4	19	21	0	61
Annual Exceedance Probability	Cash losses (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	0.7	1	0	0	0.3	0	
1%	0.7	3	0	0	6	0	
0.1%	0.7	7	0	0	22	0	

These damages produce PV losses of £132k when discounted across the 100-year appraisal period.

5.4.6 Sensitivity testing

5.4.6.1 Change in willingness to pay valuations

A sensitivity test has been undertaken to test a change in the level of willingness to pay values for heritage assets. The test has assessed a 25% increase and decrease in the willingness to pay rates for all heritage asset types. This test was applied to both Do Nothing and Maintain scenarios.

Table 5-65: Do Nothing – PV heritage losses when the willingness to pay rates are changed by increasing 25 percentage points (£k)

Appraisal year (Year)	PV damages (£k): +25 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	33	79	0	7	0	0	33
1	66	155	11	14	0	0	82
2	130	238	22	21	16	0	168
3	192	335	32	206	104	0	310
4	253	429	42	539	205	0	505
5	311	519	52	861	302	0	808
99	1,990	3,129	333	10,147	3,118	0	9,558

Appraisal year (Year)	PV damages (£k): +25 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	11	9	0	0	43	0	
1	32	33	0	0	190	0	
2	52	56	0	0	818	0	
3	72	79	0	0	1,579	0	
4	91	100	0	0	2,314	0	
5	109	121	0	0	3,024	0	
99	639	724	0	0	23,510	0	

Table 5-66: Do Nothing – PV heritage losses when the willingness to pay rates are changed by decreasing 25 percentage points (£k)

Appraisal year (Year)	PV damages (£k): -25 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	20	47	0	4	0	0	20
1	39	93	7	9	0	0	49
2	78	143	13	13	10	0	101
3	115	201	19	123	62	0	186
4	152	257	25	323	123	0	303
5	187	312	31	516	181	0	485
99	1,194	1,877	200	6,088	1,871	0	5,735

Appraisal year (Year)	PV damages (£k): -25 percentage points						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	6	6	0	0	26	0	
1	19	20	0	0	114	0	
2	31	34	0	0	491	0	
3	43	47	0	0	947	0	
4	54	60	0	0	1,388	0	
5	66	73	0	0	1,814	0	
99	384	434	0	0	14,106	0	

Table 5-67: Maintain scenario – heritage losses when the willingness to pay rates are changed by increasing 25 percentage points (£k)

Annual Exceedance Probability)	PV damages (£k): +25 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	0	0	0	1	1		4
1%	0	2	0	12	26		72
0.1%	1	4	0.4	24	26		77
Annual Exceedance Probability	**PV damages (£k): +25 percentage points**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	1	1	-	-	0.4		
1%	1	4	-	-	7		
0.1%	1	8	-	-	27		

Table 5-68: Maintain scenario – heritage losses when the willingness to pay rates are changed by decreasing 25 percentage points (£k)

Annual Exceedance Probability	PV damages (£k): -25 percentage points						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
3.33%	0	0	0	1	1	0	3
1%	0	1	0	7	15	0	43
0.1%	1	2	0.3	14	15	0	46
Annual Exceedance Probability	**PV damages (£k): -25 percentage points**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
3.33%	1	1	0	0	0.2	0	
1%	1	3	0	0	4	0	
0.1%	1	5	0	0	16	0	

5.5 Infrastructure damages

The catchment plays host to mostly minor country roads, with two primary routes (A16 and A17) and two A roads (A151 and A1175) crossing the catchment. There is one railway line, the Peterborough to Lincoln line running north-south, along with the train station at Spalding. Other major infrastructure, such as major electrical distribution networks, also cross the catchment.

Whilst infrastructure assets are generally protected to a fairly high standard for infrequent flood events, if the catchment were to become permanently or extensively impacted, vast swathes of infrastructure would be abandoned with alternative capacities or diversions required.

There are localised areas of existing risk, which whilst not primary roads or assets, are key connections between communities. Closures of these connections leads to disruption and local financial losses for businesses such as shops and pubs with customers having to take a longer route to access them or going elsewhere. These localised risks of disruption and financial losses are not captured as part of this assessment.

Infrastructure assets are assumed to be largely protected to a high standard against short term flooding from infrequent events, and as such only damages associated with the Do-Nothing permanent flooding case have been calculated. The following two sections describe impacts to transport and utilities infrastructure.

5.6 Transport damages

5.6.1 Do-Nothing scenario approach

The Do-Nothing scenario assumes gradual inundation of the catchment resulting in highways infrastructure being written off as flood levels increase across the catchment. Damages from infrequent flood events, as per MCM guidance, are typically calculated based on disruption to traffic or damage repair costs (e.g. resurfacing). In this instance, highways are assumed to be permanently inundated resulting in a loss of the asset. The damage value has been defined from the length of highway impacted at each step-change in inundation of the catchment.

A sense check on highways being written off was undertaken to ensure these were only valued where they connect settlements outside of the catchment and aren't valued where they just serve settlements within the catchment. This is because the highway would cease to have any value if the settlement it serves is lost to permanent inundation.

Further to the consideration of highways written off, the impact on rail infrastructure has also been considered. The same approach as highways is used for railways, with the length of infrastructure impacted used to define the damage value. No allowance has been made for loss of railway stations, as it is considered these would cease to have value when the communities they serve become permanently inundated.

5.6.2 Key assumptions

Table 5-69: Do Nothing transport assumptions

<table>
<tr><th colspan="2">Key assumptions:</th></tr>
<tr><td>Value of lost highway infrastructure</td><td>The value of lost roads has been based on the Future Fens (Great Ouse) economic analysis, which considered recent data from new build road schemes. No further publicly available information was considered to better the information utilised. Costs expressed in 2025 values.
<table><tr><th>Type of Road</th><th>Cost per Metre (£)</th></tr><tr><td>A Road</td><td>22,122</td></tr></table></td></tr>
<tr><td>Roads impacted</td><td>A-Roads and primary roads (such as motorways) have been identified within the catchments using OS Open Roads dataset.</td></tr>
<tr><td>Value of lost railway infrastructure</td><td>The value of lost railway has been based on the Future Fens (Great Ouse) economic analysis, which considered recent data from new build rail schemes. No further publicly available information was considered to better the information utilised. Costs expressed in 2025 values.
<table><tr><th></th><th>Cost per Metre (£)</th></tr><tr><td>Railway cost</td><td>6,301</td></tr></table></td></tr>
<tr><td>Railway impacted</td><td>Railway identified within the catchments using OS Open dataset.</td></tr>
<tr><th colspan="2">Key datasets:</th></tr>
<tr><td colspan="2">• Length and type of highway impacted defined from OS Open Roads dataset (2023)
• Length of railway impacted defined from OS Open dataset (2024)</td></tr>
</table>

5.6.3 Do-Nothing scenario outcomes

Table 5-70: Do-Nothing - length of road network impacted (cumulative) (m)

Appraisal year (Year)	Length of road impacted (m)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	2,845	5,126	0	13	0	372	107
1	5,417	5,826	0	19	0	664	141
2	5,581	6,097	0	946	4	1,602	3,292
3	5,581	6,190	0	3,834	10	1,763	7,733
4	5,581	6,224	0	5,810	11	1,783	13,158
5	5,581	6,224	0	5,810	11	1,783	15,924
99	5,581	6,224	0	5,810	11	1,783	15,924

Appraisal year (Year)	Length of road impacted (m)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	187	0	
1	0	0	0	0	2,121	0	
2	18	0	0	0	10,877	0	
3	24	0	0	0	11,882	0	
4	24	0	0	0	11,882	0	
5	24	0	0	0	11,882	0	
99	24	0	0	0	11,882	0	

Table 5-71: Do-Nothing - PV road network damages (cumulative) (£k)

Appraisal year (Year)	PV Highways damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	94,104	169,518	0	427	0	12,312	2,751
1	176,291	191,880	0	613	0	21,629	3,556
2	181,340	200,262	0	21,232	790	50,602	68,719
3	181,340	203,026	0	82,965	205	55,046	157,507
4	181,340	204,021	0	126,187	223	55,438	262,198
5	181,340	204,021	0	126,187	223	55,438	313,813
99	181,340	204,021	0	126,187	223	55,438	313,813

Appraisal year (Year)	PV Highways damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	6,184	0	
1	0	0	0	0	67,979	0	
2	380	0	0	0	338,308	0	
3	489	0	0	0	368,287	0	
4	489	0	0	0	368,287	0	
5	489	0	0	0	368,287	0	
99	489	0	0	0	368,287	0	

Table 5-72: Do-Nothing - length of rail network impacted (cumulative) (m)

Appraisal year (Year)	Length of rail impacted (m)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	0	0	0	0	0	81
1	0	0	0	0	0	0	87
2	0	0	0	0	0	0	285
3	0	0	0	0	0	0	6,557
4	0	0	0	0	0	0	11,389
5	0	0	0	0	0	0	13,912
99	0	0	0	0	0	0	13,912

Appraisal year (Year)	Length of rail impacted (m)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	24	0	0	0	0	
1	0	33	0	0	44	0	
2	0	33	0	0	4,755	0	
3	0	33	0	0	5,643	0	
4	0	33	0	0	5,643	0	
5	0	33	0	0	5,643	0	
99	0	33	0	0	5,643	0	

Table 5-73: Do-Nothing - PV rail network damages (cumulative) (£k)

Appraisal year (Year)	PV Railway damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	0	0	0	0	0	508
1	0	0	0	0	0	0	545
2	0	0	0	0	0	0	1,709
3	0	0	0	0	0	0	37,353
4	0	0	0	0	0	0	63,883
5	0	0	0	0	0	0	77,268
99	0	0	0	0	0	0	77,268

Appraisal year (Year)	PV Railway damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	152	0	0	0	0	
1	0	204	0	0	266	0	
2	0	204	0	0	27,973	0	
3	0	204	0	0	33,022	0	
4	0	204	0	0	33,022	0	
5	0	204	0	0	33,022	0	
99	0	204	0	0	33,022	0	

The damages associated with impacted road and rail networks for the Do-Nothing scenario are seen in Table 5-71 and Table 5-73. Approximately 47,239 m of road network is impacted, resulting in total damages of £1,249,798k by the end of the appraisal period. Around 19,588 m of rail network is impacted over the same period, leading to an observed £110,494k of damages. When combined, these damages give us a transport damage total of £1,360,291k.

5.6.4 Sensitivity testing

Sensitivity testing has been undertaken to assess:

- the valuations used for roads, with variance by 25%.
- the valuations used for railways, with variance by 25%.

The damages associated with decreasing and increasing the valuations of roads and railways by 25% each can be seen in Table 5-74 to Table 5-77.

Table 5-74: Do-Nothing - PV road damages (cumulative) (£k) with a 25% decrease in valuations

Appraisal year (Year)	PV Highways damages (£k) with a 25% decrease in valuations						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	70,578	127,139	0	320	0	9,234	2,063
1	132,219	143,910	0	460	0	16,221	2,667
2	136,005	150,197	0	15,924	59	37,951	51,539
3	136,005	152,269	0	62,224	154	41,284	118,130
4	136,005	153,015	0	94,640	167	41,578	196,649
5	136,005	153,015	0	94,640	167	41,578	235,360
99	136,005	153,015	0	94,640	167	41,578	235,360

Appraisal year (Year)	PV Highways damages (£k) with a 25% decrease in valuations						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	4,638	0	
1	0	0	0	0	50,984	0	
2	285	0	0	0	253,731	0	
3	367	0	0	0	276,215	0	
4	367	0	0	0	276,215	0	
5	367	0	0	0	276,215	0	
99	367	0	0	0	276,215	0	

Table 5-75: Do-Nothing - PV rail network damages (cumulative) (£k) with a 25% decrease in valuations

Appraisal year (Year)	PV Railway damages (£k) with a 25% decrease in valuations						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	0	0	0	0	0	381
1	0	0	0	0	0	0	409
2	0	0	0	0	0	0	1,282
3	0	0	0	0	0	0	28,015
4	0	0	0	0	0	0	47,912
5	0	0	0	0	0	0	57,951
99	0	0	0	0	0	0	57,951

Appraisal year (Year)	PV Railway damages (£k) with a 25% decrease in valuations						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	114	0	0	0	0	
1	0	153	0	0	200	0	
2	0	153	0	0	20,980	0	
3	0	153	0	0	24,767	0	
4	0	153	0	0	24,767	0	
5	0	153	0	0	24,767	0	
99	0	153	0	0	24,767	0	

Table 5-76: Do-Nothing - PV road damages (cumulative) (£k) with a 25% increase in valuations

Appraisal year (Year)	PV Highways damages (£k) with a 25% increase in valuations						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	117,630	211,898	0	534	0	15,390	3,439
1	220,364	239,851	0	767	0	27,036	4,445
2	226,675	250,328	0	26,540	99	63,252	85,899
3	226,675	253,782	0	103,706	256	68,807	196,883
4	226,675	255,026	0	157,733	279	69,297	327,748
5	226,675	255,026	0	157,733	279	69,297	392,266
99	226,675	255,026	0	157,733	279	69,297	392,266

Appraisal year (Year)	PV Highways damages (£k) with a 25% increase in valuations						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	7,730	0	
1	0	0	0	0	84,974	0	
2	475	0	0	0	422,884	0	
3	611	0	0	0	460,359	0	
4	611	0	0	0	460,359	0	
5	611	0	0	0	460,359	0	
99	611	0	0	0	460,359	0	

-

Table 5-77: Do-Nothing - PV rail network damages (cumulative) (£k) with a 25% increase in valuations

Appraisal year (Year)	PV Railway damages (£k) with a 25% increase in valuations						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	0	0	0	0	0	635
1	0	0	0	0	0	0	681
2	0	0	0	0	0	0	2,136
3	0	0	0	0	0	0	46,691
4	0	0	0	0	0	0	79,853
5	0	0	0	0	0	0	96,585
99	0	0	0	0	0	0	96,585

Appraisal year (Year)	PV Railway damages (£k) with a 25% increase in valuations						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	190	0	0	0	0	
1	0	255	0	0	333	0	
2	0	255	0	0	34,966	0	
3	0	255	0	0	41,278	0	
4	0	255	0	0	41,278	0	
5	0	255	0	0	41,278	0	
99	0	255	0	0	41,278	0	

With a 25% decrease in road valuation, there is a total damage value of £937,347k by the end of the appraisal period. This means that there was a decrease in PV damages of £312,451k. Similarly, a 25% decrease in rail valuation resulted in a decrease in PV damages of £27,623k, resulting in a total of £82,871k. When combined, these damages give us a transport damage total of £1,020,218k.

With a 25% increase in road valuation, there is a total damage value of £1,562,246k by the end of the appraisal period. This means that there was an increase in PV damages of £312,448k. A 25% increase in rail valuation resulted in an increase in PV damages of £27,624k, resulting in a total of £138,118k. When combined, these damages give us a transport damage total of £1,700,364k.

5.7 Utilities damages

For each of the utilities damage streams, damages are assumed (conservatively) to include only the assets directly impacted by permanent inundation within the Do-Nothing scenario. This does not account for the wider impacts and disruption likely to occur as parts of the network become flooded but was considered an appropriate approach at this stage where broad representation of damages is required and the data and effort to assess wider disruption would be disproportionate.

5.7.1 Power networks

Data pertaining to power generation assets within the catchments have been obtained from partners. The costs for the construction of infrastructure generating the equivalent power impacted by the Do-Nothing scenario has been calculated based on data from the UK Energy Generation Costs report[15] (Department for Energy Security and Net Zero) and used as a proxy for the value of infrastructure lost.

Electrical distribution assets across the catchments have been identified for Western Power Distribution (WPD), UK Power Networks and National Grid. The damages have been defined by the number of their assets within the permanently inundated extents, based upon publicly available GIS asset databases. This primarily relates to substations and pole tower assets. The value assigned to these assets is detailed in Table 5-78.

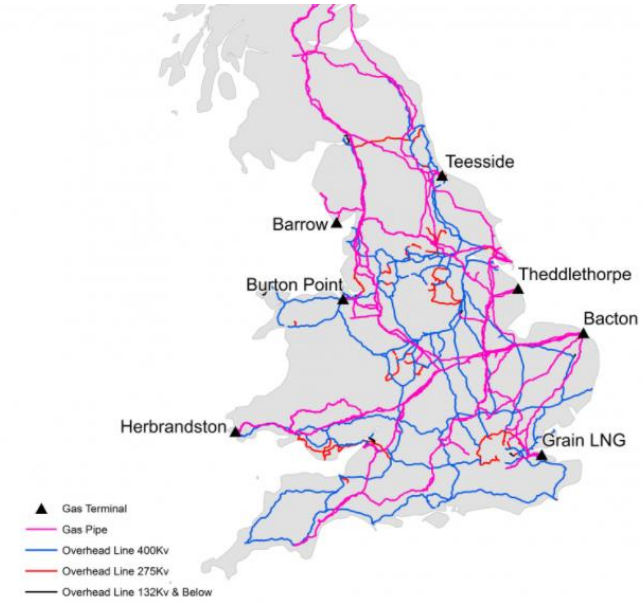

Figure 14: National Grid electricity and gas distribution network

Source: National Grid 2021

5.7.2 Water

Damages to above-ground water utility assets are assumed to have been captured through the NRD datasets, providing a proxy of the damages associated with these assets.

No further data was available from Anglian Water to understand the asset-base at risk of inundation where these assets are not represented in NRD. The value of assets not included within the NRD data is therefore excluded from this assessment.

[15] https://www.gov.uk/government/publications/electricity-generation-costs-2023

5.7.3 Gas

Damages have been calculated for the loss of National Grid gas distribution assets based on the length (km) of gas main impacted at the permanently inundated water level, with geographically referenced data for the location of the pipeline being obtained from National Grid.

5.7.4 Key assumptions

Table 5-78: Do Nothing utilities assumptions

<table>
<tr><th colspan="2">Key assumptions:</th></tr>
<tr><td>Electrical asset replacement costs</td><td>Electrical asset replacement costs for Poles and Substations are based on stakeholder engagement undertaken by the Future Fens (Great Ouse) economic analysis with UKPN. Overhead Conductors replacement costs have been derived from data by Electrical Engineering Portal, whilst Underground Cables replacement costs are derived from data by Roadnight Taylor. These costs have been applied across the National Grid and WPD assets as a proxy. All costs are expressed as 2025 values.
<table>
<tr><th>Asset (UKPN & WPD)</th><th>Replacement cost (£) (2025)</th></tr>
<tr><td>Pole Tower (33kV)</td><td>£3,752</td></tr>
<tr><td>Pole Tower (11kV)</td><td>£3,752</td></tr>
<tr><td>Substation (132kV)</td><td>£3,877,438</td></tr>
<tr><td>Substation (33kV)</td><td>£93,809</td></tr>
<tr><td>Substation (11kV)</td><td>£31,270</td></tr>
<tr><td>Overhead Conductors (132kV)</td><td>£144 per m</td></tr>
<tr><td>Overhead Conductors (33kV)</td><td>£58 per m</td></tr>
<tr><td>Overhead Conductors (11kV)</td><td>£23 per m</td></tr>
<tr><td>Underground Cables (33kV)</td><td>£339 per m</td></tr>
<tr><td>Underground Cables (11kV)</td><td>£169 per m</td></tr>
</table></td></tr>
<tr><td>Electricity assumptions</td><td>Costs relating to safe clearance of temporarily and permanently flooded assets have not been provided, nor have costs for a new submarine power network. Should the network become permanently inundated, the assets will be abandoned. Indirect damages from power outages outside the study area are not captured as part of this appraisal.</td></tr>
<tr><td>Gas replacement costs</td><td>In the absence of UK specific data, losses associated with the gas replacement costs have been based on a collection of 30” gas pipeline projects in the US for large gas transmission pipeline. The cost of the reference pipeline is seen below, with £/m in 2025 values.
<table>
<tr><th>Valuation</th><th>Cost</th><th>Comments</th></tr>
<tr><td>Construction 30” pipeline ($ per mile (2017))</td><td>5,340,000</td><td>Source: Oil and Gas Pipeline Construction Costs - Global Energy Monitor (gem.wiki)</td></tr>
<tr><td>£ / m</td><td>3,327</td><td>Conversion to present day £ and meters. Source:

1 USD to GBP - US Dollars to British Pounds Exchange Rate (xe.com) (Conversion date</td></tr>
</table></td></tr>
</table>

Key assumptions:			
			used- 01/07/2017) Uplifted to 2025 price

Key datasets:

- Electricity: Western Power Distribution and National Grid geographical datasets of their assets
- How close does an energy scheme need to be to an electricity network? | Roadnight Taylor
- Typical constructions of overhead lines (electrical-engineering-portal.com)
- Gas: National Grid Gas Distribution Network

5.7.5 Do-Nothing outcomes

Table 5-79: Do-Nothing – number of pole towers impacted (cumulative)

Appraisal year (Year)	Number of pole towers impacted (all)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	194	210	4	33	1	9	378
1	219	251	5	85	1	15	672
2	223	286	5	354	1	17	894
3	224	310	5	942	2	19	1,066
4	224	315	5	1,115	2	19	1,164
5	224	315	5	1,115	2	19	1,205
99	224	315	5	1,115	2	19	1,205

Appraisal year (Year)	Number of pole towers impacted (all)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	10	0	0	4	357	10	
1	37	0	0	8	803	13	
2	46	0	0	11	984	14	
3	46	0	0	14	1,011	14	
4	46	0	0	23	1,011	14	
5	46	0	0	29	1,011	14	
99	46	0	0	29	1,011	14	

Table 5-80: Do-Nothing – number of substations impacted (cumulative)

Appraisal year (Year)	Number substations impacted (all)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	17	43	1	7	0	1	37
1	25	54	1	15	3	4	97
2	27	66	1	44	10	5	141
3	28	70	1	163	17	8	205
4	28	71	1	204	19	8	288
5	28	71	1	204	19	8	312
99	28	71	1	204	19	8	312

Appraisal year (Year)	Number of substations impacted (all)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	56	3	
1	0	0	0	2	148	3	
2	2	0	0	5	206	3	
3	2	0	0	10	215	3	
4	3	0	0	11	215	3	
5	3	0	0	14	215	3	
99	3	0	0	14	215	3	

Table 5-81: Do-Nothing –length of overhead conductors impacted (cumulative) (m)

Appraisal year (Year)	Length of overhead conductors impacted (all) (m)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	19,313	16,853	415	2,483	0	2,661	51,384
1	21,448	20,891	507	6,358	2	3,146	77,231
2	21,789	24,060	507	33,506	5	3,312	98,714
3	21,841	26,376	507	100,910	5	3,347	113,134
4	21,845	26,769	507	117,413	5	3,351	122,307
5	21,845	26,769	507	117,413	5	3,351	125,398
99	21,845	26,769	507	117,413	5	3,351	125,398

Appraisal year (Year)	Length of overhead conductors impacted (all) (m)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	1,724	37	0	7,433	28,889	2,141	
1	4,257	75	0	8,443	68,109	4,373	
2	5,412	75	0	8,889	85,685	4,542	
3	5,513	75	0	9,592	87,945	4,542	
4	5,532	75	0	10,376	87,945	4,542	
5	5,532	75	0	11,178	87,945	4,542	
99	5,532	75	0	11,178	87,945	4,542	

Table 5-82: Do-Nothing – length of underground cables impacted (cumulative) (m)

Appraisal year (Year)	Length of underground cables impacted (all) (m)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
99	0	0	0	0	0	0	0

Appraisal year (Year)	Length of underground cables impacted (all) (m)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	0	0	0	0	0	
1	0	0	0	0	0	0	
2	0	0	0	0	0	0	
3	0	0	0	0	0	0	
4	0	0	0	0	0	0	
5	0	0	0	0	0	0	
99	0	0	0	0	0	0	

Table 5-83: Do-Nothing – length of gas pipeline impacted (cumulative) (m)

Appraisal year (Year)	Length of gas pipeline impacted (m)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	404	0	15	0	0	0
1	0	1,409	0	91	0	0	0
2	0	2,595	0	6,785	0	0	0
3	0	3,215	0	14,837	0	0	0
4	0	3,215	0	14,837	0	0	0
5	0	3,215	0	14,837	0	0	0
99	0	3,215	0	14,837	0	0	0

Appraisal year (Year)	Length of gas pipeline impacted (m)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	2	0	0	2,552	0	
1	0	3	0	0	4,975	0	
2	0	3	0	0	5,190	0	
3	0	3	0	0	5,190	0	
4	0	3	0	0	5,190	0	
5	0	3	0	0	5,190	0	
99	0	3	0	0	5,190	0	

Table 5-84: Do-Nothing - PV electrical network damages (cumulative) (£k)

Appraisal year (Year)	PV Electricity damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	2,094	2,522	56	425	4	364	5,642
1	2,495	3,093	62	968	95	502	9,403
2	2,575	3,634	62	3,662	299	544	12,131
3	2,608	3,876	62	12,348	499	635	14,885
4	2,608	3,928	62	14,675	554	635	17,687
5	2,608	3,928	62	14,675	554	635	18,568
99	2,608	3,928	62	14,675	554	635	18,568

Appraisal year (Year)	PV Electricity damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	110	1	0	1,045	3,823	357	
1	306	2	0	1,246	9,226	633	
2	470	2	0	1,374	12,249	656	
3	476	2	0	1,588	12,660	656	
4	506	2	0	1,690	12,660	656	
5	506	2	0	1,808	12,660	656	
99	506	2	0	1,808	12,660	656	

Table 5-85: Do-Nothing - PV Gas network damages (cumulative) (£k)

Appraisal year (Year)	PV Gas damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	1,346	0	51	0	0	0
1	0	4,575	0	294	0	0	0
2	0	8,256	0	21,083	0	0	0
3	0	10,118	0	45,241	0	0	0
4	0	10,118	0	45,241	0	0	0
5	0	10,118	0	45,241	0	0	0
99	0	10,118	0	45,241	0	0	0
Appraisal year (Year)	PV Gas damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	6	0	0	8,488	0	
1	0	11	0	0	16,277	0	
2	0	11	0	0	16,945	0	
3	0	11	0	0	16,945	0	
4	0	11	0	0	16,945	0	
5	0	11	0	0	16,945	0	
99	0	11	0	0	16,945	0	

The total lengths and counts of electrical utilities impacted for the Do-Nothing scenario can be found in Table 5-79 to Table 5-82, with damage totals for both located in Table 5-84 The total lengths for gas utilities can be found in Table 5-83, with damage totals located in Table 5-85.

For electrical utilities by the end of the appraisal period, around 3,985 pole towers and 878 substations are impacted during the final inundation level, whilst approximately 404,560m of overhead conductor are impacted and no underground cables are impacted, resulting in total electricity damages of £56,662k.

For gas utilities by the end of the appraisal period, approximately 23,245m of pipeline is impacted, resulting in total gas damages of £72,315k.

5.7.6 Sensitivity testing

A sensitivity analysis has been undertaken to assess the impact of varying the valuation for electricity distribution and assets by 10%, both as an increase and a decrease. The damages associated with decreasing and increasing the valuations of these assets by 10% can be seen in Table 5-86 to Table 5-91.

Table 5-86: Do-Nothing - PV electrical network damages with -10% valuations (cumulative) (£k)

Appraisal year (Year)	PV Electricity damages with -10% valuation (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	1,885	2,269	51	382	3	328	5,078
1	2,244	2,783	55	871	85	452	8,463
2	2,317	3,270	55	3,295	268	489	10,919
3	2,347	3,488	55	11,113	449	571	13,396
4	2,347	3,536	55	13,208	498	572	15,919
5	2,347	3,536	55	13,208	498	572	16,712
99	2,347	3,536	55	13,208	498	572	16,712

Appraisal year (Year)	PV Electricity damages with -10% valuation (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	97	1	0	941	3,440	320	
1	275	2	0	1,120	8,304	571	
2	424	2	0	1,236	11,023	590	
3	430	2	0	1,429	11,393	590	
4	454	2	0	1,519	11,393	590	
5	454	2	0	1,627	11,393	590	
99	454	2	0	1,627	11,393	590	

Table 5-87: Do-Nothing - PV electrical network damages with +10% valuations (cumulative) (£k)

Appraisal year (Year)	PV Electricity damages with +10% valuation (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	2,302	2,774	62	468	4	4	6,206
1	2,743	3,402	67	1,065	104	552	10,344
2	2,832	3,998	67	4,028	328	597	13,345
3	2,868	4,265	67	13,582	550	698	16,374
4	2,868	4,320	67	16,144	610	698	19,457
5	2,868	4,320	67	16,144	610	698	20,424
99	2,868	4,320	67	16,144	610	698	20,424

Appraisal year (Year)	PV Electricity damages with +10% valuation (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	120	1	0	1,150	4,204	392	
1	336	2	0	1,369	10,148	697	
2	518	2	0	1,511	13,474	721	
3	524	2	0	1,746	13,926	721	
4	555	2	0	1,858	13,926	721	
5	555	2	0	1,989	13,926	721	
99	555	2	0	1,989	13,926	721	

Table 5-88: Do-Nothing - PV gas network damages with -10% valuations (cumulative) (£k)

Appraisal year (Year)	PV Gas damages with -10% valuation (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	0	1,211	46	0	0	0
1	0	0	4,118	265	0	0	0
2	0	0	7,430	18,975	0	0	0
3	0	0	9,106	40,717	0	0	0
4	0	0	9,106	40,717	0	0	0
5	0	0	9,106	40,717	0	0	0
99	0	0	9,106	40,717	0	0	0

Appraisal year (Year)	PV Gas damages with -10% valuation (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	5	0	0	7,639	0	
1	0	10	0	0	14,649	0	
2	0	10	0	0	15,250	0	
3	0	10	0	0	15,250	0	
4	0	10	0	0	15,250	0	
5	0	10	0	0	15,250	0	
99	0	10	0	0	15,250	0	

Table 5-89: Do-Nothing - PV gas network damages with +10% valuations (cumulative) (£k)

Appraisal year (Year)	PV Gas damages with +10% valuation (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	1,480	0	56	0	0	0
1	0	5,033	0	324	0	0	0
2	0	9,082	0	23,191	0	0	0
3	0	11,130	0	49,765	0	0	0
4	0	11,130	0	49,765	0	0	0
5	0	11,130	0	49,765	0	0	0
99	0	11,130	0	49,765	0	0	0

Appraisal year (Year)	PV Gas damages with +10% valuation (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	6	0	0	9,337	0	
1	0	12	0	0	17,905	0	
2	0	12	0	0	18,639	0	
3	0	12	0	0	18,639	0	
4	0	12	0	0	18,639	0	
5	0	12	0	0	18,639	0	
99	0	12	0	0	18,639	0	

Table 5-90: Do-Nothing - PV gas network damages with -25% valuations (cumulative) (£k)

Appraisal year (Year)	PV Gas damages with -25% valuation (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	1,009	0	38	0	0	0
1	0	3,431	0	221	0	0	0
2	0	6,192	0	15,812	0	0	0
3	0	7,589	0	33,931	0	0	0
4	0	7,589	0	33,931	0	0	0
5	0	7,589	0	33,931	0	0	0
99	0	7,589	0	33,931	0	0	0

Appraisal year (Year)	PV Gas damages with -25% valuation (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	4	0	0	6,366	0	
1	0	8	0	0	12,208	0	
2	0	8	0	0	12,708	0	
3	0	8	0	0	12,708	0	
4	0	8	0	0	12,708	0	
5	0	8	0	0	12,708	0	
99	0	8	0	0	12,708	0	

Table 5-91: Do-Nothing - PV gas network damages with +25% valuations (cumulative) (£k)

Appraisal year (Year)	PV Gas damages with +25% valuation (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
0	0	1,682	0	64	0	0	0
1	0	5,719	0	368	0	0	0
2	0	10,320	0	26,354	0	0	0
3	0	12,648	0	56,551	0	0	0
4	0	12,648	0	56,551	0	0	0
5	0	12,648	0	56,551	0	0	0
99	0	12,648	0	56,551	0	0	0

Appraisal year (Year)	PV Gas damages with +25% valuation (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	
0	0	7	0	0	10,610	0	
1	0	14	0	0	20,346	0	
2	0	14	0	0	21,181	0	
3	0	14	0	0	21,181	0	
4	0	14	0	0	21,181	0	
5	0	14	0	0	21,181	0	
99	0	14	0	0	21,181	0	

With a 10% decrease in electrical distribution asset valuation, there is a total damage value of £50,994k by the end of the appraisal period. This means that there was a decrease in PV damages of £5,668k. With a 10% increase in electrical distribution asset valuation, there is a total damage value of £62,324k by the end of the appraisal period. This means that there was an increase in PV damages of £5,662k.

With a 10% decrease in gas distribution asset valuation, there is a total damage value of £65,083k by the end of the appraisal period. This means that there was a decrease in PV damages of £7,232k. With a 10% increase in gas distribution asset valuation, there is a total damage value of £79,546k by the end of the appraisal period. This means that there was an increase in PV damages of £7,231k.

5.8 Isolated land and properties

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. This aspect looks to account for the notion that areas of elevated land may not be directly flooded, but if surrounded by water are likely to be abandoned - with similar impacts to that of the damage streams described prior.

The term 'isolated properties' includes properties that are cut-off from existing road networks due to inundation, thus properties that are not flooded but are able to access an existing road network to either leave the study area and/or navigate around flooded extents through a longer, more indirect route are not classified as 'isolated'.

Similarly, properties that are scattered and/or are not part of a geographic cluster of isolated properties that share an existing road connection are not classified as being part of an 'isolated community'. In order to be classified as a community, a cluster of isolated properties that share a road network connection must be comprised of at least 10 NRD receptors with a non 9/999 value.

5.8.1 Do-Nothing scenario approach

In accordance with HM Treasury Green Book[16] guidance, the analysis looks to define the “lowest cost to the nation”. As such, the approach considered damages associated with isolated areas (at the point of permanent inundation) which are assumed to be abandoned; these costs were compared to cost of re-provision of services and to reconnect the isolated communities to the ‘mainland’. This has conservatively been based on the cost of a new road to the isolated community utilising the same costs as described in Section 5.6. It is assumed new services could be provided along the route of any new raised road.

Whilst abandonment is considered to be the most likely scenario or outcome if a Do-Nothing event were to occur, recognising that the community would have no wider flood defence measures and be extremely vulnerable to coastal storm events, the approach taken provides a conservative estimate of potential losses where there is uncertainty.

The analysis has focused towards identifying isolated populated communities. Each settlement’s residential and non-residential properties have been identified and values associated with their abandonment defined (as per the approach described in Section 5.1). Recognising the high-level nature of this assessment, it is assumed the majority of the losses associated with isolated agricultural land have been captured as part of the agricultural land assessment, and due to the small spatial extents, it is not considered to be proportionate to define isolated agricultural land losses. This logic also applies to the analysis of wider isolated infrastructure and environmental designations.

[16] The Green Book: appraisal and evaluation in central government - GOV.UK

5.8.2 Key assumptions

Table 5-92: Key assumptions for isolated property damages

<table>
<tr><th colspan="2">Key assumptions</th></tr>
<tr><td>Isolated community connection costs</td><td>Road connection costs are based on ‘A Road’ costs seen in Section 5.6. Costs are then multiplied by a factor of 2 to allow for uncertainty and complications of raising road above flood level. Electricity Distribution costs (per km) associated with raising roads has been provided by National Grid and Western Power Network. Likewise, water utilities costs have been provided by Anglian Water. All costs are assumed to be from 2021, with costs uplifted to 2025 values.
<table>
<tr><th>Element</th><th>Cost / m</th></tr>
<tr><td>Road</td><td>£44,244</td></tr>
<tr><td>Electricity Distribution</td><td>£1,399</td></tr>
<tr><td>Water Utilities</td><td>£1,786</td></tr>
</table></td></tr>
<tr><td>Defining isolated properties</td><td>Due to the rural nature of the catchments across the Fens, transport access through roads was used to determine isolation of properties due to the distances between rural settlements being deemed too great for pedestrian use. Whilst certain footpaths may not be inundated, we cannot assume all pedestrians have equal capability to carry out daily tasks on foot (elderly, physically disabled, etc.), even in more well-connected urban areas.</td></tr>
</table>

5.8.3 Do-Nothing scenario outcomes

The total PV costs for isolated communities are shown in Table 5-93. Isolated communities and properties were determined whilst observing the maximum contour level flood extents for a given subcompartment, these being 3.90m.

Note: Some communities do not have a reconnection cost as it is ‘main road’ that is already included in the transport damages, and therefore has been excluded here to avoid double counting

Table 5-93: Do-Nothing - summary of which communities were reconnected or abandoned as well as the discounted costs (£k) for the preferred option

Community	Write-off costs (£k)	Distance for reconnection (m)	Reconnection costs (£k)	Reconnected	Abandoned	Total Discounted Costs (£k)
4	3,933	16	759	Yes	No	639
5	76,912	-	-	Yes	No	-
6	13,466	391	18,545	No	Yes	11,339
8	6,525	1,005	47,666	No	Yes	5,885
13	174,033	-	-	Yes	No	-
14	4,396	282	13,375	No	Yes	3,831
15	3,082	282	13,375	No	Yes	2,686
17	2,395	79	3,747	No	Yes	2,017
18	755,497	-	-	Yes	No	-
19	3,239	147	6,972	No	Yes	2,727
20	24,413	3,517	166,808	No	Yes	22,018
21	17,358	116	5,502	Yes	No	4,632
22	4,627	-	-	Yes	No	-
23	9,881	-	-	Yes	No	-
24	14,775	-	-	Yes	No	-
25	8,527	-	-	Yes	No	-
26	22,805	5	237	Yes	No	207
27	3,933	294	13,944	No	Yes	3,427
28	5,255	50	2,371	Yes	No	2,066
29	5,090	156	7,399	No	Yes	4,435
39	3,702	1,250	59,286	No	Yes	3,117
40	3,008	626	29,691	No	Yes	2,532
41	16,761	1,785	84,661	No	Yes	14,112
42	9,020	-	-	Yes	No	-
46	4,790	1,298	61,563	No	Yes	4,034
47	4,859	-	-	Yes	No	-
48	2,314	606	28,742	No	Yes	2,016
49	58,637	665	31,540	Yes	No	27,484
56	3,008	2,446	116,011	No	Yes	2,621

Table 5-94: Do-Nothing - summary of the discounted costs (£k) per year

Appraisal year (Year)	Total discounted costs (£k)
0	-
1	-
2	-
3	27,903
4	48,772
5	45,147

Across the catchment there were 29 isolated communities identified. The location of these isolated communities is shown in Figure 15. It was found to be more cost-effective to write-off 15 of the communities than to reconnect the communities to nearby road networks through building raised roads.

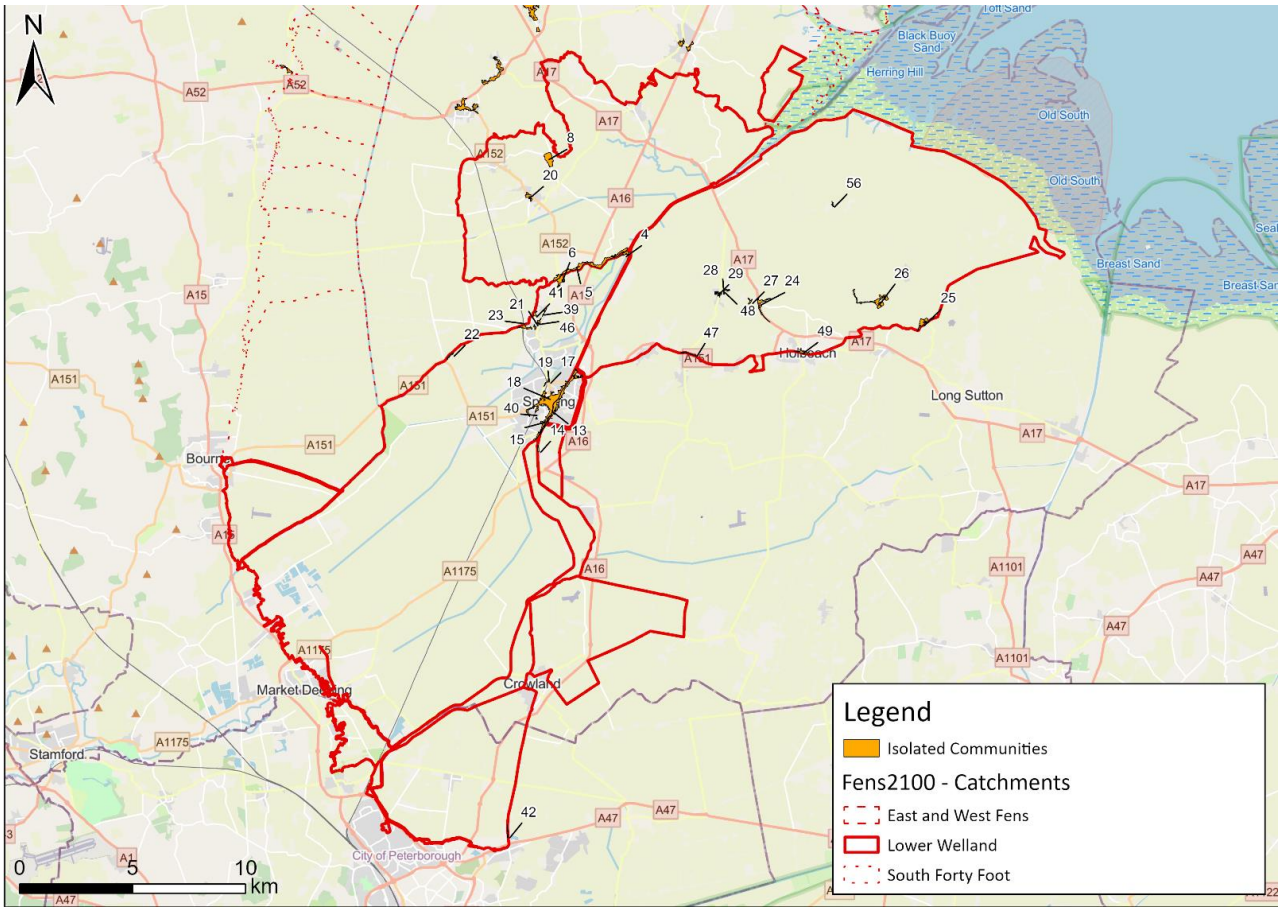

Figure 15: Indication of the spread of the isolated communities across the catchment

5.8.4 Sensitivity testing

Sensitivity testing has been undertaken to assess the impact of including unknown ‘999’ NRD receptors into the calculations using non-residential sector average values. This only impacts those settlements for which the cost of property write off is lower than the cost of reconnecting the land to the ‘mainland’.

The total costs for isolated communities including unknown ‘999’ NRD receptors are shown in Table 5-95.

Table 5-95: Do-Nothing - summary of which communities were reconnected or abandoned whilst including unknown '999' NRD receptors, as well as the discounted costs (£k) for the preferred option

Community	Write-off costs (£k)	Distance for reconnection (m)	Reconnection costs (£k)	Reconnected	Abandoned	Total Discounted Costs (£k)
4	4,107	16	759	Yes	No	639
5	80,494	-	-	Yes	No	-
6	13,672	391	18,545	Yes	No	11,512
8	11,975	1,005	47,666	No	Yes	10,800
13	175,693	-	-	Yes	No	-
14	4,431	282	13,375	Yes	No	3,861
15	3,562	282	13,375	No	Yes	3,104
17	2,395	79	3,747	Yes	No	2,017
18	763,300	-	-	Yes	No	-
19	3,239	147	6,972	Yes	No	2,727
20	24,913	3,517	166,808	No	Yes	22,469
21	17,358	116	5,502	No	Yes	4,632
22	4,706	-	-	Yes	No	-
23	10,885	-	-	Yes	No	-
24	14,775	-	-	Yes	No	-
25	9,513	-	-	Yes	No	-
26	25,062	5	237	Yes	No	207
27	4,282	294	13,944	No	Yes	3,732
28	5,643	50	2,371	Yes	No	2,066
29	5,090	156	7,399	Yes	No	4,435
39	3,702	1,250	59,286	No	Yes	3,117
40	3,008	626	29,691	Yes	No	2,532
41	17,004	1,785	84,661	No	Yes	14,317
42	9,059	-	-	Yes	No	-
46	4,790	1,298	61,563	No	Yes	4,034
47	4,859	-	-	Yes	No	-
48	2,314	606	28,742	No	Yes	2,016
49	59,812	665	31,540	No	Yes	27,484

Community	Write-off costs (£k)	Distance for reconnection (m)	Reconnection costs (£k)	Reconnected	Abandoned	Total Discounted Costs (£k)
56	3,008	2,446	116,011	No	Yes	2,621

Note: Some communities do not have a reconnection cost as it is 'main road' that is already included in the transport damages, and therefore has been excluded here to avoid double counting

Table 5-96: Do-Nothing - summary of residential and non-residential cumulative write-off costs for isolated properties whilst including unknown '999' NRD receptors, as well as the discounted costs (£k) per year

Appraisal year (Year)	Non-Residential write-off costs (£k)					
	North Level (B)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)	Welland & Deepings (F)
0	-	-	-	-	-	-
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	11,359
4	-	304	-	716	-	-
5	-	-	-	-	10,841	-

Table 5-97: Do-Nothing - summary of the discounted costs whilst including unknown '999' NRD receptors (£k) per year

Appraisal year (Year)	Total discounted costs (£k)
0	-
1	-
2	-
3	33,269
4	49,526
5	45,526

5.9 Mental health costs

The impacts on mental health due to the higher rates of anxiety, depression and post-traumatic stress disorder after a flood event have been calculated using the latest guidance from the Environment Agency. The costs associated with these illnesses include treatment costs and the loss of employment. Co-morbidity and the proportion of those seeking treatment have also been considered.

As no local model data was available, and a depth damage approach was not able to be taken, this has been estimated at £2,399 per residential property affected by flooding.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

5.9.1 Do Nothing scenario outcomes

Table 5-98: Do Nothing - PV mental health costs (£k)

Appraisal Period (Years)	PV Mental health costs (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	1	15	0	829	1,109	91	4,096
Appraisal Period (Years)	**PV Mental health costs (£k)**						
	Welland & Deepings (B)	**Welland & Deepings (C)**	**Welland & Deepings (D)**	**Welland & Deepings (E)**	**Welland & Deepings (F)**	**Welland & Deepings (G)**	**Total**
100	0	614	0	9	192	1	6,957

Total Do Nothing PV mental health costs over the 100-year appraisal period are £6,957k.

5.9.2 Maintain scenario outcomes

Table 5-99: Maintain - PV mental health costs (£k)

Appraisal Period (Years)	PV Mental health costs (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	453	1,370	0	6,510	7,181	329	20,363
Appraisal Period (Years)	**PV Mental health costs (£k)**						
	Welland & Deepings (B)	**Welland & Deepings (C)**	**Welland & Deepings (D)**	**Welland & Deepings (E)**	**Welland & Deepings (F)**	**Welland & Deepings (G)**	**Total**
100	0	614	0	42	4,472	33	41,365

Total PV mental health costs over the 100-year appraisal period are £41,365k.

5.10 Intangible impacts to human health

Intangible health benefits reflect the longer-term personal impact of flooding on the health and wellbeing of those affected; a reduction in flood risk is correlated with an approximate equivalent financial benefit.

The MCM 2013 methodology was used to estimate intangible benefits with flood risk management improvements at a property level. The basis of the estimation is that flooding of residential properties causes stress, disruption, illness, and other losses that are not assigned a value in the main economic assessment. Generally, rather than increase the losses in each flood event to include this, the intangible impacts assessment provides a positive benefit that can be added to the 'damages avoided'. The magnitude of the benefit is dependent on the number of residential properties benefitting from flood risk management (i.e. with a reduced threshold of flooding), and the size of the change in threshold of flooding at each property. For the Fens 2100+ assessments, Intangible Benefits have been calculated based on an assumed loss at each flooded property, such that the benefits would be equal to these losses being avoided should Do Something options been appraised in future. As no local model data was available, and a depth damage approach was not able to be taken, this has been estimated at £332 per residential property affected by flooding.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

5.10.1 Do Nothing scenario outcomes

Table 5-100: Do Nothing - PV intangible impacts costs (£k)

Appraisal year (Years)	PV Mental health costs (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	0	2	0	115	154	13	567
Appraisal year (Years)	**PV Mental health costs (£k)**						
	Welland & Deepings (B)	**Welland & Deepings (C)**	**Welland & Deepings (D)**	**Welland & Deepings (E)**	**Welland & Deepings (F)**	**Welland & Deepings (G)**	**Total**
100	0	85	0	1	27	0	964

Total Do Nothing PV intangible impact costs over the 100-year appraisal period are £964k.

5.10.2 Maintain scenario outcomes

Table 5-101: Maintain - PV intangible impacts costs (£k)

Appraisal year (Years)	PV Mental health costs (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	63	190	-	901	994	46	2,820
Appraisal year (Years)	**PV Mental health costs (£k)**						
	Welland & Deepings (B)	**Welland & Deepings (C)**	**Welland & Deepings (D)**	**Welland & Deepings (E)**	**Welland & Deepings (F)**	**Welland & Deepings (G)**	**Total**
100	-	85	-	6	619	5	5,728

Total Maintain PV intangible impact costs over the 100-year appraisal period are £5,728k.

5.11 Emergency service costs

Emergency service costs are calculated to account for the cost of police, fire, ambulance, local authority, and Environment Agency response to flood incidents. This has been estimated at 10.7% of the total cost of direct damages to properties as befits a rural area, in line with MCM guidance.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

5.11.1 Do Nothing scenario outcomes

Table 5-102: Do Nothing - PV emergency services costs (£k)

Appraisal Period (Years)	PV Emergency Service costs (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	1	12	0	710	291	17	2,104
Appraisal Period (Years)	**PV Emergency Service Costs (£k)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
100	22	501	0	4	92	5	3,759

Total PV emergency service costs over the 100-year appraisal period are £3,759k.

5.11.2 Maintain scenario outcomes

Table 5-103: Maintain - PV emergency services costs (£k)

Appraisal Period (Years)	PV Emergency Service costs (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	231	288	0	2,002	1,202	55	5,249
Appraisal Period (Years)	**PV Emergency Service Costs (£k)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
100	0	137	0	17	1,042	147	10,371

Total PV emergency service costs over the 100-year appraisal period are £10,371k.

5.12 Risk to life

Risk to life assesses the potential for loss of life as a result of flooding. As no local model data was available, and a depth damage approach was not able to be taken, this has been estimated at 25% of the total cost of direct damages to properties.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

5.12.1 Do Nothing scenario outcomes

Table 5-104: Do Nothing - PV risk to life (£k)

Appraisal Period (Years)	PV Risk to Life (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	1	43	0	2,670	1,077	66	8,145
Appraisal Period (Years)	**PV Risk to Life (£k)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
100	53	2,134	0	14	295	12	14,510

Total PV risk to life over the 100-year appraisal period is £14,510k.

5.12.2 Maintain scenario outcomes

Table 5-105: Maintain - PV risk to life (£k)

Appraisal Period (Years)	PV Risk to Life (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	985	1,225	0	8,529	5,122	233	22,362
Appraisal Period (Years)	**PV Risk to Life (£k)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
100	0	585	0	74	4,438	626	44,179

Total PV risk to life over the 100-year appraisal period is £44,179k.

5.13 Evacuation and temporary accommodation costs

The evacuation and relocation of people from flood affected residential properties is often undertaken as a short-term emergency response to flooding. In addition to where residential properties are affected by flooding, evacuation from the property may also be necessary to allow flood damage to be repaired. In such cases, evacuation requires temporary or alternative accommodation for households affected and this incurs costs.

As no local model data was available, and a depth damage approach was not able to be taken, this has been estimated at £5,813 per residential property affected by flooding.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

5.13.1 Do Nothing scenario outcomes

Table 5-106: Do Nothing - PV evacuation and temporary accommodation costs (£k)

Appraisal Period (Years)	Evacuation and Temporary Accommodation costs (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	2	26	0	1,434	1,775	132	6,571
Appraisal period (Years)	**Evacuation and Temporary Accommodation costs (£k)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
100	0	816	0	13	363	1	11,133

Total PV evacuation and temporary accommodation costs over the 100-year appraisal period is £11,133k.

5.13.2 Maintain scenario outcomes

Table 5-107: Maintain - PV evacuation and temporary accommodation costs (£k)

Appraisal Period (Years)	Evacuation and Temporary Accommodation costs (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	602	1,821	0	8,651	9,543	437	27,062
Appraisal period (Years)	**Evacuation and Temporary Accommodation costs (£k)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
100	0	816	0	55	5,944	43	54,973

Total PV evacuation and temporary accommodation costs over the 100-year appraisal period is £54,973k.

5.14 Vehicle damages

Economic losses associated with damage to vehicles are estimated for all residential properties. As no local model data was available, and a depth damage approach was not able to be taken, this has been estimated at £6,668 per residential property affected by flooding.

This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

5.14.1 Do Nothing scenario outcomes

Table 5-108: Do Nothing – PV Vehicle Damages (£k)

Appraisal Period (Years)	Vehicle Damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	2	29	0	1,645	2,036	152	7,537
Appraisal period (Years)	**Vehicle Damages (£k)**						
	Welland & Deepings (B)	**Welland & Deepings (C)**	**Welland & Deepings (D)**	**Welland & Deepings (E)**	**Welland & Deepings (F)**	**Welland & Deepings (G)**	**Total**
100	0	936	0	15	416	2	12,770

Total PV vehicle damages over the 100-year appraisal period are £12,770k.

5.14.2 Maintain scenario outcomes

Table 5-109: Maintain – PV Vehicle Damages (£k)

Appraisal Period (Years)	Vehicle Damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	690	2,088	0	9,923	10,946	501	31,041
Appraisal period (Years)	**Vehicle Damages (£k)**						
	Welland & Deepings (B)	**Welland & Deepings (C)**	**Welland & Deepings (D)**	**Welland & Deepings (E)**	**Welland & Deepings (F)**	**Welland & Deepings (G)**	**Total**
100	0	936	0	63	6,818	50	63,057

Total PV vehicle damages over the 100-year appraisal period are £63,057k.

5.15 Utilities disruption

Disruption to utilities at an individual property level have been calculated only for properties in the Maintain scenario and in the Do Nothing scenario where properties are not written off but are subject to residual risk. This is to avoid double counting with damages related to the distribution assets as described in Section 5.7. As a broad assessment of the potential scale of impacts, an indicative value of 5% of total residential and non-residential property AAD damages have been used to estimate utilities disruption costs in these events. This damage was calculated for the residual risk to properties which are not written off in a Do Nothing scenario, and for all properties impacted in the Maintain scenario.

5.15.1 Do Nothing scenario outcomes

Table 5-110: Do Nothing - PV utilities disruption damages (£k)

Appraisal year (Years)	PV Utility Damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	0	6	0	332	136	8	983
Appraisal year (Years)	**PV Utility Damages (£k)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
100	10	234	0	2	43	2	1,757

Total Do Nothing PV utilities disruption damages over the 100-year appraisal period are £1,757k.

5.15.2 Maintain scenario outcomes

Table 5-111: Maintain - PV utilities disruption damages (£k)

Appraisal year (Years)	PV Utility Damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	108	134	-	936	562	26	2,453
Appraisal year (Years)	**PV Utility Damages (£k)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
100	-	64	-	8	487	69	4,846

Total Maintain PV utilities disruption damages over the 100-year appraisal period are £4,846k.

5.16 Health service disruption

There are 25 health service assets located in the Lower Welland catchment area including the Johnson Community Hospital. There are a total of 770 beds across these facilities where the day bed occupancy averages 86% as reported by NHS England. Health service assets located within the catchment are highlighted in Figure 16 and Table 5-112 and comprise of care/nursing home assets and hospital assets.

No assessment of disruption and losses because of flooding to General Practitioner surgeries or pharmacies has been included, though the direct damages associated with these facilities is included under the direct damages to properties.

The cost of health service losses has been based on the cost of transfer of a patient (£353.48) and bed redundancy (£453.15) taken from the MCM and uplifted to 2025 using GDP deflators.

Damages as a result of the loss of health service provision have been calculated for the Maintain scenario only. This has been calculated based on the total cost of patient transfer at the point of flooding in the defended mechanism, and the cost of the beds per day assuming these beds will need to be provided at alternative facilities. Damages due to write off are represented in the Do Nothing property write off calculations.

These disruption damages would only be assessed in the Maintain scenario as the health facilities will be written off in the Do Nothing scenario and the majority of the population they serve will have moved out of the area.

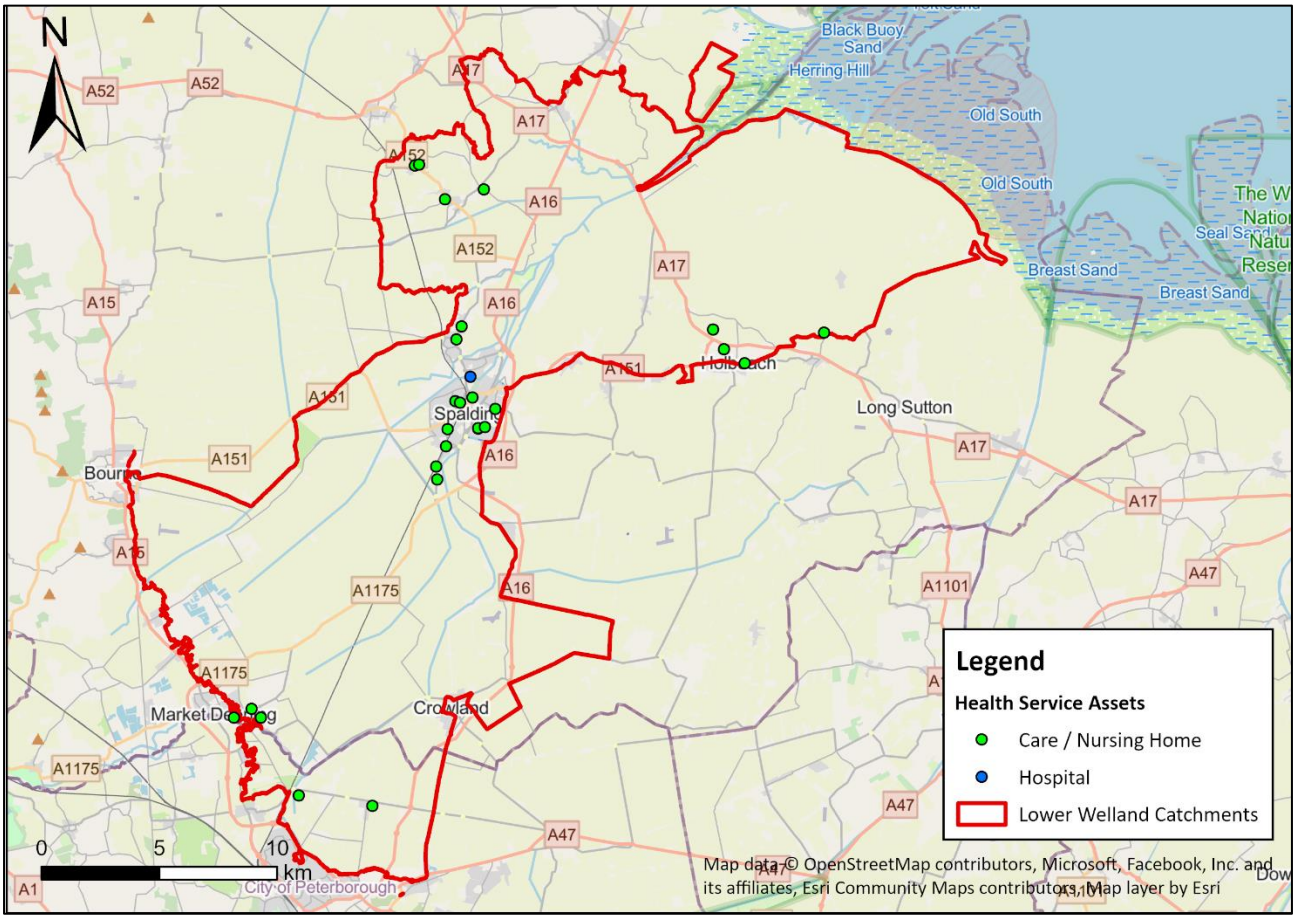

Figure 16: Location of Health Service assets in the Lower Welland catchment area

Table 5-112: Health Service assets and their capacity in the Lower Welland catchment area

Name	Capacity
Johnson Community Hospital	32
SENSE, 25 Horsegate, Deeping St James, PE6 8EW	5
Barchester Braeburn Lodge Care Home, Braeburn Road, Deeping St James, PE6 8GP	60
SENSE, 32A Broadgate Lane, Deeping St James, PE6 8NW	6
11 Meadow Road, Peakirk, PE6 7NX	TBC
Acacia House, 37A School Road, Newborough, PE6 7RG	5
Stonehaven, Main Road, Quadring, PE11 4PJ	26
SENSE, 18 Water Gate, Quadring, PE11 4PY	5
Fenchurch House Care Home, Spalding Common, Spalding, PE11 3AS	60
Ashwood Care & Nursing Home, 43 Spalding Common, Spalding, PE11 3AU	47
Gosberton House Care Home, Westhorpe Road, Gosberton, PE11 4EW	48
Cedar Falls Nursing Home, Little London Road, Spalding, PE11 2UA	93
St John's Care Home, 66 Hawthorn Bank, Spalding, PE11 1JQ	56
Southfield House, Woolram Wygate, Spalding, PE11 1PS	32
SENSE, 38 Church Street, Pinchbeck, PE11 3UB	6
The Bungalow Care Home, 156 Park Road, Spalding, PE11 1QZ	28
Brun Lea, 21 Surfleet Road, Pinchbeck, PE11 3XY	20
Cedar House, Pinchbeck Road, Spalding, PE11 1QF	7
SENSE, 21a and 21b Johnson Avenue, Spalding, PE11 2QE	6
Bank House Residential Care Home, Gosberton Bank, Gosberton, PE11 4PB	33
Southernwood House, 20 Matmore Gate, Spalding, PE11 2PN	28
Halmer Court Care Home, 108 Halmer Gate, Spalding, PE11 2EL	61
Holbeach & East Elloe Hospital Trust, Boston Road North, Holbeach, PE11 8AQ	47
Nutten Stoven, 81 Boston Road South, Holbeach, PE11 8AA	30
Mayfield Residential Home, Fleet Street, Holbeach, PE12 7AG	29
Fleet Bank, Fleet, PE12 8LW	TBC

5.16.1 Maintain scenario outcomes

Table 5-113: Maintain - PV health service damages (£k)

Appraisal year (Years)	PV Health Service damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	0	0	0	4,893	7,500	0	25,131

Appraisal year (Years)	PV Health Service damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
100	0	0	0	0	0	0	37,524

Total PV health service damages over the 100-year appraisal period are £37,524k.

5.17 Educational disruption

There are 28 educational assets located in the Lower Welland catchment area as highlighted in Figure 17 and Table 5-114 and comprise of primary and secondary schools. Losses to education can be assessed based on both the impacts to the buildings, and contents such as books and technology, and as a result of disruption to education of students and days of education lost.

Damages have been based on the cost of alternative classroom accommodation, taken as £15,000 per school based on evidence from the Pitt report in the 2007 floods[17]. This value was uplifted to a 2025 price base using GDP deflator values.

Disruption costs calculated in line with the MCM also include the cost of loss of education per day for pupils, impacts on parent productivity through missing employment to look after dependent children (assumed at one adult per three primary aged children), and the costs of counselling for children impacted by flooding. It was assumed that flooding leads to five days of disruption before alternative accommodation or ways of working can be enacted (as per MCM Chapter 6e Education and Health). Ofsted data was used to estimate the number of pupils attending each education facility[18].

Losses relating to disruption of education has been calculated in the Maintain scenario only.

Permanent inundation in the Do Nothing scenario will lead to the complete loss of educational facilities and as a result a requirement to find alternative educational facilities for students. It is assumed that the loss of building is covered under the direct damage to properties calculations based on write-off of the buildings. The loss of educational services in the write-off assessment is also taking the total educational loss per event into account assuming that it will take five days to find alternative facilities to resume education elsewhere.

[17] Chatterton, J., Viavattene, C., Morris, J., Penning-Rowsell, E.C. and Tapsell, S. (2010) The costs of the summer 2007 floods in England, Project: SC070039/R1, Environment Agency, Bristol

[18] https://reports.ofsted.gov.uk/

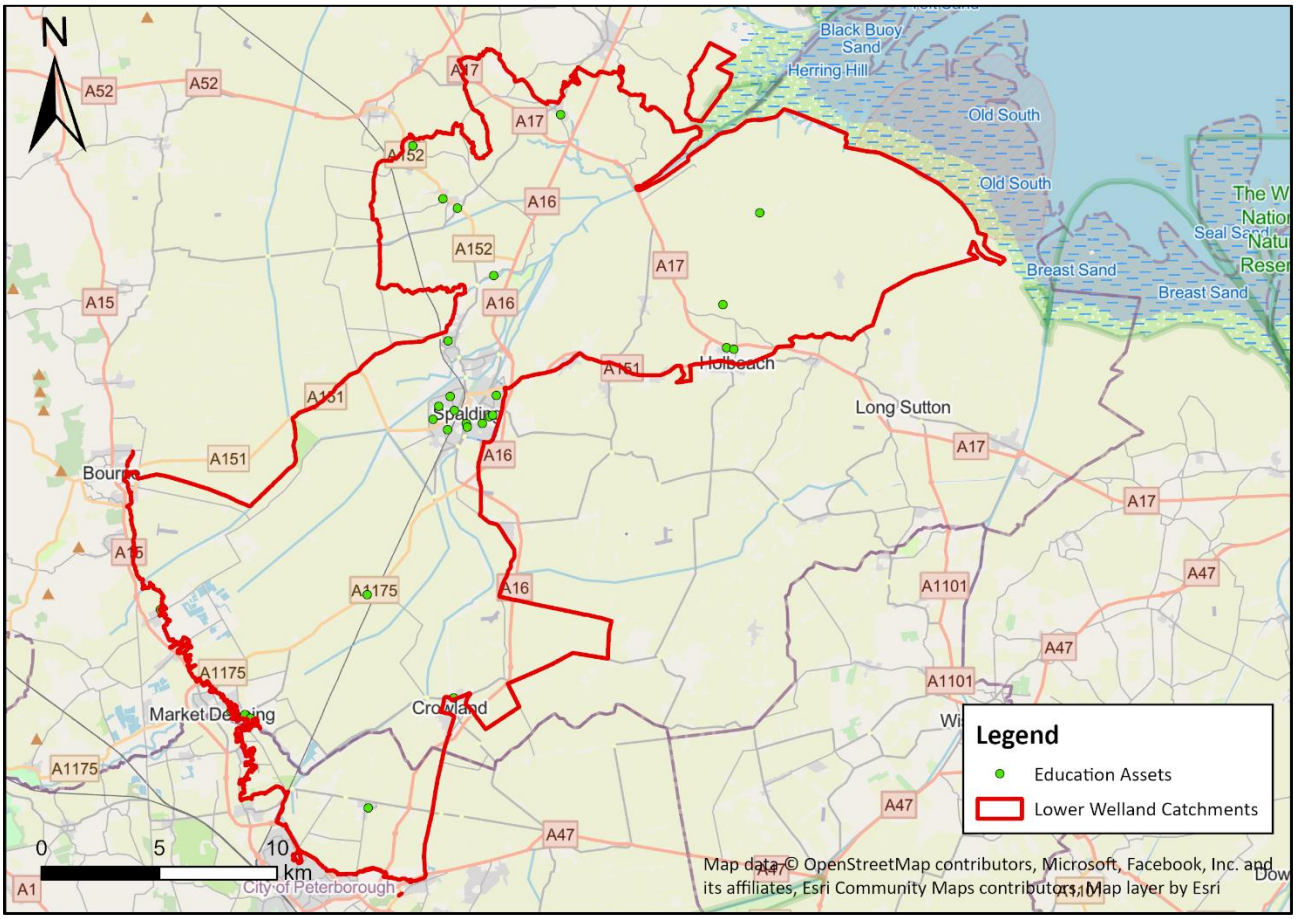

Figure 17: Location of educational assets in the Lower Welland catchment area

Table 5-114: Educational assets and their education level/number of pupils in the Lower Welland catchment area

Name	Education level	Number of pupils (2023)
Ayscoughfee Hall School	Primary	131
Baston CE Primary School	Primary	181
Deeping St James Community Primary School	Primary	207
Deeping St Nicholas Primary School	Primary	66
Gosberton Academy	Primary	129
Gosberton House Academy	Special School	101
Holbeach Bank Primary Academy	Primary	100
Holbeach Primary Academy	Primary	312
Linchfield Academy	Primary	324
Monkshouse Primary Academy	Primary	456
Newborough CofE Primary School	Primary	210
Quadring Cowley & Brown's Primary School	Primary	107
South View Community Primary School	Primary	416

Name	Education level	Number of pupils (2023)
Spalding Academy	Secondary	1420
Spalding Grammar School	Secondary	999
Spalding High School	Secondary	940
Spalding Primary Academy	Primary	416
St Norbert's Catholic Voluntary Academy	Primary	209
St Paul's Community Primary School	Primary	232
Surfleet Primary School	Primary	65
The Deepings School	Secondary	1235
The Fourfields Church of Englnd School, Sutterton	Primary	140
The Holbeach St Mark's Church of England Primary School	Primary	38
The Pinchbeck East Church of England Primary Academy	Primary	395
The Spalding St John the Baptist Church of England Primary School	Primary	430
Tulip Academy	Special School	214
University Academy Holbeach	Secondary	1390
Wygate Park Academy	Primary	282

5.17.1 Maintain scenario outcomes

Table 5-115: Maintain - PV educational losses (£k)

Appraisal year (Years)	PV Educational damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
100	-	35	-	223	1,708	-	1,918
Appraisal year (Years)	**PV Educational damages (£k)**						
	Welland & Deepings (B)	**Welland & Deepings (C)**	**Welland & Deepings (D)**	**Welland & Deepings (E)**	**Welland & Deepings (F)**	**Welland & Deepings (G)**	**Total**
100	-	-	-	-	186	-	4,070

Total PV educational losses over the 100-year appraisal period are £4,070k.

5.18 Losses to the local economy

The Fens has a diverse economy, to which agriculture contributes significantly, as previously highlighted within Section 5.2. In addition, there are a range of retail, industrial and manufacturing businesses across the catchments which would be impacted by flooding in the Do-Nothing scenario.

5.18.1 Do-Nothing scenario approach

Losses to the local economy can be expressed in terms of Gross Value Added (GVA). GVA measures the contribution made to an economy by one individual producer, industry, sector or region. As per the HM Treasury Green Book[19] (2022), local or regional benefits cannot be included in applications for Grant in Aid funding (only those identified as losses to the nation are eligible). As such, only a high-level analysis of GVA has been undertaken to understand the regional impacts, particularly in terms of the number of jobs at risk under a Do-Nothing scenario (and thus benefiting from the existing FCERM arrangements). GVA has been calculated for the Do-Nothing scenario and Maintain scenario and is considered a broad high-level assessment.

The GVA has been defined based on DEFRA's Frontiers Toolkit[20] (2014). For each of the NRP's impacted by permanent inundation (at each write-off level), the associated floor areas have been captured. These were converted to Net Gross Floor areas, which were utilised to determine the number of jobs impacted based upon the application of the associated employment densities (as per the Employment Density Guidance, 3rd Edition (Homes and Communities Agency, 2015)) for the general business/industry type (refer to Table 5-116). The total number of jobs per non-residential property were multiplied by the gross annual average salary of the region to define the annual GVA losses. An uplift of 30% was applied (Table 4.14 Multiplier effects in HCA guidance (2000)) to account for the net indirect and induced jobs (i.e. the supply chain). As the methodology is centred around buildings and their floor area, it may not cover all agricultural jobs, some of which may be transient in nature. A 10% leakage reduction factor was applied to represent the level of benefits that are likely to go to residents who commute into the catchment. A 25% displacement reduction factor was also applied to represent the proportion of economic benefits that are displaced from elsewhere in the region.

The GVA annual losses are assumed to apply for a period of 10 years following inundation, to account for the notion that new businesses and employment opportunities will be displaced elsewhere across the nation to accommodate the loss in the provision of these services.

5.18.2 Key assumptions

Table 5-116: Do Nothing GVA assumptions

Key assumptions:					
Assumed employment density (m^2) and Gross annual wage per head (£)		SIC Code and Description	m2 per FTE	Mean gross annual wage (2025) (£)	
		A - Agriculture, forestry and fishing	36	29,723	
		B - Mining and quarrying	-	56,864	

[19] The Green Book: appraisal and evaluation in central government - GOV.UK

[20] _FD2662_full_toolkit.pdf

Key assumptions:				
		C - Manufacturing	37	42,282
		D - Electricity, gas, steam and air conditioning supply	36	60,114
		E - Water Supply; Sewerage, Waste Management and Remediation Activities	36	42,267
		F - Construction	-	44,749
		G - Wholesale and retail trade; repair of motor vehicles and motorcycles	26	31,649
		H - Transportation and storage	30	41,688
		I - Accommodation and Food Service Activities	19	20,679
		J - Information and communication	32	58,071
		K - Financial and Insurance Activities	16	80,397
		L - Real estate activities	-	36,403
		M - Professional, scientific and technical activities	45	51,632
		N - Administrative and support service activities	16	33,042
		O - Public administration and defence; compulsory social security	29	38,428
		P - Education	36	34,090
		Q - Human health and social work activities	33	33,182
		R - Arts, Entertainment and Recreation	58	31,193
		S - Other service activities	33	30,056
		T - Activities of households as employers; undifferentiated goods- and services-	-	16,368

<table>
<tr><th colspan="4">Key assumptions:</th></tr>
<tr><td></td><td colspan="3"><table>
<tr><td>producing activities of households for own use</td><td></td><td></td></tr>
<tr><td>U - Activities of extraterritorial organisations and bodies</td><td>-</td><td>-</td></tr>
</table>
Sources:
Homes & Communities Agency (2010) Employment Densities Guide (2nd ed.).
OBS (2025) The economy forecast: Inflation.
ONS (2024) Earnings and hours worked, industry by two-digit SIC: ASHE Table 4.7a Annual Pay - Gross 2024 (Provisional Data)</td></tr>
<tr><td>Net indirect and induced jobs multiplier</td><td colspan="3">30% - Ready reckoners for composite multiple (regional level) (HCA guidance (section 4.5 and 5))</td></tr>
<tr><td>Displacement</td><td colspan="3">25%</td></tr>
<tr><td>Leakage</td><td colspan="3">10%</td></tr>
<tr><td colspan="4">Key datasets:
National Receptor Database</td></tr>
</table>

5.18.3 Do-Nothing scenario outcomes

Table 5-117: Do Nothing high-level estimates of number of jobs impacted (GVA - direct and indirect) (cumulative)

Appraisal Period (Years)	Number of jobs						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
10	539	1,041	0	9,887	1,430	147	11,713
Appraisal period (Years)	**Number of jobs**						
	Welland & Deepings (B)	**Welland & Deepings (C)**	**Welland & Deepings (D)**	**Welland & Deepings (E)**	**Welland & Deepings (F)**	**Welland & Deepings (G)**	**Total**
10	83	0	0	233	4,303	37	29,413

Table 5-118: Do Nothing high-level PV GVA losses (direct and indirect) (cumulative) (£k)

Appraisal Period (Years)	Total PV GVA losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
10	129,842	320,164	0	1,845,507	220,404	15,933	2,534,943
Appraisal period (Years)	**Total PV GVA losses (£k)**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
10	12,499	0	0	50,963	1,297,456	8,210	6,435,921

Based on the number and area of non-residential properties impacted during the first 10 years of the appraisal period for the Do Nothing scenario, a high-level estimate of the number of jobs and associated GVA losses can be seen in Table 5-118. During this period an estimated 29,413 jobs are impacted whilst total GVA losses in excess of £6,435,921k are accrued.

5.18.4 Maintain scenario outcomes

Table 5-119: Maintain - high-level estimates of number of jobs impacted (GVA - direct and indirect) (cumulative)

Appraisal Period (Years)	Number of jobs						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
10	539	1,263	0	7,397	1,779	230	19,530
Appraisal period (Years)	**Number of jobs**						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
10	83	223	0	1,316	4,570	37	29,413

Table 5-120: Maintain - high-level PV GVA losses (direct and indirect) (cumulative) (£k)

Appraisal Period (Years)	Total PV GVA losses (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
10	129	148	0	1,325	415	44	3,534
Appraisal period (Years)	**Total PV GVA losses (£k)**						
	Welland & Deepings (B)	**Welland & Deepings (C)**	**Welland & Deepings (D)**	**Welland & Deepings (E)**	**Welland & Deepings (F)**	**Welland & Deepings (G)**	**Total**
10	20	75	0	40	643	5	6,378

Based on the number and area of non-residential properties impacted during the first 10 years of the appraisal period for the Maintain scenario, a high-level estimate of the number of jobs and associated GVA losses can be seen in Table 5-120. During this period an estimated 29,413 jobs are impacted whilst total GVA losses in excess of £6,378k are accrued.

6. Economic Damages and Benefits Summary

A summary of the Do-Nothing and Maintain scenario economic damages, and Maintain scenario benefits, are provided in the tables below.

6.1 Summary of Do Nothing Damages

Table 6-1: Summary of PV Do Nothing damages (£k)

Type	Do Nothing Damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
Residential properties	88,098	378,486	-	884,786	725,826	28,893	2,348,357
Non-residential properties	20,187	43,614	-	301,364	48,729	10,453	490,443
Indirect commercial losses	0	2	-	124	27	1	350
Agricultural losses	57,147	77,405	1,048	366,339	198	6,197	369,157
Environment and recreational losses	4,752	3,511	-	24,329	2,022	1,417	42,595
Heritage losses	1,592	2,503	266	8,118	2,495	-	7,646
Transport damages	181,340	204,021	-	126,187	223	55,438	391,081
Utilities damages	2,608	14,046	62	59,916	554	635	18,568
Isolated land and properties	-	-	-	42,257	-	6,516	45,159
Mental health costs	1	15	-	829	1,109	91	4,096
Intangible impacts	0	2	-	115	154	13	567
Emergency service costs	1	12	-	710	291	17	2,104
Risk to life	1	43	-	2,670	1,077	66	8,145
Evacuation and temporary accommodation	2	26	-	1,434	1,775	132	6,571
Vehicle damages	2	29	-	1,645	2,036	152	7,537
Utilities disruption	0	6	-	332	136	8	983
Total (excludes losses to the local economy)	**355,731**	**723,720**	**1,375**	**1,821,154**	**786,653**	**110,029**	**3,743,361**
Losses to the local economy (GVA)	129,842	320,164	-	1,845,507	220,404	15,933	2,534,943

Type	Do Nothing Damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
Residential properties	-	1,278	-	7,808	801,576	897	5,266,006
Non-residential properties	6,002	3,403	-	8,356	148,686	1,442	1,082,679
Indirect commercial losses	6	102	-	1	8	1	621
Agricultural losses	23,543	6,545	45	28,550	192,935	9,781	1,138,889
Environment and recreational losses	17,688	675	-	554	16,295	5,082	118,919
Heritage losses	511	579	-	-	18,808	-	42,518
Transport damages	489	204	-	-	401,310	-	1,360,291
Utilities damages	505	13	-	1,809	29,605	656	128,976
Isolated land and properties	-	-	-	-	27,903	-	121,835
Mental health costs	-	614	-	9	192	1	6,957
Intangible impacts	-	85	-	1	27	0	963
Emergency service costs	22	501	-	4	92	5	3,760
Risk to life	53	2,134	-	14	295	12	14,510
Evacuation and temporary accommodation	-	816	-	13	363	1	11,133
Vehicle damages	-	936	-	15	416	2	12,770
Utilities disruption	10	234	-	2	43	2	1,757
Total (excludes losses to the local economy)	**48,830**	**18,119**	**45**	**47,134**	**1,638,552**	**17,881**	**9,312,584**
Losses to the local economy (GVA)	12,499	-	-	50,963	1,297,456	8,210	6,435,921

Total damages in the Do Nothing scenario is £9.3 billion across all subcompartments.

6.2 Summary of Maintain Damages

Table 6-2: Summary of PV Maintain damages (£k)

Type	Maintain Damages (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
Residential properties	962	2,141	-	12,253	9,780	488	31,277
Non-residential properties	1,198	547	-	6,458	1,457	24	17,781
Indirect commercial losses	36	16	-	194	44	1	533
Agricultural losses	727	623	2	10,967	0	47	4,049
Environment and recreational losses	3	2	-	22	1	1	19
Heritage losses	0	2	0	15	25	-	71
Mental health costs	453	1,370	-	6,510	7,181	329	20,363
Intangible impacts	63	190	-	901	994	46	2,820
Emergency service costs	231	288	-	2,002	1,202	55	5,249
Risk to life	985	1,225	-	8,529	5,122	233	22,362
Evacuation and temporary accommodation	602	1,821	-	8,651	9,543	437	27,062
Vehicle damages	690	2,088	-	9,923	10,946	501	31,041
Utilities disruption	108	134	-	936	562	26	2,453
Health services	-	-	-	4,893	7,500	-	25,131
Educational losses	-	35	-	223	1,708	-	1,918
Total (excludes losses to the local economy)	**6,056**	**10,482**	**2**	**72,476**	**56,065**	**2,186**	**192,129**
Losses to the local economy (GVA)	129	148	-	1,325	415	44	3,534

Type	Maintain Damages (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
Residential properties	-	1,263	-	58	7,680	97	65,999
Non-residential properties	-	21	-	105	2,057	1,276	30,924
Indirect commercial losses	-	1	-	3	62	38	928
Agricultural losses	18	9	0	1	14	4	16,461
Environment and recreational losses	12	2	-	0	11	1	74
Heritage losses	1	6	-	-	12	-	132
Mental health costs	-	614	-	42	4,472	33	41,365
Intangible impacts	-	85	-	6	619	5	5,728
Emergency service costs	-	137	-	17	1,042	147	10,371
Risk to life	-	585	-	74	4,438	626	44,179
Evacuation and temporary accommodation	-	816	-	55	5,944	43	54,973
Vehicle damages	-	936	-	63	6,818	50	63,057
Utilities disruption	-	64	-	8	487	69	4,846
Health services	-	-	-	-	-	-	37,524
Educational losses	-	-	-	-	186	-	4,070
Total (excludes losses to the local economy)	**32**	**4,540**	-	**434**	**33,841**	**2,388**	**380,630**
Losses to the local economy (GVA)	20	75	**0**	40	643	5	6,378

Total damages in the PV Maintain scenario is £381M across all sub-compartments.

It is noted that mental health, risk to life, evacuation and temporary accommodation and vehicle damages are relatively high when compared to direct damages to properties. This is due to the nature of the assessment and the WAAD approach taken, with a single set value taken for these damages where properties may not flood until low probability events. The impact of any over estimation of these damages is not considered significant at this stage of study given the scale of damages in the Do Nothing scenario and the relatively minor impact on total benefits as a result.

6.3 Summary of Maintain Benefits

Table 6-3: Summary of PV benefits (£k)

Type	Benefits (£k)						
	North Level (A)	North Level (B)	North Level (C)	South Holland (A)	South Holland (B)	South Holland (C)	Welland & Deepings (A)
Residential properties	87,136	376,345	-	872,533	716,046	28,405	2,317,080
Non-residential properties	18,989	43,067	-	294,906	47,272	10,429	472,662
Indirect commercial losses avoided	-36	-14	-	-70	-17	0	-184
Agricultural losses avoided	56,421	76,782	1,046	355,372	198	6,151	365,108
Environment and recreational losses avoided	4,749	3,509	-	24,307	2,021	1,416	42,575
Heritage losses avoided	1,592	2,501	266	8,103	2,470	-	7,575
Transport damages avoided	181,340	204,021	-	126,187	223	55,438	391,081
Utilities damages avoided	2,608	14,046	62	59,916	554	635	18,568
Isolated land and properties	-	-	-	42,257	-	6,516	45,159
Mental health costs* avoided	-452	-1,354	-	-5,681	-6,072	-238	-16,266
Intangible impacts	-63	-188	-	-787	-841	-33	-2,252
Emergency service costs* avoided	-231	-276	-	-1,292	-911	-37	-3,145
Risk to life*	-983	-1,182	-	-5,859	-4,045	-167	-14,216
Evacuation and temporary accommodation * avoided	-600	-1,795	-	-7,217	-7,768	-305	-20,490
Vehicle damages avoided	-688	-2,059	-	-8,279	-8,910	-350	-23,504
Utilities disruption avoided	-108	-129	-	-604	-426	-17	-1,470
Health services	-	-	-	-4,893	-7,500	-	-25,131
Educational losses avoided	-	-35	-	-223	-1,708	-	-1,918
Total (excludes benefits to the local economy)	**349,674**	**713,239**	**1,373**	**1,748,677**	**730,587**	**107,843**	**3,551,232**
Benefits to the local economy (GVA)	129,713	320,016	-	1,844,182	219,989	15,889	2,531,409

Type	Benefits (£k)						
	Welland & Deepings (B)	Welland & Deepings (C)	Welland & Deepings (D)	Welland & Deepings (E)	Welland & Deepings (F)	Welland & Deepings (G)	Total
Residential properties	-	15	-	7,750	793,896	800	5,200,007
Non-residential properties	6,002	3,382	-	8,251	146,629	166	1,051,755
Indirect commercial losses avoided	6	101	-	-2	-54	-37	-306
Agricultural losses avoided	23,525	6,536	45	28,548	192,921	9,777	1,122,429
Environment and recreational losses avoided	17,676	673	-	554	16,285	5,080	118,845
Heritage losses avoided	510	573	-	-	18,796	-	42,386
Transport damages avoided	489	204	-	-	401,310	-	1,360,291
Utilities damages avoided	505	13	-	1,809	29,605	656	128,976
Isolated land and properties	-	-	-	-	27,903	-	121,835
Mental health costs* avoided	-	-0	-	-33	-4,281	-32	-34,408
Intangible impacts	-	0	-	-5	-593	-4	-4,765
Emergency service costs* avoided	22	363	-	-14	-950	-142	-6,611
Risk to life*	53	1,548	-	-61	-4,143	-614	-29,669
Evacuation and temporary accommodation * avoided	-	0	-	-43	-5,581	-42	-43,841
Vehicle damages avoided	-	-0	-	-49	-6,402	-48	-50,287
Utilities disruption avoided	10	170	-	-6	-444	-66	-3,089
Health services	-	-	-	-	-	-	-37,524
Educational losses avoided	-	-	-	-	-186	-	-4,070
Total (excludes benefits to the local economy)	**48,798**	**13,579**	**45**	**46,701**	**1,604,711**	**15,493**	**8,931,954**
Benefits to the local economy (GVA)	12,479	-75	-	50,923	1,296,813	8,205	6,429,543

* These damage streams show negative benefits because they do not accumulate in the permanent inundation property write-off damages in the Do Nothing. They only accumulate in the residual flood risk above the permanent inundation which is over a smaller area than for the Maintain residual flooding.

** These damages show negative benefits as they include the ecosystem service gains associated with long term land use change under the Do Nothing (i.e. agricultural land becoming coastal or freshwater habitats), that do not occur under the Maintain scenario.

***These damage streams show negative benefits because they have only been assessed in the Maintain scenario and not in the Do Nothing scenario. The reason for exclusion from the Do Nothing assessment is that the health and education assets would be written off due to permanent inundation. The direct asset impacts are included in the non-residential property benefits.

Total benefits in the PV Maintain scenario is £8.9 billion across all sub-compartments.

6.4 Sensitivity Testing

The impact of changes to assumptions have largely been reported under the individual damage sections in Section 5. The impact of three of the more uncertain elements with larger impacts on the overall damage figures are summarised below for context and comparison with the baseline values reported in Sections 6.1 to 6.3.

6.4.1 Variance of fill rate in the Do Nothing scenario

Two sensitivity tests have been undertaken across all damage streams to determine the impact of variance in the rate at which the catchment fills with water. The baseline assessment assumes a rate of 0.5m per year. For the sensitivity analyses, the rate has been varied to a slower rate of 0.25m a year, and a faster rate of 0.75m per year. The impact on benefits for the Maintain scenario as a result of this change in the Do Nothing baseline is shown in Table 6-4 and Table 6-5 for the decrease and increase in fill rates respectively.

Table 6-4: Summary of PV benefits (£k) with a 0.25m per year fill rate

Type	0.25m fill rate sensitivity		
	Do Nothing PV Damages (£k)	Maintain PV Damages (£k)	Maintain PV Benefits (£k)
Residential properties	4,900,285	65,999	4,834,286
Non-residential properties	1,004,629	30,924	973,705
Indirect commercial losses	677	928	-250
Agricultural losses	1,136,160	16,461	1,119,699
Environment and recreational losses	115,388	74	115,313
Heritage losses	39,920	132	39,788
Transport damages	1,288,116		1,288,116
Utilities damages	123,035		123,035
Isolated land and properties	109,385		109,385
Mental health costs	18,341	41,365	-23,023
Intangible impacts	2,540	5,728	-3,188
Emergency service costs	4,349	10,371	-6,021
Risk to life	16,008	44,179	-28,171
Evacuation and temporary accommodation	26,021	54,973	-28,952
Vehicle damages	29,847	63,057	-33,210
Utilities disruption	2,032	4,846	-2,814
Health services		37,524	-37,524
Educational losses		4,070	-4,070
Total (excludes losses to the local economy)	**8,816,734**	**380,630**	**8,436,104**
% change compared to the baseline values	-5.3%	0.0%	-5.6%
Losses to the local economy (GVA)	4,037,113	6,378	4,030,735
% change compared to the baseline values	-37.3%	0.0%	-37.3%

Table 6-5: Summary of PV benefits (£k) with a 0.75m per year fill rate

Type	0.75m fill rate sensitivity		
	Do Nothing PV Damages (£k)	Maintain PV Damages (£k)	Maintain PV Benefits (£k)
Residential properties	5,399,210	65,999	5,333,211
Non-residential properties	1,110,063	30,924	1,079,139
Indirect commercial losses	602	928	-325
Agricultural losses	1,120,338	16,461	1,103,878
Environment and recreational losses	120,215	74	120,141
Heritage losses	43,534	132	43,402
Transport damages	1,384,023		1,384,023
Utilities damages	130,943		130,943
Isolated land and properties	127,721		127,721
Mental health costs	6,453	41,365	-34,912
Intangible impacts	894	5,728	-4,834
Emergency service costs	3,544	10,371	-6,826
Risk to life	13,982	44,179	-30,197
Evacuation and temporary accommodation	9,969	54,973	-45,004
Vehicle damages	11,436	63,057	-51,622
Utilities disruption	1,656	4,846	-3,190
Health services		37,524	-37,524
Educational losses		4,070	-4,070
Total (excludes losses to the local economy)	**9,484,584**	**380,630**	**9,103,954**
% change compared to the baseline values	1.8%	0.0%	1.9%
Losses to the local economy (GVA)	7,285,793	6,378	7,279,415
% change compared to the baseline values	13.2%	0.0%	13.2%

The catchment benefits will reduce by 6% with the lower 0.25m/year fill rate and increase by 2% with the higher 0.75m/year fill rate. This demonstrates that the assessment is relatively insensitive to the rate at which it is assumed to fill, due to the relatively short duration which is required to reach the 3.9m AOD limiting level.

6.4.2 Extreme catchment fill scenario – 6m AOD

A further sensitivity test has been undertaken across all damage streams to determine the impact of an extreme event or scenario in which assets up to 6m AOD are written off. This test demonstrates the potential additional losses above the assumed limiting levels in the Do Nothing scenario, and how sensitive the assessment may be to changes in this level.

The impact on benefits for the Maintain scenario as a result of this extreme Do Nothing catchment fill scenario is shown in Table 6-6.

Table 6-6: Summary of PV benefits (£k) with the 6m AOD extreme catchment fill scenario

Type	6m AOD extreme level sensitivity		
	Do Nothing PV Damages (£k)	Maintain PV Damages (£k)	Maintain PV Benefits (£k)
Residential properties	6,386,243	65,999	6,320,244
Non-residential properties	1,688,704	30,924	1,657,780
Indirect commercial losses	225	928	-703
Agricultural losses	1,132,838	16,461	1,116,377
Environment and recreational losses	165,152	74	165,077
Heritage losses	97,004	132	96,872
Transport damages	2,074,386		2,074,386
Utilities damages	144,668		144,668
Isolated land and properties	22,813		22,813
Mental health costs	400	41,365	-40,965
Intangible impacts	7,303	5,728	1,575
Emergency service costs	6,367	10,371	-4,004
Risk to life	2,891	44,179	-41,288
Evacuation and temporary accommodation	4,391	54,973	-50,582
Vehicle damages	774	63,057	-62,283
Utilities disruption	1,656	4,846	-3,190
Health services		37,524	-37,524
Educational losses		4,070	-4,070
(excludes losses to the local economy)	**11,735,816**	**380,630**	**11,355,185**
% change compared to the baseline values	26%	0.0%	27%
Losses to the local economy (GVA)	13,630,850	6,378	13,624,472
% change compared to the baseline values	112%	0%	112%

The catchment benefits will increase by 27% with the extreme 6m AOD fill level. This demonstrates that increasing the fill level from 3.9m AOD to 6m AOD could increase the Do Nothing damages by a significant amount, with the most significant increases being in the residential and non-residential properties and transport damages.

7. Costing

This section sets out the approach to defining the estimated capital cost interventions required for all FRM assets in the Lower Welland catchment and the estimated point in time at which interventions are required, along with maintenance and operational expenditures.

This exercise has not considered any limitations on funding or the affordability of the investments needed, rather just examining the total investment requirements to sustain the existing asset base to continue to provide the existing Standard of Service, and to inform the cost benefit analysis for the Maintain scenario. An assessment of eligibility for funding at a catchment scale gives a better indication of the limitations on funding based on current Partnership Funding rules and is included in Section 9.

The exercise has been completed to gain a high-level understanding of the broad investment requirements for sustaining the existing asset base, and to understand the cost benefit ratio and available funding to do so. The results should be treated as indicative and used solely for planning of intervention works. For specific interventions, the costs should be reviewed considering existing knowledge, engineering assessment and site constraints in order to most effectively plan future intervention works, and ensure a robust cost is developed at business case development stage for individual investments.

A single “best estimate” cost has been produced based on best available data and standard approaches to estimation of uplifts for elements such as appraisal, design and risk. This has been used to determine the cost benefit analysis and eligibility for funding. However, noting the high-level nature of the data available at this stage, an additional range of costs has been estimated to demonstrate the uncertainty in the cost estimation at this stage.

Risk has been represented with the application of optimism bias; for the best estimate this has been included at 60% for all costs given the uncertainty in cost information at this stage. For the range estimation, optimism bias was included at 30% for the lower bound and 100% for the upper bound.

7.1 Capital costs

Cost information for assets have been collated based on comparable asset types from the Great Ouse and Witham Tactical Plans, along with data provided by the Middle Level Commissioners on their planned capital interventions. Where there is a lack of data, or the data is not representative, the cost estimation guidance has been used[21] to calculate an estimate of capital costs. Table 7-1 details these assumed costs.

Capital costs are assumed to be the cost of replacement of the asset at the end of its design life. The point in time at which these investments are required has been based on asset deterioration rates as defined in ‘Practical guidance on determining asset deterioration and the use of condition grade deterioration curves: Revision 1 (Report – SC060078/R1, Environment Agency, 2013). It has been assumed that all assets will deteriorate in line with maintenance regime standard 2 as defined this guidance, and that following investment assets will be returned to condition grade 3.

[21]https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/long-term-costing-tool-for-flood-and-coastal-risk-management

Conservatively, future investments are assumed required when the asset reaches condition grade 5, though it is noted that target condition grade is 3. Information on future investment needs is available from discussions with the North Level and South Holland Internal Drainage Boards, and so for those assets this information has been used instead of the average capital costs derived.

No adjustment is made to this approach for the lower and upper bound costs.

Table 7-1: Estimate of capital costs per asset type

Asset type	Asset Information	Assumed capital cost (£k)
Pumping station	0-1 m^3/s capacity	1,097
	1-2 m^3/s capacity	2,275
	2-5 m3/s capacity	3,708
	5-10 m^3/s capacity	3,708
	10+ m^3/s capacity	87,156
Embankments	Per m	2
Walls	Per m	4
Outfalls	Per unit	39
Sluices	Per unit	2,314
Control gates	Per unit	38
Open channels	Per m	-
Simple culvert	Per m	249
Weirs	Per unit	246
Debris screen	Per unit	19

7.2 Appraisal costs

Consultancy fees and Environment Agency staff costs have been estimated using Project Cost Tool (PCT) curves. At this stage, indicative costs have been included for environmental enhancement and survey exercises (including Ground Investigation (GI) and non-intrusive survey including topographic survey). It has been assumed that Environmental enhancement will equate to 3% of capital costs, that GI will be 5% and non-intrusive survey will be 3% of capital costs. These uplifts were derived based on outturn costs from similar packages of work.

For the lower bound cost estimate, the minimum percentage uplifts from the PCT curves for consultancy and Environment Agency staff costs have been used, regardless of

estimated construction value. Conversely, for the upper bound estimate the maximum percentage uplift has been used.

7.3 Future Costs

Where costs have been provided for short term investments or capital interventions which are not a full asset replacement, these have been assumed as separate to the capital costs of asset replacement as described in Section 7.1. These costs are referred to as future costs, as they are planned interventions on a programme. However, it should be noted that in some cases these are expected to occur before asset replacement and capital costs.

No adjustment is made to this approach for the lower and upper bound costs.

7.4 Maintenance and Operational Costs

Anticipated maintenance and operational costs have also been based on expenditure for similar assets in the Great Ouse and Lower Witham catchments. Where this information is not available the relevant cost estimation guidance has been used[22]. These costs were projected out over the whole appraisal period and a 60% risk applied to represent uncertainty in future maintenance and operational activities.

Maintenance and operational cost estimates were adjusted for the cost range estimation by reducing the 60% risk value to 30% for the lower bound estimate and increasing it to 100% for the upper bound estimate.

7.5 Whole life costs

The cost information received from the Environment Agency and partner RMAs was forecast over the appraisal period to understand the profile of investment required over a 20 year and a 100-year period. These costs were discounted using HM Treasury discount rates to provide Present Value estimates of Whole Life Costs per asset, summed per sub catchment and totalled for the entire Lower Welland catchment.

The best estimate of cost to be used in cost benefit analysis, alongside the lower and upper bound costs accounting for uncertainty in investment needs at this stage, are presented in Table 7-3.

[22]https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/long-term-costing-tool-for-flood-and-coastal-risk-management

Table 7-2: Estimate of whole life costs for the Lower Welland catchment and each subcompartment (£k)

	North Level (A) (£k)	North Level (B) (£k)	North Level (C) (£k)	South Holland (A) (£k)	South Holland (B) (£k)	South Holland (C) (£k)	Welland & Deepings (A) (£k)	Welland & Deepings (B) (£k)	Welland & Deepings (C) (£k)
Capital costs	1,764	3,896	251	33,885	957	6,985	68,372	13,025	11,827
Appraisal costs	811	1,790	115	16,061	441	3,504	29,780	5,987	6,065
Risk contingency	1,545	3,411	220	29,967	839	6,293	58,891	11,407	10,735
Future costs	-	-	-	-	-	-	-	-	-
Maintenance and operational costs	2,939	4,249	601	24,272	4,544	371	53,113	23,360	13,356
Whole life cost	**7,060**	**13,347**	**1,186**	**104,185**	**6,780**	**17,153**	**210,155**	**53,778**	**41,983**

	Welland & Deepings (D) (£k)	Welland & Deepings (E) (£k)	Welland & Deepings (F) (£k)	Welland & Deepings (G) (£k)	Watercourse* (£k)	Lower Welland (£k)
Capital costs	30	1,212	11,395	6,043	13,025	**195,453**
Appraisal costs	14	558	5,723	2,781	5,987	**93,011**
Risk contingency	26	1,062	10,270	5,294	11,407	**173,079**
Future costs	-	-	-	-	-	**-**
Maintenance and operational costs	1,049	2,944	18,816	3,354	23,360	**195,645**
Whole life cost	**1,119**	**5,775**	**46,204**	**17,472**	**53,778**	**657,188**

*Watercourse costs are those associated with watercourses which span the entire catchment and cannot be allocated to individual sub catchments. These are included within the cost for the Lower Welland catchment as a whole but no benefits have been derived for these specifically. The costs are shown here for clarity.

Table 7-3: Range of whole life costs for the Lower Welland catchment and each subcompartment (£k)

	North Level (A) (£k)	North Level (B) (£k)	North Level (C) (£k)	South Holland (A) (£k)	South Holland (B) (£k)	South Holland (C) (£k)	Welland & Deepings (A) (£k)	Welland & Deepings (B) (£k)	Welland & Deepings (C) (£k)
Lower bound cost	6,113	11,259	1,052	76,137	6,266	12,799	178,808	48,790	34,636
Best estimate cost	7,060	13,347	1,186	104,185	6,780	17,153	210,155	53,778	41,983
Upper bound cost	8,841	17,283	1,440	137,632	7,745	23,738	286,826	70,645	52,923
	Welland & Deepings (D) (£k)	**Welland & Deepings (E) (£k)**	**Welland & Deepings (F) (£k)**	**Welland & Deepings (G) (£k)**	**Watercourse * (£k)**	**Lower Welland (£k)**			
Lower bound cost	709	4,020	39,318	14,226	107,184	541,316			
Best estimate cost	1,119	5,775	46,204	17,472	53,778	657,188			
Upper bound cost	1,149	6,997	56,937	23,569	162,618	858,341			

8. Cost Benefit Analysis

Capped PV damages, the net PV benefits of implementing the Maintain scenario, and the project costs are used to calculate the benefit cost ratios, shown in Table 8-1.

Table 8-1: Cost Benefit Analysis

Option	Damages (£k)	Benefits (£k)	Whole life costs (£k)	Benefit Cost Ratio
Total – Lower Welland				
Do Nothing	9,312,584	-	-	-
Maintain	380,630	8,931,954	657,188	13.59
North Level A				
Do Nothing	335,731	-	-	-
Maintain	6,056	349,674	7,060	49.53
North Level B				
Do Nothing	723,720	-	-	-
Maintain	10,482	713,239	13,347	53.44
North Level C				
Do Nothing	1,375	-	-	-
Maintain	2	1,373	1,186	1.16
South Holland A				
Do Nothing	1,821,154	-	-	-
Maintain	72,476	1,748,677	104,185	16.78
South Holland B				
Do Nothing	786,653	-	-	-
Maintain	56,065	730,587	6,780	107.76
South Holland C				
Do Nothing	110,029	-	-	-
Maintain	2,186	107,843	17,153	6.29
Welland & Deepings A				
Do Nothing	3,743,361	-	-	-
Maintain	192,129	3,551,232	210,155	16.9

Option	Damages (£k)	Benefits (£k)	Whole life costs (£k)	Benefit Cost Ratio
Total – Lower Welland				
Welland & Deepings B				
Do Nothing	48,830	-	-	-
Maintain	32	48,798	53,778	0.91
Welland & Deepings C				
Do Nothing	18,119	-	-	-
Maintain	4,540	13,579	41,983	0.32
Welland & Deepings D				
Do Nothing	45	-	-	-
Maintain	-	45	1,119	0.04
Welland & Deepings E				
Do Nothing	47,134	-	-	-
Maintain	434	46,701	5,775	8.09
Welland & Deepings F				
Do Nothing	1,638,552	-	-	-
Maintain	33,841	1,604,711	46,204	34.73
Welland & Deepings G				
Do Nothing	17,881	-	-	-
Maintain	2,388	15,493	17,472	0.89
Watercourse				
Do Nothing	-	-	-	-
Maintain	-	-	130,992	-

9. Partnership Funding

The maximum level of Grant in Aid (GiA) available at a catchment (and sub compartment) level has been calculated using the benefits derived as damages avoided following the methodologies set out in Section 5, and compared with whole life costs for all assets within the catchment (or sub compartment) as derived under Section 7.

Outcome Measure 2 counts follow a simplified approach detailed in Section 9.3 of the Calculate GiA funding for FCERM projects guidance[23]. Outcome Measure 2 properties better protected from flood risk have been defined based on the number of properties at risk in the Maintain scenario, together with those written off in the Do Nothing scenario which are assumed to be at Low Risk in the "after" counts; for the "before" count of properties, these properties are shifted one risk band higher.

No Outcome Measure 4 have been included in the Partnership Funding calculators at this stage of assessment.

Table 9-1 to Table 9-28 detail the number of Outcome Measure 2a properties that are better protected against flood risk by sustaining the existing defences over the 100 years benefits period.

Table 9-1: Outcome Measure 2 – Lower Welland catchment - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	117	-	-	1
21% to 40% most deprived	-	2,870	4,994	-	49
60% least deprived	-	5,798	13,209	-	87
All deprivation bands	-	8,785	18,203	-	137

[23] https://assets.publishing.service.gov.uk/media/66e15a1c44b517b5cc5e2688/LIT_58360__Calculate_GIA_funding.pdf

Table 9-2: Outcome Measure 2 – Lower Welland catchment - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	117	-	-	1	-
21% to 40% most deprived	2,870	4,994	-	49	-
60% least deprived	5,798	13,209	-	87	-
All deprivation bands	8,785	18,203	-	137	-

Table 9-3: Outcome Measure 2 – North Level A - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	-
60% least deprived	-	228	143	-	6
All deprivation bands	-	228	143	-	6

Table 9-4: Outcome Measure 2 – North Level A - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	-
60% least deprived	228	143	-	6	-
All deprivation bands	228	143	-	6	-

Table 9-5: Outcome Measure 2 – North Level B - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	268	137	-	-
60% least deprived	-	800	469	-	1
All deprivation bands	-	1,068	606	-	1

Table 9-6: Outcome Measure 2 – North Level B - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	268	137	-	-	-
60% least deprived	800	469	-	1	-
All deprivation bands	1,068	606	-	1	-

Table 9-7: Outcome Measure 2 – North Level C - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	-
60% least deprived	-	-	-	-	-
All deprivation bands	-	-	-	-	-

Table 9-8: Outcome Measure 2 – North Level C - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	-
60% least deprived	-	-	-	-	-
All deprivation bands	-	-	-	-	-

Table 9-9: Outcome Measure 2 – South Holland A - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	1,445	1,147	-	44
60% least deprived	-	799	1,261	-	4
All deprivation bands	-	2,244	2,408	-	48

Table 9-10: Outcome Measure 2 – South Holland A - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	1,445	1,147	-	44	-
60% least deprived	799	1,261	-	4	-
All deprivation bands	2,244	2,408	-	48	-

Table 9-11: Outcome Measure 2 – South Holland B - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	2,043	-	1
60% least deprived	-	-	1,619	-	-
All deprivation bands	-	-	3,662	-	1

Table 9-12: Outcome Measure 2 – South Holland B - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	2,043	-	1	-
60% least deprived	-	1,619	-	-	-
All deprivation bands	-	3,662	-	1	-

Table 9-13: Outcome Measure 2 – South Holland C - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	2	2	148	-	1
60% least deprived	14	14	9	-	-
All deprivation bands	16	16	157	-	1

Table 9-14: Outcome Measure 2 – South Holland C - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	2	148	-	1	-
60% least deprived	14	9	-	-	-
All deprivation bands	16	157	-	1	-

Table 9-15: Outcome Measure 2 – Welland & Deepings A - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	206	848	-	-
60% least deprived	-	3,035	8,324	-	46
All deprivation bands	-	3,241	9,172	-	46

Table 9-16: Outcome Measure 2 – Welland & Deepings A - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	206	848	-	-	-
60% least deprived	3,035	8,324	-	46	-
All deprivation bands	3,241	9,172	-	46	-

Table 9-17: Outcome Measure 2 – Welland & Deepings B- at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	-
60% least deprived	-	-	-	-	-
All deprivation bands	-	-	-	-	-

Table 9-18: Outcome Measure 2 – Welland & Deepings B - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	-
60% least deprived	-	-	-	-	-
All deprivation bands	-	-	-	-	-

Table 9-19: Outcome Measure 2 – Welland & Deepings C - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	19	23	-	1
60% least deprived	-	44	183	-	9
All deprivation bands	-	63	206	-	10

Table 9-20: Outcome Measure 2 – Welland & Deepings C - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	19	23	-	1	-
60% least deprived	44	183	-	9	-
All deprivation bands	63	206	-	10	-

Table 9-21: Outcome Measure 2 – Welland & Deepings D - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	-
60% least deprived	-	-	-	-	-
All deprivation bands	-	-	-	-	-

Table 9-22: Outcome Measure 2 – Welland & Deepings D - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	-
60% least deprived	-	-	-	-	-
All deprivation bands	-	-	-	-	-

Table 9-23: Outcome Measure 2 – Welland & Deepings E - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	-
60% least deprived	-	20	20	-	-
All deprivation bands	-	20	20	-	-

Table 9-24: Outcome Measure 2 – Welland & Deepings E - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	-
60% least deprived	20	20	-	-	-
All deprivation bands	20	20	-	-	-

Table 9-25: Outcome Measure 2 – Welland & Deepings F - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	930	646	-	-
60% least deprived	-	855	1,179	-	21
All deprivation bands	-	1,785	1,825	-	21

Table 9-26: Outcome Measure 2 – Welland & Deepings F - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	930	646	-	-	-
60% least deprived	855	1,179	-	21	-
All deprivation bands	1,785	1,825	-	21	-

Table 9-27: Outcome Measure 2 – Welland & Deepings G - at risk today

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	-	2
60% least deprived	-	-	2	-	-
All deprivation bands	-	-	2	-	2

Table 9-28: Outcome Measure 2 – Welland & Deepings G - at risk after duration of benefits

	Low risk	Moderate risk	Intermediate risk	Significant risk	Very significant risk
20% most deprived	-	-	-	-	-
21% to 40% most deprived	-	-	-	2	-
60% least deprived	-	2	-	-	-
All deprivation bands	-	2	-	2	-

Table 9-29 details the maximum eligible GiA and the raw PF score for the whole of the Lower Welland catchment and each subcompartment.

Table 9-29: Partnership funding calculator results

	pv maximum eligible FCERM GiA (£k)	raw PF score (%)
Lower Welland	543,780	83
North Level A	20,866	296
North Level B	43,128	323
North Level C	82	7
South Holland A	106,180	102
South Holland B	46,129	680
South Holland C	6,628	39
Welland & Deepings A	215,749	103
Welland & Deepings B	-	-
Welland & Deepings C	-	-
Welland & Deepings D	-	-
Welland & Deepings E	2,805	49
Welland & Deepings F	97,010	210
Welland & Deepings G	-	-

The subcompartments Welland & Deepings B, C, D, and G have a benefit cost ratio below 1 as shown in Table 8-1 and so is not eligible for FCERM GiA.

10. Limitations

There are a number of limitations for the work undertaken at this stage of assessment:

- National model data (Risk of Flooding from Multiple Sources) has been used to determine risk in the Maintain scenario and residual risk above permanent inundation levels in the Do Nothing scenario. This data allows for an indicative assessment of the risk and potential damages but caution is advised when using this data at a local level, and consideration given to the use of local model data for future business cases at individual assets.
- The benefits assessment undertaken is broad given the strategic nature of the project, and the damages assumed to accrue under Do Nothing and Maintain scenarios are based on a standardised set of assumptions. This does not allow for more discrete impacts of a Do Nothing scenario such as blockage or failure of structures which may exacerbate risk in discrete areas in the short term.
- The costs developed at this stage are considered indicative only and should be reviewed at more detailed stages of appraisal for individual investments.
- Costs and estimated years for interventions have not been provided by all RMAs for all assets and as such there may be assets for which no cost information is included. However, benefits have been allocated across all eligible FRM assets such that these assets do have available benefits. Further to this, standardised costing assumptions have been made for a number of assets which may not be appropriate across all assets. The overall impact of this is not considered likely to change the general outcome of the analysis, and the indication of affordability and value for money.

11. Conclusions

Over the next 100 years, the Do Nothing scenario is projected to result in PV damages exceeding £9.3 billion, compared to £381 million under the Maintain scenario. By continuing the current FRM approach, the Maintain scenario delivers estimated benefits of around £8.9 billion. The primary driver of these benefits is the high standard of existing flood protection, which does not lead to considerable flooding from overtopping of defences. In total, 24,870 residential properties as OM2a are protected by the FRM assets maintained under this scenario. Benefits include:

- £6 billion of property damages avoided[24], including 24,870 residential and 3,124 non-residential properties avoiding write off
- £1.1 billion of agricultural losses avoided, and 40,491ha of land protected
- £118.9m of environmental and recreational losses avoided
- £42.4m of heritage losses avoided
- £1.4 billion of transport damages avoided
- £126m of utilities damages avoided
- £121.8m of land lost to isolation being avoided.

In addition to these economic benefits, there is an estimated £6.4 billion of financial losses to the local economy avoided in the first ten years.

To provide this level of protection, a total of 24 pumping stations, 44 outfalls, and significant reaches of open channel and linear flood defences will need to be sustained over the next 100 years, with total whole life costs estimated at £657 million to do so.

Based on the analysis, it is clear that the current FRM measures and activities provide substantial benefits across the Lower Welland catchment. However, these benefits are not evenly distributed. Welland & Deepings A demonstrates the highest level of benefit, with a strong return on investment for the FRM interventions implemented. In contrast, Welland & Deepings D shows a bad return on investment, with the lowest cost benefit ratio of 0.04. This is likely due to the limited amount of benefits generated in the smallest subcompartment. In reality, the nature of this catchment is such that the benefits afforded by coastal assets should be split across all assets and therefore the overall Lower Welland catchment level BCR and PF score is considered more representative of value for money for sustaining the assets, and a better indication of eligibility for FCERM GiA funding, than the individual compartment values.

Given the high value of benefits and large numbers of residential properties protected, the catchment is eligible for £544 million of GiA funding with a PF score of 83%. Consequently, there is a funding gap of £113 million that needs to be closed when compared to the total whole life cost of sustaining the FRM assets.

[24] Includes direct residential and non-residential damage as well as indirect commercial losses, mental health costs, emergency services costs, risk to life, evacuation and temporary accommodation costs and intangible impacts to human health

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