Humber 2100+

Humber 2100+ Sustainability Appraisal Scoping Report addendum

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Contents

1. Introduction

The Environment Agency and the 11 local authorities from around the Humber are working in partnership to develop a long-term strategy to manage tidal flood risk and enable sustainable growth. This new, updated strategy (Humber 2100+) will replace the previous Humber Flood Risk Management Strategy (Environment Agency 2008).

Humber 2100+ is being developed in three main steps as illustrated in Figure 1.1.

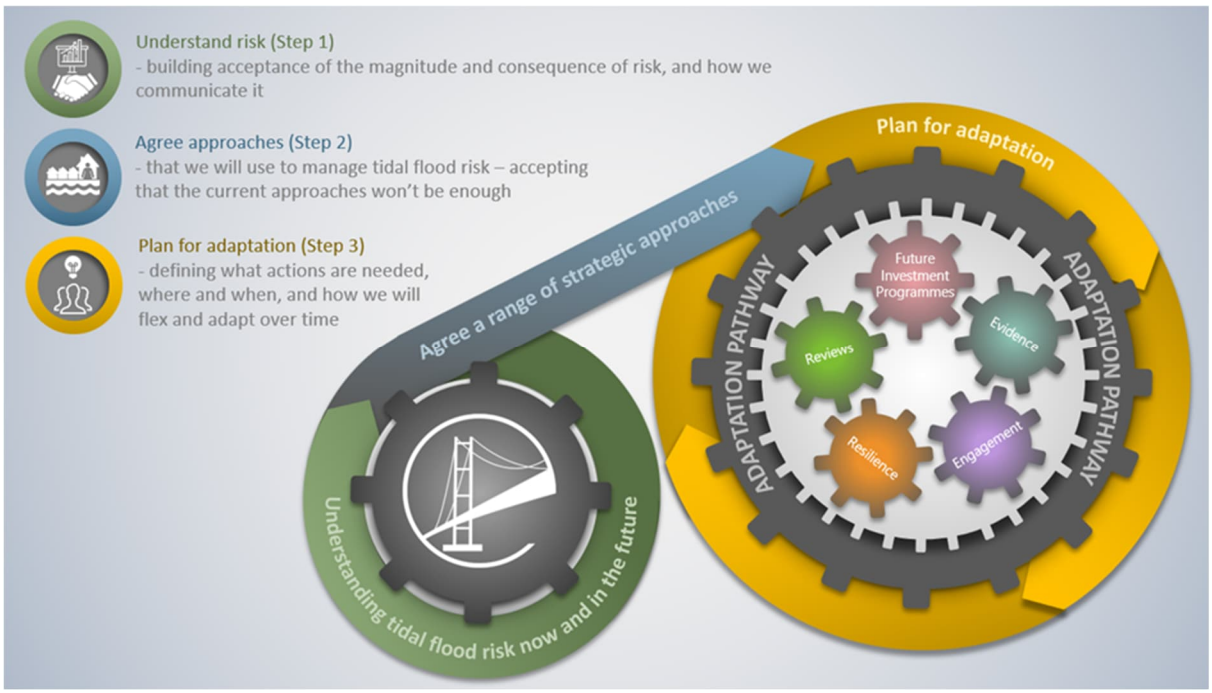

Figure 1.1: Stepped approach for Humber 2100+

The development of Humber 2100+ is currently nearing the end of Step 1. This step seeks to understand and build acceptance of Present Day tidal flood risk within the Humber estuary (the strategy area) and anticipate how this may vary in the future by testing a range of future baseline scenarios (i.e. prior to any future change in flood risk management which Humber 2100+ may recommend) – see Section 3.2 for details. This will inform Step 2 which will propose approaches to the future management of tidal flood risk.

During the development of Humber 2100+, various environmental studies/assessments, including Sustainability Appraisal (SA) (incorporating Strategic Environmental Assessment (SEA)) and Habitats Regulations Assessment (HRA), are being undertaken. These will ensure compliance with legal requirements, help identify sustainable options that work with natural processes, and identify potential impacts, mitigation and monitoring from the implementation of Humber 2100+.

The new assessments will refer to and build on the assessments completed for the Humber Flood Risk Management Strategy (Environment Agency 2008), including an SEA and Habitat Regulations work (a shadow Appropriate Assessment in 2005 and approved HRA in 2011, following the change in legislation).

2. Purpose and content of this document

This document is an addendum to the SA Scoping Report (Jacobs, 2020) previously prepared and consulted on by the Environment Agency for Humber 2100+. This addendum updates relevant aspects (see below for details) of that SA Scoping Report that are key to the current step (Step 1) and future development of Humber 2100+; and should be read alongside the full SA Scoping Report for completeness.

SA is a systematic process carried out during the preparation of plans and/or strategies. Its role is to promote sustainable development by assessing the extent to which an emerging plan (or strategy), when judged against reasonable alternatives, will help to achieve relevant environmental, economic and social objectives.

As described in Chapter 1, a SA is being undertaken to inform the development of Humber 2100+, incorporating an SEA, to assess the sustainability of the strategic proposals being considered in the emerging strategy in terms of relevant environmental, social and economic factors.

Scoping is the initial stage in the SA process, which considers the context and scope of the SA and establishes an assessment process. The SA Scoping Report was prepared to record the findings of the SA scoping stage, and had the following aims:

- To set out the baseline information for a defined study area across economic, social and environmental themes;
- To record the review of legislation, plans and policies that are most relevant to flood risk management proposals in the study area;
- To develop a 'SA Framework' comprising a set of sustainability objectives that Humber 2100+ will look to achieve and a set of criteria against which the proposed options will be appraised; and
- To elicit feedback from key stakeholders on the scoping stage baseline information and proposed framework of objectives, to inform the appraisal of strategic flood risk management options.

The SA Scoping Report prepared in 2017 was consulted on over a five-week statutory period between December 2017 and January 2018 and was finalised as a post-consultation SA Final Scoping Report in 2018. The report was also publicly consulted on for another five weeks between February 2020 and March 2020 (although the baseline information remained the same as in the earlier 2018 version).

In 2020/21, following a review of the approach to Humber 2100+ (see Section 3.2), a need to update relevant aspects of the SA Scoping Report to inform the present Step 1 and the future development of Humber 2100+ was identified.

Therefore, the purpose and scope of this addendum to the SA Scoping Report is to:

- Identify and ensure compliance with relevant recent policy and legislative changes;
- Document key changes to baseline conditions (Present Day) and the wider planning/policy context;
- Provide a qualitative understanding of the environmental, social and economic changes and strategic issues/opportunities that could result from alternative modelled future 'baseline' scenarios over time;
- Review and update the identified future trends and strategic issues relating to the Humber 2100+; and
- Be cognisant of possible future alignment of the SA framework with the Humber 2100+ Adaptation Pathways approach.

This addendum is structured as follows:

1. Introduction
2. Purpose and content of this document

3. Strategy context
4. Approach and methodology
5. Baselines: predicted changes and key strategic issues/opportunities – covering the following topics:
    - Description of future baselines
    - Present and future baselines and key strategic issues for each SA topic.
6. Review of proposed SA Assessment Framework and methodology
7. Next steps

To support this addendum, a **GIS WebApp data viewer** has been produced containing the updated baseline data, tidal flood likelihood maps and relevant administrative/spatial boundaries considered within this addendum. This resource has been provided in place of a large number of fixed figures to enable the reader to independently view and interrogate the data on which the content of this report is based. To access this mapping, please email hstrategy@environment-agency.gov.uk and refer to ArcGIS online (AGOL).

3. Strategy context

3.1 Background

The existing Humber Flood Risk Management Strategy was approved by the Department for Environment, Food and Rural Affairs (Defra) in 2007, published in 2008 and began to be implemented in 2009. It sets out a strategic approach for managing tidal flood risk around the Humber estuary over 100 years. The existing strategy examined different ways of managing flood risk around the estuary, raising defences where appropriate but considering the potential benefits of providing flood storage at three locations. It also identified sites where the defences could be realigned to provide compensatory habitat under the Habitats Regulations. Managed realignment sites delivered since 2008 include Donna Nook and Welwick to Skeffling. It aimed to ensure a good standard of protection from tidal flooding for the first 25 years and beyond for 99% of residents around the estuary and the important industrial areas. There were, however, substantial lengths of frontage for which making defence improvements was uneconomic, so the standard of protection would diminish as sea levels rise. In addition, the changes introduced by the Flood and Water Management Act 2010 suggested an increased role for local authorities in flood risk management and introduced the partnership funding approach.

When the original Humber Strategy was developed, regular reviews of the strategy were anticipated to ensure it meets the future needs of the people, property and the environment around the Humber estuary. However, since the publication of the strategy, policy changes (e.g. relating to new funding opportunities) and further technical information (e.g. a tidal surge in 2013 providing better evidence for how flood water will behave) have become available. These changes made the case for a comprehensive review and update of the strategy. The new strategy was named 'Humber 2100+' and will redefine the strategic approach to managing tidal risk on the Humber estuary.

3.2 Humber 2100+ Strategy

The purpose of Humber 2100+ is to develop a new strategy for managing tidal flood risk around the estuary for the next 100 years, taking into account predicted sea level rise linked to climate change.

Humber 2100+ is being undertaken by the Environment Agency in full partnership with 11 local authorities around the Humber and in association with Natural England and internal drainage boards, as well as other statutory agencies, risk management authorities and other key stakeholders. The aim is to produce an updated strategy that is agreed and formally adopted by all the partners.

As explained in Chapter 1 and shown on Figure 1.1, the development of Humber 2100+ is now being progressed through a number of steps. It is currently nearing the end of Step 1 which seeks to understand tidal flood risk within the Humber estuary (the strategy area) and anticipate how this may vary in the future. The objectives of Step 1 are to provide:

- A strategic scale understanding of what is at tidal risk, both now and in the future, in terms of the value of properties (residential and non-residential) and other significant assets within the tidal floodplain. This will help determine, in financial terms, the benefits of managing tidal risk;
- A strategic scale understanding of what would happen in the tidal floodplain if the Environment Agency were to continue with the status quo (i.e. continuation of existing 2008 strategy). This will help to clearly articulate why a different approach is needed and will also help shape thinking around that new approach;
- Evidence to show how tidal flood risk changes at different time horizons: namely 2021, 2046, 2071 and 2121. This will help to understand the pace of adaptation or change to tidal flood risk that will be needed;
- A strategic scale assessment of indicative costs for providing defence improvements, which would preserve the status quo or deliver a 1 in 200 standard of protection. This will help determine, in financial and carbon terms, the costs of continuing to deliver the existing 2008 strategy; and

- An acceptance of the future tidal flood risk and an agreed way to communicate this risk, so that partners can work together to develop the new future strategy for tidal flood risk on the Humber.

3.3 Sustainability Appraisal and related assessments

The approach to the SA, as set out in the SA Scoping Report, is based on the Department for Communities and Local Government (DCLG) Guidance on the SA of Plans, Policies and Programmes (DCLG 2005). It follows four stages, which are continuously linked to the preparation of the strategy: (i) Scoping; (ii) Initial Options Appraisal; (iii) Preferred Option Appraisal; and (iv) Adoption/Strategy Submission. The SA is currently revisiting the scoping stage, updating relevant aspects from the SA Scoping Report (Jacobs 2020) previously consulted on and reporting them in this addendum.

Alongside the SA, there are other separate, but interlinked, environmental processes that will inform the development of Humber 2100+. These processes are described in the SA Scoping Report, although some of the terminology and assessment processes have evolved since its publication. These assessments are:

- Habitat Regulations Assessment (HRA) – an HRA will be required in accordance with The Conservation of Habitats and Species Regulations 2017 (as amended) and the Offshore Marine Conservation (Natural Habitats & c.) (Amendment) Regulations 2010 (the 'Habitats Regulations'), to assess the potential effects of Humber 2100+ on the integrity of internationally designated nature conservation sites ('Habitats sites').

- Water Framework Directive (WFD) assessment – a compliance assessment of the preferred options with the Water Environment (WFD) (England and Wales) Regulations 2017 to identify the likely effects on relevant waterbodies within the strategy area (see Section 4.2) and their status, including cumulative effects and recommendations for achieving good ecological potential through the implementation of flood risk management-related mitigation measures.

To inform the consideration of the sustainability of future options, the development of Humber 2100+ has included the following at Step 1:

- Carbon assessment: narratives are being produced for the future baseline scenarios to estimate their operational 'carbon cost' and identify which have the greatest potential to sequester/absorb carbon and greatest impact (i.e. benefits from carbon saved from damages avoided). This involves a calculation of whole life carbon emissions associated with the construction, operation and maintenance of flood risk management assets for each baseline quantified using the Whole Life Carbon Tool (WLCT).

- Natural capital assessment: a natural capital baseline is being developed during Step 1 by collating open access habitat mapping, determining relevant quantities and inputting this data into the Environment Agency's Natural Capital Register and Account Tool (NCRAT) (version 1.2), which details the areas of individual habitats. This baseline provides a 'snapshot' of existing natural capital assets and ecosystem service provision (and benefits), from which a qualitative assessment is made to understand the impact of future baseline scenarios on assets and services, across a six-point scale, identifying where trade-offs are possible.
- As a precursor to a future HRA, considerable work has been undertaken to develop a functional understanding of the Humber estuary system in terms of its key physical and biological elements to, for example, help promote the inclusion of nature-based solutions within the approaches to be considered during future stages of the development of Humber 2100+ and inform a future HRA. A Statement of Common Ground (SoCG) between Natural England and the Environment Agency has been agreed, based on current information, to help scope and develop this understanding and the future HRA. The SoCG will be developed over time as new information becomes available.

In addition to progressing the above, future steps of the development of Humber 2100+ will also consider:

- Exploration of strategic opportunities for delivering future Biodiversity Net Gain (BNG) (e.g. through habitat creation/enhancement and establishment of coherent ecological networks), for implementation during the delivery of future flood risk management schemes (in line with the requirements of The Environment Act 2021, which makes it mandatory for developments applying for planning consent under the Town and Country Planning Act 1990 to achieve at least a 10% net gain in value for biodiversity from February 2024).

- The need to ensure compliance with other relevant legislation e.g. demonstrating compliance with the Public Sector Equality Duty through the development of an Equality Assessment.

3.4 Consultation and engagement

3.4.1 Consultation on SA Scoping Report

To meet the statutory requirements for consultation and add rigour to the appraisal process, the SA Scoping Report Consultation Version (Jacobs 2018) was made available to statutory bodies and other key stakeholders, including Natural England, Historic England, Marine Management Organisation, local planning authority teams, Environment Agency teams, and other relevant bodies, such as the Yorkshire and Lincolnshire Wildlife Trusts and RSPB. This consultation was carried out between December 2017 and January 2018, adhering to the statutory consultation period prescribed in the SEA Regulations (five weeks).

After the five-week consultation period, the responses were collated and analysed. Based on the responses, some baseline and policy information was revised and the SA assessment framework (hereafter referred to as assessment framework) was refined in order to prepare the final SA Scoping Report (Jacobs 2020).

3.4.2 Consultation on addendum

The Humber 2100+ partnership members were engaged during the preparation of this addendum, as follows:

- Planning and environmental spatial datasets were requested from and provided by the relevant local authorities in the strategy area;

- Consultation was undertaken on the scope of the baseline data collated and considered, and the approach to the production of the 'consequence narratives' (see Section 4.4 for details), as reflected in the Technical Note in Appendix A; and

- Consultation on the consequence narratives is being undertaken via an initial draft of this addendum to ensure that key information is considered and the predicted consequences are endorsed to meet the objectives of Step 1. Any changes from this initial draft will be reflected in an updated full version of the SA Scoping Report addendum.

Consultation on this addendum is planned in early 2025 with statutory bodies and other key stakeholders to seek their views on the key updates provided in this document, including the review of the assessment framework. Any feedback received will be reviewed and changes made, as appropriate. A final version of this addendum will be produced, which will set the context for the future progression of the SA through Step 2 and beyond, of the development of Humber 2100+.

The Environment Agency is working closely with Natural England throughout the development of Humber 2100+ to ensure compliance with statutory processes (e.g. future HRA and BNG requirements) and seeking to optimise positive outcomes for nature conservation, biodiversity and estuarine processes, consistent with the agreed SoCG.

4. Approach and methodology

4.1 Introduction

Step 1 of Humber 2100+ focuses on a number of baselines which describe how the future of tidal flood risk management *could* evolve over the next 100 years.

The Strategic Flood Damage Assessment undertaken as part of Step 1 provides quantitative evidence of some economic, social and environmental impacts of the present-day and future tidal flood risk. To supplement these quantitative assessments, 'consequence narratives' have been developed to describe how tidal flood risk for each of the future baseline scenarios could affect a wider range of environmental, social, and economic receptors, based on the scope of the SA. These consequence narratives will inform the understanding and communication of present and future flood risk and influence the future development of Humber 2100+, including the SA.

This chapter provides an overview of the methodology used to produce these 'consequence narratives', which are described in Chapter 5 of this document. This chapter describes:

- The Humber 2100+ Strategy area in relation to the SA;
- Data sources used, including how flood modelling and the assessment of economic flood damages have informed the consequence narratives;
- Approach to this assessment; and
- Key assumptions and limitations.

4.2 Strategy area

The strategy area, which forms the study area for the SA and this addendum, is shown in Figure 4.1. It comprises the area of tidally dominant flooding around the Humber estuary and the lower reaches of the Rivers Ouse, Ancholme, Hull, Aire, Don and Trent (extending further upstream and along the coast compared with the existing 2008 strategy). The strategy area is divided into 35 reporting units, termed Flood Cells, which provide the focus for tidally dominated flood risk management.

The strategy area includes homes of more than 500,000 people, over 200,000 properties and over 37,500 businesses (UK government n/d). It includes major industrial and commercial properties, the country's largest port complex and extensive areas of highly productive farmland. The strategy area is at risk of being flooded by another storm surge in the North Sea and is protected to varying standards by existing flood defences.

The whole area is of heritage interest and the estuary itself is protected by national and international designations due to its importance for nature conservation, particularly for intertidal habitats and birds.

The strategy area covers, either in full or part, the following 11 local authorities:

- Bassetlaw District
- East Lindsey District
- East Riding of Yorkshire
- West Lindsey District
- North East Lincolnshire

- North Lincolnshire
- City of Doncaster Council
- City of Kingston upon Hull
- Lincolnshire County Council
- North Yorkshire Council
- Nottinghamshire County Council

Note that for the purposes of this addendum, the study area considered for international and national conservation sites in the SA extends 15km from the strategy area boundary shown on Figure 4.1, to enable consideration of potential impacts in a wider zone of influence.

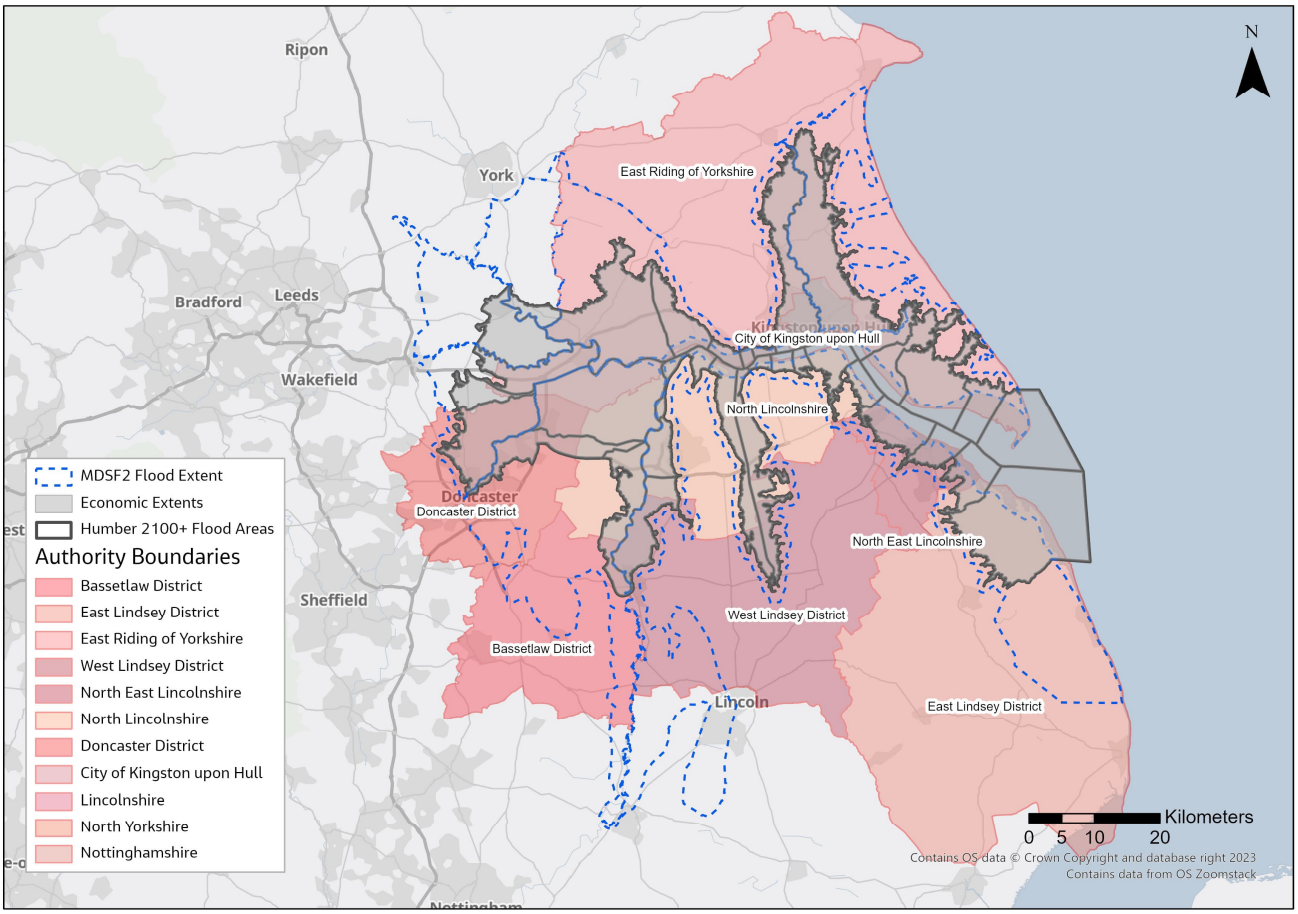

Figure 4.1: The Humber 2100+ Strategy area in black, overlying the local authority boundaries, modelled extents in blue and the extent of the economics calculation in grey.

4.3 Data sources and updates

4.3.1 Baseline data

The key data sources used in this addendum to provide an understanding of future tidal flood risk consequences are detailed in a technical note provided in Appendix A. This technical note was consulted on with Humber 2100+ partnership members to enable their review of the proposed approach and data sets to be used.

The key types of baseline data sources used comprise:

- Planning and environmental spatial datasets requested from and provided by relevant local authorities within the strategy area;
- Web-based publicly available environmental, economic and social spatial data sets; and
- Contextual information and reports.

The 'scoped in' SA topics and data (air quality was previously scoped out) considered in this addendum comprise:

- Population and human health;
- Access and recreation;
- Economic activity, growth and inward investment;
- Rural land use and economy;
- Material assets;
- Biodiversity;
- Water;
- Geomorphology;
- Landscape;
- Cultural heritage and archaeology;
- Climate change;
- Waste and contaminated land; and
- Cumulative effects.

Details of the specific receptors considered are provided in the technical note in Appendix A. Note that the datasets and receptors considered in this SA addendum are at a spatial scale considered appropriate to the strategic nature of this assessment and therefore, not all receptor datasets available will have been considered.

All spatial data obtained and used for this assessment have been uploaded to a GIS WebApp Viewer specifically developed to support the interpretation of future tidal flood risk consequences and enable readers of this report to interrogate the baseline data and flood modelling outputs independently.

4.3.2 Flood modelling and identification of flood risk changes

The Environment Agency's MDSF2 (Modelling and Decision Support Framework) software was adopted by HR Wallingford to carry out tidal floodplain risk modelling for the Present Day and four future baseline scenarios, as summarised below and described in Section 5.3.1. The MDSF2 methodology was applied to assess the predicted tidal flood risk over time, specifically for the 2046, 2071 and 2121 epochs, as shown in Table 4.1. MDSF2 was also used to assess the risk profile through time and establish present value damages for a range of receptors, including key infrastructure.

- Do Nothing: The Do Nothing baseline provides a high-level assessment of risk should all tidal flood risk management (FRM) activities cease (i.e. hypothetically walk away). Key aspects are:
    - All operation, maintenance and repair of tidal assets (including breaches) ceases from 2021 (year 0).
    - Active gates (Hull Barrier and Barmby Barrage) fail (open) in year 0 and River Hull fluvial defences are tidally loaded.
    - All passive gates fail (open) in 2046.
    - Once South Ferriby sluice fails, River Ancholme defences are tidally loaded.

- Legal Requirement: The Legal Requirement baseline represents the least cost FCERM actions needed to meet specific legal obligations. Key aspects are:
    - All defences maintained (minimum level) and operated until they reach condition grade 5 and fail (open).
    - Only defences with legal requirements (Barmby Barrage, Hull Barrier, South Ferriby Sluice Gates) are replaced/repaired; replacement/repair does not include defences flanking main structures.
- Maintain: The Maintain baseline provides a high-level assessment of risk should all tidal FRM activities continue only as they are today, with no future improvements in the standard of protection provided. Key aspects are:
    - All defences maintained and operated as present, with repairs/replacements to any that fail.
    - Defences with legal requirements (Barmby Barrage, Hull Barrier, South Ferriby Sluice Gates) are maintained as they are between condition grades 2 and 4.
    - No improvements (e.g. raising) to any defences in response to climate.
- Status Quo: The Status Quo baseline represents the impact of the current 2008 Humber Strategy on future flood risk and suggests why a new 2100+ Strategy – and an increase in strategy area - is required.
    - Flood storage (including Flixborough and Sandhall) and defence raising in line with climate at locations identified by the 2008 Strategy and maintaining defences elsewhere.
    - Where the 2008 Strategy indicated raising would not be undertaken, existing defences maintained/repaired and smaller assets (e.g. flood gates) replaced at end of life (assumed to be 30 years).
    - Defence raising follows existing approaches i.e. walls in urban areas and earth embankments in rural areas, except where buildability issues with continuing the existing approach (e.g. no space for embankment widening) are identified.
    - Compensatory habitat provision (as determined by the 2008 Strategy HRA) through managed realignment of defences in Skeffling, Alkborough, Paull Holme Strays, Donna Nook, Sunk Island, Keyingham and Goxhill.
    - Any possible "Recovery works" funding of larger capital works not included.

Sea levels and fluvial flows have been uplifted for 2046, 2071 and 2121 according to the Environment Agency guidance[1] which is based on UKCP18 projections. The relevant values are provided in Table 4.2. Note that future optioneering of tidal flood risk management will also use more severe climate scenarios.

[1] https://www.gov.uk/guidance/flood-and-coastal-risk-projects-schemes-and-strategies-climate-change-allowances

Table 4.1: Modelled outputs considered for present and future baseline scenarios.

Year	2021 Baseline	Do Nothing	Legal Requirement	Maintain	Status Quo
2021 (Present Day)	X	X			
2046		X		X	X
2071		X	X	X	X
2121		X		X	X

Table 4.2 Climate change uplifts based on Environment Agency guidance.

Scenario (Environment Agency Guidance)	Tidal (Sea Level Rise)	Fluvial (Peak River Flow)	Present Day (2021)	25-years (2046)	50-years (2071)	100-years (2121)
Design (baseline and all future options)	Higher Central (Representative Concentration Pathway (RCP)8.5 70th)	Central (RCP8.5 50th)	SLR: 0.02m Ouse: 4% Aire: 4% Don: 3% Trent: 13%	SLR: 0.19m Ouse: 13% Aire: 13% Don: 15% Trent: 17%	SLR: 0.42m Ouse: 23% Aire: 23% Don: 28% Trent: 29%	SLR: 1.02m Ouse: 23% Aire: 23% Don: 28% Trent: 29%

The outputs of the MDSF2 modelling were subsequently used to generate tidal flood likelihood maps in a GIS WebApp Viewer, to enable visual interpretation of the changes in future tidal flooding to specific environmental, social and economic receptors.

In the absence of specific spatial data, the interpretation of potential tidal flood risk impacts on some key infrastructure was based on predicted tidal economic flood damages.

4.4 Scope of and approach to assessment

The overall approach to the assessment and production of the 'consequence narratives' provided in Chapter 5 comprised:

- Collation of GIS environmental datasets (see Section 4.3 and Appendix A) from a range of sources including open source datasets and the Humber 2100+ partnership members, and in agreement with Humber 2100+ partnership members.

  The environmental baseline data collated was cropped to the strategy area defined in Section 4.2 (i.e. the Humber 2100+ flood cells, with the exception of international and national nature conservation sites that were cropped to a 15km buffer from the flood cell boundary due to their wider pathways for impact from flooding).

- For each topic, provision of an overview of the key changes to the Present Day environmental baseline since the SA Scoping Report with key updates, changes and differences, identifying any new key trends and strategic issues that should be addressed that were not previously covered within the SA Scoping Report. This summary overview includes consideration of relevant key policy and legislative changes since the SA Scoping Report (e.g. the Environment Act (2021)) and presents our understanding of Present Day tidal flood risk.

- Review of changes in tidal flood likelihood from the Present Day baseline for the four future baseline scenarios through various modelled epochs (see Section 4.3.2), based on visual interpretation of GIS data layers and guided by the interpretation of economic assessment data (i.e. flood damages to key receptors).

  The future baseline scenarios considered are described in Section 5.3.

  Flood likelihood bandings were used to represent an appropriate range of flooding i.e. from regular flooding events (i.e. very significant likelihood) to more extreme events (i.e. low likelihood) that adopt the precautionary principle due to the uncertainty associated with future tidal flood risk. Consequently, the key strategic environmental issues and effects associated with the future baseline scenarios have been described with regard to the modelled likelihood of flooding changing from a 'low' likelihood (i.e. rare event - 0.5% Annual Exceedance Probability (AEP) or less) in Present Day (2021) up to a 'very significant' likelihood category (i.e. frequent event - more than 5% AEP) in 100 years' time (2121) – see Table 4.3.

  Table 4.3: Flood likelihood bands used to present modelled results

Likelihood Band	Annual Exceedance Probability
Low	AEP <=0.5%
Moderate	1% <= AEP < 0.5%
Intermediate	2% <= AEP < 1%
Significant	5% <= AEP < 2%
Very significant	AEP >5%

- Preparation of consequence narratives of future trends for topic specific environmental receptors within the strategy area over time (i.e. under a range of future baseline scenarios) within the strategy period, supported by a GIS WebApp viewer.

4.5 Assumptions and limitations

The key assumptions and limitations that have influenced this assessment are provided below:

- Some SA data sets and sources identified and provided by the local authorities have not been used in the assessment, either because:
  - Datasets are not available, data gaps exist (e.g. spatially or temporally limited) or there are inconsistencies in the data received;
  - The data are not at the appropriate scale to influence strategic and high-level flood risk management planning; and/or
  - The data do not help assess changes to the environmental topics or flood risk in the strategy area over different scenarios and time periods.

  The datasets that have been excluded from use in the assessment are described in the technical note in Appendix A. Some of the excluded datasets are instead likely to be collated through desk-based assessment or survey as part of any future individual scheme development.

- The assessment is based on external data provided in May 2024 and open source data accessed between May and October 2024, which may have subsequently been updated – refer to Technical Note for details. This information was correct at the time of assessment/writing.
- Only mapped SA datasets included in the GIS WebApp viewer were interpreted and reported within the future baseline scenarios consequence narratives, except where additional information was available from the MDSF2 modelling outputs.
- Consideration of potential impacts on some key receptors (i.e. key infrastructure, material assets) was guided by where economic damages were predicted.
- The interpretation of tidal flood risk consequences is constrained by any assumptions and limitations of the flood modelling techniques used (refer to Step 1b Future Baselines Technical Report for details).
- Only 2071 was modelled for the Legal Requirement scenario, therefore there are limitations in understanding when flood risk changes occur to environmental assets, prior to this epoch.
- Changes in flood likelihood to social and environmental assets under the future baseline scenarios has been largely considered with reference to a low likelihood and/or very significant likelihood of flooding to ensure adoption of the precautionary principle (although some reference is occasionally made to flood likelihood bandings between low and very significant), and to demonstrate the variability in tidal flood risk under the modelled epochs. This approach helps to highlight for example, how rare flood events may become more frequent in the future. Where land within the strategy area is not mapped within the defined tidal flood likelihood bandings (e.g. areas of high ground), the consequence narratives in Section 5.4 assume that these areas may also be subject to a low likelihood of tidal flooding.
- The assessment considers the present and future likelihood and implications of tidal flood risk – other sources of flooding such as fluvial, pluvial or groundwater are not considered within this assessment or reported on.

5. Baselines: predicted changes and key strategic issues/ opportunities

5.1 Introduction

This chapter provides the 'consequence narratives' that describe how tidal flood risk in the Present Day and for each of the future baseline scenarios could affect a range of environmental, social, and economic receptors, based on the scope of the SA. These consequence narratives will inform the understanding and communication of present and future flood risk and influence the future development of Humber 2100+, including the SA.

This chapter provides details of:

- Present Day baseline (Section 5.2) – key aspects of the Present Day (2021) baseline to be used for the SA, highlighting any changes and updates from the SA Scoping Report in terms of environmental topics, receptors and policy context. This section also highlights the Present Day likelihood of tidal flooding to the baseline environment described, as appropriate.
- Future baseline scenarios (Section 5.3) – provides a summary of predicted changes in tidal flood risk for the modelled future baseline scenarios which form the basis for the consequence narratives.
- Predicted changes and key strategic issues/opportunities (Section 5.4) – sets out potential future trends for key receptors within the strategy area and broadly describes (at a high strategy level) how the Present Day environmental, social and economic baseline may develop over time (with reference to the modelled future baseline scenarios) within the strategy period, based on the methodology (including modelling outputs) described in Section 4.4.

5.2 Present Day baseline

As described in Section 4.1, all Present Day baselines consider a revised strategy area boundary (see Figure 4.1) and any changes since the publication of the 2018 SA Scoping Report are described in Section 4.2.

The topic-specific present-day baselines are described in Section 5.4. All flood maps and assessments discussed in this document (unless otherwise stated) refer to the likelihood of tidal flooding from the Humber estuary and do not explicitly represent flooding from other sources such as rivers, surface water, groundwater and sewers. This means that a location at low likelihood of tidal flooding might still have a higher likelihood of flooding from other sources. Further, since the probability of flooding can never be described as zero, we use the term 'low' likelihood of flooding to describe any area shaded dark green on the maps provided below, as well as any area shaded grey or where the base mapping is visible. All flood modelling assumes the presence of tidal defences that are representative of each scenario.

In 2021 (Present Day: Figure 5.1), land already at very significant (more than 5% Annual Exceedance Probability (AEP)) tidal flood likelihood is mainly located:

- in the outer estuary on the northern frontage between Skeffling and Kilnsea
- in the upper estuary between the Rivers Ouse and Aire
- in isolated areas between the M62 and the River Ouse
- on the west bank of the River Trent opposite Gainsborough, where there is a flood storage area
- on the south bank of the outer estuary between Immingham and Cleethorpes and then around to Saltfleet

Land with a low likelihood of tidal flooding (0.5% AEP or less) is mainly found around the River Hull including Hedon, in the west between the M62 and Doncaster, extending southwards from Goole down to the River Idle and around the River Trent north of Gainsborough. There are more isolated areas around the River Ancholme to the south of Brigg and inland from Immingham round to Cleethorpes and then at Saltfleet.

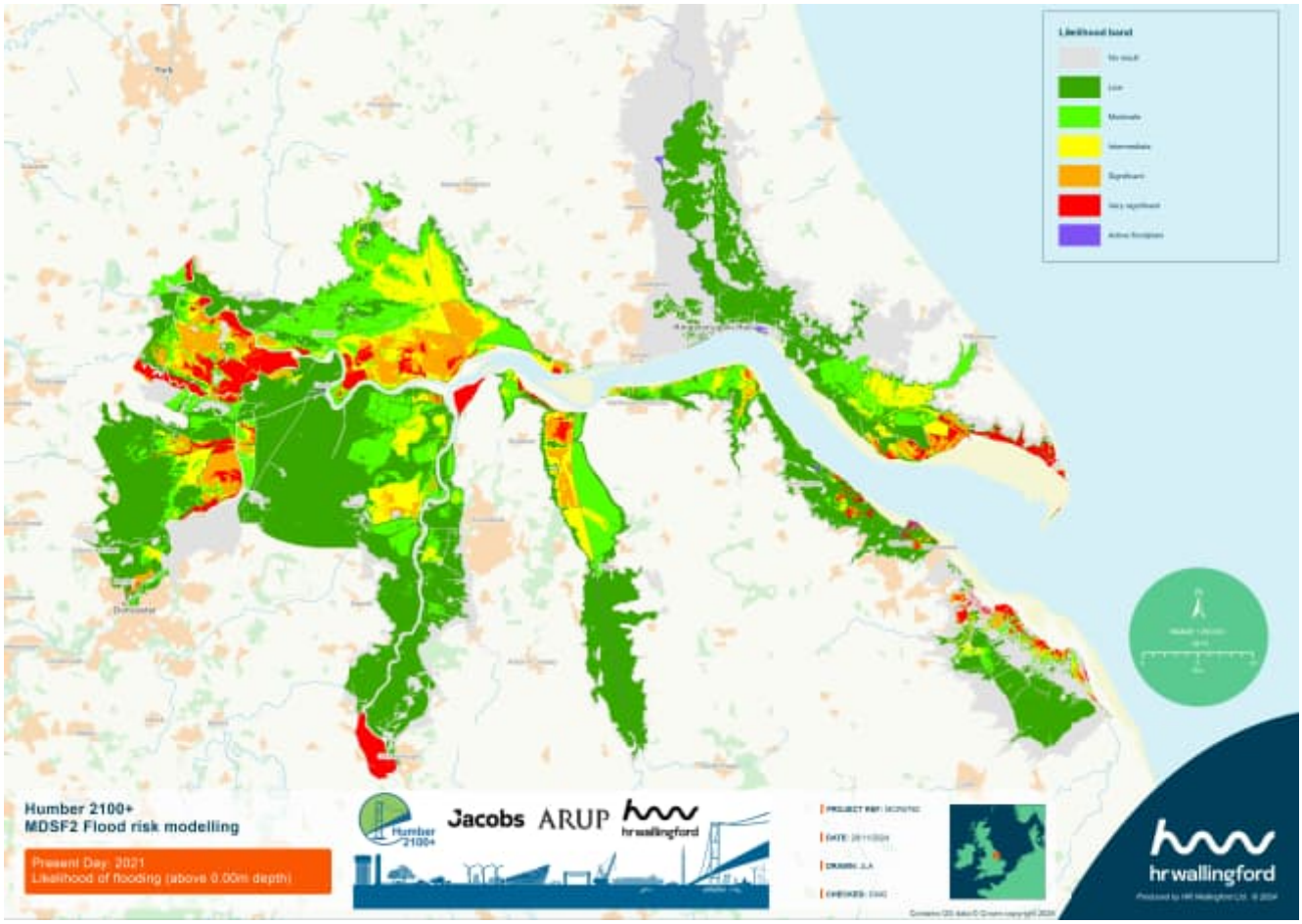

Figure 5.1. 2021 baseline flood risk likelihood map

5.3 Future baseline scenarios

5.3.1 Baselines considered

Step 1 has considered four main scenarios that describe how the future of tidal flood risk management *could* evolve over the next 100 years unless we do something different. The purpose of each scenario is briefly explained in the following sections with a description of its key characteristics. Further detail on the modelling of these scenarios is provided in Section 4.3.2. Together, these scenarios will provide an understanding of how tidal flood risk may change in the strategy area, helping to inform flood risk management decision-making under Step 2 and provide comparators for their appraisal.

5.3.2 Future baselines: predicted changes in tidal flooding likelihood

The following provides an overview of how the likelihood of tidal flooding above 0.0m depth is modelled to change with time for each future baseline scenario. Depths above zero are used to inform potential impact on environmental and other receptors in subsequent sections.

5.3.2.1 Do Nothing Scenario

Under a Do Nothing scenario, where all tidal flood risk management ceases, the entire H2100+ Strategy area, with the exception of high ground, has a very significant likelihood of tidal flooding by the end of the strategy period in 2121 (Figure 5.2). This stark change has largely occurred by 2046 except for low likelihood persisting in areas to the west of the River Hull to north of Beverley and at the fringes of the strategy area.

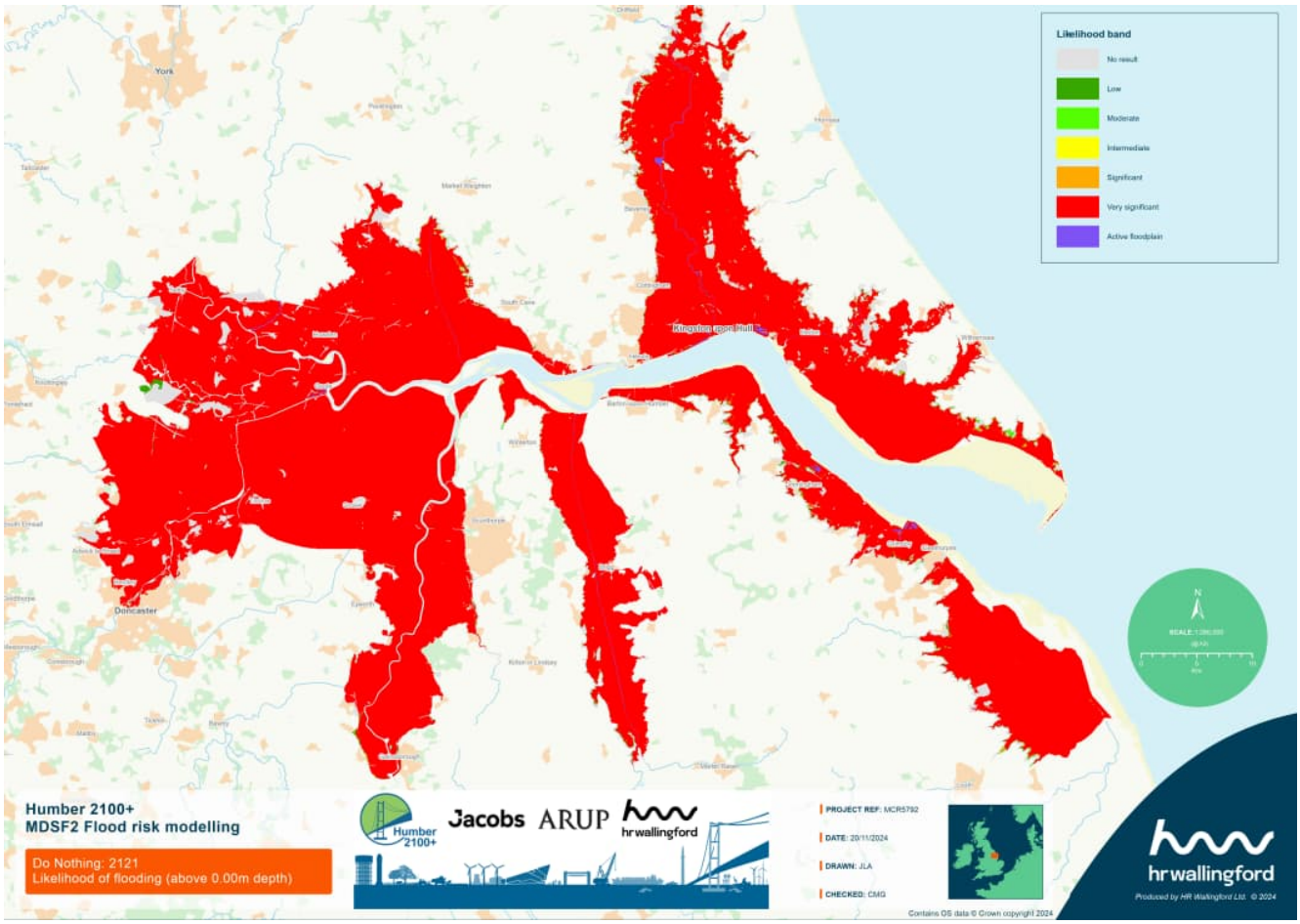

Figure 5.2. 2121 Flood likelihood map in a Do Nothing flood risk management scenario[2]

5.3.2.2 Maintain Scenario

The Maintain scenario assumes all tidal FRM activities continue only as they are today, with no future improvements in the standard of protection provided. From the same picture of likelihood in Present Day (2021; Figure 5.1), the majority of the strategy area similarly has a very significant likelihood of tidal flooding by 2121, except in a few locations, for example, at its western extent between the M62 and Doncaster where the likelihood remains low in isolated patches (Figure 5.3).

However, unlike Do Nothing, this change occurs more steadily. By 2046, there are large areas of land with a very significant likelihood of flooding developing around and to the north of Sunk Island, between the M62 and the River Ouse, between the Rivers Ouse and Aire and south around the River Don between the M18 and Fishlake. More isolated areas are beginning to have a very significant likelihood to the north-west of the Rivers Trent and Ancholme. By this stage, low likelihood is constrained to land to the north-east of the River Hull, between the River Aire and Dutch River to the west of Goole, to the west between the M62 and Doncaster, to the west of the River Trent and to the north-west of Saltfleet.

By 2071, the likelihood has increased to very significant almost entirely to the east of Hedon on the northern estuary, to the west of North Ferriby north of the Rivers Ouse and Aire, more extensively around the River Don, to the north-west of the River Trent, almost the full extent of the River Ancholme to Bishopbridge, eastwards along

[2] It should be noted that the flood map shows the likelihood of flooding regardless of whether the flooded area is designed to flood (e.g. in managed realignment or flood storage schemes) or not. Areas designed to flood can show the likelihood of flooding instead of being designated specifically as active floodplain.

the estuary from Barton-upon-Humber to the Skitter Beck and then on the coast around Donna Nook. By this stage, land to the east of the River Hull is the only significant area remaining at low likelihood.

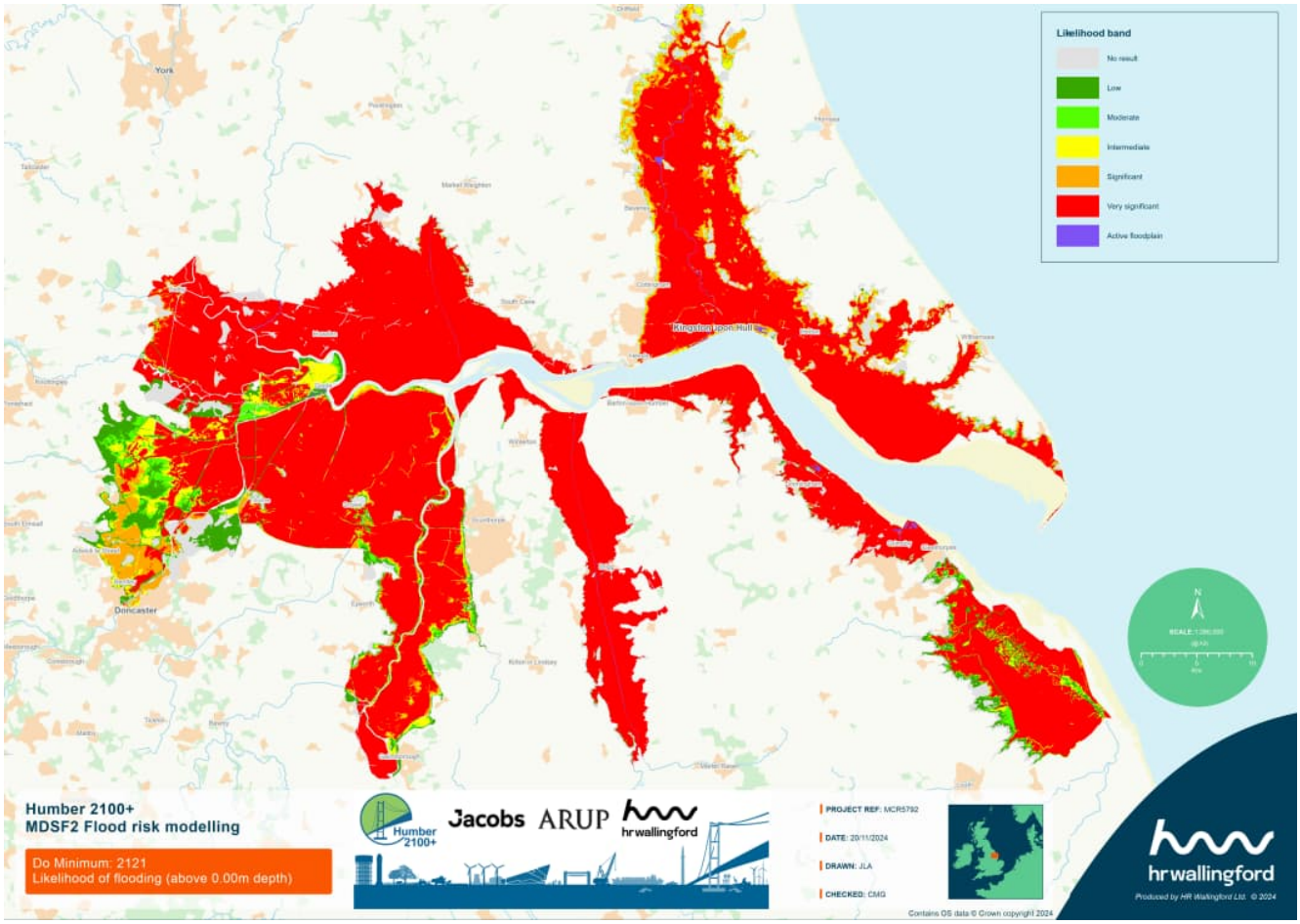

Figure 5.3. 2121 Flood likelihood map in a Maintain flood risk management scenario[3]

5.3.2.3 Status Quo Scenario

The Status Quo scenario represents the impact of the current 2008 Humber strategy and, again, shares the same picture of Present Day (2021) likelihood as in Figure 5.1. The outcome of this 2008 strategy by 2121 (Figure 5.4) is largely similar to the Maintain approach in Figure 5.3. The majority of the strategy area has a very significant likelihood of tidal flooding, with the exception of land to the north-west of the River Hull, at the western extent between the M62 and Doncaster and adjacent to the River Trent north-east of Crowle and north of Gainsborough. The only low likelihood areas are around the fringes of the strategy area.

Under Status Quo, very significant likelihood develops firstly by 2046 in the west, between the Rivers Ouse and Aire, and south around the River Don between the M18 and Fishlake. Larger areas of land at low likelihood remain evident to the east of the River Hull, between the River Aire and Dutch River to the west of Goole, to the west between the M62 and Doncaster, around the River Trent and to the north-west of Saltfleet.

By 2071, large areas of land to the east of Hedon on the northern estuary, to the west of North Ferriby north of the Rivers Ouse and Aire, around the River Don and on the coast around Donna Nook have a very significant

[3] It should be noted that the flood map shows the likelihood of flooding regardless of whether the flooded area is designed to flood (e.g. in managed realignment or flood storage schemes) or not. Areas designed to flood can show the likelihood of flooding instead of being designated specifically as active floodplain.

likelihood of tidal flooding. Only some land to the east of the River Hull and east of the River Trent remains at low likelihood.

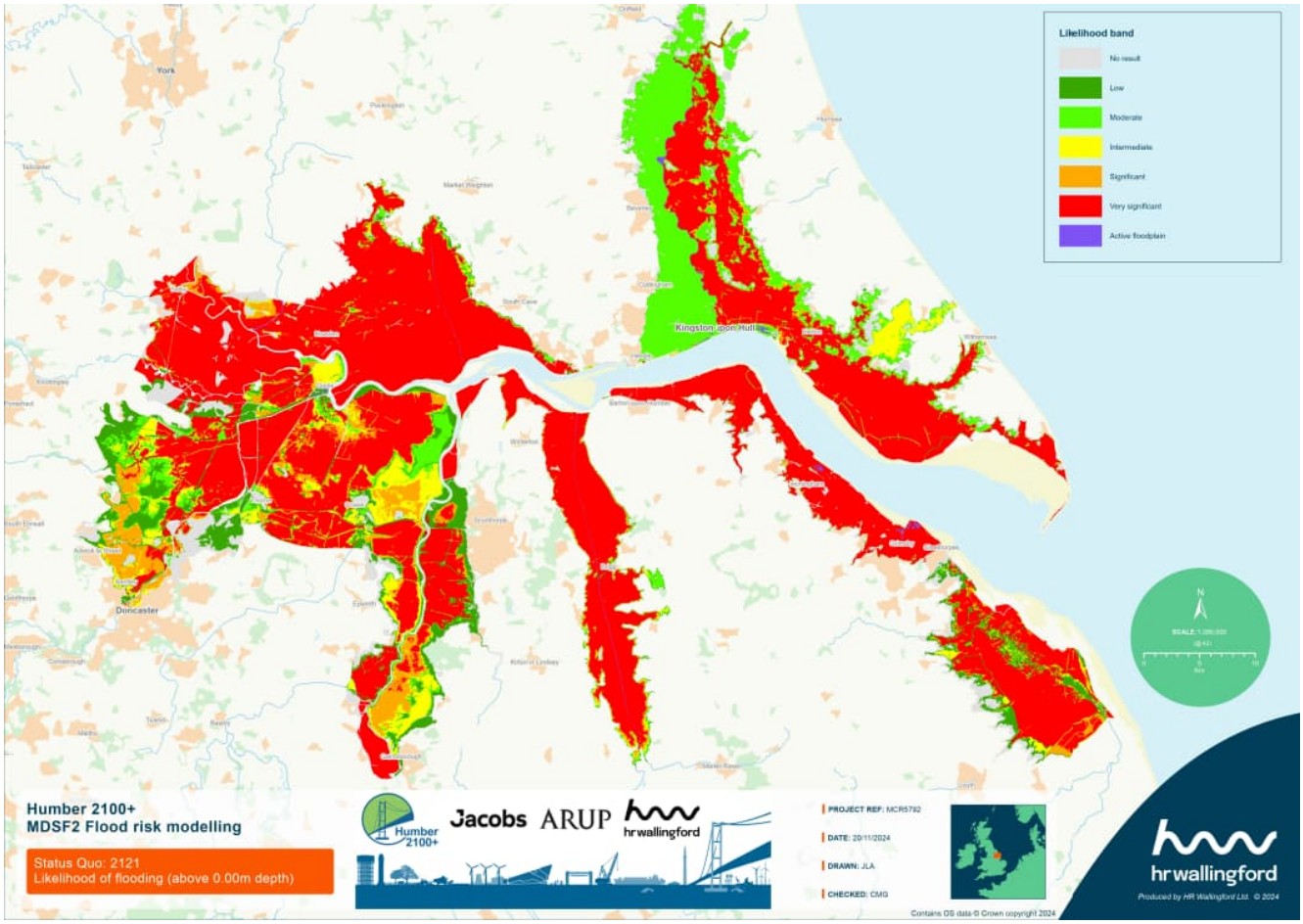

Figure 5.4. 2121 Flood likelihood map in a Status Quo flood risk management scenario[4]

5.3.2.4 Legal Requirement Scenario

The Legal Requirement scenario demonstrates the impact of only maintaining three major structures, namely the Barmby Barrage at the confluence of the River Derwent with the Ouse, Hull Barrier at the mouth of the River Hull and South Ferriby Sluice Gates at the mouth of the River Ancholme. From the same picture of Present Day (2021) likelihood as in Figure 5.1, the likelihood in 2046 is anticipated to be the same as Maintain and the 2121 outcome the same as Do Nothing (Figure 5.2). Between these points in 2071, very significant tidal flood likelihood dominates all areas with the exception of land to the west of the River Hull.

[4] It should be noted that the flood map shows the likelihood of flooding regardless of whether the flooded area is designed to flood (e.g. in managed realignment or flood storage schemes) or not. Areas designed to flood can show the likelihood of flooding instead of being designated specifically as active floodplain.

5.4 Predicted changes and key strategic issues/opportunities (present and future)

5.4.1 Population and human health

5.4.1.1 Present day baseline

Population and demography

Risk of tidal flooding to people and population centres

Over 500,000 people[5] live in the strategy area and are therefore at risk of tidal flooding either now or in the future. The greatest population density in the strategy area is concentrated in Hull, which is currently at a low likelihood of tidal flooding due to the presence of existing tidal defence structures. However, there are other sources of flooding, including from the River Hull and surface water that might impact the city. There is always the risk that defences can breach especially when tested by persistent high tides and storms. The Living with Water Partnership has brought together Hull City Council, East Riding of Yorkshire Council, the Environment Agency and Yorkshire Water to ensure a strategic, joined-up approach to effective flood management (Living with Water Partnership 2024). Investment in flood infrastructure measures by the partnership led to Hull being awarded the status of a Global Water Resilient City in 2018.

As well as Hull, other key urban centres at risk of tidal flooding, but benefitting from existing defences, include Goole, Immingham, Barton-Upon-Humber and Cleethorpes. These locations are also major employment and growth centres, and are important for housing, industrial and port operations. Bassetlaw and East Riding of Yorkshire are predominantly rural in nature and have a predominantly low likelihood of flooding (except in a few areas such as South Holderness/east Sunk Island, which has a very significant likelihood of tidal flooding). These areas along with North Lincolnshire and North East Lincolnshire contribute significantly to the agricultural economy, both regionally and nationally.

Population change and age distribution

Population growth in the strategy area over the period 2011 to 2021 is likely to have been less than 4% which is considerably lower than the 6.3% average for England and Wales (based on figures for 'Yorkshire and the Humber' and 'East Midlands' sub-regions - Office for National Statistics 2022). A similar rate of growth is predicted to continue to 2028. There are areas of higher-than-average population growth in some of the urban areas like Selby and there are also some rural areas in the outer estuary where growth is very low or the population is declining.

The 2021 Census indicates that age distribution is similar across the local authorities within the strategy area with persons under 16 years ranging from approximately 15% to 20% (2021 Census, Office for National Statistics 2022) and persons over 65 ranging from 15-30%. The highest proportions of ageing population tend to be in the more rural areas of East Lindsey (which has a low to intermediate likelihood of tidal flooding inland and up to very significant likelihood of flooding along the coast), followed by East Riding of Yorkshire and West Lindsey.

The populations of all regions within England are projected to grow by mid-2028, and all regions are projected to have a greater proportion of people aged 65 years and over by mid-2028. There will be a need to make housing space for the growing population, both in the rural and urban areas of the strategy area and to consider the needs of the ageing population.

[5] This number is derived from the flood map for planning and the national receptor dataset.

Flood risk and human health

Currently, over 200,000 properties[6] are at risk of tidal flooding in the strategy area and are protected to varying standards by existing flood defences. Most of these people are concentrated in urban areas, with relatively fewer people living in the larger, rural expanse of the study area.

Flooding, and the fear of flooding, can affect both the long and short-term physical (risk to life and injury) and mental health/wellbeing of people (Public Health England 2017, Mulchandani *et al.* 2020). Mental health issues may include depression, anxiety and post-traumatic stress disorder amongst those who had floodwater in their homes, but also in those whose homes were not flooded but whose lives were otherwise disrupted.

Social deprivation

The Humber is home to some of the most deprived wards in the country and there are wide disparities in income, employment, education and training and levels of crime (The Humber Coast and Vale Health and Care Partnership 2022). In addition, the life chances of people can vary significantly across the Humber with many individuals and communities disproportionately affected by ill-health and premature death. The average age that people will expect to live a healthy life is lower in comparison to both the regional and national position. For males it currently stands at 12.7 years less in Hull and 9.7 years less in North Lincolnshire and for females it is 10.2 years less in Hull and 9.1 years less in North Lincolnshire. In addition, people in the area are spending an increasing proportion of their lives with more serious health conditions.

The Indices of Deprivation (IMD) (Ministry of Housing, Communities & Local Government 2019) is the official measure of deprivation and social vulnerability in England. Supporting the information above, the IMD show that North-East Lincolnshire and Hull are among the 10% of local authority districts in England that contain the largest proportion of highly deprived neighbourhoods. Additionally, Hull City Council is one of five local authorities with the highest proportion of neighbourhoods among the most deprived in England (Ministry of Housing, Communities and Local Government 2019).

Increasing social deprivation generally correlates with poorer health, poorer mental wellbeing and reduced capacity to be resilient to the effects of flooding.

5.4.1.2 Future baselines

Using the modelled tidal flood extents under the future baseline scenarios, an overview of the future tidal flood risk to the strategy area's population and human health includes these key findings:

- Under all the future baseline scenarios, the likelihood of tidal flooding to people and settlements in the strategy area (including areas important for housing and employment) increases over time. By 2121, all scenarios result in most of the strategy area as having very significant likelihood of tidal flooding. The greatest increase over time is expected under the Do Nothing scenario, where the likelihood of tidal flooding increases quickly. Generally, the Maintain and Status Quo scenarios provide the lowest likelihood of tidal flooding over time, and tidal flooding increases more gradually than under the Do Nothing scenario, thus reducing effects on people, homes, communities and employment areas for a longer time, and the associated disruption, and risks to safety, health and wellbeing.
- Under a Do Nothing scenario, the majority of settlements have a very significant likelihood of tidal flooding by 2046 apart from those to the north of Beverley or at the fringes of the strategy area such as Thorne and Hatfield which have low to intermediate likelihood. For example, this includes Hull, with some of the most densely populated areas in the strategy area and also some of the most highly deprived neighbourhoods in England. However, by 2121, the likelihood of tidal flooding increases in all the remaining areas to very significant.
- Under a Maintain scenario, tidal flood likelihood increases more steadily than under Do Nothing. By 2046, although there are some areas of very significant likelihood of tidal flooding such as in rural communities at South Holderness/east Sunk Island and the inner estuary, such as at Broomfleet and

[6] This number is derived from the flood map for planning and the national receptor dataset.

Cambleforth, there are large areas with low to intermediate likelihood. By 2071, the likelihood increases to intermediate east of the River Hull, and to significant or very significant at Immingham, Grimsby and Grainthorpe in the outer estuary (North East Lincolnshire contains some of the most highly deprived neighbourhoods in England), Brigg in the Ancholme valley, and larger areas in the inner estuary. By 2121, the likelihood of tidal flooding in the strategy area is very significant, including Hull and land by the River Hull, except for isolated areas at its western extent of the study area, such as Hatfield, where the likelihood remains low.

- Of all the baseline scenarios, the Status Quo scenario generally provides the greatest reduction of risk to people and properties from tidal flooding. Similar to the Maintain scenario, tidal flood likelihood increases more slowly than under Do Nothing, and by 2046 there are large areas of low likelihood still, with a few areas of very significant likelihood evident such as in the west, between the Rivers Ouse and Aire, and south around the River Don between the M18 and Fishlake, and southern Holderness. By 2071, there are areas increasing in likelihood of tidal flooding to significant or very significant similar to Maintain, except for example, more areas of low to moderate (such as east Hull, north east of Hull and beside the River Trent) and intermediate likelihood (such as by Immingham and Grimsby). By 2121, it has a largely similar outcome as Maintain scenario with the majority of the strategy area having a very significant likelihood of tidal flooding, with the exception of west Hull, Hessle and land to the north-west of the River Hull having moderate likelihood, Gainsborough having intermediate likelihood, north Doncaster having significant likelihood, and with Hatfield, Thorne and the fringes of the strategy area remaining low likelihood.
- Under a Legal Requirement scenario, the settlements affected by tidal flooding in the strategy area is anticipated to be the same as Maintain by 2046, with the 2121 outcome the same as Do Nothing. By 2071, very significant tidal flood likelihood dominates all areas apart from land to the west of the River Hull, such as at east Hull, Hessle, Beverley which have a low likelihood at that intermediate point in time.

Future trends:

- Population growth in the strategy area is expected to be less in the strategy area than the average growth across England and Wales. It is uncertain how population growth may be affected in areas of increasing flood likelihood in the strategy area.
- The physical and mental health impacts of flooding is projected to increase with population growth and as climate change and sea level rise cause increased tidal flooding. This is likely to lead to secondary effects, such as greater pressure on health services and reduced productivity.
- Income and employment (amongst other social measures) could be affected positively by the proposed economic growth plans in the region, depending on workforce skills. If this comes with increased investment in FCRM and helps reduce the risk of flooding, this could unlock opportunities directly linked to social deprivation indices, for example Barriers to Housing and Services or Living Environment.

Strategic issues:

- Communities are at flood risk throughout the strategy area, with differing standards of protection from existing defences, with the greater number and higher densities of people at risk in the urban centres, and relatively fewer people at risk in the larger expanses of rural areas.
- Currently, government funding for flood risk management is traditionally focussed in areas of deprivation and where most people can benefit. It is possible that funding mechanisms change in future.
- Local authorities with a higher proportion of rural populations have a higher proportion of people over 65 years of age.
- North-East Lincolnshire and Hull are in the 10% of local authority districts in England that contain the largest proportion of highly deprived neighbourhoods. Those living in areas likely to experience some of the greatest annual flood damages to properties under the various future baseline scenarios (e.g. Hull and East Grimsby) are also located in some of the highest deprived areas in England.

5.4.2 Access and recreation

5.4.2.1 Present day baseline

As described in the SA Scoping Report (Jacobs 2020a), there are many formal and informal assets and destinations within the strategy area that are important for residents and visitors for access, leisure, recreation and tourism. The promotion of green and blue infrastructure to support sustainable development (given the close links between community infrastructure, cultural, recreational and natural spaces and landscapes to local economic growth, community cohesion, leisure, recreation and nature-based tourism) remains a key overarching goal in the Humber region. This ambition is reflected in the 2016 Humber Integrated Landscape and Investment Study (Sheils Flynn 2016), unpublished) stakeholder-centred studies that mapped visitor destination locations and identified numerous aspirational opportunities for partnership investment in flood risk management and green infrastructure projects in the strategy area.

Visitor attractions are constantly changing within the strategy area with new assets being proposed or constructed. Examples include the enhanced waterfront attractions at Hull Waterside and Marina. East Riding of Yorkshire Council completed a study including a visitor survey in 2022 (Saunders et al 2022) to better understand the impacts of visitors and recreation arising from new housing and tourism growth on the Humber estuary European Habitats sites, to inform future mitigation. Spurn Point, Hornsea, and Humber Bridge were the most commonly identified visitor locations across the eight survey locations along the northern edge of the Humber estuary. The busiest location for visitors on the southern bank of the Humber estuary is at Waters' Edge according to a 2023 visitor survey (Caals et al 2023). Currently, some of the key access and recreation features within the strategy area are at risk of tidal flooding under Present Day (2021) conditions (described in Section 5.2). These include:

- The networks of paths, bridleways and cycleways traversing the area (many of which are historic routes, or were so, connecting historic places together) that provide permitted access to the countryside and coast have a low likelihood of tidal flood risk[7]. However, the majority of the National Cycle Network (NCN) routes have a moderate to low likelihood of tidal flooding.
- Many of the areas of open space that provide residents and visitors informal access for leisure and recreational activities within the area, including the coast, estuary foreshore and open green spaces interspersed throughout the area, currently have a low likelihood of tidal flood risk. However, a few features have a very significant likelihood of tidal flooding, for example the golf course near Humberston in the outer estuary, and the golf course and playing fields near Drax in the inner estuary.

5.4.2.2 Future baselines

Using the modelled tidal flood extents under the future baseline scenarios, an overview of the future tidal flood risk to key designated access and recreational assets is given below. This focuses on features for which spatial data and mapping is available, such as NCNs and national/regional trails[8]. For other features, general inferences have been made from the changes in the likelihood of tidal flooding to the strategy area as a whole, described in Section 5.3.2. It has not been possible at this strategic level to consider the changes in flood likelihood to individual visitor attractions or informal recreation assets, such as features used for walking, cycling, bird-watching, horse-riding, fishing, angling and water sports.

The potential changes in tidal flooding to access and recreational assets under the future baseline scenarios may include:

- Under all the future baseline scenarios, the likelihood of tidal flooding to access and recreational assets increases over time. The greatest increase in frequency is expected under the Do Nothing scenario, where the chance of tidal flooding of public access and recreation assets increases quickly. Generally, the

[7] Since the probability of flooding can never be described as zero, the term 'low' likelihood of tidal flooding is used to describe any area shaded dark green on the maps (see Section 3.6), as well as any area shaded grey or where the base mapping is visible.

[8] An interactive viewer is available so that users can zoom into certain environmental features and understand potential changes in tidal flood likelihood. To access this mapping, please email hstrategy@environment-agency.gov.uk and refer to ArcGIS online (AGOL).

Maintain and Status Quo scenarios provide the lowest likelihood of tidal flooding to access and recreational assets over time, and tidal flooding increases more gradually than under the Do Nothing scenario, thus retaining connectivity and reducing community severance issues for a longer time.

- Under the Do Nothing scenario, the Viking Way, most stretches of NCN, and many open green spaces will have an increased likelihood of tidal flooding to a very significant likelihood by 2046. By 2071, most of the strategy area is expected to experience a very significant likelihood of flooding, and therefore all national trails and green spaces are expected to have a very significant likelihood (other than green spaces on high ground at Snaith, which will only have a low likelihood by 2071, but expected to increase to a very significant likelihood of flooding by 2121).
- Under the Maintain scenario, access routes, recreational trails and open green spaces are thought to generally remain at low likelihood of tidal flooding until 2046 except features in the inner estuary that will increase to very significant likelihood, such as around Selby and on the bank of the River Ouse. By 2071, the risk increases for the majority of NCN routes and open green spaces, which will have a significant to very significant likelihood of tidal flooding (except for example, those located on the left bank of the Humber between Hessle and Hull, and NCN routes beside the River Hull). Also the likelihood of tidal flooding to national trails will have increased by 2071 from low to significant. However, by 2121, the increase in predicted tidal flood likelihood means that most of the open green spaces, rights of way, NCN routes and national trails could experience a very significant likelihood of tidal flooding except for those in a few very isolated pockets, for example, open green spaces around Goole and Hatfield.
- Under the Status Quo scenario, similar to the Maintain scenario, access routes, recreational trails and open green spaces are thought to generally remain at a low likelihood of tidal flooding by 2046 except in a few areas in the inner estuary. However, by 2071, some of the NCN routes and open green spaces (such as the left bank of the River Ouse south of Eastrington) are expected to experience a very significant likelihood of tidal flooding, with those located by Immingham and Grimsby expected to have an intermediate likelihood of tidal flooding and those located on the north bank of the Humber between Hessle and Hull, and NCN routes beside of the River Hull expected to continue to be at low likelihood). Some sections of national trail will be affected by a significant likelihood of flooding between 2071 and 2121, for example the Trans-Pennine Trail to the north-east of Hull, and the Viking Way. By 2121, more NCN routes and open green spaces will be subject to a very significant likelihood of tidal flooding but a few areas, for example, land between Hull and North Ferriby, and between Hatfield and Thorne, would continue to have a low to moderate likelihood of tidal flooding.
- Under the Legal Requirement scenario, by 2071 the majority of NCN routes, rights of way and open green spaces are expected to have an increased tidal flooding likelihood of very significant. This includes the full length of the Viking Way within the strategy area and short sections of the Yorkshire Wolds Way and Trans-Pennine Trail. However, there are likely to be some exceptions, such as stretches of NCN and open green spaces on the west bank of the River Hull, and open green spaces around Hatfield and north of Humberston, where the likelihood of tidal flooding would remain low.

Unlike the other future baseline scenarios, the Status Quo scenario provides opportunities to create new washlands or new managed realignment schemes through the setting back of tidal defences. These new areas of habitat could also incorporate improvements to the network of footpaths, bridlepaths, cycleways and trails, or visitor facilities, potentially enhancing opportunities for residents and visitors to access the countryside, recreation activities, outdoor education and nature-based tourism.

Future trends:

- There will be increasing requirements to maintain, improve and transform access as urbanisation and the likelihood of tidal flooding increases, with a focus on community well-being and inclusivity. For example, the new King Charles III England Coast Path is planned to be able to adapt to climate change effects by being moved back over time away from the coast.
- There is likely to be an increase in nature-based tourism and outdoor recreation, particularly with the growing interest in the region and the continued development of the King Charles III England Coast Path.

Strategic issues:

- The Humber has numerous facilities and destinations for access and recreation, both inland and along the coast, and through formal and informal access. Current networks of footpaths, cycle paths, bridleways and trails connect many of these destinations. Many of these are within sensitive environmental areas, such as being within nature conservation sites and historic sites and landscapes. When considering future options and pathways, the strategy will need to consider sensitive features relating to access and recreation alongside any strategic opportunities for environmental improvements.
- Flood risk management measures may impact on formal or informal access to the estuary and recreational pursuits, which should be considered during strategy development. Many parts of the strategy area offer excellent spots for angling and other water sports, requiring the maintenance of safe access to designated fishing areas. Angling can also be dependent on water levels.
- Local communities may access intertidal or coastal areas to undertake traditional activities such as foraging - these may not always be formal access routes and are often facilitated by the presence of existing flood defences.
- The Humber estuary is a regionally significant green infrastructure corridor and the strategy area supports other key green (and blue) infrastructure elements, such as country parks, nature reserves, wetlands used for flood risk management and woodlands, as well as an important network of paths, bridleways and cycle paths enabling public access to such areas. Most of these elements are at increasing tidal flood risk under Present Day and all future baseline scenarios. Interventions to manage tidal flood risk in the strategy area have the potential to affect public access.
- However, there are opportunities for the Humber 2100+ Strategy to create more green (and blue) infrastructure (for example managed realignment schemes) in combination with other projects, plans and programmes including (but not limited to) public realm improvements, eco-tourism and the provision of new and improved multi-user public access, with associated opportunities for social interaction and creation of learning opportunities.

5.4.3 Economic activity, growth and inward investment

5.4.3.1 Present day baseline

Key economic sectors

The key economic sectors in the Humber in 2021 were classified as manufacturing, electricity, gas, steam and air, water supply and sewerage, insurance, agriculture, forestry and fishing. The Humber and Yorkshire region, within which the majority of the strategy area is located, is in a transition from traditional heavy industry industries to more diversified business areas. However, manufacturing remains an important contributor to the economy, accounting for 10% of the employment, by comparison to the English average of 7% (Office for National Statistics n/d).

Ports, ports-related development and transportation sectors are also of significant importance (described further below), and there has been growth in the region in the digital and technology sectors.

As described in the SA Scoping Report (Jacobs 2020a), the chemicals and petrochemicals industry continues to contribute to the economy of the strategy area, given its proximity to the Southern North Sea gas fields. Also, the

Humber estuary continues to be an important trade gateway containing the UK's largest ports complex, with its ports and wharves now handling 17% of the nation's trade (Humber Freeport 2024). The Humber's growth zones and corridors continue to be centred on the major ports of Grimsby, Goole, Hull, Immingham and Killingholme, and the Humber Freeport.

Port and port-related developments continue to present significant economic development opportunities in the Humber, particularly in relation to the development of manufacturing and servicing facilities for the development of recent North Sea offshore wind industry, which is helping to drive economic growth in the strategy area. For example, in recent years, the Humber estuary has gained prominence in the renewables sector and is often referred to as the 'Energy Estuary'. It has secured major investments in wind energy from international companies. The Humber ports are ideally situated to attract further manufacturing activity throughout the supply chain, having recently secured investment to upgrade and expand a wind turbine blade factory (Siemens Gamesa). The Green Port Hull collaboration programme (Hull City Council et al 2024) promotes investment (and thus creates jobs) in renewable energy. Through the growth programme, over 800 local businesses have been assisted to enter the renewables supply chain, and contracts over £249m were awarded to businesses in the area (Heylep[9] 2021). There are also investments in the education sector to promote offshore wind energy related education, and there is an increasing prevalence of onshore solar development within the strategy area.

The focus in plans for industrial transition and priorities for economic growth plans by the economic partnerships that operate in the area include industrial decarbonisation and a wider adoption of renewables and clean energy developments (see Sections 5.4.5 'Material Assets' and 5.4.11 'Climate Change').

Key industrial areas in the strategy area are centred on the following sites, all of which are sited in areas currently with low to significant likelihood of tidal flooding under Present Day (2021) conditions (inside or outside of the port areas) (also see Section 5.4.5 'Material Assets'): Drax Power Station; Flixborough Industrial Estate; Goole Chemicals and Glass; Keadby Power Station; Killingholme Oil Refineries; Saltend Complex; and South Humber Complex.

Economic indicators

The working age population in employment in the wider Yorkshire and the Humber region has increased slightly from those reported in the SA Scoping Report (Jacobs 2020a) i.e. from 73.5% (2017) to 74.2% (2023) but remains below the national average of 76%. The unemployment rate for the region was at 3.4% for the same 2023 period, slightly lower than the national average, and has fallen by 1.6% in comparison with the previously reported year 2017 (ONS, n.d.).

As reported in the SA Scoping Report (Jacobs 2020a), significant numbers of the local population continue to be employed in manufacturing, wholesale, retail, education, health and social work activities in comparison to the UK average (ONS, n/d). Employment in the construction sector is similar to the national average. An analysis of workforce employment across the sectors since those reported between 2015 and 2017 in the SA Scoping Report (Jacobs 2020a) suggest the following shifts across the sectors between 2017 and 2024:

- A slight reduction in employment in 'administrative and support services' and 'agriculture' sectors, which is now slightly lower than the UK average; and
- An increase in numbers employed in the 'education' and 'human health and social work activities' sectors, which are above the UK average.

The Gross Value Added (GVA) measure provides a useful indication of the trajectory of the local economy and although there are technical issues with estimating GVA at the local and regional level, it is widely accepted as a key measure of overall economic activity that could provide an indication of how productively the economy is utilising its resources (including labour). Updated information indicates that manufacturing accounts for a quarter of the wider Humber region's £20.23bn GVA (Heylep 2021), which is higher than the national average.

[9] Hull and East Yorkshire Local Enterprise Partnership (Heylep)

Spatial planning and development

Since the SA Scoping Report (Jacobs 2020a), there have been changes to some of the policies and plans proposed by local authorities within the strategy area (e.g. new or emerging local plans), which contribute to the achievement of sustainable development. These local plans support the economic plans and ambitions for the area, and many of these proposals and allocated sites are currently at tidal flood risk under Present Day (2021) conditions, which will increase over the lifetime of the strategy. Various sites have been allocated for future housing throughout the strategy area, with some of the largest areas being concentrated around Hull, Scunthorpe, Brigg, Anlaby and Hessle and Hatfield to Stainforth (the Unity Project). There are also smaller allocations such as those within the villages of Grainthorpe and Tetney. Most of the allocated land for housing is currently at low likelihood of tidal flooding under Present Day (2021) conditions.

Also, a range of sites have also been allocated as development/employment zones for future land uses, for example in Hull, on the western edge of Scunthorpe, South Humber Bank near Immingham and Grimsby, around Hedon, Brigg, Selby and Goole. The majority of these allocated development areas are currently at low likelihood of tidal flooding under Present Day (2021) conditions. Future changes in flood risk could influence the economic viability of these areas.

Strategic economic partnerships

The strategy area has several areas for planned economic growth, indicated by strategic economic partnerships and development planned by the 11 local authorities. Local authorities, through their local plans, propose land-use policies and spatial plans to enable economic growth and associated development such as housing, shopping and leisure.

There are multiple economy-focussed partnerships that operate across the Humber 2100+ Strategy area. As described in the SA Scoping Report (Jacobs 2020a), the strategy area historically incorporated several Local Economic Partnerships (LEPs), including Humber LEP, Sheffield City Region LEP, York, North Yorkshire and East Riding LEP, and Greater Lincolnshire LEP. In 2023, the government announced plans to transfer the current responsibilities of the LEPs to combined/local authorities from April 2024. Continued public-private sector collaboration through local authorities and future mayoral combined authorities is likely to be key to realising the Humber's economic potential.

Since the SA Scoping Report (Jacobs 2020a), there has been a move towards developing a Humber Economic Strategy and Investment Plan (Arup 2024), which is a collective vision to deliver sustainable and inclusive economic growth in the Humber while protecting its unique environment. This plan would be delivered as part of devolution across Greater Lincolnshire and Hull and East Yorkshire.

In 2021, the Humber was granted Freeport status as part of the UK government's freeport initiative. The Humber Freeport covers strategically and economically important areas in the Humber region, designed to boost economic growth, job creation and attract investment. While encompassing the key ports with access to global markets, the Humber Freeport provides designated areas where businesses can invest in productive capacity receiving capital allowances, tax and regulatory incentives and deferred customs duties. The Freeport area includes three tax sites, comprising:

- Able Humber Port (ABLE Marine Energy Park) located within and adjacent to the Port of Immingham (currently at low likelihood of tidal flooding under Present Day (2021) conditions except for a few isolated areas next to the Humber estuary that have a greater likelihood)
- Hull East which occupies several areas of land including ABP's Humber International Enterprise Park, the Yorkshire Energy Park, Saltend Chemicals Park and eastern portion of the Port of Hull. Most of the Hull East site currently has a low likelihood of tidal flooding under Present Day (2021) conditions.
- Goole site, which is a large undeveloped site proposed to be fully operational in 2025. There are plans for this site to be established as a hub for rail sector innovation and supply chain development. This site is predominantly at low likelihood of tidal flooding under Present Day (2021) conditions with some areas in the north-eastern end adjacent to the A614 with an intermediate likelihood.

Visitor economy

As described in the SA Scoping Report (Jacobs 2020a), there are numerous indoor and outdoor tourist attractions within the strategy area along the estuary, coast and inland (see Section 5.4.2 Access and Recreation), many of which provide educational and recreational resources for the local communities and visitors, and growing interest in nature tourism. These assets reflect the area and its diversity so would not be easily replaced elsewhere.

Since the SA Scoping Report (Jacobs 2020a), there has been a change in visitor demographics to the strategy area from the impact of the COVID-19 pandemic (which resulted in international travel restrictions and a focus on domestic tourism) together with improved connectivity from investment in the region's road infrastructure and changes to the cost of living. Since the pandemic, the number of people in the leisure and tourism sector in the region has grown, together with the visitor economy, which includes food and service management, gambling, hotels, bars, restaurants, holiday parks, private accommodation providers, tourist services and visitor attraction centres.

The continued evolution of the visitor economy in the strategy area is reflected in Yorkshire and Humber Councils' updated priorities for 2023/24, which include a visitor economy priority to '*restore and rebuild the hospitality, leisure and tourism offer in our places; furthering collaborative working and co-ordination of resource around tourism and culture, using our assets to capitalise on a thriving visitor economy and ensuring this reflects the diverse needs of the region*' (Yorkshire & Humber Councils 2024). In addition, tourism in Hull has had a boost in terms of investment in recent years as the city centre has undergone massive transformations with sites including Albion Square, Whitefriargate, Queens Gardens, and the Maritime Project having been completed.

5.4.3.2 Future baselines

In future, businesses, key infrastructure, tourism assets, proposed and developing economic growth zones, and sites allocated for housing and development that will be important for the economic growth of the region will be under pressure from climate change effects, such as extreme weather, sea level rise, increased prevalence of storms, flooding, droughts, and wildfires. Tidal flooding may result in economic damages to these assets, with associated loss of business, tourist numbers and assets, reduction in viability of land for development, and potential damage and disruption to economic activities/facilities and infrastructure.

An overview of the key findings of the modelled flood extents under the alternative future baseline scenarios (described in Section 5.3.2), includes:

- Under all the future baseline scenarios, by 2121, a large number of key features of importance to the economy and tourism industry within the strategy area are located within areas with a very significant likelihood of tidal flooding, with potential to sustain significant economic damages from flooding over the 100-year period. The rate of increase in the extent and likelihood of tidal flooding compared with Present Day (2021) conditions would be greatest under the Do Nothing scenario and would be least under the Status Quo scenario.
- Under a Do Nothing scenario, by 2046, the Humber Freeport tax sites would have an increased likelihood of tidal flooding compared with Present Day conditions to intermediate at Hull East and very significant likelihood at the Goole and Able sites. The likelihood of tidal flooding at the Hull East site would also increase to very significant by 2071. Similarly, the visitor economy will become increasingly vulnerable to tidal flood risk with many tourist assets including those in Hull at very significant likelihood by 2071. Also, most sites allocated for future housing and development/employment zones would experience a very significant likelihood of tidal flooding by 2046 with the exception of a few areas that would remain at low likelihood such as at North of Hatfield Lane (Barnby Dun) and Epworth. By 2121, only a very limited number of allocated areas would remain at a low likelihood of tidal flooding and all of the key industrial clusters in the strategy area would sustain economic damages through flooding over a 100-year period under this scenario.
- Under a Maintain scenario, the Humber Freeport tax sites would have similar likelihoods of tidal flooding to Present Day conditions until 2046. After this, the tidal flooding likelihood would increase to a very

significant likelihood by 2121 for parts of the Hull East site, the Goole site would have an intermediate to very significant likelihood by 2121, and the Able tax site would have a significant likelihood by 2071 and a very significant likelihood by 2121. Unlike the Do Nothing scenario, most tourist sites and sites allocated for future housing and development/employment zones, would experience a low to intermediate likelihood of flooding by 2046 but would experience a very significant likelihood of flooding by 2121 (with the exception of a limited number of areas).

- Under a Status Quo scenario, much of the Humber Freeport tax sites would have similar likelihoods of tidal flooding to Present Day conditions until 2046. Then, the likelihood of tidal flooding at parts of the Hull East would be between low and very significant by 2121. The likelihood of tidal flooding at the Goole tax site would steadily increase and by 2121, most of the site would have a very significant flood likelihood. For most of the Able tax site, the likelihood of tidal flooding would steadily increase to intermediate by 2071 and to very significant by 2121. Similar to the Present Day and Maintain scenarios, most tourist sites and sites allocated for future housing and development/employment zones would experience a low to intermediate likelihood of flooding by 2046, but then would experience an intermediate or very significant likelihood of flooding by 2121 (with the exception of a limited number of areas).
- Under a Legal Requirement scenario, initially much of the Humber Freeport tax sites would have similar likelihoods of tidal flooding to the Maintain scenario. However, by 2071, most of the Hull East site would be affected by an intermediate to very significant likelihood of tidal flooding (except for a parcel of land at the eastern end of the Port of Hull which would have a low likelihood of flooding) and all of the Goole tax site and most of the Able tax site would have a very significant likelihood. Most tourist sites and sites allocated for future housing and development/employment would experience an Intermediate to Very Significant likelihood of flooding by 2071, with the exception of a few areas such as at Anlaby, Hessle, Humberstone Road and Tetney (which would experience a low likelihood of flooding).

Future trends:

- The wider Humber and Yorkshire region is in a transition from traditional heavy industries to more diversified business areas, for example continuing to support the increase in renewables and clean energy developments and industrial decarbonisation.
- Ambitious economic growth activities are planned for the Humber with the aim of making the region a leader in low carbon economy, developing its port-based economy and its chemicals-processing and digital and technology sectors.
- Important industries, businesses, infrastructure and future growth zones will potentially be affected by climate change, with implications for their future viability and economic growth in the absence of flood risk management. Consideration will need to be given as to how these assets can become more resilient to climate change as well as seeking opportunities for decarbonisation.
- Recreational activities, including increased formal access to the estuary and coast, is expected to increase local growth and tourism in the future. Increased visitor numbers could damage the designated features in the study area, so care will be needed.
- Should the vision for shared economic growth be realised through the strong collaboration of the public and private sectors (i.e. local authorities, mayoral combined authorities), the Humber may become a leader in the low carbon economy, develop its port-based economy, as well as its chemicals-processing and digital and technology sectors.

Strategic issues:

- The Humber has ambitious plans for economic growth through strategic economic partnerships and local authorities' spatial planning. Being a major UK import and export hub (and previously more reliant on EU markets for trade in comparison to other UK regions), economies in the region have changed following the departure from the EU. Changes in global freight transportation, increasing shipping services, and the opening up of alternative northern shipping routes, as well as proposals to facilitate the greater use of inland waterways could bring opportunities for economic growth.

- Planning for new residential and associated developments will be critical in supporting the economic development plans for the region.
- The viability of proposed and developing economic growth zones including the Humber Freeport will be dependent on solutions that manage the increasing tidal flood risk to these assets as well as investment (i.e. to manage decarbonisation and safeguard the long-term competitiveness of existing strategically important industries).
- Access to the Humber's countryside, estuary and coast, as well as other key visitor attractions, is a major draw for tourists and for the local population, contributing to growth in the leisure and tourism sector.

5.4.4 Rural land use and economy

5.4.4.1 Present day baseline

Land use classification

As described in the SA Scoping Report (Jacobs 2020a), extensive parts of the strategy area are in agricultural use, and significant parts of the strategy area fall within local authority areas listed as 'predominantly rural' in the 2011 Census Rural-Urban Classification (RUC). The new RUC based on the 2021 Census was due to be released in November 2023 but remains under review and therefore there are no changes to report on the land use classification since the SA Scoping Report.

Farming

Wider data on the total farmed area in the Yorkshire and Humber region in 2023 (Defra 2024a) and the agricultural land classification for the strategy area have not changed significantly from those presented in the SA Scoping Report (Jacobs 2020a).

Areas of agricultural land within the strategy area that are currently at risk of tidal flooding were derived from the tidal flood modelling outputs (see Section 4.3.2). The greatest area of land at risk of tidal flooding under Present Day (2021) conditions is classified as Grade 3 land, and the greatest area of land at significant or very significant likelihood of tidal flooding is classified as Grade 2.

Recognising the need to manage water pollution linked to agriculture and farming, deliver more sustainable farming, and manage the landscape character, the Catchment Sensitive Farming scheme and Environmental Stewardship schemes are being progressed in the strategy area. The Agricultural Transition Plan (updated in January 2024) (Defra 2024b) also sets out the changes that the former government were going to make to agricultural policy in England from January 2021. This includes the design and delivery of environmental land management (ELM) schemes to farm productively and in a way that benefits the environment.

Three ELM schemes are being piloted; sustainable farming incentives, countryside stewardship and landscape recovery. In 2022, Lincolnshire Wildlife Trust (as part of the Humberhead Levels Partnership) led an ELM scheme Test and Trial in the Humberhead Levels (Defra 2022). These findings may be considered during strategy development.

Local communities and local businesses have also come together to improve the environment in the strategy area. An example is where the Humberhead Levels Partnership successfully created a unique network of wetlands (including one of the first pilot Nature Improvement Areas in England) whilst supporting communities and wildlife through adopting sustainable land management practices (Yorkshire Wildlife Trust 2024). This work continued until April 2018 as part of the Reconnecting the Humberhead Levels project.

The Humber Landscape and Green Infrastructure Study (Sheils Flynn 2016) included a study titled 'Humber estuary Farmland - options for dynamic flood risk management' that explored the options available for farmers and landowners around natural flood management to consider at different scales appropriate for the local agricultural landscape alongside physical measures such as improvements to flood defences.

Additionally, the Yorkshire and Humber Climate Change Action Plan (Yorkshire and Humber Climate Commission 2024) provides a strategic framework to help deliver the actions required to address the effects of climate change in Yorkshire and the Humber including rural land use changes within the strategy area.

Fisheries

As reported in the SA Scoping Report (Jacobs 2020a), the Humber estuary is recognised for supporting many commercially important fish species, such as whiting, sprat, common (or Dover) sole, flounder, cod, saithe, pollack, dab, plaice and eel. The estuary also provides spawning and nursery grounds for commercially important North Sea fisheries, such as common sole, lemon sole, herring, flounder, plaice and sprat. The estuary's shellfish species with commercial interest include brown shrimp, lobster, brown crab, cockles, mussels and whelk.

Provisional annual volumes of fish and shellfish landings (weight in tonnes) for 2024 in the strategy area are available for Grimsby and Hull (UK Government 2024). Landings at Grimsby totalled approximately 2,200 tonnes, comprising 24 species, with the greatest landed weight being for crabs. Landings at Hull totalled approximately 1,400 tonnes, comprising six species, with the greatest landed weight being for cod.

The North Eastern Inshore Fisheries and Conservation Authority (IFCA), together with the Eastern IFCA, are responsible for managing the exploitation of sea fisheries resources within the strategy area. The number of aqua/mariculture projects located within the North Eastern IFCA district has increased significantly since 2020, and this, for example, includes the culture of native oysters at Spurn Point on the Humber estuary by Yorkshire Wildlife Trust as a trial (rather than as a commercial fishery). In recent years, new byelaws have also been created to protect sensitive habitats including eelgrass in the estuary.

The Humber supports an important fish processing industry, predominantly located at Grimsby and based on sea-caught fish and shellfish. This industry is located in areas currently at risk from tidal flooding (with a low to very significant likelihood).

Rural economy

As described in the SA Scoping Report (Jacobs 2020a), the wider Yorkshire and Humber region remains of importance to the UK's agricultural output (and associated UK's food economy), bioeconomy (for example, production of biofuel at Saltend) and employment in the food and agriculture sector. In the strategy area, in 2023, predominant farm types were cereal crops (wheat being the largest crop output) and grazing livestock (pigmeat being the largest livestock output) (Defra 2023). Between 2021 and 2022, the total income from farming increased by 10%, with the total livestock outputs making the biggest contribution to outputs and subsidies in the region annually for the past six years.

The region is also seeing an increase in the diversification of farmland, for example from agri-tourism, nature tourism and schemes that deliver environmental benefits, such as through environmental stewardship or ELM schemes, which will impact the rural economy and influence changes in land use and management.

In 2024, the City of Doncaster secured UNESCO Biosphere Candidate status across the whole of its borough with the aim of shaping and attracting opportunities for green investment, land use and sustainable land management.

5.4.4.2 Future baselines

In future, land use and the rural economy in the strategy area will be under pressure from the transitioning of agricultural policies and changing needs of local communities and visitors. There will also be impacts from increasing resilience and adapting to climate change effects, such as extreme weather, sea level rise, increased prevalence of storms, flooding, droughts, and wildfires, with economic damages that may occur from climate change effects. There will be increased drivers and opportunities for a move towards more sustainable land management practices (such as through nature-based solutions, integrating water storage and regenerative farming methods and decarbonisation).

The potential changes in tidal flooding to rural land use and economy under the future baseline scenarios may include:

- Under all the future baseline scenarios, agricultural land would experience an increase in tidal flooding extent and likelihood in each epoch, which would likely make current land use practices unviable in many areas around the estuary. The greatest increase compared with Present Day (2021) is land classed as Grade 3. The fastest increase in tidal flood risk to agricultural land is under the Do Nothing scenario, whereas it is more gradual for the other scenarios.
- Under a Do Nothing scenario, the greatest increase in tidal flood risk to agricultural land is between 2021 and 2046 compared with later epochs. Most of the agricultural land at tidal risk would be at a very significant likelihood of flooding by 2071 (including approximately 17,100ha of Grade 1 land and 48,000ha of Grade 2 land).

  By 2046, this scenario would expose most areas of land around Hull fishing port to a low likelihood of flooding (increasing to a very significant likelihood of tidal flooding by 2071) and industrial areas of fish processing concentrated at Grimsby would be subject to a very significant likelihood of tidal flooding.
- Under a Maintain Scenario, the change in tidal flood risk (and likelihood of flooding) to agricultural land would be more gradual than the Do Nothing scenario. Much of the agricultural land at risk would be at very significant likelihood of tidal flooding by 2121 (but not all). Less agricultural land would be at risk of tidal flooding in each epoch compared to the Do Nothing scenario, and considerable less land would be at very significant likelihood of tidal flooding compared to the Do Nothing scenario.

  This scenario would expose some areas of land around Hull fishing port to a low likelihood of tidal flooding by 2046, increasing to an Intermediate to significant likelihood by 2121. By 2046, industrial areas of fish processing concentrated at Grimsby Port would generally be subject to a very significant likelihood of tidal flooding. Fish processing industries along the A180 to the north-west of Grimsby would be at increasing risk of flooding ranging from a low likelihood by 2046, to very significant likelihood by 2121.
- Under Status Quo, the change in tidal flood risk (and likelihood of tidal flooding) to agricultural land would be gradual. Compared with other scenarios, this scenario provides the greatest reduction in tidal flood risk to agricultural land. Under this scenario, not all areas of agricultural land at tidal flood risk would have a very significant likelihood of flooding by 2121. Less agricultural land would be at flood risk in each epoch compared to the Do Nothing scenario and the Maintain scenario, and considerably less land would be at very significant likelihood of flooding compared to the Do Nothing and Maintain scenarios.

  By 2046, industrial areas of fish processing concentrated at Grimsby Port would be subject to a low to very significant likelihood of flooding. Fish processing industries along the A180 to the north-west of Grimsby would be at increasing risk of flooding from low likelihood by 2046, to very significant likelihood by 2121.
- Under a Legal Requirement scenario, less agricultural land would be at tidal flood risk in each epoch compared to the Do Nothing scenario but there would be a greater flood risk (and higher likelihood of flooding) under this scenario compared to the Maintain and Status Quo scenarios by 2071.

  This scenario would expose Hull fishing port to a low likelihood of flooding by 2071. By this epoch, industrial areas of fish processing concentrated at Grimsby and Grimsby Port area would be subject to a significant or very significant likelihood of flooding.

Future trends:

- Land use and the rural economy will increasingly be under pressure from the need to adapt to transitioning of agricultural policies, the changing needs of local communities and visitors, and the effects of climate change.
- There will be increased drivers and opportunities (such as increasing climate resilience) for a move towards more sustainable land management practices (such as through nature-based solutions, integrating water storage and regenerative farming methods and decarbonisation).

- The wider Yorkshire and the Humber region accounts for 10% of the nation's bioeconomy and with the global move towards concepts of a circular economy, this trend is likely to continue, dependent on government commitment and market take-up.
- Large expanses of farmland will be subject to a greater risk of tidal flooding with climate change under future baseline scenarios if the risk is not addressed. There could be significant impacts on the rural economy and changes to land use and agricultural practices.
- Climate change will also increase the potential tidal flood risk to areas with fishing ports assets and fish processing plants.
- New fishing byelaws are continuing to be introduced to ensure protection of the sensitive habitats within the estuary.

Strategic issues:

- The impact of flood risk management options on high value agricultural land (grades 1 and 2) will need to be considered during the development of the strategy.
- Agricultural areas that are less populated are typically less attractive to government funding for flood risk management than more populated areas. These areas may provide space for flood storage or managed realignment and/or opportunities for farming to adopt more sustainable land management and environmental stewardship practices.
- Agricultural land management, agricultural landscape, flooding, habitats and wildlife, and water pollution are inter-related. These interdependencies are increasingly being recognised within the strategy area. This has reflected within initiatives such as the Reconnecting the Humberhead Levels Partnerships and the emerging Environmental Land Management schemes. These networks could help to explore opportunities to manage flood risk in the strategy area.
- The impact of flood risk management options on commercial fisheries (including the increasing number of aqua/mariculture projects in the strategy area) should be considered during the development of the strategy.

5.4.5 Material assets

5.4.5.1 Present day baseline

Key Infrastructure

Since the SA Scoping Report (Jacobs 2020a), there have been some changes in key infrastructure assets such as those relating to transport, hospitals, power stations, utilities, manufacturing industry, petrochemicals and mineral assets. Whilst digital infrastructure has also recently been bolstered in the strategy area to improve communications and operational efficiency in the region's ports and industrial hubs, this is not considered within the scope of this report.

There has been significant investment in the region's road infrastructure. Improvements include the A160 road access to the Port of Immingham in 2017 and the A63 road improvements in Hull that connect the Port of Hull to the national motorway network. Current figures for vehicles crossing the iconic Humber Bridge, which forms a major link between the north and the south bank of the estuary are that more than a quarter of a billion vehicles have crossed the bridge since 1981, and between April 2023 and May 2024, an estimated 220,677 pedestrians and 78,104 cyclists used the walkway (Humber Bridge Board 2024).

Recent improvements to the rail network include the South Humber Gauge Enhancement scheme, which was completed in 2019. This scheme allows the transport of larger containers by rail from the Port of Immingham. Investment will be required in a similar scheme in the future to enable larger gauge clearance to the Port of Hull.

Goole also provides a key interface between rail, road, the Humber estuary and the inland waterway network west to Leeds. The increased use of rail freight and inland waterways will help relieve pressure on the M62. Also, a new rail manufacturing factory was opened recently in Goole[10].

The Humber estuary is an important trade gateway with an average of 40,000 ship movements per year. It contains the UK's busiest ports complex and its ports and wharves handle 17% of the nation's trade (Humber Freeport 2024). Since 2017, there has been an increase of over 30% in the number of shipping services connecting Hull and Immingham to ports on the continent with new services from Amsterdam and Ghent plus the introduction of deep-sea feeder services into the Port of Hull. In November 2023, Associated British Ports (ABP) introduced a new weekly service operated by Samskip to its Port of Hull from Riga in Latvia and Helsinki in Finland. There are over 100 shipping lines operating, with Humber logistics companies shipping to over 50 countries.

The Humber supports the recent offshore wind development in the North Sea, which is helping to drive economic growth in the strategy area. New facilities in Hull and Grimsby build and maintain offshore installations, while stimulating wider adoption of renewable and clean energy developments, including bioenergy and energy from waste. Several of the gas fired power stations are currently exploring decarbonisation through switching to hydrogen fuel or employing post-combustion capture. For example, SSE Thermal is developing an option for Keadby Three, a low-carbon combined cycle gas turbine plant alongside its existing power stations near Scunthorpe. There is also potential and/or proposals for new gas power stations at Stallingborough, Eggborough and Ferrybridge as well as new hydrogen production sites near the refineries on the south Humber bank and outside of the current chemical park at Saltend. Currently, some key material assets sit within parts of the strategy area that are at risk of tidal flooding (from low to very significant likelihood) under Present Day (2021) conditions (refer to Section 5.2). These include:

- Roads, particularly in the inner estuary such as south of Selby;
- Rail, as most of the passenger and rail network is routed through areas currently at low to moderate likelihood of tidal flooding and there are short lengths of the rail network, for example, between Goole and Saltmarshe that traverse areas currently at a very significant likelihood of tidal flooding. It should be noted that there are also sections of railway adjacent to the Humber estuary (e.g. between North Ferriby and Hessle) which may become at risk of erosion due to channel movements;
- Hospitals, such as Hull Royal Infirmary, Goole Hospital, Selby War Memorial Hospital;
- Emergency service assets, such as fire and rescue services at Immingham East and Peaks Lane, and ambulance stations at Doncaster, Hull East and Sutton Fields;
- Prisons, such as HMP Hull;
- Oil and gas terminals, and refineries, such as Tetney Terminal, and Humber and Lindsey Oil Refineries;
- Power stations and energy substations, such as Immingham CHP, Keadby, South Humber Bank and Drax; and
- Others, including some water and wastewater treatment assets (pumping stations, sewage treatment works and reservoirs), schools and universities.

Mineral sites

Since the SA Scoping Report (Jacobs 2020a), the new Joint Minerals Local Plan 2016 – 2033 (East Riding of Yorkshire Council and Hull City Council 2019) has been adopted. The plan identifies significant deposits of a wide range of minerals within the plan area, including sand and gravel, chalk, clay, silica sand, salt and peat. There are also potential resources of oil, gas and coal. The plan also defines areas safeguarded for possible future mineral extraction around the Humber.

The Humber estuary is one of six main dredging areas off the coast of England, which produces marine dredged aggregates (mixture of gravels, sandy gravels and gravelly sands, and sand banks) (East Riding of Yorkshire Council and Hull City Council 2019). A number of dredging licences have been granted by the Marine

[10] https://www.gov.uk/government/news/transport-secretary-opens-200-million-rail-manufacturing-factory-in-goole (accessed October 2024)

Management Organisation for dredging aggregates. Local authority planning controls relating to marine extraction are limited to the siting, environmental issues and development of the wharves where the minerals are unloaded. These are sited in Hull within the Minerals Local Plan area. Recent data indicates that the overall sales of sand and gravel in Yorkshire and the Humber region steadily increased between 2015 and 2018, but has since dropped, and there has generally been a decreasing trend in sand and gravel reserves (Yorkshire and Humber Aggregate Working Party 2022).

5.4.5.2 Future baselines

In future, existing and new material assets in the strategy area, such as transport routes, key infrastructure and mineral sites, will be under pressure from the need to adapt to changing needs from the population and the effects of climate change. Where these assets are located in areas at risk of tidal flooding, economic damages may occur.

Using the modelled tidal flood extents under the future baseline scenarios (described in Section 5.3.2), an overview of the future tidal flood risk to key material assets is provided below. This overview selects only a few key features as it is not possible at this strategic level to consider the changes in flood likelihood to all individual material assets.

Potential changes in tidal flooding to areas where key material assets are located under the future baseline scenarios may include the following:

- Under all the future baseline scenarios, by 2121, most of the key material assets within the strategy area are located within areas with significant or very significant likelihood of tidal flooding. This may include areas with important road networks, large stretches of the rail network, many of the hospitals, HMP Hull, many of the power stations, oil terminals and refineries, emergency service assets and some energy substations. However, the rate of increase in the extent and likelihood of tidal flooding in areas with key material assets compared with Present Day (2021) conditions would be greatest under the Do Nothing scenario and would be least under the Status Quo scenario.
- Under the Do Nothing scenario, by 2046, there would be an increasing likelihood of tidal flooding to areas with important road networks (for example the recent A63 Castle Street Scheme in Hull could have a very significant likelihood of tidal flooding) and most areas with sections of the rail network would have a very significant likelihood of tidal flooding by 2046, with the exception of a few lines such as between New Arram and Hutton Cranswick, which would only have a low likelihood by this epoch. By 2046, the likelihood of tidal flooding would increase in those areas with many of the other key material assets such as HMP Hull and many of the hospitals, power stations, oil terminals and refineries, and emergency service assets.
- Under the Maintain scenario, by 2046, areas with key material assets such as important road networks would experience an increase in the likelihood of tidal flooding compared with Present Day. However, unlike the Do Nothing scenario, the area with the A63 Castle Street Scheme in Hull may have a low likelihood of tidal flooding until 2071. By 2046, all areas with sections of the rail network would have low to a very significant likelihood of tidal flooding and some of the other key material assets such as hospitals, power stations, oil terminals and refineries, HMP Hull, and emergency service assets would have an increased likelihood.
- Under the Status Quo scenario, there would be an increased likelihood of tidal flooding to areas with important road networks and stretches of the rail network compared with Present Day but increasing at a slower rate than under the other scenarios. For instance by 2046, most areas with sections of the rail network would have low to intermediate likelihood of tidal flooding, however, the area with the A63 Castle Street Scheme in Hull would remain a low likelihood (and would then be moderate likelihood by 2121), and by 2071 some of the other key material assets such as hospitals, power stations, oil terminals and refineries, HMP Hull, and emergency service assets would have an increased likelihood.
- Under the Legal Requirement scenario, by 2071, there would be an increasing likelihood of tidal flooding in areas with important road networks (although the area with the A63 Castle Street Scheme in Hull would only have a low likelihood), and most sections of rail network would be in areas with a very

significant likelihood of tidal flooding (except between Hessle and Hutton Cranswick, which would only have a low likelihood by this epoch, for example). The likelihood of tidal flooding would also increase by 2071 in the areas with many of the other key material assets such as HMP Hull and many of the hospitals, power stations, oil terminals and refineries, and emergency service assets.

Future trends:

- Existing and any new material assets in the strategy area will increasingly be under pressure from the need to adapt to changing needs of the population and the effects of climate change.
- Key assets in the strategy area are likely to change over the next ten years as new infrastructure is developed. These may include energy developments created as a result of moving towards 'net-zero' technologies. Future assets will likely be built in already developed industrial areas but these may increase the pressure on and risk to existing key infrastructure at these locations.
- Existing and future assets will need to increase their resilience to climate change and seek opportunities for decarbonisation.
- The increasing availability of hydrogen may lead to new industrial users seeking sites within the strategy area from 2030 onwards.
- Changes in freight transportation, including the increasing use of rail, inland waterways and shipping services/routes, could bring opportunities for growth. These opportunities could increase congestion on local road infrastructure.

Strategic issues:

- The Humber estuary's key infrastructure is at increasing tidal flood risk. The future viability of these assets will affect both the region's economy and the local communities that the infrastructure serves, so will need considering in relation to future flood risk management options. The strategy should seek to align with the strategic plans of National Highways, Network Rail, National Grid, local authorities and other national or regional agencies.
- The in-combination and cumulative effects of tidal flood risk on material assets will require a strategic and coordinated approach to their future management.
- The strategy area comprises varied types of mineral resources. Minerals development requires careful planning and adaptation to avoid increased vulnerability to the effects of climate change including increasing flood risk. Mineral workings can have positive, as well as detrimental, effects relating to flood risk management and mitigation.
- Strategy development should consider direct and cumulative impacts on minerals' safeguarded areas, if any are near proposed option sites.

5.4.6 Biodiversity

5.4.6.1 Present day baseline

As described in the SA Scoping Report (Jacobs 2020a), the strategy area is of considerable importance for nature conservation, comprising many international, national and local statutory designated sites as well as non-statutory sites, habitats and species, some of which are rare or threatened. Climate change and associated sea level rise, together with other drivers such as intensive agricultural management, economic growth and changes to recreation/tourism, is exacerbating pressures on some of these designated sites, habitats and species and are creating challenges to their management. This section describes some context around key legislative changes any biodiversity baseline information that is in addition to that presented in the Scoping Report, along with an overview of the tidal flood risk to key biodiversity features from the modelled Present Day (2021) scenario.

Key legislative changes

Since the 2008 Humber Strategy and the SA Scoping Report (Jacobs 2020a), there have been considerable changes to nature conservation legislation for the benefit of biodiversity. As a result of the Conference of Parties (COP)15 global agreement (the Kunming-Montreal Global Biodiversity Framework (UNEP 2024)) and reflected in legislation (especially the UK Environment Act 2021), there is a strengthened duty to conserve biodiversity. There is also an increasing shift from delivering mitigation and compensation to delivering nature recovery, to address the nature crisis and enhance biodiversity. As a key component of the Environment Act (2021), a suite of new spatial strategies are being developed across England. Local Nature Recovery Strategies (LNRS) will form a 'Nature Recovery Network', to identify locations to improve nature and provide other environmental benefits, such as carbon sequestration, flood regulation through nature-based solutions, and increased access to nature-rich spaces. These strategies, which include the emerging Hull and East Yorkshire LNRS and Greater Lincolnshire LNRS, will help direct new funding streams including for agri-environment funding within the study area and set out locally agreed priorities and opportunities for nature recovery (particularly in areas outside designated sites) with clear links to Biodiversity Net Gain (BNG).

BNG is a planning requirement under Schedule 7A of the Town and Country Planning Act 1990 (as inserted by Schedule 14 of the Environment Act 2021) to ensure habitat for wildlife is in a better state than it was before development. BNG can help mitigate the effects of climate change (see Section 5.4.11) and deliver multiple benefits. There may be opportunities to consider BNG strategically in future steps within the strategy area through habitat creation or enhancement to help address the nature crisis.

Statutory designated features

Since the 2018 SA Scoping Report (Jacobs 2020a), the Humber estuary's status as one of the most important estuaries in Europe for nature conservation has been recognised by its inclusion in the East Coast Flywheel wetland sites. In 2023, it was added to the UK's tentative list of UNESCO World Heritage Sites (WHS) for its wetland status.

The area immediately to the east of the Humber estuary Special Protection Area (SPA) is now designated as the Greater Wash SPA along the east coast of England. The Lincolnshire Coronation Coast NNR, which extends from Mablethorpe to Cleethorpes, was designated in 2023. It is the first in the new King's Series of NNRs, which is being launched by Natural England to enhance biodiversity and nature recovery. Holderness Inshore Marine Conservation Zone (MCZ), which was not previously described in the SA Scoping Report (Jacobs 2020a), is located just north of the Humber estuary mouth and partially overlaps the study area. Further offshore is the Holderness Offshore MCZ.

Where habitat compensation areas associated with the designated sites have been secured as part of the 2008 Humber FRM Strategy (such as Donna Nook and Welwick to Skeffling Managed Realignment Scheme), planning policy emphasises the need to consider these compensation areas as part of the designated sites. This also applies for other developments' consent requirements.

Between 2019-2021, several studies were completed by KPAL that improved our understanding of the past habitat changes in the Humber estuary's designated sites and intertidal areas. These studies concluded that there were no significant losses in intertidal habitat area between 1946-2019, and that there had been an overall net expansion of vegetated intertidal areas across all parts of the estuary. Any change was deemed unlikely to represent losses from coastal squeeze against the tidal defences, although there were some localised areas of losses in intertidal habitat extents (KPAL 2019, 2020; Jacobs 2022a).

To support the development of Humber 2100+ and its HRA, a Statement of Common Ground has been developed with Natural England that sets expectations around addressing any compensation needs associated with direct and indirect effects on the designated sites.

Under the modelled 2021 Present Day tidal flood scenario:

- The species-rich meadows in the Aire floodplain (Eskamhorn Meadows SSSI) that would have traditionally been seasonally flooded currently have a very significant likelihood of tidal flooding; and
- The majority of the inland international, national and statutory local conservation sites are currently subject to a low to moderate likelihood of tidal flooding.

Other biodiversity features

In addition to biodiversity associated with the designated sites, there are other habitats of principal importance for the conservation of biodiversity within the study area, including (but not exclusive to) grassland (floodplain and coastal grazing marsh, lowland grassland and meadows), woodland (ancient woodland, deciduous woodland) and wetland habitats (lowland fens and bogs, reedbeds) as listed in Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006. Many of these habitats are also of amenity value for local communities, for example as a community forest.

Other notable biodiversity present in the study area includes protected species, and farmland bird populations (such as lapwing that also use the estuary, and corn bunting and yellow hammer that are terrestrial). Farmland bird populations within the Humber area are considered important due to strong declines in populations elsewhere in the UK (as reported in the 2023 State of Nature Report (State of Nature Partnership 2023)). Complex changes in bird populations and migratory patterns are taking place on a regional and global scale, and this is thought to be linked to climate and habitat change.

Recent trend analysis of the Humber's waterbird populations identified differences in population status over time between the species (Cutts & Hemingway Estuarine Ecology and Management Ltd 2023). For example, geese had a steady increase in recent decades, duck numbers peaked in the 1980s and 1990s, and waders peaked in 1990s and 2000s and have since declined. The conclusion was that the pattern of waterbird utilisation of the estuary over time is complex. Whilst external factors affect some of species (e.g. the recent increase in golden plover and decrease in mallard), other patterns reflect the effects of localised changes in carrying capacity based largely on habitat extent and quality.

Invasive and non-native species are recorded in the strategy area. Japanese knotweed, giant hogweed and Himalayan balsam are regularly recorded on watercourses around the Humber estuary, especially on the rivers and streams that feed into the Humber. These plants can outcompete native species, degrading the habitat quality. Where development takes place in the presence of these species, local control and eradication can be implemented. Many of the drainage ditches harbour mats of water fern which restrict native plant growth. Mink predate ground nesting birds, fish and water voles and can cause significant declines in these populations. Another example in the estuarine environment includes zebra mussels, which pose a threat to natural fauna and structures like abstraction and discharge pipes/infrastructure. There are also several planktonic non-native species in the marine waters.

5.4.6.2 Future baselines

Biodiversity in the study area, including the designated sites, has been historically under pressure from development, agricultural intervention and recreation activities. In future, these pressures will change with the transitioning of agricultural policies, changing needs of the local communities and visitors (such as the increased formal access to the coast and nature tourism), changes associated with the ports-based economy, and with climate change effects. Many agri-environment schemes and evidence studies such as the Humber Green Mapping Project (Natural England) have been undertaken to manage the pressure on biodiversity and to integrate land-use and economic development with nature conservation.

The effects of climate change will pose continuing and new challenges to the management of designated sites, habitats and species, which are being afforded increasing legal protection. Changes to the flooding regime may detrimentally affect water quality by changing the balance of aquatic ecosystems, salinisation and eutrophication of water bodies.

Natural England will be undertaking a study to identify protected sites that require adaptation to climate change in terms of site management and changes to designation status; the findings of which will be integrated into the development of Humber 2100+, as appropriate. As described in Section 5.4.8 'Geomorphology', how the morphology of the Humber estuary would respond to future climate change effects is highly uncertain given the uncertainties associated with the driving forces (such as sea level rise, sediment supply, channel movements, wave energy), the anthropogenic influences (e.g. dredging, reclamation) and the estuary's morphological response (e.g. erosion and accretion). The extent and quality of the estuarine habitats would change over time in response to these changes and vegetation development. Recent studies into actual changes in intertidal areas over the last 70 years emphasised the difficulties in predicting potential future losses associated with flood defences with future rates of sea level rise (Jacobs 2022a).

The potential changes in tidal flooding to areas where key biodiversity features are located under the future baseline scenarios indicate that:

- Under all the future baseline scenarios, by 2121, most of the key biodiversity features within the strategy area are located within areas with very significant likelihood of tidal flooding, with only a few features (mainly priority habitat) on high land remaining at low flood risk over the 100 year duration of the strategy.
- Under the Do Nothing scenario, the majority of inland conservation sites and priority habitats would experience at least a low likelihood of flooding. By 2046, these sites would experience a very significant likelihood of flooding. By 2021, only a few locations would have lower likelihood of flooding, such as priority habitats around Hatfield, and conservation sites and priority habitats around the River Hull in the northern extent of the strategy area). Only a few areas of nature conservation value (mainly priority habitat) on high land would remain at low flood risk.
- Under the Do Minimum scenario, by 2046, the majority of the inland conservation sites and priority habitats would experience a low to very significant likelihood of flooding (the lowest being to the west of the River Hull, and by Hatfield). Compared with the Do Nothing scenario, the extent of tidal flooding to designated sites and habitats and flooding likelihood level increases more steadily, and fewer biodiversity features have a very significant likelihood of flooding by 2071. However, by 2121, most of the areas of nature conservation value would experience a very significant likelihood of tidal flooding but a few areas (mainly priority habitat) on high land would remain at low or intermediate flood likelihood.
- Under the Status Quo scenario, the changes in tidal flooding to areas of nature conservation value largely reflects that of the Do Minimum scenario, but generally with a slightly lower likelihood. There would be an increasing likelihood and extent of flood risk by 2071 and many areas of nature conservation value would experience a very significant likelihood of tidal flooding by2121 (although not as much as the Do Minimum scenario) apart from, for example local designated sites and priority habitats west of the River Hull and in the area north of Doncaster that would remain at low flood likelihood, or sites north of Saltfleetby All Saints that would be at significant likelihood levels.
- Under a Legal Requirement scenario by 2071, the extent of tidal flooding of inland conservation sites would increase significantly with the majority of conservation sites and habitats throughout the strategy area having a very significant likelihood of flooding by 2071. However, there would be a few locations, where conservation sites (mainly Local Wildlife Sites (LWS)) and priority habitats would have a lower likelihood of flooding, for example, some LWSs and coastal grazing marsh to the west of the River Hull and areas of deciduous woodland between Waxholme and Burstwick would have a low likelihood of flooding.

Maintaining the defences under the Legal Requirement and Maintain scenarios, and the construction and maintenance activities proposed within the existing strategy under the Status Quo scenario may result in negative effects on biodiversity. These include direct habitat losses from the increasing footprint of defences encroaching into the SPA/SAC/Ramsar and their designated habitats (saltmarsh, mudflats, sand dunes, saline lagoons) and freshwater habitats, indirect habitat losses (such as from changes in water levels in the estuary), or disturbance impacts. In addition to providing compensatory habitat, the Status Quo scenario may provide

opportunities for biodiversity gain through habitat creation, such as at the proposed managed realignment sites. The Status Quo scenario is the only future baseline scenario that includes an agreed approach to delivering strategic intertidal habitat creation schemes (via managed realignment of defences) to ensure the long-term functioning of the SPA/SAC/Ramsar and would therefore create more associated opportunities to protect and restore nature than the other baseline scenarios.

There are significant uncertainties about how intertidal areas could change in future. However, in the short term it is possible that the extent of intertidal areas would broadly remain the same under Maintain, Legal Requirement and Status Quo scenarios. This is due to the relatively low rates of sea level rise currently experienced throughout the estuary. There is increased potential for localised erosion due to increased freshwater flows and wave energy as a result of climate change (Jacobs 2023). There is also the potential for the presence of maintained defences under these three scenarios to result in indirect losses or coastal squeeze related changes of intertidal SPA/SAC/Ramsar and other designated habitat (such as sand dunes, saline lagoons) as rates of sea level rise are anticipated to increase and there is potential for increasing foreshore erosion or a reduction in habitat quality. The various 2019-2021 studies on the actual changes in the extent of intertidal areas and comparisons with the previous predictions of habitat losses associated with coastal squeeze, will be considered in during the development of Humber 2100+. The strategy will continue to investigate how to address any potential future coastal squeeze effects, including approaches to monitoring and adaption.

Any habitat losses, as well as associated changes in habitat quality, would require mitigation and/or compensation. Potential changes in habitat extent and quality (and associated changes to species) from flood risk management are likely to be exacerbated by predicted population growth, urbanisation and development, access to the coast, nature tourism, land management practices (e.g. expansion and intensification of agriculture) and threats associated with invasive non-native species.

The Humber 2100+ Strategy will consider linkages within the estuarine system to ensure an integrated understanding and management of the natural environment. The approach is based on understanding of individual attributes of the estuary (such as hydro-morphology, physico-chemistry, and ecology), their interactions, and how they, and the system, respond to change. The outputs of the flood modelling and future baseline scenarios will be important in informing decision-making at this systems scale.

Future trends:

- Climate change poses continuing and new challenges to the management of designated sites, habitats and species. Large expanses of nature conservation sites will be subject to a greater risk of tidal flooding under future baseline scenarios if the risk is not addressed. There are considerable uncertainties with predicting how these changes could affect biodiversity in the strategy area, but Natural England's designated sites climate change adaptation plans will identify any changes to site management and designation statuses of the protected nature conservation sites to help them adapt to climate change.
- Predicted population changes, plans for growth, access to the coast, nature tourism and changes in land management practices will place further pressure on biodiversity and future sites for habitat creation.
- Complex changes in bird populations and migratory patterns are taking place on a regional and global scale, and this is linked to climate and habitat change. The trends in changes in waterbird populations around the Humber vary for different species, and although some species are affected by external factors, other patterns reflect the effects of localised changes in the carrying capacity of the habitats present.
- Considering the Humber estuary as a system will allow an integrated understanding and management of the natural environment, rather than delivering mitigation, compensation and restoration in a piecemeal fashion.

Strategic issues:

- The Humber is important for nature conservation. When considering flood risk management options, the strategy's impact on international, national and local statutory designated sites as well as non-statutory sites, habitats and species and areas of functionally linked land will need to be considered.

- The biodiversity of the Humber estuary has been affected by urbanisation and agricultural intensification. Freshwater and wet grassland habitats are a particularly limited and threatened resource.
- Maintaining tidal defences may result in coastal squeeze effects on SPA/SAC/Ramsar habitat, alongside any direct habitat losses and other adverse ecological effects from flood risk management interventions. Recent studies looking at changes in intertidal areas over the past 70 years emphasised the difficulties in predicting future losses in the extent of intertidal areas associated with flood defences. The development of the strategy will need to continue to consider future coastal squeeze losses and potential changes in habitat quality. This should include appropriate monitoring and adaption approaches.
- BNG requirements (and associated monitoring) will apply to the proposed flood risk management schemes. There is a role for LNRS in providing opportunities to inform action in specific areas mapped within the LNRS Nature Recovery Network, particularly for those areas identified outside of designated sites.
- The Humber 2100+ Strategy may present opportunities for (a) the proactive and strategic delivery of BNG sites and habitat banking within the strategy area through habitat creation and enhancement; (b) a co-ordinated approach to improving and prioritising biodiversity (including carbon sequestration and access to nature) through flood risk management; (c) improving the conservation status of designated sites and improving habitat quality (through habitat quality, size and connectivity), increasing resilience to climate change by reducing fragmentation and enabling species movement; and (d) delivering nature restoration to help address the nature crisis. This will also present challenges from managing the strategic nature restoration opportunities at a landscape scale and any potential impacts on heritage assets and cultural landscapes.

5.4.7 Water

5.4.7.1 Present day baseline

WFD water bodies

As described in the SA Scoping Report (Jacobs 2020a), the strategy area comprises a complex hydrological system with the estuary, interconnected rivers, ditches, canals, lakes/ponds and groundwater bodies. Ongoing economic activities, including industry and agriculture are both dependent on these systems and have an influence on the water bodies, such as the way they flow and their quality.

Latest information on the status of water bodies in the strategy area classed by the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (WFD Regulations) for surface waters and groundwaters shows that:

- The Humber estuary is classed as a 'Heavily Modified Transitional' water body (divided into Upper, Middle and Lower reaches); the Ouse and Derwent within the strategy area are 'Heavily Modified', and the Trent within the strategy area is 'Artificial'. All these water bodies currently have overall 'Moderate' status according to the River Basin Management Plan (RBMP)[11] (Environment Agency 2022a; Environment Agency 2023a).
- There are 15 classified groundwater bodies in the strategy area; many of which had overall poor status in 2019 (Environment Agency Catchment Data Explorer 2023a). Of note is that the Hull and East Riding Chalk groundwater body has poor overall status in part due to saline intrusion from historic groundwater abstraction, which will require consideration during the development of projects arising from the strategy.

The Humber RMBP includes a summary of the measures needed for water dependent Habitats sites (under the Habitats Regulations) to meet their conservation objectives. For the second cycle of RBMPs, Site Improvement Plans are being used to capture the priorities and new measures required for water dependent habitats on Habitats sites.

[11] Note that the Humber RMBP encompasses the entire strategy area.

Since the SA Scoping Report (Jacobs 2020a), the Environment Agency has published updated guidance on how to assess the impact of activities in transitional and coastal waters for the WFD, referred to as 'Clearing the Waters for All' (Environment Agency 2016, updated 2023), which will be used during the development of the strategy and its WFD assessment.

Water quality

As described in the SA Scoping Report (Jacobs 2020a), water quality within the Humber estuary is determined by a combination of many factors, many related to human activity, such as the discharge from effluent treatment plants and from the densely populated and industrialised parts of the inland catchment. Water quality is strongly linked to elevated concentrations of suspended solids, trace metals, boron and ammonia. The estuary receives sewage effluent for approximately 25% of the population in England. In 2019, analysis of water samples in the estuary by the University of Leeds revealed high levels of pharmaceuticals concentrations (University of Leeds 2019). There are also localised high concentrations of other pollutants resulting from coal mine drainage, soil pollution caused by past ore mining, bedrock geology, and the agricultural use of fertilisers. The concentrations of particulate components are high in the intertidal zones due to sediment trapping and suspension.

However, a decline in polluting industries in the catchment and more stringent controls on the release of pollutants and habitat restoration initiatives is likely to be leading to water quality improvements in the catchment. This may also be a contributory factor for a slow recovery in the numbers of migratory fish such salmon and trout in the estuary. Improvements to facilitate the upstream passage of fish is key to their success.

The strategy area also supports two designated bathing areas at Cleethorpes and Humberston Fitties. Both are classified as having 'good' water quality in 2023 (Defra 2024c).

Since the SA Scoping Report (Jacobs 2020a), to inform the development of Humber 2100+, a "*conceptual understanding*" of components of the hydromorphological, physico-chemical and biological systems of the estuary was developed to help understand how they interact and how they respond to changes and pressures. The physico-chemical model (Cutts & Hemingway Estuarine Ecology and Management Ltd ((CHEEML) 2022) noted that in the Humber and its tributaries, large scale oxygen depletion has historically been recorded, particularly around Trent Falls in the upper reaches of the estuary as a result of organic enrichment and this event has been classed as the most serious form of pollution in the estuary (National Rivers Authority 1993, cited by CHEEML 2022). Water from tributaries in the River Ouse catchment which drain into the Humber have been the main source of organic pollution, although oxygen depletion has been exacerbated by direct discharges of sewage and industrial waste to the estuary. It also noted the estuary water contains very heavy loads of suspended solids and therefore will have very poor light penetration.

Of the designations described in the SA Scoping Report (Jacobs 2020a):

- Many of the Nitrate Vulnerable Zones (NVZ) designated to prevent nitrate pollution arising from agriculture, are at tidal flood risk under the Present Day baseline.
- The Drinking Water Safeguard Zones (DWSZ) to manage nitrate concentrations in groundwater are generally at low likelihood of flooding. However, some of the DWSZ to the north and east of Snaith are at a very significant likelihood of flooding under the Present Day baseline which poses potential pressures on the water resource.

Surface and ground water resources

As described in the SA Scoping Report (Jacobs 2020a), the strategy area supports numerous water abstraction licences and associated abstraction licensing strategies, ranging from small to large abstractions for tidal, surface and ground water, contributing to the drinking water supply as well as industrial uses in the Humber area and around the country.

5.4.7.2 Future baselines

The effects of climate change, including increased freshwater flows due to increased precipitation during the winter months, sea level rise, hotter and drier summers (drought), increased exposure to storm surge frequency and magnitude and increasing risk of tidal flooding, would present challenges to the management of water quality within affected water bodies, and vulnerable ground and surface water resources in the strategy area.

Water quality and water resources would also continue to be under pressure from the demands and potential pollution from the changing population, industry and land use, potentially affecting drinking water supplies, groundwater quality, habitats and wildlife, and industries (e.g. water supply for energy intensive factories and hydrogen production facilities) in future.

With regards to how tidal flood risk could affect the water environment, the key findings of the modelled flood extents under the future baselines indicate that:

- Under a Do Nothing scenario, the majority of land around the Humber would experience at least a low likelihood of tidal flooding in 2021 under a Do Nothing scenario. The likelihood of land flooding would increase over time with an associated increasing risk of pollution to receiving water bodies including the Humber transitional water body, groundwater, the two designated bathing waters at the estuary mouth, the NVZ and most of the DWSZ. The tidal flood risk would increase by 2046, when the majority of land would experience a very significant likelihood, with the exception of a few locations (for example, river water bodies and DWSZ south of Hensall and north-east of Doncaster), which would have a low likelihood. most of the strategy area would experience a very significant likelihood of tidal flooding by 2071 with associated impacts on water quality in the water bodies and on water resources.
- Under a Maintain scenario, by 2046, the majority of land would experience a low to very significant likelihood of tidal flooding, but from 2046 to 2121, the extent of tidal flooding to water resources increases more steadily than the Do Nothing scenario. By 2121, most of the strategy area would experience a very significant likelihood of flooding with associated impacts on water quality and water resources.
- Under a Status Quo scenario, the water resources and water bodies at risk of tidal flooding would largely reflect that of the Maintain scenario (albeit with generally a slightly lower likelihood of flooding).
- Under a Legal Requirement scenario, by 2071, the very significant tidal flood likelihood of land around the Humber would present a pollution risk to the receiving water bodies including the Humber transitional water body, groundwater, the two designated bathing waters at the estuary mouth, most NVZs and most of the DWSZs.

Future trends:

- Climatic changes combined with the anticipated population growth and urban development in the strategy area will exacerbate pressure on the water environment, potentially affecting drinking water supplies, habitats and wildlife, and water supply for the increasing number of industries around the Humber in the future.
- Climate change predictions show that summers will become hotter and drier, winters will become warmer and wetter, there will be more frequent and intense weather extremes and sea level rise will continue (Meteorological Office 2024).
- This is predicted to result in increased tidal flooding and foreshore erosion, which without coordinated flood risk management activities, would lead to the existing defences being breached or overtopped and the large low-lying areas behind the defences being inundated more frequently.
- Current passive outfalls will be impacted by sea level rise on low water, for example, compromising their ability to drain land for agriculture and potentially impacting on third party infrastructure.
- Continued population growth and changes in rainfall have the potential to increase pollution entering water bodies. In urban areas there will be increased pressure on the sewer network due to increasing stormwater

overflows and surface water run-off. Flooding of contaminated land would also increase pollution risk. In rural areas, intense rainfall is likely to exacerbate erosion and sediment run-off. Flooding of agricultural land is also likely to lead to increased pollution from fertilisers, herbicides and pesticides.

- Population increase and associated economic growth could increase the demand for abstraction and physical modifications to the water environment.

Strategic Issues:

- The strategy will need to consider important features within the water environment, such as the network of watercourses, ponds/lakes, drains, ditches and dykes. There are several NVZs, DWSZ and GSPZs, and many water abstraction sources to be aware of when developing strategy options. As these sources are subject to revision, addition or removal, they should be reviewed at relevant stages during the strategy's development.
- The effects of climate change and the associated increase in flood risk has the potential to adversely affect water quality with associated impacts on biodiversity and human health.
- All surface water bodies within the strategy area are classified as Heavily Modified or Artificial water bodies and have a Moderate status (in relation to the Water Framework Directive), implying that, with appropriate mitigation, they could be improved to achieve a Good Ecological Potential status. The strategy must aim to prevent deterioration of the WFD status of surface waters and groundwater, and consider opportunities to implement relevant mitigation measures to help achieve Good status, such as:
- **Flood risk management measures:** avoid or reduce the impacts of physical modifications of the waterbodies, remove obsolete structures, realign flood defences, soften and rehabilitate banks, and encourage habitat preservation and restoration, enable fish passage.
- **Operations and maintenance**: sediment management regimes; retain and enhance habitats.
- **Habitat creation:** intertidal habitat creation; bank improvement; 'Green Infrastructure' and other types of habitat creation.
- The opportunity to encourage the creation and management of permanent grass field margins and buffers to watercourses, would help to reduce nutrient and sediment run-off, and protect key sewerage infrastructure from flood risk.

5.4.8 Geomorphology

5.4.8.1 Present day baseline

Overall morphological form

Since the SA Scoping Report (Jacobs 2020a), a "*conceptual understanding*" of components of the hydromorphological, physico-chemical and biological systems of the estuary has been developed. This aims to understand how these components interact and how they respond to changes and pressures (CHEEM 2023, Jacobs 2023). The hydromorphological studies completed a comprehensive review of all the literature on the geomorphology of the Humber estuary (Jacobs 2020b), and built understanding of the morphological form over time, and key geomorphological processes in the estuary (summarised in Jacobs 2023).

A significant amount of work has been done to investigate the observed changes in intertidal extent over time in the Humber estuary (since 1946), reviewing previous predictions of intertidal habitat losses due to coastal squeeze[12] effects, and consider the morphological changes that bring about changes in intertidal areas (KPAL 2019, 2020; Jacobs 2022a). These indicated there have not been significant losses of intertidal habitat and no steady change over time across the estuary. However, there has been a net expansion of vegetated intertidal areas in all parts of the estuary, although localised losses of vegetated intertidal areas have occurred in scattered places (KPAL 2019, 2020). It is therefore thought overall unlikely that widespread coastal squeeze losses in the

[12] From the presence of flood defences preventing the landward transgression of habitats that would otherwise naturally occur in response to sea level rise.

extent of intertidal habitats have occurred under the rates of sea level rise experienced to date (Jacobs 2022a). There is a moderate to high confidence in this assessment.

Currently, the risk of drowning or widespread erosion of vegetated intertidal areas due to sea level rise throughout the Humber estuary is considered to be low. Rather than being driven by incremental rates of sea level rise, intertidal habitat changes appear to be dominated by changes in channel and bank positions. For example, in the inner estuary, the size and position of subtidal channels and banks vary. The regular switching of the preferential channel flow path around Read's Island over an approximate 10-20 year pattern (prior to 2000) being well documented, although due to the island's recent erosion it is considered unlikely to migrate for the foreseeable future (Jacobs 2022a). However, it is considered possible at some point in the future that there is a potential 'tipping point' when saltmarsh accretion cannot keep pace with increased rates of sea level rise (Jacobs 2022b).

Physical processes

In addition to information provided in the SA Scoping Report (Jacobs 2020a), further studies noted that:

- The historic sea level and tidal range trends over the last 100 – 200 years are considered uncertain, in part due to poor quality tide gauge data within the Humber (KPAL 2020).
- The importance of the various geomorphological processes differ along the estuary, with wave processes generally being more important in the outer estuary and freshwater flows being more important in the inner estuary. Wave height reduces from the outer to inner estuary by approximately 3m (Environment Agency 2020).
- Tidal heights increase up estuary and the tidal range increases from the outer estuary up to Humber Bridge, after which it gradually reduces into the inner estuary and tidal rivers (UKHO 2021).
- Sediment transport in the subtidal is driven by tidal, freshwater and salinity currents whilst in the intertidal it is driven by a mixture of wave and tidal currents (Jacobs 2023).
- Salinity steadily decreases upstream from around 30ppt in the outer estuary to less than 1ppt around Goole in the tidal rivers. This change in salinity creates a current near the estuary bed, which is important in transporting sediment from Holderness Cliffs into the estuary despite the ebb-dominance of tidal flows in the outer estuary (IECS 1994).
- The removal of sediment through maintenance dredging is generally limited to docks and jetties in the middle and outer estuary, and some subtidal channels in the middle and outer estuary. Deposition of dredged sediment mainly occurs in dredge disposal sites licenced by the MMO.

Observations have also been made regarding how Spurn has changed since the 2013 tidal surge; that the height of the washover has increased through deposition of sediment, and that dune vegetation is developing (Natural England pers. comms).

5.4.8.2 Future baselines

In future, the climate change impacts that are likely to affect the geomorphology of the Humber estuary include the increased freshwater flows due to increased precipitation during the winter months, sea level rise, and increased exposure to storm surge frequency and magnitude, also decreased freshwater flows due to more summer droughts. As sea level rises, freshwater flows will be impeded by reduced (or lost) gravity discharge windows. There would also be effects felt from the continuation or changes in management activities within the estuary and outside it (such as of the Holderness coast, an important source of sediment) or other activities (such as reclamation) that could also influence estuarine processes, in particular channel orientation, exposure to wind waves, intertidal geometry and the long-term stability of estuary morphology (Jacobs 2020b, 2022c).

Therefore, predicting the future evolution of an estuary such as the Humber is subject to large uncertainties arising from a large number of sources. Examples of potential geomorphology changes under the future baseline scenarios could include:

- Under all the baseline scenarios, larger waves driven by sea level rise or a change in wave climate could increase the frequency of overwashing and the presence of a permanent tidal breach through Spurn. This, in turn, may expose the estuary to larger North Sea waves, which would have previously been dissipated on Spurn. However, it is thought that there will be a relationship between the availability of additional sediment (such as from Holderness Cliffs) that could prevent or quickly infill any potential breaches, and so the risk of a permanent breach in Spurn forming in the next 100 years is considered low (Lee and Pethick 2018). There is uncertainty around the future changes to Spurn, and it is subject to active monitoring which will help inform future predictions.
- Under all the baseline scenarios, it is possible that there could also be increased erosion of the Holderness Cliffs outside the estuary that could increase sediment transported into the estuary and increase estuary bed levels, potentially allowing the overall extents of intertidal areas to broadly remain the same and keep pace with sea level rise (this assumes no management changes that may affect sediment supply). However, the intertidal areas could experience an increased volatility in localised erosion in places due to increased freshwater flows and possible increases in wave energy. Sea level rise could also potentially increase tidal flows leading to erosion of subtidal and intertidal areas to create larger channel cross sections.
- Depending on the rates of sea level rise and sedimentation experienced, it is possible that vegetated intertidal areas (saltmarsh) could be potentially resilient to sea level rise in terms of vertical accretion given the high availability of suspended sediments and high tidal ranges, up to a point in time, when a 'tipping point' may be reached from the accelerating sea level rise, drowning the saltmarsh (Jacobs 2022a; Jacobs 2022b). However, lateral (i.e. marsh edge) erosion due to the interaction with deep water channels and wind waves is considered more likely to present a risk of intertidal change this century, driven by internal geomorphological adjustments such as the movement of subtidal channels and major bedforms.
- In the tidal rivers, increased winter precipitation could increase the frequency of high freshwater water flows sufficient to cause channel switching in the estuary, or reduction in the crest level of intertidal banks, which may lead to loss of intertidal area in the tidal rivers, inner, and middle estuary. However, at present there is limited evidence to support this theory.
- In the outer estuary, the future morphological response to climate change is highly uncertain. It could include the lowering of mudflat and erosion of vegetated intertidal areas from increasing water depths if sedimentation rates do not keep pace with sea level rise, leading to increasing wave erosion of intertidal areas, potentially further exacerbated by any increases in wind speed. Also uncertain are the potential for changes in wave energy that could be influenced by changing extent of the flood and ebb tidal deltas in response to sea level rise.
- Under the Status Quo scenario, the opportunity to create washlands or new managed realignment schemes may alter water levels by increasing the amount of water that propagates into the estuary on the flood tide. The effects differ according to the location of the intervention and the risk of estuary channel erosion to accommodate the increased volumes of water. For example, if located in the middle and outer estuary, they would generally increase water levels by a relatively small amount but affecting a large area of the estuary (Jacobs 2022b). The risk of erosion is less in the outer estuary where the channel is relatively wide. If located in the tidal rivers and inner estuary, they generally reduce water levels by a greater amount but tending to be more limited in extent (Jacobs 2022b).
- Under the Status Quo scenario, the potential to create new large-scale managed realignment sites in the estuary would create new intertidal areas that would act as sediment sinks. These sinks could reduce the supply of sediment to existing intertidal and subtidal areas, although given the scale of past intertidal areas prior to reclamation and the turbidity of the Humber this seems unlikely.

Future trends:

- Climate change is likely to affect the geomorphology of the Humber estuary from the increased freshwater flows due to increased precipitation during the winter months, sea level rise, and increased exposure to storm surge frequency and magnitude.

- The continuation or changes in management activities within the estuary and outside it (such as of the Holderness coast, an important source of sediment) or other activities (such as reclamation) could also influence estuarine processes, in particular channel orientation, exposure to wind waves, intertidal geometry and the long-term stability of estuary morphology.
- The morphological response of the Humber estuary to future climate change effects is highly uncertain.
- Predicting the future evolution of an estuary such as the Humber is subject to large uncertainties arising from a number of sources, including: (i) the driving forces (e.g. sea level rise, sediment supply, channel movement); (ii) anthropogenic influences (e.g. dredging, reclamation) and (iii) the estuary responses (e.g. erosion/accretion).
- Studies looking more closely at the actual changes in intertidal areas in the Humber over the last 70 years indicated the lack of evidence of widespread coastal squeeze losses to the intertidal areas across the estuary under the current rates of sea level rise and emphasised the difficulties in predicting potential future losses in the extent of intertidal areas associated with flood defences.

Strategic issues:

- The strategy will need to consider how the continuation or changes in management activities within the estuary and outside it (such as of the Holderness coast, an important source of sediment) or other activities (such as reclamation) could influence estuarine processes during the development of Humber 2100+.
- Aim to prevent deterioration of the WFD status of the water bodies and consider opportunities to include relevant mitigation measures.
- Seek opportunities for enabling natural coastal and estuarine processes to continue, to benefit geomorphology and allow habitats to respond to the constantly changing patterns of accretion and erosion.
- Seek opportunities to increase the extent of intertidal habitats (saltmarsh, reedbeds and mudflats) to provide effective defence against wave energy and to support biodiversity.
- Consider ways to address key areas of uncertainty identified in the conceptual model (Jacobs 2023).

5.4.9 Landscape

5.4.9.1 Present day baseline

Landscape character

As described in the SA Scoping Report (Jacobs 2020a), the Humber estuary is the most significant component of the regional landscape – it has a unifying presence and is a focus for settlement, communication routes and the economy. It is a low-lying estuarine landscape with open and expansive waters, and extensive intertidal habitats. Much of the adjacent land has been reclaimed and the wider area includes flat, low-lying, large scale agricultural landscapes bound by diverse topography.

The landscape in the strategy area is characterised by 11 National Character Areas (NCA) (Natural England 2024): Central Lincolnshire Vale; Holderness; Northern Lincolnshire Edge with Coversands; Humber estuary; Humberhead Levels; Lincolnshire Coast and Marshes; Lincolnshire Wolds; Trent and Belvoir Vales; Vale of York, Southern Magnesian Limestone and Yorkshire Wolds. Since the SA Scoping Report (Jacobs 2020a), some of these NCAs may also have been modified through environmental and land management changes, as well as changes to conservation initiatives and priorities. The NCA profiles are now available through an interactive Natural England website launched in May 2024.

The existing landscape resources are currently under pressure from development (including urban expansion, housing, tourism, recreation and infrastructure provision) in the strategy area. Also, under Present Day (2021) conditions (described in Section 6.2), the majority of the NCAs currently have a low[13] to intermediate likelihood

[13] Since the probability of flooding can never be described as zero, we use the term 'low' likelihood of tidal flooding to describe any area shaded dark green on the maps (see Section 3.6), as well as any area shaded grey or where the base mapping is visible.

of tidal flooding. Exceptions include the Trent and Belvoir Vales NCA and parts of the Humberhead Levels NCA which currently have a very significant likelihood of flooding.

Landscape designations

The strategy area does not have any statutory, national landscape designations. However, it does host the Spurn Heritage Coast, also known as Spurn Point or Spurn Head, located within East Riding of Yorkshire. A heritage coast is defined by agreement between the relevant maritime local authorities and Natural England to conserve the best stretches of underdeveloped coast in England. While heritage coasts are recognised by the National Planning Policy Framework (NPPF) and their landward and lateral boundaries are clearly defined, there is ambiguity over their status in marine planning (i.e. where they extend below mean low water).

Spurn Heritage Coast is a 302ha, 5km long sand and shingle spit arcing into the mouth of the Humber, which is constantly reshaped by coastal drift and maintained by the deposition of soft sediments from the coastline to the north. Under Present Day (2021) conditions, large parts of Spurn Heritage Coast currently have a very significant likelihood of tidal flooding.

There are proposals for a new Yorkshire Wolds Proposed Area of Outstanding Natural Beauty (AONB) designation project on which consultation ended in January 2024. Should this designation be accepted, it will extend to the Humber estuary on its northern side. Additionally, outside of the strategy area to the south, the Lincolnshire Wolds is designated as a National Landscape (formerly an AONB) on account of its high scenic beauty and there have been ongoing reviews and updates to its boundary.

Other studies

Various green infrastructure studies were undertaken within the strategy area, summarised in the SA Scoping Report (Jacobs 2020a), that describe landscape character and sensitivity, and detail landscape enhancement and green infrastructure projects that could be delivered through flood risk management in the strategy area.

Some of the ELM and agri-environment schemes around the strategy area, described in Section 5.4.4, also integrate opportunities for protecting and enhancing the local landscape.

5.4.9.2 Future baselines

Landscape resources in the strategy area will increasingly be under pressure of change from development and climate change effects, such as sea level rise, increased prevalence of storms, flooding, droughts, wildfires and waterlogging (e.g. of peatlands). Landscape resources are also likely to change when, for example, land use, water storage and agriculture adapt to the challenges of climate change.

Increased tidal flooding is likely to result in significant changes to the coastal habitats and landscape character of the strategy area. In the short term, the overall extent of intertidal areas in the estuary may broadly remain the same. Localised erosion may increase due to more rainfall, increased freshwater flows, and possible increases in wave energy and saltmarsh erosion due to sea level rise (Jacobs 2023). There is also a risk of changes to intertidal areas from future coastal squeeze effects against tidal defences, although making predictions is considered difficult due to the uncertainties described in Section 5.4.8 'Geomorphology'.

Future tidal flood risk to key landscape resources has been reviewed using the modelled tidal flood extents under the future baseline scenarios (see Section 5.3). Whilst it has not been possible to consider the changes to all landscape features or local landscapes at this strategic level, the key potential changes in tidal flood likelihood to the Spurn Heritage Coast and NCAs are summarised below:

- Under all the future baseline scenarios, the Spurn Heritage Coast will continue to be subject to a very significant likelihood of tidal flooding under all the future baseline scenarios and therefore has potential for an associated significant change in landscape. Larger waves driven by sea level rise or changes in wave climate could potentially increase the risk of a breach through Spurn. However, there is uncertainty around the future changes to Spurn. Due to the potential increased sediment supply that could prevent

or quickly infill any potential breaches, the risk of a permanent breach in the next 100 years is considered low (Lee and Pethick 2018). Spurn is subject to active monitoring which will help inform future predictions.

- Under the Do Nothing scenario, the likelihood of tidal flooding quickly increases, which could bring about significant landscape change. By 2046, the majority of land within the NCAs in the strategy area would experience a very significant likelihood, with the exception of a very few locations (for example, the northern edge of Holderness NCA within the strategy area north-east of New Arram and Humberhead Levels near Finningley that would have a low likelihood). However, by 2071, all of the land within the NCAs would experience a very significant likelihood of tidal flooding and would remain so into the 2121 epoch.
- Under the Do Minimum scenario, by 2046, the majority of the land within the NCAs will have a low to intermediate likelihood of tidal flooding similar to Present Day (2021) conditions but with larger areas experiencing very significant likelihood, such as within the Humberhead Levels NCA. From 2046 to 2071, tidal flooding within NCAs increases with the majority experiencing significant to very significant likelihood of tidal flooding which could bring about significant landscape change, although increasing at a steadier rate than the Do Nothing scenario. By 2121, most of the land within the NCAs would experience a very significant likelihood of tidal flooding.
- Under the Status Quo scenario, the potential increase in tidal flooding within NCAs largely reflects that of the Maintain scenario except with generally a slightly lower likelihood. From 2046 to 2071, tidal flooding within NCAs increases with most experiencing an intermediate to very significant likelihood of tidal flooding. By 2121, again most of the land within the NCAs would experience a very significant likelihood of tidal flooding (except for part of Holderness and Humber estuary NCAs near Hull), which could bring about significant landscape character change.
- Under the Legal Requirement scenario, tidal flooding within NCAs will increase faster than the Maintain scenario, with the majority experiencing a very significant likelihood of tidal flooding by 2071, which could bring about significant landscape character change (albeit increasing at a steadier rate than the Do Nothing scenario).

Future trends:

- Landscape resources in the strategy area will be under pressure of change from climate change effects. The landscape is also likely to change when, for example, land use, water storage and agriculture adapt to climate change.
- Predicted sea level rise due to climate change would lead to the existing defences being breached or overtopped and the large low-lying areas behind the defences being inundated more frequently. This may lead to erosion and loss of intertidal areas through coastal squeeze. Coastal squeeze may affect habitat/landscape quality.
- There will likely be increasing pressure on landscape character from the predicted increase in population (including changes in visitor numbers) and planned economic growth and development around the estuary. Restrictions on development within areas at risk from flooding may help to protect landscape character from degradation but would need to be balanced against economic growth and development.

Strategic issues:

- Much of the landscape character is open and expansive, dominated by the Humber estuary, with long views and tranquil and remote places, such as Spurn Heritage Coast. Low-lying rural areas and small, remote historic settlements are commonplace, as is farmland which is managed with a network of ditches such as that along the banks of the Don, Ouse and Aire. This is in contrast with the large urban areas and industrial complexes, such as the city of Hull and Immingham. Important interdependencies that contribute to the character of the area include heritage and biodiversity. Maintaining the distinctive landscape character of different areas while adopting changes relating to development and adapting to climate change effects remains a challenge and presents opportunities.

- Landscape and green infrastructure studies for the Humber estuary highlight the potential for flood risk management projects to deliver creative opportunities that benefit communities, strengthen landscape and townscape character and enhance green and blue infrastructure through dynamic partnership-working with stakeholders.
- When developing the strategy, there are likely to be opportunities to engage with those local communities who are involved in delivering the many integrated landscape and ELM/agri-environment schemes.

5.4.10 Cultural heritage and archaeology

5.4.10.1 Present day baseline

Historical overview

No further information is added to the historical overview of the strategy area provided in the SA Scoping Report (Jacobs, 2020).

Statutory designations

The number of statutory designations within the strategy area is now higher than that reported in the SA Scoping Report (Jacobs 2020a). This is a result of changes in the strategy area boundary as well as newly listed sites. There are also likely to have been some changes to archaeological designations to reflect updates in heritage management and revisions to the boundaries or status of existing designations.

There are now 99 scheduled monuments (heritage features of national importance) within the strategy area. Recent additions include the Round Barrow Cemetery scheduled monument at Tetney, which was designated in 2021. These scheduled monuments are at a low likelihood of flooding or greater.

There are over 2,000 listed buildings widely distributed throughout the strategy area; of which 66 have been listed as Grade I. The Humber Bridge is Grade I listed and Hull Barrier is Grade II listed. Since 2018, 12 new Grade II Listed Buildings have been designated within the strategy area. These include war memorials and telephone kiosks. The majority of the listed buildings in the strategy area are at a low likelihood of tidal flooding or greater under the flood model's Present Day (2021) scenario.

Within the strategy area, there are approximately 140 conservation areas, designated for their special architectural and historic interest. Most of these are currently at low likelihood of tidal flooding under the Present Day (2021) scenario, although some of the conservation areas such as Sunk Island at the mouth of the Humber estuary (a historic landscape of interesting landscape character and one of the largest conservation areas in the strategy area) may experience a very significant likelihood of tidal flooding.

There are also four Registered Parks and Gardens (RPG) in the strategy area (outer estuary), designated for their specially designed landscapes. All four (two in Hull, one near Grimsby and one at Cottingham) have a low likelihood of tidal flooding.

Since the SA Scoping Report (Jacobs 2020a), Historic England has updated the Heritage at Risk Register online, which will be used, as appropriate, during the development of the strategy.

Archaeology

As described in the SA Scoping Report (Jacobs 2020a), significant palaeo-environmental and archaeological evidence has been preserved within the estuary's wetland soils. There are an ever-increasing number of archaeological finds in the strategy area.

5.4.10.2 Future baselines

The existing archaeology resource and historic environment of the strategy area is increasingly threatened by development pressures. Flood and erosion risks to archaeological and architectural assets may increase due to

climate change, through increasing waterlogging/flooding, eroding substrate, damage from wildfires or drying out buried archaeological remains that were previously preserved. Subsequent changes to heritage assets could also impact the sense of place that collections of heritage designations provide. They could also affect landscape and townscape character.

It has not been possible to consider how future tidal flood risk will affect many individual heritage features, non-designated heritage sites (including Areas of Historic Landscape Interest or buried archaeological) at this strategic level. It has also been difficult to identify assets that would benefit from rewetting, which may be adaptable and which are likely to be adversely affected by the tidal flooding. The potential changes in tidal flood likelihood to the statutory designated assets (based on the modelled flood extents under the alternative scenarios) are summarised below.

- Under a Do Nothing scenario, the majority of the statutory heritage designations would experience at least a low likelihood of flooding in the Present Day (2021), with the exception of a few locations, which would be at greater flood risk. For example, many designated sites to the west of the River Hull would have a very significant likelihood of tidal flooding. By 2046, the majority of statutory heritage sites would experience a very significant likelihood of tidal flooding, with the exception of a few locations in the outer extremities of the strategy area (such as listed buildings around Hatfield and scheduled monuments/listed buildings north of New Arram), which would have a low likelihood of tidal flooding.
- Under a Maintain scenario, by 2046, the majority of the statutory heritage sites would experience some tidal flood risk, varying from a low to very significant likelihood of flooding. The four RPGs within the strategy area would not experience any greater risk by 2046 than the current 2021 baseline. From 2046 to 2121, the extent of tidal flooding to statutory designated heritage sites increases more steadily than the Do Nothing scenario. However, by 2121, most of the designated sites would experience a very significant likelihood of flooding except for a few isolated sites (predominantly listed buildings on higher ground)
- Under a Status Quo scenario, by 2046, most designated heritage assets would have a low likelihood of tidal flooding. Between 2046 and 2071, the increase in tidal flood likelihood to the RPGs will be minimal, with only the flood likelihood to the RPG at Grimsby increasing to intermediate. However, by 2121, most heritage sites would be at a very significant likelihood of tidal flooding with the exception of a few sites that would be subject to a low likelihood (for example, listed buildings, scheduled monuments and RPGs west and north-west of Hull).
- Under a Legal Requirement scenario, the extent of tidal flooding of statutory heritage designations would increase significantly throughout the strategy area with most designated sites having a significant to very significant likelihood of flooding by 2071 (with some exceptions, for example, scheduled monuments and listed buildings to the west of the River Hull and Thwaite Hall RPG at Cottingham, which would have a low likelihood of tidal flooding).

Future trends:

- The existing archaeology resource and historic environment is increasingly threatened by development pressures and climate change effects. Sea level rise is likely to affect heritage assets and buried archaeology not already at risk of flooding and erosion. Conversely, it might aid the preservation of palaeo-environmental and archaeological features that are at risk of being dried out.
- Challenges might arise in the future from potentially conflicting legislation and policies in a need to address climate and nature emergencies, for example in selecting which heritage features to protect and/or manage in a continually changing landscape.
- While archaeological finds continue to be discovered and preserved in the strategy area (e.g. through mitigation associated with development works), there is also potential for archaeological deposits to continue to be negatively affected by urbanisation including the development of flood risk management schemes.

- Heritage can play an important role by contributing understanding of past changes in land use scale/patterns and land management and how this could benefit future sustainable farming/land management practices and adaptions to improve climate change resilience.

Strategic issues:

- The estuary and its floodplain contain a complex array of historic buildings, settlements, landscapes and archaeological sites that are a fundamental component of the regional identity and focus for education, tourism and recreation, which the Humber 2100+ Strategy must consider. The strategy should seek opportunities to support cultural identity, protect and enhance these assets, and consider maintaining access and services (including archives/museums as final repositories).
- The strategy will need to consider how sustaining or adapting to changes in landscape character (including those brought about by climate change effects such as tidal flooding as well as BNG opportunities) affects peoples' experience of heritage.
- Knowledge changes over time through new discoveries, so what is known now of the baseline might not be the same in ten years' time. Some archaeology will become rarer and then be identified as more significant that it is now. Legislation is also likely to change, and there is likely to be a broader change in approach to adaptation management and building in a framework for transformation to support decision-makers.
- How to assess potential impacts on individual or groupings of heritage assets – known or unknown - at a strategic level, with such varied impacts (some of which might benefit from rewetting, some may be adaptable, some are likely to be unsustainable) and differing appropriate responses.

5.4.11 Climate change

5.4.11.1 Present day baseline

As described in the SA Scoping Report (Jacobs 2020a), the Climate Change Act 2008 set a UK government target for reducing greenhouse emissions[14] and to make provisions for adapting to climate change risks, amongst other things. The act also establishes the framework to deliver on these requirements, as well as requiring the government to set legally-binding 'carbon budgets' to act as stepping stones towards achieving a defined 2050 target and to produce a National Adaptation Programme.

The strategy area faces a growing threat from the effects of climate change and has the second highest flood risk in the country (Hull and East Yorkshire Local Enterprise Partnership (Heylep) 2021). This was emphasised in the Yorkshire and Humber Climate Change Action Plan (Yorkshire and Humber Climate Commission 2024) which identified that the region faces a unique set of climate-related challenges including flooding, the need to decarbonise its heavy industry and the poor energy efficiency of the housing stock. It noted that those natural assets which are threatened by climate change, such as the peat stores and wetlands, also have potential to be part of the solution. The plan provides a strategic framework to help deliver the actions required to address the effects of climate change in Yorkshire and the Humber, set around four pillars of climate action: climate adaptation, rapid emissions reduction, nature restoration and a just transition.

The Present Day (2021) tidal flood risk within the strategy area is described in Section 6.2. Recent measures taken to reduce tidal flooding includes the Hessle Foreshore Tidal Defences, which reduces risk to nearly 4,500 homes in the Hessle and West Hull area, and the Humber: Hull Frontage Scheme, which upgraded the tidal flood defences along the city's estuary shoreline and reduced risk to over 28,000 homes.

There are several groups responsible for managing other sources of flooding in the study area. For example, the Living With Water partnership in Hull (comprising Hull City Council, Yorkshire Water, the Environment Agency and East Riding of Yorkshire Council) has been working to reduce flood risk in Hull through infrastructural projects at a community level (Living with Water Partnership 2024). The Energy and Environment Institute has been working with Living with Water to understand the impacts of the 2007 and 2013 floods and produced a

[14] by at least 100% of 1990 levels (net zero) by 2050; a target based on advice from the Committee on Climate Change's 2019 report, 'Net Zero – The UK's contribution to stopping global warming.'

2018 baseline of resilience to flooding in Hull and East Yorkshire (University of Hull 2020), together with carrying out a household survey that helped to understand the long-term impacts of the floods on local communities from these flood events. Also, the Doncaster, Immingham and Grimsby (DIG) surface water resilience project (by North East Lincolnshire Council, City of Doncaster Council, Anglian Water, and Yorkshire Water) focuses on using sustainable drainage systems (SuDS) within urban areas (Environment Agency 2024b), and the Connected By Water project, which is an alliance between seven organisations across wider South Yorkshire, aims to help communities to become resilient to the impacts of climate change (Connected by Water 2024). Furthermore, there are also activities from the adjacent or overlapping coastal partnerships and flood and coastal erosion strategies such as the Saltfleet to Gibraltar Point Strategy (Environment Agency 2019) and the East Riding of Yorkshire's Changing Coasts East Riding project (East Riding of Yorkshire Council 2024) that is developing approaches to support coastal communities impacted by coastal change.

The Humber also has the largest cluster of energy-intensive industries and emits more carbon dioxide than anywhere else in the UK (Heylep 2021). There is therefore a need to transition from being the highest carbon emitting industrial cluster in the UK to net zero[15] emissions, whilst maintaining the region's contribution to the UK economy. The Humber Estuary Plan (Heylep 2021), produced in 2021 and owned by the Humber Leadership Board, sets out a framework for collaboration across the Humber estuary economy, based on shared strategic opportunities including clean economic growth (i.e. '*becoming a global leader in the transition to net zero carbon emissions; driving further growth from clean energy generation and securing the long-term competitiveness of energy-intensive industries')*. This plan will be delivered in partnership with organisations across the region. The Humber Industrial Cluster Plan (UKRI *et al*. 2023) was also set up in 2021. It provides an evidence-based framework for identifying, understanding, prioritising and delivering decarbonisation measures that will enable the Humber Industrial Cluster to significantly reduce emissions by 2030 and achieve net zero by 2040, while maximising strategic opportunities to drive the green recovery.

Net zero carbon is an increasingly important driver for the Humber's Flood and Coastal Erosion Risk Management (FCERM) decisions and wider stakeholders in the region. The Environment Agency, partners and wider stakeholders have announced various decarbonisation policies, goals and climate emergency declarations in recent years. This included the Environment Agency's current roadmap for cutting carbon emissions by 45% by 2030 and to be net zero by 2045-2050 (Environment Agency 2024a). The Environment Agency has stated the desire for nature-based climate mitigation as part of their roadmap to net zero (Environment Agency 2021).

5.4.11.2 Future baselines

The climate is changing – with rising temperatures, summer rainfall is projected to decrease and winter rainfall is expected to increase. Four million people are at risk of flooding from rivers or sea in England (Environment Agency 2023b). Significant impacts from climate change are now considered inevitable, especially for flood and coastal risks, water management, freshwater wildlife and industrial regulation.

As described in Sections 4.3 and 4.4, the likelihood of flooding above 0.0m depth has been modelled against predicted sea level rise to better understand how flood risk in the strategy area may change over time and based on different baseline future scenarios. The strategy will use up-to-date climate change predictions (with consideration of extreme rainfall, river flood flows, sea level rise and storm surges) when identifying strategic options for the future management of the estuary. This will enable a programme of coordinated measures for improving climate change adaptation and community resilience in the strategy area to be developed.

Flood risk management activities have an impact on the hydrological system, which must be understood as far as possible and considered by the Humber 2100+ Strategy. Additionally, as part of the strategy, any updated flood risk management plans will be considered, such as the Humber River Basin District Flood Risk Management Plan

[15] *In simple terms, 'net zero' means our total emissions are equal to or less than the emissions we remove from the environment. This can be achieved by a combination of emission reduction and removal by offsetting. Emissions can be removed or absorbed by natural processes such as tree planting or by using technologies like carbon capture* (UK Parliament 2018).

2021 to 2027 (Environment Agency 2022b), which identifies measures to reduce the likelihood and consequences of flooding and improve resilience.

Although flood risk management helps communities to adapt to climate change effects (by reducing flood risk through defences, pumps, washlands and other assets), it can also contribute to greenhouse gas emissions through the embodied carbon associated with the operation, construction and maintenance of these assets. Flood risk management may also enable delivery of nature-based climate mitigation, such as through saltmarsh creation in managed realignment sites. The implications of how the Humber 2100+ Strategy will align with decarbonisation targets and net zero ambitions will need to be assessed.

A narrative has been produced (Jacobs 2024) for all the future baseline scenarios that includes high-level estimates of their construction 'carbon cost' (or embodied carbon) using a whole-life costing tool. This identifies which future baseline scenarios could have the greatest potential to sequester carbon through nature-based measures. Drawing upon the results of the economics model, the carbon assessment considers which scenarios have the greatest impact through the carbon saved from flood damages avoided. It also considers the carbon storage opportunities associated with managed realignment schemes (illustrated with the Outstrays to Skeffling scheme case study) and provide information on which factors to consider when designing such managed realignment schemes for carbon benefits.

A summary of the potential key issues relating to carbon under the different future baseline scenarios includes:

- The future baseline scenarios involving more capital works (such as new defences or defence-raising in the Status Quo scenario) would have greater embodied carbon emissions from construction and maintenance of the assets compared with future scenarios with no or less capital works proposed (such as the Do Nothing and Maintain scenarios).
- There will be carbon emission savings associated with flood damages avoided through reducing flood risk to properties and other assets in those scenarios where the risk is reduced the greatest (the most being under the Status Quo scenario). These benefits are from avoiding carbon emissions associated with refurbishing flooded buildings, replacing damaged furniture or equipment, repairing damaged infrastructure, energy demand from recovery (such as cleaning, drying and repairing properties and infrastructure) and rehoming or re-instating damaged properties, or travel associated with repairs, replacement and damage assessments.

There are strategic implications for carbon from the potential impacts of 'water on land' and changes in water levels under the different future baselines, including:

- The potential carbon emissions associated with any drainage activities, such as fuel used in temporary pumping during flood events or permanent pumping. The emissions associated with temporary pumping are likely to be greatest in the scenarios with the greatest likelihoods of tidal flooding (i.e. the Do Nothing and Legal Requirement scenarios).
- The Status Quo scenario is the only future baseline scenario that includes an agreed, proactive programme for the managed realignment of defences that delivers strategic intertidal habitat creation schemes. This therefore creates more opportunities to deliver nature-based climate mitigation as part of habitat creation schemes, such as creating saltmarsh habitat to capture and store carbon.
- It is uncertain whether there would be any opportunities for potential changes in habitats and land use under the Do Nothing, Legal Requirement and Maintain scenarios to capture and store more carbon than Present Day conditions from floodwaters remaining on land and, for example, by creating 'unintentional/unplanned' flood storage and managed realignment sites.
- The presence of peat in the strategy area may present an opportunity to support the restoration of damaged peatland (such as through re-wetting), which may reduce a significant source of greenhouse gas emissions, or support healthy peatlands acting as carbon sinks.
- The salinity gradients and water quality of estuaries can affect the greenhouse gas dynamics of wetlands (Ho *et al*., 2024). Any siting of coastal wetland sites designed for carbon storage benefits would need to

prioritise where there are saline conditions around the estuary over freshwater conditions to minimise the release of greenhouse gases, such as methane.

These will be considered further as part of the carbon assessment work.

Future trends:

- Climate change predictions show that temperatures will continue to rise, winter rainfall will increase, more rain will fall in intense storms and sea level rise will continue. This is predicted to result in increased flooding and foreshore erosion, which without coordinated flood risk management activities, would lead to the existing defences being breached or overtopped and the large low-lying areas behind the defences being inundated more frequently (as shown by the Do Nothing scenario in Section 5.3.)
- The increased risk of flooding under the future baseline scenarios will increase pressure on land not at risk of flooding for future development.
- Whilst greenhouse gas emissions are continuing to grow, government targets indicate significant cuts in these emissions by 2030 and the objective to be net zero by 2045-2050.
- The Humber is well positioned to continue scaling up alternative fuels and renewable energy sources to reduce carbon emissions while continual improvements in rail and inland waterway infrastructure may help reduce emissions from the road network. The Humber is also addressing carbon reduction through development of retrofitting programmes that ensure homes can support the carbon neutrality goals of the Humber Estuary Plan (Heylep 2021).

Strategic issues:

- The strategy will consider how to help communities (and ecosystems) to adapt to climate change effects (sea level rise, storm events, extreme weather). Monitoring change within the Humber estuary will play an important role in understanding the impacts of climate change.
- The embodied carbon of the strategy proposals, potential for nature-based climate mitigation measures (such as carbon stored by saltmarsh in managed realignment sites) and alignment with net zero ambitions will be assessed to help select a sustainable approach to flood risk management.

5.4.12 Waste and contaminated land

5.4.12.1 Present day baseline

Data reviewed since the SA Scoping Report (Jacobs 2020a) indicates there are over 250 historic landfill sites and over 30 active landfill sites (permitted waste sites) and known or potential contaminated land sites, as well as other waste management and disposal facilities within the strategy area. Land that is contaminated includes any historical land use that may have given rise to environmental contaminants or where intense industrial activity, or landfilling has occurred. Most of these sites are currently at a low likelihood of flooding (2021 baseline).

The landfill sites cover all types of waste, including inert waste, industrial waste, commercial waste, household waste, special waste and liquid and sludge, and together with waste management facilities have potential to cause water pollution related issues.

5.4.12.2 Future trends

The effects of climate change including rising sea levels and extreme weather will result in an increasing likelihood of flooding of historic and active landfills, areas of known or potential contaminated land and made ground. Flooding of these sites presents an increasing pollution risk to the surrounding environment, with associated impacts on water quality, aesthetics, human health and ecology including designated sites. There is also the potential for tidal flood risk under future baseline scenarios to cause erosion and pollution pathways

that expose unknown or buried contaminants. Any proposed developments, such as FCERM schemes, that may disturb landfill sites and contaminated land will need managing at a project level.

It is not possible to consider the tidal flood likelihood changes to individual sites at this strategic level. However, the key changes in flood likelihood to landfills or land that is potentially contaminated (based on the modelled tidal flood extents under the future baseline scenarios) are summarised below:

- Under a Do Nothing scenario, the majority of the landfill sites would experience at least a low likelihood of tidal flooding. However, in a few locations, there would be a greater tidal flood risk to landfills, such as those historic landfill sites to the west of the River Hull, which would have a very significant likelihood of flooding. By 2046, the majority of landfill/known contaminated sites would experience a very significant likelihood of tidal flooding, with the exception of a few locations. These exceptions include landfills in the outer extremities of the strategy area (e.g. northern end of the River Hull), which would have a low likelihood of flooding until 2071 (when most, if not all landfills would experience a very significant likelihood of tidal flooding).
- Under a Maintain scenario, by 2046, the majority of the landfill sites would experience some tidal flood risk, varying from a low to very significant likelihood of flooding. From 2046 to 2121, the extent of tidal flooding to landfills and known contaminated sites increases more steadily than the Do Nothing scenario. By 2121, most of the landfills and contaminated sites would experience a very significant likelihood of tidal flooding except in a few isolated locations (e.g. around Cleethorpes and areas north of Stockbridge).
- Under a Status Quo scenario, by 2046, most landfills/contaminated sites would have a low likelihood of flooding. Between 2046 and 2071, the increase in flood likelihood to the landfills/contaminated sites would be minimal. By 2121, most landfills/contaminated sites would be at a very significant likelihood of tidal flooding with the exception of a few locations that would be subject to a low likelihood (for example, landfills around Hatfield and north-west of Hull).
- Under a Legal Requirement scenario, the extent of tidal flooding of landfills/contaminated sites would increase significantly throughout the strategy area with most sites having a significant to very significant likelihood of tidal flooding by 2071 (with some exceptions, for example, landfills to the west of the River Hull, which would have a low likelihood).

Strategic issues:

- Consideration must be given to the location of waste management facilities including active and historic landfill sites, contaminated land sites, incineration/thermal treatment sites and hazardous waste treatment facilities when assessing strategy options to identify potential impacts of flood risk and works on soil and water pollution.
- Potential opportunities in terms of land remediation may be identified in the strategy where these coincide with strategy proposals.
- Any opportunities for a strategic approach to minimising any waste and materials should be encouraged.

5.4.13 Consideration of cumulative effects

Cumulative effects can be effects resulting from incremental changes caused by current or reasonably foreseeable activities, developments or plans together with the strategy (i.e. multiple projects/plans acting in combination). To assess the cumulative effects of strategic options, the long-term development plans of Humber 2100+ partnership members have informed the modelled future baselines.

The identification and assessment of the cumulative effects of other plans, programmes, strategies and ongoing or planned developments within the strategy area will be undertaken throughout the development of the strategy and aligned with future and planned development (as described in other sections of this report). Such cumulative effects will include consideration of longevity/permanency of effects, their duration and recovery timescales where appropriate.

The potential issues that will be scoped into the 'cumulative effects and inter-relationships' assessment of the strategy are:

- In-combination or interrelationships between a single or group of environmental receptors arising from different aspects of the strategy within the strategy area (also referred to as intra-strategy effects).
- Cumulative effects (i.e. combined environmental effects) arising between the strategy and other developments in the strategy area that may overlap spatially or temporally.

6. Review of proposed assessment framework and methodology

6.1 Introduction

This chapter reviews the proposed approach to the SA. It considers the assessment framework described in the SA Scoping Report (Jacobs 2020a) in the context of the current proposals for the development of Humber 2100+. It also considers any implications relating to the 'adaptation pathways' approach that the strategy is expected to take.

6.2 Previous approach to the SA

The SA Scoping Report set out an assessment framework to be used as part of the wider integrated multi-stage decision-making process for Humber 2100+. This assessment framework was divided into social, economic and environmental themes and was informed by consultation on the SA Scoping Report. The original assessment framework enabled the likely effects of Humber 2100+ to be assessed and measured by setting out the objectives of the SA assessment, together with the decision-making criteria and indicators to be used in the assessment.

The original SA Scoping Report anticipated that there would be two main parts to the Humber Strategy. A detailed strategic approach for the first time period (around 25 years) would be followed by a less detailed approach for the remainder of the strategy (up to 2121), which would set out update requirements. Whilst the SA would consider the full duration of the strategy, the SA would include more detail during the first time period, due to greater certainty associated with the impacts of the detailed strategic approach, in terms of baseline data, impact assessment, mitigation, enhancement and monitoring.

The previous approach to the SA is outlined in the SA Scoping Report (Jacobs 2020a). This includes details of the assessment framework, the methodology for evaluating alternatives and assessing cumulative effects, as well as its interactions with other assessments.

6.3 Current status and future development of Humber 2100+

Since the preparation of the SA Scoping Report, the Environment Agency's National FCERM Strategy for England (Environment Agency 2020) promotes adaptation pathways as a way of enabling local places to better plan for future flooding and coastal change and adapt to future climate hazards. Planning for an uncertain future requires a holistic process. The development of the pathways as sequences of actions to manage risk, sits within the wider context of governance arrangements, balancing national and local priorities, funding, implementing the plan and monitoring and evaluating the plan. This holistic Adaptation Pathway Planning (APP) process is illustrated in Figure 6.1 (a version of the British Standard 8631 'wheel'), which emphasises the central role of stakeholders at all stages.

Figure 6.1: Adaptation Planning Process Wheel (adapted from British Standard 8631:2021)

Stakeholder engagement is integral to the SA process. As well as raising awareness of tidal flood risk, engagement will help to improve decision-making by ensuring that views and concerns are demonstrably considered and conflicts resolved at an early stage. Stakeholder engagement will help gather information to inform strategy development, form partnerships and ensure that the strategy influences inter-related decisions and plans.

Adaptation pathways are most useful where there is significant uncertainty in the direction or timing of future changes. Rather than emphasising the flexibility of future choices, in the context of local planning, it may be more appropriate to use pathways to identify choices that are robust to future shocks and stresses and that avoid maladaptation (i.e. avoiding adaptations to climate change that worsen the effects of tidal flood risk in the strategy area).

The Environment Agency, working with partner organisations, is developing a Humber Adaptation Pathways (HAP) process and framework to manage tidal flood risk within the Humber estuary. This approach will support the development of adaptation pathways to include in Humber 2100+.

Following an initial 'discovery' phase, the 'design' phase of HAP will shape what data, modelling and evidence is needed to implement the adaptation pathways process. Two of the biggest requirements, which will be integrated and aligned with the SA, include:

1. Through existing work and stakeholder engagement, develop a regional vision and understand values which can translate into local objectives and criteria for choosing flood risk management actions and pathways, and that appropriately integrates SA requirements. Overall, this can be termed a decision support framework.
2. Use of available evidence and local expertise to start developing plausible combinations (spatially and temporally) of flood risk management actions which can be tested using a region-wide model to appraise their benefits.

As further work will be needed to identify how the SA assessment framework will align with the adaptation pathways approach, this review of the assessment framework is limited to:

- An initial review of the original assessment framework to identify the type of actions needed to ensure that it reflects the current understanding of relevant environmental, social and economic criteria, indicators and monitoring information.
- Identification of additional considerations that could form part of a future decision support framework, incorporating a revised assessment framework. This is to ensure sustainability informs future decisions for tidal flood risk management in the Humber. The SA/SEA (alongside economic and technical feasibility assessments) will be an integral part of the decision support framework.

6.4 Future considerations for the assessment framework

Following the review of present and future baselines described in Chapter 5, the scope of the topics and the content of the proposed assessment framework largely remain valid. However, some minor amendments or updates will be required (in discussion with the Humber 2100+ partnership members) to reflect the baseline information that has been collated to prepare this addendum, as outlined below:

- Requirement for new criteria to cover 'changes in baseline and legislation', such as those relating to BNG;
- Need to modify some criteria that are not now considered to be of sufficient strategic importance to influence decision-making, such as the inclusion of children's play areas as receptors;
- Need to modify some indicators to cover 'changes in baseline and legislation'. For example, new indicators to cover new or extended designated conservation sites, and removal of indicators that are not present within the strategy area, such as National Landscape Areas (formerly AONBs);
- Terminology updates such as replacing Natura 2000 sites with Habitats sites, and AONBs to National Landscape areas, etc;

- Review of objectives to ensure these fully reflect the strategic issues and opportunities identified within this addendum; and
- Updates to Outcome Measures (e.g. OM4) to reflect updates to national FCERM Appraisal Guidance.

The updated objectives, criteria and indicators will also need reviewing to ensure or retain flexibility in their wording so that they can accommodate future changes in baseline conditions through the SA process.

Further work, in consultation with Humber 2100+ partnership members, is needed to determine how the values that will guide the overall adaptation pathway framework and the objectives and criteria to be used to decide between FRM actions and pathways will comfortably align and overlap with the processes of SA and SEA as part of a future decision support framework. This process will also need to ensure that robust consideration of reasonable alternatives is undertaken and allow for the consideration of secondary and cumulative effects.

Further consideration about how to integrate the SA into future steps of the strategy development will be needed. The SA (incorporating SEA), which will help to support the adaptation pathway process, will be carried out as a systematic, iterative process, with SA being embedded into the decision-making process rather than as a separate process. The SA will facilitate early and continued involvement of stakeholders to ensure that their feedback that can inform the strategy's development. This will include engagement on the impact and opportunities of future options and pathways.

In addition to the requirements of the FCERM appraisal guidance, those separate, but interlinked, environmental processes described in Section 3.3 will be built into the decision support framework incorporating the SA requirements. These include assessments to ensure compliance with statutory requirements, such as the Habitats Regulations, WER Regulations and Equality Act, as well as consideration of carbon, natural capital and strategic opportunities for delivering BNG.

7. Next steps

Following the stakeholder consultation in January 2025, the next steps in the SA process are likely to include:

- Preparation of a final version of this addendum, taking consultation feedback into account, which will help set the context for the future progression of the SA through Step 2 and beyond, of the development of Humber 2100+.
- Review of the objectives for Humber 2100+ (including the SA objectives), to take account of the strategic issues and opportunities identified within this addendum across the social, economic and environmental themes.
- Review and updating of the assessment framework to reflect the recommendations of this addendum. Then, in line with the next steps of Humber 2100+, identification of how this forms part of an integrated Decision Support Framework for the appraisal and selection of flood risk management measures; aligned with the Humber 2100+ Adaptation Pathway approach. Key aspects to be determined relevant to the SA will include:
    - How to embed the SA assessment within the context of the wider Decision Support Framework;
    - Whether to apply the SA framework to individual flood cells to understand changes under the alternative scenarios and in each epoch to inform when and where FRM decisions are required (from an environmental, social and economic perspective);
    - Whether to assign and agree flood likelihood thresholds for individual environmental and social receptors/indicators (with consideration of those assets with statutory importance), at which point those receptors would likely experience a significant change; and
    - What requires monitoring in the strategy area to inform future decision-making and how best to monitor and manage change in the strategy area together with thresholds for adaptation and action.
- Ongoing consultation and engagement with the Humber 2100+ partnership members, statutory bodies and key stakeholders to inform the development of the approach to Humber 2100+ and its SA.

Throughout the future steps of the development of Humber 2100+, the Environment Agency will ensure that the requirements of the SA and SEA processes, including other statutory requirements, are fully integrated into strategy development while seeking to bring about positive and sustainable environment change and outcomes in the strategy area.

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Appendix A. Technical note: Humber 2100+ Sustainability Appraisal scoping report addendum: data for inclusion (as consulted on)

Humber 2100+ Sustainability Appraisal scoping report addendum: data for inclusion

Date:	30/04/24
Project name:	Humber 2100+ Strategy
Project no:	692947CH
Attention:	Nick Pedder
Company:	Environment Agency
Prepared by:	CM
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Document no:	ENV0000300C-CH2-ZZ-3A0-RP-EN-0032
Revision no:	01
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1. Introduction

As part of the ongoing development of the Humber 2100+ (H2100+) Strategy (and associated development of an addendum to the 2018 Sustainability Appraisal (SA) Scoping Report), topic-specific baseline 'consequence narratives' (hereafter referred to as narratives) are being prepared. These narratives will:

- summarise present-day baseline conditions and key receptors within the H2100+ Strategy area (see Figure 1.1); and
- set out future trends for key receptors within the strategy area over time within the Strategy period.

Separate narratives will be prepared for each of the five future baseline scenarios being considered at the current step of Strategy development, which will describe how the future of tidal flood risk management *could* evolve over the next 100 years unless we do something different. The narratives will be based on visual interpretation of GIS data layers, modelling outputs, receptor data and an understanding of the planning/policy context background. Where appropriate, spatial receptor datasets will be mapped using a GIS viewer, as outlined in Table 2.1.

This technical note has been prepared to present the key data sources (see Section 2) that will be used to inform the narratives and enable review of the proposed approach by project partners. Additionally, this technical note describes the data that will not be included in the narratives together with a justification.

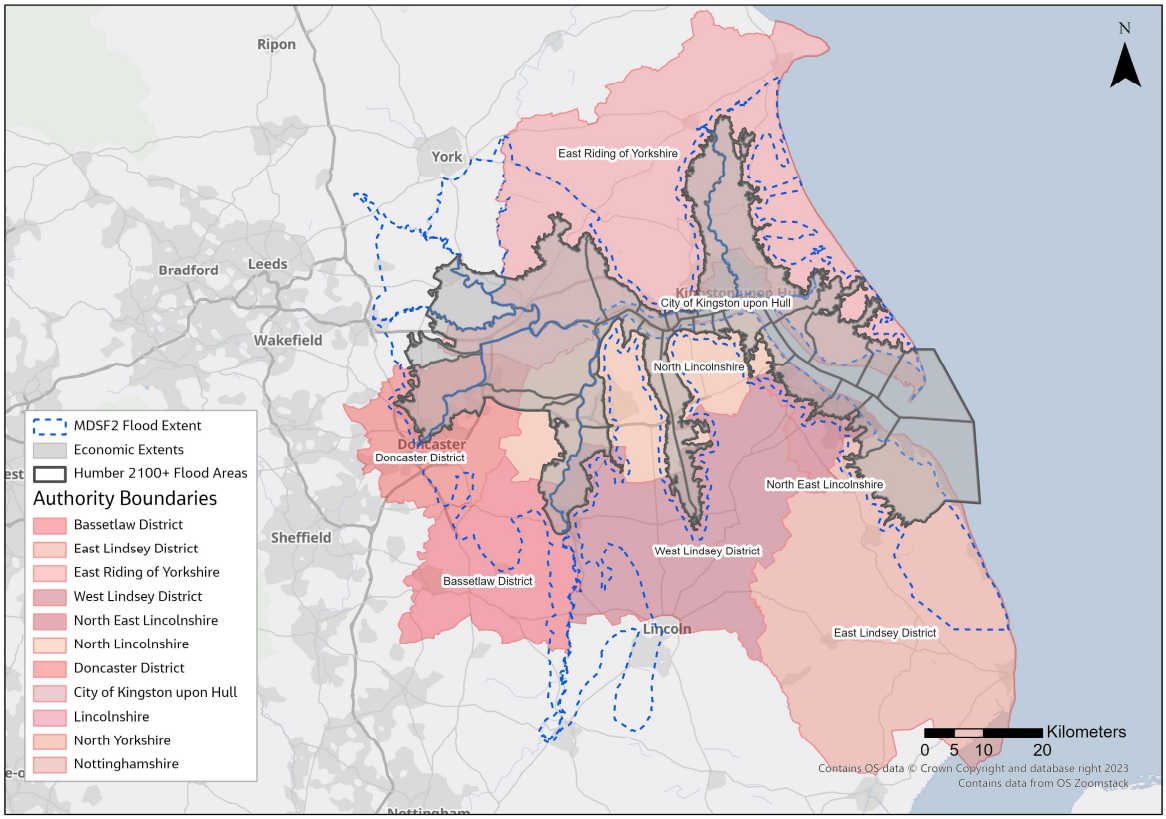

Figure 1.1: H2100+ Strategy area (comprising the H2100+ flood areas) in black, overlying the local authority boundaries and modelled extents (in blue)[16].

2. Data sources for narratives

Table 2.1 describes the data sources that are proposed to be used to inform the narratives (subject to agreement), which comprise a combination of freely available web-based data sourced by Jacobs and datasets sourced by the Environment Agency from local authorities/partners and external organisations. In particular, Table 2.1:

- outlines the key data sources that will be used to build on the environmental, social and economic baseline presented in the 2018 SA Scoping Report, to define narratives for the following specific topics to enable an understanding of likely future changes in the H2100+ Strategy area:
    - population and human health
    - access and recreation
    - economic activity
    - rural land use and economy
    - material assets

[16] The outer MDSF2 (modelling and decision support framework) boundary is the maximum possible extent of modelling that will be undertaken to understand flood risk within the tidally-dominated areas of the H2100+ strategy area, shown by the black H2100+ Flood Cells. Collecting data within this largest extent ensures that no wider data need be collected in the future, regardless of which Do Something options are considered.

    - biodiversity
    - water
    - geomorphology
    - landscape
    - cultural heritage and archaeology
    - climate change
    - waste and contaminated land
    - cumulative effects

- summarises how we propose to present the data in the narratives i.e. through qualitative descriptions and/or through visual representation.

Natural capital data will also be collated through the Natural Capital Register and Account Tool (NCRAT) and used within the narratives as appropriate and relevant. Similarly the risks and opportunities associated with carbon sequestration will be produced for the Future Baseline scenarios and used within the narratives as appropriate. Both natural capital and carbon baselines will be linked to the relevant specific topics outlined above.

3. Data limitations

We are grateful to all local authorities who supplied data layers to inform the strategy development and specifically the narratives, however, some data sets and sources identified and provided by the local authorities are not proposed to be used, either because:

- datasets are not available, data gaps exist (e.g. spatially or temporally limited) or there are inconsistencies in the data received; and/or
- the data is not at the appropriate scale to influence strategic and high-level flood risk management planning; and/or
- the data does not help assess changes to the environmental topics or flood risk in the strategy area over different scenarios and time periods.

Some of these excluded datasets are instead likely to be collated through desk-based assessment or survey as part of any future individual scheme development.

The baseline data to be excluded from the narratives are:

- Population and human health
    - Community facilities such as cemeteries/churchyards, places of worship, care homes and allotments
    - Baseline noise and vibration
    - Air quality including Air Quality Management Areas
    - Health of population
- Rural land use and economy
    - Geology and soils
    - Agri-environment schemes
- Material assets

    - Wharfs
- Biodiversity
    - Individual, protected, rare, invasive or notable species
    - Farmland bird populations
- Water
    - Details of small-scale drainage systems.
    - Abstraction and discharge licences
    - Pollution incidents
- Landscape and visual amenity
    - Local landscape designations – will exclude locally designated landscapes including Areas of Landscape Importance (we have not received datasets from all local authorities).
    - Visual amenity
- Cultural heritage and archaeology
    - Non-designated heritage sites including Areas of Historic Landscape Interest
- Waste and contaminated land
    - Known areas of contaminated land (we have not received datasets from all local authorities). However, we will include point data as defined in Table 2.1.
- Cumulative effects
    - Cumulative effects of small-scale developments, due to the strategic nature of the study.

Table 2.1: Key data sources for use in narratives

Topic	Scoped in to narratives	Aspect/receptor - baseline	Source (where cited)	Data use in narratives (output for SA Scoping Report Addendum)	What will be shown on maps?
Population & human health *Place and communities*	Population and properties within flood and erosion risk areas. Socially deprived communities whose quality of life may be affected by flood risk management.	Number of residential and commercial properties at flood and erosion risk	National receptor database (NRD)	Data will be presented qualitatively to summarise the properties at flood risk and to provide an understanding of changes over time to people, property and settlements (including connectivity between settlements) in the strategy area.	Flood (flood zone/local flood risk areas will be mapped on an OS baseline, together with built up area polygons.
		Population and demography within flood and erosion risk areas – age distribution and structure of population	Office of National Statistics (ONS) - Census data		None
		Social deprivation – socially vulnerable areas or areas of deprivation (Most Deprived Areas)	Indices of Multiple Deprivation (IMD)	Data will be presented qualitatively to identify geographical areas that are deprived or socially vulnerable, and how they may change over time with consideration of flood and erosion risk.	None
		Neighbourhood Plan Areas	Local authorities on-line	These plans will be considered qualitatively in the context of the Strategy to identify how they can complement each other as well as to capture potential conflicts in the Strategy area.	None
Access and recreation	Access to the countryside via rights of way and cycle routes and recreation destinations that may be affected by flood risk management decisions or pedestrian access to coast that	Public Rights of Way, National Cycle Routes, and National Trail. Regional routes. England Coast Path. Informal access to coast and estuary	Local authorities (definitive rights of way maps) Sustrans National Cycle Network (Open Data (arcgis.com)	Access routes will be described and consideration given to access, connectivity and community severance changes that may occur in the Strategy area, as well as future requirements to maintain and improve access.	The England Coast Path, National Trails and Sustrans National Cycle Network will be mapped.

Topic	Scoped in to narratives	Aspect/receptor - baseline	Source (where cited)	Data use in narratives (output for SA Scoping Report Addendum)	What will be shown on maps?
	may be affected by flood risk management decisions. Green infrastructure that may be affected by flood risk management decisions.				The Public Right of Way network will not be mapped.
		Open space/green space/natural and semi-natural open spaces/protected open spaces	Ordnance Survey open green space data Open access land (CRoW Act 2000 - Open Access Mapping Areas - data.gov.uk)	Ordnance Survey open green space data will be used to describe these areas and consideration given to how they may change in the future.	Open spaces/access will be mapped.
		Strategic Green Infrastructure	Humber Landscape and Green Infrastructure Study (Cambridge Studios (Sheils Flynn)) Natural England Green Infrastructure Mapping Project Natural England - Yorkshire and the Humber Green Infrastructure Mapping Project (nationalarchives.gov.uk)	Strategic green infrastructure will be described with consideration of changing flood risk to these sites, and the opportunities they provide.	Reference to mapping or reproduction of the maps in the 2018 SA Scoping Report only.
		Key visitor and tourist destinations (including nature reserves, country parks, coastal paths, and seaside resorts)	Sheils Flynn report Recreational visitor data (ORVal)	These sites will be described together with potential future changes to existing, proposed or new tourist and visitor attractions and education opportunities.	Key visitor destination location were mapped as part of the Humber Integrated Landscape and Investment Study (Cambridge Studios (Sheils Flynn), unpublished), and these

Topic	Scoped in to narratives	Aspect/receptor - baseline	Source (where cited)	Data use in narratives (output for SA Scoping Report Addendum)	What will be shown on maps?
					will be referenced or reproduced in the narratives.
		Angling – key locations	Available on-line sources	The locations of known good angling spots in the Strategy area will be described with consideration of how they may be affected by changes in flood risk including changes to water levels and access to designated fishing areas.	None
Economic activity	Existing and proposed housing, industry, commercial and economic activities as well as tourist, recreational and amenity resources that may be affected by flood and coastal management decisions.	Economic sectors – composition and structure of economic sectors (e.g. manufacturing, shipping and logistics, agriculture and fisheries) in Strategy area	ONS	Data will be presented qualitatively to describe the baseline and future changes in the local and wider economy of the Strategy area.	None
		Employment – employment and unemployment rates associated with different sectors	ONS	Data will be presented qualitatively to provide an understanding of how employment rates compare to the national average and how they are changing in the Strategy area with consideration of flood risk changes.	None
		Employment policy areas or sites/employment allocations	Local authorities	Current employment sites and future sites allocated for employment through Local Plans or Core Strategies policies will be presented qualitatively together with associated changes in economic growth. Consideration will be given to how changes in flood risk could influence the viability of these areas.	Areas identified by local authorities for employment allocations will be mapped, where appropriate

Topic	Scoped in to narratives	Aspect/receptor - baseline	Source (where cited)	Data use in narratives (output for SA Scoping Report Addendum)	What will be shown on maps?
		Proposed development zone/development sites	Local authorities	Current development sites and sites allocated for future land uses such as retail, open spaces, and traveller sites through Local Plans or Core Strategies will be presented qualitatively together with associated changes in economic growth. Consideration will be given to how changes in flood risk could influence the viability of these areas.	Areas identified by local authorities for development sites will be mapped, where appropriate
		Visitor economy (associated with tourist and recreation attractions)	On-line sources	Data will be presented qualitatively to provide an understanding of how the tourist and recreation sector, which contributes to visitor economy may change.	None
		Strategic economic partnerships – Local Economic Partnerships (LEPs) (including Humber Enterprise Zone)	On-line sources	A description will be provided of important strategic economic partnerships and plans for economic growth, together with how these could be affected by changes in flood risk.	None
		Housing allocations/future residential development	Local authorities	Sites allocated for future housing through Local Plans or Core Strategies will be presented qualitatively together with associated changes in economic growth. Consideration will be given to how changes in flood risk could influence the viability of these areas.	Areas identified by local authorities for housing allocations will be mapped, where appropriate
		Spatial planning and development policies	Local development plans	Data will be presented qualitatively to provide an understanding of how development and the local/wider	None

Topic	Scoped in to narratives	Aspect/receptor - baseline	Source (where cited)	Data use in narratives (output for SA Scoping Report Addendum)	What will be shown on maps?
				economy may change over time, with consideration of changing flood risk.	
Rural land use and economy	Grade 1 and 2 agricultural land that may be affected by flood risk management decisions. Issues and opportunities linked to agricultural land-use, including soil erosion or loss of top soil.	Land use classification	ONS - census	Data will be presented qualitatively to describe the distribution of high value agricultural land and land productivity, and future trends, as well as identify opportunities for flood risk management solutions or adoption of environmental stewardship practices.	The distribution of agricultural land classification will be mapped.
		Agricultural land classification (Grades 1 and 2) and farming	OGL		
	Commercial fisheries	Fisheries	On-line sources: - Annual volumes of fish landings (MMO annual report) Annual volumes of shellfish landings (MMO annual report)	Data will be presented qualitatively to describe commercial fisheries within the estuary and how these may change over time with consideration of flood risk.	None
	Rural economy	Defra aggregate agricultural accounts	On-line sources	Data will be presented qualitatively to describe the state of the agricultural economy and bioeconomy and future trends with consideration of flood risk.	None
Material assets	Critical infrastructure (CAT 3-5) that may be affected by Strategy, including transport networks. Navigation routes that may be affected by Strategy. [Mineral and extraction sites and landfills/contaminate land are	Transport – road, rail, navigation/port/shipping	Ordnance survey (OS) maps	The spatial distribution of key infrastructure will be presented qualitatively to provide an understanding of flood and erosion risk to the operation and maintenance of existing and proposed critical infrastructure. Major transport connections, hospitals, power stations and utilities will be described, together with how the	Strategic transport routes (road, rail network including railway stations, and location of port areas) and known industrial clusters/key infrastructure including sites within the Humber Enterprise Zone will be mapped where available.
		Humber Enterprise Zone	Humber Local Enterprise Partnership NRD		
		Hospitals, power stations and utilities (including emergency service assets, water and waste water treatment assets, cooling for energy generation and any	Ordnance survey mapping and open source data		

Topic	Scoped in to narratives	Aspect/receptor - baseline	Source (where cited)	Data use in narratives (output for SA Scoping Report Addendum)	What will be shown on maps?
	covered under 'Waste and contaminated land' below]	offshore wind infrastructure, as appropriate)		viability and operation (and maintenance) of strategic transport infrastructure and existing and proposed power stations and other critical infrastructure in the strategy area may change over time. Navigation routes will be described but not mapped.	
		Chemical and petrochemical and oil refineries	On-line sources Humber Local Enterprise Partnership	The distribution of refineries will be described with consideration of future changes to the operation and maintenance of existing and proposed refineries.	None
Biodiversity	International (Ramsar, SPA and SAC), national (SSSI, NNR) and local conservation sites, and non-statutory designated features may be affected by flooding and defence intervention and/or by coastal squeeze.	Statutory designated sites – Natura 2000, Ramsar, SSSI, NNR, LNR – conservation/condition status and threats/pressures on these sites.	Natural England	Statutory conservation sites and future baseline changes to these sites will be described, with consideration of changing statutory requirements.	Statutory conservation sites will be mapped.
		Non-statutory designated features – county wildlife sites, local wildlife sites, SINCs, Wildlife Trust nature reserves, community forests, other nature reserves (including RSPB Reserves), peat (presence and condition) and key wildlife corridors. Natura 2000 habitat compensation areas	Natural England Local authorities LWS from EA Wildlife Trusts	Non-statutory wildlife sites and future baseline changes to these sites will be described, with consideration of changing statutory requirements.	Non-designated wildlife sites will be mapped. Non-designated wildlife features will not be mapped. [It should be noted that the data set will need future review as local

Topic	Scoped in to narratives	Aspect/receptor - baseline	Source (where cited)	Data use in narratives (output for SA Scoping Report Addendum)	What will be shown on maps?
					authorities may designate new sites at any time].
	Priority habitats and species known to be found within the study area (based on available information).	Habitats of principal importance (NERC Act), protected species including fish and eels (migratory routes, nursery and spawning sites)	Open source data Environment Agency	A qualitative description of habitats of principal importance, key species and other nature conservation receptors will be provided, together with any future baseline changes and opportunities for creating and strengthening habitats.	Priority habitats will be mapped (priority and protected species will not be mapped).
Water	WFD waterbodies that may be affected by the Strategy.	River network Water Framework Directive (WFD) waterbodies and classifications/objectives , water quality – River Basin Management Plan (RBMP), WFD protected areas	Environment Agency Catchment explorer (Cycle 2)	These receptors will be described quantitatively with consideration of future baseline changes to the water environment and future opportunities to deliver mitigation measures to help achieve good status in the WFD waterbodies.	WFD classified waterbodies (surface and groundwater), Nitrate Vulnerable Zones and Source Protection Zones will be mapped.
		Nitrate vulnerable zones (NVZ) Groundwater Source Protection Zones (SPZs) Groundwater and Drinking Water Safeguard Zones (SGZ) Catchment partnerships	Environment Agency		
Geomorphology	Geomorphology of the estuary and rivers that could be affected by flood risk management decisions.	Morphological form	On-line data sources/Environment Agency	Data will be presented qualitatively to summarise existing morphological form and physical processes operating in the Humber estuary together with potential future changes to its evolution.	None
		Physical processes – sea level rise; waves, tides and freshwater flows; tidal influence; suspended sediment levels	On-line data sources/Environment Agency		

Topic	Scoped in to narratives	Aspect/receptor - baseline	Source (where cited)	Data use in narratives (output for SA Scoping Report Addendum)	What will be shown on maps?
Landscape	Landscape character areas, local character and Heritage Coast that could be significantly affected by flood risk management decisions.	Landscape character – national character areas, local landscape character areas	OGL, Local authorities	Data will be presented qualitatively to summarise existing character and quality of townscapes, landscapes and seascapes, and future baseline changes with consideration of flood risk.	National landscape character areas will be mapped
		National landscape designations – Spurn Heritage Coast and Lincolnshire Wolds national landscape (former AONB).	Local authorities Natural England	Data will be presented qualitatively to describe nationally designated landscapes, and future baseline changes with consideration of changing flood risk and sea level rise.	National landscape designations will be mapped
		Other studies: Humber Estuary and Green Infrastructure Study Report; agri-environment schemes	Humber Landscape and Green Infrastructure Study (Cambridge Studios (Sheils Flynn)) Defra	These studies will be described to provide a strategic context against which baseline changes can be discussed.	None
Cultural heritage and archaeology	Known designated assets and their settings including scheduled monuments, listed buildings, Registered Parks and Gardens, conservation areas and the potential for 'unknown' or buried archaeological remains within study area that may be affected by flood risk management decisions.	Historical overview	On-line data sources and existing studies	A historic overview will be provided of the historical context of the Strategy area, which may be subject to change over time.	None
		Statutory designations - scheduled monuments, listed buildings	Historic England	Data will be presented qualitatively to provide an understanding of the statutory designations in the Strategy area and how these heritage assets (including management, maintenance and enhancement) may change in the future.	Heritage assets (as defined by the National Planning Policy Framework) will be mapped.
		Statutory designations – registered parks and gardens	Local authorities		
		Statutory designations - conservation areas	Local authorities		

Topic	Scoped in to narratives	Aspect/receptor - baseline	Source (where cited)	Data use in narratives (output for SA Scoping Report Addendum)	What will be shown on maps?
	Known non-designated sites, where information is available from local authorities.	Rapid Coastal Zone Assessment (RCZA) – key areas of archaeological importance	Historic England	The present day and future archaeological resource and potential of the Strategy area will be described.	A map of archaeological potential may be reproduced from the Humber Landscape and Green Investment Study. The RCZA will be reviewed during the narrative preparation to determine if there are any strategically important datasets to map.
		Archaeology – significant palaeo-environmental and archaeological evidence.	Historic England Local authorities Humber Landscape and Green Investment Study		
Climate change	Climate change predictions and sea level rise Sustainability	Climate and climate change adaptation/resilience Flood risk and predicted sea level rise	On-line data sources	A qualitative description will be provided of how climate change is affecting flood water levels and sea level rise, and how these changes affect other receptors including local communities (see 'Population and human health').	Flood risk will be mapped (see 'Population and human health')..
Waste and contaminated land	Current or historic landfill sites and contaminated land may be affected by flood and coastal management decisions, positively (remediation) or negatively (flooding and water pollution). Current and safeguarded mineral extraction areas that may be affected by flood risk management activities.	Known historic landfills Active authorised landfills	Government Defra data source	Current and historic landfill sites and areas of known contaminated land will be described together with how these sites may change over time, both positively (remediation) and negatively (flooding, erosion and soil/water pollution).	Known historic landfill sites and permitted authorised landfill sites will be mapped
		Known/potential contaminated land/brownfield sites	Part 2a contaminated land and brownfield data (pre- March 2019) from Environment Agency		Point locations of contaminated land will be mapped (polygon areas will not be mapped)

Topic	Scoped in to narratives	Aspect/receptor - baseline	Source (where cited)	Data use in narratives (output for SA Scoping Report Addendum)	What will be shown on maps?
Cumulative effects and evolution of baseline	Inter-relationships between topics where relevant i.e. where strategic options give rise to the potential for secondary or indirect effects. Synergistic effects. Cumulative effects from other proposed developments at a high level. Evolution of baseline in absence of Strategy	Existing plans, programmes, strategies and ongoing or approved future development proposals	Local plans Marine Management Organisation Public Register	A qualitative description will be provided of existing and future inter-relationships between topics where relevant and cumulative effects from other proposed developments at a high level that have the potential to affect future flood risk management decision-making.	None