MOTT MACDONALD

Environmental Appraisal Report (RAPID Gate Two)

South Lincolnshire Reservoir

November 2022

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Acronyms and Abbreviations

AA	Appropriate Assessment
AC	Alternating Current
ACWG	All Company Working Group
ALC	Agricultural Land Classification
AOD	Above Ordnance Datum
AONB	Area of Outstanding Natural Beauty
AQMA	Air Quality Management Areas
AWTP	Advanced Water Treatment Plant
BAP	Biodiversity Action Plan
BEIS	Department for Business, Energy and Industrial Strategy
BMV	Best and Most Versatile
BNG	Biodiversity Net Gain
BU	Biodiversity Units
CEMP	Construction Environmental Management Plan
CO_2	Carbon Dioxide
DC	Direct Current
DCO	Development Consent Orders
DEFRA	Department for Environment, Food and Rural Affairs
dWRMP	Draft Water Resource Management Plan
EA	Environment Agency
EAR	Environmental Appraisal Report
ECJ	European Court of Justice
ECoW	Ecological Clerk of Works
EDD	Emergency Drawdown
eDNA	Environmental DNA
EIA	Environmental Impact Assessment
EMS	Environmental Management Systems
ENCA	Enabling a Natural Capital Approach
ENG	Environmental Net Gain
EqIA	Equality Impact Assessment
EU	European Union
FLL	Functionally Linked Land
FR	Fens Reservoir
FRA	Flood Risk Assessment
FSA	Flood Storage Area
GDP	Gross Domestic Product
GES	Good Ecological Status
GUC	Grand Union Canal
GVA	Gross Value Added
GWDTE	Groundwater Dependent Terrestrial Ecosystems
HER	Historic Environment Record

HGV	Heavy Goods Vehicle
HMT	HM Treasury
HMWB	Heavily Modified Water Bodies
HRA	Habitats Regulations Assessment
HVO	Hydrogenated Vegetable Oil
IDB	Internal Drainage Board
IEMA	Institute of Environmental Management and Assessment
IMD	Index of Multiple Deprivation
INNS	Invasive Non-native Species
IRZ	Impact Risk Zones
km	Kilometres
kV	Kilovolt
LDF	Local Development Framework
LDO	Local Development Order
LEEP	Land, Environment, Economics and Policy Institute
LERC	Lincolnshire Environmental Records Centre
LI	Landscape Institute
LNR	Local Nature Reserve
LNRS	Local Nature Recovery Strategies
LSE	Likely Significant Effects
LSOA	Lower-layer Super Output Area
LWS	Local Wildlife Sites
m	Metres
MAGIC	Multi-Agency Geographic Information for the Countryside
MCM	Million Cubic Metres
Ml/d	Megalitres per Day
MLWS	Mean Low Water Springs
mm	Millimetres
MW	Megawatts
NBN	National Biodiversity Network
NCA	Natural Capital Assessment
NCN	National Cycle Network
NGET	National Grid Electricity Transmission
NECR285	National Natural Capital Atlas: Mapping Indicators
NERC	Natural Environment and Rural Communities
NEVO	Natural Environment Valuation Online Tool
NFM	Natural Flood Management
NNR	National Nature Reserve
NPPF	National Planning Policy Framework
NPS	National Policy Statement
NPV	Net Present Value
NRN	Nature Recovery Network
NSIP	Nationally Significant Infrastructure Projects

NVZ	Nitrate Vulnerable Zones
ONS	Office for National Statistics
ORVal	Outdoor Recreation Valuation Tool
OS	Ordnance Survey
PPG	Pollution Prevention Guidance
PRoW	Public Rights of Way
RAG	Red-Amber-Green
RAPID	Regulator's Alliance for Progressing Infrastructure Development
RBMP	River Basin Management Plan
RP&G	Registered Parks and Gardens
RSPB	Royal Society for the Protection of Birds
RWT	Raw Water Transfer
SAC	Special Areas of Conservation
SIC	Sites of Community Importance
SEA	Strategic Environmental Assessment
SFFD	South Forty Foot Drain
SLR	South Lincolnshire Reservoir
SLRWP	South Lincolnshire Reservoir Working Partnership
SLWP	South Lincolnshire Water Partnership
SPA	Special Protection Area
SSSI	Sites of Special Scientific Interest
SR	Service Reservoir
SRO	Strategic Resource Option
SuDS	Sustainable Drainage Systems
STEM	Science, Technology, Engineering and Mathematics
STT	River Severn to River Thames Transfer
SPZ	Source Protection Zones
SUE	Sustainable Urban Extension
TCC	Temporary Construction Compounds
tCO_2e	Tonnes of Carbon Dioxide Equivalent
ToLS	Test of Likely Significance
TPO	Tree Preservation Order
TPS	Transfer Pumping Station
TWA	Temporary Works Areas
TWAO	Transport and Works Act Orders
UK	United Kingdom
UKWIR	UK Water Industry Research
WFD	Water Framework Directive
WRE	Water Resources East
WRPG	Water Resources Planning Guideline
WTW	Water Treatment Works
WwTW	Wastewater Treatment Works
ZoI	Zone of Influence

Executive summary

A new strategic reservoir in Lincolnshire, referred to as the South Lincolnshire Reservoir (SLR), has been proposed for development as one of several nationally Strategic Resource Options (SRO) required to address increasing deficits in public water supply. The scheme is being progressed through the fast-tracked delivery framework overseen by the Regulatory Alliance for Progressing Infrastructure Development (RAPID). SLR has previously progressed through gate one, the first opportunity to check progress on investigations and development of solutions in the gated process and is now at gate two.

This Environmental Appraisal Report (EAR) has been prepared with updated information since the gate one submission and includes the potential risks, barriers and proposed mitigation measures of SLR. The aim of this EAR is to meet the requirements of the RAPID gate two guidance. It draws together the conclusions of all gate two environmental appraisal work into a single document.

This EAR has been informed by desk-based assessments using publicly available information in line with the requirements of the gate two submission. The work is at a preliminary stage and establishes an initial appraisal that can be built on during subsequent project stages. In future, this will also be informed by the undertaking of site surveys and collection of additional information and data that will inform an Environmental Impact Assessment likely to be required as part of any future consenting process. This EAR includes topic-based desk-based informal, strategic assessments. A summary of the key topic findings is outlined below:

- **Water Framework Directive Assessment (WFD)**– the level 1 assessment identified 24 waterbodies which could potentially be affected by the scheme. Following the Level 1 assessment, seven of these waterbodies were identified as requiring a Level 2 assessment due to the potential effects on the WFD waterbodies. The Level 2 assessment couldn't rule out the risks of deterioration in six of these waterbodies, so further study and assessments would be required as the project progresses.
- **Informal Habitats Regulations Assessment (HRA)** - the Stage 1 Test of Likely Significance ("Screening") identified seven designated sites subject to likely significant effects as a result of the construction or operation of the Scheme; The Wash SPA and Ramsar, The Wash and North Norfolk Coast SAC, Humber Estuary SAC, SPA and Ramsar, and Baston Fen SAC. The informal Stage 2 Appropriate Assessment concluded that no residual effects would arise from the construction phase for any of the designated sites, provided that proposed mitigation was implemented. Operational effects associated with proposed abstraction and discharge could not be ruled out at this stage for any site with the exception of Baston Fen SAC where no residual adverse effects are expected. Further surveys, data collection, modelling and assessment, together with the detailed consideration of mitigation measures, will be required in order to conclude that there will be an absence of adverse effect on the integrity of designated sites. The strategy to produce the evidence base required for the formal stages of HRA will be agreed at the next stage in consultation with the regulator. Ultimately, a strong and robust evidence base will be required to conclude that there will be no adverse effects on the integrity of any designated site as a result of the construction or operation of the scheme. The level of detail available at this stage (which is considered proportionate) means that such effects cannot be ruled out. As a result, this will need further consideration and assessment as part of the next stages of design development to conclude what the effects (if any) of the Scheme on designated sites will be and any further work required by the HRA process. All of this would need to be undertaken in

dialogue with key stakeholders, including Natural England and the Environment Agency.

- **Invasive Non-Native Species (INNS)** – INNS were recorded within the proposed abstraction sources and transfer water bodies, and within associated study areas. The assessment concluded that the proposed transfers will not introduce a new hydrological connection between 'isolated' WFD Operational Catchments. However, the proposed scheme would result in increased connectivity between other catchments and waterbodies. The INNS risk associated with abstraction from the River Trent was previously identified at gate one, and mitigation has been considered and developed in the concept design with an INNS treatment works being identified for the River Trent abstraction. The risk assessment undertaken at gate two concludes that the abstraction and transfer from the River Witham will need to be further assessed and appropriately mitigated as the design develops.
- **Natural Capital Assessment (NCA) and Biodiversity Net Gain (BNG)** - the scheme is likely to generate the permanent and temporary loss of natural capital stocks during construction. However, some habitat is expected to be reinstated/compensated to pre-construction conditions following best practice technique and will likely have no permanent impact to the provision of ecosystem services. The scheme is likely to result in a biodiversity net gain for habitat biodiversity units and a biodiversity net loss for river biodiversity units. The option presents an opportunity to improve the existing habitats through post construction remediation and replacement of low value habitats with higher value habitats.
- **Strategic Environmental Assessment (SEA)**– the SEA ratings were informed by the other environmental assessments undertaken for the scheme. The SEA considered anticipated construction and operational effects, both without any mitigation applied and expected residual effects after implementation of indicative mitigation measures. It identified potential effects for Biodiversity, Flora and Fauna, Soil, Water, Air, Climatic Factors, Landscape, Historic Environment and Material Assets. Positive effects were identified for Population and Human Health. In-combination effects have been considered for WFD and HRA and cumulative effects have been considered as part of the wider environmental appraisal process.

The wider benefits assessment considered the potential benefits for employment impacts, tourism, health and well-being, education and apprenticeships. A summary of the results from the assessment are outlined below:

- **Employment Benefits** - employment impacts are expected to result in positive outcomes. The beneficiaries are those who are directly employed, as well as indirect and induced impacts on the local economy (goods and services).
- **Tourism** – there is the potential to create a new tourism destination, as there is a local catchment area for visitors to the new reservoir. Several opportunities were identified including the creation of wetlands, cycleways, footpaths, bridleways, a visitor centre, transport links and a bathing area.
- **Health and Wellbeing** – greener environments are associated with better mental health and wellbeing outcomes including reduced levels of depression, anxiety, and fatigue, and enhanced quality of life for both children and adults. Numerous opportunities were identified following the construction activity on the reservoir site associated with potential for public access and recreation.
- **Education** - the new reservoir could provide an additional educational resource for the community. The existing Anglian Water Parks provide opportunities for school visits and is it anticipated that features of SLR scheme, including the Visitor Centre, which would include an educational centre, would also afford this opportunity.

- **Apprenticeships** – The project promotors have existing apprenticeship schemes to assist in introducing people to the workplace and develop skills through a variety of advanced, higher and degree level apprenticeships across a range of roles.
- **Partnership Strategy** - The South Lincolnshire Water Partnership have been involved in the development of concept designs and provided representations on the gate one submission. The ongoing design development will identify and engage partner organisations to identify and enhance the benefits of the SLR scheme. This is expected to include working with agricultural stakeholders and environmental regulators on issues such as irrigation supply and flood storage areas (FSAs).

Recommendations have been included for further, more detailed and site-specific environmental assessments and surveys as the scheme progresses.

Notice

Position statement

This EAR has been produced to accompany the gate two submission for the SLR SRO, which is part of the process set out by RAPID in the 'Strategic regional water resource solutions guidance for gate two published in February 2022.

As the scheme progresses and the preferred planning route is identified, it is expected that a full environmental appraisal will be produced, which will set out the likely environmental impacts and mitigation. The RAPID guidance for gate three states that most solutions will require a statutory Environmental Impact Assessment (EIA) to support planning and permitting applications. The EIA should be sufficiently advanced to support EIA scoping requirements for the gate three process. All pre-application activities will be carried out in accordance with the requirements of the Planning Act 2008.

Community and stakeholder engagement is crucial to the development of the scheme. Some high-level activity has been undertaken to date, but more detailed engagement and formal consultation will be required as the scheme progresses. Prior to applying for the necessary permissions and consents, the project promotors will need to demonstrate that information about the proposals has been presented to the community for feedback and stakeholder views and this has been considered throughout the design's development.

The scheme is currently at an early stage of development and the details set out in the gate two documents are still in a formative stage. The information contained within the report is intended to identify whether there are any 'showstopper' concerns that would mean the scheme could not progress to gate three. The report is based on available information relevant to the stage of development. It should be noted that this is an initial environmental appraisal and it has not been prepared for the purpose of seeking permits.

Disclaimer

This document has been written in line with the requirements of the RAPID gate two guidance. The information presented relates to material or data which is still in the course of completion. Should the solution presented in this document be taken forward, the project promotors will be subject to the statutory duties pursuant to the necessary consenting process, including environmental assessment and consultation as required. This document should be read with those duties in mind.

1 Introduction

1.1 Background

A new strategic reservoir in Lincolnshire, referred to as the South Lincolnshire Reservoir (SLR), has been proposed for development as one of several nationally strategic water resource options required to address increasing deficits in public water supply. The scheme is being is promoted by Anglian Water and is being progressed through the fast-tracked delivery framework overseen by the RAPID.

The SLR has previously progressed through gate one in 2021, the first opportunity to check progress on investigations and development of solutions in the gated process and is now at gate two. Gate two is intended to look at solutions in more detail, with focus on ensuring that funding for continued investigation and development of solutions is aligned to water resources planning.

The SLR environmental assessments carried out as part of the gate one submission considered three potential concept design options. The gate one assessments carried out included an informal Habitats Regulation Assessment (HRA), a Water Framework Assessment (WFD) assessment, a Strategic Environmental Assessment (SEA), an Invasive Non-Native Species (INNS) risk assessment, a Natural Capital Assessment (NCA) and an analysis of Biodiversity Net Gain (BNG). The combination of environmental assessments carried out at gate one showed that some environmental benefits would result from the SLR scheme. At gate one it was also concluded that construction would likely result in adverse environmental impacts even after the application of proposed mitigation measures, for example associated with loss of predominately agricultural land and changes to the water regime.

Since gate one, a four-stage site selection process has been completed to identify and assess potential locations for the development of a strategic reservoir against community, environmental, economic, planning and technical criteria. A separate process was used to identify suitable locations for the water abstraction and potential pipeline corridors. Further detail on the site selection process is outlined within Section 2.2.

Updated environmental appraisals have been carried out for the scheme and to support the gate two submission, as summarised in this report.

1.2 Regional resource planning context

The regional draft water resources plan for Eastern England, Water Resources East (WRE) has identified the need for two new strategic raw water reservoirs in the region to address part of the supply deficit – one of which is the SLR. This has been confirmed in Anglian Water's draft Water Resource Management Plan 2024 (dWRMP24).

Water resources modelling has confirmed that the required reservoir capacity to meet public water supply requirements should be 55 million cubic metres (MCM) to provide a supply of up to 166 megalitres per day (Ml/d). The source of the water for the SLR is proposed to come from the River Witham (400Ml/d) with a back-up transfer to the River Witham from the River Trent (300Ml/d), subject to abstraction consents and water availability. As a waterbody the reservoir would also provide environmental, socio-economic and wellbeing benefits for the communities around it.

1.3 Environmental appraisal report (EAR)

This EAR is a technical document prepared to support the gate two submission for the SLR SRO. The aim of this EAR is to meet the requirements of the RAPID gate two guidance. It draws together the conclusions of all gate two environmental appraisal work into a single document.

This EAR has been informed predominantly by desk-based assessments using publicly available information in line with the requirements of the gate two submission. The work is at a preliminary stage and establishes an initial appraisal that can be built on during subsequent project stages. In future, this will also be informed by the undertaking of site surveys and collection of additional information and data that will inform any future consenting process.

This EAR does not definitively scope potential environmental effects in or out of any future EIA process at this stage and the recommendations for further technical work outlined within this EAR are subject to change as further information becomes available at subsequent project stages. Future work will be carried out in conjunction with relevant stakeholders to inform the approach to the subsequent EIA.

The details set out in this EAR are still at a formative stage and consideration should be given to that when reviewing the proposals. They are for the purposes of making decisions on progress but does not form part of the Development Consent Order (DCO) process.

1.4 Scope of environmental assessment

For the purpose of the gate two submission, the SLR has been subject to a predominantly desk-based environmental appraisal, building on the work undertaken at gate one, to identify potential environmental and social impacts, potential mitigation measures and enhancement opportunities. The following informal, strategic (appropriate for this stage) environmental assessments have been undertaken for the gate two submission:

- WFD Stage 1 and Stage 2 assessments, updating the gate one WFD assessment (summarised in Section 3.1 and full assessment in Appendix A.1 Water Framework Directive Assessment).
- Informal HRA Test of Likely Significance (ToLS) and report to inform Appropriate Assessment (AA), updating the gate one HRA (summarised in Section 3.3 and full assessment in Appendix A.2 Informal Habitat Regulations Assessment).
- SEA to align with the WRE Regional Plan and the Anglian Water dWRMP24, updating the gate one SEA (summarised in Section 0 and full assessment in Appendix A.3 Strategic Environmental Assessment)
- INNS risk assessment, updating the gate one INNS risk assessment (within Chapter 12).
- NCA, updating the gate one NCA (within Chapter 13).
- BNG calculations using Defra Metric 3.0, updating the gate one consideration of BNG (within Chapter 13).
- Qualitative assessment of how the scheme achieves Environmental Net Gain (ENG), including potential mitigation measures or enhancements required (within Section 13.6).

The following additional technical documents relevant to the SLR scheme, have also informed and are referred to within this EAR:

- Water Quality Risk Assessment, RAPID gate two.

Table 1.1 signposts relevant sections of this EAR that demonstrate the requirements of the RAPID gate two guidance.

Table 1.1: EAR sections for informing gate two requirements

Gate two requirement	Relevant sections of this EAR
WFD Assessment (6.1)	Section 3.2 (Water Framework Directive Assessment)
Informal HRA (6.2)	Section 3.3 (Informal Habitat Regulations Assessment)
Environmental assessment to feed into Regional Plan and WRMP SEA (6.3)	Section 0 (Strategic Environmental Assessment)
Update to gate one environmental appraisal work where relevant (6.3)	All
Summary of environmental appraisal work undertaken to date, likely to be at strategic scale (6.3)	All
Summary of environmental baseline and analysis undertaken (6.3)	Chapters 4 – 14
Options assessment, with sufficient detail to allow comparison of options within the solution and identify potential effects (positive and negative) and opportunities (6.3)	Section 2.2 (Alternatives considered) See also separate Site Selection Report for how proposed option was selected balancing multiple factors.
Assessment of the effects of the solution, an evaluation of their significance and any cumulative or in-combination effects (6.3)	Chapters 4 – 14
Clear justification as to options discounted, those taken forward, and the proposed option selected, and potential environmental effects and opportunities associated with the proposed option (6.3)	Section 2.2 (Alternatives considered). Chapters 4 –15. See also separate Site Selection Report for how proposed option was selected balancing multiple factors.
Consideration of resilience (e.g., to climate change) (6.4)	Chapter 7 (Carbon)
Description of connections to other assessments (e.g. biodiversity net gain, WFD, natural capital, carbon) and demonstration of how they have been considered (6.3)	Chapter 3 (Environmental Assessments), Chapters 4 –15
Summary of proposed mitigation and enhancement opportunities (6.3)	Chapters 4 – 14
Summary of future monitoring requirements and efficacy of proposed mitigation measures (6.3)	Chapters 4 – 14
Plan to address uncertainties and data gaps (6.3)	Section 15.3 (Recommended gate three activities)
Consideration of BNG, supporting the net gain actions in the 25-year Environment Plan (6.4)	Chapter 13 (Natural Capital and Biodiversity Net Gain)
Natural capital assessment, consistent with approaches for the Regional Plan and WRMP (6.4)	Chapter 13 (Natural Capital and Biodiversity Net Gain)
Assessment of the whole life carbon cost (6.5)	Chapter 7 (Carbon)
Description of how innovative designs and opportunities to generate or be powered by renewable energy and/or sequester carbon are embraced, and joint opportunities with other sectors are explored (6.5)	Chapter 7 (Carbon)

1.5 Structure of this report

This EAR is structured as follows below, other topics (such as air quality, noise and vibration, transport and accidents) will be considered at the next stage of the project.

- Chapter 1 (Introduction).
- Chapter 2 (Scheme description) presents an overview of the SLR option and signposts to other Technical Supporting Documents where further information can be found.
- Chapter 3 (Environmental assessments) the results of the informal HRA and WFD assessments and updates to the WRE SEA as part of the gate two submission).
- Chapter 4 (Biodiversity, flora and fauna appraisal) presents desk-based assessment undertaken to inform the gate two submission.
- Chapter 5 (Soil appraisal) presents desk-based assessment undertaken to inform the gate two submission.
- Chapter 6 (Water appraisal) presents desk-based assessment undertaken to inform the gate two submission.
- Chapter 7 (Carbon appraisal) presents desk-based assessment undertaken to inform the gate two submission.
- Chapter 8 (Landscape appraisal) presents desk-based assessment undertaken to inform the gate two submission.
- Chapter 9 (Historic environment appraisal) presents desk-based assessment undertaken to inform the gate two submission.
- Chapter 10 (Population and human health appraisal) presents desk-based assessment undertaken to inform the gate two submission.
- Chapter 11 (Cumulative and in-combination effects appraisal) presents desk-based assessment undertaken to inform the gate two submission.
- Chapter 12 (Invasive Non-Native Risk Assessment) presents desk-based assessment undertaken to inform the gate two submission.
- Chapter 13 (Natural Capital and BNG appraisal) presents desk-based assessment undertaken to inform the gate two submission.
- Chapter 14 (Wider benefits) study to inform the gate two submission.
- Chapter 15 Conclusions and next steps.

1.6 Stakeholder engagement

The principles of the approach to stakeholder engagement applied to the SLR scheme are as follows:

- To build on the engagement undertaken to date, taking account of any issues and concerns raised by the local communities or stakeholders, ensuring discussions are timely and inform the final design.
- To fit within the regulatory processes established under relevant guidance to understand and agree expectations.
- To be integrated with regional and company water resource planning.

Stakeholder engagement has been important to the gate two work from site selection to preliminary scheme concept development. The South Lincolnshire Reservoir Working Partnership (SLRWP) was established in September 2021 to bring together stakeholders with an interest in the project. This was supported by the South Lincolnshire Water Partnership (SLWP), which had a broader remit to consider multi-sectoral opportunities for public water supply, flood risk management, agriculture, environment and recreation/tourism.

Membership of the SLRWP included, amongst others, representatives from local authorities, the Environment Agency (EA), Natural England, Historic England, Internal Drainage Boards (IDBs), Lincolnshire Wildlife Trust and the National Farmers Union. SLWRP meetings were held monthly throughout the gate two period and allowed stakeholders the opportunity to challenge and influence site selection and scheme development. The stakeholders also contributed towards the multiple-criteria decision analysis tool, used in Stage three of site selection. The main gate two report contains further details of stakeholder engagement.

In terms of environmental stakeholders, monthly meetings were convened jointly with the Environment Agency and Natural England. These provided the opportunity for the project team to share updates on technical work packages and discuss comments. Outside of the monthly meetings, bespoke workshops were held with the environmental stakeholders to cover specific work packages such as hydro-ecology and flood risk studies.

Periodic meetings were also held with Historic England to discuss heritage and archaeological considerations relating to site selection.

In some cases, draft technical reports were shared with the environmental stakeholders at various points throughout site selection (including for this EAR), which allowed the project team to review and respond to comments and refine the reports in light of challenges/suggestions.

In order to inform stage four of site selection (preferred site selection), the project team organised a series of in-person topic workshops to allow stakeholders to share their local knowledge and discuss both the constraints and opportunities associated with the prospective reservoir sites. Workshops were convened for the following topic areas: ecology and biodiversity, landscape and heritage, flood risk and community opportunities. The workshops were well-attended, and the outputs captured and fed into site selection decision making.

Further engagement with stakeholders will continue into gate three and focus on refinement of scheme options and more detailed concept design development. Both statutory and non-statutory consultations are an important part of the Development Consent Order (DCO) and EIA process, with a requirement that they iteratively influence scheme design and environmental assessment.

1.7 Assumptions and limitations

The following overarching assumptions have been applied in the environmental assessments that inform this gate two EAR:

- Aside from the broad area of the proposed reservoir site, all other components of the scheme (including abstraction and transfer locations and associated infrastructure) are indicative at this stage.
- A summary of the site selection process and consideration of alternatives is contained in Section 2.2.
- All scheme components identified for gate two are provisional only, and the designs indicative, and will be subject to further refinement, informed by the outcomes of further assessments and stakeholder engagement that will be undertaken between gates two and three.
- The main construction period, inclusive of enabling works has been assumed as between 2027 to 2041. The earliest that the scheme is estimated to be in supply is between 2039 to 2041.
- All assessments undertaken to date have been predominantly desk-based and based on third party information, although some preliminary site investigations have been undertaken. Desk-based assessment will in some cases be subject to verification by site surveys in the next phase of work.

- Water abstractions from rivers will be in line with future licence agreements from the EA.
- For the purposes of this appraisal, the water transfer corridors have been assumed to be up to 100m wide.
- All assessments for gate two are based on assumed pipe transfer conveyances and not open water transfer (although this will be investigated as a potential supply option).
- For infrastructure associated with the reservoir, only key elements (e.g. the waterbody, embankments, water treatment works, inlets, outlets) have been assessed as indicative concepts have been developed to support the gate two works. Information on the status and design of associated infrastructure and amenity elements is not available at this stage.
- Emergency drawdown (EDD) details are under consideration, and further work will be required to assess the implications of new required infrastructure and discharge of water as the design progresses.
- The types of emergency situation that would require use of the EDD are considered to be highly unlikely to arise and would fall outside the normal operating conditions of the scheme.
- Detailed design and construction information for the scheme will be progressed in subsequent stages of development, so while good practice is assumed, detailed assessments of construction impacts have not been carried out at this stage. The following assumptions have been made in relation to construction methodology.

  - Whilst proposed mitigation within this report follows good practice, any recommended mitigation measures should be considered provisional and not confirmed at this stage. Mitigation will be refined in an iterative process as the scheme design evolves in future phases, and in response to more detailed environmental impact assessment.
  - While temporary construction compounds will be required, locations for these have not yet been confirmed so they are not considered within gate two environmental assessments (but would be considered further as the scheme progresses).
  - Risk assessments with regard to impact on water quality and water levels would be undertaken at appropriate points in subsequent phases of the scheme development for site investigations and construction phase excavation works and dewatering. This will be to mitigate temporary adverse impact on water quality or water levels from site works on watercourses, wetland habitats or abstractions and inform relevant mitigation measures.
  - Water extracted from the ground during construction would be assumed to be treated to a standard agreed with the regulatory authority before discharging at less than the agreed maximum rate to the water environment.
  - Discharge from the new water treatment works (WTW) would be assumed to be treated to a standard agreed with the regulatory authority at less than the agreed maximum rate so as to mitigate potential impacts to water quality of the receiving water body.
  - A Construction Environmental Management Plan (CEMP), or similar construction management plan, would be developed at an appropriate stage to ensure that environmental risks such as uncontrolled discharges from construction are minimised and that Emergency Response Plans are in place in the event of an incident.
  - Good practice pollution prevention assumed to be followed with reference to relevant good practice guidance.

The project promotors will need to have established Environmental Management Systems (EMS) in place for their assets. The EMS aims to identify and implement the necessary actions to avoid adverse effects to the environment during the operational phase. For example, the EMS will include standard measures relating to pollution control and control of disturbance from light and noise. It is expected that these would be updated to incorporate the requirements of new assets, and the appropriate EMS will be followed to avoid adverse effects to the environment.

Other assumptions relating to specific assessments and components of this report are also outlined in the sections and appendices to which they apply.

2 Scheme Description

2.1 Scheme overview

The SLR scheme includes the development of a new embanked raw water reservoir for water storage for public water supply. It also comprises abstractions from the River Witham and River Trent, raw water transfers, treatment works, and distribution into supply.

Key scheme parameters include:

- River Trent maximum abstraction and transfer flow to River Witham: 300Ml/d
- River Witham maximum abstraction and transfer flow to reservoir: 400Ml/d
- Reservoir total capacity: 55MCM
- Reservoir usable volume: 50MCM
- Treatment distribution flow[1]: 150Ml/d

2.1.1 Reservoir overview

The proposed reservoir site is shown in Figure 2.1, and is located approximately 7km southeast of the town of Sleaford, between the settlements of Swaton, Scredington and Helpringham in the North Kesteven District Council area. South Kesteven District Council's administrative boundary is approximately 100m south of the polygon, south of the A52 Holland Road. The Peterborough to Lincoln railway line runs along the north-eastern boundary with the North Beck watercourse situated just north of the site boundary.

An indicative concept plan has been developed for the scheme. This indicative concept has been established to provide reference for cost and carbon estimation in gate two. The summary provisional details are provided below, but much work is still required to develop the scheme and the final details will develop accordingly.

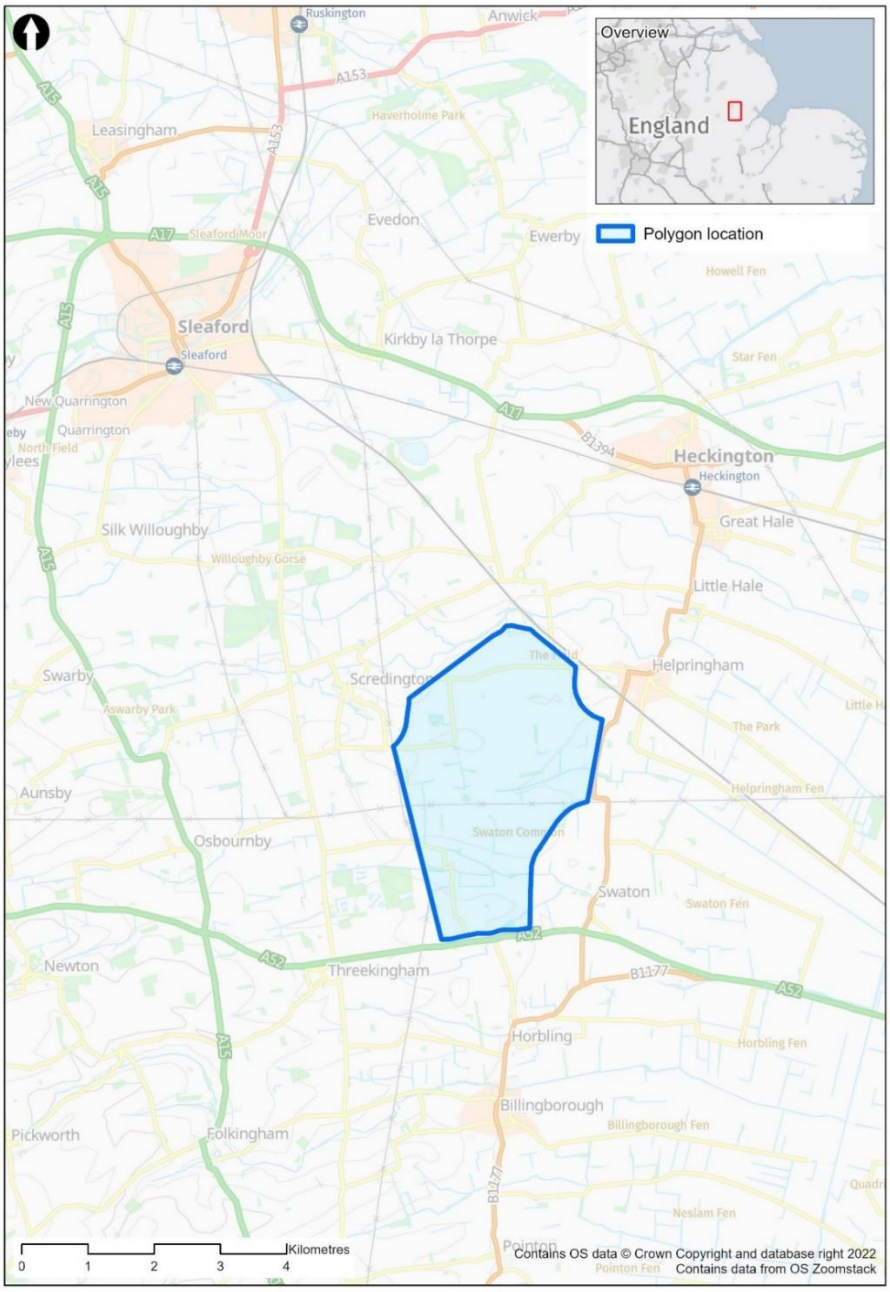
The provisional reservoir parameters are:

- At its greatest dimensions the reservoir is about 2.6km wide and 3.2km long to the embankment toe.
- The embankment crest is estimated at 26mAOD (above ordnance datum) making the embankment an average of 14m above the typical existing ground level at the toe. This is with approximate relative embankment elevations of maximum 19m and minimum of 5m above existing ground levels.
- The total perimeter length of the crest is about 8.5km and the estimated reservoir surface area is 4.8km^2.

[1] The proposed capacity of the water treatment works and transfer pipelines has been updated since this assessment was completed. The figures quoted in the gate two report include a scheme deployable output of 166Ml/d and works capacity up to 180Ml/d. These changes are not anticipated to have any material impact on the completed assessments.

The reservoir would include key infrastructure necessary for its safe operation, including intake and outtake structures; drawdown facilities; a spillway and water sampling facilities. The reservoir will also be expected to provide benefits beyond public water supply. Opportunities to incorporate facilities to enable recreation (such as a visitor centre and parking), infrastructure to improve health and wellbeing (such as multi-use footpaths, quiet areas and leisure opportunities) and careful design to enhance and encourage biodiversity are planned and will be developed further, with the features that would deliver these wider benefits being subject to further assessment and consultation. Landscaping would be carefully designed surrounding the reservoir to minimise the visual impact of the reservoir whilst ensuring it sits within the existing landscape and delivers wider recreational and biodiversity benefits.

Figure 2.1: Site context map



2.1.2 Raw water abstraction and transfers

It is proposed that water will be abstracted from the River Witham. The abstraction location has currently been assumed, for indicative purposes, to be at an intake between Chapel Hill and Langrick Bridge. The precise abstraction location will be identified following further detailed work (including stakeholder engagement) for gate three. The current design includes the transfer of water into the reservoir by about 18km of 1600mm (millimetres) diameter steel pipeline.

The proposed abstraction rate from the River Witham is up to 400Ml/d when flows allow. This is subject to further assessment undertaken in collaboration with the Environment Agency (EA) to develop an abstraction rate which is licensable. The associated abstraction licence is expected to stipulate a minimum flow and minimum water level requirement at the point of abstraction below which it would not be possible to abstract. Abstraction to fill the reservoir would only be possible during high flow periods.

It is proposed that flows in the River Witham would be supported via a transfer from the River Trent. Up to 300Ml/d would be abstracted from the River Trent, with an intake currently assumed for indicative purposes to be located near Newark-on-Trent (although, as with the River Witham abstraction, the precise abstraction location will be identified following further detailed work for gate three) and transferred by about 10km of 1400mm diameter steel pipeline to the River Witham near Claypole. Without mitigation, there is a risk of INNS transferring between catchments (see Section 12).

Further work is planned for the next stage to confirm locations for the abstraction points and routes for the transfers involving landowner engagement, environmental surveys, and preliminary ground investigations. The opportunity for the transfer conveyance to be open channel is still being investigated and will be confirmed during the next stage of project development. The information provided in this report and accompanying appendices are assumptions based on indicative locations only at this stage. The indicative transfer routes are shown in Figure 2.2.

The abstraction facilities are expected to comprise an intake structure, a transfer pumping station (TPS) and pipeline.

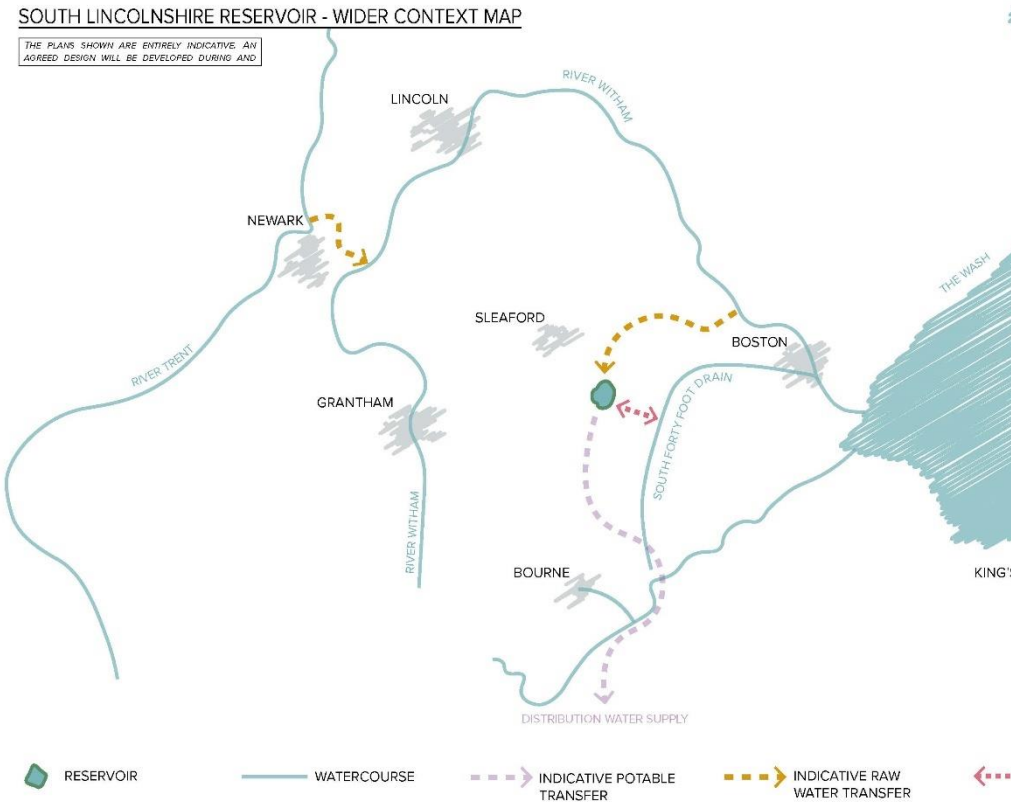
2.1.3 Water treatment and potable transfers

Stored water will subsequently be abstracted from the reservoir and treated to a potable quality. It is proposed that a WTW is located on land adjacent to the reservoir with a peak throughput capacity of 180Ml/d.

It is proposed that the treated (potable) water will be transferred by an approximate 37km 1100mm diameter steel pipeline into the potable supply network by an existing Anglian Water Service Reservoir. The reservoir is to supply over 500,000 homes in Lincolnshire and the south-west of the Anglian region.

Further work is planned for the next stage to confirm the routes for the transfers involving landowner engagement, environmental surveys, and preliminary ground investigations. The information provided in this report and accompanying appendices are assumptions based on indicative locations only at this stage. See Figure 2.2 for an illustration of indicative proposed transfer corridor locations.

Figure 2.2: Proposed transfer corridors



2.1.4 Summary of operation and use

Development and operation of the reservoir will be subject to the Reservoirs Act 1975 (as amended by the Floods and Water Management Act 2010). The embankments and associated water retaining elements of the reservoir will need to be maintained and supervised in accordance with the Act to maintain public safety.

Provision of emergency drawdown must be designed in accordance with the Reservoirs Act. The proposed solution at this stage is to discharge to the SFFD, but this is to be further modelled and confirmed as part of the next stage of development. Although the risk of needing to fully drawdown the reservoir is very low, there is a need for regular testing and maintenance to confirm functionality. This will involve the opening and testing of relevant valves and gates. Test flows are envisaged to be held in a pond to avoid disruption and to enable water to be returned back to the reservoir.

The operation and maintenance of the water treatment works and the distribution water supply system inclusive of distribution pump stations are expected to be in constant regular use according to water supply demand. The water supply components will need regular inspections and maintenance activities in accordance with the requirements of the respectively installed equipment.

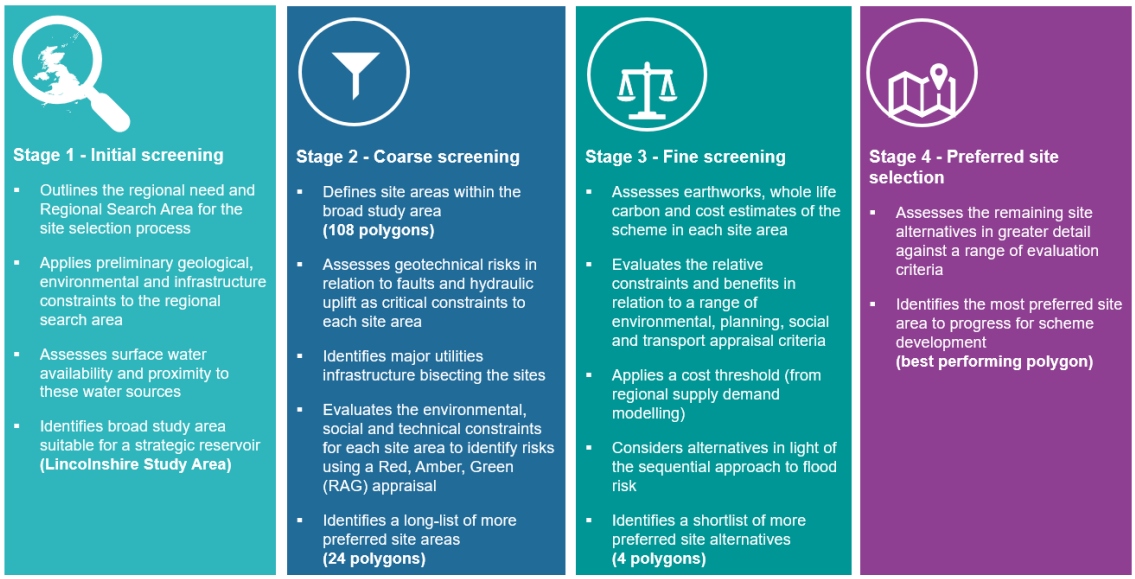
2.1.5 Associated infrastructure and features

It is proposed that there will be a need for associated infrastructure and other features such as environmental mitigation to minimise the impacts of the reservoir, as well as enhancement opportunities. The location and design of the additional infrastructure has not been established and will therefore need to be confirmed at the next phase of scheme development.

2.2 Alternatives considered and site selection

A site selection process was undertaken to identify a best performing site in Lincolnshire suitable for a strategic reservoir, as summarised in Figure 2.3. Stakeholders, legal advisors, planning advisors and land agents influenced and informed this process to ensure it was robust and that the best performing site was identified.

Figure 2.3: Summary of the four-staged site selection process



The application of the four-stage site selection process has identified and assessed potential suitable locations for the new reservoir based upon a broad range of community, economic, environmental, and other technical criteria (constraints and opportunities). The methodology, criteria and findings have been informed by subject matter experts and local stakeholders. These stakeholders were engaged through the South Lincolnshire Reservoir Working Partnership which includes the South Lincolnshire Water Partnership, local planning authorities and statutory stakeholders.

Stage 1 – initial screening - comprised a high-level review within the Regional Search Area of underlying geology, proximity to the abstraction sources, sites designated for the protection of nature conservation, major infrastructure, and large areas of existing developments such as settlements. This was used to define the Lincolnshire Study Area, providing the boundaries for the site selection process.

Stage 2 – coarse screening - involved the delineation of areas of land (referred to as “polygons”) within the Lincolnshire Study Area that could accommodate a strategic reservoir with a minimum footprint of 5km^2, based on preliminary design requirements to accommodate a reservoir of the size determined as being required by regional water resources modelling. 108 polygons were delineated. These polygons were screened against a more detailed review of geological risks, an analysis of major existing utilities and other technical constraints. Polygons were then ranked to identify those containing the greatest level of constraint on project delivery. 24 polygons which presented the lowest level of risk to project delivery were taken forward to fine screening.

Stage 3 – fine screening - these 24 polygons were then subjected to more detailed investigation and evaluated against key differentiators, including community, economic, environmental and planning criteria. In consultation with the Environment Agency, a strategic Sequential Test was carried out to prioritise polygons which were both affordable and carried the lowest level of flood risk. This stage identified a shortlist of four best performing alternatives taken forward to Stage 4 – preferred site selection. These were titled Polygons A, B, C and D.

Stage 4 – preferred site selection - more detailed desk-based assessments by subject matter experts and further stakeholder engagement informed a comparative review of the four remaining polygons. These polygons were considered against nineteen criteria to identify the best performing polygon, having regard to the advantages and disadvantages of each Polygon against each criterion. This best performing polygon has been taken forward as the proposed site for the reservoir.

A separate option selection process was used to identify suitable locations for the water abstraction and potential pipeline corridors. A longlist of feasible corridor routes were identified and environmental and engineering assessments completed to determine the best performing route option. The route corridor assessments were based on achieving a balance between the shortest distance from the abstraction locations to the SLR location and from the SLR location to the potable network, and high level checks that the route is functional in terms of pipeline hydraulics, as well as avoiding environmentally sensitive areas.

The proposed reservoir site, the indicative transfer routes, abstractions and associated infrastructure, will all be subject to further analysis and stakeholder engagement and consultation between gates two and three. At present the proposals put forward to gate two therefore remain provisional.

3 Environmental Assessments

3.1 Introduction

Three environmental assessments; WFD, informal HRA and SEA have been undertaken to support the gate two submission and are presented as standalone Technical Supporting Documents and are included as appendices to this report. This section of the EAR presents a summary of these assessments. Chapters 3 through to 13 inclusive provide an updated feasibility statement in relation to gate one that includes potential risks, barriers and mitigation measures for the scheme, this is informed by these environmental assessments.

The environmental appraisals have highlighted effects requiring further consideration and assessment. These were mostly associated with changes to the aquatic environment, impacts on biodiversity, landscape and heritage. There would also be a permanent loss of soils and agricultural land on the reservoir site.

Overall, the gate two environmental assessment and report work has identified key issues that will inform the next stages of the project design, including measures and plans to mitigate and manage predicted impacts. As the project progresses, the design will be subject to an iterative process of environmental assessment, informed by further surveys and modelling, to identify and agree suitable mitigation and enhancement measures. This work will be undertaken in consultation with the relevant stakeholders.

Although further work is required to clarify the nature of WFD and HRA effects, the environmental appraisal work undertaken for the gate two submission has not identified any fundamental regulatory barriers that mean the project cannot be progressed to the next stages of development and investigation.

SEA is implemented at the strategic scale and applies to plans and programmes. The SLR scheme feeds into the dWRMP24 and Regional Plan, which are both undergoing SEAs, and as such the scheme is more appropriately assessed for SEA purposes as part of these plans. Therefore, the environmental assessments and appraisal that has been undertaken for this scheme has been fed back into the Regional Plan and dWRMP24 and is correctly represented below.

3.2 Water Framework Directive assessment

The Water Framework Directive is transposed into law for England and Wales through *The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003* and updated in 2017[2].

The WFD requires all waterbodies (both surface and groundwater) to achieve ‘good status or potential’. The Directive also requires that waterbodies experience no deterioration in status or potential. Good status/potential is a function of good ecological status (GES)/potential (biological, physico-chemical and hydromorphological elements and specific pollutants) and good chemical status (Priority Substances and Priority Hazardous Substances).

[2] The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. Available online at: https://www.legislation.gov.uk/uksi/2017/407/made

The All Company Working Group (ACWG[3]) has developed a consistent framework for undertaking WFD assessments for SROs to demonstrate that options will not cause deterioration in status/potential of any WFD waterbodies. The assessment considers mitigation that would need to be put in place to protect waterbody status/potential. The assessment also considers WFD future objectives to ensure the option would not preclude affected WFD waterbodies from reaching good status/potential.

At the time of writing, the EDD concept is not developed sufficiently for a valid WFD assessment to be undertaken and is therefore excluded from this assessment. The EDD will be developed further in the subsequent phases of the scheme and is to be included within the WFD assessment at gate three once the design has been developed.

3.2.1 Screening process

The WFD assessment included two stages, an initial Level 1 basic screening and a Level 2 detailed impact screening. Full details of this methodology are set out in the WFD Assessment report (Appendix A.1).

The Level 1 screening calculates a score on a six-point scale (from -2 to +3) based on scheme information. Waterbodies and scheme activities with no or very minor potential impacts are screened out, while others (with a maximum impact score greater than +1) are taken forward to Level 2 screening. Level 2 screening involves expert assessment of potential impacts, levels of confidence and certainty, mitigation needs and their effectiveness for reducing impacts, and identification of activities to improve certainty in assessment outcomes.

Level 1 assessment identified 24 waterbodies which could potentially be affected by the scheme. Following the Level 1 assessment, seven of these waterbodies were identified as requiring a Level 2 assessment due to the potential effects on the WFD waterbodies. The waterbodies included in the Level 2 assessment are as follows:

- GB105030056520 – South Beck
- GB105030056515 – Swaton Drains
- GB104028053110 – Trent from Soar to Beck
- GB105030062370 – Witham – conf Brant to conf Catchwater Drain
- GB205030062425 – Witham – conf Catchwater Drain to conf Bain
- GB105030056780 – Witham – conf Cringle Bk to conf Brant
- GB205030062426 – Lower Witham conf Bain to Grand Sluice

With regard to in-combination effects (see Appendix A.2 for details) the search concluded that the combination of SLR and with one major planning application and two other SRO schemes have the potential to adversely impact on a WFD waterbody.

3.2.2 Summary of results

3.2.2.1 South Beck (ID: GB105030056520)

No risk of deterioration to the South Beck (ID: GB105030056520) has been identified from the loss of open watercourse and loss of up to 4% of open watercourse within the catchment due to the presence of the reservoir. This loss of catchment and watercourses would impact on habitat, flow and hydromorphology in this waterbody.

[3] All Company Working Group (Nov 2020). Water Framework Directive: Consistent framework for undertaking no deterioration assessments

3.2.2.2 Swaton Drains (ID: GB105030056515)

A risk of deterioration to the Swaton Drains (ID: GB105030056515) has been identified. Within the reservoir footprint over 2.5km of open channel would be lost, along with 28% of the catchment. The loss of open channel would impact on habitat, flow and hydromorphology in this waterbody. Mitigation options include the provision of new open water channels and compensatory flows from the reservoir to Swaton Drains.

3.2.2.3 Trent from Soar to Beck (ID: GB104028053110)

A potential risk of deterioration to the Trent from Soar to Beck (ID: GB104028053110) was identified as a result of the new surface water abstraction. Abstraction rates are expected to be <10% of the total volume of the Trent catchment and the change in flow and velocity has the potential to impact biological elements. Further investigation is required to determine the full extent of the impacts. A potential adverse risk was also identified due to potential for changes in water quality due to the surface water abstraction.

3.2.2.4 Witham – conf Brant to conf Catchwater Drain (ID: GB105030062370), Witham - conf Catchwater Drain to conf Bain (ID: GB205030062425), Witham – conf Cringle Bk to conf Brant (ID: GB105030056780).

A risk of deterioration to the following waterbodies has been identified as a result of the discharge from the Trent from the Soar to Beck waterbody into the Witham – conf Cringle Bk to conf Brant (ID: GB105030056780) waterbody.

- Witham – conf Brant to conf Catchwater Drain (ID: GB105030062370)
- Witham – conf Catchwater Drain to conf Bain (ID: GB205030062425)
- Witham – conf Cringle Bk to conf Brant (ID: GB105030056780)

A high-level water quality assessment of the proposed transfer from the Trent to the Witham was conducted, it concludes there is an expected 69% increase in ammonia within the Witham – conf Cringle Bk to conf Brant (ID: GB105030056780) waterbody. As of the River Basin Management Plan (RBMP) Cycle 2 the status of ammonia is ‘High’, this increase in ammonia has the potential to cause a significant effect on the water quality. In combination with an increase in the other physico-chemicals, this has the potential to decrease the chemical status of this waterbody from ‘Moderate’ to ‘Poor’.

A high-level water quality assessment concluded there is an expected 46% increase in phosphate levels by the time the newly discharged water reaches the downstream Witham – conf Brant to conf Catchwater Drain (ID: GB105030062370) and the Witham - conf Catchwater Drain to conf Bain (ID: GB205030062425) catchments. Within the catchments, phosphate levels are expected to be lower. However, further investigation is required to determine the predicted percentage change.

3.2.2.5 Lower Witham conf Bain to Grand Sluice (ID: GB205030062426)

A risk of deterioration to the Lower Witham conf Bain to Grand Sluice (ID: GB205030062426) has been identified as a result of the discharge from the Witham – conf Cringle Bk to conf Brant (ID: GB105030056780) discussed in Section 3.2.2.4. A high- level water quality assessment, concludes there is an expected 46% increase in phosphate by the time it reaches the catchment. A potential adverse effect (risk of deterioration) was also identified for biological status elements due to the transfer of water from upstream and subsequent abstraction at this waterbody leading to changes in water velocity and level, which could impact on biological status elements. Within the catchment, phosphate levels are expected to be lower. However, further investigation is required to determine the predicted percentage change.

3.2.3 Mitigation

Potential mitigation measures have been suggested for each individual waterbody and scheme activity based on the risk that it poses. The risks identified to the surface water bodies are due to either:

- The loss of catchment area and open watercourses, particularly associated with larger channels; or
- A decrease in the water quality or change in flow, due to the transfer of water from the River Trent to the River Witham and subsequent abstraction from the River Witham.

Potential, indicative mitigation measures have been suggested for each individual waterbody and scheme activity based on the risk that it poses. The potential mitigation measures should be considered and where feasible embedded into the scheme design.

Potential, indicative mitigation measures for the surface water bodies are set out below:

- Watercourses should be realigned around the reservoir footprint, as far as reasonably practicable, to re-provide lost habitat and flow into the main rivers.
- Channel modifications should seek to offer the change to incorporate environmental gain by widening drains to allow fringe vegetation to be retained or berms to be constructed, subjection to financial burdens during construction, land take and maintenance.
- Considerations to avoid deterioration to hydromorphological determinants including how the flow and quantity of water changes over time.
- Intake structures should be fitted with appropriate fish / eel screens.
- INNS treatment for the transfer from the River Trent to the River Witham.
- If required, consideration of potential water quality treatment of water from River Trent before discharge to River Witham, if additional investigation into nutrient loads indicates a risk of WFD deterioration in water quality.
- Potential low flow releases from the reservoir into local watercourses to help maintain flow (if further investigation suggest this is needed).
- Industry good practice measures including Environment Agency Pollution Prevention Guidance (PPG's)[4].
- Ensure all works carried out in accordance with guidance provided by the regulator, the Environment Agency, for working on/or near water.[5]
- Consideration of mitigation options in line with guidance provided in 'A Guide to Management Strategies and Mitigation Measures for Achieving Good Ecological Potential in Fenland Waterbodies'[6].

[4] Although PPGs are considered to be out of date, they remain good practice for the industry and should be used as embedded mitigation when applicable.

[5] Environment Agency, Protecting and improving the water environment. Water Framework Directive compliance of physical works on or near rivers

[6] Mayer, L., Moodie, I., Carson, C., Vines, K., Nunns, M., Hall, K., Redding, M., Sharman, P. & Bonney, S. (2017) Good Ecological Potential in Fenland Waterbodies: A Guide to Management Strategies and Mitigation Measures for achieving Good Ecological Potential in Fenland Waterbodies. Association of Drainage Authorities & Environment Agency

3.2.4 In-combination effects

A high level in-combination effects assessment has been undertaken. The assessment identified one major project that intersects the scheme. The project is the Viking Link electrical interconnector with an approximate capacity of 1400 megawatts (MW) extending from Revising, Jutland (Denmark) to Bicker Fen, Lincolnshire (United Kingdom)[7]. In-combination effects are possible, as the cable route intersects the River Witham within the same area as the assumed SLR River Witham abstraction location. The cables also intersect the SLR transfer route between the River Witham and the A17.

The Environmental Impact Assessment for the Viking Link interconnector project states the construction of the cables will involve trenchless activities (i.e. horizontal directional drilling) of the watercourse crossings. The activities associated with this construction method could lead to an increase in turbid run-off and spillages/leaks of fuel, oil or other pollutants; with the potential to impact on the water quality in the receiving the watercourses. Additionally, there could be an increase in soil erosion, along the exposed cable trenches. This has the potential to generate turbid (sediment laden) run-off affecting the nearby watercourses. Mitigation for the Viking Link Project includes areas of risk of spillage to be bunded or otherwise isolated to minimise the risk of hazardous substances entering the local watercourses, any surface water flowing into the trenches, will be pumped via settling tanks to remove sediment and potential contaminants before being discharged back into the watercourse, as well application of the Environment Agency standard good practice measures (such as PPGs). Similar mitigation is anticipated to be implemented for the SLR project. Further consideration of potential, indicative mitigation measures for the SLR will be required, and the potential for in-combination effects will be reviewed at gate three, based on the ongoing hydrological assessments.

There is the potential for in-combination impacts on The Wash as a result of the SLR and Fens reservoir schemes. Further work will be undertaken at gate three to determine the extent of potential in-combination effects on The Wash, following the outcome of the ongoing hydrological assessments. Similarly, there are potential in-combination effects as a result of SLR and Minworth SRO on the River Trent. Further work will be undertaken at gate three to identify the potential in-combination effects, based on the ongoing hydrological assessments (assuming Minworth SRO is taken forward to gate three).

3.2.5 Regulation 19

It is possible that an exemption would need to be sought under Regulation 19 of the Water Environment (WFD) (England & Wales) Regulations 2017 (WFD Regulations 2017) in respect of potential deterioration in status of one or more waterbodies. Further investigation will be required to fully quantify the impact, identify possible mitigation and determine the need for any potential exemption.

[7] National Grid (2017) Viking Link. Available at: (sholland.gov.uk)

3.2.6 Proposed future work

The following recommendations for proposed future work have been identified in the WFD assessment to improve confidence in the assessment of the surface water bodies:

- On-going refinement of the design in consultation with a WFD specialist.
- Land drainage and site drainage design, to understand which watercourses will be diverted/realigned and which are lost.
- Request for further specific details of mitigation measures assessment and RBMP measures (including heavily modified water bodies (HMWB) measures where relevant) from the Environment Agency to understand the impact of the scheme, and to identify opportunities to improve the water body as part of the scheme.
- Update to WFD baseline data to include 2019 status in line with Cycle 3 2021-2027 RBMPs, once published
- It is recommended that a hydrology study is undertaken to understand the potential reduction in catchment area, impacts on flow and therefore biological status elements for South Beck and Swaton Drains waterbodies.
- A hydrological and hydroecology study is recommended to understand potential impacts of reduced flow in the Trent from Sour to The Beck catchment on the hydrological regime and water quality (including both continuous and spot sample water quality monitoring), and therefore on biological status elements.
- It is recommended that additional water quality monitoring (both continuous and spot monitoring) is carried out on the four Witham waterbodies. This data should then be used in further water quality analysis to determine the effects of the discharge from the River Trent on water quality and therefore biology.
- It is recommended hydraulic modelling analysis is undertaken to determine the effects of the increase in flow volume and velocity on the four Witham waterbodies as a result of the discharge.
- Development of WFD mitigation to offset impacts of the scheme.
- Completion of full WFD assessment for consenting stage.

3.3 Informal Habitat Regulations Assessment

An informal HRA for the scheme was undertaken, building on the informal HRA for gate one and in accordance with the following guidance, which can be found in Appendix A.2.

Although the Habitats Regulations have been amended by The Conservation of Habitats and Species (Amendment) (European Union (EU) Exit) Regulations 2019, due to the United Kingdom (UK's) exit from the EU, the effect of these amendments is largely related to wording and requirements and processes remain the same, as protection levels remain unchanged. This assessment has been undertaken in an iterative and objective manner following the above stages, with reference to best practice guidance and relevant case law, notably that provided by the Waddenzee case (European Court of Justice (ECJ) 2002) and Sweetman (ECJ 2011) to inform the interpretation and therefore correct application of the terms 'likelihood, 'significance' and 'in combination'. The HRA followed the methodology in the Environmental Assessment Guidance for Water Resources Management Plans and Drought Plans (21/WR/02/15).

All potential options were included in the HRA screening and potential sites were identified from this process. This assessment has been undertaken in an iterative and objective manner following the stages detailed in Appendix A.2. with reference to good practice guidance and relevant case law.

3.3.1 Summary of results

The Stage 1 Screening identified ten designated sites within the Zone of Influence (ZoI) of the Scheme. These are:

- The Wash Special Protection Area (SPA) (UK9008021)
- The Wash Ramsar (UK11072)
- The Wash and North Norfolk Coast Special Areas of Conservation (SAC) (UK0017075)
- Humber Estuary SPA (UK9006111)
- Humber Estuary SAC (UK0030170)
- Humber Estuary Ramsar Site (UK11031)
- Baston Fen SAC (UK0030085)
- Nene Washes SPA (UK9008031)
- Nene Washes SAC (UK0030222)
- Nene Washes Ramsar (UK11046)

At this stage, Likely Significant Effects (LSE) could not be ruled out for the any of these sites other than the Nene Washes SPA, SAC and Ramsar and, therefore, the HRA has progressed to the Appropriate Assessment (AA) stage for the remaining seven sites. The AA provides an assessment to determine whether the scheme will result in an adverse effect on the site integrity (AESI) of the Designated Sites identified at the screening stage with potential for LSE.

The AA found that the Scheme is located sufficiently distant from the designated sites at the Wash and the Humber Estuary to exclude significant adverse effects as a result of noise, light, dust or other human disturbances during the construction phase assuming that best practices and proposed mitigation measures are implemented. There is the potential for adverse effects on the qualifying species of Baston Fen SAC as a result of biological disturbances to functionally linked habitat used by spined loach populations. However, no residual adverse effects are expected once mitigation measures have been taken into account.

During the operation phase, however, the Scheme has the potential to adversely affect the integrity of The Wash SPA and Ramsar, The Wash and North Norfolk Coast SAC, and the Humber Estuary SPA, SAC and Ramsar designated sites and functionally linked habitats used by their qualifying species. No operation effects are expected for Baston Fen SAC.

3.3.1.1 Construction effects

The Wash SPA and Ramsar Site and The Wash and North Norfolk Coast SAC

Reservoir construction effects

The proposed location of the South Lincolnshire Reservoir is sufficiently distant from The Wash Designated Sites (located approximately 23km east of the Scheme) to exclude noise, light and dust effects during the construction phase of the new reservoir.

This site is hydrologically connected to The Wash SPA via the South Forty-Foot Drain (located 5km from the reservoir site). However, considering the nature of these connections through a small, slow flowing ditch network and the distance to the construction area, it is unlikely that any pollution events during the construction phase will have any potential adverse effects as they will be contained and/or diluted before reaching the Designated Site (assuming good practice and all proposed mitigation measures are implemented). This will be further assessed as the scheme develops in future phases.

Transfer construction effects

The Wash Designated Sites are located approximately 15km (at the nearest point) from the indicative transfer route with limited hydrological connectivity. Therefore, it is sufficiently distant to exclude adverse effects on this Designated Site and its qualifying species due to noise, dust, light, visual or human disturbance during the construction phase of the transfer. Additionally, there is no potential for the physical loss, degradation or fragmentation of supporting habitats, including FLL (functionally linked land) for this Designated Site due to construction activities assuming best practice and mitigation measures are implemented.

The Humber Estuary SPA, SAC and Ramsar Site

Reservoir construction effects

The proposed new reservoir is located is sufficiently distant from the Humber Estuary Designated Sites (approximately 74.5km northeast of the site) to exclude adverse effects on this Designated Site bird qualifying species due to light, noise, dust, visual or human disturbance during the construction phase assuming best practice and all proposed mitigation measures are implemented.

It is also unlikely that any construction activities will have an adverse effect on the grey seal populations and the designated sandbanks, mudflats, sandflats, Atlantic salt meadows and reefs and associated vegetation at the Humber Estuary.

River and sea lamprey, however, spawn in freshwater sites many kilometres upstream of the Humber Estuary SAC/Ramsar Site. Therefore, activities during the construction of the reservoir may have adverse effects on functionally linked habitats used by these qualifying fish species. Further investigations are needed to identify key spawning areas in the ZoI of the scheme to better determine adverse effects for these designated species.

Transfer construction effects

The Humber Estuary Designated Sites are located approximately 52.5km from the proposed abstraction point on the River Trent. The abstraction point is hydrologically connected to the Humber Estuary via the River Trent that feeds directly into this designated site. Therefore, there is a pathway for potential effects during construction, including pollution events and biological disturbances that cannot be dismissed at this stage.

Activities during the construction of the pipeline and its associated intake infrastructure may lead to habitat loss and degradation of functionally linked habitats used by qualifying fish species. The Humber Estuary SAC is designated as an important migration route for both, river lamprey and sea lamprey between coastal waters and their spawning areas, therefore any changes to water and/or habitat quality has the potential to disrupt migratory patterns of these designated species.

The river lamprey and, to a lesser extent, sea lamprey, may use the watercourses within the ZoI of this scheme and are dependent on good water quality conditions. Changes in water quality due to run-off and pollution events during the construction of the intake infrastructure in the River Trent may lead to changes in turbidity and increased sedimentation that can also have negative effects on the life cycle of the qualifying species.

Further investigations are needed to identify key spawning areas in the ZoI of the scheme to better determine adverse effects for these designated species.

Grey seals are unlikely to be affected as the construction effects of the pipeline are expected to be localised and of short duration and unlikely to affect the estuary due to the distance and the use of best practice measures.

Baston Fen SAC

Reservoir construction effects

The proposed reservoir is located sufficiently distant from Baston Fen SAC (approximately 20 km away from the construction area) to exclude potential adverse effects during the construction phase on this designated site and its qualifying features.

Transfer construction effects

The proposed transfer route of the SLR potable water pipeline is hydrologically connected to the site, therefore, there is a pathway for potential effects due to construction, including potential pollution events and biological disturbances of functionally linked habitat used by spined loach populations.

The construction of river water course crossings has the potential to impact downstream water quality, increase sedimentation and affect the hydrological regime, resulting in adverse effects on functionally linked habitat used by the qualifying species.

Construction activities may lead to changes in water turbidity and increased sedimentation that can have adverse effects on the life cycle of the spined loach. Non-physical disturbance, including vibration effects during the construction of the transfer pipeline may affect functionally linked habitat used by spined loach, leading to changes in species distributions and habitat avoidance. Physical damage and disturbance of functionally linked habitat may displace populations from current spawning grounds and feeding areas, affecting adult survival**.**

Additionally, physical modification of river channels may remove habitat heterogeneity and the mosaic of microhabitats utilised by spined loach at different stages of their lifecycle. Spined loach may be particularly vulnerable to deposited pollutants due to their burrowing and feeding habits. Pollutants may result in obvious lethal effects, however, a wide variety of sub-lethal effects, such as reduced fertility may affect the overall fitness of spined loach. The effects of non-toxic contamination and non-physical disturbance are considered to be temporary and localised.

If proposed mitigation and good practice measures are implemented, it is considered no residual adverse effects on site integrity remain for Baston Fen SAC as a result of the construction of the indicative transfers.

3.3.1.2 Operation effects

The Wash SPA, Ramsar Site and The Wash and Norfolk Coast SAC

Abstraction effects

The Witham/Haven estuary, located at the mouth of the River Witham, transitions into the larger Wash embayment. The embayment is approximately 25km in length from the landward side to the entrance of the embayment from the North Sea and is located within the counties of Norfolk and Lincolnshire. The Witham/Haven estuary primarily contains extensive saltmarshes and mudflats whilst the larger Wash area contains extensive saltmarshes, intertidal banks of mud and sand, shallow waters and deeper channels, and supports breeding/non-breeding and overwintering migrant wildfowl and wading bird species.

On the basis of current modelled scenarios, water transfer from the River Trent could result in significant flow increases during the year, with proportionately greater impact in summer. The increase would be most pronounced at the point of transfer into the River Witham, and the effect would reduce with distance downstream. The proposed abstraction from the River Witham between Chapel Hill and Langrick may also lead to adverse effects on the Wash habitats and species.

Further studies and modelling are recommended, including an additional hydrodynamic modelling and analysis of salinity changes to determine the effects on The Wash designated sites and its qualifying features.

Changes in water quality and flows

A change in flow due to new abstractions may alter the opportunity for dilution of pollutants, increasing the concentration of pollutants/contaminants. This could have an impact on ecology downstream of the abstractions.

Water abstraction from the River Trent and its transfer into the River Witham could also lead to changes to water quality due to increased turbidity and sedimentation that could affect natural estuarine-coastal processes downstream, potentially worsening the sediment accretion which is already happening in the Wash embayment[8].

The saltmarshes, wading birds and coastal lagoons at the Wash are dependent on freshwater availability and maintaining levels of dissolved oxygen. Increased suspended sediment can smother the estuarine floor leading to anoxic conditions, affecting primary productivity by decreasing the light levels needed for photosynthesis and reducing habitat complexity of coastal ecosystems. Qualifying SPA bird species can be adversely affected by sedimentation altering estuarine processes and food webs on which they depend. Additionally, sediments can also transport pollutants and microplastics to The Wash estuarine environment, which can bioaccumulate in the prey of seabirds and shorebirds. Sedimentation effects may be worsened by the projected increase in the frequency and intensity of storm and flood events triggered by climate change, leading to less-resilient ecosystems.

There is potential for the loss or damage of the Ramsar qualifying vegetation an indirect result of physical habitat damage and habitat degradation due to changes in salinity, water quality and sediment transport. These could be within the designated sites itself and/or in adjacent areas functioning as supporting habitats.

The Wash and North Norfolk Coast SAC is designated for supporting otters *Lutra lutra*. Otter can occupy very large ranges (around 32km for males and 20km for females) and the habitats close to the scheme may be used by these qualifying species when they are functionally linked to the designated site (linkage habitat). Populations in coastal areas utilise shallow, inshore marine areas for feeding but also require freshwater for bathing and terrestrial areas for resting and breeding holts. Therefore, otters can potentially be adversely affected by habitat degradation as a result of changes in water quality leading to a reduction in their food supply.

The Wash and North Norfolk Coast SAC is also designated for supporting the largest colony of common seals *Phoca vitulina* in the UK, with some 7% of the total UK population. The extensive intertidal flats here and on the North Norfolk Coast provide ideal conditions for breeding and hauling out. Changes in water quality and flows, including changes in changes in sediment transport could potentially affect the intertidal banks of sand, mud and shallow water at The Wash as well as FLL used by these qualifying species. Changes to supporting processes including sediment movement and hydrodynamic regime can affect common seal habitats and habitats that the species relies on. The sediment movement is mostly influenced by tide and wave-driven water flow and hydrodynamic conditions that support this include the speed and direction of wave and tidal currents, seabed shear stress and wave exposure, which are not expected to be affected by this option. However, the reduction in flow during high flow conditions could affect the quantity of the sediments reaching estuarine habitats changing

[8] Natural England, 2014. Site Improvement Plan: The Wash. Available from http://publications.naturalengland.org.uk/publication/5327498292232192. Accessed 23/08/2022

natural water flow and sediment movement. Alterations to these processes could affect species presence and distribution.

Further modelling is required to understand the changes due to the transfer from the Trent and abstraction form the River Witham on flow velocity, water quality, turbidity, water level and temperature, particularly during spring/summer, and how these changes may affect the designated habitats and species assemblages of The Wash. A detailed review of the baseline ecological data is also recommended.

Invasive non-native species

The proposed transfers from the River Trent involve raw water and as such there is a risk of INNS transmission which may impact the designated site qualifying habitats and species. As these transfers involve freshwater transfers the potential for the establishment of new INNS in coastal and saline habitats at The Wash designated sites is reduced; however, it cannot be excluded. Following further surveys to confirm presence of INNS, mitigation measures would be required to reduce this risk. Further consideration of the impact of the Scheme on invasive non-native species is included in Section 12, Invasive Non-Native Species risk assessment.

The Humber Estuary SPA, SAC and Ramsar Site

Abstraction effects

During operation, water abstraction has the potential to result in habitat loss and degradation of the designated site itself and/or Functionally Linked Land (FLL) used by its bird and fish qualifying species. Changes in water levels and flows as a result of the new abstraction in the River Trent could lead to changes to water quality downstream, adversely affecting estuarine processes and feeding grounds of designated bird species. Abundant food resources attract wildfowl and waders to the site. If these are impacted by the above effects this could result in the habitat no longer being able to support the population levels for which the site is designated. At this stage, further studies are recommended to reduce uncertainty and to estimate the potential effects on the estuarine processes and its designated habitats and bird species.

Changes to water levels and flows due to the new abstraction in the River Trent may also lead to functionally linked habitat degradation and biological disturbances for the river lamprey and the sea lamprey, including disturbance to migratory journeys to spawning grounds and potential for populations to be displaced from current spawning grounds and feeding areas. Disturbance to qualifying species migratory routes may impact upon adult survival. Designated fish species migrating between the Humber Estuary upstream the River Trent may also be caught or entrained at the new intake point leading to fish mortality. Further investigations will be undertaken as the design progresses.

The Humber Estuary SAC is also designated for supporting grey seals that come ashore in autumn to form breeding colonies on the sandy shores of the south bank at Donna Nook. Changes in water quality and flows, including changes in changes in sediment transport could potentially affect the intertidal banks of sand, mud and shallow water at the Humber Estuary as well as FLL used by these qualifying species. Changes to supporting processes including sediment movement and hydrodynamic regime can affect grey seal habitats and habitats that the species relies on. The sediment movement is mostly influenced by tide and wave-driven water flow and hydrodynamic conditions that support this include the speed and direction of wave and tidal currents, seabed shear stress and wave exposure, which are not expected to be affected by this option. However, the reduction in flow may affect the quantity of the sediments reaching estuarine habitats changing natural water flow and sediment movement. Alterations to these processes could affect species presence and distribution.

There is also the potential for the loss or damage of qualifying vegetation as a result of changes in water levels and flows, sediment and nutrient loads leading to changes in natural succession. At this stage, further studies are recommended to reduce uncertainty and to estimate the potential effects on the estuarine processes and its designated habitats and species.

Baston Fen SAC

No operation effects are anticipated for this option which could affect this designated site and its qualifying features.

3.3.2 Mitigation

The potential mitigation measures assume a worst-case scenario at this stage, in the absence of detailed survey data or local records. Mitigation measures have been proposed for both construction and operation phases at all sites. However, more detailed and targeted mitigation measures can only be formulated once the exact nature of the impacts are better understood, following the additional assessment work recommended by the informal HRA.

In addition to best practice measures for construction including pollution control, biosecurity, and disturbance, the mitigation measures proposed to avoid or reduce adverse effects include reducing the working pipeline width in order to minimise the temporary loss of functionally linked habitats, as well as sensitive timings of construction and operation works to avoid the spawning season for sea and river lamprey, and key periods for overwintering and breeding bird populations. It is also recommended that a CEMP be in place that will include the proposed mitigation measures in this AA as well as any other specific measures identified following an HRA undertaken at project level.

3.3.3 In-combination effects

3.3.3.1 In-combination effects with other plans and projects

Adverse effects were identified during the operation stage that can affect the integrity of the following sites:

- The Wash SPA (UK9008021)
- The Wash Ramsar (UK11072)
- The Wash and North Norfolk Coast SAC (UK0017075)
- Humber Estuary SPA (UK9006111)
- Humber Estuary SAC (UK0030170)
- Humber Estuary Ramsar Site (UK11031)
- Baston Fen SAC (UK0030085)

Consequently, an in-combination assessment is required for the scheme. The following developments have been identified within 10km of the Scheme (Table 3.1). This geographic distribution is based on UK Water Industry Research (UKWIR) guidance (UKWIR, 2022).

Table 3.1: Plans and developments within 10km of the SLR Scheme

Planning Authority	Local Plan	Reference	Location/ Description	Potential for in-combination effects
Boston Borough Council	N/A	H04-0823-17	North Ing Drove Donington Spalding. Works to facilitate the Viking Link electrical interconnector with an approximate capacity of 1400 MW extending from Revsing, Jutland, (Denmark) to Bicker Fen, Lincolnshire (UK) comprising: - Installation of two (2) subsea high voltage direct current (DC) cables between Mean Low Water Springs (MLWS) and landfall at Boygrift in East Lindsey; - Installation of two (2) onshore DC cables between the landfall at Boygrift and the converter station at North Ing Drove in South Holland; - Construction of associated Temporary Construction Compounds (TCC) and Temporary Works Areas (TWA) and temporary vehicle access arrangements required for DC and alternating current (AC) cable installation; - Erection of converter station buildings together with the formation of internal roads, permanent access road from the A52, erection of security fencing, formation of landscaping with associated temporary construction compounds; - Installation of up to six (6) onshore high voltage AC cables between the converter station at North Ing Drove and the existing Bicker Fen 400 kilovolt (400kV) Substation owned and operated by National Grid Electricity Transmission Plc (NGET); - Installation of link pillars along the AC cable route for inspection and maintenance purposes, these will be contained within fenced areas; - Installation of all associated drainage mitigation works; and - Installation of fibre-optic cable(s) with the high voltage AC and DC cables	Yes, Crosses River Witham between the two SLR abstraction locations (trenchless cable crossing at 525245, 349316) and runs across the pipeline route between River Witham and A17. Potential increase in turbidity and site run off (pollution) into River Witham and Skerth Drain (trib of South Forty-foot drain) hydrologically connected to The Wash Designated Sites.

3.3.3.2 In-combination effect with other SROs

Fens Reservoir (FR) SRO

The FR SRO scheme includes the development of a new raw water reservoir for public water supply within the Anglian Water region. The informal HRA undertaken for FR has identified potential effects to the following sites that also may share potential effects with the SLR SRO scheme:

- The Wash SPA (UK9008021)
- The Wash Ramsar Site (UK11072)
- The Wash and North Norfolk Coast SAC (UK0017075)

Minworth SRO

Minworth SRO is investigating the potential to provide water to the River Severn to River Thames Transfer (STT) SRO by diverting some of the Minworth wastewater treatment works (WwTW) final effluent to the River Avon which is a tributary of the River Severn as well as to the Grand Union Canal (GUC) via the Coventry Canal. Additional treatment at Minworth WwTW – the Advanced Water Treatment Plant (AWTP) is proposed to ensure water quality is appropriate for discharge to the River Avon and the Coventry Canal allowing water to be diverted from the final effluent flow at Minworth and transferred to a combination of the River Avon and Coventry Canal.

The informal HRA undertaken for the Minworth SRO scheme has identified potential effects to the following sites that also may share potential effects with the SLR SRO scheme:

- The Humber Estuary SAC (UK0030170)
- The Humber Estuary Ramsar Site (UK11031)

The HRA identifies that the only potential impact pathway identified between the WwTW outfall locations and the Humber Estuary Designated sites (200km) relates to a reduction in water levels in the Humber Estuary SAC or Ramsar Site, or upstream of the site, sufficient to disrupt the ability of sea lamprey and river lamprey to travel to and from the SAC/Ramsar Site. Upstream dispersion of river and sea lamprey in the River Trent is considered to be severely limited by 2.6m high, 100m broad Cromwell Weir, which is impassable to both species. However, there is a consented proposal to install two eel passes which would also be passable to lamprey.

The potential in-combination effects from SLR, FR and Minworth SROs are presented in Table 3.2.

Table 3.2: FR, Minworth and SLR in-combination effects

Designated Sites/Qualifying Feature	FR adverse effects	Minworth adverse effects	SLR adverse effects	In-combination effects
The Wash SPA and Ramsar bird assemblages	Yes – uncertainty around potential effects from changes in flows and water quality and indirect effects on estuarine habitats	NA	Yes– uncertainty around potential effects from changes in flows and water quality and indirect effects on estuarine habitats	Uncertain - further modelling should aim to look at the potential effects from water quality changes and changes in flows. Although effects are not anticipated to be significant in-combination due to the scale of the Wash and distance between the two affected estuaries further modelling would reduce uncertainty in this assessment.
The Wash SAC Common seals	Yes -– uncertainty around potential effects from changes in flows and water quality and indirect effects on estuarine habitats	N/A	Yes– uncertainty around potential effects from changes in flows and water quality and indirect effects on estuarine habitats	Uncertain – further modelling should aim to look at the potential effects from water quality changes and changes in flows. Although effects are not anticipated to be significant in-combination due to the scale of the Wash and distance between the two affected estuaries further modelling would reduce uncertainty in this assessment.
The Wash SAC Otters	Yes – uncertainty around potential effects from changes in flows and water quality and indirect effects on estuarine habitats	N/A	Yes– uncertainty around potential effects from changes in flows and water quality and indirect effects on estuarine habitats	Uncertain – further modelling should aim to look at the potential effects from water quality changes and changes in flows. Although effects are not anticipated to be significant in-combination due to the scale of the Wash and distance between the two affected estuaries further modelling would reduce uncertainty in this assessment.
The Wash and North Norfolk Coast SAC and The Wash Ramsar saltmarsh vegetation	Yes -– uncertainty around potential effects from changes in flows and water quality and indirect effects on estuarine habitats	N/A	Yes– uncertainty around potential effects from changes in flows and water quality and indirect effects on estuarine habitats	Uncertain – further modelling should aim to look at the potential effects from water quality changes and changes in flows. Although effects are not anticipated to be significant in-combination due to the scale of the Wash and distance between the two affected estuaries further modelling would reduce uncertainty in this assessment.
The Humber Estuary SAC and Ramsar Site sea lamprey and river lamprey	N/A	Yes – uncertainty around potential effects from changes in flows and water quality affecting functionally linked habitat and	Yes – uncertainty around potential effects from changes in flows and water quality affecting functionally linked habitat and indirect effects on estuarine habitats	Uncertain – further modelling should aim to look at the potential effects from water quality changes and changes in flows. Although effects are not anticipated to be significant in-combination due to the scale of the Humber Estuary and distance between the site and the estuary further modelling would reduce uncertainty in this assessment

Designated Sites/Qualifying Feature	FR adverse effects	Minworth adverse effects	SLR adverse effects	In-combination effects
		indirect effects on estuarine habitats		

3.3.4 Proposed future work

Further studies are recommended to address uncertainty and should include:

- Hydrodynamic modelling of flows and salinity into The Wash Designated Sites.
- Studies and modelling of the water demand from the River Trent and the River Witham to identify whether the changes in the water levels and flows as a result of the operation of the South Lincolnshire Reservoir will have an impact on the Designated Sites and their qualifying features.
- Further modelling of the current nutrient level analysis due to the abstraction to determine the effect of nutrient loading.
- Further assessment and modelling of the effects of the inter-catchment transfer from the River Trent to the River Witham to reduce uncertainty and determine the effects on the Designated Sites located downstream.
- Climate change scenario analysis to assess whether the adverse effects identified through this HRA may be compounded through the more frequent and intense effects of heat waves, droughts, floods and rising sea levels.

3.3.5 Conclusion

Potential adverse effects cannot be ruled out at this stage for:

- The Wash SPA (UK9008021)
- The Wash Ramsar (UK11072)
- The Wash and North Norfolk Coast SAC (UK0017075)
- Humber Estuary SPA (UK9006111)
- Humber Estuary SAC (UK0030170)
- Humber Estuary Ramsar Site (UK11031)

This informal HRA Appropriate Assessment, considered that the scheme is located sufficiently distant from the Designated Sites in the Wash and the Humber Estuary to exclude significant adverse effects as a result of noise, light, or other human disturbance during the construction phase after the good practice and proposed mitigation measures are implemented.

During the construction phase for the transfer intake from the Trent, adverse effects cannot be ruled out on the Humber designation.

During the operation phase, however, the scheme has the potential to adversely affect the integrity of The Wash and the Humber Estuary Designated Sites and functional linked habitats used by their qualifying species through the following pathways:

- Changes to water levels and flows due to abstraction from the River Trent and inter-catchment transfer into the River Witham, water storage and emergency discharge drawdown flows leading to fluctuations in water temperature regimes and salinity levels downstream.
- Physical damage as a result of changes in flow velocity and sediment fluxes leading to changes in natural coastal processes; functionally linked habitat degradation as a result of water quality changes.
- Toxic contamination leading to biomass reduction and food web disruptions that may affect the life cycle of qualifying species. Sediments can transport pollutants and microplastics to estuarine environment, which can bioaccumulate in the prey of seabirds and shorebirds.
- Non-toxic contamination as a result of changes in water turbidity, sediment loading and silt deposition altering ecosystem processes and food webs; as well as dust effects smothering habitats, affecting photosynthesis and reducing productivity. Sediment deposition can smother the estuarine floor, reduce habitat complexity and cause anoxic conditions where dissolved oxygen is depleted by the overgrowth or change in bacterial diversity affecting food resources for qualifying species.
- Biological disturbance including direct mortality; changes to habitat availability including functional linked habitat used by qualifying species; changes in species abundance or distribution; potential for populations to be displaced from current foraging/spawning areas; changes in natural succession; introduction of new pathways for spread of INNS as a result of inter-catchment water transfers.

These effects may lead to changes to:

- The extent and distribution of qualifying habitats
- The structure and function of the qualifying habitats
- The supporting processes on which habitats of qualifying species rely

Additionally, the identified effects have the potential to reduce the extent and quality of functional linked habitats supporting qualifying species' populations.

An in-combination assessment was undertaken with other plans or projects and identified potential effects in-combination with:

- Fenland Reservoir SRO – potential effects on The Wash SPA (bird qualifying species) and The Wash and North Norfolk Coast SAC / Ramsar Site (common seals, otters and saltmarsh vegetation).
- Viking Link electrical interconnector project extending from Revsing, Jutland, (Denmark) to Bicker Fen, Lincolnshire (UK) – potential effects include increased turbidity and site run off (pollution) into River Witham and Skerth Drain (tributary of South Forty-foot drain) hydrologically connected to The Wash Designated Sites.
- Minworth SRO – potential effects on The Humber Estuary SAC and Ramsar Site qualifying fish species (sea lamprey and river lamprey).

It should be noted that these conclusions are based on preliminary, indicative design assumptions available at this time, commensurate with the stage of scheme development the project is at and are primarily informed by available, appropriate desktop information. Further design iterations will require revisions to this document and may result in changes to the current conclusion.

Further surveys, data collection, modelling and assessment, together with the detailed consideration of mitigation measures, will be required in order to conclude that there will be an absence of effect on the integrity of designated sites. The strategy to produce the evidence base required for the formal stages of HRA will be agreed at the next stage in consultation with the regulator. Ultimately, a strong and robust evidence base will be required to conclude that there will be no adverse effects on the integrity of any designated site. as a result of the construction or operation of the scheme. The level of detail available at this stage (which is considered proportionate) means that such effects cannot be ruled out at this stage. As a result, this will need further consideration and assessment as part of the next stages of design development to conclude what the effects (if any) of the SLR on designated sites will be, and any further work required by the HRA process. All of this would need to be undertaken in dialogue with key stakeholders, including Natural England and the Environment Agency.

3.4 Strategic Environmental Assessment

The SEA Review (see Appendix A.3) presents an update to the SEA level option assessment for the SLR prepared by WRE for the regional plan and included in the dWRMP24. This is in-line with the methodology in the WRE Regional Plan Environmental Assessment Methodology Guidance9. This formed an update to the SEA undertaken at gate one. The SEA was broken down into environmental topics and objectives. It assigned ratings to each on a seven-point scale (from 'Major Positive' to 'Major Negative') based on scoring criteria. The ratings were informed by the other environmental assessments (WFD, HRA, BNG, NCA, INNS) for the scheme. The SEA considered anticipated construction and operational effects, both without any mitigation applied and expected residual effects after implementation of proposed mitigation measures.

The SEA topic and objectives can be found below in Table 3.3.

Table 3.3: SEA topics and objectives from dWRMP24

SEA topic	SEA objective
Biodiversity, flora and fauna	• To protect designated sites and their qualifying features. • To deliver BNG, protect biodiversity, priority species and vulnerable habitats such as chalk rivers. • To avoid spreading and, where required, manage INNS. • To meet WFD objectives relating to biodiversity.
Soil	• To protect and enhance the functionality and quality of soils, including the protection of high-grade agricultural land, and geodiversity.
Water	• To reduce or manage flood risk, taking climate change into account. • To enhance or maintain surface water quality, flows and quantity. • To enhance or maintain groundwater quality and resources. • To meet WFD objectives and support the achievement of environmental objectives set out in River Basin Management Plans. • To increase water efficiency and increase resilience of water supplies and natural systems to droughts.
Air	• To reduce and minimise air emissions during construction and operation.
Climatic factors	• To minimise/reduce embodied and operational carbon emissions. • To introduce climate mitigation where required and improve the climate resilience of assets and natural systems.
Landscape	• To conserve, protect and enhance landscape and townscape character and visual amenity.
Historic environment	• To conserve/protect and enhance historic environment and heritage assets, and their setting, including archaeologically important sites.
Population and human health	• To maintain and enhance the health and wellbeing of the local community, including economic and social wellbeing. • To secure resilient water supplies for the health and wellbeing of customers. To increase access and connect customers to the natural environment, provide education or information resources for the public. • Maintain and enhance tourism and recreation
Material assets	• Avoid negative effects on built assets and infrastructure. Minimise resource use and waste production

[9] WRSE Regional Plan Environmental Assessment Methodology Guidance, Mott MacDonald June 2020

The SEA identified the following potential effects, outlined in Table 3.4.

Table 3.4: Summary of potential effects.

SEA topic	Main effects
Biodiversity, flora and fauna	Proposed water abstraction from the River Trent and its transfer into the River Witham could lead to changes to water quality due to increased turbidity and sedimentation that could affect natural estuarine-coastal processes downstream, potentially impacting the sediment accretion which is already happening in the Wash embayment**.** The saltmarshes, wading birds and coastal lagoons at the Wash are dependent on freshwater availability and maintaining levels of dissolved oxygen which could be affected by the scheme.
Soil	Permanent loss of soils and associated Grade 2 and 3 agricultural land.
Water	There is the potential to cause a deterioration in the status of affected waterbodies or a failure to achieve good status.
Air	No long terms effects on air quality are anticipated, there may be short term effects arising from construction.
Climatic factors	The proposed scheme is unlikely to affect the local environment's resilience to hazards such as flood risk, temperature extremes, storms, and gales, but may assist in managing resilience of surrounding flora and fauna to drought. There may be short and medium term increases in carbon emissions.
Landscape	The reservoir itself and above ground infrastructure associated with the WTW, potential visitor centres, pumping stations and access infrastructure have potential to negatively affect landscape character and visual amenity.
Historic environment	The reservoir and associated built infrastructure have the potential to permanently and adversely alter the setting of historic assets, through visual intrusion. There may also be operational impacts resulting from increased noise pollution, traffic and potential tourism that may impact the setting of historic assets although these are considered minor.
Population and human health	There may be minor benefits to local community as facilities at the reservoir may generate jobs. The reservoir would promote local recreational activities.
Material assets	Direct land take may be required from the Helpringham /Scredington Road and a road replacement is to be built to the north of the reservoir such that any effects are expected to be temporary. There may be construction and operational effects to roads that will connect the reservoir.

3.4.1 Mitigation

As the scheme is developed further mitigation will be proposed. However, it should be noted the WFD and informal HRA assessments provide details of specific proposed mitigation and further investigations that will increase confidence in assessments that will inform the ongoing scheme design.

4 Biodiversity, flora and fauna appraisal

4.1 Introduction

This section presents potential impacts on biodiversity, flora and fauna from the SLR scheme. It is based on the desk-based assessments that were carried out for the scheme for the reservoir and transfer routes, complemented by findings from the scheme-wide SEA. The objectives of the section are to summarise the biodiversity baseline associated with the scheme, and identify constraints, opportunities, and issues that require further investigation.

The need to consider biodiversity, flora and fauna is underpinned by legislation (including the Conservation of Habitats and Species Regulations 2017, Wildlife and Countryside Act 1981 and Natural Environment and Rural Communities Act 2006) and national planning policy.

To inform the assessments, the following biodiversity-related receptors were considered:

- Statutory designated sites identified using Multi-Agency Geographic Information for the Countryside (MAGIC)
- Non-statutory sites identified using data from Lincolnshire Environmental Records Centre (LERC)
- Sites of Special Scientific Interest Impact Risk Zones (SSSI IRZ) identified using MAGIC
- Other sites identified for nature conservation such as Royal Society for the Protection of Birds (RSPB) Reserves
- Priority habitats identified using the Priority Habitats inventory on MAGIC
- Ancient woodland identified on MAGIC
- Tree Preservation Orders (TPOs)
- European Protected Species licences identified using MAGIC
- Great crested newt class survey licence returns, and pond surveys identified using MAGIC
- Biological records, including protected species, from LERC
- A ‘first pass’ habitat map using OS Mastermap data converted into UK Habitat Classification (UKHab) data
- Statutory designations – Local Nature Reserves (LNRs), National Nature Reserves (NNRs), Ramsar Sites, SACs (including candidate SACs), Sites of Community Importance (SCIs), SPAs (including proposed SPAs), SSSIs, SSSI risk zones, Marine Protected Areas and Marine Conservation Zones.
- Non-statutory designations; Ancient Woodlands, Local Wildlife Sites (LWS), Priority Habitat.
- Biodiversity opportunity areas – Nature Improvement Areas, National Priority Focus Areas.

The overarching assumptions and limitations outlined in Section 1.7 apply to the appraisal of biodiversity, flora and fauna, as do the following issue-specific limitations:

- Biological records obtained from third parties and presented in the desk study do not represent a full and complete species list for the area (they are mostly given by individuals on an ad hoc basis often meaning there are areas of deficiency in the data).
- The resolution of location data for biological records is variable and often limited to a 1km grid square.
- No site visits or species-specific surveys have been undertaken to confirm habitat suitability and potential presence of any protected species.
- The potential for wider benefits identified within this section are subject to the constraints of associated environmental and social appraisals set out within this environmental appraisal.

A summary of potential effects of the SLR scheme on biodiversity, flora and fauna is provided below.

4.2 Reservoir and associated infrastructure

Desk-based baseline assessments indicated that there are no statutory designated sites within 2km of the reservoir site. No relevant SSSI Impact Zones (i.e, those that relate to the proposed development type) overlap with the proposed footprint of the reservoir site. Three LWSs (Horbling Line, Threekingham Road Verges and Aswarby Thorns) are located within 2km of the reservoir site. There are no Ancient Woodland or TPOs within 1km of the reservoir site.

Habitat mapping, inclusive of the site area with a 2km buffer, identified that the following habitats are present: cropland, grassland (neutral, other), modified grassland, dense scrub, developed land and buildings, broadleaved woodland (small, discrete areas with little connectivity to other woodland blocks) and watercourses (rivers and streams). The habitats on site have the potential to support the following protected species: badger *Meles meles*, bats, breeding and overwintering birds, great crested newt *Triturus cristatus*, otter *Lutra lutra*, water vole *Arvicola amphibius*, widespread reptiles, notable plant species, aquatic and terrestrial invertebrates, macrophytes and fish; as well as invasive non-native species.

Of the habitats identified, broadleaved deciduous woodland is considered a priority habitat. Seven areas of broadleaved deciduous woodland are located within the reservoir site footprint, and a further 10 areas of broadleaved deciduous woodland are within 1km of the site. They are generally small, discrete areas with little connectivity to other woodland blocks. In addition, one area of floodplain grazing marsh is located within 1km of the reservoir site, along South Scredington Beck to the immediate north of Scredington.

Assessment of potential impacts suggests that works within the reservoir site are unlikely to have any direct adverse effects on designated sites. A small number of areas of priority habitat would be permanently lost to the scheme; however, the value of other habitats within the site is generally low, being dominated by intensive arable agriculture.

Following relevant ecological field surveys to determine presence of protected species, and subsequent confirmation of presence, mitigation measures would likely be required, such as translocation preceded by creation of suitable habitat elsewhere. Habitat creation associated with the site should tie closely to the Nature Recovery Network areas to the northwest and southeast, both of which focus on watercourses and associated riparian habitats. Habitat creation for translocation of protected species could be combined with opportunities for habitat creation and enhancement around Aswarby Thorns and towards the South Forty Foot Drain. Wider potential nature conservation opportunities in the area surrounding the reservoir site have

been identified. Many of these could not be delivered by the proposed reservoir scheme alone and would require external partnership and funding to deliver.

Potential opportunities could include:

- Enhancement of the Boston-Peterborough wetland corridor
- Enhancement of Swaton Fen
- Enhancement of river corridors, such as North Beck
- Association with water running on limestone which is alkaline and provides habitat for unique species assemblages
- Enhancement of drains for Swaton and Helpringham Fen to the east
- Connection to the Bourne-Sleaford corridor

Further mitigation of impacts on biodiversity has been considered through prioritising avoidance of the permanent loss of important habitats. Key biodiversity assets identified included priority woodland habitat located in the centre and to the southwest of the reservoir site, broadleaved woodland located to the southwest of the reservoir site, and the drain across the centre of the reservoir site. Good practice construction practices will also be prescribed to reduce the habitat clearance required. Furthermore, areas around the reservoir have been identified as potential target areas for habitat enhancement and delivery of BNG.

4.3 Transfers

4.3.1 Abstractions

To provide water to the scheme, it is proposed that water will be abstracted and transferred from the River Trent to the River Witham, and from the River Witham to SLR. The overall scheme is potentially indirectly hydrologically connected to the following Designated Sites:

- The Wash and North Norfolk Coast SAC (UK0017075)
- The Wash Ramsar Site (UK11072)
- The Wash SPA (UK9008021)
- Humber Estuary SPA (UK9006111)
- Humber Estuary SAC (UK0030170)
- Humber Estuary Ramsar Site (UK11031)
- Baston Fen SAC (UK0030085)

4.3.1.1 Changes in flows

The results of the hydrological modelling indicate decreases in flows at the Witham outlet into the Wash. The most pronounced decreases will be seen in the winter months with seasonality and environmental cues largely triggering when abstraction will occur.

On the basis of current modelled scenarios, water transfer from the River Trent could result in flow increases throughout the year in the River Witham, with proportionately greater impact in summer. The increase would be most pronounced at the point of transfer into the River Witham, and the effect would reduce with distance downstream.

Habitats within the Wash embayment are subject to significant daily changes in flow velocity from flooding and draining of the waterbody into the North Sea. Flow conditions are in constant flux and the habitats associated with these areas are adept at coping with stressors derived from these changes. The proposed changes to flow at the River Witham outlet are unlikely to affect estuarine habitats that are subject to greater daily background changes due to the tidal

nature of the Wash embayment. However, further studies and modelling are recommended to confirm that any changes to flow will be negligible.

4.3.1.2 Changes in water quality

A change in flow due to new abstractions may alter the opportunity for dilution of pollutants, increasing the concentration of water quality parameters. This could have an impact on ecology downstream of the abstractions.

Water abstraction from the River Trent and its transfer into the River Witham could also lead to changes to water quality due to increased turbidity and sedimentation that could affect natural estuarine-coastal processes downstream, potentially worsening the sediment accretion which is already happening in the Wash embayment[10].

The saltmarshes, wading birds and coastal lagoons at the Wash are dependent on freshwater availability and maintaining levels of dissolved oxygen. Increased suspended sediment may smother the estuarine floor leading to anoxic conditions, affecting primary productivity by decreasing the light levels needed for photosynthesis and reducing habitat complexity of coastal ecosystems. Qualifying bird species may be adversely affected by sedimentation altering estuarine processes and food webs. Additionally, sediments may also transport pollutants and microplastics to the Wash estuarine environment, which can bioaccumulate in the prey of seabirds and shorebirds. Sedimentation effects may be worsened by the projected increase in the frequency and intensity of storm and flood events triggered by climate change, leading to less-resilient ecosystems.

Short term changes to water quality throughout the year may occur as highlighted by the flow concentration calculations. These are expected to be lower than water quality changes during historical drought events and only occurring during autumn and winter when the reservoir is being filled. Negative impacts may occur in the short term during wash off or drought events in the autumn and winter, with 2% of samples modelling a change in WFD status where a WFD status could be attributed to the baseline and revised water quality. These changes will impact the River Trent downstream of the two abstractions and potentially the transitional waters downstream of Boston.

Changes to salinity, nutrient levels and thermal regime may also adversely affect the Designated Sites and their qualifying features due to the direct increased water abstraction, discharges, storage, and flow releases into the River Witham. This includes otter *Lutra lutra* and common seals *Phoca vitulina*, qualifying features of The Wash and North Norfolk Coast SAC, qualifying bird species of The Humber Estuary SPA and Ramsar Site, and river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus* migratory routes, qualifying species of The Humber Estuary SAC, and qualifying vegetation.

Further modelling is, therefore, required to understand the changes which may take place due to the transfer from the Trent on flow velocity, water quality, turbidity, water depth and temperature particularly during spring/summer. Further studies including field-based hydraulic and river physical habitat investigations to enable some quantification of potential impacts on aquatic ecology are recommended. A detailed review of the baseline ecological data is also recommended.

[10] Natural England, 2014. Site Improvement Plan: The Wash. Available from http://publications.naturalengland.org.uk/publication/5327498292232192. Accessed 23/08/2022

4.3.2 Transfers

The appraisal below is based on broad indicative proposed transfer routes. The exact location of the routes, and their consequent impacts on designated sites, will require confirmation at the next stage of project development.

Desk-based assessments carried out to inform the indicative transfer routes adopted a traffic light system to assign Red-Amber-Green (RAG) ratings to demonstrate how each route performed against environmental criteria. All routes were assigned 'green' rankings in relation to impacts on nature conservation and biodiversity, with the exception of the SLR to Anglian Water (SR) where potential impacts on SSSIs and their qualifying features were assigned an Amber ranking due to close proximity with several SSSIs.

Further information about the potential extent of construction and operational effects of the pipeline routes on biodiversity features, and proposed mitigation, enhancement and monitoring recommendations, is provided below.

4.3.2.1 Nationally designated sites and their qualifying features (SSSI)

- River Trent to Witham
  - There are no SSSIs in proximity to the route, the closest site being Besthorpe Meadows SSSI approximately 5.5km to the north of the option. The proposed route is not located in any SSSI risk zones.
  - This route is not considered to have an effect on nationally designated sites and their qualifying features.
- River Witham to SLR
  - This proposed route is not in close proximity to SSSIs. The closest site is Wilsford & Rauceby Warrens SSSI approximately 8.75km west of the proposed route. Part of the proposed route, including the abstraction location at the Witham, is located within SSSI risk zones associated with Troy Wood, Tattershall Cars, Tattershall Old Gravel Pits and Fulsby Wood SSSI areas.
- SLR potable water pipeline
  - There are a number of SSSIs in proximity to the route. Cross Drain SSSI is located approximately 30m from the proposed route. Langtoft Gravel Pits SSSI is approximately 1km to the west of the proposed route. The proposal is partially located within SSSI IRZs associated with several SSSIs in the surrounding area, including Cross Drain SSSI.
  - Potential effects upon the SSSIs in proximity to this route cannot be ruled out. Consultation with Natural England is likely to be needed. Standard mitigation measures can be utilised during construction to ensure that works do not encroach upon any SSSIs. Potential issues are likely to be able to be overcome. Other designated sites (ancient woodland, NNR, LNR) and priority habitats.

- River Trent to Witham
  - Stapleford Wood Ancient Woodland is located between the proposed abstraction location and the discharge at the River Witham, approximately 950m from the proposed route. Devon Park Pastures LNR is located approximately 5km to the south of the proposed route. Approximately 0.59% of the proposed route is located within areas of priority habitat, 0.12% of which is coastal and floodplain grazing marsh, and 0.47% of which is broadleaved deciduous woodland.
  - The potential risk to Stapleford Wood is low however steps should be taken to ensure that potential effects are mitigated for.
  - The LNR and priority habitats are likely to be directly impacted by the proposals. There will be some minor permanent loss of priority habitat associated with the pipeline and intake infrastructure. The affected priority habitat is not considered irreplaceable and with application of best practice construction measures and reinstatement of habitat.
  - Trenchless tunnelling to protect priority habitats should be further assessed and confirmed at detailed design. Further site-specific ecological assessments and discussions with regulators will be required to help inform the detailed design of the scheme.
- River Witham to SLR
  - There are no areas of ancient woodland in proximity to the proposed route.
  - There are no NNRs or LNRs in proximity to the proposed route. There is no direct impact on priority habitat from the proposed route. The abstraction location is approximately 75m from areas of priority habitat (broadleaved deciduous woodland) on the opposite bank of the River Witham. An area of coastal and floodplain grazing marsh is located approximately 25m from the proposed route, where the route crosses the A17.
  - There will likely be no direct impact upon priority habitat during construction and operation
- SLR potable water pipeline
  - The proposed route is not in proximity to ancient woodland.
  - 0.29% of the proposed route is located within areas of priority habitat, 0.13% of which is coastal and floodplain grazing marsh, and 0.16% of which is deciduous woodland.
  - The areas of priority habitat which the route is located within will be directly impacted by the proposal. There will be some minor loss of priority habitat associated with the pipeline infrastructure. The affected priority habitat is not considered irreplaceable and with application of good practice construction measures and reinstatement of habitat, the overall effect of other designated sites comprises a minor environmental constraint to the development of the scheme.
  - Trenchless tunnelling to protect priority habitats should be further assessed and confirmed at detailed design. Further site-specific ecological assessments and discussions with regulators will be required to help inform the detailed design of the scheme.

4.4 Scheme summary

Following the completion of a HRA Appropriate Assessment, construction phase effects on The Wash SPA/Ramsar Site, The Wash and Norfolk Coast SAC and the Humber Estuary SPA/SAC/Ramsar Site are considered unlikely, provided proposed mitigation and best practices are followed. However, the potential adverse effects on protected species, and on the designated sites, cannot be ruled out until ecological surveys are undertaken to determine presence or likely absence of protected species within or adjacent to the footprint of the scheme. The results of these further investigations will provide the basis of mitigation design.

Furthermore, at this stage it is not possible to rule out adverse effects for the operational phase, as the potential adverse effects of increased sedimentation and changes in water levels and flows and are currently unknown. Studies and modelling of the water demand from the River Trent and River Witham are needed to identify whether the changes in the water levels and flows as a result of the operation of the SLR will have an impact on the Habitat Sites and their qualifying features, as well as functionally linked habitats supporting qualifying species' populations. Further modelling of the current nutrient level analysis due to the abstraction also is required to determine the effect of nutrient loading.

Additional information about scheme options, including a further assessment and modelling of the effects of the abstraction on the River Trent and the inter-catchment water transfer to the River Witham are also needed to reduce uncertainty and determine the effects on the designated sites located downstream.

A detailed review of the baseline ecological data will be undertaken for gate three including site-based ecological surveys. These will inform the baseline for the EIA and any permitting applications required prior to the start of construction.

5 Soil appraisal

5.1 Introduction

This section presents potential impacts and permanent loss of soils arising from the SLR scheme. The objectives of this section are to summarise the soil baseline associated with the scheme, and identify constraints, opportunities, and issues that require further investigation.

The need to consider soils and land quality is underpinned by national planning policy, which seeks to minimise the loss of the best and most versatile (BMV) agricultural land where possible to minimise impacts on soil quality.

Loss of agricultural land to the SLR scheme and its associated infrastructure will be unavoidable. A key principle for development of the scheme is to avoid losing soil, this is in line with Defra's Safeguarding our Soils: A Strategy for England.

To inform the assessments, the following were considered:

- Soils of the Cambridge and Ely District (SS10) 1:63,360 Outline Soil Map (R. S. Searle and C. A. H Hodge, 1976)
- Digitised Detailed National Soil Mapping (Cranfield University)
- Digitised Soil Auger Bore Profile Records (Cranfield University)
- Post-1988 Agricultural Land Classification (ALC) Mapping (Natural England)
- Provisional ALC Mapping (Natural England)
- Predictive Best and Most Versatile (BMV) Land Assessment (Natural England, 2017)
- Peaty Soils Locations (Natural England)
- SSSIs designated for their geological importance
- Historic and permitted landfill sites
- Nationally significant infrastructure including mineral sites, allocated major developments, major planning applications (Nationally Significant Infrastructure Projects (NSIP) land, mineral safeguarded land, allocated local plan major development, EIA development planning applications)
- Land Referencing Data for Farm Holdings
- Land quality – authorised landfill sites, historic landfill sites
- Land use – Grade 1 agricultural land, Grade 2 agricultural land
- Geological SSSIs

The overarching assumptions and limitations outlined in Section 1.7 apply to the appraisal of soils, as do the following topic-specific limitations:

- Post-1988 ALC survey records are not available within the site area, and only provisional information is available for ALC grade distribution and soil mapping, which is coarse by nature. While there are ten available auger bore records available within the scheme area, this number does not offer an appropriately robust distribution of data to be confident in mapping soils.
- Site surveys were not undertaken and confirmation of desk study outputs would be achieved through a subsequent detailed field survey.
- The outputs of the desk-based assessment were limited without the detailed data provided by a Soil Resources Survey but informed the need for future surveys and a Soil Management Plan, where required.

5.2 Reservoir and associated infrastructure

5.2.1 Soil types and agricultural land classification

The soils at the SLR site are generally prone to seasonal waterlogging. National Soil Mapping shows that much of the area comprises the Beccles 3 Association (44%), described as 'slowly permeable seasonally waterlogged fine loamy over clayey soils and similar soils with only slight seasonal waterlogging' and the Ragdale (31%) soil association ('slowly permeable, seasonally waterlogged clayey and fine loamy over clayey soils'). There are also bands of Denchworth (20%), characterised as 'slowly permeable seasonally waterlogged clayey soils with similar fine loamy over clayey soils' and Ruskington (5%), described as 'deep permeable calcareous coarse and fine loamy and sandy soils affected by groundwater' in the south of the site.

No post-1988 ALC data was available for this site area. Provisional ALC mapping suggests that the site is 96% grade 3, deemed moderate-good, with a small section of grade 2 land in the north east. The predictive nature of the data means that it is not possible to separate the grade into subgrade 3a (good quality, BMV land) and subgrade 3b (moderate quality, not considered BMV).

There are no Nationally designated sites (SSSI geodiversity) within the scheme boundary and no existing or historic landfill sites within 1000m.

5.2.2 Potential impacts on soils

The main impacts of construction of the SLR scheme will be associated with the temporary disturbance of soil during construction, including during enabling works (such as access roads and compounds), and permanent loss of agricultural (and notably, BMV) land during construction of the reservoir. The magnitude of impact in the temporary phase would be dependent on the adoption of appropriate soil management practices to reuse soils where possible. A further impact could be the loss of stored carbon from the soils during construction.

5.3 Transfers and associated infrastructure

The main impacts of construction of the SLR scheme transfer will be associated with the temporary disturbance of soil during construction of pipeline routes. This comprises potential disturbance during enabling works (such as access roads and compounds), and some permanent loss of agricultural (and notably, BMV) land from water treatment facilities.

5.3.1.1 River Trent to Witham

The majority of the proposed River Trent to Witham pipeline route is located within Grade 3 agricultural land. There will be temporary loss of this Grade 3 agricultural land, however, the potential effects on these soils will be temporary and reversible with the application of best construction practices. The pipeline will also be constructed in phases, to reduce impacts.

There will be permanent loss of Grade 3 agricultural land where permanent limited infrastructure is developed, however, this will be of a minor scale.

There are no geological SSSIs within 1000m of the proposed route, and there are no existing or historic landfill sites in proximity to the proposed route.

5.3.1.2 River Witham to SLR

52.21% of the proposed River Witham to SLR pipeline route is located within Grade 2 agricultural land and 47.79% of the route is located within Grade 3 agricultural land. There will be some permanent loss of Grade 2 agricultural land where permanent limited infrastructure is developed, however, this will be of a minor scale. The permanent loss footprint will be minimised where possible to reduce potential effects upon agricultural land.

The proposed route lies within 750m of a historic landfill site. Due to the site's proximity, it is unlikely that there will be impacts associated with hazardous or contaminated waste. There are no geological SSSIs within 1000m of the proposed route

5.3.1.3 SLR potable water pipeline

83.46% of the proposed SLR potable water pipeline route is located within Grade 2 agricultural land, with 16.54% of the proposed route located within Grade 3 agricultural land. There will be temporary loss of Grade 2 and 3 agricultural land, however, the potential effects on these soils will be temporary and reversible with the application of best construction practices. The pipeline will also be constructed in phases, to reduce impacts.

There will be permanent loss of Grade 3 agricultural land in locations across the proposed route due to the requirement for permanent infrastructure. There will be permanent loss of Grade 3 agricultural land where permanent limited infrastructure is developed, however, this will be of a minor scale. The permanent loss footprint will be minimised where possible to reduce potential effects upon agricultural land.

There are no geological SSSIs within 1000m of the proposed route. A historic landfill site is located approximately 115m to the north-west of the proposed route. Due to the site's proximity, it is unlikely that there will be impacts associated with hazardous or contaminated waste.

5.3.2 Mitigation

To mitigate against potential impacts, construction methodologies should seek to incorporate soil management plans to promote sustainable handling during construction and ensure reuse wherever possible. Reusing site soils within landscaping and ecological plans, for instance, represents an opportunity to maximise sustainability. Correct soil handling also ensures that carbon loss from the soil is minimised. Sustainable reuse (e.g., landscaping) has the potential to promote greater carbon storage than current agricultural practices.

To enable mitigation of impacts on soils, the following activities should be considered:

- Undertaking a detailed soil survey (soil resource survey) to confirm the soil resources present, map the distribution of soil types and inform a soil management plan. This would likely require auger boreholes at appropriate points along the route.
- The stripping, stockpiling, maintenance, reinstatement and aftercare of soil resources should be undertaken in accordance with Defra11 and British Standards12,13 soil guidance.
- Producing a soil management plan to detail the above guidance and provisions for stripping, stockpiling, maintenance, reinstatement and aftercare of soil resources.
- During construction activities, a qualified soil scientist to undertake on-site monitoring visits to ensure the good practice and guidance as stated in the soil management plan is followed.

5.4 Scheme summary

Loss of agricultural land to the SLR scheme and its associated infrastructure will be unavoidable. Therefore, a key principle for development of the scheme is to avoid losing soil where possible, as this a non-renewable natural resource and vital component of natural capital, soil resource reuse will therefore be maximised.

The main impacts of construction of the scheme in relation to soil are associated with the temporary disturbance of soil during construction, including during enabling works and permanent loss of agricultural (and notably, BMV) land as well further impact of the loss of stored carbon from the soils.

The impacts of the transfers could be minimised during detail design by careful realignment of the route to avoid areas of BMV (where practicable) and/or use of tunnelling. The construction methodologies should seek to incorporate soil management plans to promote sustainable handling during construction and ensure reuse wherever possible.

The scheme also presents soil enhancement opportunities by reusing site soils within landscaping and ecological plans to maximise sustainability which has the potential to promote greater carbon storage than current agricultural practices.

Further work is required to confirm the desk study outputs through detailed soil resources surveys and implementation of soil management plans into construction methodologies, where required.

[11] Department for Environment, Food & Rural Affairs. (2009) *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites.* London: Defra.

[12] British Standards Institution. (2015) *BS 3882:2015 Specification for topsoil*. London: BSI Standards Limited.

[13] British Standards Institution. (2013) *BS 8601:2013 Specification for subsoil and requirements for use*. London: BSI Standards Limited.

6 Water appraisal

6.1 Introduction

This section presents potential impacts on the water environment as a result of the SLR scheme. The following assessments have been carried out relating to appraisal of water-related impacts for the scheme:

- Level 1 and Level 2 WFD assessments for the scheme, to the evaluate impacts on waterbodies affected by the site.
- An preliminary flood risk assessment (FRA) for the scheme, to provide a quantitative analysis of flood risk to support scheme design.
- A water quality risk assessment to support the scheme.
- A scheme-wide SEA for the scheme, which considered aspects related to groundwater and surface water.

The need to consider water is reinforced by national planning policy.

The WFD is transposed into law for England and Wales through *The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003* and updated in 2017[2].

The WFD requires all waterbodies (both surface and groundwater) to achieve 'good status or potential'. The Directive also requires that waterbodies experience no deterioration in status or potential. Good status/potential is a function of GES/potential (biological, physico-chemical and hydromorphological elements and specific pollutants) and good chemical status (Priority Substances and Priority Hazardous Substances).

The ACWG[14] has developed a consistent framework for undertaking WFD assessments for SROs to demonstrate that options will not cause deterioration in status/potential of any WFD waterbodies. The assessment considers mitigation that would need to be put in place to protect waterbody status/potential. The assessment also considers WFD future objectives to ensure the option would not preclude affected WFD waterbodies from reaching good status/potential. The WFD assessments are summarised in section 3.1, and the assessments are provided in Appendix A.1 and the supporting WFD assessment report.

When assessing flood risk associated with the reservoir, preliminary flood risk mitigation was developed as part of the gate two design. It analysed flood risk impacts from:

- Residual risk of overtopping assuming the defences remain in place
- Residual risk of flood defence breach assuming the defences remain in place across the rest of the catchment but breach at a single critical breach location
- An emergency drawdown scenario

The water quality risk assessment adopted a system approach (Source – Pathway – Receptor – Treatment Works) to provide a high-level qualitative assessment of water quality in the reservoir, and inform design considerations and future activities.

[14] All Company Working Group (Nov 2020). Water Framework Directive: Consistent framework for undertaking no deterioration assessments

The SEA considered the scheme including the reservoir waterbody and associated infrastructure, abstractions and transfer routes. As part of the SEA the following aspects relating to water were considered:

- Ground water – Environment Agency Source Protection Zones (SPZ1, SPZ1c, SPZ2, SPZ2c), Environment Agency Groundwater Vulnerability Zones (Major Aquifer High, Intermediate and Low, and Minor Aquifer High, Intermediate and Low), WFD groundwater status, WFD ground water classifications, incursion into aquifers of 'good yield' and 'good quality' under the WFD (principle aquifer / secondary aquifer).
- Surface water – Environment Agency flood defences, Environment Agency main rivers, Environment Agency Flood Zone 3 (1 in 100 year), Environment Agency Flood Zone 2 (1 in 1000 year), OS Surface Water Features.

A summary of potential effects of the SLR scheme on water is provided below.

6.2 Reservoir and associated infrastructure

6.2.1 Surface water

The WFD concludes a risk of deterioration to the Swaton Drains waterbody. Within the reservoir footprint over 2.5km of open channel would be lost, along with 28% of the catchment. The loss of open channel would impact on habitat, flow and hydromorphology in this waterbody. No risk to the South Beck waterbody is expected due to the loss of open watercourse and loss of up to 4% of open watercourse within the catchment due to the presence of the reservoir. This loss of catchment and watercourses could impact on habitat, flow and hydromorphology in this waterbody.

6.2.2 Groundwater

No WFD groundwater bodies were identified within the footprint of the reservoir. The confined Lincolnshire Limestone aquifer is present at depth beneath the Oxford Clay. However, there is no connection between the proposed reservoir, surface water and deep groundwater in this area. Therefore, the Lincolnshire Limestone aquifer is not considered further. There are no Nitrate Vulnerable Zones (NVZ) or Groundwater Dependent Terrestrial Ecosystems (GWDTE)s within proximity to the reservoir footprint.

The reservoir footprint intersects SPZs, SPZ 1, SPZ2 and SPZ3. Construction of reservoir may impact on quality or ground water sources. Good practice mitigation techniques will be implemented to prevent disturbance of contaminated material during construction.

6.2.3 Flood risk

6.2.3.1 Fluvial flooding

The reservoir is expected to capture 5.6ha of local sub-catchment which would reduce the flows into Helpringham Eau, Helpringham South Beck and Swaton Eau. The FRA concludes there will be a widespread reduction in peak water levels throughout these watercourses. This reduction in peak water levels will reduce the pressure on the flood defences and reduce the risk of a breach of the defences in this area.

Due to the storage of rainwater within the reservoir, the catchment flowing to Helpringham Eau, Helpringham South Beck and Swaton Eau is reduced and the peak flows from these catchments will be reduced. The reservoir would therefore lead to a reduction in peak modelled water levels within these local watercourses and the South Forty Foot Drain due to the removal of this inflow of water.

The widening of Helpringham South Beck has the impact of lowering level throughout the watercourse and particularly in the upstream reach of the watercourse where the bed levels have been reduced. This lower level, combined with the wider channel would provide increased flood storage in the event of a significant flood event in the catchment.

6.2.3.2 Surface water flooding

The reservoir is located in the upstream of several IDB catchments feeding Helpringham Eau, Helpringham South Beck and Swaton Eau and the reservoir will capture rainfall on a large portion of this area. This effectively reduces the contributing catchment to these watercourses and would have the impact of reducing peak flows. This is likely to have the impact of reducing existing flood risk to the villages of Helpringham and Swaton.

A sustainable drainage system (SuDS) drainage scheme will be implemented at the site to ensure drainage from impermeable surfaces is appropriately managed, as well as to manage surface water flood risk to the scheme. The SuDS drainage scheme will assess the surface water flood risk and ensure surface water flooding is not increased elsewhere.

6.2.3.3 Groundwater flooding

The scheme is considered to be at low risk from groundwater flooding. There are therefore no flood risk impacts of the scheme on this source of flooding.

6.2.3.4 Flood risk from existing reservoirs

The scheme is not shown to be at risk of flooding from existing reservoirs. There are therefore no flood risk impacts of the scheme on this source of flooding.

6.3 Abstractions and discharges

6.3.1 Surface water

To provide water to the reservoir, it is proposed that water will be abstracted from the River Trent then discharged into the River Witham, this water will then be abstracted from the River Witham downstream and transferred into the reservoir via a pipeline. The WFD concludes a potential risk of deterioration to the Trent from Soar to Beck waterbody, as a result of the new surface water abstraction. Abstraction rates are expected to be <10% of the total volume of the Trent catchment and the change in flow and velocity has the potential to impact biological elements.

A risk of deterioration to the Witham – conf Cringle Bk to conf Brant was identified as a result of the discharge from the Trent from Soar to Beck. A high-level water quality assessment of the proposed transfer was conducted, it concludes there is an expected 69% increase in ammonia concentrations. The RBMP Cycle 2 status of ammonia is currently ‘High’. The expected increase in ammonia concentration has the potential to lead to a risk of deterioration in water quality. There is an expected increase 17% in phosphate concentrations, with a Cycle 2 classification of ‘High’ and ‘Moderate’. This is expected to have a potential risk of deterioration.

The water flows downstream for approximately 60km, through the Witham conf Brant to conf Catchwater Drain and the Witham – conf Catchwater Drain to conf Bain. Transferring water from the River Trent to the River Witham to support flow and abstraction in the River Witham results in higher orthophosphate concentrations at the Langrick Bridge abstraction point. A potential risk of deterioration was identified to both watercourses an expected 46% increase in phosphate by the time it reaches both catchments. Within the catchments, phosphate levels are expected to be lower. However, further investigation is required to determine the predicted percentage change. It is recommended additional water quality modelling analysis should be undertaken to assist in determining the proportionate mitigation measures.

A potential risk of deterioration to the Lower Witham - conf Bain to Grand Sluice was identified as a result of changes in water quality due to the discharge from the River Trent into the upstream River Witham waterbody (Witham – conf Cringle Bk to conf Brant).

A potential risk of deterioration was also identified (Lower Witham - conf Bain to Grand Sluice) for biological status elements. This is due to change in flow velocity and volume, from the additional flow from the upstream waterbodies and subsequent abstraction (to supply SLR) at this waterbody will lead to changes in water velocity and level, which could impact on biological status elements.

It is assumed good practice design will be implemented for the intake structure. Further investigation is required to determine the extent of impacts. It is recommended additional water quality modelling analysis should be undertaken to assist in determining the appropriate mitigation measures. Further hydraulic modelling is required to determine the extents of the impact within the catchments.

6.3.2 Groundwater

No WFD groundwater bodies were identified within the footprint of the abstractions and discharges.

The abstraction located in the River Trent and the discharge located in the River Witham is underlain by a Secondary B aquifer (bedrock) and Secondary A (superficial) aquifer. Good practice techniques to prevent disturbance of contaminated material during construction. The abstraction downstream in the River Witham is not underlain by any bedrock or superficial aquifer. There are no SPZ and NVZs within the footprint of the abstractions and discharges.

6.4 Transfers

6.4.1 Surface water

The transfers will intersect 14 WFD surface waterbodies. At this stage it is assumed the construction of the pipeline will not involve in-channel modifications to the watercourse. Construction methods are anticipated to involve trenchless activities and therefore the impact on the watercourse catchment as a result, the pipeline is expected to be negligible risk. As the design processes through to gate three, this may need to be revised and would be reassessed as appropriate at that time.

6.4.2 Groundwater

Three groundwater bodies were identified within the footprints of the pipelines: Cornbash, Lower Trent Erewash – Secondary Combined and Witham Lias. The WFD concluded there will be no impact on these groundwater bodies. The transfers intersect SPZ1, SPZ2 and SPZ3. Therefore, good practice techniques to prevent disturbance of contaminated material during construction will be implemented.

6.4.2.1 Trent to Witham

The abstraction located in the River Trent and the discharge located in the River Witham is underlain by a Secondary B aquifer (bedrock) and Secondary A (superficial) aquifer. Good practice techniques to prevent disturbance of contaminated material during construction would be implemented.

6.4.2.2 Witham to SLR

Witham to SLR route pipeline is not underlain by any bedrock aquifers, parts of the pipelines closest to the reservoir is underlain by Secondary A and Secondary (undifferentiated) aquifer.

6.4.2.3 SLR potable water pipeline

Parts of the SLR potable water pipeline route is underlain by a Secondary A bedrock and superficial aquifer.

6.4.2.4 GWDTEs

Sites dependent on groundwater are Baston and Thurlby Fens SSSI GWDTE, Cross Drain SSSI GWDTE. Langtoft Gravel Pits SSSI is likely to have some groundwater dependency. Where the proposed route is in proximity to groundwater dependent SSSIs, mitigation measures should be identified that prevents damage to groundwater dependent habitats and plant species. Like-for-like mitigation is required for irreplaceable habitat/plants should there be any permanent loss.

6.5 Proposed further work

The recommendations identified in the WFD assessment to improve confidence in the assessment of the surface water bodies are set out in Section 3.2.6.

6.6 Mitigation

Potential mitigation measures have been suggested for each individual waterbody and scheme activity based on the risk that it poses. The potential mitigation measures should be considered and where feasible embedded into the scheme design. The potential mitigation measures relating to the Water Framework Directive are set out in Section 3.2.3. Additional potential mitigation measures are set out below:

- Industry good practice during construction to prevent contamination of ground and surface water.
- A geomorphology walkover should be undertaken at future project stages to understand the status of the waterbodies, to provide suitable mitigation.
- The scheme shall be designed to be resilient to surface water flooding and to reduce residual flood risk.
- Inclusion of a suitable sustainable drainage system (SuDS) drainage scheme at the site to ensure drainage from impermeable surfaces is appropriately managed, as well as to manage surface water flood risk to the scheme.
- Where the indicative transfer route is in proximity to groundwater dependent SSSIs, mitigation measures should be identified that prevents damage to groundwater dependent habitats and plant species. Like-for-like mitigation is required for irreplaceable habitat/plants should there be any permanent loss.

6.7 Scheme summary

6.7.1 Surface water

The WFD concludes, post mitigation, risks of deterioration are expected for Swaton Drains, Witham – conf Cringle Bk to conf Brant, Witham conf Brant to conf Catchwater Drain, Witham – conf Catchwater Drain to conf Bain and Lower Witham – conf Bain to Grand Sluice waterbodies. A potential risk of deterioration is expected for Trent from Soar to Beck waterbodies, post mitigation. No risk of deterioration is expected for South Beck waterbody post mitigation.

6.7.2 Groundwater

No WFD groundwater bodies will be impacted because of the scheme. Groundwater features have the potential to be impacted by the scheme, good practice techniques should be implemented to prevent disturbance of contaminated material during construction.

6.7.3 Flood risk

The reservoir is expected to capture 5.6 ha of local sub-catchment which would reduce the flows into Helpringham Eau, Helpringham South Beck and Swaton Eau. The widening of Helpringham South Beck has the impact of lowering level throughout the watercourse and particularly in the upstream reach of the watercourse where the bed levels have been reduced.

7 Carbon appraisal

7.1 Introduction

A whole-life carbon assessment, covering an 80-year period, has been undertaken along with a review of the opportunities to mitigate emissions across the life of the asset.

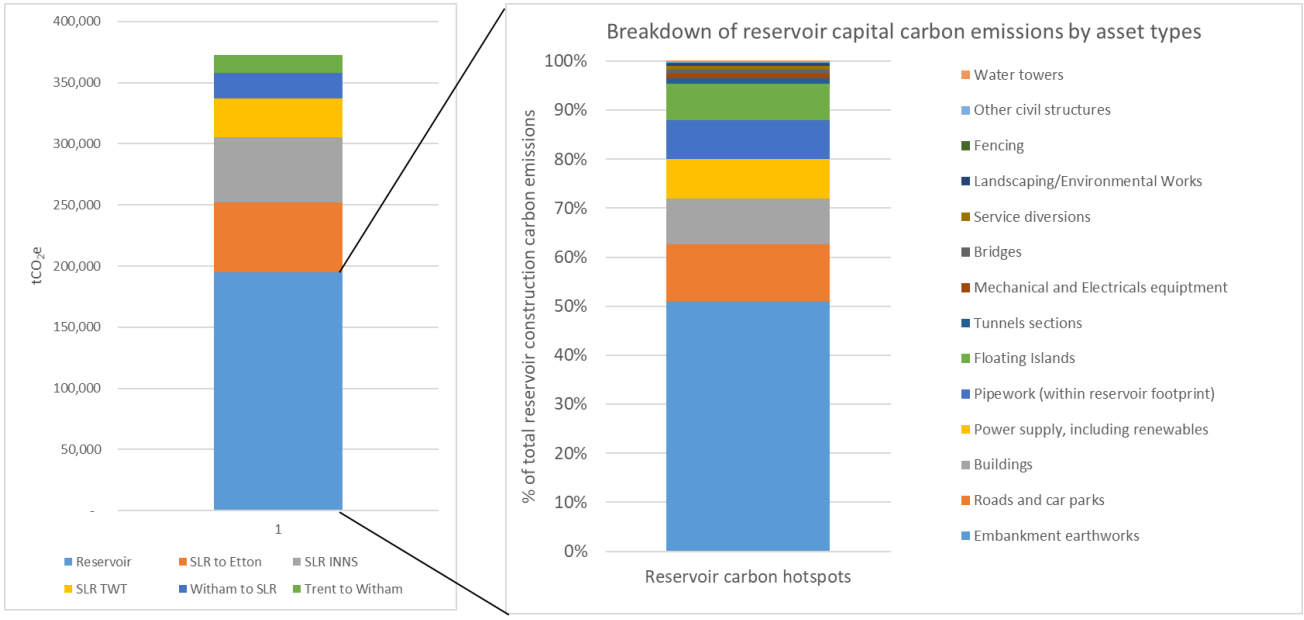
The carbon assessment and emissions mitigation approach has followed PAS2080[15] principles, having focussed on:

- Establishing a baseline assessment to determine carbon hotspots
- Identifying opportunities through the design, construction and supply chain to further mitigate emissions
- Prioritising emissions reductions to minimise residual emissions before developing a detailed carbon offsetting strategy
- Aligning with targets to achieve net zero operational emissions by 2030.

7.2 Assessment of capital carbon

Figure 7.1 summarises the capital carbon assessment. The total scale of capital carbon emissions is estimated to be 376,250tCO_2e (tonnes of Carbon Dioxide equivalent) and the capital carbon 'hotspots' identified at this stage of the design are summarised in Table 7.1.

Figure 7.1: Total capital carbon of scheme and breakdown of reservoir carbon emissions by asset type



[15] PAS 2080 is a global standard for managing infrastructure carbon and has been authored to meet World Trade Organization requirements. The framework looks at the whole value chain, aiming to reduce carbon and reduce cost through more intelligent design, construction and use.

Table 7.1: Capital carbon hotspot summary

Scheme element	Capital carbon contribution
Reservoir embankment works	Reservoir embankment works account for 27% of total capital carbon emissions for the scheme and just under 50% of the reservoir emissions. The majority of these emissions are driven by earthworks shift and haulage, including construction of associated haul roads and imported materials.
Transfer pipelines and pumping stations	The transfer pipelines account for 25% of scheme capital carbon emissions, with SLR to Peterborough accounting for 15%, Witham to SLR 6% and Trent to Witham 4%. The scheme accounts for steel pipe material and this contributes the majority of emissions followed by the excavation and reinstatement works required.
Water treatment	The invasive species treatment (14%) and water treatment works (9%) account for a total of 23% of scheme emissions. The majority of these emissions are associated with civil structures required for process units and associated buildings.
Roads	Reservoir roads account for 7% of scheme emissions, predominantly driven by the largescale perimeter roads and footpaths around the reservoir.
Buildings	Visitor centre buildings account for 5% of scheme capital carbon emissions. These have not been modelled in detail and will be refined as the design detail is developed.
Solar Power	The floating and land solar power arrays have been estimated to account for 4% of capital carbon emissions of the scheme but will also provide renewable power to be utilised on site.

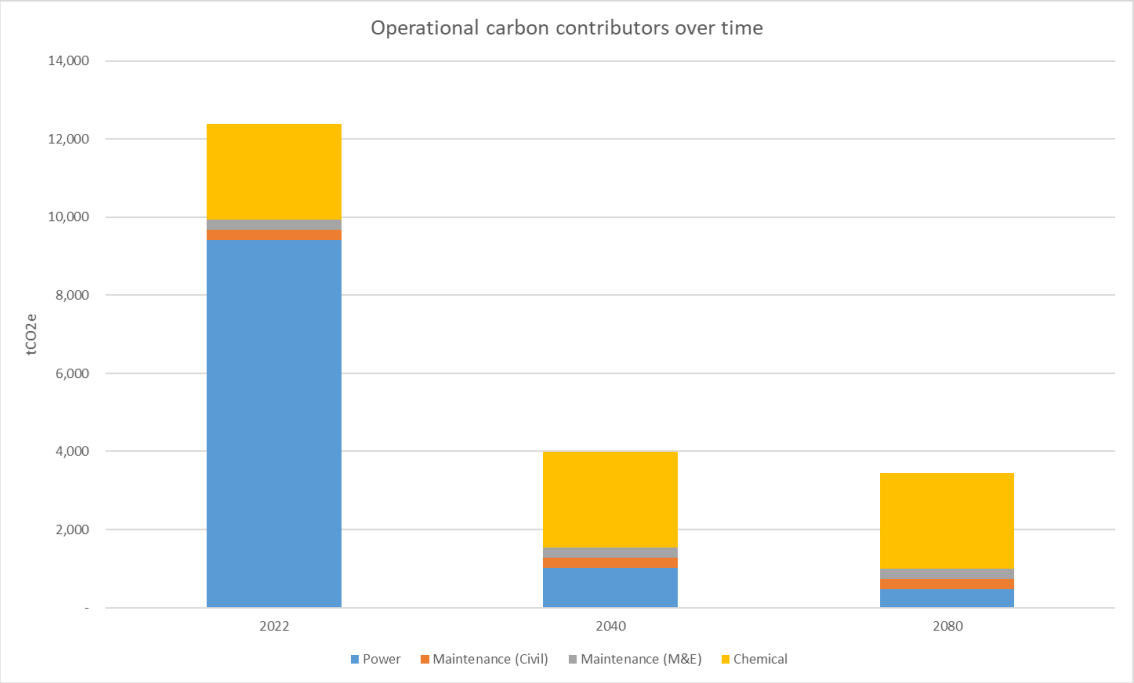
7.3 Assessment of operational carbon

Figure 7.2 summarises the total operational carbon emissions presented at three different time frames to highlight the impact of the predicted rate of grid decarbonisation on the scale of emissions associated with power consumption of the scheme. These include:

- Present day using the Defra 2021 emission factor for grid power consumption
- 2040 using Department for Business, Energy and Industrial Strategy (BEIS) grid carbon intensity forecasts (representing the forecast timeframe by when Fens Reservoir may become operational)
- 2080 using BEIS grid carbon intensity forecasts (representing predicted future grid carbon intensity impact)

Operational carbon is dominated by power and chemical consumption. At current day (2022) grid carbon intensity, power emissions account for ~75% of annual operational emissions. By 2040, when the scheme may come into full operation power emissions are estimated to contribute 20% of annual operational emissions and chemical consumption for water treatment becoming the major operational emissions source at 66%. This highlights the impact of predicted UK grid carbon decarbonisation, without accounting for the significant renewables also included within the SLR scheme, which further reduces the emissions associated with power consumption. The assessment does not currently account for future decarbonisation of chemicals as no reliable future forecast is available for the future carbon intensity of the chemicals required for the WTWs. This is an area where the scheme and wider sector will need to work closely with the chemicals supply chain to drive decarbonisation across the life of the asset.

Figure 7.2: Total operational carbon in 2022, 2040 and 2080 grid carbon intensities at 100% utilisation



7.4 Assessment of whole-life carbon

A whole life carbon assessment has been undertaken aligned to the same parameters as the whole life cost assessment and extending over 80 years. The assessment is based on 100% utilisation of the scheme at 166Ml/d and accounts for average utilisation rates for the reservoir filling components to allow maximum deployable output to be achieved by the overall scheme.

Total whole life carbon emissions are estimated at 473,150tCO_2e.

The breakdown of whole life carbon is presented in:

- Figure 7.3 – showing annual emissions across the life of the scheme by emissions category
- Figure 7.4 – showing cumulative annual emissions across the life of the scheme by emissions category

Figure 7.3: Annual emissions across the life of the scheme by emissions category

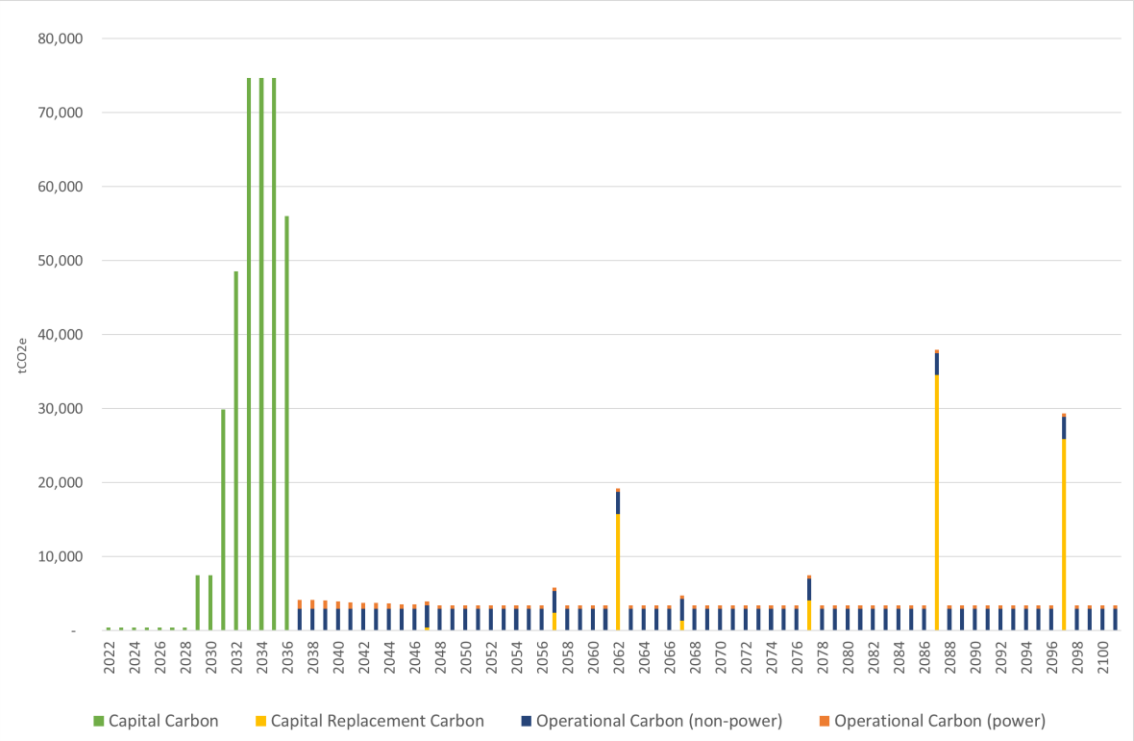
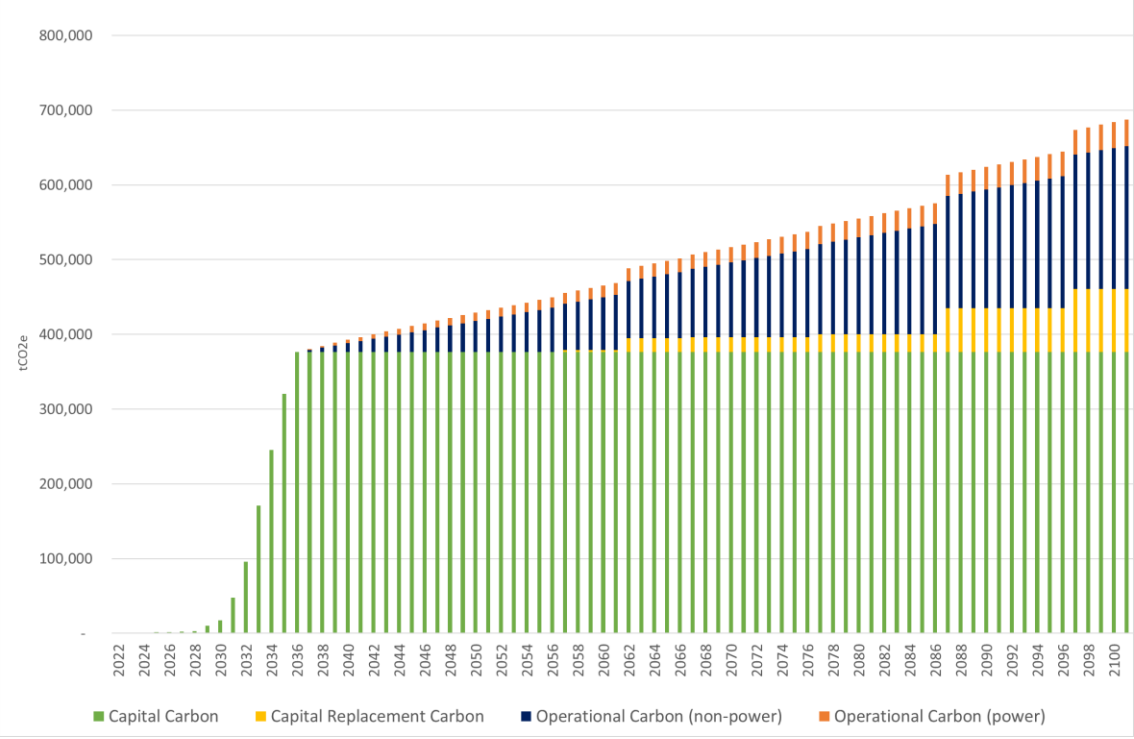


Figure 7.4: Cumulative annual emissions across the life of the scheme by emissions category



Capital carbon, all emissions associated with the construction and delivery of the scheme, account for 55% of whole life carbon. This highlights the importance of continuing to explore opportunities with supply chains to decarbonise key construction activities and materials in the build of the scheme delivery.

- Non-power related operational emission mainly associated with chemical consumption are estimated to contribute 28% of whole life emissions. This highlights the importance continuing to optimise the design of the WTWs to minimise chemical consumption and work with the supply chain to understand the potential to decarbonise to production and supply of these chemicals.
- Power related emissions are estimated to contribute 5% of whole life carbon, the scheme already has ambitious plans to generate renewable power and further work will be explored to maximise the utilisation of the power generated, as well as improve the efficiency of pumping and treatment processes.

Table 7.2 summarises the main emissions categories across the whole life of the scheme and also provides the estimated carbon costs as a net present value (NPV) for each emissions category. The total Carbon NPV is estimated at £109M. The table highlights that capital carbon emissions account for approximately 69% of carbon costs, followed by non-power related operational carbon at 20%. Capital replacements and power related operational emissions account for 7% and 4% of emissions respectively. These carbon costs can be used to further assess cost efficiency of future mitigation measures as alternatives are tested in more detail at later design stages.

- Capital carbon, all emissions associated with the construction and delivery of the scheme, account for 55% of whole life carbon. This highlights the importance of continuing to explore opportunities with supply chains to decarbonise key construction activities and materials in the build of the scheme delivery.
- Non-power related operational emission mainly associated with chemical consumption are estimated to contribute 28% of whole life emissions. This highlights the importance continuing to optimise the design of the WTWs to minimise chemical consumption and work with the supply chain to understand the potential to decarbonise to production and supply of these chemicals.
- Power related emissions are estimated to contribute 5% of whole life carbon, the scheme already has ambitious plans to generate renewable power and further work will be explored to maximise the utilisation of the power generated, as well as improve the efficiency of pumping and treatment processes.

Table 7.2: Summary of whole life carbon emissions and associated carbon costs

Emissions type	tCO_2e	% total emissions	Carbon £M NPV	% carbon costs
Capital Carbon	376,250	55%	75.6	69%
Capital Replacement Carbon	84,440	12%	7.5	7%
Operational Carbon (non-power)	191,450	28%	21.8	20%
Operational Carbon (power)	35,250	5%	4.3	4%
Total	687,390		109.2	

7.5 Opportunities for carbon reduction

The key mitigation opportunities to reduce carbon in the scheme design and operation are summarised in Table 7.3. Further opportunities for carbon reduction to be explored further as the scheme evolves are presented in Table 7.4. Both tables also provide an indication of the areas of supply chain and wider stakeholder engagement required to drive these opportunities through to realised emissions reductions.

Table 7.3: Carbon mitigations embedded within the existing design

Scheme area	Mitigation measures	Supply chain engagement requirements
Cut-fill balance	The site selection process considered a number of factors including whole life carbon emissions. A key driver for both cost and carbon was identifying a site where a cut-fill balance could be achieved thus reducing the need for import and disposal of surplus materials. The best performing site was one of the lowest whole life carbon options of those considered.	Not applicable
Transport of materials – Opportunity for rail transport of materials	Transport of construction materials can contribute significant emissions but also have implications on road congestion and air quality. The scheme has allowed for costs to develop and utilise rail transport for construction materials, which has the potential to then be integrated and utilised for public transport post construction.	Product and material suppliers
Renewables	The scheme has made allowances for significant land and floating solar array infrastructure to generate renewable power	District Network Operators and other power users to maximise value of renewables in the region

Table 7.4: Carbon mitigations opportunities as scheme evolves

Scheme area	Mitigation measures	Supply chain engagement requirements
Low carbon construction plant	The earthworks element of the reservoir construction is the largest hotspot area of the scheme. A significant proportion of this is driven by the fuel used in the construction plant to carry out the earthworks. The current assessment has been undertaken assuming conventional plant using diesel fuel. However, there are significant savings possible through further exploration of use of alternative fuels, such as Hydrogenated Vegetable Oil (HVO), hydrogen or electric for smaller scale excavations. These alternative fuels would also have knock on air quality impacts during the construction programme.	Equipment manufacturers HVO suppliers Hydrogen suppliers Other asset owners: Highways England, Defra, EA Other water companies delivering similar schemes
Low carbon construction materials	There are significant emissions associated within the embodied carbon of construction materials used. Particularly for substantial civil structures for the WTWs and also temporary and permanent road structures. The opportunity to work with the supply chain to identify low carbon alternatives for concrete, steel, pipelines and other construction materials can have a significant impact on the scheme. There is also opportunity to engage with the supply chain to help support them to decarbonise the products and materials they supply.	Contractors Concrete suppliers Structural steel suppliers Road and temporary road product/material suppliers
Efficient construction approaches	The use of efficient construction approaches that improve fuel and resource efficiency during delivery of the scheme will be explored in more detail as the scheme design detail develops. This includes consideration of automation and opportunities to minimise waste generated though construction.	Contractors
Transport of materials – Opportunity for water transport of materials	Transport of construction materials can contribute significant emissions but also have implications on road congestion and air quality. There is an opportunity for the scheme to develop and utilise water transport for construction materials, which has the potential to then be integrated and utilised for navigation post construction.	Product and material suppliers
Multi-sector opportunities	The Fens Reservoir scheme has further opportunities to integrate with the wider region and potentially support multi-system benefits, including supporting regional decarbonisation efforts. These opportunities continue to be explored with relevant stakeholders across the region.	Regional stakeholders
Maximise land-use benefits	As the scheme progresses there will be greater detail built into maximising the value generated within and beyond the scheme footprint. This will focus on maximising overall value, incorporating water quality, flood defence, biodiversity and carbon sequestration benefits to help offset residual emissions associated with the scheme.	Various technical disciplines and regional stakeholders

Overall, the scheme at its current stage of design has looked to minimise carbon impacts whilst maximising water supply and wider environmental benefits within the region. However, there are still significant opportunities available to further mitigate the whole life emissions associated with the scheme. As the scheme progresses to gate three and beyond, it is expected more mitigation measures will be embedded into the scheme design and costing and a detailed offsetting plan to cover the remaining residual emissions will be developed. The scheme carbon assessments will continue to be updated as the design evolves.

8 Landscape and visual appraisal

8.1 Introduction

This section presents potential impacts on landscape from the SLR scheme. The appraisal of landscape effects associated with the indicative transfer routes and associated infrastructure have not been undertaken, this will be assessed as the project progresses. At this stage, only a short summary of the potential effects from these elements has been made.

The objectives of the section are to establish the landscape baseline associated with the scheme, and identify constraints, opportunities, and issues that require further investigation. Consideration of landscape sensitivities are considered integral to the design of the SLR scheme.

To inform the assessments, the following sources of information relating to landscape and visual amenity were considered:

- Statutory landscape designations (National Parks, Area of Outstanding Natural Beauty (AONB)) identified using MAGIC.
- Non-statutory designations identified using data from Natural England and local development plans.
- National landscape character assessments, including – 47 Southern Lincolnshire Edge, 46 – The Fens and 75 – Kevesten Uplands National character area profile areas,
- Local landscape character assessments, including North Kesteven Landscape Character Assessment 200716
- Public Right of Way (PRoW), national trails and Sustrans cycle routes using MAGIC.
- Common land/open access land.
- Green infrastructure strategies.
- Greenbelt designated land.
- Topography.
- Other resources including Google Streetview were also utilised as necessary.

Other data sources that primarily informed appraisal against other environmental topics were also considered, for example historic landscape appraisal, conservation area maps and appraisals, historic parks and gardens and historic battlefields, scheduled monuments and listed buildings, ancient woodlands, and wetlands.

The assessment criteria used to determine the likely landscape and visual impact upon the introduction of a reservoir draws upon the best practice methodology highlighted within the ‘Guidelines for Landscape and Visual Impact Assessment: Third Edition’ (Landscape Institute, LI, and Institute of Environmental Management and Assessment, IEMA, 2013) and ‘Landscape Character Assessment – Guidance for England and Scotland’ (Countryside Agency/Scottish Natural Heritage, 2002). It should be noted that a full assessment using the above methodology is not provided at this stage. Following the above guidance, this section sets out landscape character and visual amenity separately.

[16] North Kesteven District Council, 2022. North Kesteven Landscape Character Assessment. Available at Landscape Character Assessment | North Kesteven District Council (n-kesteven.gov.uk) [Accessed 20/05/2022]

The assessment does not identify sensitive visual receptors or the impact on their views because this would require more detailed design information and validation on site. It is acknowledged that the scheme, particularly the reservoir component, will incur potentially significant visual changes for local residents living adjacent to it. This will be an important consideration as the project progresses through its development stages.

8.2 Reservoir and associated infrastructure

8.2.1 Overview of landscape character

Desk-based baseline assessments indicated that the site falls within the south-eastern corner of the Southern Lincolnshire Edge National Character Area (No. 47) close to the boundary with The Fens (No. 46) and Kesteven Uplands (No. 75) National Character Areas. The Southern Lincolnshire Edge landscape is characterised by the gently undulating topography of the dip slope that connects from the limestone cliff to the west to the fens in the east. No statutory landscape designations were recorded.

Local landscape character areas defined in the North Kesteven landscape character assessment and initial site surveys have been used to identify key characteristics of the study area.

A number of PRoWs radiating from Scredington, Helpringham and Horbling, including a few terminating within the reservoir site area, and a PRoW crossing the reservoir site area connecting Swaton to Spanby; and a Cross Britain Way passes close to the site, south of Swaton. Conservation areas recorded are designated for the settlements of: Helpringham; Osbournby; and Aswarby. One Registered Parks and Gardens (RP&G) was recorded; Aswarby Park Grade II (2.7km west of Scredington).

The presence of the reservoir would adversely impact key landscape characteristics through the presence of large-scale earthworks changing localised topography patterns, adversely impact the landscape setting of the historic line of Fen edge villages and Scheduled Ancient Monument south of Helpringham and Thorpe Latimer, sever existing PRoW connectivity between villages and alter the gently undulating landform on the edge of the fens.

Along the indicative transfer routes, there would a temporary effect on local landscape character due to construction activity and the loss of landscape cover (mainly arable land). However, it is expected that the pipelines would be located underground, and the land reinstated to the previous land use following construction. There would be localised effects on landscape character during operation from permeant structures associated with the transfers, such as intake pipes and pumping stations.

8.2.2 Key landscape features, sensitivities and constraints

The site is located within the gently undulating fen-edge landscape, between the historic villages of Burton Pedwardine, Northbeck, Scredington, Spanby, Threekingham to the west and Swaton, Thorpe Latimer and Helpringham which form part of the medieval line of fen edge settlements to the east. The settlements are generally well screened by mature vegetation around the boundaries, although church spires help to identify them in the landscape. Well-kept hedgerows along roadsides and between fields and scattered small copses of broad-leaved woodland are characteristic of the area and often limit views. Drainage ditches along field boundaries and small streams are found throughout the area and the rivers North Beck and Cliff Beck join north of the site, although they are not prominent features of the landscape. Local high points, where there are breaks in vegetation, allow for clear views over the rural landscape. Overhead pylons and wind turbines are visible throughout the area.

There are no landscape designations that would be directly impacted by the scheme in this location. Impacts to the setting of Aswarby Park Grade II Registered Park 3.5km west of the reservoir site would likely be minimal due to the distance and limited intervisibility.

The height and form of the embankments and scale of the reservoir will create a potentially prominent and uncharacteristic element in the gently undulating fen-edge setting. The site is in an area that includes local high points and east-west ridgelines. The scale and profile of the proposed engineered embankments would be steeper, and more uniform than the existing topography. Variation in microtopography in the existing landform should be replicated in the proposed embankment design where possible.

Table 8.1: Key landscape features, sensitivities and constraints

Landscape features	Potential impacts	Potential mitigation
Strong topographic pattern to the west and east. Transitional landscape. Line of historic fen edge villages. Long views from higher ground and Fens areas.	Adverse impact on landscape setting of Fen edge villages, including Helpringham, Swaton and Thorpe Latimer, sense of place and long views. Loss of undulating landform and Gorse Hill, local high point within the site, and changes to the form of the prominent landscape on the edge of the fens with the creation of higher embankments along the east side of the proposed reservoir.	Gently undulating topography provides some options to mitigate impacts. Incorporation of shallow earthwork slopes and avoid steep 'valley' landforms. Due to the scale of the proposed earthworks it would not be possible to completely mitigate impacts and there will be residual effects.
Well-kept hedgerows. Small copses of broadleaved woodland	Loss of characteristic features.	Opportunities for enhancement include increased hedgerow and tree planting and maintaining village character.
Large open, flat and low-lying fields under wide skies associated with the adjacent Fenland. Some sense of remoteness and tranquillity although some detracting elements present (overhead power lines, railway and distant windfarm to the east) but overall rural landscape.	Adverse impact on landscape setting, sense of place and remoteness	Scale of proposed earthworks and extensive flat topography limit options to mitigate impacts.

The prevalent presence of mature hedgerows and woodland copses, characteristic of the area, will help to contain the impact of the proposed reservoir structure.

8.2.3 Overview of Visual Amenity Characteristics

The relatively flat topography of the fens to the east potentially allows for far reaching views of the proposed scheme (although buildings and tree cover along the fen edge villages of Helpringham, Thorpe Latimer and Swaton would provide some screening). The gently undulating topography of the Central Plateau allows for some screening of views towards the proposed reservoir site, although due to the scale of the proposals, creating a new landform higher than the immediate surrounding landscape, the views are still likely to be wide reaching.

Despite the potential to impact visual amenity across a wide area, it is recommended that the embankments are designed to be sympathetic to the existing undulating landform characteristic of the landscape to better integrate it into views. Use of woodland planting and hedgerow planting characteristic of the area would also aid in integration and screening of the reservoir embankments. Due to the scale of the proposed earthworks, it would not be possible to completely mitigate impacts and there will be residual effects for some receptors.

There are no protected views identified within the study area.

The majority of the visual effects associated with the indicative proposed transfers would be temporary in nature and associated with the construction phase. It is expected that the pipelines would be located underground, and the land cover reinstated to its previous use following construction. However, there would some visual effects during operation from permanent new structures associated with the transfers, such as intake pipes and pumping stations. Mitigation will be required for the permanent structures once their locations have been confirmed at the next stage of scheme design.

Table 8.2 Key Visual Amenity Sensitivities and Constraints

Key Views	Potential Impact	Potential mitigation measures
Views from Helpringham	Partly screened from the majority of Helpringham by the existing tree line along the railway. For properties south of the railway the presence of the proposed reservoir will be dominant in views.	Creating shallower undulating embankments and use of woodland and hedgerow will help to make the appearance of the proposed embankments more characteristic of existing views of the rising landscape.
Views from Swaton, Spanby and Osbournby	Views of the proposed reservoir will be partially screened by existing tree belts, blocks and hedgerows around the settlement edges. Despite this the presence of the proposed reservoir is likely to be dominant in views and create a new skyline in views from these villages that are on lower ground than the proposed scheme.	Use of woodland and hedgerow will help to mitigate the visual impact of the embankments.
Views from Scredington	Due to the topography of the site, the relative height of the embankments to the existing ground levels will be lower in this area, as such it is likely to have a lower impact on the views of receptors. Vegetation and woodland blocks around the boundary of Scredington will partially screen views of the embankments although they are still likely to create a new skyline.	Strengthening the existing woodland blocks will help to mitigate the visual impact of the embankments.
Views from PRoW	Dominant in views from PRoW running close to the site	Strengthening the existing hedgerows will help to mitigate the visual impact of the embankments.

8.2.4 Key landscape opportunities

Landscape enhancement opportunities include the retention of existing important landscape and ecological features such as the setting of the medieval moated site, Scheduled Ancient Monument, settlement and cultivation remains, post-medieval park and garden, Thorpe Latimer.

Areas adjacent to the reservoir footprint could be considered for the suitability for the development of wetlands, grassland and woodland habitats with the benefits of improving the water quality and habitat value. Habitat creation and enhancement on site, creating linkages to wider initiatives such as Network Enhancement Zones and Swaton Natural Flood Management scheme. Introduction of wetland habitat to complement existing and proposed water features. Use of existing topography to create bunded areas of wetland habitat within the reservoir water body extents.

Opportunities to improve green infrastructure through the creation of walking and cycling leisure routes around the reservoir and connections between surrounding settlements of Helpringham, Scredington, Swaton, and Billingborough linking to the 'Sleaford - Spalding Link' Strategic Green Access opportunities for multi-user strategic access routes could be considered.

Table 8.3: Key landscape opportunities for the site

Opportunity	Existing opportunity/feature	Location
Enhancement of connectivity to long distance walking trails	The Cross Britain Way passes near to the site south of Swaton.	Enhance linkages within the site. Links outside the site delivered by third parties
Use of existing topography to create bunded areas of wetland habitat within the water body extents	A site specific topography allows for creation of such wetland habitat within the site area.	Within the site boundary
Enhancement of local PRoW routes between surrounding settlements	A number of PRoW radiate from the surrounding villages within and beyond the site footprint.	Enhance linkages within the site. Links outside the site delivered by third parties
Creation of a recreational destination	Creation of new recreation facilities would benefit local communities. Potential to create wider links to heritage assets. Interpretation of the Fen edge landscape. Connect with the existing recreational provision at the holiday fishing retreat to the southwest.	Locate adjacent to proposed embankments and close to Helpringham and possible new rail link.
Sustainable transport for construction and visitor traffic	Creation of a new station at Helpringham would benefit local communities and potentially reduce the environmental impact of the construction and operation of the scheme.	On the site boundary to the north. Delivered by third parties.
Green Infrastructure Enhancement	The site and surrounding landscape have been targeted for environmental and access improvements. The site intersects / is adjacent to the 'Sleaford - Spalding Link' Strategic Green Access Link (Green Infrastructure Study for Central Lincolnshire, 2011) which allows opportunities for multi-user, predominately off-road, strategic access routes. The reservoir development could potentially connect to / provide opportunities for Green Access Links.	Enhance linkages within the site. Links outside the site to be by third parties

8.3 Scheme summary

The height and form of the embankments and scale of the reservoir would create a potentially prominent and uncharacteristic element in the gently undulating fen-edge setting. The site is in an area that includes local high points and east-west ridgelines The proposed reservoir embankments would sit amongst a gently undulating landform. The design approach to the reservoir embankments should seek to adopt a sympathetic profile, balanced against land take, cut and fill balance amongst other wider considerations, However, the scale and profile of the proposed engineered embankments would be steeper, and more uniform than the existing topography. Variation in microtopography in the existing landform should be replicated in the proposed embankment design where possible.

Irregular field patterns are legible in long views over the landscape, positioning of hedgerows and trees on the reservoir embankments should be used to continue this pattern. The prevalent presence of mature hedgerows and woodland copses, characteristic of the area, would help to contain the impact of the proposed reservoir structure. The scheme also presents landscape enhancement opportunities through increasing hedgerow and tree planting activities and maintaining the wooded character of the villages. Extensive areas of tree planting would not be in keeping with the existing character of the area but the design of strategic copse planting and connecting hedgerows could replace the areas of broadleaved deciduous woodland that are located within the reservoir site extents and provide connectivity to other woodland blocks identified within 1km of the reservoir site. Currently these are generally small, discrete areas with little connectivity to other woodland blocks.

Native woodland habitats may be introduced alongside strengthening connections between existing woodland blocks and hedgerows. Introduction of wetland habitat by using existing topography to create bunded areas of wetland habitat within the reservoir water body extents, may complement existing and proposed water features.

The majority of landscape effects for the proposed transfers would be temporary in nature and confined to the construction phase, with the exception of a small number of permanent built structures.

Further work is required to improve green infrastructure through allowing opportunities for multi-user, predominately off-road, strategic access routes and providing sustainable transport for construction and visitor traffic through the creation of a new station at Helpringham.

9 Historic environment appraisal

9.1 Introduction

This section presents potential impacts on archaeology and historic assets from the SLR scheme. The objectives of the section are to summarise the historic environment baseline associated with the scheme, and identify constraints, opportunities, and issues that require further investigation.

The need to consider the historic environment is underpinned by legislation (Ancient Monuments and Archaeological Areas Act 1979 and Planning (Listed Buildings and Conservation Areas) Act 1990), Infrastructure Planning (Decisions) Regulations 2010 and planning policy.

The appraisal of constraints and opportunities in relation to the historic environment focussed on the potential for impact on built heritage, historic landscape and archaeological remains.

To inform the appraisal in relation to historic environment considerations, a preliminary visual appraisal was undertaken and a review of the archaeological and historic baseline, including a brief remote sensing appraisal.

Construction and operational effects have been considered on statutory designated heritage assets including Listed Buildings, Scheduled Monuments and Conservation Areas, and other heritage assets such as Registered Parks and Gardens and Battlefields.

The overarching assumptions and limitations outlined in Section 1.7 apply to the appraisal of historic environment as do the following issue-specific limitations:

- Information available about the historic environment depends on previous opportunities for research, fieldwork and discovery, and therefore may be limited – where nothing of historic interest was shown in a particular area, this could have been down to lack of targeted research or investigation rather than the genuine absence of sub-surface archaeological deposits.
- Documentary sources are rare before the medieval period, and many historic documents are inherently biased – older primary sources often fail to accurately locate sites and interpretation can be subjective.
- Historic maps provide a glimpse of land-use at a specific moment – it is therefore possible that short-term structures or areas of land-use are not shown and therefore not recorded within this assessment.

9.2 Reservoir and associated infrastructure

Desk-based assessments outline that there is little evidence for prehistoric activity within the reservoir, with evidence limited to isolated findspots. Much of the underlying geology consists of till and may have been unfavourable for occupation. Prehistoric communities appear to have been concentrated on the freely draining sands and gravels to the east, upon which Swaton and Helpringham are located. They also appear to have favoured locations closer to the Fen edge, approximately 1km east of the site.

This pattern of activity appears to continue into the Roman period, with Car Dyke constructed at this time (approximately 1.2km south-east of the site). This facilitated drainage of the Fens and evidence for activity, such as saltworking, is recorded in close proximity. There may have been some evidence for occupation, with a scatter of Roman pottery recorded within a field close to the A52, within the south-west part of the site.

There is no evidence within the site for activity during the early medieval period. However, the settlements at Helpringham, Swaton, Spanby, Scredington and Burton Pedwardine, which surround the site, are all recorded in the Domesday Survey of 1086 and were probably established during the early medieval period. Many of these settlements have parish churches that originated during this period, such as the Church of St Michael in Swaton and the Church of St Andrew in Helpringham. Archaeological evidence has also recorded medieval activity within some of these settlements. However, evidence within the site suggests that it was largely agricultural, as shown by the ridge and furrow along the eastern side, associated with a deserted settlement and moated manorial site at Thorpe Latimer. Place names within the landscape such as Swaton Common and Gorse Hill are suggestive of areas of common land that would have been used as grazing pasture during the medieval or post-medieval periods.

Post-medieval activity is largely characterised by a number of isolated farmsteads, which may have originated in the medieval period. A large number of these still survive within the landscape today, albeit altered or added to. There is also evidence for a battle at Swaton Common, within the southern part of the site, in 1689. Scottish troops in Ipswich mutinied and on their way to Scotland, were met by General de Ginkel who caught up with them at Swaton, defeating the Scots. The site today remains largely agricultural and is characterised by isolated farmsteads. Historic mapping shows the presence of sheepfolds within the landscape, suggesting a shift by the post-medieval period from the mixed arable agriculture of the medieval period to sheep-grazing, likely for the valuable wool trade.

There are no designated heritage assets within the reservoir site, but 19 designated assets have been identified with 1km. These comprise:

- 4 Scheduled Monuments (all high value)
- 1 Grade I Listed Building
- 1 Grade II* Listed Building
- 12 Grade II Listed Buildings (all high value)
- 1 Conservation Area (medium value)

In addition to those identified within 1km, further heritage assets have been identified within 5km of the site (that have potential intervisibility), including:

- 10 Grade I Listed Buildings of high value
- 1 Grade II* Listed Buildings of high value
- 101 Grade II Listed Buildings of high value
- 14 Scheduled Monuments of high value
- 1 Grade II Registered Park and Garden of high value
- 4 Conservation Areas of medium value

17 non-designated heritage assets are recorded on the Historic Environment Record (HER) within the site, and two within 100m of the boundary. They range in date from the Bronze Age to the post-medieval period and range from negligible to medium value. Further information about key identified heritage assets is provided in Table 9.1.

Table 9.1: Key heritage assets that the reservoir site may affect.

Heritage asset	Description
Medieval moated site, settlement and cultivation remains, post-medieval park and garden, Thorpe Latimer	The Scheduled Monument is described by Historic England as: "The moated manorial site at Thorpe Latimer is associated with the remains of a small contemporary settlement and ridge-and-furrow cultivation which together represent an important period of expansion of arable into the marginal lands of the fen-edge which took place in the early Middle Ages. The manorial complex, settlement and cultivation remains survive in good condition as a series of earthworks and buried deposits preserved beneath a later park and garden. Archaeological deposits of both the medieval and post-medieval periods are likely to survive intact, and water-logging in part of the monument will preserve organic material such as timber, leather and food remains, which will provide an insight into the changing economic and social activity on the site." The Scheduled Monument derives its heritage value from its archaeological and historic interest. The asset has the potential to increase our understanding of the nature and processes of medieval settlement. There is also the potential for the preservation of archaeological and palaeoenvironmental remains, as well as understanding the development of the site into the post-medieval period. Moated sites are considered by Historic England to be, "… a significant class of medieval monument and are important for the understanding of the distribution of wealth and status in the countryside." Large tracts of well preserved, non-designated ridge and furrow (MLI90028) are recorded in the immediate surroundings of the Scheduled Monument. While non-designated, the ridge and furrow earthworks remain well preserved and form an enduring part of the medieval agricultural landscape related to, and having a group value with, the Scheduled Monument. The surrounding agricultural fields, particularly those containing the ridge and furrow, form the setting of the Scheduled Monument. They help to inform an understanding of the asset and thus makes a positive contribution to its heritage value.
Thorpe Latimer House	Thorpe Latimer House is a Grade II Listed house of mid-18th century origin, with early 19th and 20th century alterations. To the west, the building is mostly surrounded by mature tree growth in the immediate vicinity of the house, and high hedges of varying alongside the B1384. While visually screened, the agricultural fields immediately to the west of the building have a functional relationship to the building through its farming connections, and therefore forms part of the setting. The rural setting of the house makes a substantial positive contribution to its heritage value. It also has group value with the medieval landscape of the Scheduled Monument of the 'Medieval moated site, settlement and cultivation remains, post-medieval park and garden, Thorpe Latimer', which surrounds the house to its north, east and south.

Heritage asset	Description
Helpringham Conservation Area and designated heritage assets	Helpringham is a rural village whose development centred around the medieval Church of St Andrew, forming a predominantly nucleated village. The village is of medieval origin, which retains its early street plan, including the small green close to the church, and predominantly 19th and 20th century houses. The village has expanded to include modern housing, with modern housing estates present to the south-east of the village. The Helpringham Conservation Area lies within the historic core of the village, beyond which 20th century development has extended to partially sever the connection with the rural landscape. The conservation area includes one Scheduled Monument and six Listed Buildings. The earliest of these assets are the Grade I Listed Church of St Andrew (NHLE 1168938), the Scheduled Monument of 'Helpringham village cross' (NHLE 1009232) and the Grade II Listed 'Steps to base of former village cross now war memorial' (NHLE 1306821) which all have their origins in the medieval period. The Grade II* Listed 'Manor farmhouse' (NHLE 1061814) dates to the late 17th century, while the Grade II Listed '29 High Street' (NHLE 1360591) and '5 and 7 North Fen road' (NHLE 1061816) date to the late 18th century. The Grade II Listed 'Pound behind Methodist Chapel' (NHLE 1061815) dates to the early 19th century. The listed buildings are of historic interest which is derived from their ability to inform on the development of the settlement. The heritage assets also hold architectural interest derived from the differing styles of vernacular architecture represented. The setting of the listed buildings is the historic core of the village which makes up the conservation area, which makes a positive contribution to the value of the assets. The setting of the conservation area to the west is the surrounding rural agricultural fields beyond the edge of the village which also includes modern buildings, part of the Conservation Area to the north of the village directly borders the fields to the north and therefore has a direct visual connection with the rural countryside. To the south-west of the Conservation Area the presence of the raised embankment of the railway line partially screens the village from the predominantly agricultural farmland to the west/south-west. The south of the conservation area is also surrounded predominantly by modern housing.
The Old Mill, Helpringham	The Old Mill (NHLE 1168949) lies at the south-west limits of Helpringham village, outside the Conservation Area. The building is a mid-19th century tower mill with a tapering tower of red brick. Most of the original workings have been removed, but some bins, sack hoists and other fittings remain. The building is of value for its historical interest relating to post-medieval industry and for its architectural interest as an example of a tower mill. At the time of construction, the building would have been within rural agricultural land at the fringe of the village. The setting of the building is now within a modernised estate, with the line of the Great Northern and Great Eastern Joint Railway adjacent to the south-west. The estate is surrounded by tall tree growth that encloses the estate, screening it from the surroundings and the railway track. The setting makes little contribution to the value of the asset.
Burton Pedwardine designated heritage assets	There are two Grade II Listed Buildings in Burton Pedwardine. Glebe Farmhouse (NHLE 1168511) is located on the Helpringham Road. The asset is an 18th century farmhouse constructed of coursed limestone rubble with ashlar quoins and a slate roof. The asset is of high heritage value, derived from its historic and architectural interest. It displays early architectural form and is a record of historic farming practices. The rural village setting aids in an appreciation and understanding of the asset's value and contributes to its value. The Church of St Andrew (NHLE 1061836) is the parish church of Burton Pedwardine and dates to between the 12th and 14th centuries, although was subject to major restoration and rebuilding between 1870 and 1871. The church is constructed of limestone ashlar and has a slate roof. The asset is of high heritage value derived from its historic and architectural interest. The churchyard and surrounding rural village are key elements of the asset's setting which contribute to its heritage value.

Heritage asset	Description
Scredington designated heritage assets	There are three Grade II Listed Buildings and a Scheduled Monument within Scredington. The Church of St Andrew (NHLE 1306729) is thought to date to the 5th century but underwent major restoration in 1869. The church is constructed of coursed rock faced ashlar with ashlar dressings and plain tiled roofs. The asset is of high heritage value derived from its archaeological, historic and architectural interest, displaying evidence for early church architecture. The asset is located to the south-east of the village within a graveyard which forms the setting of the church. The graveyard is edged by hedges and mature tree growth along the north and east edges, while the west and south are open and bordered by modern housing and Church Lane, respectively. There are clear views of the church from the south and south-east over agricultural fields that form part of its setting. These fields contribute to its heritage value as they help explain it is a church serving a rural parish. Blue Bell House (NHLE 1061819) is a former public house dating to 1770, with later alterations, and is constructed of coursed squared limestone rubble. The asset is of high heritage value derived from its historic and architectural interest as a good example of post-medieval public house architecture. The asset is located within the village at the junction of Main Street and Church Lane, with a garden to the rear lined by mature tree growth. The village and garden form the setting of the house. The setting at a key village junction allows an appreciation of the asset and despite modern residential development nearby, this does not detract from this understanding. The setting therefore makes a positive contribution to the heritage value of the asset. Packhorse Bridge is the site of both a Scheduled Monument and a Grade II Listed Building of medieval origins (NHLE 1018396, 1169024). The asset consists of a small, two-span limestone ashlar bridge spanning North Beck. The asset is of high heritage value derived from its historic and architectural interest as a good example of a medieval packhorse bridge. The asset is located to the north of Scredington, where the Scredington Road crosses the North Beck. The road, beck and rural surrounds form the setting of the building and monument. These form key elements to understanding the asset's past importance as a transport link and therefore the setting makes a positive contribution to its value. However, the present road has been diverted round the bridge and the new crossing dominates the setting on the eastern side. This element of the asset's setting detracts from its heritage value.

Table 9.2 details specific mitigation for the proposed scheme.

Table 9.2 Potential measures to mitigate impacts on the historic environment for the scheme

Approach	Mitigation measures proposed
Embedded mitigation	The landscape design of the reservoir should look to minimise the impacts of changes to setting and key views. Specific measures could include: • Where possible, key views identified, should be retained or adapted. This includes views from within Helpringham Conservation Area and of listed churches across the landscape of the site. If views are lost, alternative viewpoints should be considered to church spires. • Appropriate landscape earthworks should be utilised to minimise the scale of the reservoir, such as softening of the embankment slope and blending into the landscape topography. This could help to minimise the impact upon the surrounding historic settlements and wider landscape. • Planting that is appropriate to the landscape to reduce and visually break up the scale of embankments. This should reflect the rural pattern of hedgerows and copses, and look to enhance key views of the rural churches, villages and conservation areas • Redesign to avoid significant archaeological remains through retention in situ. In particular, avoidance of the well-preserved, non-designated ridge and furrow recorded adjacent to the Scheduled Monument of 'Medieval moated site, settlement and cultivation remains, post-medieval park and garden, Thorpe Latimer'. Combined with appropriate landscape earthworks and planting this could help to preserve the setting of the Scheduled Monument.

Approach	Mitigation measures proposed
Historic landscape	Further work should also be undertaken to characterise the historic landscape within the site, to assess its value and the impact of the scheme. This should be fed into the landscape and visual assessment. • A detailed assessment should be undertaken to identify any specific key views within the site that would be lost, such as views of church spires. This would include: • An analysis of historic landscape character to identify and assess the significance of individual landscape areas and how readily the historic landscape can accommodate change. • Visibility analysis to identify key locations within the landscape relating to historic villages and church spires, followed by site visits to carry out assurance; • Statements of significance on designated landscapes that could be impacted; • Setting assessments, including photomontages and wireframes, in association and agreement with landscape and visual about what key views are likely to need this level of assessment. The results of this would feed back into the design process to identify potential for retaining critical views or areas of preserved historic landscape through redesign.
Archaeological assessment/mitigation	The programme of archaeological mitigation proposed would form an evaluation phase, to assess the nature, extent and significance of the archaeological resource within the site. This should be designed in consultation with relevant stakeholders. These works would likely lead on to a full programme of recording, including excavation and topographic survey of earthworks. Evaluation and excavation do not mitigate the loss of heritage assets but helps to offset the effect and retain an understanding of the historic environment. The archaeological mitigation programme could include: • A full programme of aerial investigation and mapping to identify areas of potential archaeology that have not yet been identified, and to gain a more thorough understanding of the nature and extent of known archaeological sites; • Assessment of sediment sequences within areas of alluviation, particularly within the southern area of the site. This should involve a desktop study of existing information, such as boreholes and ground investigation works and a programme of intrusive investigations, undertaken by professional archaeologists. This work should assess the potential for paleoenvironmental remains as well as survival of archaeological remains; • A programme of archaeological field investigation to identify areas of unknown archaeology. This would include fieldwalking, geophysical survey, metal-detecting and trial-trenching; • Targeted programmes of archaeological investigation where sites of archaeological potential have been identified. This should include any known locations of archaeology, such as sites identified on the HER, by aerial investigation and mapping and/or geophysical survey. Specifically, investigation should be undertaken to ascertain the nature and extent of remains related to the deserted settlement of Thorpe Latimer that would be destroyed, and to investigate the area of the Romano British pottery scatter (MLI90574).

9.3 Transfers and Associated Infrastructure

The appraisal of proposed transfers and associated infrastructure summarised below is based on indicative broad corridors only. Further work to confirm the exact locations, considering any heritage constraints in more depth, will be undertaken at the next stage of scheme development.

9.3.1 River Trent to Witham transfer route

Listed buildings across the proposed route are sporadically located in populated areas including North Muskham, Langford, Winthorpe, Barnby and Beckingham. The closest of which is the Grade II listed “The Dairy Farmhouse” which is approximately 50m to the north of the proposed route, at Langford. The setting of this listed building is not likely to be affected due to the presence of vegetation/hedgerow which would screen the building from view. The closest scheduled monument is an iron age settlement approximately 350m to the south of the abstraction location at the River Trent. There are likely to be no adverse effects upon scheduled monuments during construction of the route. In addition, Coddington and Barnby in the Willows are Conservation Areas, 550m west and 225m south respectively. The operation of the pipeline would not have an effect on statutory designated heritage assets as it would be below ground level with the ground reinstated following completion of works.

There are no registered parks and gardens, registered battlefields, located in the vicinity of the proposed route.

9.3.2 River Witham to SLR transfer route

Listed buildings are sporadically located across the proposed indicative route, with clusters in the Heckington and Ewerby areas. The closest listed building is Grade II listed Howell Hall, approximately 350m to the north of the proposed route.

The nearest scheduled monument is a Settlement site 650yds (600m) E of Holme House, approximately 2km to the south of the proposed route, at Heckington Fen. The Heckington and Hecklington station are conservation areas, approximately 2km to the south-east of the proposed route.

There are no registered parks and gardens, registered battlefields, located in the vicinity of the proposed route.

9.3.3 SLR potable water pipeline

There are a large number of listed buildings sporadically located across the proposed route, including clusters in Market Deeping, Peterborough, Maxey, Bourne and Billingborough. The closest listed building is the Grade II listed maltings at towngate house farm, approximately 150m to the east of the proposed route at Market Deeping. There are a number of Scheduled Monuments in the wider study area, the closest of which is “Maxey Castle: a moated site with associated enclosures and a fishpond” approximately 550m to the west of the proposed route.

Langtoft, Maxey, Peterborough, Market Deeping and Billingborough are also conservation areas, the closest of which is Peterborough, which is immediately adjacent to the route. Through the application of good construction practice construction and operational effects on statutory designated heritage assets are considered to be a minor constraint to the scheme.

There are no registered parks and gardens, registered battlefields, located in the vicinity of the proposed route.

9.4 Mitigation and further investigations

Potential mitigation measures and further investigations that should be considered for at the next stage of scheme design could include

- Good practice measures to be implemented to minimise setting effects for other heritage assets during construction.
- Incorporate measures to reduce setting impact of the reservoir and embankment e.g., planting of trees as screening and reducing the height of any embankment. However, although design features will likely reduce the setting impact, there may be residual effects.
- Further work likely to be required to determine significance of effect, depending on the presence or absence of buried archaeology. Residual effects may remain due to potential loss of archaeological remains.
- A programme of archaeological field investigation to identify areas of unknown archaeology. This would include fieldwalking, geophysical survey, metal-detecting and trial-trenching.
- Targeted programmes of archaeological investigation where sites of archaeological potential have been identified. This should include any known locations of archaeology, such as sites identified on the HER, by aerial investigation and mapping and/or geophysical survey.

9.5 Scheme summary

The overall key impacts due to the construction and operational of the scheme in relation to the historic environment are the loss of key views of prominent historic environment elements alongside the loss of heritage value due to the permanent loss of habitats within the reservoir site.

Construction and operational effects on statutory designated heritage assets are considered to be a minor constraint to the scheme for all proposed transfer routes.

Some impacts could be mitigated by creating alternative viewpoints, where possible, and retaining and/or adapting key original views, where possible. Redesigning sections of the scheme to avoid significant archaeological remains may allow for retention in situ.

The scheme also presents historic environment enhancement opportunities through availing education, outreach and community programmes to explain and interpret the historic environment and collaborating with land-based disciplines including landscape and ecology to produce trails, walks and viewpoints with digital and/or permanent viewpoints/display boards including in visitor centres, which explain the historic landscape around the overall scheme.

Further work is required to undertake a heritage assessment, a historic landscape assessment and form an archaeological mitigation programme; the results of which would feed back into the design process to identify potential for retaining critical views or areas of preserved historic landscape through redesign.

10 Population and human health appraisal

10.1 Introduction

This section presents potential impacts on population and human health arising from the scheme. The objectives of the desk-based assessment were to establish the population and human health baseline associated with the indicative design elements of the site, identify constraints and opportunities, and identify the issues and features that require further investigation.

The need to consider population and human health is underpinned by planning policy, including the draft NPS for Water Resource Infrastructure (Section 3.12 Health, Section 4.10, Land use including open space, green infrastructure and Green Belt and 4.13, Socio-economic impacts) and NPPF (Section 8, Promoting healthy and safe communities, Section 12, Achieving well-designed places, Section 15, Conserving and enhancing the natural environment, paragraph 185).

To inform potential population and human health constraints, the following sources were considered, as outlined in Table 10.1 below.

Table 10.1: Population and human health – data sources

Data to be collected	Source
Housing and private property	AddressBase Plus Pro, Google Maps and land referencing data[17],
Businesses	AddressBase Plus Pro, Google Maps and land referencing data
Community facilities, focusing on: • Schools and education facilities • Hospitals and medical facilities • Care homes • Places of worship	AddressBase Plus Pro, Google Maps and land referencing data
Open space and recreation, focusing on: • National and regional trails Recreational facilities • Allotments • Regional tourist attractions	AddressBase Plus Pro, Google Maps and land referencing data
Population demographics and health	English Indices of Multiple Deprivation (IMD) 2019 – for the measurement and comparison of relative levels of deprivation (poverty – total IMD and individual domains for Health, Employment and Living Environment Public Health England data sets Office for National Statistics (ONS) data sets on demography Nomis datasets Department for Education datasets

[17] Land referencing data has been used to appraise only the reservoir waterbody area, and not the associated reservoir grey infrastructure, transfer pipelines and abstractions and water treatment works.

The appraisal identifies the likely impacts on population and human health resources and receptors including:

- Land requirement – a temporary or permanent (or both) requirement for land affecting resources.
- Change in access – a temporary or permanent (or both) alteration or change in access, either directly affecting a resource (such as a trail) or affecting the ability of a resource to function (e.g. customers being able to access a business, or children/staff being able to access a school). This could also include positive changes where new or enhanced facilities are provided. a detailed assessment of transport infrastructure that bisects design elements has not been undertaken at this stage but will be undertaken at the scheme develops.
- Change in amenity – a temporary or permanent (or both) in-combination change in environmental conditions (e.g. noise, air quality, visual impacts, presence of heavy goods vehicle (HGV) traffic) which may affect the enjoyment of residential property, neighbourhoods, or community and recreational facilities.
- Changes to transport routes – temporary or permanent changes to transport routes including roads, PRoW, cycle routes, bus stops and routes, rail, stations are not included in this report. This will be considered in the next stages of assessment.

The appraisal considered the greatest impacts to be where:

- A residential property would need to be demolished, or a business cannot continue to operate.
- A community facility or recreational facility cannot function, or a new / enhanced facility is provided.
- Impacts occur over a long period (e.g. over a year) and/or affect an activity that is undertaken frequently (e.g. daily trip to school).
- Limited accessible alternatives to a resource, such as a recreational facility, are available.
- A large number of people are affected or those with vulnerabilities are affected.

Assessment of potential population and human health opportunities is covered in section 14 of this report, Wider benefits.

10.2 Assumptions and limitations

- The overarching assumptions and limitations outlined in Section 1.7 apply to the appraisal of landscape, as well as the following:
- At this early stage of the scheme, only an indicative scheme design was available for assessment. For the purposes of quantifying the number of affected receptors assumptions have been made about the location of the main features including the reservoir, water treatment works and transfer routes. However, the locations of these features have not been agreed and further work will be necessary to update this assessment.
- Appraisal of potential impacts on transport routes including roads, PRoW, cycle routes, bus stops and routes, and rail corridors and stations is not included in this report. This should be considered in the next stages of assessment.
- The study area for this topic is a minimum 500m buffer around each of the design elements, therefore some receptors may be double-counted where design elements are close by. This approach was taken to ensure all potential impacts associated with each design element are captured.
- Whilst Ordnance Survey (OS) AddressBase is the most accurate dataset available at the time of reporting, the accuracy of this data cannot be guaranteed and therefore can only provide an approximation of numbers of residential properties, community facilities, businesses, open spaces and recreational areas.

10.3 Baseline summary

Table 10.2 provides an overview of the six local authority areas within the scheme working area and its 500m buffer.

Table 10.2: Local authority areas within the scheme working area and a 500m buffer of the scheme working area.

Element	North Kesteven	South Kesteven	South Holland	Newark and Sherwood	Boston	Peterborough
Abstraction point: River Trent to River Witham				✓		
Abstraction point: River Witham to SLR					✓	
Transfer: River Trent to River Witham Route	✓			✓		
Transfer: River Witham to SLR	✓				✓	
Transfer: SLR potable water pipeline	✓	✓				✓
Reservoir	✓	✓	✓		✓	
Water Treatment Works	✓					

10.3.1 Housing and private property

There are over 800 residential properties located within 500m of, and within, the scheme working area. A large proportion of these are within 500m of the proposed SLR potable water pipeline and the River Trent to River Witham transfer routes. The communities in which these residential properties are located are outlined below in Table 10.3.

Table 10.3: Communities within 500m of the scheme working area

Location	Number of residential properties within 500m of the scheme working area
Amber Hill	11
Barnby	89
Billingborough	91
Birthorpe	3
Boughton	1
Burton Pedwardine	11
Coddington	24
Danethorpe	1
Donington	1
Etton	47
Glinton	10
Haconby	1
Heckington	5
Helpringham	3
Helpringham Fen	8
Holland Fen	8
Holme	1
Horbling	8
Howell	20
Kirton Fen	4
Langford	20
Langrick	1
Langtoft	35
Marholm	1
Market Deeping	252
Maxey	1
Millthorpe	2
Morton	5
North Muskham	62
Northborough	1
Pointon	5
Pointon Fen	6
Rippingale	5
Scredington	15
Sempringham	6
South Kyme	7
Spanby	7
Swaton	5
Thorpe Latimer	5
Tongue End	16
Twenty	4
West Deeping	2
Bourne	8
Spalding	10

Location	Number of residential properties within 500m of the scheme working area
Threekingham	3

Source: OS MasterMap (2022)

10.3.2 Businesses

There are 62 businesses located within 500m of the scheme working area, comprising of 47 businesses and 15 agricultural receptors. These businesses include farms, restaurants and cafes, service stations and steelworks. These businesses are within 500m of the proposed transfer options.

Table 10.4: Businesses within 500m of the scheme working area

Location	Number of businesses and agricultural receptors within 500m of the scheme working area
Amber Hill	1
Barnby	4
Billingborough	5
Burton Pedwardine	2
Coddington	4
Etton	3
Glinton	3
Heckington	1
Helpringham Fen	1
Horbling	2
Howell	1
Langford	3
Marholm	1
Market Deeping	15
Maxey	2
Pointon	1
Rippingale	1
Scredington	2
Sempringham	1
Swaton	1
Thorpe Latimer	2
West Deeping	1
Helpringham	2
Spalding	2
Threekingham	1

Source: OS MasterMap (2022)

10.3.3 Community facilities

There are five community facilities located within 500m of the scheme working area. The locations of these facilities are as outlined below and include churches, village halls and schools.

Table 10.5: Community facilities within 500m of the scheme working area

Location	Number of community facilities within 500m of the scheme working area
Billingborough	1
Etton	1
Howell	1
Market Deeping	1
North Muskham	1
Billingborough	1

Source: OS MasterMap (2022)

10.3.4 Open space and recreation

There are 8 open spaces located within 500m of the scheme working area as outlined below. These include play parks, lakes, gold courses, open spaces, playing fields and nature reserves.

Table 10.6: Open spaces and recreation areas within 500m of the scheme working area

Location	Number of open spaces and recreational areas within 500m of the scheme working area
Winthorpe	1
Coddington	1
Newark on Trent	1
Barnby In The Willows	1
Etton	2
Pointon	1
Bourne	1

Source: Google Maps (2022)

10.3.5 Population and health

10.3.5.1 Population data

Table 10.7 provides an overview of key population indicators for each affected local authority area as outlined in Table 10.2. These indicators highlight that, the age-based proportions for the local authorities do not broadly align with those for England. The percentage of the population aged 16 or under is considerably higher for Peterborough (24%) than the England proportion (19%). The proportion of the population aged 16-24 is considerably lower for North Kesteven (59%), South Kesteven (58%) and South Holland (58%) than the national figure (62%). Moreover, the percentage of the population aged over 65 is considerably higher for North Kesteven (24%), South Kesteven (23%) and South Holland (24%) than the national proportion (19%), while the proportion for Peterborough is considerably lower (15%).[18]

[18] In comparing these local authorities, where a local authority deviates by more than 3% from the England rate/value, the difference is regarded to be considerable and is reported as such.

Table 10.7: Key population indicators by local authority

Indicator	North Kesteven	South Kesteven	South Holland	Newark and Sherwood	Boston	Peterborough	England
Total population (2020)	118,149	143,225	95,857	123,127	70,837	202,626	6,269,200
Percentage of population aged under 16 (2020 mid year estimates)	17%	18%	18%	18%	19%	24%	19%
Percentage of population aged 16-64 (2020 mid year estimates)	59%	58%	58%	60%	60%	61%	62%
Percentage of population aged 65 and over (2020 mid year estimates)	24%	23%	24%	22%	21%	15%	19%

Source: ONS Mid-year population estimates 2020

10.3.5.2 Health data

Table 10.8 provides an overview of key health indicators for the population within each affected local authority areas as outlined in Table 10.2. These indicators include conditions and impairments that might be affected by the potential effects associated with the scheme (for example, changes in air pollution, noise, traffic, employment and physical activity).

Table 10.8: Key health indicators by local authority

Indicator	North Kesteven	South Kesteven	South Holland	Newark and Sherwood	Boston	Peterborough	England
Life expectancy at birth (Male), 2018-2020	80.2	80.6	80.0	79.8	77.4	78.6	79.4
Life expectancy at birth (Female), 2018-2020	83.2	84.2	83.4	79.8	82.4	82.5	83.1
Under 75 mortality rate: all causes (per 100,000), 2018-2020	301.6	283.6	307.2	313.3	393.6	375.7	336.5
Under 75 mortality rate from cardiovascular diseases (per 100,000), 2017-19	63.0	56.9	78.8	58.1	94.6	93.1	70.4

Indicator	North Kesteven	South Kesteven	South Holland	Newark and Sherwood	Boston	Peterborough	England
Emergency hospital admissions from Chronic Obstructive Pulmonary Disease (COPD), 2019-2020	367	396	350	354	428	516	415
Percentage of people who reported having a long term illness or disability, 2011	19%	17%	21%	20%	20%	17%	18%
Under 75 mortality rate from cancer (per 100,000), 2017-19	125.0	111.3	128.5	126.9	141.8	139.4	129.2
Percentage of physically active adults (over 19); 2020-2021;	65%	61%	54%	73%	57%	57%	66%
Percentage of adults (aged 18+) classified as overweight or obese (2020/2021)	63%	69%	73%	67%	73%	61%	64%
Percentage of people in employment , 2020-2021	74%	72%	76%	74%	74%	75%	75%
Percentage of Universal Credit claimants as a proportion of resident population of area aged 16-64 (2022)	2%	3%	3%	3%	5%	5%	3%

Source: Public Health England (2022), Department of Education and Nomis (2022)

As shown in Table 10.8 above, most local authorities perform relatively well on key public health indicators, broadly aligning with the national rates. Life expectancy (male) is slightly higher than the England average for all local authorities except Boston, whilst life expectancy (female) is slightly higher than the national rate for all local authorities except Newark and Sherwood and Boston. The under-75 mortality rates (from all causes) are lower than the national rate for all local authorities except Boston and Peterborough. The percentage of physically active adults is considerably lower than the national average (66%) for all local authorities except Boston and Newark and Sherwood which is considerably higher (73%), and North Kesteven (65%) which aligns with the national rate.

The English Indices of Multiple Deprivation (IMD) 2019 are commonly used for the measurement and comparison of relative levels of deprivation (poverty). Table 10.9 summarises the IMD for the Lower-layer Super Output Areas (LSOAs) within each local authority and outlines the deprivation data by quintile.

Table 10.9: IMD for the LSOAs

Deprivation Quintiles	North Kesteven	South Kevesten	South Holland	Newark and Sherwood	Boston	Rushcliffe	England
Most deprived	0%	1%	1%	5%	4%	0%	20%
Second most deprived	6%	7%	20%	11%	35%	1%	20%
Third most deprived	11%	15%	38%	29%	24%	4%	20%
Fourth most deprived	32%	18%	28%	31%	32%	19%	20%
Least deprived	51%	50%	14%	24%	5%	76%	20%

Source: 2019 mid-year population estimates, ONS and 2019 English Indices of Deprivation

The table above shows that for each local authority a large proportion of LSOAs are in the fourth most or least deprived quintiles in the country, however there are also a considerable proportion of LSOAs within the second and third most deprived quintiles.

Table 10.10 outlines the deprivation data for total IMD and health deprivation and disability, employment deprivation, and living environment deprivation in turn.

Table 10.10: Deprivation indicators

Local Authority	North Kesteven	South Kesteven	South Holland	Newark and Sherwood	Boston	Rushcliffe
IMD total - Proportion of LSOAs in most deprived 10% nationally	0%	0%	0%	1%	1%	0%
Health Deprivation and Disability - Proportion of LSOAs in most deprived 10% nationally	0%	0%	0%	0%	0%	0%
Employment - Proportion of LSOAs in most deprived 10% nationally	0%	0%	0%	1%	1%	0%
Living Environment - Proportion of LSOAs in most deprived 10% nationally	0%	0%	0%	1%	1%	0%

Source: 2019 mid-year population estimates, ONS and 2019 English Indices of Deprivation

As shown in Table 10.10 above, a very small proportion of the LSOAs within the local authorities are within the most deprived 10% nationally for total IMD, employment and living environment. None of the LSOAs for the local authorities fall within the most deprived 10% nationally for health deprivation and disability.

10.3.5.3 Location of community assets relevant to health outcomes

There are no community assets relevant to health outcomes identified within the scheme working area and their 500m buffers as outlined in the community baseline described above that have particular relevance to the health assessment.

10.4 Scheme summary

The potential impacts on housing and private property, businesses, community facilities and open space and recreation were considered as part of the evaluation of the proposed scheme development. It is expected that there would be a range of population and human health impacts affecting housing and private property, businesses and open space and recreation as a result of the scheme during both construction and operation. These potential impacts include land requirement, road, PRoW and cycle route closure, travel disruption and employment impacts during construction.

During operation, several beneficial impacts are expected as a result of the scheme. These include:

- A new community facility for local people, through the provision of new water sports infrastructure.
- A new recreation opportunity for walkers and cyclists, through the provision of new recreational routes.
- Potential beneficial employment impacts on local economy, through new jobs associated with the new reservoir facilities.
- A potential visitor centre could provide environmental education opportunities for the local community and schools in wider area.

10.4.1 Mitigation and enhancement opportunities

To avoid or mitigate potential disruption and disturbance to communities during construction and operation of the scheme, good practice mitigation should be implemented during construction and be managed through development of a CEMP. This could include:

- Setting out how engagement with local communities will be undertaken during construction.
- Implementation of specific measures in relation to air quality and noise to reduce impacts on neighbouring residents' communities, particularly for sensitive community resources such as educational facilities, health facilities and care homes.
- Developing mitigation for local road closures and diversions when details are known regarding timing and duration of closure.
- The above ground assets should have landscaping, air quality and noise mitigation included in their design, in order to limit the potential indirect impacts from noise and air pollution on properties and businesses and open spaces.
- Sensitive layout and siting of potential construction compounds that take into consideration the potential impacts from noise, traffic, air quality and visual effects on communities
- Maintenance or diversion of key routes used by the community such as footpaths and pedestrian and cycling routes.

The following enhancements should also be considered:

- New recreational paths for walking and cycling should be designed to be accessible, addressing the mobility needs of all user groups.
- Local community input on the design of the new facilities should be sought, including target user groups.
- Inclusive design principles should be followed in the design of reservoir facilities.
- There should be assessment of the impact of the scheme on different sections of society, including those living, working or owning businesses who may be displaced as a result of the scheme. This could be undertaken through an EqIA.

11 Cumulative and in-combination effects appraisal

11.1 Introduction

Initial cumulative and in-combination effects assessments have been undertaken as part of the gate two informal HRA, WFD and updates to the SEA assessments. The scheme is selected as an option in the WRE Regional Plan and Anglian Water dWRMP24 and as such it will be subject to further in-combination effects assessments with the other selected options, neighbouring water company plans and neighbouring regional plans. Until the WRE Best Value Regional Plan has been finalised and agreed, it is not known when the other schemes would be implemented or which other developments it could act in-combination with.

For the purposes of this assessment, assumptions have been made about other plans, programmes and projects that could act in-combination with the SLR scheme, and the following were considered within the in-combination effects assessments these assumptions were based on scale, type of development or plan, and temporal and spatial location:

- Other SROs – Fens Reservoir and Minworth
- Local Development Frameworks (LDFs)
- DCOs for NSIP
- Hybrid Bills
- Relevant Transport and Works Act Orders (TWAO)
- Relevant planning applications (only where there is the potential for cumulative effects on the future baseline)

During construction there is the potential for noise and air quality effects on single receptors this can be increased when there are multiple construction projects within a short timeframe. During operation there is the potential for water quality impacts associated with multiple abstractions from a waterbody.

11.2 Reservoir and associated infrastructure

Table 11.1 summarises the findings of the in-combination effects assessments.

Table 11.1 Summary of cumulative and in-combination effects

Project or plan	Cumulative/in-combination construction effects
Minworth SRO is investigating the potential to provide water to the STT SRO by diverting some of the Minworth WwTW final effluent to the River Avon which is a tributary of the River Severn as well as to the GUC via the Coventry Canal.	There is the potential for in-combination effects – further modelling should aim to look at any predicted effects from water quality changes and changes in flows. Although effects are not anticipated to be significant in-combination due to the scale of the Wash and distance between the two affected estuaries further modelling would reduce uncertainty in this assessment.
Fens Reservoir - FR is being developed as an earth embanked reservoir with a storage capacity of 50MCM to provide over 87Ml/d of public water supply.	HRA has identified potential effects to the following sites: Ouse Washes SPA (UK9008041); Ouse Washes Ramsar (UK11051); Ouse Washes SAC (UK0013011); The Wash SPA (UK9008021); The Wash Ramsar (UK11072); The Wash and North Norfolk Coast SAC (UK0017075). Potential effects were identified due to uncertainty around potential effects from changes in flows and water quality and indirect effects on estuarine habitats.
Works to facilitate the Viking Link electrical interconnector with an approximate capacity of 1400 MW extending from Revsing, Jutland, (Denmark) to Bicker Fen, Lincolnshire (UK)	The plan crosses River Witham between the two SLR abstraction locations (trenchless cable crossing at 525245, 349316) and runs across the pipeline route between River Witham and A17. The H04-082317 development has potential for an increase in turbidity and site run off (pollution) into River Witham and Skerth Drain (trib of South Forty foot drain). WFD level 2 assessment indicates that with implementation of construction good practice mitigation from both the proposed option and the development, this will have a negligible risk on the affected watercourses, therefore cumulative effects are unlikely.
North Kesteven District Council- Application reference CL1016- 59.82ha Sustainable Urban Extension (SUE) for mixed use development including 1450 homes	Timing and phasing of construction is unknown at present. Site allocation is approx. 6.7km from the proposed reservoir site. There is the potential for cumulative impacts on traffic and local roads during the construction period.
North Kesteven District Council- Application reference CL3036 - 77.95ha SUE for mixed use development including 1400 homes	Timing and phasing of construction is unknown at present. Site allocation is approx. 6.7km from the proposed reservoir site. There is the potential for cumulative impacts on traffic and local roads during the construction period.
North Kesteven District Council Application reference CL1002- 6.81 ha of land is allocated for the development of 204 homes.	Timing and phasing of construction is unknown at present. Site allocation is approx. 5.6km from the proposed reservoir site. There is the potential for cumulative impacts on traffic and local roads during the construction period.
North Kesteven District Council- Application reference- CL1013- 25.52ha of land is allocated for the development of 290 homes.	Timing and phasing of construction is unknown at present. Site allocation is approx. 7.4km from the proposed reservoir site. There is the potential for cumulative impacts on traffic and local roads during the construction period.
North Kesteven District Council- Application reference CL1013a- 13.37ha of land is allocated for the development of 200 homes.	Timing and phasing of construction is unknown at present. Site allocation is approx. 4.8km from the proposed reservoir site. There is the potential for cumulative impacts on traffic and local roads during the construction period.

Project or plan	Cumulative/in-combination construction effects
North Kesteven District Council - Application reference CL1023- 6.3ha of land is allocated for the development of 204 homes.	Timing and phasing of construction is unknown at present. Site allocation is approx. 5.4km from the proposed reservoir site. There is the potential for cumulative impacts on traffic and local roads during the construction period.
North Kesteven District Council- Application reference E6 - Land to be designated Local development orders (LDOs) based on defined in an LDO securing new Agri-food Enterprise Zone. Masterplan to be developed.	No operational in-combination effects are anticipated.
Boston Borough Council- Application reference Swi015- 5.81ha of land is allocated for development of 116 homes.	Timing and phasing of construction is unknown at present. Site allocation is approx.10km from the proposed reservoir site. There is the potential for cumulative impacts on traffic and local roads during the construction period.
Boston Borough Council- application reference Don006 - 5.49ha of land is allocated for development of 110 homes.	Timing and phasing of construction is unknown at present. Site allocation is approx. 8km from the proposed reservoir site. There is the potential for cumulative impacts on traffic and local roads during the construction period.

11.3 Transfers and associated infrastructure

11.3.1 River Trent to Witham transfer route

There are no consented or proposed NSIPs within 10km of the proposed route. The proposed route is located directly through mineral safeguarding and consultation areas associated with sand and gravel. The works to install the pipeline will be temporary in nature and the pipeline area will be limited in extent. However, the existence of the pipeline may limit future mineral workings in close proximity to the installed pipeline. Further investigation of any potential plans for development along the pipeline route is recommended during the development of the detailed design. There are no EIA development planning applications in proximity to the proposed route, or allocated local plan major development. Major planning applications include application 22/00120/FULM (new equipment/machinery store, approximately 350m to the west of the route), and 22/01251/OUTM (residential development for 18 affordable dwellings, approximately 750m north-west of the route). Overall, construction and operational effects on EIA development and major planning applications is considered to be minor as they are likely to be completed before construction on the SLR commences.

11.3.2 Witham to SLR transfer route

The proposed route is directly intersected by the proposed Viking Link electrical interconnector (East Lindsey District Council N/110/01549/17) which will connect Bicker Fen substation to Revsing substation in Denmark. Mitigation measures will be sought at the next stages of the project to understand how the proposed route can avoid interacting with the Viking Link development. Further investigation and discussion over this potential interaction would be undertaken at detailed design with mitigation measures including realignment of the route and tunnelling potential measures. There are no other major planning applications or EIA development planning applications in either temporal or spatial proximity (within 1km) of the proposed route. There is an allocated residential site of approximately 4.72ha in the Central Lincolnshire Local Plan. This site is approximately 2km from the proposed route and is already in the process of being utilised for development (application 17/1776/FUL). There are no Mineral Safeguarding Sites in proximity to the proposed route. The proposed Heckington Fen Solar Park is an NSIP project approximately 900m from the proposed route but the construction period does not coincide with the SLR.

11.3.3 SLR potable water pipeline

The proposed route is located in direct proximity to connection cables (along A52 Holland Road) from Bicker Fen bulk supply point to the proposed Temple Oaks Renewable Energy Park, and NSIP proposal. As the proposed route will be utilising trenchless techniques to cross the A52, it is likely that the connection cables will not be affected. An alternative site for the Heckington Fen solar park NSIP proposal is located within 1km of the proposed route. Planning application s16/0834 (proposed irrigation reservoir) is located immediately adjacent to the proposed route at Langtoft. Note Hybrid Planning application 22/00275/FUL in relation to a proposed Anglian Water pipeline route, which this proposal is in direct proximity to. The South Kesteven local plan details a residential allocation (approx. 3.12 hectares) and a strategic employment site (approx. 4.2 hectares) approximately 200m from the proposed route. Two other residential allocations and strategic employment sites are also located in relative proximity to the route, in the Deeping area. The proposed route is located directly within the site-specific safeguarding area associated with MS27-SL, Baston No. 2 Quarry Phase 2 at Langtoft. The route also runs directly adjacent to Mineral Allocation Area M033 associated with Maxey Quarry. The route also intersects the Mineral Development Area and consultation area associated with Maxey Quarry. Mitigation to avoid intersecting with Maxey would be recommended.

11.4 Summary

There are a number of potential cumulative effects arising from the development of the scheme as there are some key interactions with Local Development Plan allocations. These will need further investigation and may support the scheme design.

12 Invasive Non-Native Species risk assessment

12.1 Introduction

12.1.1 Background

The transfer of water from one location to another may increase the risk of spreading INNS. The introduction of INNS to a waterbody can have significant detrimental effects on ecosystem structure and functioning, as well as jeopardising compliance with environmental legislation – including the Wildlife and Countryside Act (1981), the Invasive Non Native Species Regulations (2019), the Invasive Alien Species Order (2019), and the Water Environment (WFD) Regulations (2017). Understanding the INNS risk associated with each of the proposed SLR transfer and asset components is essential to inform the development of appropriate mitigation measures. A high-level investigation into the impact of abstraction from the River Trent and River Witham on the potential to increase habitat suitability for INNS is also included within the scope of this section.

12.1.2 Assessment objectives

The overall aim of this section is to present an assessment of the potential increase in INNS risk arising from the scheme, and will:

- Outline of the legislative context of INNS risk assessment.
- Establish if the scheme will introduce a new hydrological connection between previously isolated catchments.
- Identify INNS within an appropriate study area to understand the current INNS distribution.
- Provide a high-level overview of potential impacts on INNS in relation to the abstraction of water from the River Trent and River Witham.
- Use the SRO Aquatic INNS Risk Assessment Tool[19] (SAI-RAT) developed by on behalf of the Environment Agency to quantify the INNS risk associated with the scheme, based on the conceptual design information currently available.
- Review potential biosecurity options for implementation to mitigate the INNS risk associated with the scheme.

[19] Environment Agency (2021). SRO Aquatic INNS Risk Assessment Tool (SAI-RAT) – User Guide. Developed by APEM Ltd on behalf of the Environment Agency.

12.2 Key legislation and guidance

12.2.1 Key legislation

The translocation of INNS is subject to regulation under the following national legislation:

- **Wildlife and Countryside Act 1981 (as amended)** - Under Section 14 it may be an offence to release or allow to escape into the wild any animal which 'is of a kind which is not ordinarily resident in and is not a regular visitor to Great Britain in a wild state'; or is included in Part I of Schedule 9. Under Section 14 it may also be an offence to plant or otherwise cause 'to grow in the wild any plant which is included in Part II of Schedule 9.
- **Invasive Non-native Species (Amendment etc.) (EU Exit) Regulations 2019** - ensures the continued operability of the EU **Invasive Alien Species Regulation 1143/2014** legislation, which outlines a set of measures to combat the spread of INNS on the list of EU concern – through prevention by a number of robust measures that aim to prevent introduction of INNS; early detection and eradication of INNS through a surveillance system and rapid eradication measures; and management action to prevent further spread and harm.
- **Invasive Alien Species (Enforcement & Permitting) Order 2019** - it may be an offence to release or allow to escape, plant, or grow species of animal or plant 'not ordinarily resident in' and 'not a regular visitor to Great Britain in a wild state', or otherwise listed in Part 1 of Schedule 2.
- **Water Environment (Water Framework Directive) (England and Wales) Regulations 2017** guidance[20] states that a waterbody initially classified as 'High Status' (representing near-natural conditions), may drop in classification if populations of High Impact INNS are showed to be significantly affecting the waterbody. High Impact INNS are identified on the current aquatic alien species list produced by the Water Framework Directive UK Technical Advisory Group[21]. Species on the High Impact list are used within the WFD Classification process.

[20] Water Framework Directive – United Kingdom Technical Advisory Group (WFD UKTAG) *Guidance on the assessment of alien species pressures* [pdf] Available at: https://www.wfduk.org/sites/default/files/Media/Characterisation%20of%20the%20water%20environment/Alien%20species%20guidance%20modified%20from%20Feb%2004%20-%20March%202013.pdf [Accessed 24 October 2022].

[21] Water Framework Directive – United Kingdom Technical Advisory Group

(WFD UKTAG) *UKTAG Assessment Method – Alien Species* [pdf] Available at: http://wfduk.org/sites/default/files/Media/Characterisation%20of%20the%20water%20environment/Biological%20Method%20Statements/Alien%20Species%20UKTAG%20Method%20Statement.pdf [Accessed 24 October 2022].

12.2.2 EA guidance

The Environment Agency position statement *Managing the Risk of Spread of Invasive Non-Native Species Through Raw Water Transfers*[22] outlines how INNS risks associated with raw water transfers (RWT) should be managed. The key points of relevance to this report are as follows:

- The focus of the Environment Agency's approach is on the pathways that the transfers create, not on current INNS distribution.
- New schemes that create a hydrological connection between isolated catchments must have mitigation measures in place to ensure INNS cannot be spread by the new transfer.
- Where water transfer into another watercourse remains the proposed solution, mitigation will need to be fail safe, resilient, and completely effective for all life stages and forms (e.g. plant propagules, animals, microscopic organisms and larval stages).
- Where catchments are already connected, a risk assessment will be required, which the Environment Agency will use to decide whether subsequent mitigation is required, to ensure the risk of INNS transfer is not significantly increased.

12.3 Methodology

12.3.1 Study area

This SRO involves the transfer of raw water from the River Trent to the SLR via the River Witham, and transfer to the WTW from the reservoir. The exact locations of the transfer routes and abstraction points has yet to be determined and are considered indicative. This assessment is divided into two components and examines the risk associated with the transfer of water to and from the reservoir, and the risk associated with the operation of assets which form part of this SRO. The scheme was divided into the following transfer sections for the purposes of assessment using the raw water transfer[23] assessment tab in the SAI-RAT:

- Transfer of raw water from the River Trent to outfall location on the River Witham
- Transfer of raw water from the River Witham to SLR
- Transfer of raw water from SLR to emergency drawdown (EDD) testing discharge pond
- Discharge of water from SLR to a tributary of the SFFD for EDD – intended to be used in emergency situations only
- Reservoir spillway to local drain network – expected to be higher than operating water level and unlikely to required operationally for embankment reservoir.

[22] Environment Agency (2017). Managing the Risk of Spread of Invasive Non-Native Species Through Raw Water Transfers. Position 1321_16.

[23] Note the SAI-RAT defines raw water transfer as 'movements of untreated water by means other than the natural flow of the water source'

The asset components were defined as:

- Inlet pumping station and water sampling building – for control of water supply to the proposed reservoir
- SLR – the proposed reservoir
- EDD pond – used to hold and slowly release water in testing of the emergency drawdown system
- Proposed SLR WTW – for treatment of water abstracted from the SLR
- Potable pumping station – for pumping of water to supply network
- Outlet pumping station – for distribution of potable water to the established distribution network
- Buried service reservoir (SR) – for storage of treated water

A high-level qualitative study into the impact of abstraction on INNS was also undertaken using all available literature detailing the habitat preferences and flow requirements of all INNS records found within 1km of the abstraction points on the River Trent and River Witham. This 1km search radius was aligned with the search buffer required for scheme components being assessed using the SAI-RAT[19].

12.3.2 Screening against EA guidance

The scheme was screened to determine if it will create a link between isolated catchments, as mapped in the Environment Agency document *Invasive Non-Native Species Isolated Catchment Mapping*[24].

12.3.3 Desk study

Open-source macroinvertebrate, macrophyte and fish data for the period 1965 to 2020 was obtained for the study area as relevant to each water transfer and asset component of the scheme. This data was collated from the Environment Agency Ecology and Fish Data Explorer app[25] and the National Biodiversity Network (NBN) Atlas online records[26]. The data was screened against Schedule 9 of the Wildlife and Countryside Act 1981 (as amended) and WFD-UKTAG guidance[27] to determine INNS distribution within the study area.

The desk study also included records from surveys undertaken during October 2020 and reported at gate one. These surveys involved physical surveys and environmental DNA (eDNA) at four sites of relevance to the proposed design at gate two, which are detailed in Table 12.1.

Table 12.1: Gate one INNS field survey sites.

Waterbody	Location	NGR	Survey Date
Brayford Pool	Lincoln, at Fossdyke-Witham confluence	SK 97285 71053	01/10/2020
River Witham	Towards tidal limit, Antons Gowt	TF 29974 47435	01/10/2020
SFFD	Swineshead Bridge	TF 21785 42860	01/10/2020

[24] Environment Agency (2018). Invasive Non-Native Species Isolated Catchment Mapping. v3.

[25] EA Ecology and Fish Data Explorer app available online at: https://environment.data.gov.uk/ecology/explorer/

[26] NBN Atlas available online at: https://nbnatlas.org/

[27] WFD-UKTAG V8 (2021). UK Technical Advisory Group on the Water Framework Directive. Revised classification of aquatic alien species according to their level of impact. Public working draft.

Waterbody	Location	NGR	Survey Date
SFFD	Near tidal limit, Boston	TF 32483 42917	01/10/2020

Furthermore, assessment work undertaken in support of the Minworth SRO, including desk and field studies, was reviewed to identify additional information of relevance to this INNS risk assessment. The assessment for the Minworth SRO assumed that the River Trent to River Witham transfer would be located further upstream than is being currently assumed for the transfer route. The results are not directly comparable to this assessment, but do provide some relevant information.

12.3.4 Limitations

The SAI-RAT tool used in this assessment quantifies the risk associated with the operational phase of a water transfer option, rather than the construction phase. The scheme would involve the construction of a new transfer, which poses the risk of INNS being spread through the movement of personnel, vehicles and equipment to and from construction sites, as well as the excavation and disposal of materials (e.g., sediment and vegetation). As the conceptual design is developed, construction-phase risks relating to INNS should also be considered as more information becomes available.

The data and information input into the INNS risk assessment tool were based on the latest available conceptual design. As the conceptual design is still in development, these details may be subject to change. The INNS risk assessment should be revised during the design process to ensure that it remains accurate with the availability of new information.

12.4 Results

12.4.1 Screening against EA guidance

The source of the transfer, the River Trent, falls within Area 97 of the Environment Agency's *Invasive Non-Native Species Isolated Catchment Mapping v3*[24]*.* This area connected to 'Canal – CRT', meaning that it is connected to navigable canals controlled by the Canal and Rivers Trust. Part of the transfer pathway – the River Witham, and the SLR itself, fall within Area 92, which is also connected to 'Canal – CRT'. Therefore, it is concluded that the scheme will not create a new hydrological connection between 'isolated' catchments.

The Environment Agency guidance for RWTs states: 'where catchments are already connected, a risk assessment will be required, which the Environment Agency will use to decide whether subsequent mitigation is required, to ensure the risk of INNS transfer is not significantly increased'.

Although the scheme would not create a link between isolated catchments as defined in EA guidance[24], the scheme has the potential to create or increase connectivity between catchments or waterbodies not already connected, and this should be considered and appropriately mitigated as the design develops.

12.4.2 Desk study

12.4.2.1 Gate one field survey results

Gate one INNS field survey results are shown in Table 12.2. Thirteen non-native species were identified across the four surveys sites within Brayford Pool, the River Witham and SFFD. This included two High Impact species, the zebra mussel (*Dreissena polymorpha*) and the bloody-red mysid (*Hemimysis anomola*).

Field surveys indicated the presence of four non-native species which were not identified during desk searches of the SFFD, the High Impact species bloody red mysid (*Hemimysis anomola*), non-native invertebrates Conrad's false mussel (*Mytilopsis leucophaeata*) and Gulf wedge clam (*Rangia cuneata*), and the non-native aquatic plant species red duckweed (*Lemna turionifera).*

Table 12.2: Gate one INNS field survey results: physical surveys (●) and eDNA sampling (○).

Species	Taxon group	Brayford Pool, Lincoln, at Fossdyke-Witham confluence	River Witham, Towards tidal limit, Antons Gowt	SFFD, Swineshead Bridge	SFFD, near tidal limit, Boston
Nuttall's waterweed (*Elodea nuttallii*)	Flowering plant		●	●	
Least duckweed (*Lemna minuta*)	Flowering plant	●	●	●	●
Red duckweed (*Lemna turionifera*)	Flowering plant			●	●
Water fern (*Azolla filiculoides*)	Fern			●	●
Bloody red mysid (*Hemimysis anomola*)	Invertebrate				●
Demon shrimp (*Dikerogammarus haemobaphes*)	Invertebrate			●	●
Caspian mud shrimp (*Chelicorophium curvispinum*)	Invertebrate		●		●
Conrad's false mussel (*Mytilopsis leucophaeata*)	Invertebrate			○	○
Sideswimmer (*Gammarus tigrinus*)	Invertebrate			●	●
Zebra mussel (*Dreissena polymorpha*)	Invertebrate		●○	●	●
Gulf wedge clam (*Rangia cuneata*)	Invertebrate		○		○
Asiatic clam (*Corbicula fluminea*)	Invertebrate	○			
Jenkin's spire shell (*Potamopyrgus antipodarum*)	Invertebrate				●

As the SFFD is to only be used during emergency operations, it is of low likelihood that the species listed above will be introduced and spread to new waterbodies as a result of this scheme, however this possibility remains during emergency operations.

12.4.2.2 Minworth SRO and SLR SRO assessment

Work in support of the Minworth SRO and SLR SRO identified the following species present in the River Witham, and assigned a Priority for Mitigation, as shown in Table 12.3 below. The two High Priority species found were crayfish plague (*Aphanomyces astaci*) and New Zealand pigmyweed (*Crassula helmsii*). Neither species has previously been recorded in the River Witham; therefore constitute a High Priority for Mitigation. A further seven species were

identified as being of Medium Priority for Mitigation, three of which have also not been recorded in the River Witham, and four of which have been recorded downstream of Brayford Pool.

Table 12.3: INNS of Medium and High Priority for Mitigation for the Minworth SRO.

Common name	Scientific name	Taxon group	Presence in River Witham	Priority for Mitigation
Crayfish plague	*Aphanomyces astaci*	Water mould	Not recorded	High
Water fern	*Azolla filiculoides*	Fern	Yes – downstream of Brayford Pool only	Medium – present in River Witham
New Zealand Pigmyweed	*Crassula helmsii*	Flowering plant	Not recorded	High
Zebra mussel	*Dreissena polymorpha*	Invertebrate	Yes – downstream of Brayford Pool only	Medium – not statutory and present within River Witham
A freshwater limpet	*Ferrissia californica (wautieri)*	Invertebrate	Not recorded	Medium – non-statutory
A polychaete worm	*Hypnadia invalida*	Invertebrate	Not recorded	Medium – non-statutory
Parrot's feather	*Myriophyllum aquaticum*	Flowering plant	Not recorded	Medium – widely spread
Signal crayfish	*Pacifastacus leniusculus*	Invertebrate	Yes – downstream of Brayford Pool only	Medium – present in River Witham and widely spread
Japanese knotweed	*Reynoutria japonica*	Flowering plant	Yes – downstream of Brayford Pool only	Medium – present in River Witham

12.4.2.3 Raw water transfers to the SLR

A total of fifteen INNS were identified in the Environment Agency and NBN Atlas records within 1km of the raw water transfer routes between the River Trent and the River Witham and the River Witham and the SLR. This included three High Impact plant species (as identified in WFD-UKTAG Classification[21]) and three High Impact macroinvertebrate species. No non-native or invasive fish were found within the study area.

The Environment Agency and NBN Atlas INNS records for the study area are summarised in Table 12.4.

Table 12.4: Non-native species records identified in Environment Agency (●) and NBN Atlas (○) records within 1km of the RWT.

Common name	Scientific name	Taxon group	Functional group	Non- native status	Transfer from River Trent to River Witham	Transfer from River Witham to SLR
Bivalve mollusc	Dreissenidae	Invertebrate	Sessile, juvenile <1mm, eggs	UKTAG - Unknown[28]		●

[28] WFD-UKTAG listed INNS, categorised as High / Medium / Low / Unknown Impact

Common name	Scientific name	Taxon group	Functional group	Non- native status	Transfer from River Trent to River Witham	Transfer from River Witham to SLR
Bladder snail	*Physella acuta*	Invertebrate	Mobile, juvenile <1mm, no eggs	UKTAG - Unknown		●○
Bloody red mysid	*Hemimysis anomala*	Invertebrate	Mobile, juvenile >1mm, no eggs	UKTAG – High		●
Canadian waterweed	*Elodea canadensis*	Aquatic plant	Vegetative, aquatic, perennial	UKTAG – Moderate WACA 1981 Sch. 9[29]		●○
Caspian mud shrimp	*Chelicorophium curvispinum*	Invertebrate	Mobile, juvenile >1mm, no eggs	UKTAG – Unknown		●
Demon shrimp	*Dikerogammarus haemobaphes*	Invertebrate	Mobile, juvenile >1mm, no eggs	UKTAG – High		●
Freshwater snail	*Physella spp.*	Invertebrate	Mobile, juvenile <1mm, no eggs	UKTAG - Unknown		●○
Himalayan balsam	*Impatiens glandulifera*	Flowering plant	Seed, riparian, annual	UKTAG - High WACA 1981 Sch. 9 EU species of special concern[30] IAS Order 2019 Sch. 2[31]	○	
Jenkins' spire snail	*Potamopyrgus antipodarum*	Invertebrate	Mobile, juvenile <1mm, no eggs	UKTAG – Moderate	●○	●○
Northern river crangonyctid	*Crangonyx pseudogracilis*	Invertebrate	Mobile, juvenile >1mm, no eggs	UKTAG - Unknown		●
Northern river/Florida crangonyctid	*Crangonyx pseudogracilis/ floridanus*	Invertebrate	Mobile, juvenile >1mm, no eggs	UKTAG – Unknown	●	●○

[29] Listed on Schedule 9 of the Wildlife & Countryside Act 1981.

[30] Invasive Non-Native Species (Amendment etc.) (EU Exit) Regulations 2019 – listed as an 'invasive alien species of union concern'.

[31] Listed on Schedule 2 of the Invasive Alien Species (Enforcement and Permitting) Order 2019.

Common name	Scientific name	Taxon group	Functional group	Non- native status	Transfer from River Trent to River Witham	Transfer from River Witham to SLR
Nuttall's waterweed	*Elodea nuttallii*	Aquatic plant	Vegetative, aquatic, perennial	UKTAG – High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2		●○
Side swimmer	*Gammarus tigrinus*	Invertebrate	Mobile, juvenile >1mm, no eggs	UKTAG – Unknown	○	●
Water fern	*Azolla filiculoides*	Aquatic plant	Seed + vegetative, aquatic, perennial	UKTAG – High impact WACA 1981 Sch. 9		●
Zebra mussel	*Dreissena polymorpha*	Invertebrate	Sessile, juvenile <1mm, eggs	UKTAG – High		●

12.4.2.4 Water transfers from the SLR

A total of thirteen INNS were identified in the Environment Agency and NBN Atlas records within 1km of the transfer routes from the SLR. This included three High Impact plant species, and the High Impact fish common carp (*Cyprinus carpio*).

The Environment Agency and NBN Atlas INNS records for the study area are summarised in Table 12.5.

Table 12.5: Non-native species records identified in Environment Agency (●) and NBN Atlas (○) records within 1km of the transfers from the reservoir.

Common name	Scientific name	Taxon group	Functional group	Non-native status	EDD to SFFD tributary	SLR WTW to AWS WTW
Bladder snail	*Physella acuta*	Invertebrate	Mobile, juv, <1mm, no eggs	UKTAG – Unknown Impact	●	
Canadian waterweed	*Elodea canadensis*	Aquatic plant	Vegetative, aquatic, perennial	UKTAG – Moderate Impact WACA 1981 Sch. 9		●○
Common carp	*Cyprinus carpio*	Fish	Mobile, juvenile >1mm, eggs	UKTAG – High Impact	●○	
Freshwater snail	*Physella spp*.	Invertebrate	Mobile, juv, <1mm, no eggs	UKTAG – Unknown Impact	●○	●

Common name	Scientific name	Taxon group	Functional group	Non-native status	EDD to SFFD tributary	SLR WTW to AWS WTW
Himalayan balsam	*Impatiens glandulifera*	Flowering plant	Seed, riparian, annual	UKTAG – High Impact EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2		○
Jenkins' spire snail	*Potamopyrgus antipodarum*	Invertebrate	Mobile, juv, <1mm, no eggs	UKTAG – Moderate Impact	●○	●○
Least duckweed	*Lemna minuta*	Aquatic plant	Vegetative, aquatic, perennial	UKTAG – Unknown Impact		●
Northern river / Florida crangonyctid	*Crangonyx pseudogracilis/floridanus*	Invertebrate	Mobile, juv, >1mm, no eggs	UKTAG – Unknown Impact	●○	●
Northern River crangonyctid	*Crangonyx pseudogracilis*	Invertebrate	Mobile, juv, >1mm, no eggs	UKTAG – Unknown Impact	●○	○
Nuttall's waterweed	*Elodea nuttallii*	Aquatic plant	Veg, aquatic, perennial	UKTAG – High Impact EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	●○	●○
Orange balsam	*Impatiens capensis*	Flowering plant	Seed, riparian, annual	UKTAG – Low Impact		○
Side swimmer	*Gammarus tigrinus*	Invertebrate	Mobile, juv, >1mm, no eggs	UKTAG – Unknown Impact	●○	
Water fern	*Azolla filiculoides*	Aquatic plant	Seed+veg, aquatic, perennial	UKTAG – High Impact WACA 1981 Sch. 9	●○	

12.4.2.5 SLR and associated assets

As several assets occurred in very close proximity to each other, they have been grouped together to form four separate species searches. These are as described in Section 12.3.1 and have been grouped in the following manner:

- SLR (proposed reservoir)
- SLR WTW, buried SR, and potable pumping station
- Inlet pumping station and water sampling building
- EDD pond, and outlet pumping station

A total of seven invasive species records were found within 1km of the SLR and associated assets. These included High Impact macrophytes Himalayan balsam (*Impatiens glandulifera*), Nuttall's waterweed (*Elodea nuttallii*) and water fern (*Azolla filiculoides*). No records of non-native fish species were found within the study area. No INNS records were found at the WTW group and the emergency drawdown pond group and these assets have been omitted from these results. The Environment Agency and NBN Atlas INNS records for the study area are summarised in Table 12.6

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Table 12.6: Non-native invertebrate records identified in Environment Agency (●) and NBN Atlas (○) records within 1km of the reservoir and assets.

Common name	Scientific name	Taxon group	Functional group	Non- native status	SLR and Marina	Inlet water sampling building and pumping station
Bladder snail	*Physella acuta*	Invertebrate	Mobile, juv, <1mm, no eggs	UKTAG – Unknown Impact	●○	○
Freshwater snail	*Physella* sp.	Invertebrate	Mobile, juv, <1mm, no eggs	UKTAG – Unknown Impact	●○	○
Northern river/Florida crangonyctid	*Crangonyx pseudogracilis/ floridanus*	Invertebrate	Mobile, juv, >1mm, no eggs	UKTAG – Unknown Impact	●○	
Jenkins spire snail	*Potamopyrgus antipodarum*	Invertebrate	Mobile, juv, <1mm, no eggs	UKTAG – Moderate Impact	○	○
Canadian waterweed	*Elodea canadensis*	Aquatic plant	Veg, aquatic, perennial	UKTAG – Moderate Impact WACA 1981 Sch. 9	●○	○
Himalayan balsam	*Impatiens glandulifera*	Flowering plant	Seed, riparian, annual	UKTAG – High Impact WACA 1981 Sch. 9 EU species of special concern IAS Order 2019 Sch. 2	○	
Nuttall's waterweed	*Elodea nuttallii*	Aquatic plant	Veg, aquatic, perennial	UKTAG – High Impact EU species of special WACA 1981 Sch. 9	●○	○
Water fern	*Azolla filiculoides*	Aquatic plant	Seed+veg, aquatic, perennial	UKTAG – High Impact WACA 1981 Sch. 9	○	

12.4.3 Potential abstraction impact on INNS

A total of eleven distinct invasive species taxa were recorded at the abstraction locations on the River Trent and River Witham. This included three High Impact macrophytes Himalayan balsam (*Impatiens glandulifera*), Nuttall's waterweed (*Elodea nuttallii*) and Water fern (*Azolla filiculoides),* and three High Impact invertebrates - Demon shrimp (*Dikerogammarus haemobaphes*), Zebra mussel (*Dreissena polymorpha*) and Bloody red mysid (*Hemimysis anomala*). No records of non-native fish were recorded within 1km of either abstraction location.

The abstraction location on the River Witham contained a greater number of non-native species with eleven different records in comparison to two records on the River Trent.

The EA and NBN Atlas INNS records located within 1km of each abstraction location are summarised in Table 12.7.

Table 12.7: Species records within 1km of abstraction points from EA (✓) and NBN Atlas (✓).

Common name	Scientific name	Functional group	Non- native status	Trent intake (approx. SK 80115 57809)	Witham intake (approx. TF 25051 49564)
Bladder snail	*Physella acuta*	Mobile, juvenile <1mm, no eggs	UKTAG – Unknown Impact		✓
Bloody red mysid	*Hemimysis anomala*	*Mobile, juvenile >1mm, no eggs*	UKTAG – High Impact		✓
Canadian waterweed	*Elodea canadensis*	Vegetative, aquatic, perennial	UKTAG – Moderate Impact WACA 1981 Sch. 9		✓
Caspian mud shrimp	*Chelicorophium curvispinum*	Mobile, juv, >1mm, no eggs	UKTAG – Unknown Impact		✓
Demon shrimp	*Dikerogammarus haemobaphes*	Mobile, juv, >1mm, no eggs	UKTAG – High Impact		✓
Himalayan balsam	*Impatiens glandulifera*	Seed, riparian, annual	UKTAG – High Impact EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	✓	
Jenkin's spire snail	*Potamopyrgus antipodarum*	Mobile, juv, <1mm, no eggs	UKTAG – Moderate Impact		✓
Northern river / Florida crangonyctid	*Crangonyx pseudogracilis/ floridanus*	Mobile, juv, >1mm, no eggs	UKTAG – Unknown Impact		✓
Nuttall's waterweed	*Elodea nuttallii*	Vegetative, aquatic, perennial	UKTAG – High Impact WACA 1981 Sch. 9		✓
Side swimmer	*Gammarus tigrinus*	Mobile, juv, >1mm, no eggs	UKTAG – Unknown Impact	✓	✓
Water fern	*Azolla filiculoides*	Seed + vegetative, aquatic, perennial	UKTAG – High Impact WACA 1981 Sch. 9		✓
Zebra mussel	*Dreissena polymorpha*	Sessile, juvenile <1mm, eggs	UKTAG – High		✓

Habitat requirements and the potential impact of abstraction for non-native species recorded within a 1km radius of the two abstraction locations are presented below in Table 12.8 Table 12.8. The impact of the abstraction has the potential to alter the environmental conditions of the waterbody, as a reduction in flow could lead to higher temperatures, increased turbidity and greater presence of pollution through reduced dilution. Any such changes could increase habitat suitability for several species as described below. Species searches were undertaken within a 1km buffer in line with the SAI-RAT methodology, however it cannot be guaranteed that all invasive and non-native species present within the study area have been recorded.

Table 12.8: Habitat requirements and abstraction impact of non-native invertebrates recorded within 1km of abstraction locations.

Species	Habitat requirements	Abstraction locations	Potential abstraction impact
Bladder snail (*Physella acuta*)	• *P. acuta* frequently found occurring in warm water discharges 32 • Associated with slow-flowing or still freshwater33 • LIFE score: Group III-Slow/Sluggish	River Witham	Localised changes in environmental conditions may increase habitat suitability for *P. acuta* due to changes in flow and/or temperature.
Bloody red mysid (*Hemimysis anomala*)	• *H. anomala* are mostly found in lentic or very slow-flowing waters, discernible flow may prevent prolonged inhabitation34 • Prefers warmer waters. Temperature range 9 and 20° C, 0° C tolerated35 • LIFE score: Group IV-Flowing/Standing	River Witham	Localised changes in environmental conditions may increase habitat suitability for *H. anomala* due to changes in flow and/or temperature.
Canadian waterweed (*Elodea canadensis*)	• *E. canadensis* adaptable and has can spread under a wide range of conditions and nutrient concentrations ranging from oligotrophic to eutrophic[36] • Maximum depth recorded is 4m in Europe in slow moving waters • Dominates warmer, shallower waters • Can tolerate brackish waters and prefers water with organic sediment • Ellenberg Value: Light – 7, Nitrogen – 6, Moisture - 12	River Witham	Localised changes in environmental conditions may increase habitat suitability for E. canadensis if flow or depth changes occur

[32] Semenchenko, V. et al. (2008). A new record of the North American gastropod *Physella acuta* (Draparnaud, 1805) from the Neman River Basin, Belarus [pdf]. *Aquatic Invasions, 3(3),* pp359-360. Available at: < http://www.aquaticinvasions.net/2008/AI_2008_3_3_Semenchenko_etal.pdf> [Accessed 15 August 2022]

[33] The British Conchological Society of Greta Britain and Ireland n.d. Identifying British freshwater snails: Family: Physidae [online]. Available at: https://conchsoc.org/aids_to_id/Physidae.php [Accessed 15 August 2022]

[34] Stubbington, R. 2009. CABI: Invasive Species Compendium. Hemimysis anomala [online} Available at: < https://www.cabi.org/isc/datasheet/108015> [Accessed 29 July 2022]

[35] Jensen, Kathe R. (2010). NOBANIS – Invasive Alien Species Fact Sheet – Hemimysis anomala – From: Identification key to marine invasive species in Nordic waters – NOBANIS. Available at: < https://www.nobanis.org/globalassets/speciesinfo/h/hemimysis-anomala/hemimysis-anomala.pdf> [Accessed 29 July 2022]

[36] Duenas-Lopez M A, Popay I and Dawson H. (2018). Elodea canadensis (Canadian pondweed). Invasive Species Compendium. Wallingford, UK: CABI. DOI:10.1079/ISC.20759.20203483396

Species	Habitat requirements	Abstraction locations	Potential abstraction impact
Caspian mud shrimp (*Chelicorophium curvispinum*)	• *C. curvispinum* prefers large, slow flowing stagnant waters but is extremely adaptable to different environments and is regarded as a habitat generalist[37] • Optimum depth 2-3m • Optimum salinity <6 ppt • Optimum suspended solids- 30 mg/l[38] • LIFE score: Group V- Standing	River Witham	Potential for localised changes in flow regime to increase habitat suitability for *C. curvispinum*
Demon shrimp (*Dikerogammarus haemobaphes*)	• *D. haemobaphes* prefers to inhabit large rivers and lakes solid substrates, macrophytes, and filamentous algae but is very adaptable to a variety of conditions • Optimum salinity 0-8 ppt • Preference for deeper waters[39] • LIFE score: Group II- Moderate/fast	River Witham	Localised changes in flow are unlikely to increase habitat suitability for *D. haemobaphes.*
Himalayan balsam (*Impatiens glandulifera*)	• *I. glandulifera* typically inhabits riparian sites adjacent to fast flowing water and is typically drought intolerant[40] • Ellenberg Value: Light – 6, Nitrogen – 7, Moisture - 8	River Trent	Localised changes in flow are unlikely to increase habitat suitability for *Impatiens glandulifera* due to this species inhabiting riparian sites

[37] Gallardo, B and Aldridge, D. (2013). Review of the ecological impact and invasion potential of Ponto Caspian invaders in Great Britain. Cambridge Environental consulting [pdf]. Available at: < Review of the ecological impact and invasion potential of Ponto Caspian invaders in Great Britain> [Accessed 29 July 2022]

[38] Mastitsky, S. (2009). CABI: Invasive Species Compendium. *Chelicorophium curvispinum* (Caspian mud shrimp) [online]. Available at: https://www.cabi.org/isc/datasheet/108307 [Accessed 29 July 2022]

[39] Baker, E. et al. (2022) *Dikerogammarus haemobaphes* (Eichwald, 1841): U.S. Geological Survey, Nonindigenous Aquatic Species Database [online]. Available at: https://nas.er.usgs.gov/queries/greatlakes/FactSheet.aspx?Species_ID=3613&Potential=Y&Type=2&HUCNumber= [Accessed 29 July 2022]

[40] Pollard, K. (2017). CABI: Invasive Species Compendium *Impatiens glandulifera* (Himalayan balsam) [online]. Available at < https://www.cabi.org/isc/datasheet/28766#tobiologyAndEcology> [Accessed 29 July 2022]

Species	Habitat requirements	Abstraction locations	Potential abstraction impact
Jenkin's spire snail (*Potamopyrgus antipodarum*)	• *P. antipodarum* prefers to inhabit littoral zones in high nutrient waterbodies with a slower flow but can also tolerate high flow environments where sediment is prevalent[41] • Optimum salinity 15ppt • Prefers lower velocity (86400 cm/h is harmful) • Can tolerate high levels of ammonia in low pH environments • Tolerant of a wide range of dissolved oxygen and turbidity[42] • LIFE score: Group II-Moderate/fast	River Witham	Localised changes in flow are unlikely to increase habitat suitability for *P. antipodarum*
Northern river / Florida crangonyctid (*Crangonyx pseudogracilis/ floridanus*)	• Very pollution tolerant43 • Potential reductions in flow may reduce habitat suitability[44] • LIFE score: Group II-Moderate/fast	River Witham	Localised changes in flow are unlikely to increase habitat suitability *Crangonyx pseudogracilis/floridanus*
Nuttall's waterweed (*Elodea nuttallii*)	• Found in nutrient rich environments. • Competitive and well adapted to a broad array of environmental conditions[45] • Able to grow in highly eutrophic waters and turbid conditions. • Growth of *E. nuttallii* is stimulated by fertilization with nitrogen and benefits from an excess of ammonia. • Ellenberg Value: Light – 6, Nitrogen – 7, Moisture - 12	River Witham	Localised changes in environmental conditions may increase habitat suitability for *E. nuttallii.* due to possible changes in turbidity or water chemistry.

[41] Benson, A et al. 2022. *Potamopyrgus antipodarum* (J.E. Gray, 1853): U.S. Geological Survey, Nonindigenous Aquatic Species Database [online]. Available at: https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1008. [Accessed 29 July 2022]

[42] Alonso, A (2013) CABI: Invasive Species Compendium *Potamopyrgus antipodarum* (New Zealand mudsnail) [online] Available at: https://www.cabi.org/isc/datasheet/43672 [Accessed 29 July 2022]

[43] Nature Spot (no date). *Crangonyx pseudogracilis*. [online]. Available at: <https://www.naturespot.org.uk/species/crangonyx-pseudogracilis> {Accessed 29 July 2022]

[44] Naoya et al (2012). Effects of low flow on invasion process of exotic stream invertebrates *Journal of Japan Society of Civil Engineers* 67(6), pp. 29-36 DOI10.2208/jscejer.67.II_29

[45] CABI Invasive Species Compendium. n.d. Elodea nuttallii (Nuttall's waterweed) Data Sheet. [online] Available at: <https://www.cabi.org/isc/datasheet/20761> [Accessed 19 August 2022].

Species	Habitat requirements	Abstraction locations	Potential abstraction impact
Side swimmer (*Gammarus tigrinus*)	• In the UK this species is found to inhabit sheltered places at the edge of the river among leaves, roots and debris, preferring shallow turbid environments. It is also very pollution tolerant and will displace other species in this environment[46] [47] • Optimum salinity 4-20 ppt • LIFE score: Group III-Slow/sluggish	River Trent River Witham	Potential for localised changes in flow regime to increase habitat suitability for *Gammarus tigrinus*
Water fern (*Azolla filiculoides*)	• *A. filiculoides* has a preference for slow-flowing waters[48] • Not drought tolerant • Can tolerate temperature changes • Phosphorus-limited growth • Ellenberg Value: Light – 7, Nitrogen – 8, Moisture - 11	River Witham	Localised changes in environmental conditions may increase habitat suitability for *A. filiculoides* as this species has a preference for slow-flowing areas
Zebra mussel (*Dreissena polymorpha*)	• The typical habitats colonised are estuaries, rivers and lakes, particularly where there are firm surfaces suitable for attachment[49] • Capable of tolerating a wide range of conditions. They can tolerate starvation for extended periods, desiccation, extremes of high and low temperatures, and highly variable dissolved oxygen levels. • *D. polymorpha* can adapt and inhabit brackish areas. They are capable of tolerating a certain degree of pollution, although they are absent from heavily polluted waters. • LIFE score: Group IV – Slow/standing	River Witham	Localised changes in environmental conditions are unlikely to increase habitat suitability for *D. polymorpha*

12.4.4 Risk assessment

The INNS risk assessment results for all water transfers associated with this SRO as derived from the SAI-RAT are summarised in Table 12.9.

It should be noted that these scores do not take into account any engineering interventions that may be required as mitigation to prevent the spread of INNS.

[46] Kipp, R et al. (2022). Gammarus tigrinus Sexton 1939: U.S. Geological Survey, Nonindigenous Aquatic Species Database [online] Available at: https://nas.er.usgs.gov/queries/GreatLakes/FactSheet.aspx?Species_ID=2650 [Accessed 29 July 2022].

[47] Shalaeva, E. (2014). CABI: Invasive Species Compendium *Gammarus tigrinus*.[online] Available at: < https://www.cabi.org/isc/datasheet/82074> [Accessed 29 July 2022]

[48] CABI Invasive Species Compendium. n.d. Azolla filiculoides (water fern) Data Sheet. [online] Available at: <https://www.cabi.org/isc/datasheet/8119> [Accessed 19 August 2022].

[49] CABI Invasive Species Compendium. n.d. Dreissena polymorpha (zebra mussel) Data Sheet. [online] Available at: <https://www.cabi.org/isc/datasheet/85295> [Accessed 19 August 2022].

Table 12.9: INNS risk assessment scores for water transfers.

Transfer option	Transfer type	Risk Score (%)
River Trent to River Witham	Raw water transfer	44.63
River Witham to SLR	Raw water transfer	45.00
SLR to discharge pond	Raw water transfer- routine operation	30.50
SLR to spillway	Raw water transfer- emergency operation	41.50
EDD drawdown option 1 (to SFFD tributary)	Raw water transfer emergency operation	42.25

The highest scoring option was the Transfer from the River Witham to SLR with a risk score of 45.00%. This is likely due to a higher volume of transferred water and a slightly longer pipeline length. The greatest threat with this highest-scoring section of the transfer is the potential event of pipeline burst or leakage (due to the transfer crossing river catchments).

As these options involve the transfer of raw water from open receptors, the risk associated with these transfers is elevated due to the potential for INNS to be transferred to the receptors and spread further on improperly cleaned equipment, or animals which have access to the water surface.

The INNS risk assessment results for all assets associated with this SRO as derived from the SAI-RAT are summarised in Table 12.10.

Table 12.10: INNS risk assessment scores for assets.

Asset name	Risk score (%)
Buried service reservoir	7.87
EDD pond	18.21
Inlet pumping station and water sampling building	14.24
Outlet pumping station	13.04
Potable pumping station	9.44
Proposed SLR WTW	16.17
SLR	57.09

The proposed SLR was determined to have the highest risk of all assets, with a score of 57.09%. SLR is a proposed open waterbody with potential access for recreational activities such as water sports and boating, and regular access for routine site operation and maintenance - this means there is a significantly higher risk of the introduction of new INNS species transferred via improperly cleaned equipment. As it has been assumed that all assets would have some level of maintenance that requires personnel to enter the site or water within the site, all assets have a small amount of risk associated with routine operation.

It is recommended that biosecurity options are considered for all assets and water transfer options, with particular emphasis on the implementation of High confidence measures (those most robust at reducing risk) within the highest risk assets and RWT options. This is discussed in more detail in Section 12.4.5.

As the final design of this SRO is subject to change, this assessment should be updated accordingly as additional information becomes available in order to provide a more accurate account of the risk associated with the assets and RWTs assessed within this SRO.

12.4.5 Biosecurity assessment

The risk assessment tool identified a range of biosecurity measures to mitigate the risk associated with key pathways of INNS spread that would be introduced by the proposed water transfers and assets. The biosecurity measures with a 'High' confidence rating are those most likely to reduce INNS risk associated with the corresponding pathway.

Table 12.11 presents the potential biosecurity measures which could be applied to pathway routes. As all transfer routes are assumed to use pipeline, the risk of INNS transmission and introduction for these sections is lower than for open water channels, and the greatest risks directly associated with the transfer medium arise from pipeline bursts and leakages.

Table 12.11: Potential biosecurity measures for pathway types.

Biosecurity measure	Description	Applicable to pathway type(s)	Confidence
Biosecurity strategy	Biosecurity measures incorporated into water company standard operating procedure.	Pipeline	Medium
Chlorination	Chlorination of transferred water using hypochlorite, chlorine gas or chlorine dioxide. Suggested pipeline concentration of 1mg Cl/L over 10 days of continuous dosing.	Pipeline	High
Chemical treatment	Could include coagulation and flocculation, OZONE treatment, pH or salinity alteration, or application of an herbicide.	Pipeline	High
Anti-fouling paints	Paint applied to surfaces of pipeline to create toxic/unfavourable substrate for bio-fouling INNS.	Pipeline	Medium
UV treatment	UV is transmitted through water as it flows through a specialised chamber. The radiation damages cells and DNA and causes mortality in the exposed organisms.	Pipeline	Medium
Active filtration	Active filtration using screen filters, bed filters or other pumped filtration methods.	Pipeline	Medium
Passive filtration	Installation of fish screens, rundown screens or conveyor screens to prevent the passage of suspended matter and organisms.	Pipeline	Low

Potential biosecurity measures which could be incorporated at different assets are presented in Table 12.12. Assets in which personnel and equipment are likely to come into contact with raw water on a more regular basis should be prioritised.

Table 12.12: Potential biosecurity measures for implementation at assets.

Biosecurity measure	Description	Confidence
Check, clean, dry (CCD)	Promotion of CCD protocol amongst WTW personnel.	Medium
Biosecurity strategy	Biosecurity strategy developed by water company.	Medium
Site-specific operational equipment	Provision of site-specific operational equipment (eg, pontoons, buoys, vehicles) to reduce the inter-site movement of INNS.	High

Biosecurity measure	Description	Confidence
Equipment and personal protective equipment (PPE) cleaning (dry)	Installation of waterless cleaning stations. May involve the use of brushes to decontaminate dirty equipment.	Low
Static water wash equipment and PPE (cold)	Water < 35°C to aid manual removal of INNS (ambient temperature water will not cause mortality of INNS). May involve use of dip tank.	Low
Static water wash equipment and PPE (hot)	A temperature of > 35°C for 15 minutes, or > 45°C for 1 second has been proven effective against many invasive invertebrate species. May involve use of dip tank.	Medium
Running water (cold)	Running water can be effective against invertebrate INNS. However, efficacy (mortality endpoint) is reduced in comparison to pressurised water. Efficacy is dependent on the method and effort of cleaning	Low
Running water (hot)	Running water can be effective against invertebrate INNS; however, efficacy (mortality endpoint) is reduced in comparison to pressurised water. Efficacy is dependent on the method and effort of cleaning	Medium
PPE cleaning (dry)	Boot brushing/cleaning stations are a simple approach to decontamination of footwear. Can be a simple brush or boot scraper. All waste should be treated as hazardous and disposed of accordingly.	Low
PPE cleaning (dip tank or sink, cold)	A dip tank or sink to allow total immersion of PPE. Brushes and cleaning tools would be a requirement. Ambient temperature water will not cause direct mortality in INNS (unless of much different salinity), so cleaning relies on manual action (scrubbing and drying). Wastewater would be contaminated, so appropriate disposal needed	Low
PPE cleaning (dip tank or sink, hot)	A dip tank or sink to allow total immersion of PPE. A temperature of >35°C for 15 minutes, or >45°C for 1 second has been proven effective against many INNS. The efficacy of hot water against INNS plant species (mortality endpoint) is not as high as for invertebrates, so it is important that equipment is treated for sufficient time; immersion of equipment at 50°C for 5 minutes is recommended to achieve high INN plant mortality.	Medium
Pressure wash (cold)	High-pressure cold water can be effective against invertebrate INNS. However, efficacy (mortality endpoint) is reduced in comparison to pressurised hot water. Efficacy is dependent on the method of application of the spray, regarding duration and distance from surface.	Low
Pressure wash (hot)	High-pressure, hot water can be very effective against invertebrate INNS. However, the efficacy is dependent on the method of application of the spray, regarding duration and distance from surface	Medium
Drying	Allowing equipment to completely dry ensures that hitchhiker INNS are rendered non-viable. Providing a drying room or other designated area on site for this purpose would allow PPE to be stored and dried at the same location.	High
Operational equipment	Provision of site-specific operational equipment (eg, pontoons, buoys, vehicles) could reduce the inter-site movement of INNS.	High

As water sports activities are a potential amenity to the reservoir there is a risk of INNS from outside the area being introduced on equipment, implementation of High confidence biosecurity measures should be considered a priority within this asset. As shown in Table 12.13 below, there are a number of potential options which are likely to vary in their feasibility and effectiveness. This assessment indicates that site-specific and thorough drying of equipment being transported between waterbodies would be the most effective measure.

Angling is also likely to be present on the River Witham, and as water is transferred directly without treatment, there is the potential that any INNS brought in on equipment from other catchments may be directly transferred into the SLR. Angling is typically controlled by either the Canal and River Trust or an angling club; therefore, such organisations may provide a mechanism for disseminating biosecurity information and influencing practices and would be best placed to advise on mitigation options. It is however uncertain how feasible such options may be.

Table 12.13: Potential biosecurity measures for recreational activities.

Biosecurity measure	Description	Applicable to activities	Confidence
Check, clean, dry (CCD)	Promotion of CCD protocol amongst recreational users of the canal network.	Angling and water sports	Medium
Biosecurity strategy	Biosecurity strategy developed by canal recreational user groups.	Angling and water sports	Medium
Event management	A reduction in the number of events or scale of events. Increased biosecurity during events.	Angling and water sports	Medium
Site-specific recreational equipment	Equipment not to be transported between waterbodies. Use restricted to one site to prevent spread of INNS.	Angling and water sports	High
Live bait restrictions	Either prohibiting the use of live bait entirely, or managing live bait use, ensuring source from site only.	Angling	High
Equipment and personal protective equipment (PPE) cleaning (dry)	Installation of waterless cleaning stations. May involve the use of brushes to decontaminate dirty equipment.	Angling and water sports	Low
Static water wash equipment and PPE (cold)	Water < 35°C to aid manual removal of INNS (ambient temperature water will not cause mortality of INNS). May involve use of dip tank.	Angling and water sports	Low
Static water wash equipment and PPE (hot)	A temperature of > 35°C for 15 minutes, or > 45°C for 1 second has been proven effective against many invasive invertebrate species. May involve use of dip tank.	Angling and water sports	Medium
Pressure wash equipment (cold)	High-pressure cold water can be effective against invertebrate INNS; however, efficacy (mortality endpoint) is reduced in comparison to pressurised hot water.	Water sports	Low
Pressure wash equipment (hot)	High-pressure, hot water can be very effective against invertebrate INNS.	Water sports	Medium
Drying	Allowing equipment to completely dry ensures that hitchhiker INNS are rendered nonviable. Providing a drying room or other designated area for this purpose would allow PPE to be stored and dried at the same location.	Angling and water sports	High

Biosecurity measures which involve the use of hot water have a high efficacy against all functional groups and are effective against species that have demonstrated ability to resist other methods of removal, such as zebra mussel and demon shrimp.

Removal of INNS prior to the raw water entering the SLR would eliminate a large proportion of risk associated with this section of the transfer, as INNS are easier to eliminate within a closed system. Appropriate biosecurity measures should be considered to reduce the risk of INNS entering the SLR from abstracted river water.

Additionally, implementation of recreational equipment restrictions and biosecurity measures for site staff and maintenance equipment would further reduce the likelihood of INNS transmission to and from the reservoir.

The inclusion of an EDD pond to hold and return water evacuated would create a more closed reservoir system, thereby reducing INNS risk in comparison to an open system.

12.5 Conclusions

Screening against EA guidance determined that the scheme would not create a link between 'isolated' catchments. However, the scheme has the potential to create or increase connectivity between catchments or waterbodies not already connected, and this should be considered and appropriately mitigated as the design develops.

High Impact INNS have been recorded within 1km of the abstraction locations on the River Trent and River Witham, and within 1km of proposed raw water transfer routes, including the EDD.

Non-native species have been recorded within a 1km of the reservoir footprint, but no records were retuned within the proposed site boundary.

High Impact INNS species were found to be present within 1km of three of the eight assets assessed within the SAI-RAT.

The INNS assessment results for the scheme using the SAI-RAT are summarised in Table 12.14.

Table 12.14: INNS assessment results summary for SLR SRO.

	Average Risk Score (%)	**Maximum** Risk Score (%)	**Overall** Risk Score (%)
Asset modules	19.44	57.09	-
RWT modules	40.78	45.00	-
SLR SRO	-	-	30.11

- Abstraction from the River Trent and River Witham could potentially increase habitat suitability for several non-native species.
- Creation and operation of the SLR carries a greater risk of creating a new pathway for INNS to spread, through personnel entering the water frequently and the use of recreational equipment, therefore biosecurity measures should be prioritised at this location to prevent additional spread.
- Creation and operation of other new assets are associated with a lower INNS risk, however biosecurity measures should be considered to prevent additional INNS introduction
- Biosecurity measures should also be considered along the transfer between the River Witham and the SLR to reduce the risk of INNS entering the SLR from abstracted river water.

The INNS risk associated with abstraction from the River Trent was previously identified at gate one, and mitigation has been considered and developed in the concept design with an INNS treatment works being identified for the River Trent abstraction. The risk assessment has identified that the abstraction and transfer from the River Witham will need to be further assessed and appropriately mitigated as the design develops.

12.6 Proposed future work

Although the scheme would not create a link between 'isolated' catchments as defined in EA guidance[24], any potential change or increase in connectivity between other catchments should be investigated at gate three and appropriate mitigation proposed.

The data and information entered into the INNS risk assessment tool were based on the latest available conceptual design. It is recommended that the INNS risk assessment is reviewed upon finalisation of the conceptual design to account for any changes that may introduce INNS risk, and in light of further survey data or information obtained at that time.

For gate three it is recommended that a wider range of information sources are used to determine INNS distribution, including non-open-source EA records and LERC, such as those relating to floating pennywort (*Hydrocotyle ranunculoides*).

It is recommended that the proposed design and operation of the scheme are reviewed in light of the risk assessment and biosecurity assessment. Medium and High confidence biosecurity measures identified should be considered in scheme design and operational protocol, in addition to measures already embedded in the scheme design.

12.7 Mitigation and biosecurity recommendations

All opportunities to improve biosecurity practices amongst recreational users of the SLR should be encouraged. The highest confidence biosecurity measures for implementation within the reservoir are site-specific operational equipment and thorough drying of equipment. Implementation of measures would also beneficial prior to the abstracted water entering the reservoir, which would help to reduce the likelihood of further INNS spread from the reservoir. The highest confidence measures to be implemented within the pipeline between the River Witham and the SLR are chlorination and chemical treatment. Several medium confidence options are also available. Not all potential biosecurity and mitigation options are likely to be feasible and it is recommended that engagement with the Canal and River Trust, the Environment Agency, and angling clubs may identify those which are most appropriate.

Although these principles may not be universally adopted, promotion of Check-Clean-Dry[50] principles should be included in any biosecurity strategy.

Proposed mitigation measures to reduce INNS transfer at the abstraction points on the River Trent and River Witham should also be fully investigated and implemented. As discussed in Section 12.6, any potential increase in connectivity between other catchments should be considered and mitigated through biosecurity practices where appropriate.

[50] Non-native Species Secretariat (2022). Check Clean Dry.

13 Natural Capital and Biodiversity Net Gain appraisal

13.1 Natural capital and ecosystem services

Natural capital refers to the elements of the natural world that provide benefits to society and includes aspects such as woodland, grassland, freshwater, marine, urban greenspace and wetland habitats.

The benefits that are provided to humans by the natural environment vary from regulating services such as natural flood management to cultural services such as recreational value.

13.2 Biodiversity net gain

In November 2021, the Environment Bill achieved royal assent, passing into UK law and becoming the Environment Act 2021. Part 6 on nature and biodiversity covers all areas of biodiversity net gain across two core sections. The first section covers biodiversity net gain for planning as part of applications for planning and nationally significant infrastructure projects, as well as more detail on site registers and biodiversity credits. The second section focuses on the primary objective of biodiversity net gain, highlighting the importance of on-site and off-site habitat enhancement and conservation over a period of at least 30 years in all development projects, and offers an overview of biodiversity net gain reports specifically produced to cause measurable improvements to the state of biodiversity.

Although the Environment Act 2021 is a part of UK law, its policies – with mandatory biodiversity net gain included – aren't expected to be fully integrated until the year 2023 as it goes through a two-year transition period.

Many local planning authorities, however, are already enforcing the new NPPF in line with detailed guidance from Department for Environment, Food & Rural Affairs (DEFRA) and Natural England, and are applying a 10% biodiversity net gain requirement on each new development proposal in preparation for it becoming the norm.

BNG, in the context of this report, refers specifically to the combination of habitats present at a site and their ability to support biodiversity. Each habitat has an associated score, which is then weighted by characteristics such as its area, condition, distinctiveness, and connectivity. The change in habitat due to the construction and operation of the SRO determines the BNG score and whether the scheme is likely to achieve a net gain of 10% in biodiversity.

13.3 Overview of gate one

At gate one, a natural capital assessment (NCA) incorporating ecosystem services and BNG were undertaken for the SLR SRO as part of the submission to RAPID.

This assessment used the most-up-to-date guidance available at the time to undertake the assessment, The Defra Biodiversity Metric 2.0[51]. In July 2021, Defra and Natural England launched The Biodiversity Metric 3.0. The 3.0 metric presented significant improvements for measuring and accounting for nature losses and gains. The 3.0 metric was used for this gate two assessment, which updates and supersedes the assessment carried out at gate one.

[51] Defra Biodiversity Metric 2.0. Available at: ARCHIVE SITE for the Biodiversity Metric 2.0 and the Biodiversity Metric 3.0 (naturalengland.org.uk)

In April 2022 Defra released another update to the BNG metric, the Biodiversity Metric 3.1. However, the Biodiversity Metric 3.0 was used for the gate two assessment, for methodological consistency with Anglian Water's Water Resources Management Plan 2024 and the Water Resources East Regional Plan. This approach is supported by Defra guidance.

This section outlines some opportunities to achieve this, however more detailed habitat mitigation and enhancement proposals will be set out in the next phases of design.

13.4 Methodology

13.4.1 Defining the natural capital baseline

13.4.1.1 Zone of influence

The ZoI was defined as the area of receiving (i.e. a watercourse receiving a discharge) or providing (i.e. a watercourse where abstraction will occur) environment with the potential to be altered or changed as a result of the scheme.

This can include the operational catchment for a surface water abstraction in addition to the footprint of the scheme. In later stages of design, the ZoI would need to be further refined with the availability of greater design detail and site survey data, likely during gate three.

13.4.1.2 Developing a natural capital baseline

As part of the NCA, a natural capital baseline was developed for the study area. The study area was defined as Anglian Water's operating boundary. This baseline was developed using open-source data as described in the National Natural Capital Atlas: Mapping Indicators (NECR285)[52] to generate a natural capital account of the stocks within the zone of influence. The methodology used to map natural capital utilises the same breakdown of stocks as the NECR285 where possible. However, the list has been supplemented with additional abiotic stocks and key habitats that are vital such as chalk streams and rivers. The natural capital baseline was used to report the total quantity of each stock within the ZoI.

13.4.2 Overview assessment methodology: natural capital assessment

A natural capital assessment has been undertaken on the scheme in accordance with the Water Resources Planning Guideline[53] (WRPG) and Enabling a Natural Capital Approach (ENCA) requirements. ENCA is recommended for use by HM Treasury's Green Book: appraisal and evaluation in central government (2020)[54] and represents supplementary guidance to the Green Book.

In August 2021, ENCA updated its guidance. Therefore, the NCA was updated in line with the values used to quantify the provision of ecosystem services.

[52] NECR285. Available at: http://publications.naturalengland.org.uk/publication/4578000601612288

[53] 2021, Available online at Water resources planning guideline - GOV.UK (www.gov.uk).

[54] 2020. The Green Book Central Government Guidance On Appraisal And Evaluation. [online] London: HM Treasury. Available at: <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/938046/The_Green_Book_2020.pdf> [Accessed 16 March 2022].

The August 2021 ENCA guidance (GOV.UK, 2021[55]) includes updated values within the Asset Databook and Service Databook. Within the Service Databook, the carbon reduction tab now includes BEIS (2021) carbon values - a set of values produced by the government to be used in policy appraisal and evaluation, reflecting the latest evidence. The climate regulation section of the assessment has been updated in line with this.

The impact of the scheme on the natural capital stocks was reported for each element quantitatively. This impact was reported for during construction and post construction to give an estimation of the impact of the scheme's whole lifecycle. The results of the stock assessment were reported in total losses and gains within each option's zone of influence.

The results of the change in natural capital stocks informed the assessment against the eight natural capital metrics (ecosystem services) listed below using the Natural England logic chains (Figure 13.1). The cost / benefit assessment was informed by the option type, option description and any embedded mitigation. The outputs of the NCA were compared to the pre-construction provision of impacted services to assess the impact of the scheme. Five ecosystem services were monetised, and the results of the assessment reported as a discreet monetary figure (subject to the ecosystem service scoping exercise set out below), water purification was assessed qualitatively, and biodiversity has been assessed via the Biodiversity 3.0 Metric. Water regulation has not been included for assessment to avoid the potential double accounting of benefits with capacity-based and financial assessment, and to align with Environment Agency guidance[56], which recommends not including the monetisation of water regulation benefits in decision making.

Figure 13.1: Ecosystem Services valuation logic chain

[55] GOV.UK. 2021. Enabling a Natural Capital Approach guidance. [online] Available at: <https://www.gov.uk/government/publications/enabling-a-natural-capital-approach-enca-guidance/enabling-a-natural-capital-approach-guidance> [Accessed 16 March 2022].

[56] Environment Agency (2020) Water resources planning guideline supplementary guidance – Environment and society in decision-making.

The metrics used to assess the impact on natural capital include:

- Carbon sequestration (Climate regulation)
- Natural hazard management
- Water purification
- Water flow regulation
- Biodiversity and habitats
- Air pollutant removal
- Recreation and amenity value
- Food production

Both natural capital assessment strategies, as outlined in the Environment Agency's Water Resource Planning Guidelines[57] and Defra's ENCA guidance, discuss taking a proportionate approach to the assessment. It is therefore important to accommodate this when integrating a natural capital approach within the SRO gated process. A natural capital approach has the potential to inform concept design and aid decision making, by quantifying the relative cost benefits and disbenefits of the scheme to aid the initial assessment of the identified strategic solutions.

13.4.3 Ecosystem Services screening

During the initial phase of the NCA, the ecosystem services listed (excluding biodiversity and habitats which is covered under the BNG assessment) were reviewed and scoped in or out due to the geographical or socio-economic context of the scheme and its zone of influence. Guidance on the screening process for individual metrics is provided below.

13.4.3.1 Climate regulation

The climate regulation metric focuses on carbon sequestration, which can be defined as the capture and secure storage of carbon that would otherwise be emitted to, or remain, in the atmosphere. The carbon sequestration NCA will be in addition to construction and operational carbon calculations and provides a holistic assessment of carbon emissions for the scheme.

The assessment was determined by land management within the scheme's footprint which influenced the carbon store for prolonged periods of time and results in a change in net emissions. The estimate of the carbon stocks for the scheme footprint was based on the area of broad land use types according to literature and research. The estimated carbon stocks for broad habitat types are listed below and the sequestration rates are show in Table 13.1.

[57] Environment Agency (2020) Water resources planning guideline supplementary guidance – Environment and society in decision-making.

Table 13.1: Carbon sequestration rates for broad habitat types (JBA Consulting) [58] [59]

Land use type	Carbon Sequestration rate (tCO_2e/ha/yr)
Woodland - (deciduous)	4.97
Woodland – (coniferous)	12.66
Arable Land	0.107
Pastoral land	0.397
Peatland - Undamaged	4.11
Peatland - Overgrazed	-0.1
Peatland - Rotationally burnt	-3.66
Peatland - Extracted	-4.87
Grassland	0.397
Heathland	0.7
Shrub	0.7
Saltmarsh	5.188
Urban	0
Green Urban	0.397

The carbon sequestration rates were converted to monetary values using standard methods and the Department for BEIS Interim Non-Traded Carbon Values from 2021 (Table 13.2). The natural capital assessment is based on a 2022 price year; however, it is assumed that adjustments for inflation have been accounted within the annual projections provided by BEIS and therefore the 2022 value presented below has been used. High series values were used to reflect a conservative estimate for the price of carbon.

[58] Alonso, I., Weston, K., Gregg, R. and Morecroft, M. 2012. Carbon storage by habitat - Review of the evidence of the impacts of management decisions and condition on carbon stores and sources. Natural England Research Reports, Number NERR043.

[59] The Environment Agency, (2020) Water resources planning guideline supplementary guidance – Environment and society in decision-making.

Table 13.2: BEIS updated short-term traded sector carbon values for policy appraisal, £/tCO$_2$e (£2022)

Year	Low series	Central series	High series
2020	120	241	361
2021	122	245	367
2022	124	248	373
2023	126	252	378
2024	128	256	384
2025	130	260	390
2026	132	264	396
2027	134	268	402
2028	136	272	408
2029	138	276	414
2030	140	280	420
2031	142	285	427
2032	144	289	433
2033	147	293	440
2034	149	298	447
2035	151	302	453
2036	155	307	460
2037	156	312	467
2038	158	316	474
2039	161	321	482
2040	163	326	489
2041	165	331	496
2042	168	336	504
2043	170	341	511
2044	173	346	519
2045	176	351	527
2046	178	356	535
2047	181	362	543
2048	184	367	551
2049	186	373	559
2050	189	378	568

13.4.3.2 Natural Hazard regulation

Different habitat types have intrinsic flood risk management values by intercepting, storing and slowing water flows. This is known as natural flood management (NFM) and is listed as a policy within the 25-year Environment Plan[60]. The capacity of habitats to achieve this can be quantified, and then a monetary value can be assigned based on the damage-costs avoided from flooding or replacement costs due to their capacity to regulate flood waters. The capacity for a given natural capital asset to provide a flood regulation service will depend on two factors:

- Its capacity to slow overland flows
- Whether the asset is located in an area of flood risk

This ecosystem service also applies in urban areas, where vegetation can reduce surface water flooding from heavy rainfall, with benefits to sewerage capacity. Coastal flood risk, which has been predicted to increase with future climate change, is reduced by coastal margin habitats such as saltmarsh.

The scheme was assessed on its ability to positively or negatively impact flood risk through the comparison of pre and post construction natural capital stocks and the catchment in which it is located. The assessment is restricted to catchment areas which drain to downstream communities impacted by flooding. These communities were identified using the Environment Agency's Indicative Flood Map[61], which overlays areas at risk of fluvial flooding and the National Receptor Database. The ecosystem service was scoped in for assessment where it was identified that the SRO would have a temporary or permanent impact upon the relevant natural capital stocks, such as areas of woodland, located within the floodplain.

Reduced flood damage to downstream or coastal settlements as a result of reduced magnitude/ frequency of flood/storm events; and/or lower sewer capacity or water storage costs was valued in line with Broadmeadow et al, 2018[62]. This assessment was developed to provide indicative national estimates of water regulation services of woodland to inform natural capital accounts, this is based on modelling to estimate the potential volume of flood water avoided by woodland ecosystems in flood risk catchment. The methodology adopts a replacement-cost (rather than damage cost) approach to valuing the flood regulation service of woodland by applying annualised average capital and operating costs of flood reservoir storage that would be required in the absence of the ecosystem service.

Central estimate of the average annual costs of reservoir floodwater storage is £0.42/m^3. The range is from £0.10 to £1.19/m^3 per year. The central estimate was used to derive an annual average estimate for the flood regulation service of woodland in Great Britain, which was then uplifted to a 2022 price year. These "replacement costs" can be considered a lower bound of the benefit if it can be assumed that such expenditure would be deemed value for money by the flooding authorities within flood risk catchments in terms of avoided flood damage costs.[63]

[60] 25 Year Environment Plan - GOV.UK (www.gov.uk)

[61] https://flood-map-for-planning.service.gov.uk/

[62] Broadmeadow, S., Thomas, H., Nisbet, T. and Valatin, G., 2018. Valuing flood regulation services of existing forest cover to inform natural capital accounts. *Forest Research*.

[63] GOV.UK. 2021. Enabling a Natural Capital Approach guidance. Available online at: <https://www.gov.uk/government/publications/enabling-a-natural-capital-approach-enca-guidance/enabling-a-natural-capital-approach-guidance> [Accessed April 2022].

13.4.3.3 Water purification

Based on their ecological functioning, different habitat types, have varying capacities for absorbing pollutants from a given water source. This service is dependent on the location of the natural capital asset and the nature of the surrounding area. If a natural capital asset has a high capacity to remove pollutants but is not close to a water source, the service will not be provided. Due to this, valuation of the static water purification services of different natural capital assets as part of the NCA was not considered appropriate. A common value for different habitat types could not be applied due to extensive variation in local factors which determine the provisioning of this service.

To account for the provision of this service within the NCA the impact of the scheme associated with the provision or removal of woodland and semi-natural grassland was considered qualitatively and with consideration of the modelling results from the Natural Environment Valuation Online Toom (NEVO)[64] tool, developed by the Land, Environment, Economics and Policy Institute (LEEP) at The University of Exeter. The NEVO Tool is a web application to help users explore, quantify and make predictions about the benefits that are derived from existing and altered land use across England and Wales. The tool brings together spatially explicit data, natural science and economic models to provide insights into the integrated relationships between climate change, land use change, ecosystem service flows and economic values. The tool defines the resulting changes for the following water quality variables:

- Dissolved oxygen concentration
- Nitrogen concentration (including organic nitrogen, nitrate, nitrogen dioxide, ammonium)
- Phosphorous concentration (including organic and mineral phosphorous)
- Pesticide concentration (for eighteen different pesticide types

This approach followed the methodology that if an area of woodland were to be lost, the resultant impacts on water quality can be qualitatively assessed within the scheme's zone of influence. Any negative changes to the natural capital in theory, reflects the loss of this service within the schemes zone of influence.

13.4.3.4 Air pollutant removal

Air pollution presents a major risk to human health, resulting in premature deaths and reduced quality of life. By removing air pollution, habitats help to lessen these impacts on health and wellbeing. The provisioning of the service is positively related to several key aspects:

- The surrounding area of the natural capital assets with regards to background pollution, especially particulate pollutant
- The quantity and type of natural capital asset, woodland is the major service provider
- The density of population potentially benefiting from reduced exposure. Because pollutants are transported, beneficiaries may be downwind of the ecosystem.

The scheme was screened against the provision of air pollutant removal according to its location. Air pollutant removal was only considered within built up areas or when the zone of influence included Air Quality Management Areas (AQMA). The impact of the scheme was assessed according to changes in natural capital stocks within these areas.

[64] Luizzo, L., (2019) Natural Environment Valuation Online Tool - Chapter 6a: Water Quantity & Quality Model

The value provided by natural capital assets was taken from the UK government's air quality economic assessment methodology[65]. The assessment embeds these values (based on the damage cost approach, i.e. damage to health avoided from reductions in air pollution) and estimates the present value automatically based on the quantitative estimates provided.

Indicative average values for air pollution removal in 2015 for different habitats were calculated from aggregate UK values published in February 2019, as shown in Table 13.3.

The value of each habitat will be combined with the changes expected in natural capital stocks to provide a value for the change in service provision. The final impact will be reported as a single value that will be incorporated within the NCA metric.

Table 13.3: Air pollutant value by habitat type (£2022)

Habitat group	Value (£ per hectare per year)
Urban Woodland	942
Rural Woodland	299
Urban grassland	182
Enclosed farmland	17
Coastal margins	31

13.4.3.5 Recreation and amenity

The recreational value of green spaces can be significant. This value reflects both the natural setting and the facilities on offer at the site and often has a strong non-market element. It varies with the type and quality of habitat, location, local population density and the availability of substitute recreational opportunities. Recreational values can be beneficially affected by enhancements in green spaces, or adversely affected by new developments or infrastructure. The wider tourism and outdoor leisure sector is also dependent upon nature to varying degrees. This metric depends on the extent to which the natural capital stocks the scheme provides will enhance the opportunity for recreation.

The key parameter needed to estimate in this category is the number of additional or enhanced recreational visits created because of the option. This was estimated using the Outdoor Recreation Valuation Tool (ORVal). ORVal[66] is referenced in HM Treasury Green Book[67]. Random utility / travel cost model of recreational demand for all sites in England and Wales generates probabilistic predictions of visitor numbers for any publicly accessible outdoor recreation park, path or beach. It takes account of scarcity of sites and substitution possibilities, as well as travel distances to sites and their attributes. This is useful for baseline initial assessment, accounting, and multiple sites. This should be seen as an estimation in the absence of site-specific data on visitor numbers.

The change in natural capital stocks and the creation or removal of greenspace was entered into ORVal according to the NCA. The change in visitors and estimated change in value will be reported for using the ORVal online tool.

[65] Jones L., Vieno M., Morton Dan et al. (2017) Developing Estimates For The Valuation Of Air Pollution Removal In Ecosystem Accounts. Final Report For Office Of National Statistics - NERC Open Research Archive.

[66] ORVal | Land, Environment, Economics and Policy Institute | University of Exeter

[67] The Green Book: appraisal and evaluation in central government - GOV.UK (www.gov.uk)

13.4.3.6 Food production

Food is produced by a range of ecosystems and in some cases, the food for human consumption is effectively the same as the ecosystem service (e.g. wild fruit, fishing). More often the provisioning service is a raw material (e.g. crops) that is harvested and processed by humans and produced capital into added value processed food (e.g. bread). The boundary between what is provided by natural capital and the contribution of other forms of capital is often a grey area, e.g. crops require agricultural management; livestock need grassland ecosystems.

Food production has been calculated using the NEVO Tool agricultural model. The NEVO Tool is a web application developed by the LEEP Institute at the University of Exeter with support from DEFRA and Natural Environment Research Council (NERC). NEVO's primary purpose is to help explore, quantify, and make predictions about the benefits that are derived from existing and altered land use across England and Wales. This is a structural model of agricultural land use and production for Great Britain estimated using Farm Business Survey (2005-2011) and June Agricultural Census data. The agricultural land use component in NEVO builds upon the approach developed by Fezzi and Bateman[68]. NEVO was used to assess the impact of the creation or removal of agricultural land for the scheme. The change in value of food provision for the footprint of the scheme was calculated using this online tool and reported within the NCA.

13.4.3.7 Assumptions and limitations

There are number of limitations to the approach taken and several assumptions were made to keep the assessment proportionate to the requirements of the relevant guidance. Namely, these were:

- To align with the BNG assessment, the natural capital assessment has been limited to the option boundary and does not expand into the options' zone of influence.
- Impacts are largely assumed to be temporary due to the reinstatement of natural capital assets following construction. Where reinstatement is not possible due to the footprint of permanent infrastructure or the loss of irreplaceable habitats, impacts are considered to be permanent.
- All natural capital stocks are assumed lost during construction. The exception is aquatic abiotic assets such as lakes and standing water, which are assumed to be retained unless directly impacted by permanent infrastructure.

13.4.4 Overview assessment methodology: BNG

The BNG requirement as outlined in the WRPG stipulates that each SRO should look to maximise BNG. The gate one assessments used the most-up-to-date guidance available at the time to undertake the assessment, The Biodiversity 2.0 Metric. In July 2021, Defra and Natural England launched The Biodiversity 3.0 Metric[69]. The 3.0 metric presents significant improvements for measuring and accounting for nature losses and gains. It encourages users to create and enhance habitats where they are most needed to help establish or improve ecological networks through rural and urban landscapes. By linking to current and future habitat plans and strategies, including the future Local Nature Recovery Strategies (LNRS), the 3.0 metric incentivises habitat creation and enhancement where most needed. It also 'rewards' landowners who undertake work early, creating or enhancing habitats in advance, allowing them to generate more biodiversity units from their land. Condition assessment approaches have also been significantly updated and simplified for the 3.0 metric and some key changes made.

[68] Fezzi, C., Bateman, I., Hadley, D. & Harwood, A. 2019. Natural Environment Valuation Online Tool - Chapter 1: Agriculture Model

[69] Archive site for the BNG Metric 2.0 and 3.0 http://publications.naturalengland.org.uk/publication/5850908674228224

The 3.0 metric is the recommended approach to net gain assessments. The government anticipates the 3.0 metric to become the industry standard for biodiversity assessments for on-land and intertidal development types in England. As proposed in the Environment Act 2021[70] in November 2021, biodiversity net gain must be measured using a recognised biodiversity metric. The 3.0 metric essentially underpins the Environment Act's provisions for mandatory biodiversity net gain in England, subject to any necessary adjustments for application to major infrastructure projects. The Environment Act 2021 further specifies the requirement of biodiversity reports to include specified quantitative data relating to biodiversity, and as such any tool which evaluation is predominantly qualitative is not recommended.

As such, the gate two approach has updated all assessments undertaken at gate one to the 3.0 metric. Any new scheme elements brought into the gated process at this stage have also been assessed by the 3.0 metric, in line with current guidance. The BNG calculation would be revisited and updated using the latest version of the metric, including updates for Biodiversity Metric 3.1 and any subsequent revisions, in later stages of design. These calculations are to be further refined throughout the gated process to inform planning requirements.

A biodiversity baseline has been developed from spatial data sets of habitats inventories to calculate BNG change through land use. The Priority Habitat Inventory and sites with SSSI, SAC, SPA and Ramsar designations were used to consider areas with high biodiversity importance. Units have been assigned to the pre-construction land use according to the habitats present in the scheme boundary. Post construction land use described in the scheme description, has been used to calculate the post construction score. As this assessment was carried out using only open-source data, a precautionary approach has been applied. These initial BNG calculations are desk-based and will be further refined at later design stages to inform planning requirements. Habitat identification would need to be refined with habitat survey data at subsequent stages of design to refine the accuracy of the BNG calculations.

13.4.5 Assumptions and limitations of the NCA and BNG assessments

The following assumptions and limitations are applicable to the results.

- The methodology for the NCA and BNG assessments has been collaboratively developed and consistently applied across the scheme. However, the assessments undertaken for the indicative transfer pipeline have been subject to a separate assurance process.
- The NCA and BNG assessments have considered the temporary and permanent impacts associated with the main reservoir, service reservoir, water treatment works, indicative transfer pipeline, intake structures and associated outlet discharges. The NCA and BNG assessments have not considered the amenity elements, infrastructure and diversion elements, and ecological and environmental elements set out in the scheme description, at this stage. These elements would be subject to NCA and BNG assessment following further design development and informed by site surveys, at later stages of the gated process. This would avoid potentially under or over-estimating the potential benefits to BNG and NCA.

13.4.5.1 Natural Capital Assessment

To align with the BNG assessment, the natural capital assessment has been limited to the option boundary and does not expand into the options' zone of influence.

[70] Environment Act 2021 (legislation.gov.uk)

Impacts are largely assumed to be temporary due to the reinstatement of natural capital assets following construction. Where reinstatement is not possible due to the footprint of permanent infrastructure or the loss of irreplaceable habitats, impacts are considered to be permanent.

All natural capital stocks are assumed lost during construction. The exception is aquatic abiotic assets such as lakes and standing water, which are assumed to be retained unless directly impacted by permanent infrastructure.

The provision of public water supply, including an assessment of water flow regulation, has been excluded from all assessments to avoid potential double accounting of benefits with capacity-based and financial assessment.

The desk-based assessment was carried out using open-source data.

13.4.5.2 Biodiversity Net Gain

The BNG assessments have been undertaken using the natural capital stocks mapped using open-source datasets. Therefore, at this stage, the scheme has not had access to site surveys and subsequently assumptions have been made as to the condition and strategic significance of habitats in order to provide the most accurate calculations, at this stage. The assumptions used in this assessment are provided below:

- Any habitat areas that are also within the Priority Habitat Inventory have been classified as ‘Good’ condition. This includes the priority habitat category ‘No main habitat but additional habitat exists’.
- All rivers have been classified as ‘Good’ condition based on being Priority Habitats.
- All habitats within statutory sites such as SSSIs, SACs and Ramsar designations or non-statutory sites such as local nature reserves have been classified as ‘Good’ condition and ‘Formally identified in local strategy’ strategic significance.
- All remaining habitats have been classified as ‘Moderate’ condition.
- All habitats adjacent to statutory sites such as SSSIs, SACs and Ramsar designations or non-statutory sites such as local nature reserves have been classified as ‘Location ecologically desirable but not in local strategy’ strategic significance.
- All habitats within National Priority Focus Areas have been classified as ‘Location ecologically desirable but not in local strategy’ when assessing strategic significance as these are likely to be of some ecological value.
- Any habitat areas classified as ‘Active floodplain’ in the natural capital baseline map was classified as ‘Floodplain wetland mosaic (CFGM)’, where it could not be otherwise classified by the datasets used to compile the baseline map. However, as the Floodplain wetland mosaic (CFGM) is a Priority Habitat but these areas are not within the Priority Habitat Inventory, they have been classified as ‘Moderate’ condition rather than ‘Good’.
- No enhancement of biodiversity post-construction was considered. BNG habitat units were assigned to the pre-construction land use according to the habitats present within the boundary of the site. The post construction land use was used to calculate the post construction biodiversity score. Where temporary impacts are expected, it is assumed that habitats will be replaced on a like-for-like, and irreplaceable habitats are assumed to be permanently lost.
- Where habitat reinstatement is not possible due to the footprint of permanent infrastructure or the loss of irreplaceable habitats, impacts are considered to be permanent.
- The duration of disturbance and timeline for habitat creation has not been included in the assessment. Durations of disturbance, including proposals for creating habitats in

advance of disturbance, would need to be refined with greater design detail at subsequent stages in the gated process to refine the accuracy of the BNG calculations.

- Aquatic abiotic habitats such as rivers, lakes and standing water are assumed to be retained unless directly impacted by permanent infrastructure.
- It is assumed there will be no habitat loss in trenchless pipeline areas.
- All rivers are assumed to have 'No Encroachment' for both Watercourse encroachment and Riparian encroachment.
- The desk-based assessment was carried out using open-source data.

13.4.6 Opportunities

The potential opportunities for the scheme to enhance NC and BNG were considered following the NCA and BNG assessments, utilising the data and results to inform on the most appropriate potential opportunities for enhancement of the scheme and wider benefits

13.5 Results

The NCA and BNG findings are summarised in Table 13.4 to Table 13.7. Mitigation has only been considered when outlined in the scheme description, or where standard mitigation must be applied. A summary of what is included within each table is as follows:

- Table 13.4 shows the predicted impacts on natural capital during and post construction. **Note:** Only those stocks with predicted impacts are listed.
- Table 13.5 summarises the predicted impacts to the provision of ecosystem services screened in for detailed assessment.
- Table 13.6 summarises the predicted impacts to the provision of water purification for the scheme, where screened in for qualitative assessment.
- Table 13.7 shows the unmitigated BNG outputs for the scheme which have been informed using the predicted impacts on natural capital in. **Note:** At this stage the BNG only takes account reinstatement, not reprovision or additional habitat creation unless outlined in the scheme description.

Table 13.4: Predicted unmitigated impacts on natural capital during and post construction

Natural capital stock	Area within scheme boundary pre-construction (Ha)	Stocks present within scheme boundary during construction (Ha)	Stocks present within scheme boundary post construction (Ha)	Change (Ha)
Witham to SLR				
Arable	177.26	0.00	176.20	-1.06
Lakes and standing waters	0.06	0.06	0.06	0.00
Rivers (length)	0.87	0.87	0.72	-0.15
Ponds & linear features	1.12	1.12	1.12	0.00
SLR potable water pipeline				
Coastal and floodplain grazing marsh	0.15	0.00	0.15	0.00
Arable	369.74	18.56	365.74	-3.99
Pastures	0.64	0.00	0.64	0.00

Natural capital stock	Area within scheme boundary pre-construction (Ha)	Stocks present within scheme boundary during construction (Ha)	Stocks present within scheme boundary post construction (Ha)	Change (Ha)
Broadleaved, mixed and yew woodland	0.05	0.00	0.05	0.00
Woodland priority habitat	0.59	0.00	0.59	0.00
Active floodplain	4.66	0.00	4.66	0.00
Lakes and standing water	0.20	0.20	0.20	0.00
Rivers (length)	3.56	3.56	3.56	0.00
Ponds & linear features	4.41	4.33	4.33	-0.08
Trent to Witham				
Coastal floodplain grazing marsh	0.72	0.00	0.46	-0.26
Arable	100.27	8.26	89.01	-11.26
Pastures	1.28	1.12	1.28	0.00
Broadleaved, mixed and yew woodland	0.03	0.03	0.03	0.00
Woodland priority habitat	0.59	0.29	0.59	0.00
Greenspace	0.35	0.31	0.35	0.00
Active floodplain	0.44	0.21	0.44	0.00
Rivers (length)	0.33	0.21	0.21	-0.11
Ponds and linear features	0.21	0.21	0.21	0.00
SLR				
Coastal and floodplain grazing marsh	0.33	0.00	0.00	-0.33
Arable	699.32	0.00	187.42	-511.90
Pastures	48.13	0.00	0.00	-48.13
Other semi-natural grassland	0.00	0.00	1.56	1.56
Broadleaved, mixed and yew woodland	0.11	0.00	0.08	-0.02
Woodland priority habitat	2.91	0.00	0.53	-2.37
Rivers	4.12	0.00	2.78	-1.34
Modified waters (reservoirs)	0.00	0.00	479.73	479.73
Ponds & linear features	4.93	0.00	2.07	-2.86

Table 13.5: Predicted unmitigated impacts to the provision of ecosystem services screened in for detailed assessment

Ecosystem services	Baseline value (£/year)	Estimated value post construction (£/year)	Temporary impact from construction (£/year)	Total future value (£/year)	Overall change in value (£/year)
Witham to SLR					
Carbon storage	£7,075	£0	-£7,075	£7,032	-£42
Food production	£2,100,000	£2,099,532	-£468	£2,099,532	-£468
Total	**£2,107,075**	**£2,099,532**	**-£7,542.64**	**£2,106,564**	**-£510**
SLR potable water pipeline					
Carbon storage	£16,167	£741	-£15,426	£15,713	-£455
Natural hazard management	£62	£0.00	-£62	£47	-£16
Food production	£2,600,000	£2,598,500	-£1,500	£2,598,500	-£1,500
Total	**£2,616,229**	**£2,599,241**	**-£16,988**	**£2,614,260**	**-£1,971**
Trent to Witham					
Carbon storage	£5,616	£1,336	-£4,280	£4,880	-£737
Natural hazard management	£61	£32	-£29	£46	-£15
Food production	£1,200,000	£1,193,800	-£6,200	£1,193,800	-£6,200
Total	**£1,205,677**	**£1,195,168**	**-£10,509**	**£1,198,726**	**-£6,952**
SLR Reservoir					
Carbon storage	£40,838	£0	-£40,838	£8,604	-£32,234
Natural hazard management	£295	£0	-£295	£45	-£250
Food production	£769,600	£442,000	-£327,514	£442,000	-£326,700
Total	**£698,702**	**£442,000**	**-£368,647**	**£450,735**	**-£359,998**
Total scheme	**£6,739,714**	**£6,336,027**	**-£403,687**	**£6,370,285**	**-£369,431**

Table 13.6: Qualitative assessment of the unmitigated predicted impacts on the provision of water purification and water flow regulation

Ecosystem service	Option	Likely baseline provision	Construction impacts	Likely future provision	Overall change in provision
Water purification					
	SLR potable water pipeline Trent to Witham SLR Reservoir	The stock likely provides a high provision of the ecosystem service due to the natural capital assets high capacity to store and absorb pollutants and the proximity of the asset to a water source.	The provision of services will be lost during construction.	The future provision of the ecosystem service provided by the stock will likely be reduced.	The provision of water purification provided by the stock will likely be reduced due to the option.

Table 13.7: Summary of the unmitigated BNG Metric outputs

Option element	On-site Baseline (Habitat BUs*)	On-site Baseline (River BUs)	On-Site Post Intervention (Habitat BUs)	On-Site Post Intervention (River BUs)	Total Net Unit change (Habitat BUs)	Total Net Unit change (River BUs)	Total Percentage Change (Habitat BUs)	Total Percentage Change (River BUs)
Witham to SLR	364.22	17.94	350.23	14.80	-13.99	-3.14	-3.84%	-17.50%
SLR potable water pipeline	849.33	73.75	761.19	73.75	-88.14	0.00	-10.38%	0.00%
Trent to Witham	237.81	6.79	191.02	4.44	-46.79	-2.36	-19.68%	-34.70%
SLR Reservoir	1690.02	158.04	2544.15	101.89	854.13	-35.53	27.07%	-35.53%
Total scheme	3141.39	256.53	3846.59	194.88	705.20	-61.65	22.45%	-24.03%

*Biodiversity Units (BUs)

13.5.1 Summary of the NCA and BNG assessments

13.5.1.1 Natural capital and ecosystem services

The scheme is likely to generate the permanent and temporary loss of natural capital stocks during construction. However, some habitat is expected to be reinstated/compensated to pre-construction conditions following best practice technique and will likely have no permanent impact to the provision of associated ecosystem services.

Broadleaved, mixed, yew, priority, and coniferous woodland have a significant maturity time with a delay of 30 years. Therefore, this delay is considered within potential future provision of this stock through the ecosystem services assessment. This can be accounted to the tree mortality rate presumed after woodland areas are replanted.

Construction impacts include the release of CO_2 (Carbon Dioxide) due to habitat clearance, loss of natural hazard management, loss of food production and a reduction in water purification. It is expected to permanently affect the future value of the ecosystem services provided despite some stocks being reinstated. Permanent loss of woodland and grazing marsh is expected which will affect carbon storage i.e. release of CO_2 due to habitat clearance, as well as reduce natural hazard management and water purification ecosystem services. Permanent loss of some pasture and arable stocks due to option construction expected hence loss of associated carbon storage i.e. release of CO_2 due to habitat clearance, as well as the loss of food production ecosystem services are expected.

The scheme presents an opportunity to improve the existing habitats through post construction remediation and replacement of low value habitats with higher value habitats. The scheme crosses several Natural England habitat network areas, including Network Enhancement Zones, and would be suitable for the creation of new high value habitats.

13.5.1.2 BNG

The scheme is likely to cause a net gain of 22.45% in habitat biodiversity units (BU) due to the construction of the main reservoir and associated surface water. However, the scheme is anticipated to result in a net loss of 24.03% of river BU.

During gate three, with refined designs and site surveys, the amenity elements of the scheme, infrastructure and diversion elements, and ecological and environmental elements set out in the scheme description that were not assessed for BNG (as described in Section 13.5.5), would be assessed and potentially will create an overall increase in habitat and river biodiversity units. Anglian Water could also look to achieve 10% net gain offsite with collaboration with the local

authority etc. An overall BNG of 10% can only be achieved if all biodiversity units relating to habitats and rivers are achieved.

13.6 Opportunities for environmental net gain

Following the BNG and NCA, opportunities should be considered so that the natural environment is left in a better condition than pre-construction conditions. This should be achieved by one or both of the following:

- Mitigation: Opportunities to offset the net loss of biodiversity asset(s) and/or Natural Capital stock(s) (ecosystem service).
- Enhancements: Opportunities that, once introduced and established, would result in a net gain to a biodiversity asset and/or Natural Capital stock(s) (ecosystem service).

As a core principle, where possible, the scheme should aim to not only reinstate lost habitat, but also provide a greater or more diverse habitat than is lost, to achieve overall BNG. The latter could be achieved by identifying local sites of ecological interest and proposing measures. Any habitats that are created or enhanced to achieve BNG are required to be secured for 30 years, through management, maintenance and monitoring. The natural capital map which is based on the methodology described in the NECR285 should be utilised, where possible, to assist in identifying opportunities to improve natural capital.

A summary of the potential NCA, BNG proposed mitigation and enhancement measures for each sub-component type are outlined in Table 13.8. Further explanation into the potential enhancement measures is provided within the sections below.

Table 13.8: Summary of potential net gain mitigation and enhancement opportunities

Scheme element	Mitigation opportunity	Enhancement opportunity
All scheme elements	Scheme layouts to be amended to avoid the permanent loss of high value natural capital assets that once lost, cannot be easily reinstated. Assets include ancient woodland and traditional orchards.	Creation of higher value habitat within grassland, arable and pasture natural capital assets onsite to achieve an increase in BU and work towards a 10% uplift in BNG.
	Schemes to identify area for the creation and/or reinstatement of high value natural capital assets, including: • Coastal and floodplain grazing marsh • Broadleaved, mixed and yew woodland • Woodland priority habitat	Habitat creation work within the adjacent priority habitats. Scheme falls within or are in the vicinity of habitat network zones[71]: These areas identify specific locations for a range of actions to help improve the ecological resilience for each of the habitats/habitat networks. The scheme should look to identify habitat network zones and priority habitats within the near vicinity and look to improve/create/restore habitats which would help to work towards increasing BU and work towards a 10% uplift in BNG.
	Construction practices to be considered to reduce the amount of clearance required for, especially in areas that include high value natural capital assets (see above for list).	Increase the quality/quantity of freshwater assets, including lakes, ponds located in designated SSSIs, pending detailed assessment of local conditions and available space.
	Directional drilling to be used where possible to avoid loss of high value natural capital assets (see above for list).	Scheme to identify suitable areas offsite for the creation, enhancement and/or restoration in order to develop off-site net gains, working towards achieving a 10% uplift in BNG.
		Identify areas of local peatland restoration
Main reservoir		Possibly create man-made floating wetland islands, enabling plants and microbes to form and attract wildlife both above and below the water's surface and create biochemical and physical processes to improve things such as water quality.
Wastewater treatment works, abstraction and treatment works, and other scheme elements that contain above ground infrastructure		Seeding of grassland within footprints of the above ground infrastructure, where possible.

[71] Edwards J, Knight M, Taylor S & Crosher I. E (May 2020) 'Habitat Networks Maps, User Guidance v.2', Natural England

13.6.1 BNG Unit Purchase

Habitat creation possibilities, other than unit purchase, to achieve a 10% BNG gain could include:

- On-site: Improve the existing habitats on-site through post construction remediation and replacement of low BNG value habitats with higher BNG value habitats
- Off-site: Purchase suitable areas of off-site land within the local area and/or at a regional scale to offset BNG decrease by improving the existing habitats within the off-site land and/or by replacing existing habitats with higher BNG value habitats.
- On-site and off-site: Improve existing habitats and/or replacement of low BNG value habitats with higher BNG value habitats as part of the catchment management options.

It is important that, where possible, the scheme starts to consider reaching out to local non-government organisations and planning authorities who may potentially be able to carry out BNG both onsite and offsite before gate three. Early engagement may help to get the best ideas of local opportunities for enhancement, how this can be achieved, local priorities and limiting factors which can all help to inform the NCA and BNG assessments during gate three.

Currently, the scheme is anticipated to achieve a 22.45% net gain in habitat biodiversity units. The scheme is anticipated to result in a net loss of 24.05% in river biodiversity units, as set out in Table 13.7. However, this is an approximation of the potential BNG that the scheme may produce. During gate three, detailed field surveys comprising UK Habitats Classification surveys and Habitat Condition Assessments in accordance with the Metric 3.1 Technical Supplement will be required. This additional information will result in changes to the baseline biodiversity units and natural capital stocks and associated provision of ecosystem services, in addition to the units gained as part of the schemes as given above. Following this, the BNG assessments can be recalculated, and mitigation, habitat creation and/or habitat enhancement (over and above the assumed habitat reinstatement in the current assessment) developed to achieve the 10% biodiversity unit increase required for the project.

BNG may be achieved via a new statutory biodiversity credits scheme. Credits may be bought by developers as a last resort when onsite and local offsite provision of habitat cannot deliver the BNG required, the processes for the price of biodiversity credits will be set higher than prices for equivalent biodiversity gain on the market and are expected to be purchased through a national register for net gain delivery sites. Natural England is in the process of running pilot schemes to provide a practical insight into the implications of the scheme, which is expected to go live spring 2023.

13.6.2 Nature Recovery Networks

The Government's 25 Year Environment Plan[72] includes provision for a Nature Recovery Network (NRN) and states that it will deliver on the recommendations of the Lawton Report[73] and that recovering wildlife will require more habitat; in better condition; in bigger patches that are more closely connected. As well as helping wildlife thrive, the NRN could be designed to bring a wide range of additional benefits: greater public enjoyment; pollination; carbon capture; water quality improvements and flood management.

[72] 25 Year Environment Plan - GOV.UK (www.gov.uk)

[73] Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherland, W.A., Tew, T.E., Varley, J., & Wynne, G.R. (2010) Making Space for Nature: a review of England's wildlife sites and ecological network. Report to Defra.

Natural England have produced a series of habitat network maps[74] to help address the challenges outlined in the Lawton report and believe they should provide a useful baseline for the development of a NRN as required within the 25-year Environment Plan and Local Nature Recovery Strategies as proposed within the Environment Bill. The maps have been created to provide a national overview of the distribution of habitat networks with suggestions for future action to enhance biodiversity, to help stimulate local engagement with partners and to agree local priorities and identify where action might help build more ecologically resilient ecosystems across landscapes.

- **Habitat Creation/Restoration:** Areas where work is underway to either create or restore the primary habitat.
- **Restorable Habitat:** Areas of land, predominantly composed of existing semi-natural habitat where the primary habitat is present in a degraded or fragmented form and which are likely to be suitable for restoration.
- **Network Enhancement Zone 1:** Land connecting existing patches of primary and associated habitats which is likely to be suitable for creation of the primary habitat. Factors affecting suitability include proximity to primary habitat, land use (urban/rural), soil type, slope and proximity to coast. Action in this zone to expand and join up existing habitat patches and improve the connections between them can be targeted here.
- **Network Enhancement Zone 2:** Land connecting existing patches of primary and associated habitats which is less likely to be suitable for creation of the primary habitat. Action in this zone that improves the biodiversity value through land management changes and/or green infrastructure provision can be targeted here.
- **Fragmentation Action Zone:** Land within Enhancement Zone 1 that connects existing patches of primary and associated habitats which are currently highly fragmented and where fragmentation could be reduced by habitat creation. Action in this zone to address the most fragmented areas of habitat can be targeted here.
- **Network Expansion Zone:** Land beyond the Network Enhancement Zones with potential for expanding, linking/joining networks across the landscape i.e., conditions such as soils are potentially suitable for habitat creation for the specific habitat in addition to Enhancement Zone 1. Action in this zone to improve connections between existing habitat networks can be targeted here.

There are opportunities for the scheme to support the NRN, for example, where pipelines are to be constructed within one of the identified habitat zones, reinstatement of land following construction could be linked to the priorities of that area such as habitat creation, restoration or improvement.

It is recommended that these opportunities be further explored at gate three. Wider partnership working with landowners, conservation groups and other organisations should be explored to help deliver opportunities for biodiversity enhancement.

[74] Edwards J, Knight M, Taylor S & Crosher I. E (May 2020) 'Habitat Networks Maps, User Guidance v.2', Natural England

13.6.1 Potential wider benefits

Blue infrastructure systems and riparian areas provide a wide range of ecosystem services to human populations, notably because they are a key component in many biogeochemical cycles and global biodiversity and these services are seen to hold an important economic value. Some of the wider ecosystem services that these natural capital stocks can provide that are not already considered as part of the gate two assessments are listed in Table 13.9.

Table 13.9: Potential wider ecosystem services and possible restoration/improvement practices

Ecosystem service	Wider benefit	Examples of possible restoration/improvement practices
Recreation and tourism	The association of water is positively appreciated for several activities such as fishing, canoeing or aesthetic enjoyment.	Dedicate some areas to such activities to channel the public into appropriated zones, where possible.
Education values	Blue infrastructure and riparian areas provide sites for formal and informal education and heritage learning.	Create some information points or paths for the public in well-equipped zones, where possible.
Sense of place	Build community ownership and enhance the local populations spirit and sense of place. This may encourage enjoyment and understanding of the natural, historic and cultural heritage.	Improve and create the blue infrastructure and provide arts-based creative community interpretation to enhance and celebrate culture and heritage assets, where possible. This may reconnect the local population with their canal heritage and cultural assets.
Mental and physical health and wellbeing	The 'Canal and River Trust' conducted research showing that spending time by the water promotes better mental and physical wellbeing[75]	Improve and create habitats around blue infrastructure. Allow greater access to people through creating paths/parking etc.

Wider benefit case studies along the scheme are being prepared as part of a separate workstream, which will consider wider benefits the scheme can provide to people, including habitat creation, which may potentially improve the provision of ecosystem services, BNG and provide wider benefits such as those listed in Table 13.9. However, these case studies are conceptual and are yet to be finalised. These wider benefit case studies should be further considered within the gate three NCA and BNG.

13.7 Summary and next steps

At gate three, the natural capital assessment would be refined further to work alongside the environmental impact assessment process to provide a natural capital input. The assessment would be further updated, as required, in lieu of developed design and following UK Habitats Classification surveys as required.

For gate three the BNG assessment can be revisited, and mitigation or enhancement opportunities developed further to achieve the 10% BNG required within the scheme.

[75] Assessing the wellbeing impacts of waterways usage in England and Wales (canalrivertrust.org.uk)

Additionally, where possible, the scheme could aim to not only reinstate lost habitat, but also provide a greater or more diverse habitat than is lost, to achieve overall Biodiversity Net Gain in line with regulatory requirements for BNG (at the time of the project consenting) as stated as a mandatory requirement within the Environment Act 2021[76]. The latter could be achieved during the gate three assessments by identifying local sites of ecological interest and proposing measures which enhance these features.

The NCA, BNG and ecosystem services outputs identified the following:

- **NC:** The scheme will cause the temporary and permanent loss of natural capital stocks.
- **BNG:** The scheme is likely to result in mostly a net loss of BNG habitat units due to the temporary and permanent loss of natural capital assets during construction. Mitigation and enhancement opportunities for the scheme have been suggested within Section 13.6, which can work in tandem to reducing the loss of BNG and introducing net gain. These will be developed further during gate three.
- **BNG:** Further detailed assessment will be required as the design of the scheme as a whole progresses. This will need to include detailed field surveys comprising UK Habitats Classification surveys and Habitat Condition Assessments in accordance with the Metric 3.0 Technical Supplement. This additional information will result in changes to the baseline biodiversity units and natural capital stocks and associated provision of ecosystem services, in addition to the units gained as part of the schemes as given above. Following this, the BNG assessments can be recalculated, and mitigation, habitat creation and/or habitat enhancement (over and above the assumed habitat reinstatement in the current assessment) developed to achieve the 10% biodiversity unit increase required for the scheme
- **BNG:** It should be noted that the latest iteration of the Biodiversity Metric is currently version 3.1 and the use of the latest version should be considered when undertaking further BNG assessments during gate three.
- **Ecosystem services:** Permanent and temporary impacts of the scheme are likely to result in the release of CO_2 due to habitat clearance, loss of natural hazard management, loss of food production and a reduction in water purification services. The scheme presents opportunities to improve the existing habitats along the route through post construction remediation and replacement of low value habitats with higher value habitats.

The opportunities identified in the BNG/NC assessment have the potential to contribute to government ambitions for environmental net gain. This could take the form of habitat compensation, creation and/or species relocation schemes. Any schemes would need to be taken forward based on a comprehensive understanding on the interaction between natural systems and between natural systems and social uses of land.

[76] Environment Act 2021 (legislation.gov.uk)

14 Wider Benefits

14.1 Introduction

This Section summarises the wider benefits that could arise from implementing the SLR scheme. Wider benefits are those areas of environmental and social value that are associated with constructing and operating the scheme.

The consideration of wider benefits draws on the findings of other assessment work to inform the gate two submission, as well as introducing additional information where material in the context of the SLR scheme. The wider benefits have been considered for the scheme as a whole, rather than individual components. Where benefits are specific to one component of the scheme, this is identified.

14.2 Methodology

This section sets out the methodology for identifying and assessing wider benefits.

14.2.1 Six capitals framework

There is no specific methodology guiding wider benefits assessments for SROs. Approaches set out in WRMP Guidance[77] (on identifying benefits (both monetary and non-monetary) for customers, environment and society) and Ofwat's Public Value Principles[78] have influenced the methodology. The starting point for the assessment of wider benefits is the Six Capitals framework[79] (see Table 14.1), which is used by organisations, including UK water companies, as a framework for considering social, governance and environmental issues.

Table 14.1: The Six Capitals framework

Capital	Description
Financial	The pool of funds available for use in the production of goods or provision of services, obtained through financing or generated through operations or investments.
Human	People's competencies, capabilities and experiences, and their motivation to innovate.
Manufactured	Manufactured physical objects available to an organisation for use in the production of goods and services.
Intellectual	Organisational, knowledge-based intangible aspects such as intellectual property, systems and procedures.
Social	The institutions and relationships within and between communities, groups of stakeholders and other networks and the ability to share information to improve individual and collective wellbeing.
Natural	The physical stocks of renewable and non-renewable resources that provides goods and services of value to society.

[77] https://www.gov.uk/government/publications/water-resources-planning-guideline/water-resources-planning-guideline

[78] https://www.ofwat.gov.uk/about-us/our-strategy/ofwats-public-value-principles/

[79] https://www.integratedreporting.org/resource/international-ir-framework/

14.2.2 Draft National Policy Statement for Water Resource Infrastructure

The draft National Policy Statement (NPS) for Water Resource Infrastructure[80] identifies potential impacts and mitigations across several environmental and social topics. The proposed mitigations relevant to wider benefits includes:

- Biodiversity and nature conservation: Biodiversity enhancement measures (such as new habitat creation and provision of green corridors) could be incorporated where possible into the project design.
- Flood risk: New or enlarged reservoirs may provide an opportunity to address existing flood risk (for example, by providing extra space for flood water storage or by improving monitoring and control of water flows).
- Landscape and visual: Opportunities could be sought to enhance landscape character through, for example, green infrastructure provision; opportunities could be sought to improve public access to the countryside.
- Socio-economic: Where possible, work could be carried out by local firms and contractors that could help contribute to the local economy and meet any employment needs; potential opportunities for public education could be identified as part of proposals; and opportunities for proposals to provide recreation/tourism opportunities could be considered.
- Traffic and Transport: Where new transport infrastructure is required (for example, roads) consideration should be given to how this can be delivered to maximise public benefit.

14.2.3 Scoping of potential benefits

The ZoI was defined as the area of receiving (i.e. experiencing a benefit or disbenefit) or providing (i.e. providing workforce) environment with the potential to be altered or changed as a result of the SLR scheme.

A review of the potential wider benefits that are relevant to the SLR scheme was undertaken and are presented in Table 14.2.

Table 14.2: Wider benefits scoping

Capital	Description	Applicability to the SLR scheme	Scoped in to Wider Benefits
Financial	Economic benefits – Job creation	The SLR could generate temporary and permanent employment opportunities. This will bring benefits through the supply chain.	Yes
Financial	Economic benefits – through capital expenditure	The SLR could generate temporary and permanent employment opportunities. This will bring benefits through the supply chain.	Yes
Financial	Economic benefits – through supply chain	The SLR could generate temporary and permanent employment opportunities. This will bring benefits through the supply chain.	Yes
Financial	Economic benefits – increase in tourism related to new recreation assets	The SLR could create an asset that could be used for tourism or recreation.	Yes
Social	Health and wellbeing – from access to recreation and / or open space	The SLR could provide the opportunity to enhance recreation features.	Yes

[80] https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents/draftnpswaterresourcesinfrastructure.pdf

Capital	Description	Applicability to the SLR scheme	Scoped in to Wider Benefits
Social	Education – opportunities to provide educational resource	The SLR could provide the opportunity for additional educational resources.	Yes
Social	Social value – quality of life benefits associated with other economic benefits	The SLR could provide an opportunity to continue the deployment of apprenticeships.	Yes
Social	Partnerships – working collaboratively with other organisations	The SLR could provide the opportunity to link with local organisations to deliver benefits, for example, implementing BNG initiatives.	Yes
Natural	Natural capital – any additional benefits in addition to the scope of the NCA	The ability of the SLR to contribute to other aspects of natural capital has been reviewed and no additional issues to the NCA have been identified.	No
Natural	Flood risk – any additional benefits derived from decreasing flood risk	The SLR is not likely to affect wider flood risk management measures.	No

The scoping exercise identified that items applicable to financial, social and natural capital were relevant to the assessment, and that items relating to human and intellectual capital were not specifically relevant. Issues relating to manufactured capital and the benefits of functioning assets are covered in the technical engineering descriptions and performance of the scheme. The items relating to natural capital are already covered and assessed and are therefore not duplicated here.

In summary, the key issues for the SLR scheme are:

- Economic impacts deriving from employment and the benefits through the supply chain.
- Economic benefits from increase in tourism related to new recreation assets.
- Health and well-being benefits occurring from opportunities to enhance local environment.
- Education and opportunities to provide educational resource.
- Ongoing contribution to enabling apprenticeships.
- Partnership strategy to work with local organisations.

The detailed methodology for assessing the wider benefits varies for each of these issues and the following section presents these details alongside the results.

14.3 Results

This section sets out the findings from the assessment of wider benefits for employment impacts, tourism, health and well-being, education and apprenticeships.

14.3.1 Employment impacts

Employment impacts are expected to result in positive outcomes. The beneficiaries are those who are directly employed, as well as indirect and induced impacts on the local economy (goods and services).

Numbers of proposed employees can be used to calculate Gross Value Added (GVA) per worker to generate estimates for positive economic impacts (direct, indirect and induced) in GBP. This includes the benefits from spending with suppliers and spending by people whose incomes are changed directly or indirectly by the scheme.

Work has not been completed on identifying the numbers of construction workers that may be required to construct the scheme. Work has also not been completed to identify the number of staff that would be required to operate the new water infrastructure, as well as the recreational elements of the reservoir. However, as an example of the scale of potential benefits, comparable water infrastructure operations have around 15 full time equivalent staff with another 15 full time equivalent staff supporting the recreational aspects of a reservoir. The operational jobs could generate positive economic impacts (direct, indirect and induced) of approximately £15 million.

Employment impacts were calculated by applying standard data from the ONS on GVA per worker at the UK level in the production sector, as this includes employment in the utilities and water industries the number of jobs estimated by the client. This gross figure was adjusted for additionality by applying deadweight and displacement. Leakage was considered to be zero as the study area for this analysis is too large for leakage to be likely. This data was adjusted to 2022 prices using Gross Domestic Product (GDP) deflators from HM Treasury (HMT). The GVA impact was then modelled over a 30-year appraisal period and the present value of this benefit was calculated using the standard HMT discount rate of 3.5% per annum. Indirect and induced employment impacts were calculated using a standard multiplier of 1.1 from the HCA (now Homes England) Additionality Guide. GVA per worker data was then applied to the multiplier jobs and discounted.

14.3.2 Tourism

The new reservoir component of the scheme could create a new tourist destination. There are approximately 10,000 people living within 5km of the reservoir and approximately 430,000 people living in the four surrounding local authority areas. This represents a potential local catchment area for visitors to the new reservoir, providing a local recreational resource and a regional tourism destination.

Other Anglian Water Parks attract thousands of visitors each year; a comparable facility, Grafham Water, has around 300,000 visitors per year. Anglian Water Parks also host events, such as triathlons, dragon boat races, charity fun-runs and bike rides, alongside national and international fishing competitions. Anglian Water Parks provide recreational facilities, including Fishing, Walking, Cycling, Camping, Café and Picnic facilities. Some also provide opportunities for water sports.

Opportunities that could be delivered through the SLR scheme that would benefit tourism and recreation include:

- Visitor amenities could include footpaths, cycleways and bridleways, particularly along the crest of the embankment – a linking footway around the full circumference of the reservoir. These could be supported by additional paths on the external embankments allowing shorter walks and connections to a visitor centre and a bathing area. A water sports centre could support activities on the reservoir such as rowing or sailing. An educational centre can provide information for the public on reservoir operation and the ecological benefits of wetlands and woodlands.
- A potential main visitor centre could provide a focal point for people visiting the reservoir for recreation and education. A visitor centre is a primary way for people to interact and experience the site.
- The opportunity to connect to the existing rail line at Helpringham for potential use during construction may present a future opportunity for visitor rail access close to the site. There is also an opportunity to improve bus accessibility by re-routing the bus routes and providing additional bus stops closer to the proposed visitor centre. There is also an opportunity to consider the role of shuttle bus or demand-responsive transit service.

- While other forms of transport to the site are encouraged by the scheme, car parks are likely to be required for visitors in recognition of the dominant use of personal vehicles. The exact location and sizing of car parking will be based on access points and expected visitor numbers. Visitor car parking is likely be provided at key areas around the reservoir to encourage full use of the scheme.
- Potential provision of shallow water and wetland habitats. These mosaics of wetland habitats can become visitor attractions and support carefully designed public use that balances access with nature conservation.
- The reservoir waterbody itself could offer visitors a range of potential recreational activities from quiet contemplation and engagement with nature, to more active pursuits such as open water swimming, sailing, rowing and kayaking.

14.3.3 Health and wellbeing

A Public Health England[81] review concluded that people who have greater exposure to greenspace have a range of more favourable physiological outcomes. Greener environments are also associated with better mental health and wellbeing outcomes including reduced levels of depression, anxiety, and fatigue, and enhanced quality of life for both children and adults.

For the transfer routes, opportunities to enhance access to greenspace are most likely to occur in areas where construction activity is affecting existing PRoW. This is likely to benefit local people, although linkages to any national trails could have a wider benefit. No specific proposals have been incorporated into the scheme design at this stage, therefore benefits are qualitative. The benefits could accrue following construction activity.

Examples of opportunities include:

- Opportunities to enhance nearby riparian vegetation and strengthen connections within the blue-green network.
- Opportunities to enhance nearby sections of the long-distance footpaths in terms of planting, resurfacing, information boards, way markers and social enhancements.
- Opportunities to strengthen the green corridor through additional planting to link vegetation.
- Opportunities to enhance landscape character and the character of views from PRoW through additional planting.

For the reservoir, a number of elements of the scheme could contribute to health and wellbeing benefits.

Firstly, being able to access the reservoir is a key consideration, particularly making use of active travel modes – walking and cycling – to reach the reservoir. Scredington could also be connected to the reservoir with a direct cycleway. New cycle access to the south of the reservoir could be provided from new connections from Swaton and Billingborough. A pedestrian and cycleway bridge could connect Helpringham to the reservoir over the railway line. Helpringham, Thorpe Latimer, Horbling and Scredington could be connected to the site by providing additional connectivity for pedestrians and horse riders and replacing links that may be severed during construction of the scheme.

Secondly, at the reservoir, there are opportunities to provide new cycle and pedestrian routes. For example, a new footway around the full circumference of the reservoir. These could be

[81] Public Health England (March 2020): Improving access to greenspace- a new review for 2020 [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904439/Improving_access_to_greenspace_2020_review.pdf

supported by additional paths on the external embankments allowing shorter walks and connections to a visitor centre and a bathing area.

Thirdly, new greenspaces could include designated areas for wetland creation, shallow water habitats and woodland planting. The wider areas around the reservoir footprint could be used for BNG as required. As discussed above, the proposed network of pedestrian and cycle routes would enable those visiting the reservoir site to be able to access new areas of greenspace.

Finally, the creation of the reservoir as a new piece of 'blue space' provides benefits. An evidence review of the social benefits of Blue Space collated by the Environment Agency[82] found that blue spaces were found to provide a range of social and health benefits. The study reported that those people using blue space experience psychological benefits and report feeling happier when they are in proximity to water.

14.3.4 Education

The new reservoir could provide an additional educational resource for the community. The existing Anglian Water Parks provide opportunities for school visits and is it anticipated that features of SLR scheme, including the potential visitor centre could provide opportunities for educational uses.

In terms of the change in educational value expected the reservoir itself could provide easier access to incorporate primary curriculum learning alongside scientific concepts. The variety of STEM (Science, Technology, Engineering Mathematics) educational opportunities available could enable engagement upon topics such as water resource management, flood prevention and biodiversity. The infrastructure within the site could enable children to safely access the surrounding environments and effectively learn. This could also provide a greater range of educational value, catering for different key stages within schools from more basic principles around nature conservation to early career engagement opportunities presented within engineering and environmental science.

The existing Anglian Water Parks provide opportunities for volunteers to get involved in activities. As well as helping maintain and improve the water parks, volunteering provides the opportunities to learn new skills and knowledge.

14.3.5 Apprenticeships

Anglian Water has an existing apprenticeship scheme to assist in introducing people to the workplace and develop skills through a variety of advanced, higher and degree level apprenticeships across a range of roles. As well as benefits to the individual employee, a skilled workforce contribute to increased Human capital of the organisation. The educational / training facility also benefits through running successful apprenticeship programmes (developing knowledge, skills of trainers) and the local employment and economic market also benefit. Although the apprenticeships are timebound for an individual, organisations such as water companies can provide long term career options as a wide range of roles at all levels are available. Water companies also partner with other organisations, such as contractors, and it is therefore likely that apprentices contribute to construction activities.

As Anglian Water run the apprenticeship schemes at a corporate level, rather than recruit for specific projects, it is not possible to assign particular numbers of apprentices to the SLR scheme.

[82] Environment Agency (October 2020): The social benefits of Blue Space: a systematic review https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/928136/Social_benefits_of_blue_space_-_report.pdf

14.3.6 Partnership strategy

The South Lincolnshire Water Partnership and South Lincolnshire Reservoir Working Partnership have been involved in the development of concept designs and provided representations on the gate one submission.

The ongoing design development will identify and engage partner organisations to identify and enhance the benefits of the SLR scheme. In addition to the opportunities identified in this section, this is expected to include working with agricultural stakeholders and environmental regulators on issues such as irrigation supply and FSAs.

It is recognised that the reservoir scheme could be a catalyst for a much broader multi-sectoral system that has the potential to benefit a range of sectors including agriculture, nature conservation and flood risk management, as well as delivering ecosystem services such as carbon sequestration and biodiversity net gain. This wider system vision would be outside the scope of the core reservoir (public water supply) scheme and therefore would require additional funding and partnership to deliver.

A preliminary report has been undertaken to examine options for wider system opportunities and to identify and map potential landscape-scale interventions and sources of external funding.

15 Conclusions and Next Steps

15.1 Conclusions

During gate two, the environmental assessments undertaken for gate one have been updated and expanded, following selection of a scheme and initial concept design work for this site.

At gate two the Rapid guidance states[83] the submission should be supported by an annexed initial environment appraisal report that addresses a number of issues. These issues are listed in Table 15.1 and where the issue is addressed within this report.

Table 15.1: Rapid Guidance

Rapid guidance requirements	Report reference
An update of the gate one work where relevant.	Chapters 1 and 2
The environmental appraisal work undertaken to date – likely to be at a strategic scale.	Chapter 3
Baseline and analysis – this might include results of monitoring, modelling, environmental surveys, etc.	Chapters 4 - 11
Options assessment, with sufficient detail to allow comparison of options within the solution and identify potential effects (positive and negative) and opportunities.	Chapters 4 - 11
Assessment of the effects of the solution, an evaluation of their significance and any cumulative or in-combination effects.	Chapter Appendices A1, A2, A3
Clear justification as to options within the solution discounted, those taken forward, and the proposed option selected. Where the proposed option is identified, potential environmental effects and opportunities should be discussed.	Chapter 2, Chapters 4 -10
The appraisal work should include consideration of resilience (e.g. climate change,)	Chapters 2 and 7
A description of the connection to other assessments (e.g. biodiversity net gain, WFD, natural capital, carbon) and demonstrate how they have been considered within this initial appraisal work.	Chapter 13, Appendices A1, A2, A3, A4
Development of mitigation and enhancement opportunities.	Chapter 14
Any future monitoring requirements of the identified environmental effects and efficacy of any included mitigation measures.	Chapter 3 Appendices A1, A2, A3
A plan to address uncertainties and data gaps.	Chapter 15

A number of potential impacts were identified through the environmental assessment of the reservoir, and associated abstractions, transfers and water treatment works. These were mostly associated with changes to the aquatic environment, impacts on biodiversity, landscape and heritage. There would also be a permanent loss of a soils and agricultural land on the reservoir site.

[83] Regulators' Alliance for Progressing Infrastructure Development April 2022 Strategic regional water resource solutions guidance for gate two

These issues will require further investigation and may impose constraints to consider in subsequent phases of the scheme development. However, several opportunities were also identified which could be considered at the next stage of the development, which could result in enhancements to the environment and community.

A summary of the key topic findings is outlined below:

- **Water Framework Directive Assessment** – the level 1 assessment identified 24 waterbodies which could potentially be affected by the scheme. Following the Level 1 assessment, seven of these waterbodies were identified as requiring a Level 2 assessment due to the potential effects on the WFD waterbodies. The Level 2 assessment couldn't rule out the risk of deterioration in six of these waterbodies, so further study and assessment will be required as the project progresses.
- **Informal Habitats Regulations Assessment (HRA)** - an informal first stage assessment identified three designated sites (associated with the Wash) which are indirectly hydrologically connected to the site. The informal Stage 2 assessment concluded that no residual effects would arise from the construction phase, provided that standard mitigation was implemented. Operational effects associated with proposed abstraction and discharge could not be ruled out at this stage. Further surveys, data collection, modelling and assessment, together with the detailed consideration of mitigation measures, will be required in order to conclude that there will be an absence of effect on the integrity of designated sites. The strategy to produce the evidence base required for the formal stages of HRA will be agreed at the next stage in consultation with the regulator. Ultimately, a strong and robust evidence base will be required to conclude either no effect on site integrity, or if an effect cannot be ruled out, then to form the basis of a derogation case (Stage 3 of HRA).
- **Invasive Non-Native Species (INNS)** – INNS were recorded within the proposed abstraction sources and transfer water bodies, and within associated study areas. The assessment concluded that the proposed transfers will not introduce a new hydrological connection between 'isolated' WFD Operational Catchments. However, the proposed scheme would result in increased connectivity between other catchments and waterbodies. The INNS risk associated with abstraction from the River Trent was previously identified at gate one, and mitigation has been considered and developed in the concept design with an INNS treatment works being identified for the River Trent abstraction. The risk assessment undertaken at gate two concludes that the abstraction and transfer from the River Witham will need to be further assessed and appropriately mitigated as the design develops
- **Strategic Environmental Assessment** – the SEA ratings were informed by the other environmental assessments undertaken (WFD, HRA, BNG, NCA, INNS) for the Scheme. The SEA considered anticipated construction and operational effects, both without any mitigation applied and expected residual effects after implementation of indicative mitigation measures. It identified potential effects for Biodiversity, Flora and Fauna, Soil, Water, Air, Climatic Factors, Landscape, Historic Environment and Material Assets. Positive effects were identified for Population and Human Health.
- **Natural Capital and Biodiversity Net Gain** - the scheme is likely to generate the permanent and temporary loss of natural capital stocks during construction. However, some habitat is expected to be reinstated/compensated to pre-construction conditions following best practice technique and will likely have no permanent impact to the provision of ecosystem services. The option presents an opportunity to improve the existing habitats through post construction remediation and replacement of low value habitats with higher value habitats.

As well as the topic-based desk assessments, a wider benefit assessment was undertaken which looked at the potential benefits for employment impacts, tourism, health and well-being, education and apprenticeships. A summary of the results from the assessment are outlined below:

- **Employment Benefits** - employment impacts are expected to result in positive outcomes. The beneficiaries are those who are directly employed, as well as indirect and induced impacts on the local economy (goods and services).
- **Tourism** – there is the potential to create a new tourism destination, as there is a local catchment area for visitors to the new reservoir. Several opportunities were identified including the creation of wetlands, cycleways, footpaths, bridleways, a visitor centre, transport links and a bathing area.
- **Health and Wellbeing** – greener environments are associated with better mental health and wellbeing outcomes including reduced levels of depression, anxiety, and fatigue, and enhanced quality of life for both children and adults. Numerous opportunities were identified following the construction activity along the pipeline route (particularly around PRoW areas) and within the reservoir site.
- **Education** - the new reservoir could provide an additional educational resource for the community. The existing Anglian Water Parks provide opportunities for school visits and is it anticipated that features of SLR scheme could present similar potential educational resources.
- **Apprenticeships** - Anglian Water has an existing apprenticeship scheme to assist in introducing people to the workplace and develop skills through a variety of advanced, higher and degree level apprenticeships across a range of roles. As well as benefits to the individual employee, a skilled workforce contribute to increased Human capital of the organisation.
- **Partnership Strategy** - The South Lincolnshire Water Partnership have been involved in the development of concept designs and provided representations on the gate one submission. The ongoing design development will identify and engage partner organisations to identify and enhance the benefits of the SLR scheme. This is expected to include working with agricultural stakeholders and environmental regulators on issues such as irrigation supply and FSAs.

As the scheme progresses, the design will be subject to an iterative process of environmental assessment, informed by further surveys and modelling, to identify and agree suitable mitigation and enhancement measures.

A provisional summary of recommended environmental assessment activities beyond gate two is outlined in the next steps section. The scope of this additional work will be agreed in consultation with relevant environmental stakeholders and regulators, as part of a formal EIA process consented through a Development Consent Order.

15.2 Regulatory Barriers

Although detailed environmental assessments will need to be undertaken during the next stages of the project, and only indicative details of scheme design were available at gate two, the appraisal work described in this report has not identified any fundamental regulatory barriers that mean the scheme should not progress to the next stage of evaluation.

The environmental appraisals have highlighted that some uncertainties and risks remain that will need resolving, particularly in relation to the nature of Habitats Regulations and Water Framework Directive effects. For both HRA and WFD, a detailed strategy to develop a robust evidence base to inform subsequent assessments, and potentially derogation tests, will need to be developed in consultation with the regulators.

Detailed surveys and investigations will be needed to evaluate and refine the initial EAR findings in relation to topic areas such as BNG, Natural Capital, ecology (both terrestrial and aquatic), landscape and historic environment.

15.3 Proposed future work

The environmental activities carried out for the next stages of the project will be influenced by the programme for delivering the SRO. A list of activities that could be prioritised is provided below, noting that some of these will address an immediate need while for others it may be more appropriate to carry out later in the development process. Activities that should be considered include:

WFD and HRA

- Further assessment and modelling of the effects of abstraction on the River Trent and the inter-catchment transfer from the River Trent to the River Witham.
- Hydrodynamic modelling of flows and salinity into The Wash Designated Sites.
- Studies and modelling of the water demand from the River Trent and the River Witham are needed to identify impacts on the Designated Sites and their qualifying features.
- Further modelling of the current nutrient level analysis due to the abstraction is also required to determine the effect of nutrient loading.
- Further assessment and modelling of the effects of the inter-catchment transfer from the River Trent to the River Witham to determine the effects on the Designated Sites located downstream.
- Further engagement with stakeholders including the Environment Agency and angling clubs.
- Land drainage and site drainage design, to understand which watercourses will be diverted/realigned and which are lost.
- Hydrology study is undertaken to understand the potential reduction in catchment area, impacts on flow and therefore biological status elements for South Beck and Swaton Drains waterbodies.
- A hydrology study is recommended to understand potential impacts of reduced flow in the Trent from Sour to The Beck catchment on the hydrological regime and water quality.
- Additional water quality monitoring is carried out on the four Witham waterbodies. This data should then be used in further water quality analysis to determine the effects of the discharge from the River Trent on water quality and therefore biology.
- Hydraulic modelling analysis is undertaken to determine the effects of the increase in flow volume and velocity on the four Witham waterbodies as a result of the discharge.
- Detailed field surveys comprising UK Habitats Classification surveys and Habitat Condition Assessments in accordance with the Metric 3.1 Technical Supplement.
- WFD and HRA Assessments of emergency drawdown options.

Biodiversity

- Ecological walkovers and surveys.

Soil

- Detailed soil resource to confirm the soil resources present, map the distribution of soil types and inform a soil management plan.

Carbon

- Update carbon assessments as the design evolves.

Landscape

- Development of landscape proposed mitigation and opportunities to offset impacts of the scheme, including the appraisal of landscape effects associated with the indicative transfer routes and associated infrastructure.

Material assets

- A comprehensive analysis of material assets intersected by transfer routes, and in the area surrounding the reservoir. This would include further consideration of transport infrastructure, energy infrastructure, water infrastructure, waste management facilities and minerals, and inform further development of mitigation and enhancement measures.

Cumulative and in-combination effects

- There are a number of potential cumulative effects arising from the development of the scheme as there are some key interactions with Local Development Plan allocations. These will need further investigation and may support the scheme design.

Population

- Assessment of the impact of the scheme on different sections of society, including those living, working or owning businesses who may be displaced as a result of the scheme. This could be undertaken through an EqIA.

INNS

- Although the scheme would not create a link between 'isolated' catchments as defined in EA guidance, any potential change or increase in connectivity between other catchments should be investigated and appropriate mitigation proposed.
- The INNS risk assessment is reviewed upon finalisation of the conceptual design and further survey data, to account for any changes that may introduce INNS risk.
- Undertake a review of a wider range of information sources are used to determine INNS distribution, including non-open-source EA records such as those relating to floating pennywort (*Hydrocotyle ranunculoides*).

NCA and BNG

- The NCA would be refined further to work alongside the environmental impact assessment / DCO process to provide a natural capital input into the EIA. The assessment would be further updated, as required, in lieu of developed design and following Phase 1 habitat surveys as required.
- The BNG assessment can be revisited, and mitigation or enhancement opportunities developed further to achieve the 10% BNG required within the scheme.

The above activities and data are to be reviewed in the updated regulatory assessments, namely the refinished SEA, HRA, WFD, NCA, BNG and INNS assessments in next phases of the scheme development.

The RAPID guidance for gate three[84] states that for most solutions a statutory EIA will be required to support planning and permitting applications. The EIA should be sufficiently advanced to support EIA scoping requirements for the gate three process. All pre-application activities will be carried out in accordance with the requirements of the 2008 Planning Act.

[84] Gate Three Guidance, RAPID (2022), online at RAPID-Gate-Three-Guidance.pdf (ofwat.gov.uk)

A. Appendices

A.1 Water Framework Directive Assessment

A.2 Informal Habitat Regulations Assessment

A.3 Strategic Environmental Assessment

A.4 Carbon Assessment