[redacted]

Ecological Gap Analysis

The content of this document is draft and relates to material [or data] which is still in the course of completion in travel to Gate 2 and should not be relied upon at this early stage of development. We continue to develop our thinking and our approach to the issues raised in the document in preparation for Gate 2.

Minworth SRO

Severn Trent Water & Affinity Water

Tame Trent and Humber HEE

(Hydrology, Ecology and Environment)

Baseline Assessment: Data collation, literature review, stakeholder engagement and gap analysis

Topic 14: Invasive Species Presence and Mitigation

Project reference: [redacted]
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Glossary of Terms

Abbreviation	Definition
BMP	Biosecurity and Management Plan
EA	Environment Agency
GUC	Grand Union Canal
INNS	Invasive Non-Native Species
IUCN [LC]	International Union for Conservation of Nature [Least Concern – the species classification of least conservation concern]
LRC	Local (Environmental) Records Centre (or LERC)
Sch 9	Schedule 9 [of the Wildlife and Countryside Act 1981 (as amended)]
SLR	South Lincolnshire Reservoir
SRO	Strategic Resource Option
STW	Sewage Treatment Works (see WwTW below)
WCA	Wildlife and Countryside Act 1981 (as amended)
WFD	Water Framework Directive
WwTW	Wastewater Treatment Works

1. Introduction

1.1 Project Overview

1.1.1 The purpose of the study is to improve the understanding of baseline data relating to River Tame and River Trent processes, hydrology, ecology and wider river environment.

1.1.2 The objective of the overall Hydrology, Ecology and Environment baseline assessment is to gather baseline information and undertake a gap analysis of the understanding of the river ecology, environment and hydrology of the rivers Tame and Trent and the Humber Estuary, relating to 19 distinct topic areas. This Topic 14 Report is titled 'Invasive Species Presence and Mitigation' and is the first phase of work to gather baseline information to the specific topic 14 titled *"Summarise the findings of existing INNS studies along the Trent and tributaries and mitigation techniques available in the UK and Europe*".

1.1.3 The 19 distinct topic areas relate to two Strategic Resource Option (SRO) programmes which form part of the water industry's support to the national ambition to improve the resilience of water resources against increased growth, demand and climate change[1]. Both the Minworth SRO (Affinity Water and Severn Trent Water Limited (Severn Trent Water)) and the South Lincolnshire Reservoir (Affinity Water and Anglian Water Services Limited (Anglian Water) schemes are part of this study and have relationship with the Tame, Trent and Humber river system. These two schemes are being investigated and will be assessed via a gated process by the Regulators' Alliance for Progressing Infrastructure Development (RAPID).

1.2 Background

1.2.1 The first phase of work to support submissions to the Gate 1 of RAPID's process is to gather baseline information and undertake a gap analysis on the understanding of the river ecology, environment and hydrology. This work will then feed further studies towards the later stages of the gated process should either or both schemes progress forwards. The outputs of this study will be used to support the progression of these options with regards to potential changes to Severn Trent's Minworth treated effluent discharges, or additional abstraction from the River Tame or Trent to support SRO transfers or Reservoirs.

1.2.2 Drivers for this literature review and gap analysis are:

- Policies may need updating to drive efficiency and make best use of water resources. Changing climate and socioeconomic demands are putting additional focus on current and future water supply options.
- The need for the Trent to be managed effectively. This will preserve the amount of water available and reduce the risk of serious environmental consequences.
- The potential transfers will have environmental and socioeconomic impacts and opportunities which must be understood. Decisions must be able to withstand reasonable scrutiny.
- Understanding of potential in-combination impacts on protected sites and supporting habitats for migratory species need to be understood in more detail. Current monitoring programmes need to be assessed for evidence gaps and cross referenced with the proposed transfer schemes to ensure they are fit for all purposes.
- Policy and legislation in England is pushing water companies to integrate regional plans but also to deliver net environmental gain. Understanding these opportunities and constraints will help shape potential transfers.

[1] Meeting our Future Water Needs: a National Framework for Water Resources. Environment Agency 2020.

- Insufficient evidence has resulted in regulators taking a precautionary approach when reviewing scheme specific risk assessments. Improved evidence will enable regulators to form more definitive opinions and schemes progress to delivery with greater confidence.
- The argument to justify change must be equally as robust as the argument for no change. Either way, the best possible evidence and data must underpin decision making process.

1.3 Study Area

1.3.1 The area covered by this study is the catchment of the Rivers Tame, Trent and the Humber Estuary, from 2 km upstream of the current discharge point (SP 16[redacted] 91[redacted]) from Minworth Wastewater Treatment Works (WwTW), to 2 km downstream of the of the confluence (SE 86[redacted] 23[redacted]) of the River Trent with the Humber Estuary. This study area therefore extends from approximate grid reference SP 14[redacted] 90[redacted] upstream of Minworth WwTW, to grid reference SE 88[redacted]24[redacted] downstream on the Humber Estuary.

1.3.2 The study area is shown on Figure 1 in Appendix A.

2. Invasive Species Study

2.1 Objectives

2.1.1 The overall aim of this topic (outlined in 2.1.2) is to identify existing Invasive Non-Native Species (INNS) records along the Humber Estuary Tame, Trent and tributaries, determine which may potentially be relevant to changes to Minworth discharge and the new abstraction relating to the South Lincs Reservoir and assess available mitigation techniques.

2.1.2 Specifically, objectives of this topic are as follows:

- identify presence of INNS from a desktop survey within the given survey boundary area;
- identify any evidence gaps in the data set for subsequent field data surveys;
- develop and provide a 'Toolkit' of potential measures that could be employed to mitigate any potential INNS impacts, based on the likely INNS present (or likely to be present) and the specifics of the proposed two strategic water resource options and
- identify any additional baseline monitoring data collection that would be needed for future project impact assessments (which is likely to include a Full Pathway Risk Assessment for Gate 2 on the Grand Union Canal) or research required to improve understanding of mitigation effectiveness.

2.2 Background and Context

2.2.1 INNS or alien species are species that have been introduced to a territory outside their natural ecological range. It is estimated that there are about 12,000 alien species present in Europe. Only a minority however is able to survive and to spread at a pace that can be detrimental to the environment (European Union, 2015). These detrimental species are referred to as INNS.

2.2.2 INNS tend to spread most easily in areas where they, unlike native species, have no natural enemies (such as diseases, predators or competitors). As such, they are generally detrimental for native biodiversity, both at the level of individual affected species and often in terms of broader ecosystem structure and function. INNS can also have negative impacts on human health and cause economic damage (Lodge et al. 2009; Gallardo et al. 2016). According to the Centre for Agriculture and Bioscience International (CABI) the cost of controlling invasive species and repairing the damage they cause in the UK is in the order of £1.7 billion annually (European Union, 2015). Undoubtedly a large part of this cost is incurred by water companies.

2.2.3 Studies indicate that INNS numbers in the UK are increasing rapidly (Keller et al. 2009). Moreover, established INNS can modify habitats and facilitate subsequent invasions by additional INNS, notably in aquatic environments (Gallardo & Aldridge, 2015). Indeed, this is considered to be the principal means by which INNS can have an adverse impact operational and service delivery of water companies, while impacting the quality of the raw water resource, and with added costs and risk of reputational and legal consequences. Impacts may also be aggravated in the longer term by climate change, whereby INNS expand their range into regions where they are currently climate-limited, or otherwise increase the likelihood of establishment and proliferation to damaging levels (Kernan, 2015; Rahel & Olden, 2008).

2.2.4 This is of growing concern to the water industry in the UK because of the potential for diverse impacts on infrastructure and the resulting costs of intervention. To minimise these requires effective prevention strategies (Gallardo & Aldridge, 2013) as well as treatment of established problems, although these are generally considered to be of limited effectiveness (Environment Agency, 2017). Risks to water companies are amplified by the current absence of long-term solutions to exclude or eradicate highest risk INNS once they are established in the raw water supply chain.

2.3 Legislation and Guidance

2.3.1 The GB Invasive Non-native Species Strategy (Defra 2015) and the Invasive Alien Species (Enforcement and Permitting) Order 2019, direct landowners and managers to adopt a proactive biosecurity driven approach to INNS management. The Environment Agency, Natural England and the Forestry Commission advocate this proactive approach.

2.3.2 This approach is underpinned by several legislative instruments within England which relate to INNS (Table 2.1). The purpose of this legislation is to prevent and reduce the negative economic and environmental impacts of these species. INNS of particular concern are referenced in relevant legislation, specifically:

- Species listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended) – WCA; and
- Species of special concern and Schedule 2 species, as per the Invasive Alien Species (Enforcement and Permitting) Order 2019.

2.3.3 Taken together, the relevant legislation makes it an offence to plant, or otherwise cause to grow (including allowing to spread), listed plant species in the wild and if transported off site, there is a duty of care with regards to the disposal of any part of the plant that may facilitate establishment in the wild and cause environmental harm (as per the Environmental Protection Act 1990). The legislation also makes in an offense to release, or allow to escape, listed animal species (or animal species not ordinarily resident in and is not a regular visitor to Great Britain in a wild state) into the wild.

2.3.4 While it is not illegal to have listed INNS within a property, even when present on managed land (e.g. forming part of landscaping), the spread of listed species should be kept under control such that the species is not having an appreciable adverse impact on habitats and their native biodiversity. If INNS animals (e.g. adult signal crayfish) become fully under the control of site teams, i.e. they are accidently captured, they must not be returned to the wild, as it is an offence to do so. Rather they must be humanely killed.

2.3.5 Species of Special Concern should not be kept, bread, transported (unless as part of control action), grown, cultivated, permitted to reproduce, or released into the environment. However, there are exemptions to these requirements where species of special concern have been identified as widespread in England (e.g. Himalayan balsam and signal crayfish). In such cases, steps should be taken to reduce further spread of these species, with localised eradication being carried out in high priority areas where possible, e.g. Sites of Special Scientific Interest (SSSIs), where rare native flora are at threat, and areas at risk of flooding and/or erosion. Management of such species should be based on a cost benefit analysis, which includes an assessment of likely effectiveness and long-term sustainability.

2.3.6 If charged with committing an offence, it is a defence against prosecution to prove that all reasonable steps were taken, and all due diligence exercised in attempting to avoid committing the offence. Therefore, in order to reduce the potential of breaching legislation and fines/prosecution, a management plan should be in place for INNS on a property and property owners should be able to demonstrate that they are following it.

2.3.7 Key guidance with respect to water transfers can be found in (refer to Section 4.3 for further detail):

- Managing the risk of spread of INNS through raw water transfers (EA, 2017); and
- PR19 - Assessing the risks of spread of Invasive non-native species posed by existing water transfers (EA, 2017).

Table 1: Summary of relevant legislation relating to INNS

Legislation	Summary of Key Aspects
Invasive Alien Species (Enforcement and Permitting) Order 2019 (as amended)	This legislation imposes restrictions on species of animals and plants in Schedule 2 of the Act or listed as 'Species of Special Concern'. These are species which pose a risk of adverse impacts across the UK and EU, such that targeted action across the UK and EU is required. Restrictions applying to these species mean they cannot not be imported, kept, bred, transported, sold, used or exchanged, allowed to reproduce, grown or cultivated, or released into the environment. Under certain circumstances a Species Control Order can be served on a landowner to require the removal of a given species (see Infrastructure Act 2015). The UK has produced an FAQ document for UK stakeholders outlining the key aspects of the legislation and the obligations of stakeholders in relation to the species on the list of species of special concern. This document states that if the containment of plant species of Special concern cannot be guaranteed, their safe removal should be considered. There are exemptions to these requirements where species of special concern have been identified as widespread in England. However, in such cases, steps must be taken to minimise their impact on native habitats, where management is feasible. Additionally, steps should be taken to reduce further spread of these species, with localised eradication being carried out in high priority areas where possible, e.g. Sites of Special Scientific Interest (SSSIs), where rare native flora are at threat, and areas at risk of flooding and/or erosion. Management of such species should be based on a cost benefit analysis, which includes an assessment of likely effectiveness and long-term sustainability.
Wildlife and Countryside Act 1981 (as amended) Schedule 9, Section 14	It is an offence to plant or otherwise cause to grow in the wild any listed plant species. It is an offense to release, or allow to escape, listed animal species (or species not ordinarily resident in and is not a regular visitor to Great Britain in a wild state) into the wild.
Infrastructure Act 2015	Environmental authorities may issue control orders under which landowners can be obligated to carry out species control operations for INNS animal and plant species.
Anti-social Behaviour, Crime and Policing Act 2014 and Community Protection Notices	Local councils and the police have the power to issue Community Protection Notices against "individuals who are acting unreasonably and who persistently or continually act in a way that has a detrimental effect on the quality of life of those in the locality" including for INNS. Breach of any requirement of a Community Protection Notice, without reasonable excuse, would constitute an offence. Guidance released by the Home Office provides information on the reformed Anti-social Behaviour, Crime and Policing Act 2014. The guidance note, primarily aimed at Japanese knotweed, giant hogweed and Himalayan balsam, provides information on how best to proceed if a neighbour is unwilling to control INNS on their property, i.e. they will not treat it with herbicide or remove it. The updated legislation means that if a neighbour 'fails to act' regarding controlling, or preventing the growth of INNS, then a Community Protection Notice can be issued requiring action to be taken. Breach of any requirement of a Community Protection Notice, without reasonable excuse, would be a criminal offence, subject to a fixed penalty notice (which attracts a penalty of £100) or prosecution. On summary conviction, an individual would be liable to a level 4 fine (£2,500). An organisation, such as a company, is liable to a fine not exceeding £20,000.
Environmental Protection Act 1990, Sections 33 and 34	If taken away from the site of origin, certain Schedule 9 species and associated material, e.g. soil, may be classified as Controlled Waste and must be disposed following a duty of care. Such waste that is disposed of at a landfill site must be accompanied by appropriate waste transfer documentation.
Town and Country Planning Act 1990	Although this Act does not make specific reference to specific weeds, it provides local authorities with power to serve notices on owners or occupiers of land to control weeds that may be harming the amenity of the surrounding area. If the owners and occupiers fail to remedy the situation, they may be liable to a fine or have to repay the costs of action taken by the local authority to control the weeds.
Common Law	There is precedent within Common Law to take civil action against neighbouring landowners where the spread of invasive species is considered to be a private or public nuisance. This is particularly relevant where Japanese knotweed is located on land assets adjacent to residential properties.

2.4 Assessment methodology

Topic Interdependencies

2.4.1 This topic report uses in part desk study information presented in Topic 3: *Ecological Desk Study*, and the relevance of Topic 14 to other topics is summarised in Table 2.

Table 2: Interdependencies of Topic 14 with other Topics

Topic	Relationship with Topic 14: Invasive Species Presence and Mitigation
Topic 1: What are the flows and levels that are required for navigation on the fluvial and tidal Trent.	Navigation is a key vector in the spread of INNS, and INNS may cause obstruction to flow regulating structures and other navigation infrastructure.
Topic 2: Protected Sites and migratory species. Topic 12: The importance of weir pool habitats for fish. Topic 13: Barriers to fish migration.	Fisheries topics focus on the importance of the river network for protected, notable and migratory fish species. INNS fish are not considered a major factor in the Tame, Trent Humber catchment, however INNS fish are described in more detail in the Ecology and Aquatic Ecology topics.
Topic 3: Ecological desk study Topic 7: Habitat and Ecological Sensitivities Topic 17: Wetlands and Avian Species	Topic 3 provides the baseline INNS data to inform this report. A summary of all INNS records is provided in Topic 3. Further Ecology topics explore the importance of designated sites, Priority Habitats and notable species in the catchment.
Topic 4: Update current understanding of site-specific ecological flow requirements. Topic 11: Confirm existing WFD status and reasons for not achieving good status for all relevant water bodies.	This topic involves the identification of ecological flow indicators alongside Water Framework Directive (WFD) compliance and other related topics. INNS are a factor in determining overall WFD water body status and reasons for not achieving good status, as described in further detail in Topic 4 and Topic 11.
Topic 5: Provide a summary of existing understanding of river flows and levels on geomorphology and sedimentation.	As well as influencing geomorphology and sedimentation, river flows and levels are an important factor in the spread and distribution of INNS. Topic 5 does not specifically refer to INNS.
Topic 6: Investigate the current/baseline hydraulic geometry for habitat quantity.	Topic 6 model outputs have been analysed in the Ecology Topics to determine potential effects on designated sites, habitats and species, which are also influenced by the presence of INNS.
Topic 8: Review of assets along the River Trent to confirm ownership and specification. Topic 9: Confirm existing licensed abstractions and discharges along the river	Assets, abstractions and discharges are often associated with the presence of INNS, which can obstruct and impede the effective functioning of these assets. Knowledge of the distribution of INNS may inform the effective management of assets.
Topic 10: Investigate the extent of saline intrusion along the tidal Trent.	Saline intrusion along the tidal Trent directly affects the habitats and species present, including INNS, for example due to tolerance of saline conditions and variation.
Topic 14: This topic	-
Topic 15: Benchmark studies which sought to define the socioeconomic benefits from habitats and species. Topic 16: Identify any literature which identifies habitat improvement/ creation to increase biodiversity gain	INNS are key factors in the quality and functioning of ecosystems, and as such they are relevant to the assessment of socioeconomic benefits and biodiversity net gain. INNS for example may lead to negative socioeconomic effects due to increased management requirements.
Topic 18: Identification of studies that reviewed humidity and soil moisture levels at SSSI and linkage to river flow or groundwater regimes.	INNS may affect the status and functioning of SSSIs and other designated sites, for example by limiting the presence of other designated features and adversely affecting habitats.
Topic 19: Identification and collation of existing core datasets and recommendations for future data gathering where necessary.	The interactive web-based GIS presents the ecological baseline and facilitates the visualisation of data gaps and locations of INNS records.

Data sources

2.4.2 An ecological desk study was carried out in Topic 3 to identify INNS relevant to the study area. A stratified and geographically restricted approach was taken when undertaking the desk study; refer to Topic 3 for further details.

2.4.3 A range of sources was accessed in order to collate all relevant ecological information for the study area and complete the desk-based assessment. These sources included:

- The Defra application Magic map2;
- Environment Agency Catchment data explorer3;
- Local Environmental Records Centres (LERCs);
- Invasive Species Mapper; and
- county floras (only one actually used)

2.4.4 Biological and ecological records were requested from LERCs, including INNS and non-statutory designated sites, including citations for those sites.

2.4.5 A data trawl was undertaken for freely available online data, including statutory designated sites, site citations and reasons for designation, priority habitats and habitats of principal importance; Environment Agency (EA) monitoring data, River Habitat Survey (RHS) data, River Basin Management Plans etc.

2.4.6 Specific data requests for site management plans and restoration plans were submitted to Natural England and Local Authorities as required.

2.4.7 Specific data requests were submitted to the EA, for example for rod catch data from Angling Associations.

2.4.8 The desk study was carried out using the data sources described above. Protected and notable habitats and species include those listed under:

- Schedules 1, 5 and 8 of the Wildlife and Countryside Act 1981 (as amended) (WCA);
- Schedules 2 and 4 of the Habitats Regulations;
- Species and habitats of principal importance for nature conservation in England listed under section 41 (s41) of the NERC Act 2006;
- Aquatic invertebrate species classified as Conservation Score 6 (Regionally Notable) and above; and
- Other species that are listed in national or local Red Data Lists and Biodiversity Action Plans.

2.4.9 Invasive species mapper takes records of non-native invasive species in relation to riparian habitats, including Japanese knotweed *(Reynoutria japonica*), Himalayan balsam *(Impatiens glandulifera*) and giant hogweed *(Heracleum mantegazzianum).* These records include existing stands of INNS plants, as well as areas where the species has been controlled.

2.4.10 Records of plants listed on relevant legislation (Section 2.3.2) and general non-native species were taken from one county flora (Derbyshire[4]). The grid references of these locations were checked against maps of the river course to determine their distance from a water body. Records within 2km of the catchment area of the three rivers were considered to be within a reasonable distance away, and potential threats to water bodies. Other county floras are available along with other published sources for records. Time did not permit a search of these which would need to be undertaken in a structured and thorough manner.

[2] https://magic.defra.gov.uk/magicmap.aspx
[3] http://environment.data.gov.uk/catchment-planning/
[4] Wilmot, A., and Moyes, N. 2015. *The flora of Derbyshire*. Pisces Publications, Newbury

2.4.11 Additionally, data were sought for those INNS listed in Schedule 9 of the WCA and as species listed under the European Union Regulation on Invasive Alien Species. All species recorded within the last 5 years have been reported, plus those older records that are considered relevant in the context of the Scheme.

Table 3: Desk study data sources

Data Source	Accessed	Data Obtained
Multi-Agency Geographic Information for the Countryside (MAGIC) website[5]	September 2020	Statutory designations within 5km, priority species and habitat within 2km of the rivers within the study area. Information on habitats and habitat connections (based on aerial photography) relevant to interpretation of planning policy and assessment of potential protected/notable species constraints.
Birmingham EcoRecord	25 September 2020	Protected, notable and invasive species and non-statutory designated sites, including citations for those sites, within 2km of the rivers.
Derbyshire Biological Records Centre		
Leicestershire and Rutland Environmental Records Centre		
Lincolnshire Environmental Records Centre (via Anglian Water)		
North & East Yorkshire Ecological Data Centre		
Nottinghamshire Biological & Geological Records Centre		
Staffordshire Ecological Record		
Warwickshire Biological Records Centre		
EA Ecology and Fish data explorer[6]	October 2020	EA WFD monitoring data including protected and notable species within the Tame, Trent and Humber catchments within the study area – including aquatic macroinvertebrates, macrophytes and fish.
INNS Mapper	November 2020	Locations of current and eradicated aquatic and riparian INNS of concern included.
Derbyshire county flora (Wilmot, A., and Moyes, N. 2015. The flora of Derbyshire. Pisces Publications, Newbury)	December 2020	Locations of non-native plant species within the county of Derbyshire (partial search only).

2.4.12 Once collated, data sources were evaluated based on a number of criteria including presence within the search area, age of records and method of collection. These data have been presented in this baseline assessment report to benchmark the existing ecology of the site.

Data analysis

2.4.13 The web-based Geographic Information System ('web GIS') has been used to map data sources in the search area (2 km zone- refer also to Topic 19: *Identification and collation of existing core datasets and recommendations for future data gathering where necessary*).

2.4.14 A summary of potential INNS mitigation is provided in Appendix B, based on literature review. In addition to this, information relevant to identifying optimal mitigation option, and a process for doing so, is also provided.

2.4.15 This supporting information, required to understand mitigation prioritisation, includes an assessment of 'risk' species, species aggregates, and pathways, on the basis of their potential to impact. Risk species/pathways were determined based on literature review, the results from similar previous

[5] https://magic.defra.gov.uk/
[6] https://environment.data.gov.uk/ecology-fish/

projects, and experiential data. Where risk species have been identified in the buffer zone, this is noted.

2.4.16 Through assessment of risk species and pathways, priorities were determined for mitigation requirements, allowing for a focused review of available options. This literature review included peer reviewed publication, stakeholder guidance, and the output from similar pervious projects.

2.4.17 Based on the results of the baseline assessment required for ecological benchmarking, a gap analysis has been undertaken to identify evidence gaps for INNS.

2.4.18 Data collection would be needed to ensure as complete a baseline as feasible for future project impact assessments, e.g. determining any parts of the search area with little or no apparent coverage which would benefit from field survey.

2.4.19 Additionally, as part of the of the mitigation identification assessment, gaps in knowledge on the availability or effectiveness of mitigation options, under a range of scenarios, for different species aggregates was reviewed, and this is presented in Appendix B of this report. This information was used to identify potential areas of interest for future research. As a full understanding of information requirements, and how to fill them optimally, with respect to INNS mitigation requires details on the specific of a given scheme, a protocol is provided for identifying optimal mitigation when this information becomes available. This will allow for a more targeted approach to prioritising research. However, a range of likely optimal potential areas of interest are provided.

2.5 Limitations

2.5.1 The aim of a desk study is to help characterise the baseline context of the study area and provide background information to inform ecological benchmarking. Ecological information obtained from Local Records Centres contains records of habitats and species from a wide variety of sources, and a wide age range. The baseline assessment identifies the data that is relevant and current; however, it is reliant on the providers in terms of the accuracy of data.

2.5.2 A ‘data freeze’ date of 14 December 2020 was agreed for the purpose of this assessment, after which it was not considered feasible to include further data or information. All data pertaining to this assessment was obtained before this date and has therefore been included.

2.5.3 Data of invasive species from the tributaries of the Tame, Trent and Humber are a key source of information relative to the INNS in the search area, which was limited to 2 km either side of the main river. Increasing the area of study may help determine the presence/likely absence of INNS that have the potential to invade these rivers and the potential for further risks to the SRO schemes in the future, in this case of relevance only to the SLR scheme, as the Minworth SRO will reduce discharges. However, it is not considered that this is a significant limitation to this baseline assessment, or to the assessment of INNS pathways at Gate 2.

2.5.4 Stakeholder consultation was undertaken where possible given restrictions during the Covid-19 pandemic to discuss evidence requirements, data gaps and identify additional data sources, where these are considered necessary to further inform the baseline assessment. In the case of Topic 14, further information on INNS was provided by the Environment Agency and Anglian Water.

2.5.5 Movement of species is in constant flux, with new INNS arriving in the UK on a frequent basis. In addition, changes in legislation can promote species to scheduled status, change the area in which a species is scheduled or remove a species from a list. Because of the fluid nature of species designations, the species shown in Section 3 represent a snapshot of species that are found in the catchment area of the three rivers.

3. Desktop Survey Results

Invasive Non-Native Species

3.1.1 Records of aquatic, semi-aquatic and riparian INNS were identified from EA data and LERC records (see Table 4). Records of INNS aquatic vertebrates, macroinvertebrates and macrophytes considered as non-native species are shown in Table 5. These have been described in further detail below, and the locations of INNS records are provided in the web GIS.

3.1.2 INNS present in the entire TTH study area are shown in the tables that follow – refer to Figure 1 for the study area. Those species present within the proposed locations of the Trent abstraction for SLR (refer also to Figure 1), or within the zone of influence of Minworth discharges (i.e. 2km upstream of Minworth effluent discharge and downstream to the Trent confluence), are indicated.

Table 4: INNS aquatic macroinvertebrates and macrophytes present in the TTH study area, and their legislative status

Species	Location of most upstream record	Location of most downstream record	Present within SLR Trent abstraction area	Present upstream of Minworth sewage treatment works	Year of most recent record / total number of records	INNS status (Sch 9[7]; INNS Regs 2019 etc.)
Aquatic INNS Macroinvertebrates						
Chinese mitten crab *Eriocheir sinensis*	SK 57500 40500	SE 87650 22250	-	-	2019 / 8	Schedule 9; INNS Regs 2019
Signal crayfish *Pacifastacus leniusculus*	SK 19850 14750	SE 84550 02450	-	-	2018 / 4	Schedule 9; INNS Regs 2019
Aquatic INNS Macrophytes / Terrestrial Plants						
Canadian pondweed *Elodea canadensis*	SP 14000 89600	SE 86500 17500	-	-	2006 / 115	Schedule 9
Curly Waterweed *Lagarosiphon major*	SP 22000 88000	SE 82550 11450	-	-	2014 / 8	Schedule 9; INNS Regs 2019
Floating pennywort *Hydrocotyle ranunculoides*	SK 19335 04265	SE 85400 24200	Present	-	2018 / 23	Schedule 9; INNS Regs 2019
Giant hogweed *Heracleum mantegazzianum*	SP 17100 91399	SK 81200 99600	-	Present	2018 / 25	Schedule 9; INNS Regs 2019
Himalayan balsam *Impatiens glandulifera*	SP 14880 90850	SK 79015 96195	Present	Present	2019 / 930	Schedule 9; INNS Regs 201
Japanese knotweed *Reynoutria japonica*	SP 15000 90000	SE 86950 16950	Present	Present	2012 / 248	Schedule 9; INNS Regs 2019
New Zealand pigmyweed *Crassula helmsii*	SP 15179 91249	SK 79500 91500	-	-	2017 / 74	Schedule 9
Nuttall's waterweed *Elodea nuttallii*	SP 14810 90500	SE 87000 23000	Present	-	2018 / 120	Schedule 9; INNS Regs 2019

[7] Listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended)

Species	Location of most upstream record	Location of most downstream record	Present within SLR Trent abstraction area	Present upstream of Minworth sewage treatment works	Year of most recent record / total number of records	INNS status (Sch 9[7]; INNS Regs 2019 etc.)
Water fern *Azolla filiculoides*	SP 15489 90780	SE 85000 19000	-	-	2017 / 80	Schedule 9
INNS Fish						
Wels catfish *Silurus glanis*	SK 78500 53500	SK 80500 57500	Present	-	2019 / 2	Schedule 9. INNS Regs 2019
Zander *Sander lucioperca*	SK 8192 7427	SK 8192 7427	Present	-	2016 / 6	Schedule 9. INNS Regs 2019
INNS Mammals						
American mink *Neovison vison*	SP 19966 91390	SE 86500 23500	-	-	2019 / 252	Schedule 9
INNS Reptiles						
Red-eared terrapin *Trachemys scripta subsp. elegans*	SP 18100 91600	SK 49400 32500	-	-	Undated / 20	Non-native/Not normally resident in the UK/ INNS Regs 2019

Table 5: Records of aquatic vertebrates, macroinvertebrates and macrophytes in the TTH study area considered as non-native species

Species	Location of most upstream record	Location of most downstream record	Present within SLR Trent abstraction area	Present upstream of Minworth sewage treatment works	Year of most recent record / total number of records	Status
Aquatic INNS Macroinvertebrates						
Bladder snail *Physella / Physella acuta*	SK 47097 31140	SK 80481 56712	Present	-	2019 / 15	Non-native/Not normally resident in the UK
Asian clam *Corbicula fluminea*	SK 49550 29350	SK 56850 39250	Present	-	2019 / 31	Non-native/ Not normally resident in the UK
Caspian mud shrimp *Chelicorophium curvispinum*	SK 21384 18206	SE 86150 17750	Present	-	2020 / 100	Non-native/Not normally resident in the UK
Crangonyx pseudogracilis/ floridanus (a freshwater shrimp)	SP 216919 5606	SE 85000 21900	Present	Present	2019 / 362	Non-native/Not normally resident in the UK
Dikerogammarus species (a freshwater shrimp)	SK 58503 38714	SK 68044 43739	-	-	2012 / 2	Non-native/Not normally resident in the UK
'Demon' shrimp *Dikerogammarus haemobaphes*	SP 16915 91464	SK 83850 78050	Present	-	2020 / 110	Non-native/Not normally resident in the UK
Hypania invalida (a Ponto-Caspian polychaete worm)	SK 21384 18206	SK 81901 74476	Present	-	2019 / 3	Non-native/Not normally resident in the UK
Killer shrimp *Dikerogammarus villosus*	SK 81500 87500	SK 81950 88150	-	-	2012 / 2	Non-native/Not normally resident in the UK
New Zealand mud-snail *Potamopyrgus antipodarum*	SP 16915 91464	SE 89926 24476	-	Present	2020 / 334	Non-native/Not normally resident in the UK.
Gammarus tigrinus (a freshwater shrimp)	SK 41750 27450	SK 81901 74476	Present	-	2017 / 40	Non-Native/Not normally resident in the UK
River Limpet *Ferrissia californica (wautieri)*	SK 58503 38714	SK 58503 38714	-	-	2019 / 2	Non-native/Not normally resident in the UK
Zebra mussel *Dreissena polymorpha*	SK 17953 05655	SK 83550 78150	Present	-	2019 / 32	Non-native/Not normally resident in the UK.
Aquatic INNS Macrophytes / Terrestrial Plants						

Italian alder *Alnus cordata*	SK 84500 74500	SE 82500 09500	-	-	2017 / 4	Non-native
Least duckweed *Lemna minuta*	SK 19705 04125	SE 87750 22050	Present	-	2017 / 27	Non-native
INNS Fish						
Common carp varieties *Cyprinus carpio*	SP 20200 90700	SK 25723 23596	-	-	2014 / 20	Non-native/Not normally resident in the UK
Rainbow trout *Oncorhynchus mykiss*	SK 19500 13500	SK 19500 13500	-	-	1992 / 1	Non-native/Not normally resident in the UK

3.1.3 Schedule 9 of the Wildlife and Countryside Act lists species that were of concern when the legislation was last amended in 1999. Because of this, some invasive species which are not legislated for are as threatening to biodiversity and economy as species listed. As such, it is recommended that the threat provided by any INNS is investigated, and appropriate mitigation for removal and or control is taken.

3.1.4 Additionally, as per the Wildlife and Countryside Act, it is 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. Where a species meets this description, as noted in Table 5, the Wildlife and Countryside Act applies.

3.1.5 It is recommended that consideration be given to INNS that are not designated under statutory legislation, as best practice, to prevent their spread to other water bodies or habitats. It is important to stay up to date on trends in INNS, e.g. the spread of species and new INNS species arriving – e.g. Quagga mussel. It is also worth noting that the Wildlife and Countryside Act is overdue for an update.

3.1.6 A recent alert from Defra indicates that Quagga mussel (***Dreissena bugensis***)[8] has been found in the Trent catchment, confirmed as being in Hall Reservoir near Newton-on-Trent, and in Rutland Water. In the case of Hall Reservoir, it is considered likely that the mussels originated from the River Trent, from where water is abstracted for the reservoir. This is a recognised INNS, and while not currently listed in statutory legislation, is not ordinarily resident in the UK.

Minworth (INNS Identified)

3.1.7 Based on the findings of the desktop study, the following INNS were identified in the study area in the vicinity of Minworth WwTW (also see Table 4):

- Giant hogweed (high risk)
- Himalayan balsam (high risk)
- Japanese knotweed (high risk)
- Crangonyx pseudogracilis/ floridanus (a freshwater shrimp) (low risk)
- New Zealand mud-snail (low risk)

3.1.8 Key points to note from these finds are:

- The list of species identified indicates that there are no especially noteworthy INNS present (rather very common or low risk species); however, this may not be a full representation, as very widespread species, such as Nuttall's waterweed, are not recorded in the area, potentially indicating that the databases available do not provide a full audit of the species present.
- The higher risk species identified are marginal plant species. One potential impact of the Minworth SLO is reduced flow rates in the Tame (see Section 4.3), which, by potentially widening margins,

[8] https://www.gov.uk/government/news/quagga-mussels-found-in-the-river-trent-and-rutland-water

could facilitate the success of such species. However, mitigation is typically feasible for marginal species, depending on upstream presence, so such impacts should be relatively each to mitigate if required.

- The aquatic species identified are low risk, or would likely be identified as low risk following risk assessment, which may ultimately allow for the determination that no action is required, e.g. *Crangonyx* and New Zealand mud-snail are both so widespread that there would be little to no value in considering them further.

SLR (INNS Identified)

3.1.9 Based on the findings of the desktop study, the following INNS were identified in the study area in the vicinity of the proposed abstraction from the Trent for SLR (also see Table 4):

- Floating pennywort (high risk)
- Himalayan balsam (high risk)
- Japanese knotweed (high risk)
- Nuttall's waterweed (low risk)
- Wels catfish
- Zander
- Acute bladder snail
- Asian clam (high risk)
- Caspian mud shrimp
- Crangonyx pseudogracilis/ floridanus (a freshwater shrimp) (low risk)
- 'Demon' shrimp (high risk)
- Hypania invalida
- Quagga mussel (high risk)
- *Gammarus tigrinus* (a freshwater shrimp)
- Zebra mussel (high risk)
- Least duckweed (non-listed plant)

3.1.10 Key points to note from these findings are:

- While the list of species identified indicates that a wide range of INNS are present, this is unlikely to be a full representation. Species known to be very widespread, such as giant hogweed or signal crayfish, are notably not recorded in the area, strongly indicating that the databases available do not provide a full audit of the species present.
- There is presence of species representing most of the higher risk species types, i.e. aquatic plants, marginal plants, bivalve molluscs and free-swimming invertebrates and fish. As such, the number of potential propagule types is reasonably high and a wide range of mitigation options may need to be considered to identify optimal options. The potential that 100% successful solutions can be identified is also diminished (see Section 4.3).
- While some of the species are low risk with little to no action being justifiable, e.g. Nuttall's Waterweed or *Crangonyx*, other are less well established in the UK and their containment is a priority, e.g. Quagga mussel or daemon shrimp and, to a lesser extent, Floating pennywort. As such, it is important to obtain high resolution data on species presence in the areas of interest such that more challenging species sets could be potentially avoided (i.e. by prioritising areas upstream of high risk INNS for works), see Section 4.2 and 4.4.

4. Evaluation

4.1 Introduction

4.1.1 This sections provides a general overview of key factors that need to be considered when identifying optimal management and covers both aquatic species and species found in marginal habitats.

4.1.2 Section 4.2 presents a gap analysis of the baseline species distribution data and Section 4.3 presents a gap analysis of available mitigation options.

4.1.3 Information specific to the Trent abstraction for the SLR SRO and Minworth SRO schemes is provided in Section 4.4. Types of mitigation potentially relevant to these schemes is denoted in Table 11 in Appendix B, which lists currently available options for INNS mitigation, and the scheme to which they are relevant.

4.2 Gap analysis (species records)

4.2.1 The data sources listed in Section 2.4 have been evaluated and records consolidated into the GIS database, which is summarised in Table 4.

4.2.2 Based on this assessment it is clear than available desktop study records are unlikely to be comprehensive, and it is likely that they do not provide a complete picture of INNS presence in the areas of interest.

4.2.3 There are additional sources of data that could be searched for records to add to the database and/or additional surveys could be carried out. These sources would also have records for species in the tributaries and catchments feeding down into the Tame, Trent and Humber, which could provide useful information with respect to likely future introductions.

4.2.4 In order to achieve maximum benefits from the various records available, in addition to the primary recommendation in Section 4.4, water companies could consider facilitating and/or supporting the LERCs to act as the reception and custodian for all these data including those collected by the EA and water company staff. Apart from the advantage of consolidated data, the LERC provides a verification and quality control role and a communication route between water companies and the recorder community. This is of greater relevance to the SLR SRO, which has a greater risk of transferring INNS than Minworth.

4.2.5 Additionally, an up to date INNS database, maintained either by data refresh or by targeted gap-filling surveys, can be used to reconstruct the movement of INNS of particular significance. This could help fill gaps in understanding relating to rates of spread and identifying critical pathways, helping inform measures to deal with these species with respect to proposed projects

4.2.6 Potential additional sources of data that could be searched for records to add to the database are listed below. There was insufficient time to search through all these data as part of this investigation:

- Regional Invasive Species Management Plan (RIMP) for the East of England and the Midlands provide useful information regarding the species present within a region including many of those in Tables 4 and 5, as well as others that were not found during the data search. The RIMPs also contain lists of potential useful partners through which water companies could request and share information with in order to have the most up to date records.
- The flora of Derbyshire (partially searched) proved a good source of aquatic macrophyte and riparian plant records (Wilmot and Moyes, 2015). Floras for all of those counties along the course of the Tame, Trent and Humber and beyond will contribute further records for these groups of plants. Additional atlases of other groups of species such as fish, invertebrates, and mammals.
- A number of the counties have natural history societies with certain members taking on the role of county recorder for a particular taxon, records for which are reported annually in the societies' transactions or annual reports along with papers and articles, the content of which can be

valuable, e.g. a review of the flora of a particular site. The Lincolnshire Naturalist is an example of one of these societies and the annual publication of the Lincolnshire Naturalists Union has had an annual report of freshwater invertebrate records for many years along with reports for other taxa including plant species, all of which are now searchable through an on-line index up to and including 2019. As for other such societies, their recent annual journals/periodicals have to purchased. In addition to annual publications, natural history societies, often in conjunction with other organisations undertake and subsequently publish projects such as one-off conferences, e.g. a conference on the freshwater ecology of Yorkshire (Henderson, 2003), and special publications, e.g. Geoffrey Fryer's "The Freshwater Crustaceans of Yorkshire" (Fryer, 1993) and an atlas of Coleoptera and Hemiptera of Derbyshire. Yorkshire (Merritt, 2006).

- Water Company staff, especially those working out on-site are a valuable source of observations and records which could be enhanced through awareness raising, training and the use of apps on staff mobile devices for both recording invasive plants and animals but also providing access to identification guidance and links to colleagues to help check or verify records. There is a range of materials for the identification of commonly seen or high-risk invasive species from, for example the GB Non-Native-Species Secretariat.
- There is scope to link with local wildlife organisations, e.g. the Wildlife Trusts to organise citizen science events focussed on recording INNS in specific locations.

4.3 Gap Analysis (Potential Mitigation Options)

4.3.1 While the principals behind effective management are well understood, specifically the hierarchy of cost-effective intervention, prevention, surveillance/rapid-response, and, lastly, long-term control, reliable methods for effective INNS mitigation in aquatic environments remains elusive.

Minworth SRO

4.3.2 Based on the findings of a study [redacted] which includes a literature review of the conditions and temperatures required to destroy INNS propagule, it is likely that the process of sewage treatment is sufficient to mitigate INNS spread risk. Accordingly, it is unlikely that effluent discharge from Minworth presents a risk of INNS spread to the River Tame (or Grand Union Canal) and, at this stage, the need to develop additional mitigation measures relating to discharge from sewage treatment for this Scheme is highly unlikely. However, this should be confirmed specifically for the Minworth Sewage Treatment Works through a risk assessment of the facility (see Section 4.4).

4.3.3 However, modifications to flow rates in the River Tame (due to reduced discharge from Minworth) could potentially create conditions that are more favourable to INNS already present. For example, reduced flow rates could widen margins, facilitating the establishment of Himalayan balsam, or reduced water flow might create more suitable habitat for species like Floating pennywort than prefer more sheltered parts of a watercourse – floating pennywort is already established on some parts of the River Trent. The potential for reduced flow rates to affect such INNS is currently unknown and should be investigated (see Section 4.4).

SLR

4.3.4 The remainder of the mitigation options gap analysis focusses on mitigation that is relevant to water transfer, specifically the transfer of water from the Trent.

4.3.5 The implementation of biosecurity protocols, coupled with training, in the context of manifesting operational change is the primary tool available to water companies to mitigate INNS risk. However, biosecurity implementation alone cannot mitigate all INNS risk associated with water transfers.

4.3.6 This creates a quandary, as beyond biosecurity implementation, there are significant limits to currently available approaches for INNS mitigation in aquatic environments, including gaps in understanding the effectiveness or how best to optimise currently available approaches, or combinations of approaches.

4.3.7 Beyond full water treatment, as highlighted above, it is important to recognise that there is currently no practical engineering solution that offers full protection against INNS. Additionally, it is unlikely that practical engineering solutions will be developed in the near, or even foreseeable future, that offer full protection against INNS.

4.3.8 While research, primarily lab-based, has demonstrated that certain treatments can be very effective at destroying INNS propagules (e.g. heated water), there are currently no viable solutions that work at the scale/volume required for water transfers that can either protect against all INNS, or deliver full, or sometimes even meaningful, protection against the transfer of high risk INNS.

4.3.9 Accordingly, at present there is a lack of realistic options to deliver Environment Agency (EA) requirements with respect to INNS mitigation and water transfers. This point is emphasised in EA guidance where it is stated that 'currently the only realistic mitigation is to avoid the need to transfer raw water, for example by changing a transfer from raw water to treated water.' A recent UKWIR working group has reached a similar conclusion (Aldous et al. 2016), particularly with regard to those aquatic INNS posing the highest risk to the water industry i.e. zebra and Quagga mussels.

4.3.10 The Environment Agency (2017) has defined mitigation requirements for water transfer networks as follows:

'*The long-term aim should be for complete removal of propagules within raw water … mitigation will need to be fail safe, resilient and completely effective for all life stages (large fragments/ animals/ microscopic organisms and larval stages)*.'

4.3.11 The Environment Agency justifies the above aim on the basis that it is:

'*the most cost beneficial and least damaging way to manage INNS is to prevent their arrival and spread*'.

4.3.12 This is based on costs to the wider economy and not water companies in isolation. It also identifies that only in:

'*the most exceptional circumstances would we consider a water transfer that created a new pathway into a catchment that offered mitigation* [below] *these stringent standards. Any such scheme would need to show that it meets all requirements of Article 4.7 of the Water Framework Directive and obtain the Agency's approval …*'

4.3.13 As identified by the Environment Agency, the only realistic option at present would be to completely reconfigure the raw water distribution and treatment network to allow more treatment at source followed by distribution of clean water.

4.3.14 However, the capital costs would likely be so disproportionate as to be beyond reasonable requirements for proactive investment, given the existing known incidence of INNS across the UK, including the areas associated with the two Schemes, and the significant number of raw water connections that water companies operate or might wish to operate.

4.3.15 To further complicate matters, there is a wide array of pathways that exist by which INNS can spread, many of which are outside the control of water companies or not directly under the control of water companies that run 'in parallel' to water transfers or potential water transfers. Completely reconfiguring the raw water distribution and treatment network would not mitigate these pathways.

4.3.16 Alternatively, one might aim to remove all INNS from relevant section of the Trent in advance of water transfer operations. However, this would be an equally unobtainable goal and, even if it were feasible, re-invasion would likely occur.

4.3.17 The limitations associated with each currently available mitigation option are summarised in Appendix B. However, the information required to address these limitations is unlikely to be currently available and research would be required to address this. As such, the key gap, in the context of this assessment, is understanding what interventions, or combinations of interventions, are likely to be of most value with respect to minimising risk to the point that an acceptable risk profile can be achieved.

In order to determine potential, and ultimately optimal, INNS mitigation for SLR, the details of the scheme will need to be determined and relevant pathways identified. This will require a full pathway

risk assessment on the transfer from the Trent, potentially to the River Witham, and ultimately to the South Lincolnshire Reservoir (SLR) – see Section 4.4.

It is worth considering that the three primary corelates with invasive success are disturbed habitats, propagule pressure and climate. Frequently or strongly disturbed habitats are more prone to invasion. The closer a location to an INNS source and the greater that INNS source (in terms of propagule production), the larger the probability that a propagule will reach and (importantly) establish. Suitable climate/environments favour invasive success. These correlates should be factored into prioritisation of mitigation investigations.

4.4 Next Steps

General Recommendations

4.4.1 Due to their invasive nature, INNS are likely to spread throughout the catchments and further species are likely to occur in the future. Therefore, it is recommended that INNS data are refreshed after a period of two years from the date of this report and throughout the impact assessment process, specifically that the INNS database provided with this report on the web GIS is maintained for the lifespan of the SRO schemes, to inform scheme design development, impact assessment and mitigation options. to maintain acceptable risk profiles

4.4.2 Understanding what INNS are present allows mitigation to be refined to ensure acceptable risk profiles are maintained, which once again is mostly relevant to SLR. Additionally, as there are many pathways by which INNS may reach a water transfer receptor location (i.e. INNS can get to relevant locations by other means than water transfers) it is important for water companies to understand presence in their assets so that the likely origin of a new record elsewhere can be better assessed.

4.4.3 A Full Pathway Risk Assessment will be required for Gate 2 for both SRO schemes. While the Minworth SRO involves removing water from the Tame system, the transfer of INNS from Minworth to GUC will need to be assessed. The Minworth Sewage Treatment Works sewage treatment process risk assessment recommended above will provide much of the information required. The Pathway Risk Assessment for SLR will consider the transfer from the Trent, potentially to the River Witham, and ultimately to the SLR. This process requires the specifics of a given scheme, including what infrastructure will be developed or used and, accordingly, is also essential for determining appropriate mitigation.

4.4.4 Any development works associated with the schemes, with the potential to interact with INNS, must have a Biosecurity Management Plan (BMP) in place to ensure associated site works do no facilitate INNS spread. As such, high detail INNS data will be required to inform the production of a BMP for development works (in both aquatic and terrestrial locations).

4.4.5 As such, it is likely that in the locations directly affected by works associated with a given scheme will require additional surveys so that INNS presence can be confirmed and mapped. At a minimum, this will likely require:

- walkover surveys of affected land and waterbody margins; and
- submerged macrophyte grapnel and shoreline kick sampling.

4.4.6 Such information is required to formulate fit for purpose BMPs and to determine, and estimate the cost associated with, mitigation that needs to be integrated into construction works (e.g. if a site overlaps with a large stand of Japanese knotweed or Himalayan balsam, waste disposal cost can be high; however, avoidance may be possible especially where control commences well in advance). The feasibility of attempting long term control of such widespread terrestrial species in a given location would also need to be considered, as if they are present up and down stream, long term local control would not be feasible, and efforts should focus on containment during site works.

Minworth SRO Specific Recommendations

4.4.7 Given that the goal of this scheme is to reduce discharge into the River Tame, it may impact flow rates which could have a knock-on impact on INNS presence (see Section 4.3). As changes in flow rate could affect the risk associated with certain species, as described in Topic 6, further targeted flow modelling or more detailed interrogation of existing models is recommended for the Rivers Tame and Trent for specific areas where impacts are considered likely, the results of which could be evaluated for impacts on INNS risk.

SLR Specific Recommendations

4.4.8 The quantity, quality, and resolution of available INNS presence data (Section 3) within the study area are not sufficient to make specific recommendations and to fully understand risk associated with abstraction from various potential abstraction locations. As such, it is recommended that detailed surveys would be carried out once the specifics of the SRO schemes abstraction points are available.

4.4.9 The requirements for this information are two fold, (1) to inform the water transfer risk assessment (including relative risk between abstraction points with respect to INNS - information from these surveys could be compiled and evaluated against scheme options), and (2) to inform the biosecurity requirements that would need to be integrated into to site works associated with the development, for which a bespoke, site specific, BMP would need to be produced.

4.4.10 Given that currently the best likely outcome will involve identifying what mitigation can reduce propagule pressure to acceptable levels such that INNS are unlikely to survive the transfer process, it would be pragmatic to prioritise research into this area. In order to better understand risk, information will be required on the impact of mitigation on reducing outward propagule pressure, in real world environments, and also on the distance propagules can travel under different scenarios, and how combinations of mitigation affect this.

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Appendix A Figure 1: Study Area

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Revision: 1

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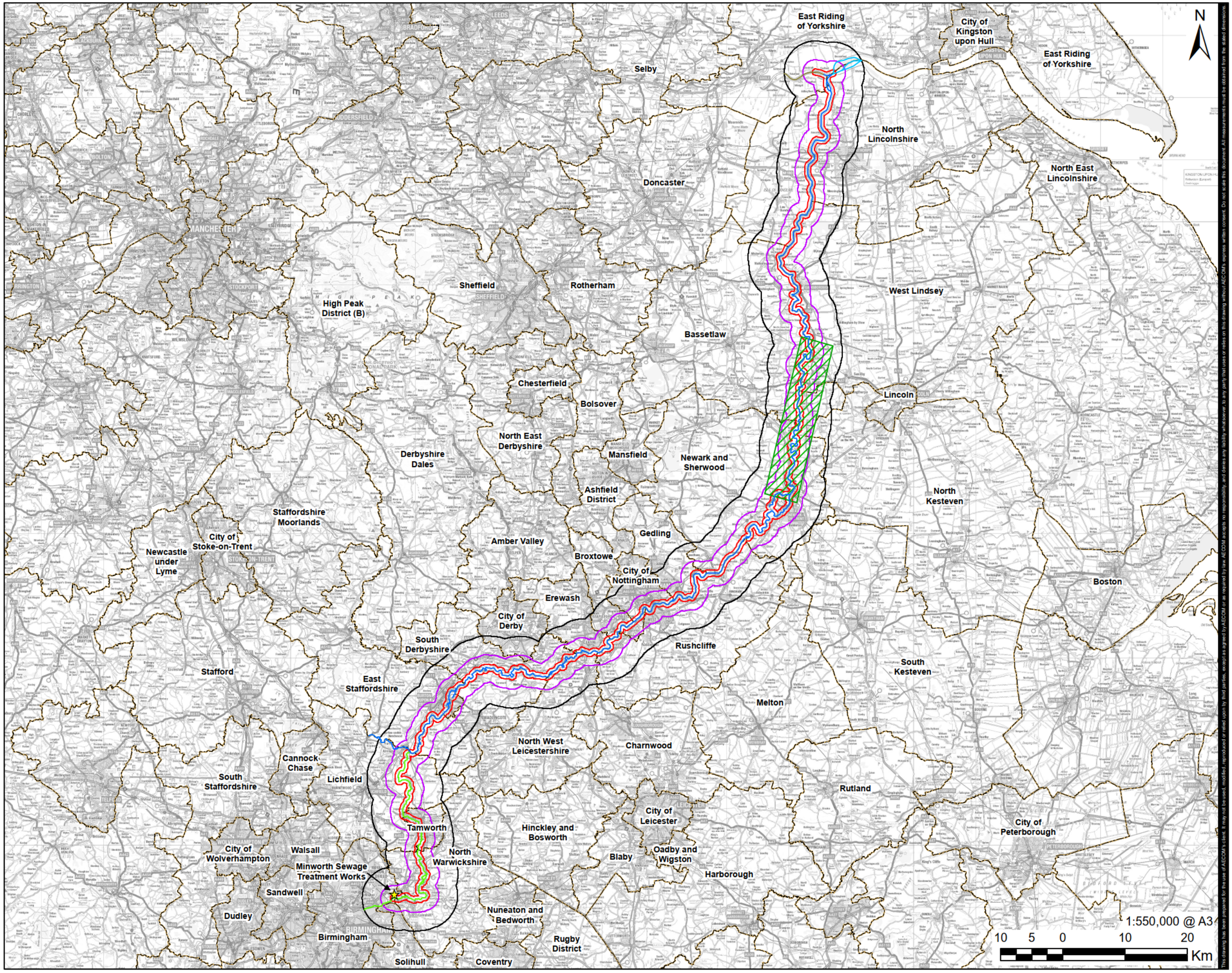

AECOM

PROJECT

Tame Trent and Humber Hydrology, Ecology and Environment [redacted]

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LEGEND

- Minworth Sewage Treatment Works
- River Humber
- River Ouse
- River Tame
- River Trent *
- 500m Study Area
- 2km Study Area
- 5km Study Area
- Indicative Location of Proposed Abstraction from Trent for South Lincs Reservoir
- District Boundary

* The OS Open Rivers layer for the River Trent includes a spur extending upstream on the River Ouse, which overlaps part of the Ouse. Therefore, for completeness this has been included in the study area for the relevant Topics.

NOTES

ISSUE PURPOSE

FINAL

PROJECT NUMBER

[redacted]

SHEET TITLE

Study Area

SHEET NUMBER

Figure 1b

Appendix B Mitigation Options

The following sections describe the possible mitigation measures that can be adopted to either attempt to remove existing INNS, or put in place to reduce propagule pressure, i.e. impede their transfer, expansion and/or establishment. There is a focus on measures that will mitigate potential INNS impacts (i.e. transfer) by operational measures that are used by water companies, including Affinity Water, Anglian Water and Severn Trent Water.

The mitigation options listed in this appendix are for INNS in general and effectively provide a 'toolkit' of options for the Rivers Tame, Trent and Humber. They do not constitute specific mitigation that the Minworth and SLR SROs should consider when mitigating their potential INNS impacts.

Review of Potential INNS Treatments and Interventions

AECOM periodically undertakes literature reviews to identify emerging trends in INNS mitigation and has been building a database of available options. This database, combined with a review of recent literature, was taken into account to identify viable options for treating established INNS or excluding them from Water Company assets and infrastructure. This was heavily informed by other detailed recent reviews of this, particularly Aldous *et al.* (2016), which identified few viable options for meaningful or cost-effective intervention for aquatic INNS. The Environment Agency (2017) has also stated that options for effective intervention are limited. The literature review provides clarity on the rationale behind this position.

The potential interventions identified are summarised in Table 11, with emphasis placed heavily on clarification of potential interventions relevant to aquatic INNS and the water environment. This is where the greatest risks to Water Companies lie. However, other interventions applicable to terrestrial assets are also summarised, where these are considered relevant, including best-practice biosecurity measures as a risk management tool.

Table 6: Review of treatment and intervention options for their applicability to water companies (relevance to SLR, Minworth or future mitigation indicated)

Intervention option	Review of applicability of different intervention options to specific assets and asset connections			Relevance to SLR and Minworth SRO schemes		
	Raw water habitats (e.g. River Tame - SLR and Minworth areas of interest)	Raw water transmission (within and at point of entry into aqueducts, pipes, etc)	Other asset types and wider grounds maintenance			
	A full barrier approach for the raw water supply requires INNS intervention here.		Full barrier and system protection require catchment-based approaches. Otherwise measures are spot treatments only.	Minworth	SLR	Future
Biobullets (aka 'silver bullets')	Not feasible. Biobullets can in theory be used for INNS molluscs but yet to be fully validated at habitat scale (e.g. reservoir or river scale). Complete eradication unlikely, especially if treatment is not possible at upstream source.	Control measure against adult INNS molluscs only but not larvae or other INNS. Eradication not feasible unless can be eradicated from upstream source. Risk to infrastructure if used on major infestation, due to impact from wash-through of dead shells. Has value as part of a wider control strategy.	Unsuitable.	N/A	N/A	Possibly
Biocides - other potential aquatic biocide treatments (excludes biobullets)	Not feasible. Not sufficiently specific, collateral damage unacceptable. No single biocide solution for all INNS.	Not feasible. Not sufficiently specific, collateral damage unacceptable. No single biocide solution for all INNS.	Unsuitable.	N/A	N/A	Possibly
Biological control	Generally unsuitable, few viable options at this time, other that water fern, and dependent on national initiatives. National trials ongoing for control of certain plant INNS, including floating pennywort and Australian swamp-stonecrop. Biological control reduces the fitness of the plants. This may be enough to rebalance ecosystems, but in most cases complete control or eradication is unlikely.	Unsuitable at point of abstraction, due to timescales involved. If developed for relevant species, could have value as part of a wider control strategy to prevent introduction to abstraction points.	Generally unsuitable, few viable options at this time and dependent on national initiatives. See left also.	N/A	Possibly, depending on species present	Possibly, depending on species present
Elemental chlorine	Unsuitable. Not appropriate given links to natural environment. Volumes of water prohibitive.	Unsuitable. Not appropriate given links to natural environment. Volumes of water prohibitive.	Unsuitable.	N/A	N/A	N/A
Herbicides	Only suitable for certain plant INNS, mostly marginal. Eradication sometimes feasible when applied at wide scales, or	Unsuitable at point of abstraction, unless integrated with upstream control.	Suitable for certain plant INNS only. Eradication feasible.	N/A	Possibly, depending on species present	Possibly, depending on species present

Intervention option	Review of applicability of different intervention options to specific assets and asset connections			Relevance to SLR and Minworth SRO schemes		
	Raw water habitats (e.g. River Tame - SLR and Minworth areas of interest)	Raw water transmission (within and at point of entry into aqueducts, pipes, etc)	Other asset types and wider grounds maintenance			
	A full barrier approach for the raw water supply requires INNS intervention here.		Full barrier and system protection require catchment-based approaches. Otherwise measures are spot treatments only.	Minworth	SLR	Future
	as part of an integrated approach, to some species.					
Hot foams	Only relevant to plant INNS. Circumstances where it might be applied are limited. No evidence of effective short or long-term control (e.g. Bridge, 2005; Ewald, 2014).	Not relevant.	Limited potential value in certain circumstances e.g. treatment of Australian swamp-stonecrop on filter beds. Needs testing.	N/A	Possibly, depending on species present	Possibly, depending on species present
Manual/ mechanical clearance	Limited suitability for certain plant/ animal INNS, but only where full catchment control possible to remove risk of re-establishment. Otherwise impractical and/or cost and H&S prohibitive. Unlikely that all propagules will be removed for high risk INNS.	Unsuitable. Action needed upstream to prevent INNS reaching the transfer.	Limited suitability for certain plant/ animal INNS. May be feasible to achieve effective control on an asset by asset basis but full catchment control needed to remove risk of re-establishment. Can be coupled with follow up herbicide treatment to impro results. Can be used to effectively remove certain plant species from terrestrial development footprints	N/A	Possibly, depending on species present	Possibly, depending on species present
Microscreen/ membrane technology	Unsuitable. Only defensible as a measure against certain INNS (propagules <1mm) but cannot be practicably applied to this situation.	Unsuitable. Only defensible as a measure against certain INNS (propagules <1mm) but cannot be practicably applied to this situation. Technology incompatible with requirements for speed and volume of water transfer.	Unsuitable.	N/A	Some form of screening could be considered	Possibly, depending on species present
Shading	Unsuitable at relevant scales.	Not relevant.	Not relevant. In theory has limited potential value e.g. for small constrained infestations of plant INNS where other interventions not feasible. It is hard to visualise circumstances where this might apply, potentially infested ponds.	N/A	Possibly, depending on species present	Possibly, depending on species present

Intervention option	Review of applicability of different intervention options to specific assets and asset connections					
	Raw water habitats (e.g. River Tame - SLR and Minworth areas of interest)	Raw water transmission (within and at point of entry into aqueducts, pipes, etc)	Other asset types and wider grounds maintenance	Relevance to SLR and Minworth SRO schemes		
	A full barrier approach for the raw water supply requires INNS intervention here.		Full barrier and system protection require catchment-based approaches. Otherwise measures are spot treatments only.	Minworth	SLR	Future
Thermal shock	Unsuitable. Volumes of water prohibitive.	Unsuitable. Volumes of water and number of connections prohibitive.	Has value as part of biosecurity wash down, including during works associated with the schemes.	Relevant to best practice biosecurity measures		
Trash racks, grates & fish screens (eel screens are best option as 1mm minimum mesh size provides highest specification and supported by Eel Regulations)	Unsuitable. Reservoirs are connected to natural watercourses and the number of upstream downstream connections are prohibitive and impractical (maintenance commitment, flood risk from blocked screens, impedance of fish movements etc) to protect.	No protection against high risk mollusc INNS. Limited protection from other INNS. Will only exclude plant fragments and faunal life stages greater than 1mm (as context zebra mussel only exceeds 1mm once settled).	Unsuitable.	N/A	Some form of screening could be considered	Possibly, depending on species present
Ultraviolet irradiation	Unsuitable. Volumes of water prohibitive. No consensus on the success of the approach. Generally, works by destroying or disrupting the DNA of organisms and kill is not always guaranteed (Anon, 2016).	Applicability not proven and application would require new infrastructure. Volumes of water and number of connections prohibitive. See left also. Might have relevance to reducing propagule pressure.	Not relevant.	N/A	N/A	Potentially with future development of technology
Digital surveillance	Not directly suitable but may have value as part of a wider control strategy. Early warning data driven system using threshold-based triggers. Could be used to support surveillance and prevention. Untested against traditional surveillance methods.	Not relevant at point of abstractive.	Not directly suitable, but may have value as part of a wider control strategy	Surveillance of INNS distribution, and tracking of INNS into the UK in the future, are relevant throughout Water Company operations		
Enhanced network resistance and habitat resilience	It is well understood that habitats that are frequently and/or strongly disturbed correlate with invasive success. Maintaining robust and diverse habitats could help reduce establishment if introductions occur. Extrapolating from this, habitat	Potentially relevant where transfer includes natural components. See left also or at outflows.	May have value as part of a wider control strategy. See left also.	Relevant to all Water Company assets and operations		

Intervention option	Review of applicability of different intervention options to specific assets and asset connections					
	Raw water habitats (e.g. River Tame - SLR and Minworth areas of interest)	Raw water transmission (within and at point of entry into aqueducts, pipes, etc)	Other asset types and wider grounds maintenance	Relevance to SLR and Minworth SRO schemes		
	A full barrier approach for the raw water supply requires INNS intervention here.		Full barrier and system protection require catchment-based approaches. Otherwise measures are spot treatments only.	Minworth	SLR	Future
	corridors with well-established natural components (e.g. rivers) could be more resistance to the movements of INNS trough them. Untested.					
Fencing and signage	Once identified, demarcation can be used to reduce spread of some species and signage can remind individuals to take extra care. Value as part of a wider control strategy.	Not relevant.	Once identified, demarcation can be used to reduce spread of some species. Value as part of a wider control strategy. See left also.	Yes – if INNS present on site during construction	Yes	Yes
Horizon scanning	No immediate value to schemes, but new INNS are on the horizon, including listed on relevant legislation. Prevention is key.	Not relevant at point of abstraction.	Value as part of a wider control strategy. See left also.	Surveillance of INNS distribution, and tracking of INNS into the UK in the future, are relevant throughout Water Company operations		
Infrastructure design	Not relevant.	New infrastructure (new or retrofitting to existing transfers) can be designed to be easier to maintain/more resilient to INNS, e.g. easily accessible pipes for cleaning or pipe material less prone to canonisation by mollusc (although this is not well tested).	Not relevant.	N/A	Yes	Yes
Operational change	Not directly relevant. See right also.	Not directly relevant. See right also	Integration of company-wide biosecurity policies into business-as-usual operations. Critical in long-term cost-effective control. Biosecurity should be viewed in a similar way to standard H&S and become ingrained in company culture.	Implementation of best practice biosecurity measures throughout operations		
Monitoring / surveillance	Knowledge of presence/absence is important in most scenarios to inform mitigation requirements. Monitoring and surveillance should be considered a key part	Knowledge of presence/absence is important in most scenarios to inform mitigation requirements. Changes in species presence at source and receptor locations should be considered in	Value as part of a wider control strategy. See left also.	Surveillance of INNS distribution, and tracking of INNS into the UK in the future, are relevant throughout Water Company operations		

Intervention option	Review of applicability of different intervention options to specific assets and asset connections					
	Raw water habitats (e.g. River Tame - SLR and Minworth areas of interest)	Raw water transmission (within and at point of entry into aqueducts, pipes, etc)	Other asset types and wider grounds maintenance	Relevance to SLR and Minworth SRO schemes		
	A full barrier approach for the raw water supply requires INNS intervention here.		Full barrier and system protection require catchment-based approaches. Otherwise measures are spot treatments only.	Minworth	SLR	Future
	of mitigation, rather than a separate element. It should be linked to rapid response control actions with pre-defined triggers for action (with pre-approved budgets)	mitigation programmes, e.g. new presence at source may modify mitigation requirements, or new presence at receptor might make existing mitigation no longer valuable.				
Pathway management plans / auditing	Not directly relevant. See right also	May be relevant depending on how the water is being transferred.	Development of pathway specific guidance, training, intervention and auditing. Can help shut down key vectors. Value as part of a wider control strategy.	N/A	Yes, depending upon method and pathway of transfer	Yes
Stakeholder engagement	Raising public awareness has been shown to be a low cost means of helping reduce INNS spread. Value as part of a wider control strategy.	Not relevant.	Raising public awareness has been shown to be a low cost means of helping reduce INNS spread. Value as part of a wider control strategy.	Low-cost value of raising public awareness throughout operations		
Wash down check/clean/dry	Biosecurity implementation is integral to operational change, with the check, clean, dry process advocated by the EA and others being the appropriate starting point. This can be augmented with plan, avoid, disinfect and so forth. It should be noted that many plant species, and adult invertebrates, have shown a resilience to drying, highlighting the importance of the clean step. Hot water cleaning is also a step up but is not always practical.	Biosecurity implementation is integral to operational change. See left also.	Biosecurity implementation is integral to operational change. See left also.	Implementation of best practice biosecurity measures throughout operations		
Water Treatment	Not relevant.	Only using treated water for water transfers is currently the only means by which INNS risk could be completely removed; however, to would be the very	Not relevant.	N/A	Potentially, if becomes cost-effective in future	Potentially, if becomes cost-effective in future

Intervention option	Review of applicability of different intervention options to specific assets and asset connections			Relevance to SLR and Minworth SRO schemes		
	Raw water habitats (e.g. River Tame - SLR and Minworth areas of interest)	Raw water transmission (within and at point of entry into aqueducts, pipes, etc)	Other asset types and wider grounds maintenance			
	A full barrier approach for the raw water supply requires INNS intervention here.		Full barrier and system protection require catchment-based approaches. Otherwise measures are spot treatments only.	Minworth	SLR	Future
		expensive to inhibitory expensive at the scale of a full water network. .				
Sewage Treatment	Not relevant.	Not relevant.	The process of sewage treatment likely destroys all INNS propagules; however, this should be confirmed on a site by site basis to ensure destructive conditions and temperatures are met and there are no points of potential re-infestation prior to discharge.	Requirement to confirm if treatment at Minworth destroys INNS propagules	N/A	N/A
Research partnerships	Water companies should be aware of and prepared to benefit from the outcomes of research projects such as the Aquainvad-ED (Tricarico et al 2017 - Developing innovative methods to face aquatic invasions in Europe: the Aquainvad-ED project) and contribute where possible.	See left also.	See left also.	Benefits of INNS awareness and surveillance throughout operations		
Bespoke BMP's for development plans	Not relevant.	Relevant when building new infrastructure.	By reviewing development or asset management plans, opportunities for integrating INNS mitigation into such plans can be identified. For example, de silting works or the creation of new infrastructure, might present opportunities for relatively low cost intervention as plant and personnel are mobilised and required temporary works in place. Any such works, with the potential to interact with INNS, should have a Biosecurity and Management Plan in place regardless, which should also aim to identify such opportunities.	N/A	Yes	Yes

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