River Severn to River Thames Transfer (STT)

Strategic regional water resource solution

Environmental Assessment Report:

INNS

July 2021

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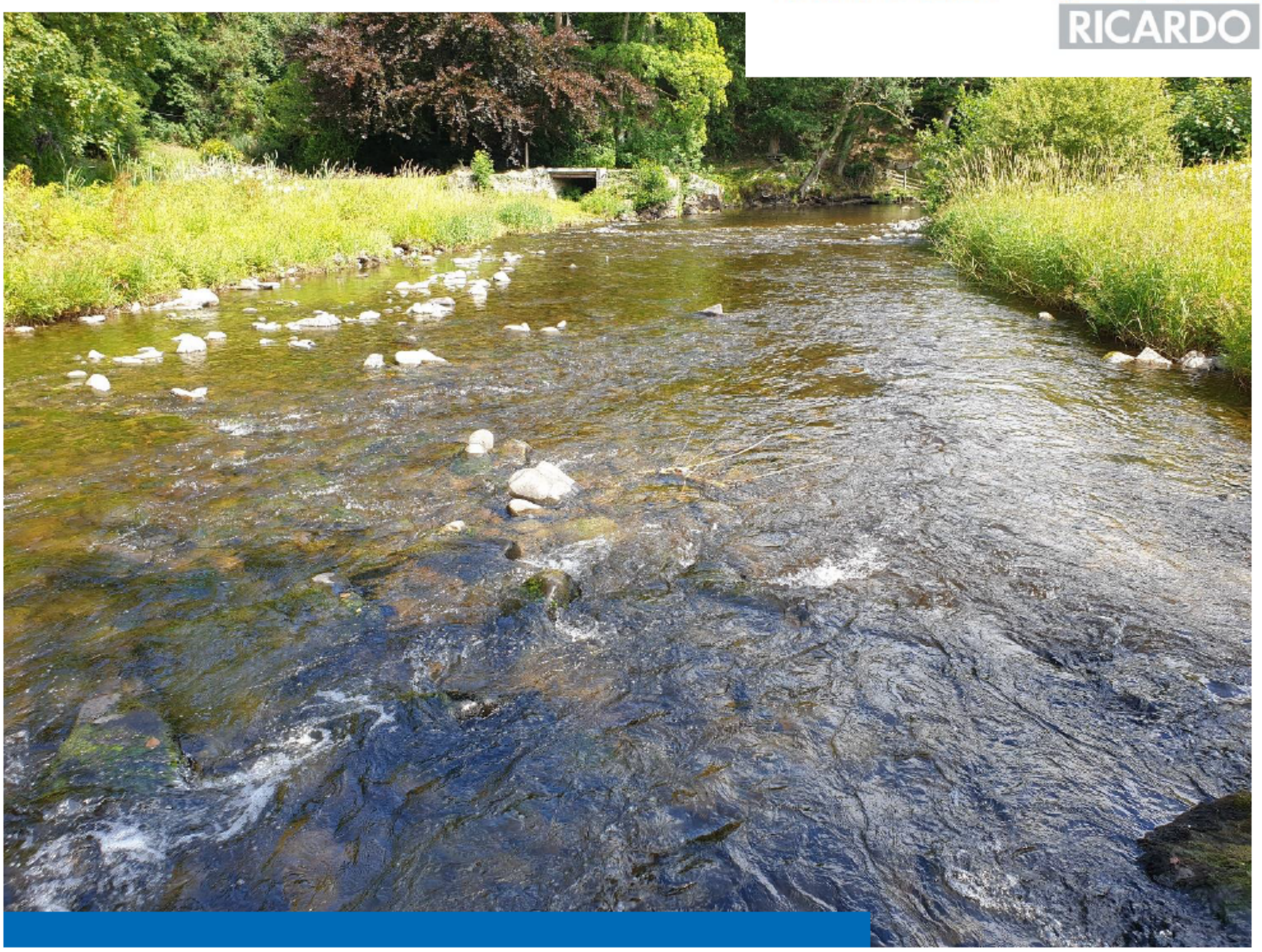

Severn to Thames Transfer SRO

Environmental Assessment Report: Appendix B3.5 INNS

STT-S5-017 | 3

Report for United Utilities on behalf of the Severn Thames Transfer Programme

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1	19/03/2021	Draft for STT review	[redacted]	[redacted]	[redacted]	[redacted]
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Contents

Tables

1. Background

A detailed review of current and future invasive species risk and mitigation techniques available in the UK and Europe was completed by APEM in 2020[1]. This included a review of previous INNS assessments completed in 2016 and 2018.

Both the review completed by APEM and the recommendation in the Evidence Report[2] recommended the need for adopting a pathway-based approach to a risk assessment of INNS. The baseline data and the survey used to inform the baseline fish community is provided in the Evidence Report.

The data for the River Severn and the tributaries identifies several INNS that could be distributed through the operation of a STT. The high-level assessment of the risk of the transfer of INNS during of the operation of the STT recommended that the detailed assessment considered the context of the current connectivity of the watercourses and transfer mechanisms. Where new connections between waterbodies are created or existing connection are modified to increase velocity and flow, it can be assumed that the risk of transfer of INNS will be increased.

The aim of the assessment report is to, firstly, identify the risk of the distribution of INNS using a pathway approach and secondly, identify those areas where further monitoring and assessment may be required to inform the Gate 2 assessments.

2. Risk Assessment Approach

The pathway-based INNS assessment approach was used to assess the possible pathways for the introduction of INNS for each SRO associated with the Severn-Thames transfer. This was accomplished using the INNS risk assessment tool developed by Ricardo Energy & Environment (REE). This tool has been subject to independent review and verification, provided by INNS specialist Dr David Aldridge, and has been agreed for use by the Environment Agency (EA).

The risk assessment tool has been developed using previous examples of similar assessment tools and with the guidance set out by the Environment Agency[3]. The EA provides a definitive list of what should be included within the INNS pathway risk assessment which includes parameters such as the nature of the connection (for example, piped transfer, natural, navigation), the distance of each connection and frequency of operation.

Additionally, the EA states that the risk assessment should not be specific to individual species of INNS but highlights the utility of understanding the transfer pathways which are likely to occur within a connection (for example, vegetative reproduction, egg dispersal, planktonic larvae)[4].

The risk assessment tool utilised in this report has been developed by REE and is standardised approach applied to all SROs. In consideration of the EA guidance, REE has developed the tool to adopt both a descriptive and quantitative approach. The descriptive elements (e.g. scheme design) are an important consideration when reviewing the options for mitigation associated with each system component.

The risk assessment tool also considers the pathway approach, advocated in EA guidance. This grouping approach recognises that certain types of asset or Raw Water Transfers (RWTs) provide a range of pathways, with different pathways having greater relevance and thus risk spread of certain INNS groups. These pathways may include new or existing pathways and may be related directly to the SRO operation or related to the usage of the asset by the public e.g. Leisure craft. The combination of pathway risk associated with groups of INNS and occurrence of this pathway at/within an asset/RWT allows INNS risk assessment and INNS risk scores to be developed. This grouping approach provides efficiencies for INNS and individual assessments. It also allows for the consideration of the current

[1] APEM (2020). STT Ecological Literature Review. APEM Scientific Report P00004288. Severn Thames Transfer Partnership, September 2020, v2.0 Final, 480 pp
[2] Ricardo Energy & Environment (2021). Severn to Thames Transfer SRO Evidence Report: Appendix B2.5 INNS. Report for United Utilities. March 2021.
[3] PR19 - Assessing the risks of spread of Invasive non-native species posed by existing water transfers – OFFICIAL. Environment Agency, 2017.
[4] EA. 2017. PR19 - Assessing the risks of spread of Invasive non-native species posed by existing water transfers - OFFICIAL

environment associated with each intake and discharge location of the system components. As such, the risk to WFD (objectives, status and measures) and protected sites can also be considered in the tool.

Horizon scanning has also been considered. Species that could potentially spread in systems in the future are included in this tool for SROs which are likely to be developed after 2050. This includes consideration of climate change, potential changes in habitat because of the development of an SRO (e.g. a new reservoir), and the creation of new pathways and environments suitable for INNS not currently considered a risk within a catchment.

The tool intends to provide a rapid, transparent assessment of the theoretical risk of transfer of INNS. The tool can be applied to a wide range of transfer options to quantify the relative risk of each transfer connection **before** the application of mitigation measures. The tool is not intended to provide a complete assessment of the impact of INNS but is intended to provide a rapid comparative tool and a foundation to which a detailed assessment and comparison of transfer options can be developed in Gate 2.

At the basis of the INNS transfer risk assessment are two questionnaires which have been created to collect the relevant information for INNS and specific water transfer connections. Data from the questionnaires are then combined in the final assessment which interprets the data collected from each to assess the risk of INNS being transferred by a raw water transfer (RWT). The output of the assessment provides a value to which further connections can be compared. The value is log10 transformed to stabilise the variation within groups and then categorised into four risk bands visible in **Table 1**.

Table 1 Risk category bands (based upon low and high risk theoretical scenarios utilising the current assessment tool (22/01/2020)

NB These bandings may change with the addition of species and/or pathways in future iterations of the tool

Risk Category	Score
Low	1.69 – 3.99
Medium	3.98 – 6.28
High	6.27 – 8.58
Very High	8.55 – 10.88

For the purposes of the REE INNS assessment tool, each RWT is split into connections. A connection is defined by three steps: the water source, the connection mechanism and the receiving water body or facility. In assessing each connection, we can provide an assessment of each stage of a water transfer option for which there may be multiple connections. For a detailed description of the tool, please see the methodology report by REE (2020[5]).

A detailed breakdown of the pathways present and species that are likely to be facilitated by each pathway type are provided for each connection. There are nine possible additional pathways included within the assessment:

Pet/ornamental release

The plant species utilising this pathway reproduce via seed/spore dispersal or vegetative reproduction and may include species with similar distribution and reproductive pathways as Japanese Knotweed or butterfly bush. It is important to note that plant species in this category, although ornamental garden species, are perhaps more likely to be transported to the site unintentionally rather than being purposefully planted at the site. As such these species are captured in more than one pathway

[5] Ricardo Energy & Environment (2020). Strategic Resource Options Invasive Non-Native Species Risk Assessment Methodology. Report for United Utilities. November 2021.

scenario. Animal species utilising this pathway reproduce via live bearing or egg laying and may include species with similar distribution and reproductive pathways as Northern River Amphipod, African Clawed-frog and various ornamental Crayfish.

Angling

The species utilising distribution pathways associated with anglers accessing the connection source, or connection mechanism habitat, where they may establish and be distributed by the RWT. The plant species selected by the tool as utilising this pathway reproduce via seed/spore dispersal or vegetative reproduction and may include species with similar distribution and reproductive pathways as Japanese Knotweed, Giant Knotweed or butterfly bush. The remaining animal species utilising this pathway reproduce via live bearing, egg laying or planktonic larva and may include species with similar distribution and reproductive pathways as Signal, White River and Red Swamp Crayfish, Killer Shrimp and other amphipods as well as New Zealand mud-snail.

Survey/Site operatives

The species utilising distribution pathways associated with site operatives accessing the connection source or connection mechanism habitat where they may establish and be distributed by the RWT. The plant species selected by the tool as utilising this pathway reproduce via seed/spore dispersal or vegetative reproduction and may include species with similar distribution and reproductive pathways as Japanese Knotweed, Pirri Piri burr, Andean Water Milfoil or butterfly bush. The remaining animal species utilising this pathway reproduce via live bearing, egg laying and planktonic larvae and may include species with similar distribution and reproductive pathways as Killer Shrimp, Signal, White River and Red Swamp Crayfish as well as New Zealand mud-snail and quagga mussel amongst others.

Animal/waterfowl (phoresis)

INNS may utilise distribution pathways associated with the transportation of adults and propagules by waterfowl or animals using the connection source or connection mechanism habitat where they may establish and be distributed by the RWT. The plant species selected by the tool as utilising this pathway reproduce via seed/spore dispersal or vegetative reproduction and may include species with similar distribution and reproductive pathways as Japanese Knotweed and Pirri Piri burr. The remaining animal species utilising this pathway reproduce via live bearing, egg laying or planktonic larvae and may include species with similar distribution and reproductive pathways as northern river amphipod, New Zealand mud-snail, zebra mussel or signal crayfish.

Boat/Leisure craft

Species utilising distribution pathways associated with use of boats and leisure craft at the connection source or connection mechanism habitat where they may be transported as propagules or adults between waterbodies where they may establish and be distributed by the RWT. The plant species selected by the tool as utilising this pathway reproduce via seed/spore dispersal or vegetative reproduction and may include species with similar distribution and reproductive pathways as Giant Knotweed and Andean water milfoil. The remaining animal species utilising this pathway reproduce via live bearing, egg laying and planktonic larvae and may include species with similar distribution and reproductive pathways as northern river amphipod, killer shrimp, zebra mussel and New Zealand mud-snail.

Walkers/Bikers

Species which may utilise distribution pathways associated with walkers and bikers utilising the connection source or connection mechanism habitat where they may establish and be distributed by the RWT. The plant species selected by the tool as utilising this pathway reproduce via seed/spore dispersal or vegetative reproduction and may include species with similar distribution and reproductive pathways as Japanese, Giant and Himalayan Knotweed and butterfly bush. Animal species utilising this pathway, reproducing via egg laying and may include species with similar distribution and reproductive pathways as New Zealand mud-snail.

Wind

These species may be distributed by wind to the connection source or connection mechanism habitat where they may establish and be distributed by the RWT. The plant species selected by the tool as utilising this pathway reproduce via seed/spore dispersal or vegetative reproduction and may include species with similar distribution and reproductive pathways as butterfly bush and pampas grass.

Flood

Species which may be distributed by flooding to the connection source or mechanism habitat where they may establish and be distributed by the RWT. The plant species selected by the tool as utilising this pathway reproduce via seed/spore dispersal or vegetative reproduction and may include species with similar distribution and reproductive pathways as Japanese and Giant Knotweed, butterfly bush and Andean Milfoil. The remaining animal species utilising this pathway reproduce via live bearing, egg laying and quagga mussel and may include species with similar distribution and reproductive pathways as the New Zealand mud-snail, signal crayfish and quagga mussel.

Construction

Species which may be distributed by construction operations at the connection source and connection mechanism habitat where they may establish and be distributed further by the RWT. The plant species selected by the tool as utilising this pathway reproduce via seed/spore dispersal or vegetative reproduction and may include species with similar distribution and reproductive pathways as Japanese and giant knotweed, butterfly bush, Andean milfoil and waterfern. The remaining animal species utilising this pathway may include species with similar distribution and reproductive pathways as the signal crayfish.

3. Assessment of connections

As part of the development of the Severn to Thames Transfer (STT) Scheme, Jacobs undertook modelling of the STT Source Support Elements to determine the order in which the support elements would become operational for each of the interconnector alternatives (i.e. canal or pipeline). This order was determined having regard to a number of factors including cost and resilience. The ordering of the support elements for both the Deerhurst to Culham pipeline conveyance and the Canal conveyance are set out in **Table 2**.

Table 2: STT Source Support Element Groupings

Pipeline conveyance		Canal conveyance	
Element Ref	Element ID	Element Ref	Element ID
7a	DeerhurstPipeline 300	8	CotswoldCanals 300
4	Mythe_15	4	Mythe_15
1b	VyrnwyRelease 75	5b	NetheridgePipelineCotswold 35
5a	NetheridgePipelineDeerhurst 35	1b	VyrnwyRelease 75
3	ShrewsburyRedeployment_25	3	ShrewsburyRedeployment_25
2a	MiddleVyrnwyBypass 80	2a	MiddleVyrnwyBypass 80
6	Minworth 115	6	Minworth 115

On the basis that the ordering of when the different STT Source Support Elements can become operational has been fixed through the work undertaken by Jacobs, the environmental assessment of each of these support elements has had regard to the changing baseline position in terms of the receiving water environment. For example, when considering the introduction of the Shrewsbury Redeployment support element, the assessment has regard that the water in the River Severn system would include the additional water being made available / provided by the Mythe (15 Ml/d); Vyrnwy release (75 Ml/d); and Netheridge (35 Ml/d) source support elements.

As noted in the sections above, where existing connection are modified to increase velocity and flow, it can be assumed that the risk of transfer of INNS will be increased. Ideally, the assessment of the risk of distribution of INNS as a result of operation of the STT will be completed in view of if the ordering of when the different STT Source Support Elements can become operational, i.e. an assessment of unsupported abstraction considered in the first instance, followed by a supported abstraction with Mythe operations, then Vyrnwy Reservoir releases of 75 Ml/d, etc.

However, due to the nature of the risk assessment approach (pathway approach) the assessment has been completed by considering the different connections of the STT SRO. A pathway-based approach is not applicable for several of the connection within the STT SRO including the Shrewsbury, Mythe, Minworth and Netheridge options.

The Shrewsbury and Mythe option implement a theoretical 15 Ml/d and 25 Ml/d reduction from the current potential abstraction. As the abstraction reduction does not represent a transfer of raw water the risk of transfer of INNS is zero and the application of a pathway-based assessment of INNS in this scenario is not applicable.

The Minworth WwTW option diverts 115 Ml/d which is currently discharged into the River Tame to the River Avon. The water from Minworth WwTW will be released into the River Avon at a location which is yet to be determined. The Netheridge WwTW diversion option diverts 35 Ml/d to either the Deerhurst pipeline or Gloucester Sharpness Canal. It is not likely that the introduction or transfer of INNS will occur during the operation of these options as the water is treated prior to release, eliminating all pathways that are likely to introduce or transfer INNS during normal operation. Therefore, the application of a pathway-based assessment of INNS in this scenario is not relevant.

3.1. Vyrnwy reservoir release & Vyrnwy Bypass

3.1.1. Vyrnwy Reservoir release

In operation there would be additional releases of 75 Ml/d from Vyrnwy Reservoir for intermittent periods of typically 30 days, up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. The option would transfer water from Vyrnwy Reservoir to the River Severn utilising the River Vyrnwy as a connection mechanism. There is an existing pathway for the distribution of INNS within this connection as Vyrnwy Reservoir provides compensation flow to the River Vyrnwy and regulation releases are often made in support of the River Severn regulation.

Vyrnwy Reservoir currently discharges into the River Vyrnwy at a compensatory flow of 45 Ml/d, though this volume changes significantly during periods of controlled flood management release, at times where the reservoir is overspilling, or when regulation releases are required. The proposed transfer volume will amount to 120 Ml/d inclusive of the 45 Ml/d compensation flow volume. For the purpose of comparison, the 75Ml/d release has been assessed based upon 100 days of operation during Summer, Autumn and Winter compared to the current 45Ml/d compensation flow over the same duration and seasons as the release. As the option is likely to operate at times of low flow it is anticipated that the releases will be made during the minimum 45Ml/d compensation flow.

Results of the assessment is visible in **Table 3**. Based upon the parameters provided for the Vyrnwy 75Ml/d release (+45Ml/d compensation flow), the connection is categorised as a “Very High Risk” transfer with a score of 8.79. A total of 23 species were selected within the tool based upon the presence of likely pathways that may facilitate the spread of the species, the location of the transfer, the types of habitat at the connection source, connection mechanism and destination and the seasonality of the transfer.

These results should be received in context of the current Vyrnwy compensation flow discharge. Assessment of the current compensation flow volume 45 Ml/d over the same period of 100 days yields a risk score of 8.36, indicative of a “High Risk” of INNS transfer. The 75 Ml/d release volume scores higher because of the increased volume, surpassing the “Very High Risk” boundary. Within the current Vyrnwy Reservoir compensation flow and proposed support release volume the additional pathways and species that are likely to establish at the connection source, connection mechanism and connection destination habitat remain the same for the period at which the transfer is likely to operate. Therefore, the species that are assessed as likely to be transferred are the same in each scenario though the risk of them being transferred is higher because of higher volumes equating to increased probability that’s INNS may become entrained and transported.

Table 3 Result of the REE Assessment tool implemented in the assessment of the Vyrnwy Release Option 1a.

	75 Ml/d (+45 Ml/d Comp Flow) Transfer	45 Ml/d Compensation Flow Only
Operation parameters	up to 100 days, in Summer, Autumn or Winter.	
Connection source habitat	Upland Reservoir	
Additional INNS transfer pathways present at the connection source habitat.	Survey/Site operative Anglers Boat/Leisure Craft Walkers/Bikers Pet/ornamental release Waterfowl/animal (Phoresis) Wind	
Connection Mechanism Habitat	Upland River	
Additional INNS transfer pathways present at the connection source habitat.	Flood Boat/Leisure Craft Walkers/Bikers Pet/ornamental release Waterfowl/animal (Phoresis) Wind Anglers	
Connection Destination	Lowland River	
INNS listed within the database which may be transported from the connection source and establish in the connection mechanism, and/or, from the connection mechanism and establish in connection destination assuming no mitigation is in place.	Japanese Knotweed Pirri-pirri burr Butterfly Bush Northern River Amphipod *Dikerogammarus haemobaphes* Killer shrimp Giant Knotweed Andean water milfoil Signal Crayfish Himalayan knotweed New Zealand Mudsnail White river crayfish Red swamp Crayfish African Clawed frog Pampas grass	
Seasonality of the transfer? Year-round, spring, summer etc.	Summer - Winter	
Connection Risk Score = ((Volume of water transferred × duration of transfer) × Frequency of transfer) × Distance of the transfer for Open Channel connections	479250	287550
INNS transfer risk score = (Sum of (species risk score x INNS Risk Potential Factor) x Connection risk score)	192658500	115595100
Waterbody connectivity	2 - Between WFD waterbodies within the same catchment.	
Final Score with Waterbody/Catchment Weighting	385317000	231190200
Logarithm transformation (Log^{10})	8.79	8.36
Category	Very High Risk	High Risk

3.1.2. Middle Vyrnwy Bypass

In operation there would be additional release 80Ml/d to the lower Afon Vyrnwy up to ~100 days, notably in June to November, particularly in the July, August & September period. Overall operation would be in the order of ~15% of dates at times of low flows in the lower River Severn. The option transfers water to the River Severn utilising the Vyrnwy reservoir and a River Vyrnwy Bypass pipeline as a connection mechanism. There is an existing pathway for the distribution of INNS within this connection as Vyrnwy Reservoir provides compensation flow to the River Vyrnwy.

For the purposes of this assessment the discharge of water via the Vyrnwy bypass to the Severn has been split into two connections. Connection A will assess the risk posed by the transfer of water to the lower Vyrnwy via the Vyrnwy Bypass pipeline. Connection B will assess the risk posed by the additional water volume entering the Vyrnwy via the Vyrnwy Bypass pipeline and transporting INNS to the River Severn.

Although the volume considered for the connection amounts to 80 Ml/d, during the same period Vyrnwy Reservoir will be discharging into the River Vyrnwy at a flow of 120 Ml/d (75 Ml/d support release and 45 Ml/d compensation release).

The species which are selected by the assessment tool as having the potential to be distributed by Connection A will be used to inform the assessment in Connection B, to maintain continuity between the two connections.

Results of the assessment is visible in **Table 4**. Based upon the parameters provided for Connection A, the connection is categorised as a “High Risk” transfer with a score of 6.47. A total of 14 species were selected within the tool based upon the presence of likely pathways that may facilitate the spread of the species, the location of the transfer, the types of habitat at the connection source, connection mechanism and destination and the seasonality of the transfer.

Based upon the parameters provided for Connection B, the connection is categorised as a “High Risk” transfer with a score of 7.92. A total of 14 species were selected within the tool based upon the presence of likely pathways that may facilitate the spread of the species, the location of the transfer, the types of habitat at the connection source, connection mechanism and destination and the seasonality of the transfer.

These results should be received in context that the Vyrnwy compensation flow discharge as well as regulation releases and overspill currently connect the Lake Vyrnwy and River Vyrnwy. Assessment of the current River Vyrnwy compensation flow volume of 45 Ml/d over the same period of 100 days between lake Vyrnwy and the Severn yields a risk score of 8.38, indicative of a “Very High Risk” of INNS transfer. The bypass pipeline in Connection A acts to reduce the total length of open channel in which INNS species may become established between Lake Vyrnwy and the Severn confluence therefore marginally reducing the potential to transfer INNS to a new habitat within the length of the River Vyrnwy between Lake Vyrnwy and the bypass outfall. The species that are selected by the assessment tool as being facilitated by the transfer are the same in each scenario with the exception of Pampas grass which is excluded from Connection A in account of the species being unlikely to be found in Upland reservoir habitats.

Table 4: Result of the REE Assessment tool implemented in the assessment of the Vyrnwy Release Option 2a.

	Connection A	Connection B
Operation parameters	up to 100 days, in Summer, Autumn or Winter.	
Connection source habitat	Upland Reservoir	Pipeline
Additional INNS transfer pathways present at the connection source habitat.	Survey/Site operative Anglers Boat/Leisure Craft Walkers/Bikers Pet/ornamental release Waterfowl/animal (Phoresis) Wind	None
Connection Mechanism Habitat	Pipeline	Upland River
Additional INNS transfer pathways present at the connection Mechanism habitat.	None	Flood Boat/Leisure Craft Walkers/Bikers Pet/ornamental release Waterfowl/animal (Phoresis) Wind Anglers
Connection Destination	Upland River	Lowland River
INNS listed within the database which may be transported from the connection source and establish in the connection mechanism, and/or, from the connection mechanism and establish in connection destination assuming no mitigation is in place.	Japanese Knotweed Pirri-pirri burr Butterfly Bush Northern River Amphipod Dikerogammarus haemobaphes Killer shrimp Giant Knotwood Andean water milfoil Signal Crayfish Himalayan knotweed New Zealand Mudsnail White river crayfish Red swamp Crayfish African Clawed-frog	Japanese Knotweed Pirri-pirri burr Butterfly Bush Northern River Amphipod Dikerogammarus haemobaphes Killer shrimp Giant Knotwood Andean water milfoil Signal Crayfish Himalayan knotweed New Zealand Mudsnail White river crayfish Red swamp Crayfish African Clawed-frog Pampas grass
Seasonality of the transfer? Year-round, spring, summer etc.	Summer - Winter	
Connection Risk Score = ((Volume of water transferred × duration of transfer) × Frequency of transfer) × Distance of the transfer for Open Channel connections	8000	201500
INNS transfer risk score = (Sum of (species risk score x INNS Risk Potential Factor) x Connection risk score)	1464000	84428500
Waterbody connectivity	2 - Between WFD waterbodies within the same catchment.	
Final Score with Waterbody/Catchment Weighting	2928000	168857000
Logarithm transformation (Log^{10})	6.47	8.22
Category	High Risk	High Risk

3.1.3. Vyrnwy Release and Vyrnwy Bypass Species Pathway breakdown

A break-down of the distribution pathways and species which have been selected by the assessment tool during the assessment of both option 1a and 2a are summarised in **Table 5**. The species listed provide an indication of the life histories and reproductive types that may be distributed by the pathways linked to the transfer of water from the Lake Vyrnwy to the River Severn. For the Lake Vyrnwy release and Vyrnwy Bypass scenarios the species selected by the tool remains the same. A summary of the pathway types is provided in **Section B.3.5.2**.

Table 5: Species within Questionnaire 1 which are selected by the assessment tool that may be distributed by pathways to the connection source or mechanism habitats and further distributed by the RWT.

Additional Pathways	No. of Species	Reproductive pathways of the species selected by additional pathway (No. of Species)		Species selected as likely to be facilitated by the water transfer.
Pet/ornamental release	10	Egg dispersal	0	Pirri-pirri burr, Butterfly Bush, Northern River Amphipod, Andean water milfoil, Signal Crayfish, Himalayan knotweed, White river crayfish, Red swamp Crayfish, African Clawed-frog, Pampas grass
		Egg laying	2	
		Live bearing	3	
		planktonic larva	0	
		Seed/spore dispersal	5	
		Vegetative	5	
Angling	10	Egg dispersal	0	Japanese Knotweed, Butterfly Bush, Dikerogammarus haemobaphes, Killer shrimp, Giant Knotwood, Andean water milfoil, Signal Crayfish, New Zealand Mudsnail, White river crayfish, Red swamp Crayfish
		Egg laying	2	
		Live bearing	4	
		planktonic larva	0	
		Seed/spore dispersal	4	
		Vegetative	4	
Survey/Site operative	11	Egg dispersal	0	Japanese Knotweed, Pirri-pirri burr, Butterfly Bush, Northern River Amphipod, Dikerogammarus haemobaphes, Killer shrimp, Giant Knotwood, Andean water milfoil, Signal Crayfish, Himalayan knotweed, New Zealand Mudsnail
		Egg laying	1	
		Live bearing	4	
		planktonic larva	0	
		Seed/spore dispersal	6	
		Vegetative	6	
Waterfowl/animal (Phoresis)	5	Egg dispersal	0	Japanese Knotweed, Pirri-pirri burr, Northern River Amphipod, Signal Crayfish, New Zealand Mudsnail
		Egg laying	1	
		Live bearing	2	
		planktonic larva	0	
		Seed/spore dispersal	2	
		Vegetative	2	
Boat/Leisure Craft	6	Egg dispersal	0	Northern River Amphipod, *Dikerogammarus haemobaphes,* Killer shrimp, Giant Knotwood, Andean water milfoil, New Zealand Mudsnail
		Egg laying	1	
		Live bearing	3	
		planktonic larva	0	
		Seed/spore dispersal	2	
		Vegetative	2	
		Vegetative	10	
Walkers/Bikers	6	Egg dispersal	0	Japanese Knotweed, Pirri-pirri burr, Butterfly Bush, Giant Knotwood, Himalayan knotweed, New Zealand Mudsnail
		Egg laying	1	
		Live bearing	0	
		planktonic larva	0	
		Seed/spore dispersal	5	
		Vegetative	5	
Wind	2	Egg dispersal	0	Butterfly Bush, Pampas grass
		Egg laying	0	
		Live bearing	0	
		planktonic larva	0	
		Seed/spore dispersal	2	
		Vegetative	2	
Flood	7	Egg dispersal	0	Japanese Knotweed, Pirri-pirri burr, Butterfly Bush, Giant Knotwood, Andean water milfoil, Signal Crayfish, New Zealand Mudsnail
		Egg laying	1	
		Live bearing	1	
		planktonic larva	0	
		Seed/spore dispersal	5	
		Vegetative	5	

3.2. River Severn Connections

3.2.1. River Vyrnwy to Deerhurst Abstraction or Gloucester Sharpness Pumping Station

During operation there would be additional release 75 Ml/d via Option 1a and 80 Ml/d via option 2a which would be received by the River Severn to the lower Afon Vyrnwy up to ~100 days, notably in June to November, particularly in the July, August & September period. The options transfer water from Vyrnwy Reservoir to the River Severn. There is an existing pathway for the distribution of INNS within this connection as Vyrnwy Reservoir provides compensation flow to the River Vyrnwy which joins the River Severn. The additional volume may increase the likelihood of INNS transfer.

In addition, 25 Ml/d will be available from the redeployment of the Shrewsbury abstraction (Option 3). The abstraction will also be supported by a 15 Ml/d made available from the Mythe abstraction and 115 Ml/d from the Minworth WwTW.

A total of 300 Ml/d would then be abstracted at Deerhurst via a pipe interconnector or the Cotswold Canal interconnector at the Gloucester Sharpness Pumping Station.

The assessment has been undertaken to understand the relative risk of the transfer INNS based upon a transfer volume of 80 Ml/d, 75 Ml/d and a combined total of 155 Ml/d from the River Vyrnwy via the River Severn. Transfer volumes are assessed to understand the likely pathways and risk of transfer of INNS as water travels between the Vyrnwy to the River Severn at Deerhurst or the Gloucester Sharpness Pumping Station.

The results should be considered in context of the current Vyrnwy Reservoir compensation flow discharge, regulation releases and overspill, which provides a pre-existing link between the River Severn and Vyrnwy Reservoir representing a continual pathway which may support the transfer of INNS.

Results of the assessment is visible in **Table 6**. In all three scenarios the risk score provided by the assessment tool exceeded "Very High Risk" thresholds. Volume in all three scenarios is the independent factor with all other parameters including duration, length and habitat remaining the same. As anticipated, the risk score increases with volume: the 75 Ml/d scenario yielded a score of 8.95; the 80 Ml/d scenario yielded a score marginally higher at 8.98; and the 155 Ml/d scenario yielded a score 9.26. A total of 27 species are selected by the assessment tool for each scenario. The species and pathways that are selected by the assessment tool as being facilitated by the transfers are the same in each scenario.

Table 6: Result of the REE Assessment tool implemented in the assessment of discharge volumes anticipated during the operation of Option 1a and 2a between the River Vyrnwy and River Severn to Deerhurst.

	75 Ml/d	80 Ml/d	155 Ml/d
Operation parameters	up to 100 days, in Summer, Autumn or Winter.		
Connection source habitat	Upland River		
Additional INNS transfer pathways present at the connection source habitat.	Anglers Boat/Leisure Craft Wa kers/Bikers Pet/ornamental release Waterfowl/animal (Phoresis) Wind Flood Survey/Site operative		
Connection Mechanism Habitat	Lowland River		
Additional INNS transfer pathways present at the connection Mechanism habitat.	Anglers Boat/Leisure Craft Wa kers/Bikers Pet/ornamental release Waterfowl/animal (Phoresis) Wind Flood Survey/Site operative		
Connection Destination	Abstraction pipeline		

	75 Ml/d	80 Ml/d	155 Ml/d
INNS listed within the database which may be transported from the connection source and establish in the connection mechanism, and/or, from the connection mechanism and establish in connection destination assuming no mitigation is in place.		Japanese Knotweed Pirri-pirri burr Butterfly Bush Pampas grass Northern River Amphipod Dikerogammarus haemobaphes Killer shrimp Giant Knotwood Andean water milfoil Signal Crayfish Himalayan knotweed New Zealand Mudsnail White river crayfish Red swamp Crayfish African Clawed-frog Zebra Mussel Cape Pondweed Australian Blackwood Tree-of-Heaven Three-cornered Garlic Common Ragweed Giant Cane Noble Crayfish Turkish Crayfish Water Fern Carolina Fanwort Asian clam Swamp Stonecrop Large-flowered Waterweed Canadian Pondweed Nuttall's waterweed Tingiringi Gum Cider Gum Shining Gum Giant Rhubarbs Floating pennywort Curly Waterweed Pumpkinseed Water Primrose American skunk cabbage Monkey flower Parrot's Feather Rusty Crayfish Spiny-cheek crayfish Virile Crayfish Marsh frog Ponto-Caspian gobies Marbled Crayfish American Bullfrog Rhododendron False acacia Zander	
Seasonality of the transfer? Year-round, spring, summer etc.		Summer - Winter	
Connection Risk Score =((Volume of water transferred × duration of transfer) × Frequency of transfer) × Distance of the transfer for Open Channel connections	1267500	1352000	2619500
INNS transfer risk score = (Sum of (species risk score x INNS Risk Potential Factor) x Connection risk score)	444892500	474552000	919444500
Waterbody connectivity		2 - Between WFD waterbodies within the same catchment.	
Final Score with Waterbody/Catchment Weighting	889785000	949104000	1838889000
Logarithm transformation (Log^{10})	9.22	9.25	9.54
Category		Very High Risk	

3.2.2. River Severn Transfer Species/Pathway Breakdown

A break-down of the distribution pathways and species which have been selected by the assessment tool during the assessment of the River Severn Transfers are summarised in **Table 7**. The species listed provide an indication of the life histories and reproductive types that may be distributed by the pathways linked to the transfer of water from the River Vyrnwy to the Lower Severn. For both Severn transfer scenarios, distance and volume are the only independent variables, therefore the species and pathways that are likely to be facilitated by the transfer remain the same. A summary of the pathway types is provided in **Section B.3.5.2**.

Table 7: Species within Questionnaire 1 which are selected by the assessment tool that may be distributed by pathways to the connection source or mechanism habitats and further distributed by the RWT.

Additional Pathways	No. of Species	Reproductive pathways of the species selected by additional pathway (No. of Species)		Species selected as likely to be facilitated by the water transfer.
Pet/ornamental release	41	Egg dispersal	0	Pirri-pirri burr, Butterfly Bush, Pampas grass, Northern River Amphipod, Andean water milfoil, Signal Crayfish, Himalayan knotweed, White river crayfish, Red swamp Crayfish, African Clawed-frog, Cape Pondweed, Australian Blackwood, Tree-of-Heaven, Three-cornered Garlic, Giant Cane, Noble Crayfish, Turkish Crayfish, Water Fern, Carolina Fanwort, Swamp Stonecrop, Large-flowered Waterweed, Canadian Pondweed, Nuttall's waterweed, Tingiringi Gum, Cider Gum, Shining Gum, Giant Rhubarbs, Curly Waterweed, Pumpkinseed, Water Primrose, American skunk cabbage, Monkey flower, Parrot's Feather, Rusty Crayfish, Spiny-cheek crayfish, Virile Crayfish, Ponto-Caspian gobies, Marbled Crayfish, American Bullfrog, Rhododendron, False acacia
		Egg laying	7	
		Live bearing	7	
		planktonic larva	0	
		Seed/spore dispersal	27	
		Vegetative	24	
Angling	29	Egg dispersal	0	Japanese Knotweed, Butterfly Bush, Dikerogammarus haemobaphes, Killer shrimp, Giant Knotwood, Andean water milfoil, Signal Crayfish, New Zealand Mudsnail, White river crayfish, Red swamp Crayfish, Zebra Mussel, Cape Pondweed, Noble Crayfish, Water Fern, Asian clam, Large-flowered Waterweed, Canadian Pondweed, Nuttall's waterweed, Floating pennywort, Curly Waterweed, Water Primrose, Monkey flower, Rusty Crayfish, Spiny-cheek crayfish, Virile Crayfish, Marsh frog, Ponto-Caspian gobies, Marbled Crayfish, Zander
		Egg laying	6	
		Live bearing	9	
		planktonic larva	2	
		Seed/spore dispersal	14	
		Vegetative	14	
Survey/Site operative	23	Egg dispersal	0	Japanese Knotweed, Pirri-pirri burr, Butterfly Bush, Northern River Amphipod, Dikerogammarus haemobaphes, Killer shrimp, Giant Knotwood, Andean water milfoil, Signal Crayfish, Himalayan knotweed, New Zealand Mudsnail, Zebra Mussel, Cape Pondweed, Common Ragweed, Water Fern, Asian clam, Large-flowered Waterweed, Floating
		Egg laying	1	
		Live bearing	5	
		planktonic larva	2	
		Seed/spore dispersal	16	
		Vegetative	17	

Additional Pathways	No. of Species	Reproductive pathways of the species selected by additional pathway (No. of Species)		Species selected as likely to be facilitated by the water transfer.
				pennywort, Curly Waterweed, Monkey flower, Parrot's Feather, Rhododendron, False acacia
Waterfowl/animal (Phoresis)	22	Egg dispersal	0	Japanese Knotweed, Pirri-pirri burr, Northern River Amphipod, Signal Crayfish, New Zealand Mudsnail, Zebra Mussel, Cape Pondweed, Australian Blackwood, Three-cornered Garlic, Water Fern, Swamp Stonecrop, Canadian Pondweed, Nuttall's waterweed, Giant Rhubarbs, Floating pennywort, Curly Waterweed, Water Primrose, Rusty Crayfish, Spiny-cheek crayfish, Virile Crayfish, Rhododendron, False acacia
		Egg laying	1	
		Live bearing	5	
		planktonic larva	1	
		Seed/spore dispersal	16	
		Vegetative	16	
Boat/Leisure Craft	18	Egg dispersal	0	Northern River Amphipod, Dikerogammarus haemobaphes, Killer shrimp, Giant Knotwood, Andean water milfoil, New Zealand Mudsnail, Zebra Mussel, Water Fern, Carolina Fanwort, Asian clam, Swamp Stonecrop, Large-flowered Waterweed, Canadian Pondweed, Nuttall's waterweed, Floating pennywort, Curly Waterweed, Parrot's Feather, Ponto-Caspian gobies
		Egg laying	2	
		Live bearing	4	
		planktonic larva	2	
		Seed/spore dispersal	10	
		Vegetative	11	
Walkers/Bikers	9	Egg dispersal	0	Japanese Knotweed, Pirri-pirri burr, Butterfly Bush, Giant Knotwood, Himalayan knotweed, New Zealand Mudsnail, Common Ragweed, Water Fern, Monkey flower
		Egg laying	1	
		Live bearing	0	
		planktonic larva	0	
		Seed/spore dispersal	5	
		Vegetative	5	
Wind	5	Egg dispersal	0	Butterfly Bush, Pampas grass, Tree-of-Heaven, Rhododendron, False acacia
		Egg laying	0	
		Live bearing	0	
		planktonic larva	0	
		Seed/spore dispersal	5	
		Vegetative	5	
Flood	22	Egg dispersal	0	Japanese Knotweed, Pirri-pirri burr, Butterfly Bush, Giant Knotwood, Andean water milfoil, Signal Crayfish, New Zealand Mudsnail, Zebra Mussel, Cape Pondweed, Water Fern, Carolina Fanwort, Large-flowered Waterweed, Canadian Pondweed, Nuttall's waterweed, Floating pennywort, Curly Waterweed, Pumpkinseed, Water Primrose, Monkey flower, Parrot's Feather, Rhododendron, False acacia
		Egg laying	2	
		Live bearing	1	
		planktonic larva	1	
		Seed/spore dispersal	18	
		Vegetative	19	

3.3. Deerhurst Pipeline Transfer

During operation the Deerhurst pipeline option would transfer up to 300 Ml/d from the River Severn to the river Thames at Culham.

Mitigation measures, including water treatment intended to prevent the transfer of INNS have been incorporated into the conceptual design of the option, however for the purpose of this assessment these mitigation measures are not considered, in order to understand the pre-mitigation risk. The assessment has been undertaken to understand the relative risk of the transfer INNS based upon a transfer volume of 300 Ml/d from the River Severn via the pipeline to the river Thames at Deerhurst. For the purpose of this assessment we have assumed a period of continuous operation for 3 months.

Results of the assessment is visible in Table 8. The risk score provided by the assessment tool for the Deerhurst Pipeline Transfer indicates the transfer poses a “High Risk” of transferring INNS. A total of 49 species are selected in this scenario. The Deerhurst pipeline option utilises a pipeline transfer, as such the distance of the transfer does not factor into the overall risk score as there is no open-channel habitat in which additional pathways may exist or INNS may become established.

Table 8: Result of the REE Assessment tool implemented in the assessment of discharge volumes anticipated during the operation of Option 1a and 2a between the River Vyrnwy and River Severn to Deerhurst.

	300 Ml/d
Operation parameters	120days, in Summer, Autumn or Winter.
Connection source habitat	Lowland River
Additional INNS transfer pathways present at the connection source habitat.	Anglers Boat/Leisure Craft Walkers/Bikers Pet/ornamental release Waterfowl/animal (Phoresis) Wind Flood Survey/Site operative
Connection Mechanism Habitat	Pipeline
Connection Destination	Lowland River
INNS listed within the database which may be transported from the connection source and establish in the connection mechanism, and/or, from the connection mechanism and establish in connection destination assuming no mitigation is in place.	Zebra Mussel Japanese Knotweed Cape Pondweed Pirri-pirri burr Australian Blackwood Tree-of-Heaven Three-cornered Garlic Common Ragweed Giant Cane Noble Crayfish Turkish Crayfish Water Fern Butterfly Bush Carolina Fanwort Asian clam Pampas grass Northern River Amphipod Swamp Stonecrop Dikerogammarus haemobaphes Killer shrimp Quagga mussel Tingiringi Gum Cider Gum Shining Gum Giant Knotwood Giant Rhubarbs Floating pennywort

	300 Ml/d
	Curly Waterweed Pumpkinseed Water Primrose American skunk cabbage Monkey flower Parrot's Feather Andean water milfoil Rusty Crayfish Spiny-cheek crayfish Virile Crayfish Signal Crayfish Marsh frog Himalayan knotweed Ponto-Caspian gobies New Zealand Mudsnail White river crayfish Marbled Crayfish Red swamp Crayfish American Bullfrog Rhododendron False acacia African Clawed-frog
Seasonality of the transfer? Year-round, spring, summer etc.	Summer - Winter
Connection Risk Score =((Volume of water transferred × duration of transfer) × Frequency of transfer) × Distance of the transfer for Open Channel connections	36000
INNS transfer risk score = (Sum of (species risk score x INNS Risk Potential Factor) x Connection risk score)	22752000
Waterbody connectivity	3 - Between WFD Catchments.
Final Score with Waterbody/Catchment Weighting	68256000
Logarithm transformation (Log^{10})	7.83
Category	High Risk

3.3.1. Deerhurst Pipeline Transfer Species/Pathway Breakdown

A break-down of the distribution pathways and species which have been selected by the assessment tool during the assessment of the Deerhurst Pipeline transfer are summarised in **Table 9** below. The species listed provided an indication of the life histories and reproductive types that may be distributed by the pipeline from the abstraction to the discharge point. A summary of the pathway types is provided in **Section B.3.5.2**.

Table 9: Species within Questionnaire 1 which are selected by the assessment tool that may be distributed by pathways to the connection source or mechanism habitats and further distributed by the RWT.

Additional Pathways	No. of Species	Reproductive pathways of the species selected by additional pathway (No. of Species)		Species selected as likely to be facilitated by the water transfer.
Pet/ornamental release	38	Egg dispersal	0	Cape Pondweed, Pirri-pirri burr, Australian Blackwood, Tree-of-Heaven, Three-cornered Garlic, Giant Cane, Noble Crayfish, Turkish Crayfish, Water Fern, Butterfly Bush, Carolina Fanwort, Pampas grass, Northern River Amphipod, Swamp Stonecrop, Tingiringi Gum, Cider Gum, Shining Gum, Giant Rhubarbs, Curly Waterweed, Pumpkinseed, Water Primrose, American skunk cabbage, Monkey flower, Parrot's Feather, Andean water milfoil, Rusty Crayfish, Spiny-cheek crayfish, Virile Crayfish, Signal Crayfish, Himalayan knotweed, Ponto-Caspian gobies, White river crayfish, Marbled Crayfish, Red swamp Crayfish, American Bullfrog, Rhododendron, False acacia, African Clawed-frog
		Egg laying	7	
		Live bearing	7	
		planktonic larva	0	
		Seed/spore dispersal	24	
		Vegetative	21	
Angling	26	Egg dispersal	0	Zebra Mussel, Japanese Knotweed, Cape Pondweed, Noble Crayfish, Water Fern, Butterfly Bush, Asian clam, Dikerogammarus haemobaphes, Killer shrimp, Quagga mussel, Giant Knotwood, Floating pennywort, Curly Waterweed, Water Primrose, Monkey flower, Andean water milfoil, Rusty Crayfish, Spiny-cheek crayfish, Virile Crayfish, Signal Crayfish, Marsh frog, Ponto-Caspian gobies, New Zealand Mudsnail, White river crayfish, Marbled Crayfish, Red swamp Crayfish
		Egg laying	5	
		Live bearing	9	
		planktonic larva	3	
		Seed/spore dispersal	11	
		Vegetative	11	
Survey/Site operative	23	Egg dispersal	0	Zebra Mussel, Japanese Knotweed, Cape Pondweed, Pirri-pirri burr, Common Ragweed, Water Fern, Butterfly Bush, Asian clam, Northern River Amphipod, Dikerogammarus haemobaphes, Killer shrimp, Quagga mussel, Giant Knotwood, Floating pennywort, Curly Waterweed, Monkey flower
		Egg laying	1	
		Live bearing	5	
		planktonic larva	3	
		Seed/spore dispersal	15	
		Vegetative	16	
Waterfowl/animal (Phoresis)	21	Egg dispersal	0	Zebra Mussel, Japanese Knotweed, Cape Pondweed, Pirri-pirri burr, Australian Blackwood, Three-cornered Garlic, Water Fern, Northern River Amphipod, Swamp Stonecrop, Quagga mussel, Giant Rhubarbs, Floating pennywort, Curly Waterweed, Water Primrose, Rusty Crayfish, Spiny-cheek crayfish, Virile Crayfish, Signal Crayfish, New Zealand Mudsnail, Rhododendron, False acacia
		Egg laying	1	
		Live bearing	5	
		planktonic larva	2	
		Seed/spore dispersal	14	
		Vegetative	14	
Boat/Leisure Craft	16	Egg dispersal	0	

Additional Pathways	No. of Species	Reproductive pathways of the species selected by additional pathway (No. of Species)		Species selected as likely to be facilitated by the water transfer.
		Egg laying	2	Zebra Mussel, Water Fern, Carolina Fanwort, Asian clam, Northern River Amphipod, Swamp Stonecrop, Dikerogammarus haemobaphes, Killer shrimp, Quagga mussel, Giant Knotwood, Floating pennywort, Curly Waterweed, Parrot's Feather, Andean water milfoil, Ponto-Caspian gobies, New Zealand Mudsnail
		Live bearing	4	
		planktonic larva	3	
		Seed/spore dispersal	7	
		Vegetative	8	
Walkers/Bikers	9	Egg dispersal	0	Japanese Knotweed, Pirri-pirri burr, Common Ragweed, Water Fern, Butterfly Bush, Giant Knotwood, Monkey flower, Himalayan knotweed, New Zealand Mudsnail
		Egg laying	1	
		Live bearing	0	
		planktonic larva	0	
		Seed/spore dispersal	8	
		Vegetative	8	
Wind	5	Egg dispersal	0	Tree-of-Heaven, Butterfly Bush, Pampas grass, Rhododendron, False acacia
		Egg laying	0	
		Live bearing	0	
		planktonic larva	0	
		Seed/spore dispersal	2	
		Vegetative	2	
Flood	20	Egg dispersal	0	Zebra Mussel, Japanese Knotweed, Cape Pondweed, Pirri-pirri burr, Water Fern, Butterfly Bush, Carolina Fanwort, Quagga mussel, Giant Knotwood, Floating pennywort, Curly Waterweed, Pumpkinseed, Water Primrose, Monkey flower, Parrot's Feather, Andean water milfoil, Signal Crayfish, New Zealand Mudsnail, Rhododendron, False acacia
		Egg laying	2	
		Live bearing	1	
		planktonic larva	2	
		Seed/spore dispersal	15	
		Vegetative	16	
Construction	12	Egg dispersal	0	Japanese Knotweed, Common Ragweed, Water Fern, Butterfly Bush, Giant Knotwood, Giant Rhubarbs, American skunk cabbage, Monkey flower, Signal Crayfish, Himalayan knotweed, Rhododendron, False acacia
		Egg laying	1	
		Live bearing	1	
		planktonic larva	0	
		Seed/spore dispersal	11	
		Vegetative	10	

3.4. Cotswold Canal Transfer

During operation a volume of up to 300 Ml/d would be transferred via a series of canals and pipelines from the River Severn at Gloucester to the Thames at Culham. Water from the River Severn is to be transported to the Thames in the following steps:

- Abstraction from the River Severn with discharge to the adjacent Gloucester and Sharpness Ship Canal at the Gloucester Docks Basin;
- Transfer by gravity along the operational Gloucester and Sharpness Ship Canal;
- Abstraction from the Gloucester and Sharpness Ship Canal at Saul Junction;
- [redacted] located at [redacted] and [redacted] to [redacted];
- Open channel transfer along Newtown Pound, part of the Stroudwater Navigation;
- Abstraction from Newtown Pound at [redacted] and [redacted] to [redacted];
- Summit pond including Sapperton Tunnel. The tunnel is to be rehabilitated to allow for open channel water transfer;
- Transfer by gravity from Summit Pound to Thames (at Inglesham near Lechlade). In this section water is transferred along the canal by gravity, until it meets the River Thames at or near

Lechlade, and the locks are by-passed. This bypass arrangement is required to enable the locks to be used for navigation during the transfer;
- Water Treatment Works; and
- Pipeline to convey transfer flows to a discharge location at Culham.

Mitigation measures, including water treatment intended to prevent the transfer of INNS have been incorporated into the conceptual design of the option, however for the purpose of this assessment these mitigation measures are not considered, in order to understand the pre-mitigation risk. The assessment has been undertaken to understand the relative risk of the transfer INNS based upon a transfer volume of 300ml/d from the River Severn via canal to the Thames.

As such, the total length of open-channel along the conveyance route including the Gloucester Sharpness Canal, Stroudwater Navigation and Thames and Severn Canal has been used to calculate the transfer distance.

Results of the assessment are visible in **Table 10**. The risk score provided by the assessment tool for the Cotswolds Canal Transfer indicates the transfer poses a "High Risk" of transferring INNS. A total of 55 species are selected in this scenario.

Table 10: Result of the REE Assessment tool implemented in the assessment of discharge volumes anticipated during the operation of Option 1a and 2a between the River Vyrnwy and River Severn to Deerhurst.

	300 Ml/d
Operation parameters	120days, in Summer, Autumn or Winter.
Connection source habitat	Lowland River
Additional INNS transfer pathways present at the connection source habitat.	Anglers Boat/Leisure Craft Walkers/Bikers Pet/ornamental release Waterfowl/animal (Phoresis) Wind Flood Survey/Site operative
Connection Mechanism Habitat	Canal
Additional INNS transfer pathways present at the connection Mechanism habitat.	Anglers Boat/Leisure Craft Walkers/Bikers Pet/ornamental release Waterfowl/animal (Phoresis) Wind Flood Survey/Site operative Construction operations
Connection Destination	Lowland River
INNS listed within the database which may be transported from the connection source and establish in the connection mechanism, and/or, from the connection mechanism and establish in connection destination assuming no mitigation is in place.	Zebra Mussel Japanese Knotweed Cape Pondweed Pirri-pirri burr Australian Blackwood Tree-of-Heaven Three-cornered Garlic Common Ragweed Giant Cane Noble Crayfish Turkish Crayfish Water Fern Butterfly Bush Carolina Fanwort Asian clam Pampas grass Northern River Amphipod

	300 Ml/d
	Swamp Stonecrop Dikerogammarus haemobaphes Killer shrimp Quagga mussel Large-flowered Waterweed Canadian Pondweed Nuttall's waterweed Tingiringi Gum Cider Gum Shining Gum Giant Knotwood Giant Rhubarbs Floating pennywort Curly Waterweed Pumpkinseed Water Primrose Monkey flower Parrot's Feather Andean water milfoil Rusty Crayfish Spiny-cheek crayfish Virile Crayfish Signal Crayfish Himalayan knotweed Ponto-Caspian gobies New Zealand Mudsnail White river crayfish Marbled Crayfish Red swamp Crayfish American Bullfrog Rhododendron False acacia Zander African Clawed-frog Alpine Newt Topmouth gudgeon Giant Salvinia Marbled newt
Seasonality of the transfer? Year-round, spring, summer etc.	Summer - Winter
Connection Risk Score =((Volume of water transferred × duration of transfer) × Frequency of transfer) × Distance of the transfer for Open Channel connections	1843200
INNS transfer risk score = (Sum of (species risk score x INNS Risk Potential Factor) x Connection risk score)	2508595200
Waterbody connectivity	3 - Between WFD Catchments.
Final Score with Waterbody/Catchment Weighting	7525785600
Logarithm transformation (Log^{10})	9.88
Category	Very High Risk

3.4.1. Cotswolds Canal Transfer Species / Pathway Breakdown

A break-down of the distribution pathways and species which have been selected by the assessment tool during the assessment of the Cotswolds Canal transfer are summarised in **Table 11**. The species listed provided an indication of the life histories and reproductive types that may be distributed by the pathways linked to the pipeline. A summary of the pathway types is provided in **Section B.3.5.2**.

Table 11: Species within Questionnaire 1 which are selected by the assessment tool that may be distributed by pathways to the connection source or mechanism habitats and further distributed by the RWT.

Additional Pathways	No. of Species	Reproductive pathways of the species selected by additional pathway (No. of Species)		Species selected as likely to be facilitated by the water transfer.
Pet/ornamental release	38	Egg dispersal	0	Cape Pondweed, Pirri-pirri burr, Australian Blackwood, Tree-of-Heaven, Three-cornered Garlic, Giant Cane, Noble Crayfish, Turkish Crayfish, Water Fern, Butterfly Bush, Carolina Fanwort, Pampas grass, Northern River Amphipod, Swamp Stonecrop, Large-flowered Waterweed, Canadian Pondweed, Nuttall's waterweed, Tingiringi Gum, Cider Gum, Shining Gum, Giant Rhubarbs, Curly Waterweed, Pumpkinseed, Water Primrose, Monkey flower, Parrot's Feather, Andean water milfoil, Rusty Crayfish, Spiny-cheek crayfish, Virile Crayfish, Signal Crayfish, Himalayan knotweed, Ponto-Caspian gobies, White river crayfish, Marbled Crayfish, Red swamp Crayfish, American Bullfrog, Rhododendron, False acacia, African Clawed-frog, Alpine Newt, Topmouth gudgeon, Giant Salvinia, Marbled newt
		Egg laying	10	
		Live bearing	7	
		planktonic larva	0	
		Seed/spore dispersal	26	
		Vegetative	25	
Angling	26	Egg dispersal	0	Zebra Mussel, Japanese Knotweed, Cape Pondweed, Noble Crayfish, Water Fern, Butterfly Bush, Asian clam, Dikerogammarus haemobaphes, Killer shrimp, Quagga mussel, Large-flowered Waterweed, Canadian Pondweed, Nuttall's waterweed, Giant Knotwood, Floating pennywort, Curly Waterweed, Water Primrose, Monkey flower, Andean water milfoil, Rusty Crayfish, Spiny-cheek crayfish, Virile Crayfish, Signal Crayfish, Ponto-Caspian gobies, New Zealand Mudsnail, White river crayfish, Marbled Crayfish, Red swamp Crayfish, Zander, Alpine Newt, Topmouth gudgeon
		Egg laying	7	
		Live bearing	9	
		planktonic larva	3	
		Seed/spore dispersal	14	
		Vegetative	14	
Survey/Site operative	23	Egg dispersal	0	Zebra Mussel, Japanese Knotweed, Cape Pondweed, Pirri-pirri burr, Common Ragweed, Water Fern, Butterfly Bush, Asian clam, Northern River Amphipod, Dikerogammarus haemobaphes, Killer shrimp, Quagga mussel, Large-flowered Waterweed, Giant Knotwood, Floating pennywort, Curly Waterweed, Monkey flower, Parrot's Feather, Andean water milfoil, Signal Crayfish, Himalayan knotweed, New Zealand Mudsnail, Rhododendron, False acacia
		Egg laying	1	
		Live bearing	5	
		planktonic larva	3	
		Seed/spore dispersal	16	
		Vegetative	17	
Waterfowl/animal (Phoresis)	21	Egg dispersal	0	Zebra Mussel, Japanese Knotweed, Cape Pondweed, Pirri-pirri burr, Australian Blackwood, Three-cornered Garlic, Water Fern, Northern River Amphipod, Swamp Stonecrop, Quagga mussel, Canadian Pondweed, Nuttall's waterweed, Giant Rhubarbs, Floating pennywort, Curly Waterweed, Water Primrose, Rusty Crayfish, Spiny-cheek crayfish, Virile Crayfish, Signal Crayfish, New Zealand Mudsnail, Rhododendron, False acacia, Topmouth gudgeon
		Egg laying	2	
		Live bearing	5	
		planktonic larva	2	
		Seed/spore dispersal	16	
		Vegetative	16	

Additional Pathways	No. of Species	Reproductive pathways of the species selected by additional pathway (No. of Species)		Species selected as likely to be facilitated by the water transfer.
Boat/Leisure Craft	16	Egg dispersal	0	Zebra Mussel, Water Fern, Carolina Fanwort, Asian clam, Northern River Amphipod, Swamp Stonecrop, Dikerogammarus haemobaphes, Killer shrimp, Quagga mussel, Large-flowered Waterweed, Canadian Pondweed, Nuttall's waterweed, Giant Knotwood, Floating pennywort, Curly Waterweed, Parrot's Feather, Andean water milfoil, Ponto-Caspian gobies, New Zealand Mudsnail
		Egg laying	2	
		Live bearing	4	
		planktonic larva	3	
		Seed/spore dispersal	10	
		Vegetative	11	
Walkers/Bikers	9	Egg dispersal	0	Japanese Knotweed, Pirri-pirri burr, Common Ragweed, Water Fern, Butterfly Bush, Giant Knotwood, Monkey flower, Himalayan knotweed, New Zealand Mudsnail
		Egg laying	1	
		Live bearing	0	
		planktonic larva	0	
		Seed/spore dispersal	8	
		Vegetative	8	
Wind	5	Egg dispersal	0	Tree-of-Heaven, Butterfly Bush, Pampas grass, Rhododendron, False acacia
		Egg laying	0	
		Live bearing	0	
		planktonic larva	0	
		Seed/spore dispersal	5	
		Vegetative	5	
Flood	20	Egg dispersal	0	Zebra Mussel, Japanese Knotweed, Cape Pondweed, Pirri-pirri burr, Water Fern, Butterfly Bush, Carolina Fanwort, Quagga mussel, Large-flowered Waterweed, Canadian Pondweed, Nuttall's waterweed, Giant Knotwood, Floating pennywort, Curly Waterweed, Pumpkinseed, Water Primrose, Monkey flower, Parrot's Feather, Andean water milfoil, Signal Crayfish, New Zealand Mudsnail, Rhododendron, False acacia, Topmouth gudgeon
		Egg laying	3	
		Live bearing	1	
		planktonic larva	2	
		Seed/spore dispersal	18	
		Vegetative	19	
Construction	23	Egg dispersal	0	Japanese Knotweed, Common Ragweed, Water Fern, Butterfly Bush, Giant Knotwood, Giant Rhubarbs, Monkey flower, Signal Crayfish, Himalayan knotweed, Rhododendron, False acacia
		Egg laying	0	
		Live bearing	1	
		planktonic larva	0	
		Seed/spore dispersal	10	
		Vegetative	10	

4. Summary and recommendations

The implementation of the REE assessment tool categorised all connection within the STT between "High Risk" and "Very High Risk" with risk scores between 6.47 and 9.88.

The lowest scoring connection assessed was Connection A of the Vyrnwy Bypass pipeline, transferring 80 Ml/d via a pipeline to the Lower Vyrnwy. This connection scored lowest on account of the relatively low volume and pipeline transfer mechanism which reduced the total available open channel habitat to which INNS may be transferred and establish.

The highest scoring connections were the 155 Ml/d transfer scenario from the River Vyrnwy (Vyrnwy release and Vyrnwy Bypass combined) to the River Severn, and the Cotswold Canal Transfer which both 9.54 and 9.88 achieving a "Very High Risk" categorisation. In both scenarios the major factor influencing the risk score was distance of open channel habitat which may be utilised by INNS.

The risk of increasing the distribution of INNS between the River Vyrnwy and the River Severn needs to be considered in the context of the existing connection of the compensation releases, regulatory releases and flood drawdown releases that are extant.

In comparison the Deerhurst Pipeline connection scored notably lower than the Gloucester Canal transfer scenario despite identical transfer volumes, source and destination habitats, addition pathways present at the source habitat and the tool selecting for a similar assemblage of INNS. The Deerhurst Pipeline scores lower because of the implementation of a pipeline, reducing the open-channel habitat that may be utilised by INNS as well as excluding the additional pathways presented by the Canal and therefore reducing the overall habitat which may be impacted by INNS because of the transfer.

It should be noted that this assessment excludes the implementation of mitigation measures. Mitigation measures, including water treatment intended to prevent the transfer of INNS have been incorporated into the conceptual design of both the pipe and canal interconnector. Despite the mitigation measures, the open-channel habitat provided by the canal, will result in additional pathway being present for the distribution of INNS into the wider catchment, particular where these pathways are associated with recreational users and the uncertainty with regards to the effectiveness of any biosecurity measures related to such users.

The National Appraisal Unit (NAU) has identified that for Gate 2 the requirements will include a full INNS Pathway Risk Assessments which complies with EA guidance. Gate 2 assessments will also need to consider:

- if risks can be mitigated and whether uncertainties can be managed; and
- consulting on mitigation measures.

The NAU will be providing an updated risk assessment tool for the Gate 2 assessments and it is recommended that the risk assessments completed to date is updated to consider the availability of any new tools.

It is also recommended that the current monitoring programme for INNS continues to ensure a robust baseline of the distribution of INNS at the relevant discharge/abstraction locations.

Although not considered in the pathway approach to risk assessment, species data is still important to inform the types of mitigation that will be most suitable to consider in any further scheme design.

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