Strategic Regional Water Resource Solutions: Annex B3.6: Protected Habitat Assessment

Standard Gate Two Submission for River Severn to River Thames Transfer (STT)

Date: November 2022

Severn to Thames Transfer

Protected Assessment

STT-G2-S3-117

November 2022

Disclaimer

This document has been written in line with the requirements of the RAPID Gate 2 Guidance and to comply with the regulatory process pursuant to Thames Water's, Severn Trent Water's and United Utilities' statutory duties. The information presented relates to material or data which is still in the course of completion. Should the solution presented in this document be taken forward, Thames Water, Severn Trent Water and United Utilities will be subject to the statutory duties pursuant to the necessary consenting processes, including environmental assessment and consultation as required. This document should be read with those duties in mind.

SEVERN THAMES TRANSFER (STT) SOLUTION

Protected Habitats Assessment Report

Ricardo ref. ED15323 Issue: 005 11/10/2022

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1. INTRODUCTION

1.1 BACKGROUND AND DESCRIPTION OF THE STT SCHEME

1.1.1 The River Severn to River Thames Transfer Description

The aim of the Severn Thames Transfer is to provide additional raw water resources of 300 to 500Ml/d to the South East of England during drought, with 500Ml/d preferred by the Water Resources in the South East (WRSE) group's emerging regional plan. The water would be provided from flows in the River Severn and transferred via an interconnector to the River Thames. For the completion of the Gate 2 assessment, a pipeline "Interconnector" has been selected as the preferred option to transfer water from the River Severn to the River Thames.

Due to the risk of concurrent low flow periods in both river catchments, additional sources of water, apart from those naturally occurring in the River Severn, have been identified to augment the baseline flows. These multiple diverse sources of additional water provide resilience in the provision of raw water transfer to the River Thames. A 'put and take' arrangement has been agreed in principle with the Environment Agency (EA) and Natural Resources Wales (NRW) which means that if additional source water is 'put' into the river, then the Interconnector can 'take' that volume, less catchment losses, regardless of the baseline flows in the River Severn itself.

The regional planning process will determine the volume, timing, and utilisation of water to be transferred. The diversity of sources means they can be developed in a phased manner to meet the ultimate demand profile as determined by the regional planning. These additional sources of water are being provided by United Utilities (UU) and Severn Trent Water (STW) who are working in collaboration with Thames Water (TW) to develop this solution. The additional sources are:

- **Vyrnwy Reservoir**: Release of 25Ml/d water licensed to UU from Lake Vyrnwy directly into the River Vyrnwy;
- **Vyrnwy Reservoir**: Utilisation of 155Ml/d water licensed to UU from Lake Vyrnwy and transferred via a bypass pipeline ("Vyrnwy Bypass") to the River Severn;
- **Shrewsbury**: Diversion of 25Ml/d treated water from UU's Oswestry Water Treatment Works (WTW) via an existing emergency transfer (the Llanforda connection), thus enabling a reduction in abstraction from the River Severn at Shelton WTW to remain in the River Severn for abstraction at Deerhurst;
- **Mythe**: 15Ml/d of the Severn Trent Water licensed abstraction at Mythe remaining in the River Severn for abstraction at Deerhurst;
- **Minworth**: The transfer of 115Ml/d of treated wastewater discharge from Severn Trent Water's Minworth Wastewater Treatment Works (WwTW) via a pipeline, to the River Severn via the River Avon at Stoneleigh; and
- **Netheridge**: The transfer of 35Ml/d of treated wastewater discharge at Severn Trent Water's Netheridge WwTW to the River Severn at Haw Bridge, via a pipeline, upstream of the current discharge to the River Severn.

The STT Gate 1 submission was assessed by the Regulators' Alliance for Progressing Infrastructure Development (RAPID) who concluded that it should progress to standard Gate 2. The recommendations and actions received from RAPID and feedback from stakeholders from the Gate 1 process have been reflected in the scheme development and environmental assessments.

1.1.2 Gate 2

RAPID issued a guidance document[1] in April 2022 to describe the Gate 2 process and set out the expectations for solutions at standard Gate 2.

The guidance stated the environmental assessment methodologies should be consistent with any relevant legislation and guidance, and follow best practice. This includes, where relevant, Water Resource Management Plan (WRMP) guidance for 2024, All Company Working Group (ACWG) guidance[2] and the Environment Agency Invasive Non-native Species risk assessment tool.

Figure 1.1 shows the investigations being undertaken for STT Gate 2 and their interactions, in order to show the full scope of work across both environmental and engineering disciplines. Reporting for the environmental investigations has been undertaken in a phased way to account for, and incorporate all previous assessments, data collection and feedback: (i) the evidence reports were produced first, and set out the data and evidence to be used in the assessments; (ii) assessment reports were then produced using the evidence to determine the potential effect of the STT solution on the physical environment, water quality and ecological receptors (dark blue box in in Figure 1.1); (iii) based on the evidence and assessments, the statutory reports, and assessments required to meet the RAPID and regulatory expectations for solutions at Gate 2 were produced.

This report presents an assessment of the effect of the solution on the physical environment. It informs other assessments, including the statutory assessments.

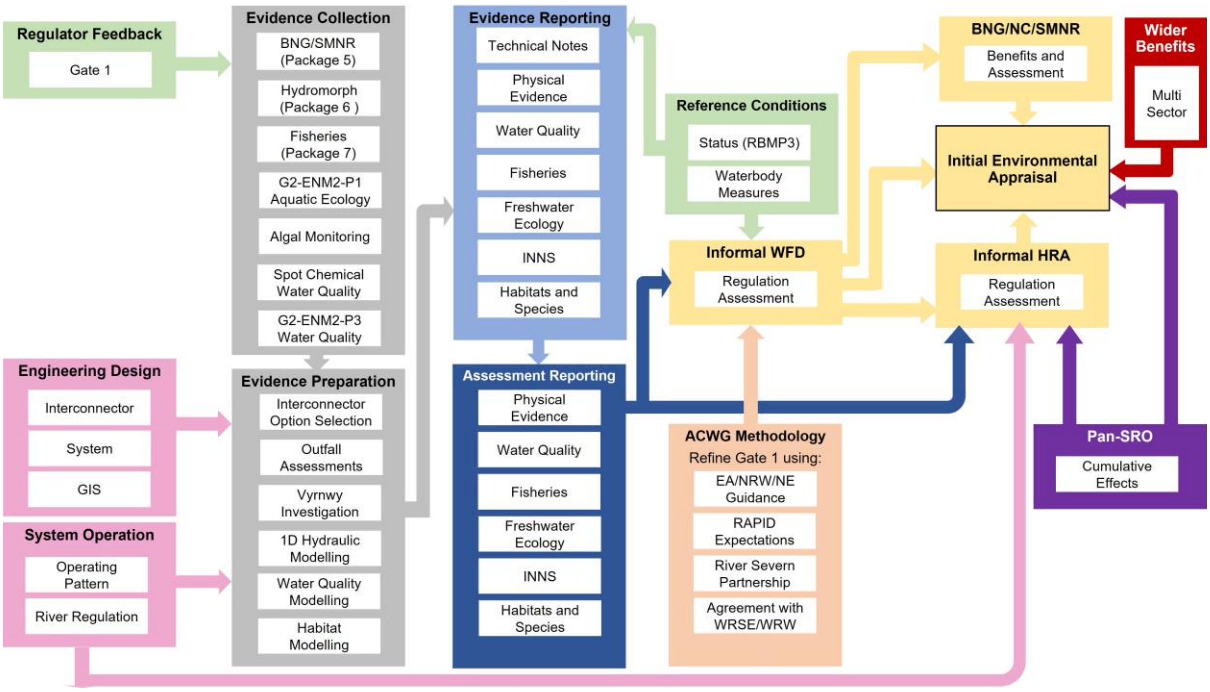

Figure 1.1 Flow chart showing the scope of investigations for STT Gate 2 and their interactions

[1] RAPID (2022) Strategic regional water resource solutions guidance for Gate 2

[2] All Companies Working Group (2020) WRMP environmental assessment guidance and applicability with SROs

1.2 STUDY AREA

The study area for the STT solution for Gate 2 assessment is limited to specific reaches, as shown in **Figure 1.2**:

1. The River Vyrnwy catchment (River Vyrnwy from Vyrnwy Reservoir to the confluence with the River Severn);
2. The River Severn catchment (River Severn from the confluence with the River Vyrnwy to the Severn Estuary), as well as those tributaries of the River Severn which could indirectly be affected by the operation of the STT solution;
3. The Warwickshire River Avon upstream of Warwick to the River Severn confluence; and
4. The River Thames catchment (River Thames from Culham to Teddington Weir)

It should be noted that the consideration of impacts in the River Tame and Trent, from the transfer of treated discharge from Minworth Wastewater Treatment Works (WwTW) to the River Avon, is included in Severn Trent Water's Minworth Strategic Resource Option (SRO) and therefore excluded from the STT solution assessment.

Similarly, the STT solution assessment accounts for the effects from the relevant SROs related to the supply of water into the STT system (United Utilities and Severn Trent Water Sources). It therefore includes an assessment of the potential effects of the water arising from the outfalls from the transfers (Minworth and Netheridge). It does not cover the impact of infrastructure construction as this is included in Severn Trent Water's Minworth and Sources SRO assessments.

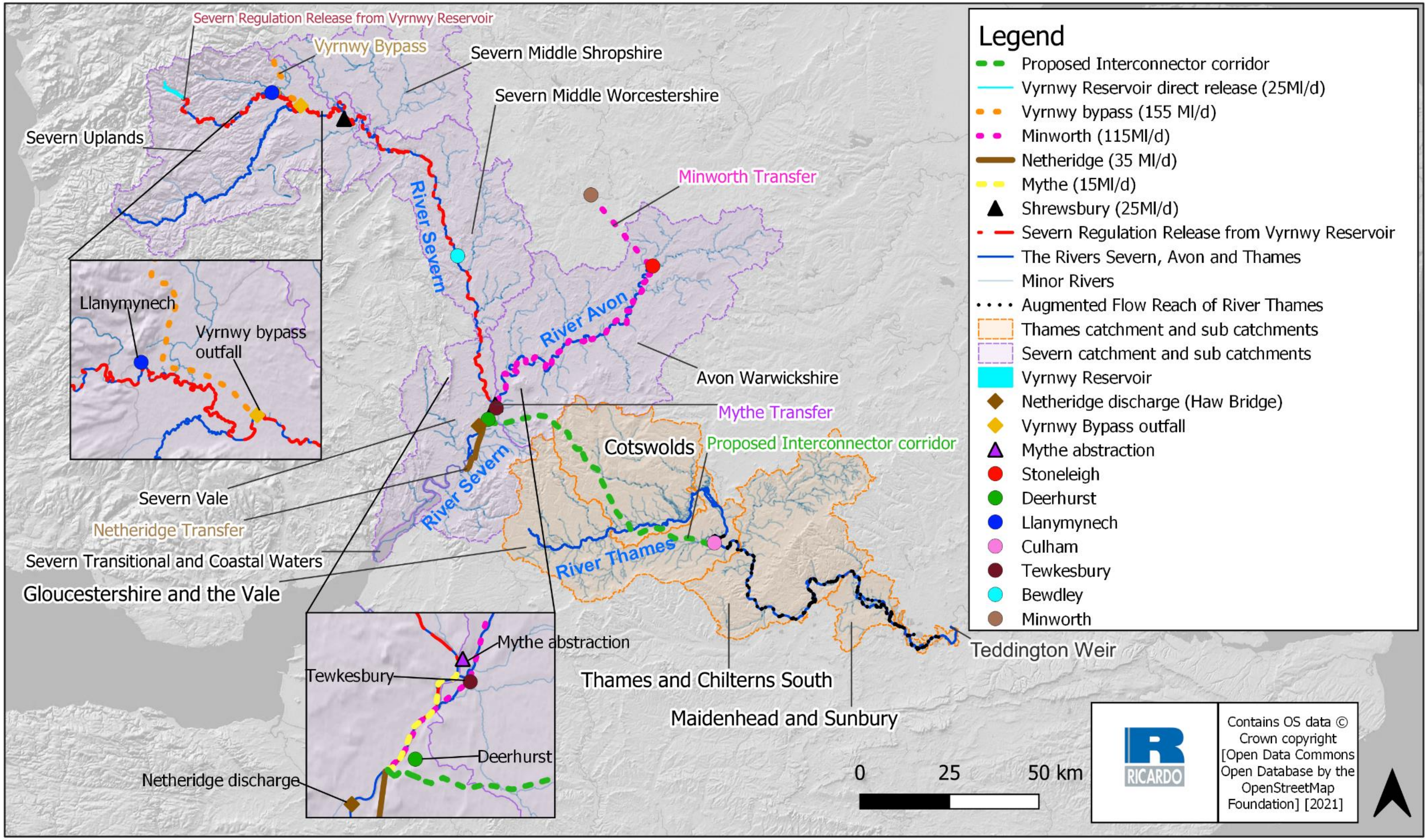

Figure 1.2 Map showing the study area and associated catchments

1.3 SUMMARY OF THE SOLUTION COMPONENTS AND OPERATION

The STT solution developed for Gate 2 is described through its engineering components in the Conceptual Design Report. For environmental assessment purposes, as these relate to in-river physical environment effects, the solution has been split into two phases, with and without support, described as (i) an *early phase* of the STT solution, which is without the inclusion of most of the support options that augment flow in the River Severn (see Section 1.1.1), and (ii) a *full STT* solution, which includes all the support options. The river flow changes that comprise these two phases are set out in Table 1-1.

Supporting options would be operational at those times when the STT is transferring water from the River Severn to the River Thames, and when flows in the River Severn are lower than hands-off flow (HoF) thresholds in the River Severn. The EA has advised that a STT abstraction licence would be imposed so flows at Deerhurst flow gauging station do not drop below 2,568 Ml/d. Above this HoF, there is a maximum abstraction limit of 172 Ml/d, up to the next HoF condition of 3,333 Ml/d, where 335 Ml/d can be abstracted, in addition to the available 172 Ml/d unsupported[3]. This is summarised in Table 1-2.

The EA has advised the STT Group of appropriate values of "in-river losses" to include in the hydraulic modelling[4] and subsequent environmental assessments. The advised values include a 20% loss in the River Vyrnwy and a 10% loss for water transferred into the River Avon, in the augmented flow reach between Stoneleigh and the River Severn confluence at Tewkesbury, with the loss occurring evenly over the distance. As such, of the total 370Ml/d supporting flows augmenting flows into the River Severn catchment for full STT, the equivalent re-abstraction value at Deerhurst used for the environmental assessment is 353Ml/d as represented in Figure 1.3.

Table 1-1 Components of Early Phase and Full STT Operation

Early Phase STT	Full STT
500Ml/d interconnector pipeline.	500Ml/d interconnector pipeline
Part-time, *unsupported* abstraction up to 500Ml/d from the River Severn at Deerhurst and transferred to the River Thames at Culham, subject to hands-off flow conditions identified by the EA.	Part-time, *unsupported* abstraction up to 500Ml/d from the River Severn at Deerhurst and transferred to the River Thames at Culham, subject to hands-off flow conditions identified by EA
Part-time, *supported* abstraction up to 35Ml/d from the River Severn at Deerhurst and transferred to the River Thames at Culham, at flows constrained by hands-off flow conditions, provided by 35Ml/d flow volume from the Netheridge Transfer. The early phase STT solution does not include the full range of support options and as such supported abstraction is limited to the value of the Netheridge Transfer, 35 Ml/d.	Part-time, supported abstraction up to 353Ml/d from the River Severn at Deerhurst and transferred to the River Thames at Culham, at flows constrained by hands-off flow conditions, and accounting for assumed river transfer losses. Flow provided by UU and STW sources. The order in which these sources are utilised has been determined by optimising the engineering solution and through the regional water resilience modelling by Water Resource South East (WRSE): 1. **Vyrnwy Reservoir:** Release of 25Ml/d water licensed to UU from Lake Vyrnwy directly into the River Vyrnwy; 2. **Vyrnwy Reservoir**: Utilisation of 155Ml/d water licensed to UU from Lake Vyrnwy and transferred via a bypass pipeline ("Vyrnwy Bypass") to the River Severn; 3. **Shrewsbury**: Diversion of 25Ml/d treated water from UU's Oswestry Water Treatment Works (WTW) via an existing emergency transfer (the Llanforda connection), thus enabling a reduction in abstraction from the River Severn at Shelton WTW to remain in the River Severn for abstraction at Deerhurst;

[3] Email from Caroline Howells (Environment Agency Environment Planning Officer) to Peter Blair (Thames Water, Water Resources Modelling Specialist) 27 February 2020.

[4] Email from Alison Williams (Environment Agency Senior Water Resources Officer) to Helen Gavin (Ricardo) and Valerie Howden (HRW) on 10 February 2022.

Early Phase STT	Full STT
	4. **Mythe**: 15Ml/d of the Severn Trent Water licensed abstraction at Mythe remaining in the River Severn for abstraction at Deerhurst; 5. **Minworth**: The transfer of 115Ml/d of treated wastewater discharge from Severn Trent Water's Minworth Wastewater Treatment Works (WwTW) via a pipeline, to the River Severn via the River Avon at Stoneleigh; and 6. **Netheridge**: 35Ml/d of the Severn Trent Water licensed abstraction piped to the River Severn for abstraction at Deerhurst.
Continuous abstraction from River Severn at Deerhurst of 20Ml/d to provide a pipeline maintenance flow, with continuous transfer to River Thames at Culham: • Either unsupported abstraction when not limited by hands-off flow conditions; or • Supported abstraction by flow volume matching from Netheridge Transfer	Continuous abstraction from River Severn at Deerhurst of 20Ml/d to provide a pipeline maintenance flow, with continuous transfer to River Thames at Culham: • Either unsupported abstraction when not limited by hands-off flow conditions; or • Supported abstraction by flow volume matching from Netheridge Transfer

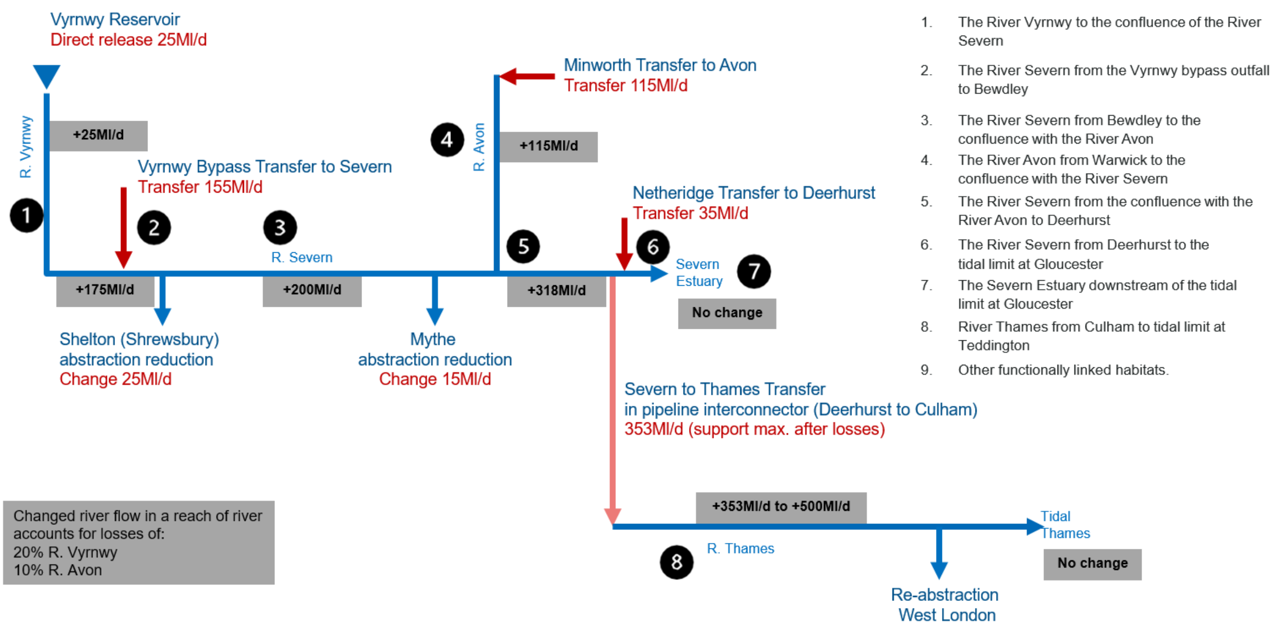

Figure 1.3 Schematic representing flow changes (accounting for losses) of STT Solution

Table 1-2 River Severn at Deerhurst: HoF conditions provided by EA

HoF	Flow threshold (Ml/d)	Maximum abstraction value at flows greater than the threshold (Ml/d)
1	2,568	172
2	3,333	527

To support the environmental assessments at Gate 2, an indicative operating pattern has been developed. The approach uses the 19,200 year stochastic flow series developed separately for the River Severn catchment for the Water Resources West (WRW) group and for the River Thames catchment for the WRSE group. The stochastic flow series represent contemporary climate conditions and provide information on the return frequency, or regularity, of both the likely river flow conditions and STT operation. The stochastic years have been made available as 48-year continuous periods, and one of those has been selected as having representative flow characteristics to inform the environmental assessments. The selected 48-year series[5] includes a suitable range of regular low and moderate low flow periods. It does not include extreme low flows that are considered to be less regular than once every fifty years. This is described further in the Physical Environment Assessment Report with the derived representation of dates with the full STT in operation (for water resources purposes) as used in environmental assessment shown in Figure 1.4. It should be noted that this operating pattern is for the STT solution used on its own for Thames Water, without conjunctive use with other Thames Water SROs (such as the South East Strategic Resource Option (SESRO)). It also uses the controlling triggers developed by Thames Water for SESRO based on lower River Thames flows and Thames Water's total London reservoir storage.

The general description in Figure 1.4 identifies periods in purple when the early phase STT pattern would be in operation: the combined purple and blue periods show the periods when the full STT operation pattern is being deployed. The review of river flows and operating patterns for the environmental assessment has identified that all support options would be on at the same time, rather than any selective or preferential use of support sources. These patterns of river flow and operational need inform the range of likely environmental effects of the scheme. Having identified these patterns, selected return frequencies have been selected for the detailed assessment for Gate 2, which has included hydraulic modelling of different scenarios. The scenarios modelled are:

- a 1:5 return frequency year with moderate-low flows in the River Severn at Deerhurst with a 1:5 return frequency operating pattern in terms of duration and season (model reference A82); and
- a 1:20 return frequency year with very low flow years in the River Severn at Deerhurst with a 1:20 return frequency operating pattern in terms of duration and season (model reference M96).

Noting the scheme would only be used on a 1:2 return frequency, these scenarios capture a suitable range of circumstances and have been discussed and reviewed with the regulators during Gate 2.

It should be noted that, in addition to the above, a 1:50 return frequency year of extremely low flows in the River Severn at Deerhurst and with a 1:20 return frequency operating pattern in terms of duration and season (model reference N17), has been prepared and reviewed for the consideration of scheme resilience. Such a low return frequency is outside the regularity of occurrence included in WFD assessments and is thus not described further in this report.

The Gate 2 assessment also incorporates climate change scenarios into 1D hydraulic models for the assessment for the rivers and Severn Estuary pass-forward flows. The A82 Future and M96 Future years are illustrative of the potential types of changes to river flows and operating patterns in the future. This is described further in the Physical Environment Assessment Report. At this stage, as the full 19,200 stochastic years have not been reworked as 2070s RCM8.5 futures, it is not possible to derive a suitable 48 year period that is representative of the return frequencies for the environmental assessments.

[5] Note these are 48 calendar years. The environmental assessment period has been selected as a water resources year (1 April to 31 March) and as such the selected period includes 47 water resources years from the 48 calendar years,

Figure 1.4 Representation of dates full STT solution would be on (for water resources purposes) as used in the environmental assessment

Where: purple indicate periods when the early phase STT would be in operation (unsupported abstraction); and the combined purple and blue periods (supported abstraction) indicate the full STT

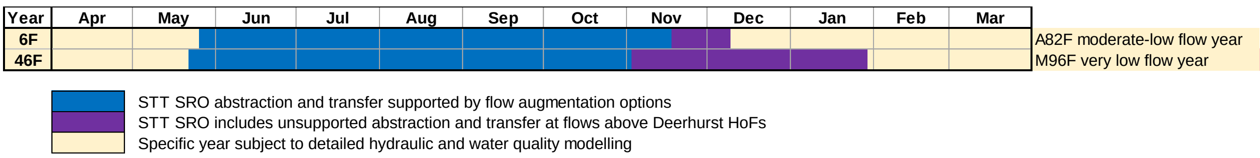

Figure 1.5 Representation of dates full STT solution would be on (for water resources purposes) for selected future scenarios as used in the environmental assessment

Where: purple indicates periods of unsupported abstraction and blue indicates periods of supported abstraction

1.4 SCOPE OF THIS REPORT

The report assesses the potential impacts of the STT solution on protected habitats. It analyses the information and data set out in the Evidence Report. The findings of the analysis are presented on a reach by reach basis, addressing each metric of change. The information is presented in this way so there is clarity over where effects from the scheme are observed.

This report also identifies where more confidence could be placed in the results, through further evidence collection and analysis. NB The Evidence Report also identifies remaining data/evidence gaps, provides a summary of the proposed programme of works and approach to address any data/evidence gaps as part of RAPID's gated assessment for the solution.

This assessment covers only operational impacts to protected habitats associated with hydrologically impacted reaches associated with the STT scheme. The assessment of impacts to European sites (Special Area of Conservation, Special Protected Areas, and Ramsar sites) are included in the Habitat Regulations Assessment Report[6]. Construction related impacts to protected habitats area included as part of the Biodiversity Net Gain and Natural Capital Assessment reports.

1.4.1 Link with other Reports

The Protected Habitats Evidence Report sets out a data catalogue of the information sources that have been used to perform the assessment.

The results and findings presented in this report show the effects of the STT scheme on the protected habitats as a result of changes in flow, velocity, depth, level and water quality. These findings are used by many of the STT Gate 2 Environmental Assessment and Statutory Reports which interpret the significance of the changes for their specific feature(s) or topic of interest.

[6] See: STT-S5-022-AppB4.2Regulatory Assessment Reports HRA

2. ASSESSMENT

2.1 SUMMARY OF THE APPROACH

2.1.1 Overview of approach

The scope of the assessment of effects on the hydrologically connected water dependent designated sites and protected habitats arising from the STT solution required for Gate 2 and the approach to undertaking this assessment is described in **Table 2.1**. This table is replicated from the Gate 2 Protected Habitats Evidence Report.

Table 2.1 Approach to the Gate 2 assessment of the protected habitats

Task item	Scope of assessment	Approach to assessment	Evidence Base for Task
a. Habitat assessment (using UKHab, hydrological connectivity walkovers, and MoRPh survey data in addition to outputs from the hydrological and physical environment assessments)	• Draft baseline sections to include the data requested from regulators and Local Record Centres • Include baseline data from UKHab, hydrological connectivity walkovers, and MoRPh River and Estuarine surveys • Complete impact assessment	• Review baseline data to determine the risk to terrestrial habitats during construction and operation of the STT solution. • Review baseline conditions to inform the extent of functionally linked habitat. • Suggest further mitigation measures (where required) for design/engineering interface. • Update the assessment to consider additional habitat data collected during Gate 1 and Gate 2. • Update the assessment to consider changes in scheme design and operation for Gate 2. • Consider the interpretation of the fluvial (flow) model, including the flow series at key locations for different scenarios to consider the risk of changes in velocities, depth and wetted margin that may impact on hydrologically (surface and groundwater) connected habitats. • Include relevant SRO monitoring programme survey data such as Acoustic Doppler Current Profiler (ADCP), habitat walkovers and River MoRPh survey outputs and additional habitat modelling at key locations. • Update assessment in consideration of the interpretation of the water quality assessment and model outputs to consider risk of water quality driven changes in vegetation community structure.	• Physical Environment and Water quality assessments will provide scenario outputs to consider in the assessments. • Open-source data on locations of protected habitats including designated sites and priority habitats. • UKHab surveys and hydrological connectivity walkovers undertaken by Ricardo for potentially hydrologically connected protected habitats and sites undertaken in August 2021. • Modular River Physical (MoRPh) surveys undertaken in July and August 2021 by Ricardo for watercourses associated with the proposed infrastructure locations and watercourses subject to hydrological or water quality changes. • Evidence and literature collated as part of the initial gap analysis of the STT.

2.1.2 Engagement with Stakeholders

In order to engage with regulators over the approach, evidence collection, monitoring programmes, and data analysis for Gate 2, the environmental assessment team have held monthly meetings with the Environment Agency (EA), Natural Resources Water (NRW) and Natural England (NE), in addition to topic-specific sessions and workshops with technical specialists. The regulators are asked to provide insights and inputs on specific aspects where needed in order to ensure the work undertaken is as robust as possible. They will review the Gate 2 assessment reports and findings.

In the monthly meetings, the programme, progress and deliverables are reviewed; issues are raised for clarification and resolution, and the regulators are asked for their views and advice on different topics or issues.

2.2 DATA AND EVIDENCE

The sensitivity of the protected habitats and potential impact pathways to physical environment changes have been informed by considering the relevant baseline data as summarised in the Protected Habitats Evidence Report[7]. These data include datasets from the National Biodiversity Network (NBN) Atlas, NBN Atlas Wales, Lle Geo-Portal, and Magic Maps. Habitats that are protected under UK legislation, considered as principle for conserving biodiversity are considered in this assessment. This includes habitats listed as of principal importance for the purpose of conserving biodiversity under Section 41 of the Natural Environment and Rural Communities Act (NERC) (2006) and habitats listed as priority in Section 7 of the Environment (Wales) Act (2016). Where possible, UK Technical Advisory Group on the Water Framework Directive Guidance on the Identification of Natura Protected Areas (final) March 2003 was used to identify whether protected habitats identified within the zone of influence are considered water depended.

This assessment is based on the results of the physical environment, water quality and flooding assessments. The Hydraulic model outputs including river flow, velocity and wetted depth used to inform the Physical Environment Assessment and flooding assessment are catalogued in the Gate 2 Physical Environment Evidence Report. Consequent wetted habitat model outputs are also catalogued in the Gate 2 Physical Environment Evidence Report.

Sites of international importance (Special Areas of Conservation, Special Protected Areas, Ramsar sites and Marine Conservation Zone) are excluded from this report as they are covered in the Habitat Regulation Assessment (HRA) for the STT scheme[8].

2.3 IDENTIFYING RELEVANT IMPACT PATHWAYS

The protected habitats associated with the STT operation provide a biological template for a number of protected species, including supporting habitat for many of the features associated with the Severn Estuary European Marine Site. The assessment of impacts on these habitats as a result of the operation of the STT should be considered in the context of the ecological requirements and the extent to which these requirements will be altered as a result of the operation of the STT. Where the supporting environmental variables within these habitats (e.g., flow, depth, water level, velocity, water quality) are modified to take them outside of their preferred envelope it can be assumed that there will be an impact on the particular habitat with potential impacts on the species depended on these habitats. Table 2.2 sets out the potential impact pathways for the different habitats associated with the STT based on the likely operational pattern and the potential changes in flow, velocity, depth and water quality.

A scoping exercise[9] was undertaken as part of the surveys of protected habitats with potential hydrological connectivity to the impacted reaches of the River Severn, and River Avon. It identified the following protected habitats and designated sites (with ecological features) (note that European designated sites are covered by the informal HRA Report[6]):

- River Severn (confluence with the River Vyrnwy to Shrewsbury):
  - Coastal and floodplain grazing marsh
  - Lowland fens
  - River Severn at Montford Site of Special Scientific Interest (SSSI)
- River Severn (confluence with the Shrewsbury to Confluence with the Avon) (reach not included in initial scoping exercise base on the Gate 1 assessment recommendations):
  - Coastal and floodplain grazing marsh
  - Lowland fens
  - Purple Moor Grass and Rush Pasture
  - Wet Woodland
- River Avon (downstream Warwick to the confluence with the River Severn):

[7] Ricardo Energy & Environment (2022). Severn to Thames Transfer SRO. Protected Habitats Evidence Report. Report for United Utilities on Behalf of the STT Group. February 2022.
[8] See: STT-S5-022-AppB4.2Regulatory Assessment Reports HRA
[9] Ricardo Energy and Environment (2021) Severn to Thames Transfer SRO Gate 2 Monitoring Programme – Protected Habitats Scoping Report. Report for Thames Water (on behalf of the STT Group). Ref: ED15474. July 2021.

- Coastal and floodplain grazing marsh
- Rectory Farm Meadows SSSI
- Upham Meadow and Summer Leasow SSSI
- Additional SSSIs adjacent to reach but not scoped in to monitoring surveys for potentially hydrologically connected protected habitats in Gate 1 assessment:
    - Guy's Cliffe SSSI
    - Welford Field SSSI
    - Racecourse Meadows SSSI
    - Tiddesley Wood SSSI

- River Severn (confluence with the River Avon to the tidal limit):
    - Coastal and floodplain grazing marsh
    - Severn Ham, Tewkesbury SSSI
    - Old River Severn, Upper Lode SSSI
    - Wainlode Cliff SSSI

Table 2.2 Potential impact pathways for the different habitats associated with the STT based on the likely operational pattern and the potential changes in flow, velocity, depth and water quality

Habitat/designated site	Habitat/site description	Potential impact pathways
Coastal and flood plain grazing marsh	Grazing marsh is defined as periodically inundated pasture, or meadow with ditches which maintain the water levels, containing standing brackish or fresh water. The ditches are especially rich in plants and invertebrates. Almost all areas are grazed and some are cut for hay or silage. Sites may contain seasonal water-filled hollows and permanent ponds with emergent swamp communities, but not extensive areas of tall fen species like reeds; although they may abut with fen and reed swamp communities	Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools • Change in river water chemistry in river altering nutrient availability from inundation and for marginal vegetation
Lowland Fens[10]	Fen habitats support a diversity of plant and animal communities. In intensively farmed lowland areas fens occur less frequently, are smaller in size and more isolated than in other parts of the UK[11]	Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools • Change in river water chemistry in river altering nutrient availability from inundation and for marginal vegetation

[10] UK Biodiversity Action Plan Priority Habitat Descriptions Coastal and Floodplain Grazing Marsh From: UK Biodiversity Action Plan; Priority Habitat Descriptions. BRIG (ed. Ant Maddock) 2008. Accessed 20/05/2022. This document is available from: http://jncc.defra.gov.uk/page-5706

[11] UK Biodiversity Action Plan Priority Habitat Descriptions Lowland Fens From: UK Biodiversity Action Plan; Priority Habitat Descriptions. BRIG (ed. Ant Maddock) 2008. Accessed 20/05/2022. Available at: This document is available from: http://jncc.defra.gov.uk/page-5706

Habitat/designated site	Habitat/site description	Potential impact pathways
Purple Moor grass and rush pastures	Purple moor grass and rush pastures occur on poorly drained, usually acidic soils in lowland areas of high rainfall in western Europe. Their vegetation, which has a distinct character, consists of various species-rich types of fen meadow and rush pasture. Purple moor grass *Molinia caerulea*, and rushes, especially sharp-flowered rush *Juncus acutiflorus*, are usually abundant[12].	Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools • Change in river water chemistry in river altering nutrient availability from inundation and for marginal vegetation
Wet woodland	Wet woodland occurs on poorly drained or seasonally wet soils, usually with alder, birch *Betula* sp. and willows *Salix* sp. as the predominant tree species, but sometimes including ash *Fraxinus excelsior*, oak *Quercus* sp, pine *Pinus* sp. and beech *Fagus sylvatica* on the drier riparian areas. It is found on floodplains, as successional habitat on fens, mires and bogs, along streams and hill-side flushes, and in peaty hollows. These woodlands occur on a range of soil types including nutrient-rich mineral and acid, nutrient-poor organic ones[13].	Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in river water chemistry in river altering nutrient availability from inundation and for marginal vegetation
Rectory Farm Meadows SSSI	The special interest of these flood meadows lies in their diversity and comparatively large size. The mesotrophic (neutral) grassland is characterised by meadow foxtail (*Alopecurus pratensis*) and great burnet (*Sanguisorba officinalis)*. Frequent grasses include sweet vernal grass (*Anthoxanthum odoratum*), red fescue (*Festuca rubra*), and soft brome (*Bromus hordeaceus*), with hairy sedge (*Carex hirta*), lesser pond-sedge (*C. acutiformis*) and common sedge (*C. nigra).* Associated herbs are marsh marigold (*Caltha palustris*), meadowsweet (*Filipendula ulmaria*) and cuckooflower (*Cardamine pratensis*). Of particular interest on this site is narrow-leaved water-dropwort (*Oenanthe silaifolia*), which is nationally scarce. There is a pond and ditch between the two meadows and also a ditch across the northern end.	Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools • Change in river water chemistry in river altering nutrient availability from inundation and for marginal vegetation
Upham Meadow and Summer Leasow SSSI	Upham Meadow managed as a hay meadow and the Summer Leasow as pasture grassland. Semi-improved neutral grassland is subject to annual winter flooding. The site is also important for overwintering waders and wildfowl which use the site to feed and roost. It regularly supports large numbers of lapwing (*Vanellus vanellus*), dunlin (*Calidris alphina*) and up to 2000 golden plover (*Pluvialis apricaria*). In some winters nationally important numbers of Bewick's swan (*Cygnus columbianus*) use the site.	Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools

[12] UK Biodiversity Action Plan Priority Habitat Descriptions Purple Moor Grass and rush Pastures From: UK Biodiversity Action Plan; Priority Habitat Descriptions. BRIG (ed. Ant Maddock) 2008. Accessed 24/06/2022. This document is available from: Purple moor grass and rush pastures (UK BAP Priority Habitat description) (jncc.gov.uk)

[13] UK Biodiversity Action Plan Priority Habitat Descriptions Wet Woodland From: UK Biodiversity Action Plan; Priority Habitat Descriptions. BRIG (ed. Ant Maddock) 2008. Accessed 24/06/2022. This document is available from: https://data.jncc.gov.uk/data/2829ce47-1ca5-41e7-bc1a-871c1cc0b3ae/UKBAP-BAPHabitats-64-WetWoodland.pdf

Habitat/designated site	Habitat/site description	Potential impact pathways
		• Change in river water chemistry in river altering nutrient availability from inundation and for marginal vegetation • Change in water level/inundation, and water quality and associated changes in vegetation communities could alter suitability for wintering waterfowl.
Guy's Cliffe SSSI	Guy's Cliffe represents a good exposure of Middle Triassic aeolian (wind-blown) and river-deposited sandstones which have yielded the finest specimens of a large labyrinthodont amphibian *Mastodonsaurus jægeri*.	No water dependent ecological features, the site is not included further in this assessment.
Racecourse Meadows SSSI	The site is an unimproved field located on the floodplain of the River Avon. It supports a diversity of herbs and grasses including pepper saxifrage *Silaum silaus*, corn parsley *Petroselinum segetum*, meadow foxtail *Alopecurus pratensis*, great burnet *Sanguisorba officinalis,* common bent grass *Agrostic capillaris* and red fescue *Festuca rubra*.	Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools
Welford Field SSSI	The site is an unimproved field located on the floodplain of the River Avon. It supports a diversity of herbs and grasses including salad burnet *Sanguisorba minor*, meadow foxtail, great burnet and red fescue.	Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools :
Tiddesley Wood SSSI	Largely broadleaved woodland which supports a diversity of butterflies and dragonflies. Along the western edge, tall fen and marsh habitat is present supporting breeding marsh warbler *Acrocephalus palustris*, which is nationally rare.	Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools
Severn Ham, Tewkesbury SSSI	One of the last remaining traditionally managed ham meadows overlying the alluvium of the Severn Vale and subject to annual winter flooding. Consists of neutral grassland and semi-improved grassland. Rare sulphurwort (*Oenanthe silaifolia*) present. The Ham is particularly rich in grass species, the commonest being cocksfoot (*Dactylis glomerata*), meadow foxtail (*Alopecurus pratensis*), meadow barley (*Hordeum secalinum*) and smooth brome (*Bromus racemosus*). Marsh foxtail (*Alopecurus geniculatus*) is also present and becomes dominant in the lower lying, wetter areas. Around the margins of the Ham, vegetation on the riverbanks includes some alder, willow and hawthorn scrub. Uncommon plants such as great dodder (*Cuscuta europaea*) and meadow rue	. Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools • Change in river water chemistry in river altering nutrient availability from inundation and for marginal vegetation • Change in velocity increasing erosion and/or suitability for marginal and bank vegetation

Habitat/designated site	Habitat/site description	Potential impact pathways
	(*Thalictrum flavum*) occur on the periphery of the site.	
Old River Severn, Upper Lode SSSI	Old meander in the River Severn, cut off from the main river when the Upper Lode lock was constructed. Presence of 6 nationally rare plants: swamp meadow grass (*Poa palustris*), greater dodder (*Cuscuta europaea*), tasteless water-pepper (*Polygonum mite*), small water pepper (P. *minus*), mudwort (*Limosella aquatica*) and needle spike rush (*Eleocharis acicularis*). Other locally rare plants include narrow-leaved water plantain (*Alisma lanceolatum*), keeled garlic (*Allium carinatus*), glaucous bulrush (*Schoenoplectus tabernaemontani*) and sea club rush (*Scirpus* maritimus). Other key features include birds with large number of duck (mainly mallard Anas platyrhynchos and coot (*Fulica atra*), reed warblers (*Acrocephalus scirpaceus*) and sedge warblers (*A. schoenobaenus*) (breeding in the willows), kingfisher (*Alcedo atthis*), waders such as redshank (*Tringa totanus*), common sandpiper (*T. hypoleucos*) and lapwing (*Vanellus vanellus*). Several species of dragonflies have been recorded including the scarce hawker (*Aeshna m*ixta) and white-legged damselfly (*Platycnemis pennipe*). Water levels fluctuate according to levels in the main river and a tidal influence is still present even this far upstream.	Changes in community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and ditches • Change in seasonality, duration, or frequency of inundation of marginal and in channel wetland vegetation including wet woodland • Change in river water chemistry in river altering nutrient availability for in-channel and connected wetland marginal/inundation vegetation communities
Wainlode Cliff SSSI	Geological SSSI designated for 'An historic locality, first described in 1842, showing a 7 m section of Rhaetian age. The regional two-fold division of Westbury and Cotham Beds is maintained here, with the correlatable 'Estheria' Bed in the latter, and a basal bone bed resting non-sequentially on the Tea Green Marls at the base of the shales. This is the type locality for *Estheria minuta brodieana*. The Insect Limestone, a productive source of insects, defines the base of the Lias in the section.'	Scoped out of the assessment – the SSSI is designate for the presence of geological formations. This site does not contain water dependent features.
Lydney Cliff SSSI	This site contains exposures in the topmost Raglan Marls (equivalent to the lower part of the Red Marls) of Lower Devonian age, up to the level of the Psammosteus Limestone. The section includes several calcrete profiles (with a variety of pseudo-anticline structures developed in the more mature profiles) and a complex sand-body which probably formed as a fluvial distributary channel.	Scoped out of the assessment – the SSSI is designate for the presence of geological formations. This site does not contain water dependent features.
Purton Passage SSSI	This is an important locality for studies of vertebrate palaeontology. Rocks of Upper Ludlow (Silurian) age exposed on the foreshore at Tites Point include bone beds which have been described as the most productive bone beds of their age.	Scoped out of the assessment – the SSSI is designate for the presence of geological formations. This site does not contain water dependent features.
Upper Severn Estuary SSSI	The site is designated for extensive areas of mud and sandflats in the Estuary, bordered by saltmarsh which grades through saltmarsh pasture to neutral grassland. The site is also of international ornithological importance, as it	The Upper Severn Estuary SSSI underlies the Severn Estuary Special Area of Conservation, Special Protection Area, and Ramsar site which are assessed as part of the STT Gate 2 Habitat Regulations

Habitat/designated site	Habitat/site description	Potential impact pathways
	regularly supports more than 10000 wintering wildfowl.	Assessment report[14] so are not taken further in this assessment. Changes in habitat community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools • Change in river water chemistry in river altering nutrient availability altering habitat suitability for aquatic and periodically inundated communities • Change in velocity altering supporting processes Change in habitat suitability, from impact pathways above, for wintering waterfowl populations
Garden Cliff SSSI	An historic site in 'Rhaetic' studies, first described in detail in 1822. It shows a complete local succession of the Rhaetian, from the Tea Green Maria to the base of the Lower Lias.	Scoped out of the assessment – the SSSI is designate for the presence of geological formations. This site does not contain water dependent features.
Severn Estuary SSSI	The Severn Estuary lies on the south-west coast of Britain at the mouth of four major rivers (the Severn, Wye, Usk and Avon) and many lesser rivers. The immense tidal range (the second highest in the world) and classic funnel shape make the Severn Estuary unique in Britain and very rare worldwide. The intertidal zone of mudflats, sand banks, rocky platforms and saltmarsh is one of the largest and most important in Britain. The estuarine fauna includes internationally important populations of waterfowl; invertebrate populations of considerable interest; and large populations of migratory fish, including the nationally rare and endangered Allis Shad *Alosa*. The SSSI forms the major part of a larger area of estuarine habitat, which includes the Upper Severn Estuary, the Taf/Ely Estuary and Bridgwater Bay	The potential impacts to the fish populations are assessed in more detail as part of the STT Gate 2 fisheries assessment report[15]. The Severn Estuary SSSI underlies the Severn Estuary Special Area of Conservation, Special Protection Area, and Ramsar site which are assessed as part of the STT Gate 2 Habitat Regulations Assessment report. Changes in habitat community composition from: • Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches • Change in seasonality, duration, or frequency of periodic inundation • Change in periodic inundation altering distribution or duration of temporary pools • Change in river water chemistry in river altering nutrient availability altering habitat suitability for aquatic and periodically inundated communities • Change in velocity altering supporting processes Change in habitat suitability, from impact pathways above, for wintering waterfowl populations

[14] Ricardo Energy and Environment (2022) Severn Thames Transfer SRO Habitat Regulations Assessment Report. Report for: United Utilities on behalf of the STT Group, Ricardo ref. ED15323. Issue: 001.

[15] Ricardo Energy and Environment (2022) Severn Thames Transfer SRO Fisheries Assessment Report. Report for: United Utilities on behalf of the STT Group, Ricardo ref. ED15323. Issue: 001. 23/05/2022

3. REACH BY REACH ASSESSMENT

3.1 INTRODUCTION

This section addresses the effects of the STT Scheme on a reach by reach basis, addressing each metric of change in turn. The reaches, as shown in **Figure 1.3** and with reference to **Figure 1.2**, are as follows:

- The River Vyrnwy from Vyrnwy Reservoir to the confluence with the River Severn
- The River Severn from the confluence with the River Vyrnwy to Bewdley
- The River Severn from Bewdley to the confluence with the River Avon
- The River Avon from Stoneleigh to the confluence with the River Severn
- The River Severn from the confluence with the River Avon to Deerhurst
- The River Severn from Deerhurst to the tidal limit at Gloucester
- The Severn Estuary downstream of the tidal limit at Gloucester
- River Thames D/S Culham to tidal limit at Teddington
- Other functionally linked habitats

For each reach, an assessment is made first of the baseline conditions, before assessing the effects of the STT operation on current and then future flow conditions.

3.2 THE RIVER VYRNWY FROM VYRNWY RESERVOIR TO THE CONFLUENCE WITH THE RIVER SEVERN

3.2.1 Baseline

Several protected habitats are present within the impacted reach. This includes the Coed Copi'r Graig Site of Special Scientific Interest (SSSI) which extends approximately 7 ha encompassing 850 m of River Vyrnwy bank and channel. The Site is located two miles from Llanwddyn and represents the only known example in Montgomeryshire of a northern woodland type which is close to the southernmost extent of its range in Britain. The site hosts a rich moss and lichen flora growing on the trees, together with a range of locally scarce northern plant species. In addition, the SSSI, several oxbow lakes are present within the reaches of the River downstream of Meifod.

Lowland fens and reedbeds and purple moor grass and rush pastures were also identified as present within 500m of the River Vyrnwy, however, no hydrological link with the River Vyrnwy was identified during the scoping exercise[16] that was undertaken as part of the surveys of protected habitats.

3.2.2 Relevant impact pathways

The proposed support releases could therefore result in changes in water quality, hydrology and hydraulics (in-stream habitat) which could result in the following:

- Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches;
- Change in seasonality, duration, or frequency of periodic inundation;
- Change in periodic inundation altering distribution or duration of temporary pools; and
- Increased flows and velocities could result in direct damage to higher plants and washout of seeds.

3.2.3 STT operation – current conditions

This section sets out the findings of the effect of the STT scheme operation during current or contemporary ('now') climate conditions.

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[16] Ricardo Energy and Environment (2021) Severn to Thames Transfer SRO Gate 2 Monitoring Programme – Protected Habitats Scoping Report. Report for Thames Water (on behalf of the STT Group). Ref: ED15474. July 2021.

3.2.3.1 *Changes to flows, velocity and depths*

In this reach, STT SRO would augment flows through a 25 Ml/d direct release from Vyrnwy Reservoir at selected times. Flow changes in this reach would typically be in the months July to October, peaking in August at 47 % of days in August. Outside this period, there would be less regular flow changes in June and November, with changes very rare in May, December and January and not anticipated in February, March or April.

The A82 scenario would include a continuous 105 day period of flow augmentation from late June to early October. The M96 scenario would include a continuous 144-day period of flow augmentation from mid-June to early November. This is a percentage change in flow of between 25 - 100 % depending on the baseline flow. The duration of the STT support changes between Scenario A82 and M96 because of when the transfer of water is required.

In A82, STT SRO releases of 25 Ml/d potentially coincide with Severn Regulation releases on 31 dates in July and August, with other managed releases (compensation flow, Severn Regulation Release) up to 95 Ml/d. In M96, STT SRO releases of 25 Ml/d potentially coincide with Severn Regulation releases on 115 dates between mid-June and mid-October, with other managed releases (compensation flow, Severn Regulation Release) up to 120 Ml/d.

Downstream of the confluence with the River Banwy, the absolute difference between the reference and fully supported condition is slightly reduced compared to immediately downstream of the reservoir due to losses. The percentage of flow due to the supported release from the reservoir reduces to 23 % of the flow downstream of the River Banwy, because the River Banwy increases the reference flow in the river from 77 to 193 Ml/d on the 25th of August. The reference flow increases from 45 Ml/d to 960 Ml/d on the 5th of December.

In the A82 scenario, the percentage change of flow in the River Vyrnwy is reduced in September and October due to the higher flow from the River Banwy. This does not occur in the lower flow scenario (M96) due to the lower flow in River Banwy under this scenario.

At the River Vyrnwy upstream Cownwy site, under the A82 scenario, there is an increase in depth between 27th June and 9th October. Over this period the depth increases by between 10.3 % and 34.0 % with the depth ranging between 0.29 m and 0.42 m (with a mean depth of 0.34 m compared to the reference which ranged between 0.22 m and 0.38 m (with a mean depth of 0.29 m).

Similarly, the velocity in this period increases under this scenario. The range in percentage increase compared to the reference is between 4.4 % and 14.8 % with the scenario velocities ranging between 0.85 m/s and 1.00 m/s (with a mean velocity of 0.92 m/s) compared to the reference which ranged between 0.74 m/s and 0.96 m/s (with a mean velocity of 0.84 m/s).

Under the M96 scenario, there is an increase in depth between 12th June and 2nd November. Over this period the depth increases by between 8 % and 35 % with the depth ranging between 0.2 m and 0.4 m (with a mean depth of 0.39 m) compared to the reference which ranged between 0.2 m and 0.4 m (with a mean depth of 0.34 m Above Ordnance Datum (AOD)).

Similarly, the velocity in this period increases under this scenario. The range in percentage increase compared to the reference is between 3 % and 15 % with the scenario velocities ranging between 0.8 m/s and 1 m/s (with a mean velocity of 0.96 m/s) compared to the reference which ranged between 0.7 m/s and 1.00 m/s (with a mean velocity of 0.91 m/s).

The results of the flood risk assessment were also considered when undertaking the assessment of the potential impacts on the SSSI, the oxbow lakes within this reach, and floodplain and grazing marsh habitats downstream of Llanymynech (see Table 3.1). The flood risk assessment considered Annual Exceedance Probability (AEP), which is the percentage chance that the flood will be equalled or exceeded in any year; and Return Period, which is the period in years in which the flood will be equalled or exceeded once on average. It should be noted that this analysis assumes a highly unlikely worst case where the STT scheme is running during a high flow event.

The impact of the STT scheme upstream of Conwy is taken from the change at the Vyrnwy reservoir gauge. The flow is increased by 0.7% in the 50% AEP (2 year return period) and by 0.3% in the 2% AEP (50 year return period). The impact on the frequency at which flooding occurs is therefore minor. The flood levels are increased by 5 mm in the frequent floods with 50% and 20% AEPs.

The impact of the STT scheme near Melverley Green is taken from the change at the Llanymynech gauge, including the additional flow from the Vyrnwy bypass component of the scheme, supported flow increase of

2.08 m^3/s. The flow is increased by 0.1% in the 50% AEP (2 year return period) and by 0.1% in the 2% AEP (50 year return period). The impact on the frequency at which flooding occurs is therefore minor. The flood levels are increased by around 1 mm in the frequent AEPs.

The impact of the STT scheme downstream of Meifod is taken from the change at the Meifod gauge. The flow is increased by 0.1% in the 50% AEP (2 year return period) and by 0.1% in the 2% AEP (50 year return period). The impact on the frequency at which flooding occurs is therefore minor. The flood levels are increased by 1 mm in the 50% AEP through to the 1% AEP.

The impact of the STT scheme upstream of Llanymynech is taken from the change at the Llanymynech gauge because the SSSI is located around the Afon Cain and Afon Tanat tributaries that join the Vyrnwy upstream of Llanymynech. The flow is increased by 0.3% in the 50% AEP (2 year return period) and by 0.2% in the 10% AEP (10 year return period). The impact on the frequency at which flooding occurs is therefore minor. The flood levels are increased by only 3 mm in the frequent AEPs.

Table 3.1 Change in water level (mm) as obtained from the flood risk assessment

River	Location	Change in peak water level (mm)				
		50% AEP	20% AEP	4% AEP	2% AEP	1% AEP
Vyrnwy	Vyrnwy Reservoir	5	4	2	2	2
Vyrnwy	Pont Robert	5	5	3	2	2
Vyrnwy	Meifod	1	1	1	1	1
Vyrnwy	Llanymynech	1	1	1	1	1

Due to the minor risk of increased frequency of flooding, there would be no discernible change in the seasonality, duration, or frequency of periodic inundation in adjacent priority habitat and SSSIs within this reach. Overall, no impacts on the hydrologically connected protected habitats as a result of hydrological and hydraulic changes in this reach are expected under the current conditions.

3.2.3.2 Changes in water quality

Assessment of changes to temperature with changes in outflow volume show a weak relationship. Under the STT scheme operation, to release an additional 25 Ml/d, similar scale increase in outflow monitored have not resulted in clear temperature changes in the River Vyrnwy above the scale of background variability already present. Consequently no potential impact pathways for protected habitats associated with the reach have been identified.

3.2.4 STT operation - future climate

This section sets out the findings of the effects of the STT operation during future climate conditions.

In comparison with the A82 scenario the A82 Future scenario would include a 40 % longer period of flow augmentation releases - with extension both 35 days earlier, to include late May and all of June; and 36 days later, to include all of October and the first half of November. The increase in regularity of the need for STT support options in late spring, early summer and later into autumn is a discernible change.

3.2.4.1 Change to flow

Downstream of the reservoir, the flow is increased by 25 Ml/d from the 23rd of May to the 20th of November in the A82 Future scenario. This is a percentage change in flow of between 10 and 100% depending on the baseline flow.

Downstream of the confluence with the River Banwy, the absolute increase in flow with the fully supported condition is slightly reduced to ~22 Ml/d compared to immediately downstream of the reservoir due to losses. The percentage of flow due to the supported release from Vyrnwy reservoir increases to approximately 5 % - 35 % of the flow downstream of the River Banwy, because the River Banwy increases the reference flow in the river. The long section shows that during low flows in the Future Scenario, on the 18th of October, the reference flow is increased by 50 % after the Banwy, whereas in current conditions, the flow more than doubles at low flows.

With the A82 Future flow scenario, the flow is increased by approximately 22 Ml/d from the 24th of May to the 20th of November from the reservoir release (less the losses between the reservoir and Llanymynech) at Llanymynech. The flow increase with the scheme is around 15 % of the total flow in the river under Future conditions on the 18th of October. Again, the flow increase is less than the release flow because of losses.

Comparison of the baseline habitat at (45 Ml/d) compensation flow only and habitat under the 25 Ml/d Vyrnwy Reservoir flow augmentation release for STT shows only limited reductions in flow under the A82 Future scenario run, but thus is likely to exacerbate the effects of prolonged, large Severn Regulation releases included in the reference scenario.

Due to the complexity and volume of data, this is a brief overview of the potential changes only.

3.2.4.1.1 Impact assessment

Based on outputs from the hydrological modelling[17], due to the natural variability in flow rate of the River Vyrnwy and limited impact on water depth due to the operation of STT SRO, no discernible impacts on the spatial distribution and feeding success of European otter and waterbirds are anticipated.

The resuspension and loss of fine sediment from Llanymynech to the confluence with the River Severn during STT SRO is unlikely to occur due to the low change in velocity anticipated. Therefore, no impacts have been identified on marginal habitats present as a result of deposition of suspended sediment.

Water depth changes in the water course are anticipated to be minimal. Therefore, there would be no discernible change in the seasonality, duration, or frequency of periodic inundation in adjacent priority habitat and SSSIs within this reach. Overall, no impacts on the hydrologically connected protected habitats as a result of hydrological and hydraulic changes in this reach are expected under the

3.2.4.2 Changes to water quality

A future flow assessment of environmental water quality effects from STT SRO operation in this reach has not been scoped in for the Gate 2 assessment due to the absence of pathways.

3.3 THE RIVER SEVERN FROM THE CONFLUENCE WITH THE RIVER VYRNWY TO BEWDLEY

3.3.1 Baseline

This section describes baseline conditions and provides a comparison of the baseline to naturalised conditions.

The STT Gate 1 assessments[18] identified the requirement for further investigation to identify protected and designated water dependent hydrologically connected habitats adjacent to the River Severn between the Vyrnwy confluence and the Shrewsbury abstraction. The subsequent desk-based assessments, based on the Priority Habitat Inventory (PHI), identified approximately 53.8ha of the Priority Habitat Coastal & floodplain grazing marsh (CFGM) and Lowland Fens within 500 m of the River Severn with potential for hydrological connectivity (within 3m elevation of the average river level and/or containing connecting watercourses).

Surveys were carried out in 2021 (detailed in the Protected Habitats Evidence Report[19]) at 12 sections of CFGM and lowland fens identified in the PHI across two survey areas, identified 5.86ha of CFGM but no lowland fens. The area of CFGM comprised modified grassland (g4 25) bordered by ditches. Other habitats identified included other neutral grassland (g3c), hedgerows with trees (h2b 11), and a pond (r1a eutrophic standing water). The surveyed areas were approximately 1.5m above river level with habitats level with bank full height in the River Severn, no connecting channels were present between the River Severn and the area of coastal and floodplain grazing marsh confirmed by surveys in 2021.

No areas of lowland fens were identified during surveys in 2021 of priority habitats identified as coastal and floodplain grazing marsh and lowland fens. The 2021 surveys of protected habitats identified that within the reach habitats were typically modified (e.g., though nutrient input and re-seeding) grassland and low diversity neutral grassland used for cattle grazing a silage production with bordered by hedgerows and/or drainage ditches. A desk-based assessment of the PHI for the lower section of the reach between Shrewsbury and Bewdley identified an additional 32 areas of water dependent priority habitat (within 500m of the impacted reach) with potential hydrological connectivity: coastal and floodplain grazing marsh (23 areas with a total area

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[17] Ricardo Energy and Environment (2022). Physical Environment Assessment Annex A. Report for United Utilities on behalf of the STT Group.

[18] Ricardo Energy and Environment (2021). Severn Thames Transfer SRO. Other habitat and species Evidence Report. Report for United Utilities on behalf of the STT Group. May 2021

[19] Ricardo Energy and Environment (2022) Severn Thames Transfer SRO Protected Habitats Evidence Report. Report for United Utilities on behalf of the STT Group. February 2022

of 3.63ha), lowland fens (eight areas with a total area of 3.84ha), and purple moor grass and rush pastures (one area, 0.6ha).

One SSSI, the Severn at Montford SSSI, is present in the reach, however the site has no ecological features of interest and potential impacts to the site are assessed as part of the Physical Environment Assessment Report[20].

3.3.2 Relevant impact pathways

The proposed support releases could therefore result in changes in water quality, hydrology and hydraulics (in-stream habitat) which could result in the following:

- Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches;
- Change in seasonality, duration, or frequency of periodic inundation;
- Change in periodic inundation altering distribution or duration of temporary pools; and
- Increased flows and velocities could result in direct damage to higher plants and washout of seeds.

3.3.3 STT operation – current conditions

This section sets out the findings of the effects of the STT scheme operation during current or contemporary (‘now’) climate conditions.

3.3.3.1 Change to flow, velocity and depth

In this reach, the STT solution would augment flows through a 25 Ml/d direct release from Vyrnwy Reservoir; an additional 155 Ml/d Vyrnwy bypass release at the confluence of the Weir Brook with the River Severn (upstream of Montford); and an abstraction reduction at Shelton intake at Shrewsbury, at selected times. Accounting for flow losses in the river systems, STT solution flow augmentation in this reach would be up to 200 Ml/d.

The A82 scenario would include a continuous 105 day period of flow augmentation from late June to early October. The M96 scenario would include a continuous 144 day period of flow augmentation from mid-June to early November.

On the River Severn, downstream of the confluence with the River Vyrnwy, the flow is increased by approximately 20 Ml/d from the 28th of June to the 10th of October in the A82 scenario. Once the STT supported flows ramp up, the flow is increased by approximately 23% during July and August. The percentage increase is variable during September due to moderate flow events increasing the baseline flows. In the M96 scenario the flow is increased by approximately 20 Ml/d on the 13th and 62 Ml/d on the 14th of June, then by approximately 160 Ml/d from the 16th of June to 2nd November. The low flow period is longer in the M96 scenario compared to A82, even after the confluence of the Rivers Vyrnwy and Severn. Once the STT supported flows ramp up, the flow is increased by approximately 23% during July, August, September and October.

At Bewdley on the River Severn the flow is increased by approximately 35 Ml/d from the 28th of June then increases by approximately 201 Ml/d from the 4th of July to the 10th of October in the A82 scenario. The flow increases then reduces and drops off by the 12th of October. The timing of the flow increase is delayed compared to the locations further upstream due to the travel time along the river. The increase in flow at Bewdley is greater than at the location of the River Vyrnwy bypass outfall upstream of Montford because of the Shrewsbury component of the fully supported scheme. Once the STT supported flows ramp up the flow is increased by approximately 23% during July and August. The percentage increase is variable during September due to moderate flow events increasing the baseline flows.

In the M96 scenario, the flow is increased by approximately 20 Ml/d on the 15th to the 18th of June, then by approximately 201 Ml/d from the 20th of June to 2nd November. This is because when the transfer of water is required the flow in the River Severn is low and full support is required from both the reservoir, the reservoir bypass and Shrewsbury. Once the STT supported flows ramp up, the flow is increased by approximately 24% during July, August, September and October.

The modelling results shows that after the confluence of the Vyrnwy bypass with the River Severn at 69 km, just upstream of Montford, the flow from the STT scheme is approximately 16% of the total flow. At Bewdley,

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[20] Ricardo Energy and Environment (2022) Severn Thames Transfer SRO. Physical Environment Assessment Report. Report for United Utilities on behalf of the STT Group. May 2022

the percentage of flow from the scheme increases to around 17% of the total flow, due to the flow not abstracted from Shrewsbury.

For the Shrewsbury right bank, under the A82 scenario, there is an increase in level between 27th June and 10th October. From the 27th of June to the 25th of August the level increases by between 1 cm and 4 cm with a mean level of 47.5 m AOD compared to the mean baseline level of 47.5 m AOD over this period. Between 26th August and 10th October the level increase is more variable, fluctuating between 1. cm and 4 cm with a mean level of 47.6 m AOD compared to a mean baseline level of 47.6 m AOD.

Under the M96 scenario the level change is relatively consistent throughout the period from the 18th of June to 3rd November. Generally, the change in level fluctuates between 0 cm and 4 cm increase in level with the mean level over the period being 47.5 m AOD compared to 47.5 m AOD in the baseline.

The modelled changes in velocity at Montford SSSI are summarised as follows:

- Velocity in this period increases under this scenario. The range in percentage increase compared to the reference is between approximately 0.2 % and 2 % with the scenario velocities ranging between 0.55 m/s and 0.70 m/s (with a mean velocity of 0.57 m/s) compared to the reference which ranged between 0.54 m/s and 0.69 m/s (with a mean velocity of 0.57 m/s).
- Velocity in this period increases under this scenario. The range in percentage increase compared to the reference is between 0.2% and 2.5% with the scenario velocities ranging between 0.5 m/s and 0.6 m/s (with a mean velocity of 0.56m/s) compared to the reference which ranged between 0.5 m/s and 0.6 m/s (with a mean velocity of 0.55 m/s).

From the results it is evident that the change in flow and level is not discernible and will not affect water levels within adjacent hydrologically connected protected habitats including coastal and floodplain grazing marsh and lowland fens. The potential changes in velocity and depth are not considered to be of a magnitude to result in impacts to hydrologically connected habitats in this reach as the velocity and depths that would be observed under a fully supported STT would be similar to baseline conditions. Flows and velocities will also not result in additional washout of marginal or bankside vegetation or the associated seedbank.

At site STT Montford, the hydraulic data and flooding assessment indicates that the flow would be increased by 0.7% in the 50% (2 year return period) Annual Exceedance Period (AEP) and by 0.4% in the 2% AEP (50 year return period). The impact on the frequency at which flooding occurs is therefore minor. The flood levels would be increased by around 10 mm in the frequent AEPs. Therefore, there would be no discernible change in the seasonality, duration, or frequency of periodic inundation in adjacent coastal and floodplain grazing marsh, lowland fens habitats or purple moor grass and rush pastures within the reach.

Overall, impacts from operation on hydrologically connected protected habitats (coastal and floodplain grazing marsh, lowland fens, and purple moor grass and rush pastures) as a result of hydrological and hydraulic changes in this reach are not expected to result in ecological effects under the current conditions.

3.3.3.2 Change to water quality

There is no pathway of general water quality, chemical water quality change or nutrients in this reach from the STT operation. This is because the water that would be discharged in this reach is from the same source (i.e., the Vyrnwy Reservoir) and will simply be discharged in the River Severn instead of entering the River Severn via the River Vyrnwy. As such no assessment is included at Gate 2 in this reach. Information on the general water quality parameters: pH, acid neutralising capacity, biochemical oxygen demand, ammoniacal nitrogen, nutrients (reactive phosphate) is available to be reviewed in the Gate 2 Environmental Water Quality Evidence Report[21]. This bespoke evidence for the STT solution is available for one site in the reach: 25 River Severn (upper) downstream Option 4.

3.3.4 STT operation - future climate

This section sets out the findings of the effects of the STT operation during future climate conditions.

[21] Ricardo Energy & Environment (2022). Severn to Thames Transfer SRO. Water Quality Evidence Report. Report for United Utilities on Behalf of the STT Group. February 2022.

In comparison with the A82 scenario the A82 Future scenario would include a 40 % longer period of flow augmentation releases - with extension both 35 days earlier, to include late May and all of June; and 36 days later, to include all of October and the first half of November. The increase in regularity of the need for STT support options in late spring, early summer and later into autumn is a discernible change.

3.3.4.1 Change to in flow, velocity and depth

On the River Severn downstream of the confluence with the River Vyrnwy, the flow is increased by approximately 20 Ml/d on from the 24th of May - 21st November in the A82 Future scenario. The flow is increased by approximately 3 % during July to October.

Downstream of the Vyrnwy Bypass, the flow is increased by a further 155 Ml/d which is a total increase of 175 Ml/d. In the A82 Future Scenario, this occurs from the 25th of May - 21st November and is a flow increase of around 22 %.

At Bewdley on the River Severn, the flow in the A82 Future scenario is increased by approximately 28 Ml/d from the 24th May then increases by approximately 198 Ml/d from the 6th of May – 2nd November. The flow increase then reduces and drops off by the 23rd of November.

The long section shows that after the outfall from the Vyrnwy bypass pipeline at 69 km, the flow increases by 175 Ml/d or 24 % of the total flow in the Future flow scenario on the 18th of October. The flow in the River Severn with the Full STT scheme in this lowest flow period is similar in magnitude to the Reference flow under A82 present day conditions.

As a guide, the change in depth-average velocity and water depth at the Severn at Bewdley assessment point from the 1D hydraulic model has been reviewed. There are 141 days in the A82 Futures scenario with modelled river flows of less than 900 Ml/d in the reference conditions and with direct release from Vyrnwy reservoir; Vyrnwy bypass release; and abstraction reduction at Shelton intake at Shrewsbury. On these dates, the mean change in depth-average velocity is modelled as approximately 0.03 m/s (a 3 % increase) and the mean change in water depth is modelled as 0.07 m (a 7 % increase). For the Shrewsbury right bank, under the A82 scenario, there is an increase in level between 23rd May and 22nd November. For this period, the level increases by between 1 cm and 4 cm with a mean level of 47.5 m AOD compared to the mean baseline level of 47.5 m AOD over this period.

3.3.4.1.1 Impact assessment

The small increase in velocity will not cause the resuspension of fine sediment or erosion of marginal habitats. The 7 % increase in water depth is not predicted to result in discernible changes in hydrological connectivity between the water course and the identified protected and notable habitats adjacent to the reach In addition, based on the future scenario outputs, there would be no discernible change in the seasonality, duration, or frequency of periodic inundation in adjacent coastal and floodplain grazing marsh, lowland fens, lowland meadows, deciduous woodland, pasture and parkland priority habitat and SSSIs within this reach. Overall, no impacts on the hydrologically connected protected habitats as a result of hydrological and hydraulic changes in this reach are expected under the current conditions.

It is noted that during the lowest flow periods, the operation of STT SRO will alter flow rates to a present day condition which may benefit potentially hydrologically connected protected habitats and designated sites present.

3.3.4.2 Changes to water quality

A future flow assessment of environmental water quality effects from STT SRO operation in this reach has not been scoped in for the Gate 2 assessment due to the absence of potential impact pathways.

3.4 THE RIVER SEVERN FROM BEWDLEY TO THE CONFLUENCE WITH THE RIVER AVON

3.4.1 Baseline

This section describes baseline conditions and provides a comparison of the baseline to naturalised conditions.

The STT Gate 1 assessments did not identify the requirement for further surveys to investigate the presence or extent of protected and designated water dependent hydrologically connected habitats adjacent to the River Severn between the Bewdley and the River Avon due to the small scale of the potential hydrological impacts. Consequently, no detailed assessments of hydrological connectivity or surveys of the extent of protected habitats within the reach were undertaken.

A desk based assessment of the PHI for the lower section of the reach between Shrewsbury and Bewdley identified an additional 98 areas of water dependent priority habitat (within 500m of the impacted reach) with potential hydrological connectivity: coastal and floodplain grazing marsh (79 areas with a total area of 36.17ha), lowland fens (13 areas with a total area of approximately 1.6ha), and wet woodland (six areas with a total area of 0.02ha).

3.4.2 Relevant impact pathways

The proposed support releases could therefore result in changes in water quality, hydrology and hydraulics (in-stream habitat) which could result in the following:

- Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches
- Change in seasonality, duration, or frequency of periodic inundation
- Change in periodic inundation altering distribution or duration of temporary pools
- Increased flows and velocities could result in direct damage to higher plants and washout of seeds

3.4.3 STT operation – current conditions

This section sets out the findings of the effects of the STT scheme operation during current or contemporary ('now') climate conditions.

3.4.3.1 Change to flow, velocity, water level, and flood regime

In this reach, the STT solution would augment flows through a 25 Ml/d direct release from Vyrnwy Reservoir; an additional 155 Ml/d Vyrnwy bypass release at the confluence of the Weir Brook with the River Severn (upstream of Montford); and an abstraction reduction at Shelton intake at Shrewsbury, at selected times. Accounting for flow losses in the river systems, STT solution flow augmentation in this reach would be up to 200 Ml/d. The operating pattern remains as per that previously described, albeit at a higher rate of flow augmentation. The A82 scenario would include a continuous 105 day period of flow augmentation from late June to early October. The M96 scenario would include a continuous 144 day period of flow augmentation from mid-June to early November.

On the River Severn upstream of the confluence with the River Avon the increase in flow due to the fully supported STT scheme (direct release from Vyrnwy Reservoir, Vyrnwy Bypass and Shrewsbury Redeployment) is approximately 14% of the reference flow during the summer period in both scenarios. The flow increase due to the scheme is around 200 Ml/d.

The fully supported flow increases are noticeable between 30th June and 12th October in the A82 scenario and between 15th June and 2nd November in the M96 scenario.

The long profile chart shows that on the 25$^{th\ of}$ August (low flow) the proportion of the total flow contributed by the scheme is approximately 17% at Bewdley and 11% at Saxons Lode. This is because of the increase in flow in the river due to tributaries, the major ones being the River Stour (at 183 km) and River Teme (at 206 km).

The modelled changes are summarised as below and are graphically presented in **Annex A** of the Physical Environment Assessment Report.

- The most discernible change **at Bewdley** as a result of the increased flows will be an average daily velocity increase of 0.1 – 15.5% from June to October in the A82 scenario and an average daily increase in velocity of 8.5 – 16.7% from June – November in the M96 scenario. The average daily increase in water depth will be 1 – 4% from June to October in the A82 scenario, and 8– 17% increase in June – November in the M96 scenario. The resulting change in velocity and depth will not be discernible, with velocity in summer expected to increase by ~0.03m/s and depths by ~3cm. As a result, average velocity in summer will remain at ~0.18m/s and depths will remain at ~1.9m.

- The impact of the STT scheme near Upton Ham is taken from the change at the Saxon Lode gauge, with supported flow increase of approximately 3 m^3/s. The flow is increased by 0.6 % in the 50 % Annual Exceedance Probability (AEP) (2 year return period) and by 0.3 % in the 2 % AEP (50 year return period). The impact on the frequency at which flooding occurs is therefore, minor. The flood levels are increased by around 15 mm in the frequent AEPs based on the change at the Bewdley gauge, as extreme water level results were unavailable at Saxon Lode[22].

The modelled changes in water level are summarised as follows:

- For Lincomb, generally the change in level fluctuates between 2 cm and 4 cm increase in level with the mean level over the period being 15.97 m AOD compared to 15.94 m AOD in the baseline.
- For Holt, generally the change in level fluctuates between a 3 cm and 4 cm increase in level with the mean level over the period being 14.08 m AOD compared to 14.04 m AOD in the baseline.
- For Bevere, generally the change is an approximate increase in level of 4 cm with the mean level over the period being 10.77 m AOD compared to 10.73 m AOD in the baseline.
- For Digilis, generally the change in level fluctuates between a 2 cm and 3 cm increase in level with the mean level over the period being 10.69 m AOD compared to 10.66 m AOD in the baseline.

It is evident from the results that the change in flow, level, and depth (1.9 – 3 cm increase in water depth and 2 – 4 cm in water level) is not discernible and will not have a discernible impact on water levels within adjacent hydrologically connected protected habitats including coastal and floodplain grazing marsh, lowland fens, and wet woodland. The potential changes in velocity and depth are not considered to be of a magnitude to result in impacts to hydrologically connected habitats in this reach as the velocity and depths that would be observed under a fully supported STT would be similar to baseline conditions. Flows and velocities will also not result in additional washout of marginal or bankside vegetation or the associated seedbank.

At Upton Ham, the hydraulic data and flooding assessment indicates that the flow would be increased by 0.6% in the 50% AEP (2 year return period) and by 0.3% in the 2% AEP (50 year return period). The impact on the frequency at which flooding occurs is therefore minor. The flood levels are increased by around 15 mm in the frequent AEPs. This is based on the change at the Bewdley gauge as extreme water level results were unavailable at the Saxon Lode gauge[23]. Therefore, there would be no discernible change in the seasonality, duration, or frequency of periodic inundation in potentially hydrologically connected priority habitats (coastal and floodplain grazing marsh, lowland fens, and wet woodland) within the impacted reach.

Overall, impacts from operation on the hydrologically connected protected habitats (coastal and floodplain grazing marsh, lowland fens, and wet woodland) as a result of hydrological and hydraulic changes in this reach are not expected to result in ecological effects under the current conditions.

3.4.3.2 Changes to water quality

A current flow conditions assessment of environmental water quality effects from the STT operation in this reach has not been scoped in for the Gate 2 assessment due to the absence of potential impact pathways. The potential for water quality benefits in this reach associated with the enhanced dilution, of wastewater discharges (e.g., Worcester WwTW) and other pollution pressures, from the flow augmentation are not included in this assessment.

3.4.4 STT operation - future climate

This section sets out the findings of the effects of the STT operation during future climate conditions.

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[23] HR Wallingford (2022) Severn Thames Transfer SRO - Hydraulic and Water Quality Modelling Flooding Assessment. FWR6568-RT001-R02-00. 13 May 2022

In comparison with the A82 scenario, the A82 Future scenario would include a 40 % longer period of flow augmentation releases - with extension both 35 days earlier, to include late May and all of June; and 36 days later, to include all of October and the first half of November. The increase in regularity of the need for STT support options in late spring, early summer and later into autumn is a significant change.

3.4.4.1 Change to in flow, velocity and depth

On the River Severn upstream of the confluence with the River Avon the increase in flow due to the fully supported STT scheme (Vyrnwy Reservoir, Vyrnwy bypass, abstraction reduction at Shelton and Mythe licence transfer) is approximately 20 % of the reference flow during the summer period in the A82 Future scenario at Bewdley and around 14 % prior to the confluence with the Avon. The flow increase due to the scheme is around 180 Ml/d, the same as with baseline conditions.

The fully supported flow increases are noticeable between 26th May and 18th November in the A82 Future scenario which is a longer duration than in the M96 baseline scenario.

As a guide, the change in depth-average velocity and water depth at the Severn at Bewdley assessment point from the 1D hydraulic model has been reviewed. There are 141 days in the A82 Futures scenario with modelled river flows of less than 900 Ml/d in the reference conditions and with direct release from Vyrnwy Reservoir; Vyrnwy bypass release; and abstraction reduction at Shelton intake at Shrewsbury. On these dates, the mean change in depth-average velocity is modelled as 0.028 m/s (a 3 % increase) and the mean change in water depth is modelled as 0.068 m (a 7 % increase).

The modelled changes in water level are summarised as follows:

- For Lincomb, generally the change in level fluctuates between 1 cm and 6 cm increase in level with the mean level over the period being 15.97 m AOD compared to 15.94 m AOD between 24th May and 23rd November.
- For Holt, the level increase is variable at the start of the scheme until 18th June, with a level increase between 1 cm and 6 cm and a mean level of 14.12 m AOD compared to the mean baseline level of 14.09 m AOD. There is subsequently low variability between 18th June and 8th September, with a mean level increase of 4 cm and a mean level of 14.04 m AOD compared to a mean baseline of 14.00 m AOD. From 9th September to 23rd November, the level change is much more variable with a level increase ranging between 1 cm and 5 cm, and a mean level of 14.12 m AOD compared to the mean baseline level of 14.09 m AOD.
- For Bevere, the level increase is variable at the start of the scheme until 17th June, with a level increase between 2 cm and 6 cm. The mean level during this period is 10.81 m AOD compared to the mean baseline level of 10.78 m AOD. There is subsequently low variability between 7th June and 8th September, with a mean level increase of 4 cm and a mean level of 10.71 m AOD compared to a mean baseline of 10.67 m AOD. From 9th September to 23rd November, the level change is much more variable with a level increase ranging between 2 cm and 6 cm, and a mean level of 10.82 m AOD compared to the mean baseline level of 10.79 m AOD.
- For Digilis, the level increase is variable at the start of the scheme until 17th June, with a level increase between 1 cm and 4 cm. The mean level during this period is 10.81 m AOD compared to the mean baseline level of 10.78 m AOD. There is subsequently low variability between 7th June and 8th September, with a mean level increase of approximately 3cm and a mean level of 10.71 m AOD compared to a mean baseline of 10.67 m AOD. From 9th September to 23rd November, the level change is much more variable with a level increase ranging between 1 cm and 4 cm, and a mean level of 10.82 m AOD compared to the mean baseline level of 10.79 m AOD.

Under the 1 – 6cm increase in water depth identified in the future scenario outputs, there would be no discernible change in the seasonality, duration, or frequency of periodic inundation in adjacent coastal and floodplain grazing marsh, lowland fens, and lowland meadows, priority habitat or SSSIs within this reach. Overall, no impacts on the hydrologically connected protected habitats as a result of hydrological and hydraulic changes in this reach are expected under the current conditions.

3.4.4.2 Changes in water quality

A future flow assessment of environmental water quality effects from the STT solution operation in this reach has not been scoped in for the Gate 2 assessment due to the absence of pathways.

3.5 THE RIVER AVON FROM STONELEIGH TO THE CONFLUENCE WITH THE RIVER SEVERN

3.5.1 Baseline

This section describes baseline conditions and provides a comparison of the baseline to naturalised conditions.

The STT Gate 1 assessments identified the requirement for further investigation into the presence of protected and designated water dependent hydrologically connected habitats adjacent to the River Avon to the confluence with the River Severn. The subsequent desk-based assessments based on the Priority Habitat Inventory (PHI) and designated sites scoped into the assessment at Gate 1 identified approximately 597ha of the Priority Habitat Coastal & floodplain grazing marsh (CFGM) 500m of the River Avon with potential for hydrological connectivity (within 3 m elevation of the average river level and/or containing connecting watercourses). This included two designated sites Upham Meadow and Summer Leasow SSSI and Rectory Farm Meadows SSSI. Coastal and floodplain grazing marsh was identified during surveys at Upham Meadow and Summer Leasow SSSI with hydrological connectivity to the River Avon. Rectory Farm Meadows was not surveyed due to access restrictions therefore using a precautionary approach the features of the SSSI are assumed to be present throughout the site and in hydrological connectivity to the River Avon.

Three additional SSSIs with water dependent feature (not scoped into the surveys for hydrological connectivity following Gate 1) were present adjacent to the impacted reach of the river Avon: Racecourse Meadows SSSI, Welford Field SSSI, and Tiddesley Wood SSSI.

Surveys were carried out in 2021 (detailed in the Protected Habitats Evidence Report) at 42 sections of CFGM (313ha based on PHI data) identified in the PHI across 13 survey areas (227ha accessed during surveys), see Figure 3.1 and Figure 3.2. The surveys confirmed the presence of CFGM across 15 areas identified on the PHI with a total surveyed area of approximately 100ha. The CFGM within the reach typically comprised modified grassland (g4 25) and other neutral grassland (g3c) bordered by ditches and/or hedgerows (h2b). Other habitats identified included: Non-cereal crops (c1d), Neutral grassland (g3), Cereal crops (c1c), Mixed scrub (h3h), Aquatic marginal vegetation (f2d), Other swamps (f2f), Other woodland; mixed (w1h), Other woodland; broadleaved (w1g), Suburban/ mosaic of developed/ natural surface (u1d), Line of trees (w1g6), Hawthorn scrub (h3f), Eutrophic standing waters (r1a), Wet woodland (w1d), Hedgerow (priority habitat) (h2a), Other rivers and streams (r2b), Other hedgerows (h2b), and Built linear features (u1e).

The surveyed areas were approximately 1.5m to 5m (average height across surveyed area of approximately 2.23m) above the water level in the River Avon at time of survey. Connecting channels were present between the River Avon and the PHI and designated sites at eight of the survey areas visited in 2021. All priority habitats/designated sites were level with the bank-full height of the relevant main river channel, so are likely to experience periodic inundation under flood conditions.

Figure 3.1 Cattle grazed modified grassland (survey parcel SPC15) bordered by ditches and hedgerows adjacent to River Severn

Figure 3.2 River Avon adjacent to coast and floodplain grazing marsh at Survey Parcel SPC15 showing marginal vegetation and hight difference between river and terrestrial habitats

3.5.2 Relevant impact pathways

Considering the baseline protected habitat and designated sites and the operational pattern, the support releases could therefore result in changes in water quality, hydrology and hydraulics (in-stream habitat) which could result in the following:

- Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches
- Change in seasonality, duration, or frequency of periodic inundation

- Change in periodic inundation altering distribution or duration of temporary pools
- Increased flows and velocities could result in direct damage to higher plants and washout of seeds
- Changes in water quality within the habitats could alter community structure of the associated vegetation communities.

3.5.3 STT operation – current conditions

This section sets out the findings of the effects of the STT scheme operation during current or contemporary ('now') climate conditions.

3.5.3.1 Change to flows, velocity and depth

In this reach, the STT solution would augment flows through a 115 Ml/d advanced treated effluent transfer from Minworth WwTW at selected times. The indicative system operation pattern of the STT solution involves discharges releases only in 24 of the 47 years, and on 15% of days overall. Flow changes in this reach would typically be in the months July to October, peaking at 46% of days in September. Outside this period, there would be less regular flow changes in June and November, with changes very rare in May, December and January and not anticipated in February, March or April.

The A82 scenario would include a continuous 99 day period of flow augmentation from early July to early October. The M96 scenario would include a continuous 138 day period of flow augmentation from mid-June to early November.

Immediately downstream of the Minworth Transfer outfall, the flow in the River Avon is increased by 115 Ml/d due to the flow augmentation from Minworth in the fully supported STT scheme, which is approximately 60% in A82 and 64% in M96 compared to the reference conditions summer flow.

Downstream of Warwick the flow is increased by around 41% in A82 and 50% in M96 compared to the reference conditions, due to the flow from Minworth in the fully supported STT scheme. The increase in the flow is approximately 113 Ml/d at Warwick due to losses. At Evesham the flow is increased by around 25% in A82 and 28% in M96 compared to the reference conditions, due to the flow from Minworth in the fully supported STT scheme. The increase in the flow is approximately 107 Ml/d at Evesham due to losses. Upstream of the confluence with the River Severn the flow is increased by around 20% in A82 and 23% in M96 compared to the reference conditions due to the flow from Minworth in the fully supported STT scheme. The increase in the flow is approximately 103 Ml/d at the downstream end of the River Avon due to losses of 10% along the River Avon.

The model outputs show that the solution increases flow by 115 Ml/d initially downstream of the Minworth transfer outfall. At Warwick the increase is 114 Ml/d. At Evesham the increase in flow is 107 Ml/d and 103 Ml/d at the downstream end of the River Avon due to losses of 10% spread along the length of the Avon. On the 5th of December the flows in the River Avon are similar in magnitude to those on 25th August, around 10% higher prior to the confluence with the Severn.

As noted above, the habitat availability and the resulting impacts of the increased flows on habitat quality and quantity as a result of changes in velocity and depth will differ when comparing the reaches upstream and downstream of Alveston weir due to the effects of the impoundment on flow velocity and level.

- The most significant change **upstream of Alveston** as a result of increased flows will be an average daily increase in velocity of between 35 - 42% in the months of July, August and September in the A82 scenario, and an average daily increase in velocity of 19 – 50% in the months of June – October in the M96 scenario (as measured downstream of Warwick). As a result, the proportionate change in the average velocities has been modelled as an increase of approximately 0.02m/s in both scenarios The potential changes in depth have been assessed as a maximum increase of 2% (~4cm) in both scenarios and is not considered significant in consideration of the local geomorphology.

- The most significant changes **downstream of Alveston** as a result of increased flows will be an average daily increase of 21 – 26% in velocity in the months of July, August and September in the A82 scenario and an average daily increase in velocity of 21 – 25% in the months of July – October in the M96 scenario. As a result, the proportionate change in the average velocities has been modelled as an increase of approximately 0.03m/s in both scenarios. The potential changes in depth have been assessed as a maximum increase of 1 % (~2cm) in both scenarios and is not considered significant in consideration of the local geomorphology.

The most significant change **upstream of the confluence with the River Severn** as a result of the increased flows will be an average daily increase of approximately 19– 26% in velocity in the months of July, August and September in the A82 scenario and an average daily increase in velocity of 22 – 26% in the months of July – October in the M96 scenario. As a result, the proportionate change in the average velocities has been modelled as an increase of approximately 0.01m/s in both scenarios. No change in depth has been identified in either of the scenarios. Differences in water level associated with the STT solution would be small; an increase not a decrease; and within normal patterns of level. Typically, the increase in water level modelled at lowest water levels associated with the STT solution would, during the period of operation, be 3 – 5 cm in this reach. Note there are localised exceptions where water levels may increase outside of this estimated range.

From the results it is evident that the change in flow and level would not result in a discernible change in water levels within adjacent hydrologically connected designated sites (Upham Meadow and Summer Leasow SSSI and Rectory Farm Meadows SSSI), potentially hydrologically connected designated sites (Racecourse Meadows SSSI, Welford Field SSSI, or Tiddesley Wood SSSI) or priority habitats (CFGM). The potential changes in depth are up to 4cm upstream of Alveston or 0-2cm in the sections of the reach downstream of Alveston where hydrologically connected designated sites and protected habitats were identified with no discernible change in level. Therefore, the potential changes in velocity and depth are not considered to be of a magnitude to result in impacts to hydrologically connected habitats in this reach as the velocity and depths that would be observed under a fully supported STT would be similar to baseline conditions. The potential changes to flows and velocities would also not result in additional washout of marginal or bankside vegetation or the associated seedbank.

For the lower River Avon, the section of the impacted reach containing the identified SSSIs and CFGM, the hydraulic data and flooding assessment indicates that the flow would be increased by 0.8% in the 50% (2 year return period) Annual Exceedance Period (AEP) and by 0.3% in the 2% AEP (50 year return period). The impact on the frequency at which flooding occurs is therefore minor. The flood levels would be increased by around 10mm in the frequent AEPs. Therefore, there would be no discernible change in the seasonality, duration, or frequency of periodic inundation in Upham Meadow and Summer Leasow SSSI and Rectory Farm Meadows SSSI or the coastal and floodplain grazing marsh adjacent to the impacted reach.

Overall, impacts from operation on the hydrologically connected designated sites (Upham Meadow and Summer Leasow SSSI and Rectory Farm Meadows SSSI), protected habitats (coastal and floodplain grazing marsh), or potentially hydrologically connected designated sites (Racecourse Meadows SSSI, Welford Field SSSI, or Tiddesley Wood SSSI) as a result of hydrological and hydraulic changes in this reach are not expected to result in ecological effects under the current conditions.

3.5.3.2 Changes in water quality

Similar changes in water quality are generally predicted for both the A82 and M96 scenarios under the fully supported STT scheme and are summarised below:

- During the scheme operation, the river water temperature would be higher. This increase is similar for both scenarios: up to 0.8°C upstream of Warwick, and up to 0.5°C at Evesham and at the confluence with River Severn. Modelled data indicates that in summer temperatures will remain below 17.5°C.
- The discharge will reduce dissolved oxygen immediately downstream of the outfall up to the confluence with the River Leme by ~1.5 mg/l. Dissolved oxygen (as % saturation) will remain above 75% within the first 20 km and remain above 90% for the remainder of the reach, up to the confluence with the River Severn.
- Ammoniacal nitrogen is expected to increase by 0.1-0.15 mg/ downstream of Warwick with the increase of 0.05 mg/l at Evesham and 0.02 mg/l at the confluence with the River Severn. Soluble reactive phosphate concentrations are reduced by the scheme throughout the River Avon by up to 0.1 mg/l.
- Increase in nonylphenols, cypermethrin, perfluorooctane sulfonic acid and its derivatives and permethrin concentrations resulting in further deterioration in current Environmental Quality Standard failures in the River Avon.

The results of the water quality modelling indicate that water quality changes are expected to be minimal with a slight decrease in some nutrients expected. The temperature and dissolved oxygen (as % saturation) will remain within the range for achieving high ecological status. No impact pathways have been identified for dissolved oxygen or temperature for hydrologically connected water dependent designated sites or protected habitats.

The reduction in soluble reactive phosphate within the River Avon associated with the STT scheme operation is not considered likely to alter community composition or vegetation structure within adjacent site or habitats due to the baseline conditions and period in which the scheme will be operational. The UKHab surveys undertaken in 2021 indicate that the habitats within the reach are typically modified through agriculture and indicative of high nutrient levels with low species diversity in a large proportion of the grasslands adjacent to the Avon. A reduction in soluble reactive phosphorus (SRP) within the river has potential benefits for the adjacent habitats.

The impacts of exposure of the hydrologically connected habitats and designated sites to contaminants (nonylphenols, cypermethrin, perfluorooctane sulfonic acid and its derivatives and permethrin) will be reviewed in detail at Gate 3.

3.5.4 STT operation - future climate

This section sets out the findings of the effects of the STT operation during future climate conditions.

In comparison with the A82 scenario, the A82 Future scenario would include a 40 % longer period of flow augmentation releases - with extension both 35 days earlier, to include late May and all of June; and 36 days later, to include all of October and the first half of November. The increase in regularity of the need for STT support options in late spring, early summer and later into autumn is a discernible change.

3.5.4.1 Change to in flow, velocity and depth

Immediately downstream of the Minworth Transfer outfall, the flow in the River Avon is increased by 115 Ml/d due to the flow augmentation from Minworth in the fully supported STT scheme, which is approximately 64 % in A82 Future compared to the reference conditions summer flow. The scheme runs from the 25$^{th\ of}$ May to the 21$^{st\ of}$ November in the A82 Future climate.

Downstream of Warwick, the flow is increased by around 50 % in A82 Future climate (similar to M96 present day) compared to the reference conditions, due to the flow from Minworth in the fully supported STT scheme. The increase in the flow is approximately 113 Ml/d at Warwick due to losses.

At Evesham the flow is increased by around 28 % in A82 Future climate compared to the reference conditions, due to the flow from Minworth in the fully supported STT scheme. The increase in the flow is approximately 107 Ml/d at Evesham due to losses.

Upstream of the confluence with the River Severn, the flow is increased by around 24 % in the A82 Future climate compared to the reference conditions due to the flow from Minworth in the fully supported STT scheme. The increase in the flow is approximately 103 Ml/d (the same as in baseline climate) at the downstream end of the River Avon due to losses of 10 % along the River Avon.

The long section plot shows the flow on the 18$^{th\ of}$ October for the reference and the fully supported STT scheme from the A82 Future scenario. Initially downstream of the Minworth transfer outfall the flow is increased by 115 Ml/d. At Warwick, the increase is 114 Ml/d. At Evesham, the increase in flow is 107 Ml/d and 103 Ml/d at the downstream end of the River Avon due to losses of 10 % spread along the length of the Avon. In the future scenario, the flows are approximately 10 % lower than the low flow in present conditions.

As a guide, the change in depth-average velocity and water depth on the River Avon immediately downstream of the Minworth Transfer outfall assessment point from the 1D hydraulic model has been reviewed. There are 176 days in the A82 Futures scenario with effluent transfer from Minworth WwTW. On these dates, mean modelled flow in the reference conditions is 185 Ml/d; the mean change in depth-average velocity is modelled as 0.024 m/s (a 5 % increase in very low reference condition velocities); and the mean change in water depth is modelled as 0.11 m (a 27 % increase).

3.5.4.1.1 Impact assessment

A 0.11 m mean increase in water depth is predicted for immediately downstream of the Minworth Transfer outfall. As flow in the Avon is predicted to be 10% lower in the future scenario the increase in flow from the stream may have a beneficial effect in maintaining current hydrological connectivity. In addition, based on the future scenario outputs, due to the small scale of the potential level changes associated with the scheme and the overall lower flow under the future scenario there would be no discernible change in the seasonality, duration, or frequency of periodic inundation due to flooding on hydrologically connected habitats (coastal floodplain grazing marsh and lowland meadows priority habitats and SSSIs) present in this reach. Overall, no impacts on the hydrologically connected designated sites or protected habitats as a result of hydrological and hydraulic changes in this reach are expected under the current future conditions..

3.5.4.2 Changes in water quality

Under Scenario A82F, the predicted water quality in the River Avon is very similar to that predicted under A82 and M96. The main difference is that the period of the operation of the scheme is longer, starting in late May and ending in late November. Although the change in concentrations described for A82/M96 in the upper part of the River Avon occurs over a longer period, the peak changes in concentrations are very similar to A82/M96 for all parameters. Note that the simulations only changed the Avon, Severn and tributary flows; the water quality data for all inputs and sewage works flows remained the same in all simulations.

3.5.4.2.1 Impact assessment

Therefore, the results of the water quality modelling indicate that water quality changes are expected to be minimal with a slight decrease in some nutrients expected. The temperature and dissolved oxygen (as % saturation) will remain within the range for achieving high ecological status. Therefore, no discernible impacts are anticipated on hydrologically connected protected habitats.

3.6 THE RIVER SEVERN FROM THE CONFLUENCE WITH THE RIVER AVON TO DEERHURST

3.6.1 Baseline

This section describes baseline conditions and provides a comparison of the baseline to naturalised conditions.

The STT Gate 1 assessments identified the requirement for further investigation into the presence of protected and designated water dependent hydrologically connected habitats adjacent to the River Severn from the Avon Confluence to Deerhurst. The subsequent desk based assessments based on the Priority Habitat Inventory (PHI) and designated sites (scoped into the assessment at Gate 1) identified three SSSIs and approximately 160.4 ha of the Priority Habitat (13 areas of Coastal & floodplain grazing marsh listed in the PHI) within 500 m of the River Severn with potential for hydrological connectivity (within 3 m elevation of the average river level and/or containing connecting watercourses).

The designated sites associated with the impacted reach are Wainlode Cliff SSSI, Severn Ham, Tewkesbury SSSI, and Old River Severn Upper Lode SSSI. Wainlode Cliffs SSSI's has been screened out of the assessment due to the absence of ecological or water dependent features of interest.

The Severn Ham Tewkesbury SSSI was surveyed in 2021 (Figure 3.3) which identified the presence of neutral grassland (g3c), modified grassland (g4), tall herb neutral grassland (g3 16) aquatic marginal vegetation (f2d), and other woodland; broadleaved (w1g).

The hydrological connectivity walkover of the Severn Ham Tewkesbury SSSI (see Figure 3.3 and Figure 3.4) identified that connecting channels were present between the River Severn/Avon and the habitats within the Severn Ham SSSI and the height difference between river level and adjacent habitats was approximately 5-6 m.

The Old River Severn Upper lode SSSI survey (Figure 3.5) confirmed direct hydrological connectivity between the water level in the SSSI and the main river channel. The habitats associated with the hydrologically connected areas of the site (see Figure 3.5) included Eutrophic standing waters (r1a), Wet woodland (w1d 121), and Aquatic marginal vegetation (f2d 16 122).

Surveys of protected habitats were undertaken (detailed in the Protected Habitats Evidence Report) at 13 sections of CFGM (160.4ha based on PHI data) identified in the PHI across five survey areas (142.1ha accessed during surveys). The surveys confirmed the presence of CFGM across four areas identified on the PHI (including Severn Ham Tewkesbury SSSI) with a total surveyed area of approximately 37ha. The CFGM within the reach typically comprised modified grassland (g4 25) bordered by ditches and/or hedgerows (h2b), and tall herb (g3c 16) and aquatic marginal vegetation (f2d) on banks of watercourses. Other habitats identified in the surveyed areas included: non-cereal crops (c1d), Neutral grassland (g3), Cereal crops (c1c), Other neutral grassland (g3c), Hawthorn scrub (h3f), Aquatic marginal vegetation (f2d), Artificial unvegetated, unsealed surface (u1c), Other woodland; broadleaved (w1g), Eutrophic standing waters (r1a), Wet woodland (w1d), and Mixed scrub (h3h).

The surveyed areas were approximately 3m to 6m (average height across surveyed area of approximately 4.5 m) above the water level in the River Severn at time of survey. Connecting channels were present between the River Severn and the PHI sites at three of the four survey areas visited in 2021. All priority habitats/designated sites were level with the bank-full height of the relevant main river channel, so are likely to experience periodic inundation under flood conditions.

Figure 3.3 Severn Ham Tewkesbury SSSI – example of modified and neutral grassland present throughout the majority of the site during survey in August 2021

Figure 3.4 Severn Ham Tewkesbury SSSI – back Avon showing height difference between terrestrial habitats and connecting channels during survey in August 2021

Figure 3.5 Old River Severn, Upper Lode SSSI – connecting channel and adjacent wet woodland

3.6.2 Relevant impact pathways

Considering the baseline protected habitat and designated sites and the operational pattern, the support releases could therefore result in changes in water quality, hydrology and hydraulics (in-stream habitat) which could result in the following:

- Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches
- Change in seasonality, duration, or frequency of periodic inundation
- Change in periodic inundation altering distribution or duration of temporary pools
- Increased flows and velocities could result in direct damage to higher plants and washout of seeds
- Changes in water quality within the habitats could alter community structure of the associated vegetation communities.

3.6.3 STT operation – current conditions

This section sets out the findings of the effects of the STT scheme operation during current or contemporary ('now') climate conditions.

3.6.3.1 Change to flow, velocity and depth

In this reach, the STT solution would augment flows through a 25 Ml/d direct release from Vyrnwy Reservoir; an additional 155 Ml/d Vyrnwy bypass release at the confluence of the Weir Brook with the River Severn (upstream of Montford); and an abstraction reduction at Shelton intake at Shrewsbury; and a 115 Ml/d advanced treated effluent transfer from Minworth WwTW at selected times. Accounting for flow losses in the river systems, the STT solution flow augmentation in this reach would be up to 318 Ml/d. The operating pattern

remains as per that described in the upstream reach albeit at a higher rate of flow augmentation. The A82 scenario would include a continuous 105 day period of flow augmentation from late June to early October. The M96 scenario would include a continuous 144 day period of flow augmentation from mid-June to early November.
The increase in flow upstream of Deerhurst, due to the fully supported STT scheme is around 15% in the A82 scenario and 17% in the M96 scenario. The period of the scheme is 30th June to the 12th of October in the A82 scenario and from 15th June to 2nd November in the M96 scenario. The flow increase during the summer period is around 309 Ml/d.

Habitats in this reach are generally uniform with some change in availability near the Upper Lode weir:

- The most discernible change **at the Upper Lode weir/downstream of the confluence with the river Avon** as a result of the increased flows is an average daily increase of between 4- 13 % in velocity in the months of June - October in the A82 scenario and an average daily increase in velocity of between 3 – 16% increase in velocity in the months of June – November in the M96 scenario. As a result, the proportionate change in the average velocities has been modelled as an increase of approximately 0.02m/s in both scenarios. The modelled data shows that water depth will not change during operation, although a slight decrease in depth is noted in October (~0.5cm).
- The most discernible changes **downstream of Upper Lode weir/upstream of Deerhurst** as a result of the increased flows will be an average daily increase of between 0.1- 16% in velocity in the months of June - October in the A82 scenario and an average daily increase in velocity of 1.9 – 18.4% increase in velocity in the months of June – November in the M96 scenario. As a result, the proportionate change in the average velocities has been modelled as an increase of approximately 0.02m/s in both scenarios. The modelled data shows that water depth will not change during operation, although a slight decrease in depth is noted in October (~0.5cm).

In relation to water level, under the full STT A82 scenario, between, roughly, the 1st of April and 20th June the level reduces by a range of 0.4 cm and 0.6 cm compared to the reference level, driven by unsupported interconnector pipeline maintenance abstraction at Deerhurst. When the Netheridge release is required to support the maintenance abstraction at Deerhurst (roughly the 24th of June), the level no longer varies from the baseline until the full STT support commences. When the full support commences (late June) there is a variation in level ranging between a reduction of 0.9 cm and an increase of 3.0 cm compared to the reference condition over an 18 day period before the level returns to being slightly below the reference level whilst the STT abstraction is fully supported.

Once the flow is sufficient at Deerhurst for the full abstraction to be achieved whilst unsupported (roughly 30th August), there is a decrease in water level until the STT is turned off in late November. Over this unsupported period, the level changes from an increase of 0.2 cm to a reduction of 12.8 cm, with the level ranging between 6.70 m AOD and 10.54 m AOD (with a mean level of 7.63 m AOD) compared to the reference levels which range between 6.71 m AOD and 10.60 m AOD (with a mean level of 7.69 m AOD). The level change in the unsupported STT A82 scenario is similar to the full STT scenario except from the level variation associated with the commencement of the support from Minworth Transfer.

Under the full STT M96 scenario, between, roughly, the 1st of April and 9th May the level reduces by a range of 0.4 cm and 0.6 cm compared to the reference level, driven by unsupported interconnector pipeline maintenance abstraction at Deerhurst. When the Netheridge release is required to support the maintenance abstraction at Deerhurst (roughly the 10th of May), the level no longer varies from the baseline until the full STT support commences. When the full support commences (roughly 15th June) there is a variation in level ranging between a 0.9 cm reduction to approximately a 3 cm increase compared to the reference conditions over an eight day period before the level returns to being similar to the reference level whilst the STT abstraction is fully supported. Once the flow is sufficient at Deerhurst for the full abstraction to be achieved whilst unsupported (roughly 27th October) there is a decrease in water level until the STT is turned off in early January. Over this unsupported period, the level reduces by between 0.5 cm and 11 cm with the level ranging between 6.78 m AOD and 11.41 m AOD (with a mean level of 9.09 m AOD) compared to the reference levels which range between 6.79 m AOD and 11.45 m AOD (with a mean level of 9.16m AOD). The level change in the unsupported STT M96 scenario is similar to the full STT scenario except from the level variation associated with the commencement of the support from Minworth Transfer.

From the results it is evident that the change in flow and level is not discernible and will not impact on water levels within adjacent hydrologically connected designated sites or protected habitats including Severn Ham, Tewkesbury SSSI, Old River Severn Upper Lode SSSI, and areas of CFGM. The potential changes in depth are limited to a 0.5 cm reduction in October. The Old River Severn Upper Lode SSSI would consequently by subject to an equivalent reduction in water level (-0.5 cm) in October. Due to the small scale and duration of water level changes in the River Severn and the existing fluctuations in water level within the site no changes in habitat distribution or species composition are anticipated within the SSSI. The potential changes in velocity and depth are not considered to be of a magnitude to result in impacts to hydrologically connected habitats in this reach as the velocity and depths that would be observed a fully supported STT would be similar to baseline conditions. The potential changes to flows and velocities would also not result in additional washout of marginal or bankside vegetation or the associated seedbank.

For the River Severn Avon to Deerhurst, the hydraulic data and flooding assessment indicates that the flow would be increased by 0.7% in the 50% (2 year return period) AEP and by 0.4% in the 2% AEP (50 year return period). The impact on the frequency at which flooding occurs is therefore minor. The flood levels would be increased by around 6 mm in the frequent AEPs. Therefore, there would be no discernible change in the seasonality, duration, or frequency of periodic inundation in Severn Ham, Tewkesbury SSSI, Old River Severn Upper Lode SSSI, and areas or the coastal and floodplain grazing marsh adjacent to the impacted reach.

Overall, no impacts are expected on the hydrologically connected designated sites (Severn Ham, Tewkesbury SSSI, Old River Severn Upper Lode SSSI) or protected habitats (coastal and floodplain grazing marsh) as a result of hydrological and hydraulic changes in this reach under the current conditions.

3.6.3.2 Changes in water quality

Similar changes in water quality are generally predicted for both the A82 and M96 scenarios under the fully supported STT scheme and are summarised below:

- In the River Severn upstream of Deerhurst, water temperature is not predicted to change due to the STT operation.
- Dissolved oxygen concentrations, nor saturations, are not predicted to change due to the STT operation.
- Ammoniacal nitrogen concentrations are also not predicted to change due to the STT operation.
- Soluble reactive phosphate concentrations are predicted to be reduced by up to 0.05 mg/l during the operation of the STT operation.
- Increase in the contaminants nonylphenols, cypermethrin, perfluorooctane sulfonic acid and its derivatives and permethrin concentrations and deterioration of hydrologically connected habitats.

As there are no changes in the physic-chemical characteristics of the water, impacts on the identified habitats and features of interest of the associated SSSIs are not expected. Decreased phosphate concentration would provide a potential benefit through a reduction in algal growth and growth of undesirable species within the Old River Severn Upper Lode SSSI. The non-discernible change in water quality will not impact on aquatic species and wetland plant species that are features of the Old River Severn Upper Lode SSSI or any marginal vegetation associated with costal and floodplain grazing marsh. Potential impacts from exposure to contaminants (nonylphenols, cypermethrin, perfluorooctane, sulfonic acid and its derivatives, and permethrin) on hydrologically connected protected habitats will be further assessed at Gate 3.

3.6.4 STT operation - future climate

This section sets out the findings of the effects of the STT scheme operation during future climate conditions.

In comparison with the A82 scenario, the A82 Future scenario would include a 40 % longer period of flow augmentation releases - with extension both 35 days earlier, to include late May and all of June; and 36 days later, to include all of October and the first half of November. The increase in regularity of the need for STT support options in late spring, early summer and later into autumn is a discernible change.

3.6.4.1 Change to in flow, velocity and depth

The increase in flow upstream of Deerhurst, due to the fully supported STT scheme is around 17 % in the A82 Future climate scenario. The period of the scheme is 28th May – 20th November in the A82 Future scenario, which is longer than in the M96 baseline scenario. The flow increase during the summer period is around 283 Ml/d.

The low flow in the future scenario is around 30 % less than the low flow in present conditions.

As a guide, the change in depth-average velocity and water depth at the Severn at Deerhurst upstream offtake assessment point from the 1D hydraulic model has been reviewed. There are 166 days in the A82 Futures scenario with modelled river flows of less than the HoF2 value of 3,333 Ml/d in the reference conditions and with direct release from Vyrnwy reservoir; Vyrnwy bypass release; abstraction reduction at Shelton intake at Shrewsbury; and effluent transfer from Minworth WwTW. On these dates, the mean change in depth-average velocity is modelled as 0.016 m/s (a 18 % increase in very low reference condition velocities) and the mean change in water depth is modelled as 0 m.

3.6.4.1.1 Impact assessment

From the results above, it is evident that the change in flow is not discernible and will not have a discernible change in the seasonality, duration, or frequency of periodic inundation in Severn Ham, Tewkesbury SSSI, Old River Severn Upper Lode SSSI, and areas or the coastal and floodplain grazing marsh adjacent to the impacted reach.

Overall, no impacts are expected on the hydrologically connected designated sites (Severn Ham, Tewkesbury SSSI, Old River Severn Upper Lode SSSI) or protected habitats (coastal and floodplain grazing marsh) as a result of hydrological and hydraulic changes in this reach under the future conditions. Note that additional water in the River Severn, upstream of Deerhurst may have positive impacts on hydrologically connected protected habitats as the flow rate has been predicted to be 30 % less than present low flow conditions.

3.6.4.2 Changes in water quality

Under Scenario A82F, the predicted water quality in the River Severn between the River Avon confluence and Deerhurst is very similar to that predicted under A82 and M96. The main difference is that the period of the operation of the scheme is longer, starting in late May and ending in late November. Although the change in concentrations described for A82F in this sub-reach occurs over a longer period, the peak changes in concentrations are very similar to A82/M96 for all parameters.

3.6.4.2.1 Impact assessment

As there are no changes in the physico-chemical characteristics of the water, no impacts on protected habitats are expected. Decreased phosphate concentration would provide a potential benefit through a reduction deposition under high flows and decreased algal growth in connecting channels.

3.7 THE RIVER SEVERN FROM DEERHURST TO THE TIDAL LIMIT AT GLOUCESTER

3.7.1 Baseline

This section describes baseline conditions and provides a comparison of the baseline to naturalised conditions.

The STT Gate 1 assessments identified the requirement for further investigation into the presence of protected and designated water dependent hydrologically connected habitats adjacent to the River Severn from Deerhurst to the tidal limit. The subsequent desk based assessments based on the Priority Habitat Inventory (PHI) and designated sites (scoped into the assessment at Gate 1) identified no designated sites and approximately 668 ha of the Priority Habitat (128 areas of Coastal & floodplain grazing marsh listed in the PHI) within 500 m of the River Severn with potential for hydrological connectivity (within 3m elevation of the average river level and/or containing connecting watercourses).

Surveys of protected habitats were undertaken (detailed in the Protected Habitats Evidence Report) at 57 sections of CFGM (290 ha based on PHI data) (see Figure 3.6 and Figure 3.7) identified in the PHI across five survey areas (158.7 ha accessed during surveys). The surveys confirmed the presence of CFGM across 16 areas identified on the PHI with a total surveyed area of approximately 100 ha. The CFGM within the reach typically comprised modified grassland (g4 25) bordered by ditches and/or hedgerows (h2b), and tall herb (g3c 16) and aquatic marginal vegetation (f2d) on banks of watercourses. Other habitats identified in the surveyed areas included: Aquatic marginal vegetation (f2d), Mixed scrub (h3h), Neutral grassland (g3), Bramble scrub (h3d), Cereal crops (c1c), Lowland mixed deciduous woodland (w1f), Other neutral grassland (g3c), Rivers and streams (r2), Other blackthorn scrub (h3a6), Line of trees (w1g6), Other hedgerows (h2b), Other rivers and streams (r2b), and Hedgerow (priority habitat) (h2a).

The surveyed areas were approximately 3 m to 4.5 m (average height across surveyed area of approximately 3.7 m) above the water level in the River Severn at time of survey. Connecting channels were present between the River Severn and the PHI sites at four of the five survey areas visited in 2021. All priority habitats/designated sites were level with the bank-full height of the relevant main river channel, so are likely to experience periodic inundation under flood conditions.

Figure 3.6 Modified grassland in the floodplain of the River Severn (survey parcel SPD05) bordered by drainage ditches, and line of trees along the river.

Figure 3.7 Drainage ditches bordering modified and neutral grassland providing hydrological connectivity to the River Severn (survey parcel SPD05), showing height difference between water level and terrestrial habitats

3.7.2 Relevant impact pathways

Considering the baseline protected habitat and designated sites and the operational pattern, the support releases could therefore result in changes in water quality, hydrology and hydraulics (in-stream habitat) which could result in the following:

- Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches;
- Change in seasonality, duration, or frequency of periodic inundation;
- Change in periodic inundation altering distribution or duration of temporary pools;
- Increased flows and velocities could result in direct damage to higher plants and washout of seeds; and
- Changes in water quality within the habitats could alter community structure of the associated vegetation communities.

3.7.3 STT operation – current conditions

This section sets out the findings of the effects of the STT scheme operation during current or contemporary ('now') climate conditions.

3.7.3.1 Change to flow, velocity and depth

In this reach, the STT solution would abstract flow for transfer in the STT interconnector. The abstraction regime is dependent on the maturity of the STT solution. For the early phase STT, abstraction would be unsupported up to 500Ml/d at selected times, subject to HoF conditions identified by EA. The indicative system operation pattern shows the STT solution abstraction occurring in 24 of the 47 years, and on 11% of days overall.

Early phase (Unsupported)

Water is abstracted at Deerhurst in the unsupported STT scheme when the flow in the River Severn is above the HOF and water is required for the River Thames. In scenario A82, this occurs from the 30th of September to the 30th of November, and in Scenario M96 from the 31st of October to the 9th of January. This leads to a reduction in the flow in the River Severn downstream of Deerhurst by 5 to 15% depending on the flow in the river.

The modelled long profile of flow on the 5th of December shows that the flow is above HOF 2 and there is unsupported abstraction at Deerhurst of 500 Ml/d. This is approximately 10% of the total flow in the river. These proportions are maintained to the normal tidal limit at Gloucester.

Full STT

In the fully supported STT scheme, there is a flow reduction of approximately 1.5% during the summer. This is due to the Mythe licence transfer of 15 Ml/d. In the autumn and early winter when flow is abstracted without support, the reduction in flow is similar to the unsupported STT scheme.

The modelling results show that the flow is below HOF 1 and there is fully supported abstraction at Deerhurst of 353 Ml/d. After the Netheridge outfall, the flow in the river with the fully supported STT scheme is slightly lower than in reference condition due to the Mythe licence transfer.

Habitats in this reach is generally uniform with some change in habitat availability near the Maismore weir.

- The most discernible change in an unsupported abstraction will be an average daily decrease of 4.6 % in velocity in November in an A82 scenario and an average daily increase in velocity of approximately 3 % in December in an M96 scenario. As a result, the proportionate change in the average velocities will not be discernible. The change in depth in both scenarios is not expected to exceed 2 % which equates to approximately 2 cm in autumn noting that depths will exceed 3 m.
- The most discernible change in a supported abstraction will be an average daily decrease of between 2- 5 % in velocity in the months of September - November in an A82 scenario and an average daily increase in velocity of 0.1 – 5 % decrease in velocity in the months of October to January in M96 scenario. Depths are likely to decrease by 0.5 – 2 % between September and November in the A82 scenario and 0.1 – 2 % in the M96 scenario. As a result, the proportionate change in the average velocities will not be discernible. The change in depth in both scenarios is not expected to exceed 2 % which equates to approximately 2 cm in autumn noting that depths will exceed 3 m.
- The impact of the STT scheme near Gloucester is taken from the change at the Deerhurst gauge with an increased flow of approximately 4 m^3/s. The flow is increased by 0.7 % in the 50 % AEP (2 year return period) and by 0.4 % in the 2 % AEP (50 year return period). The impact on the frequency at which flooding occurs is therefore minor. The flood levels are increased by around 6 mm in the less frequent AEPs based on the change at the Deerhurst gauge. As data was not available for the frequent floods an increase of around 10 mm was inferred from the Avon at Evesham and Severn at Bewdley[24].

3.7.3.2 Change in water quality

Similar changes in water quality are generally predicted for both the A82 and M96 scenarios under the fully supported STT operation and are summarised below:

- In the River Severn downstream of Deerhurst (upstream of the Netheridge discharge) and at the tidal limit, the STT operation is predicted to reduce water temperature by 0.2°C (A82) and 0.3°C (M96);
- Dissolved oxygen concentrations are predicted to be reduced by about 0.1 mg/l at both sites (a reduction of less than 1% saturation);

[24] HR Wallingford (2022). Severn Thames Transfer SRO – Hydraulic and Water Quality Modelling, Flooding Assessment. Report for Ricardo, 1 – 43.

- Ammoniacal nitrogen concentrations are predicted to be increased by about 0.02 mg/l at both sites; and
- Soluble reactive phosphate concentrations are predicted to be reduced by up to 0.02 mg/l during the operation of the scheme at both sites.
- Increase in the contaminants nonylphenols, cypermethrin, perfluorooctane sulfonic acid and its derivatives and permethrin concentrations and deterioration of hydrologically connected habitats

The results of the water quality modelling indicate that water quality changes are expected to be minimal with a slight decrease in some nutrients expected. The temperature and dissolved oxygen (as % saturation) will remain within the range for achieving high ecological status. No impact pathways have been identified for dissolved oxygen or temperature for hydrologically connected water dependent designated sites or protected habitats.

The reduction in soluble reactive phosphate within the River Severn associated with the STT scheme operation is not considered likely to alter community composition or vegetation structure within adjacent site or habitats due to the baseline conditions and period in which the scheme will be operational. The UKHab surveys undertaken in 2021 indicate that the habitats within the reach are typically modified through agriculture and indicative of high nutrient levels with low species diversity in a large proportion of the grasslands adjacent to the lower Severn. A reduction in SRP within the river has potential benefits for the adjacent habitats. Potential impacts from exposure to contaminants (nonylphenols, cypermethrin, perfluorooctane sulfonic acid and its derivatives, and permethrin) on hydrologically connected protected habitats will be further assessed at Gate 3.

3.7.4 STT operation - future climate

This section sets out the findings of the effects of the STT operation during future climate conditions.

In comparison with the A82 scenario, the A82 Future scenario would include a 40 % longer period of flow augmentation releases - with extension both 35 days earlier, to include late May and all of June; and 36 days later, to include all of October and the first half of November. The increase in regularity of the need for STT support options in late spring, early summer and later into autumn is a discernible change. In the A82 Future reference conditions River Severn flows are below HoF conditions for later in the autumn which drives the need to augmentation releases later in the autumn. Noting that in the A82 Future scenario abstraction from the River Severn for transfer to the River Thames would be required for 10 days later into autumn, the total period of unsupported abstraction would reduce from 60 days by 38 days to only 22 days. The 22 days of unsupported abstraction would be in the mid-November to early December period.

3.7.4.1 Change to flow, velocity and depth

In the fully supported STT scheme, there is a flow reduction of approximately 1.5 % during the summer. This is due to the Mythe licence transfer of 15 Ml/d. In the autumn and early winter, when flow is abstracted without support, the reduction in flow is similar to the unsupported STT scheme.

The long profile of flow on the 18th of October shows that the flow is below HoF 1 and there is fully supported abstraction at Deerhurst of 330 Ml/d. After the Netheridge outfall, the flow in the river with the fully supported STT scheme is slightly lower than in reference condition due to the Mythe licence transfer.

As a guide, the change in depth-average velocity and water depth at the Severn at Deerhurst downstream offtake assessment point from the 1D hydraulic model has been reviewed. There are 22 days in the A82 Futures scenario with unsupported abstraction above HoF conditions. On these dates, mean modelled flow in the reference conditions is 7,940 Ml/d; the mean change in depth-average velocity is modelled as 0.009 m/s (a 0.0002 % reduction); and the mean change in water depth is modelled as 0.07 m (a 1.6 % reduction).

3.7.4.1.1 Impact assessment

No impact pathways from changes in depth and velocity have been identified due to the small magnitude of change predicted change in level (mean 7cm reduction). Therefore, there would be no discernible change in the seasonality, duration, or frequency of periodic inundation in areas or the coastal and floodplain grazing marsh adjacent to the impacted reach.

Overall, no impacts on the hydrologically connected protected habitats (coastal and floodplain grazing marsh) are expected as a result of hydrological and hydraulic changes in this reach under the current conditions

3.7.4.2 Changes to water quality

Under Scenario A82F, the predicted water quality in the River Severn downstream of Deerhurst is very similar to that predicted under A82 and M96. The main difference is that the period of the operation of the scheme is longer, starting in late May and ending in late November. Although the change in concentrations described for A82F in this sub-reach occurs over a longer period, the peak changes in concentrations are very similar to A82/ M96 for all parameters.

3.7.4.2.1 Impact assessment

The results of the water quality modelling indicate that water quality changes are expected to be minimal with a slight decrease in some nutrients expected. The temperature and dissolved oxygen (as % saturation) will remain within the range for achieving high ecological status. No impact pathways have been identified for dissolved oxygen or temperature for hydrologically connected water dependent designated sites or protected habitats.

The reduction in soluble reactive phosphate within the River Severn associated with the STT scheme operation is not considered likely to alter community composition or vegetation structure within adjacent site or habitats due to the baseline conditions and period in which the scheme will be operational. The UKHab surveys undertaken in 2021 indicate that the habitats within the reach are typically modified through agriculture and indicative of high nutrient levels with low species diversity in a large proportion of the grasslands adjacent to the lower Severn. A reduction in Soluble Reactive Phosphorus (SRP) within the river has potential benefits for the adjacent hydrologically connected habitats.

3.8 THE SEVERN ESTUARY DOWNSTREAM OF THE TIDAL LIMIT AT GLOUCESTER

3.8.1 Baseline

This section describes baseline conditions and provides a comparison of the baseline to naturalised conditions.

The STT Gate 1 assessments did not identify the requirement for further investigation into the presence of protected and designated water dependent hydrologically connected habitats adjacent to the River Severn Estuary downstream of the tidal limit at Maisemore due to the small scale of the potential hydrological impacts. Consequently, no detailed assessments of hydrological connectivity or habitat surveys of the extent of protected habitats within the reach were undertaken.

A desk based assessment of the PHI for the Severn downstream of the tidal limit identified 1115 areas of water dependent priority habitat (within 500m of the impacted reach) with potential hydrological connectivity to the Severn Estuary: coastal and floodplain grazing marsh (641 areas covering an area of approximately 2360 ha), lowland fens (one area with a total area of 0.01 ha), mudflats (130 area with a total area of 639.66 ha), and saltmarsh (49 areas covering an area of approximately 23 ha).

Two Sites of Special Scientific interest with water dependent ecological features and hydrological connectivity (both sites include the aquatic habitats in River Severn Estuary) were identified within 500 m of the impacted reach: Upper Severn Estuary SSSI and Severn Estuary SSSI.

Three additional SSSIs were identified within 500m of the impacted reach but were screened out of the assessment due to the absence of water dependent features: Lydney Cliff SSSI, Aust Cliff SSSI, Purton Passage SSSI and Garden Cliff SSSI.

3.8.2 Relevant impact pathways

In environmental terms, unsupported STT abstraction would specifically be protected by licence hands-off flow conditions as set out in Table 1-2. Following these conditions, the greatest impact on pass forward flows would either be at the lowest remaining flow conditions, or highest abstraction rate. The greatest STT SRO impact under lowest remaining flow conditions would be abstraction of 172 Ml/d at river flows at Deerhurst of 2,740 Ml/d, reducing flow at Deerhurst to 2,568 Ml/d. The greatest STT SRO impact under highest abstraction rates would be abstraction of 500 Ml/d at river flows at Deerhurst of 3,661 Ml/d, reducing flow at Deerhurst to 3,161 Ml/d. These changes from STT SRO are set against a dynamic flow regime in the River Severn.

Considering the baseline designated and protected water dependent habitats and the operational pattern, the support releases could therefore result in changes in water quality, hydrology and hydraulics (in-stream habitat) which could result in the following:

- Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches
- Change in seasonality, duration, or frequency of periodic inundation of saltmarsh or intertidal mudflats
- Change in periodic inundation altering distribution or duration of temporary pools in saltmarsh
- Change in water chemistry in river altering nutrient availability or altering habitat suitability for aquatic and periodically inundated communities
- Change in velocity altering supporting processes

3.8.3 STT operation – current conditions

This section sets out the findings of the effects of the STT scheme operation during current or contemporary ('now') climate conditions.

3.8.3.1 Change to flow, velocity and depth

The A82 scenario would include a period of unsupported abstraction for 60 days from late September to late November, including 25,400 Ml abstracted; at peak rate of 500 Ml/d for 53, non-continuous days. The M96 scenario would include a period of unsupported abstraction for 70 days from late September to early January, including 32,900 Ml abstracted; at peak rate of 500 Ml/d for 64, non-continuous days.

The pass-forward flow to the Severn Estuary from the freshwater River Severn would be amended by unsupported STT abstraction. The daily pattern of unsupported STT SRO abstraction rates – either early phase STT or full STT are illustrated as the purple periods of the 47 water resources years within the Physical Environment Assessment Report[25].

It is evident that in both a moderate-low flow year (A82 scenario) and a very low flow year (M96 scenario) the proportionate change in flow is <1.5% in summer months. The most notable change in flows in the River Severn into the Severn Estuary in both modelled scenarios is a decrease of 4.2-6.9% in flow in the autumn.

Overall, the changes in freshwater inflows into the Severn Estuary is not discernible as it is within natural flow variation.

As such, the changes in pass forward flow are not expected to impact on the priority habitats within the Severn Estuary or qualifying features of the Severn Estuary and Upper Severn Estuary SSSI. This is because the changes in the freshwater inflows will not be of a magnitude to impact on the habitats that support the intertidal habitats (mudflats) and vegetation communities (saltmarsh), periodically inundated vegetation (CFGM, lowland fens, saltmarsh), fish community, wintering wildfowl, and the main habitat process will remain unchanged (considering the tidal regime of the Severn Estuary). It is also noted that flows will remain well above the above the residual flow requirements. Particularly in summer, flow will generally be higher when compared to naturalised flow conditions and the changes will be within the natural annual variations that would be observed under baseline conditions. In July the naturalised flows are around 20% lower than the A82 reference condition.

Overall, impacts on the protected and designated habitats as a result of hydrological and hydraulic changes in this reach is not expected under the current conditions. Furthermore, the operation of the STT will not impact on barrier pass ability or hydrological migration cues or impact on the structure and function of the habitats that support the fish community of the Severn Estuary and Upper Severn Estuary SSSI as identified in the STT Gate 2 Fisheries Assessment[26].

3.8.3.2 Change to water quality

Similar changes in water quality are generally predicted for both the A82 and M96 scenarios under the fully supported STT operation and are summarised below:

[25] Ricardo Energy & Environment (2022). Severn to Thames Transfer SRO. Physical Environment Assessment Report. Report for United Utilities on Behalf of the STT Group. May 2022.

[26] Ricardo Energy and Environment (2022) Severn Thames Transfer SRO Fisheries Assessment Report. Report for: United Utilities on behalf of the STT Group, Ricardo ref. ED15323. Issue: 001. 23/05/2022

- In the River Severn at the tidal limit, the scheme is predicted to reduce water temperature by 0.2°C (A82) and 0.3°C (M96).
- Dissolved oxygen concentrations are predicted to be reduced by about 0.1 mg/l for both scenarios.
- Ammoniacal nitrogen concentrations are predicted to be increased by about 0.02 mg/l for both scenarios.
- Oxidised nitrogen is increased by about 0.8 mg/l during the scheme (~10% increase on baseline). DIN concentrations are increased by a similar amount.
- Increase in the contaminants nonylphenols, cypermethrin, perfluorooctane sulfonic acid and its derivatives and permethrin concentrations and deterioration of hydrologically connected habitats

Specific additional analysis has been undertaken in relation to DIN using the EA long term water quality monitoring point at Haw Bridge[27] for the 10 year period 2013-2022. The 117 data points identify DIN concentration as approximately 6 mg-N/l with a standard deviation of 1.1 mg-N/l. Allowing for the expected removal rates of the Minworth SRO's advanced treatment processes for the Minworth Transfer, discharged concentration to the Avon could be approximately 17 mg-N/l. Allowing for the expected removal rates of the Severn Trent Sources SRO's advanced treatment processes for the Netheridge Transfer, discharged concentration to the Severn at Haw Bridge could be 15.8 mg-N/l. Modelled assessment identifies:

- For the full year of the A82 moderate-low flow year scenario, and including abstraction rates for full STT, this could lead to an annual decrease in DIN contribution from the freshwater River Severn to the Severn Estuary of 96 tonnes from a baseline of 15,369 tonnes – a reduction of 0.6%. This includes 192 tonnes/year load addition from Minworth Transfer and 67 tonnes/year addition from Netheridge Transfer; together with a 356 tonnes/year load reduction from STT abstraction. It is noted that under these circumstances at least a further 67 tonnes/year less DIN would be input into the Severn Estuary from Netheridge WwTW at the current outfall.
- For the full year of the M96 very low flow year scenario, and including abstraction rates for full STT, this could lead to an annual decrease in DIN contribution from the freshwater River Severn to the Severn Estuary of 112 tonnes from a baseline of 14,804 tonnes – a reduction of approximately 0.8%. This includes 268 tonnes/year load addition from Minworth Transfer and 90 tonnes/year addition from Netheridge Transfer; together with a 470 tonnes/year load reduction from STT abstraction. It is noted that under these circumstances, at least a further 90 tonnes/year less DIN would be input into the Severn Estuary from Netheridge WwTW at the current outfall.

As such there would be an overall reduction in DIN input from the freshwater River Severn and Netheridge WwTW combined into the Severn Estuary as result of STT operation.

Four WFD chemicals which are at risk of causing water quality deterioration in the River Severn Estuary (Permethrin, Perfluorooctane sulfonic acid and its derivatives, Cypermethrin, and Nonylphenols) are assessed in Section 3.8.2.2 of the Water Quality Assessment Report[28]. With respect to Netheridge Transfer and the planned advanced treatment processes included in the Severn Trent Sources SRO Gate 2 scheme. The water quality assessment identified that for those chemicals with an EQS, there would be no change in concentration that changes from EQS pass to EQS fail; no reduction in quality where there is EQS pass; no further reduction in quality where there is currently EQS fail; and for chemicals with current EQS fail, no impediments to achieving EQS pass. Potential impacts from exposure to contaminants (nonylphenols, cypermethrin, perfluorooctane sulfonic acid and its derivatives, and permethrin) on hydrologically connected protected habitats will be further assessed at Gate 3.

The results of the water quality modelling indicate that water quality changes are expected to be minimal with a slight decrease in some nutrients expected. The temperature and dissolved oxygen (as % saturation) will remain within the range for achieving high ecological status. No impact pathways have been identified for dissolved oxygen, temperature, or additional WFD chemicals for hydrologically connected water dependent designated sites or protected habitats and associated species.

The reduction in soluble reactive phosphate within the River Severn associated with the STT scheme operation is not considered likely to alter community composition or vegetation structure within adjacent habitats due to the baseline conditions and period in which the scheme will be operational. The UKHab surveys undertaken in 2021 indicate that the habitats within the reach are typically modified through agriculture and indicative of

[27] https://environment.data.gov.uk/water-quality/view/sampling-point/MD-00025085

[2828] Ricardo Energy and Environment (2022) Severn Thames Transfer (STT) Solution Environmental Water Quality Assessment Report Report for: United Utilities on behalf of the STT Group. Ricardo ref. ED15323. Issue: 003. 07/07/2022 high nutrient levels with low species diversity in a large proportion of the grasslands adjacent to the lower Severn[29]. A reduction in SRP within the river has potential benefits for the adjacent habitats. Therefore, no impact pathways to protected habitats, designated sites or the associated supporting habitat have been identified.

3.8.4 STT operation - future climate

This section sets out the findings of the effects of the STT operation during future climate conditions.

3.8.4.1 Changes to flow, velocity, depth and flood regime

The pass-forward flow to the Severn Estuary from the freshwater River Severn would be amended by unsupported STT abstraction. Overall, a pattern of unsupported STT solution abstraction only for 22 days in A82 Future in the mid-November to early December period is anticipated; and 88 days in M96 Future in November, December and January.

Although a fuller context of future operating patterns and flows are not currently available from modelling, review of A82 Future identified a reduction of 0.7 % in the flows passed forward to the Severn Estuary compared with reference conditions. The M96 Future, for which a flow series is only currently available for the River Thames, identifies a pattern of unsupported abstraction, which is longer than in the current climate and this later seasonal trend may be a feature of future operating patterns.

3.8.4.1.1 Impact assessment

Based on the modelling results, no impact pathways that could have discernible impacts on hydrologically connected protected habitats from flow, velocity, depth and flood regime have been identified.

3.8.4.2 Changes to water quality

Under Scenario A82F, the predicted water quality in the River Severn at the tidal limit is very similar to that predicted under A82 and M96. The main difference is that the period of the operation of the scheme is longer, starting in late May and ending in late November. Although the change in concentrations described for A82F in this sub-reach occurs over a longer period, the peak changes in concentrations are very similar to A82/ M96 for all parameters.

3.8.4.2.1 Impact assessment

Based on the modelling results, no impact pathways that could have discernible impacts on hydrologically connected protected habitats from water quality have been identified. Potential impacts from exposure to contaminants (nonylphenols, cypermethrin, perfluorooctane sulfonic acid and its derivatives, and permethrin) on hydrologically connected protected habitats under future conditions will be further assessed at Gate 3.

3.9 THE RIVER THAMES D/S CULHAM TO TIDAL LIMIT AT TEDDINGTON

3.9.1 Baseline

The STT Gate 1 assessments did not identify the requirement for further surveys to investigate the presence or extent of protected and designated water dependent hydrologically connected habitats adjacent to the River Thames. Consequently, no detailed assessments of hydrological connectivity or surveys of the extent of protected habitats within the reach were undertaken.

Protected habitats including SSSIs[30] and priority habitats[31] located in or adjacent to the impacted reach of the River Thames give an indication of potential water dependent hydrologically connected protected habitats present. These include:

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[29] Ricardo Energy and Environment (2022). Severn Thames Transfer SRO, Protected Habitats Assessment Report. Report for United Utilities on behalf of the STT Group.

[30] Site information on habitat types and associated protected species provided by Natural England SSSI citations.

[31] Site information on associated protected species provided by JNCC UK Biodiversity Action Plan Priority Habitat Descriptions.

- Little Wittenham SSSI (water dependent); area of woodland with ponds, grassland and scrub present. The site is notified due to a large breeding population of great crested newt *Triturus cristatus* and assemblage of amphibians and invertebrates it supports.
- Holies Down SSSI (not water dependent); area of unimproved chalk grassland dominated by glaucous sedge *Carex flacca* with a range of coarser grasses and chalk flowers.
- Hartslock SSSI (water dependent); site consists of semi-improved broadleaved woodland, chalk scrub and riverine fen. The insect fauna contains many species uncommon in Oxfordshire including chalkhill, adonis and small blue butterflies, the rufous grasshopper *Gomphocerrippus rufus* and several uncommon moths, beetles and true flies *Diptera*. The woodland supports a large population of European badger *Meles* and a Schedule 8 Wildlife and Countryside Act plant species has been recorded at the site.
- Temple Island Meadows SSSI (water dependent); the site consists of wet meadows including marshy neutral grassland, tall fen and wet woodland that seasonally flood and become waterlogged. It supports the nationally rare summer snowflake *Leucojum aestivum* and a range of invertebrates and birds.
- Rodbed Wood SSSI (water dependent); consists of wet woodland and water meadows that support the nationally rare summer snowflake plus breeding (kingfisher and warblers) and wintering birds (redpoll *Carduelis flamma* and siskin *C. spinus*).
- Bisham Woods SSSI (not water dependent); large area of beech dominated broadleaved woodland which supports a diversity of molluscs including *Helicigona lapicida, Pomatias elegans* and *Cochlodina laminata.*
- Cock Marsh SSSI (water dependent); site consists of wet alluvial grassland and calcareous grassland with four silted pools supporting a diversity of macrophytes such as water violet *Hottonia palustris*, marsh arrowgrass *Triglochin palustris* and marsh stitchwort *Stellaria palustris*. The SSSI is subject to periodic flooding and occasional drying out, which aids the floral richness of the site. Also supports both breeding and wintering bird populations.
- South Lodge Pit SSSI (not water dependent); citation does not mention protected species.
- Bray Meadow SSSI (water dependent); site consists of unimproved meadows with a high diversity of flora including both caliccoles and damp meadow species. Riverside vegetation includes the nationally scarce greater dodder *Cuscuta europaea*.
- Bray Pennyroyal Field SSSI (water dependent); Site supports the nationally rare pennyroyal, a species included in Schedule 8 under the Wildlife and Countryside Act 1981 and listed in the British Red Data Book of vascular plants.
- Wraysbury No. 1 Gravel Pit SSSI (water dependent); site of national importance for wintering gadwall *Anas strepera* and supports a diversity of locally important wintering bird species.
- Wraysbury and Hythe End Gravel Pits SSSI; Site consists of a mosaic of open water, islands, grassland, scrub and woodland within an area of former gravel extraction. The habitat supports nationally important numbers of tufted duck *Aythya fuligula*, gadwall and goosander *Mergus merganser*, breeding birds and two nationally scarce invertebrates (a riffle beetle *Oulimnius major* and caddisfly *Leptocerus lusitanius*).
- Langham Pond SSSI (water dependent); The site is a remnant of an old ox-bow lake and supports several nationally scarce invertebrates (Diptera (flies) and Odonata (dragonflies)) and plants including whorled water-milfoil *Myriophyllum verticillatum*, orange foxtail grass *Alopecurus aequalis* and greater water parsnip *Sium latifolium*.
- Wraysbury Reservoir SSSI (water dependent); Site supports nationally important numbers of wintering cormorant *Phalacrocorax carbo*, great crested grebe *Podiceps cristatus* and Northern shoveler *Anas clypeata.*
- Thorpe Hay Meadow SSSI (water dependent); Site lies on alluvial gravels surrounded by ditches and high hedges and consists of a range of lime-loving (calcicole) plants. Associated with the drainage ditch purple willow *Salix purpurea* Cyperus sedge *Carex pseudocyperus* and *Riccia fluitans* (an uncommon liverwort) are present.
- Thorpe Park No. 1 Gravel Pit SSSI (water dependent); Site of national importance for wintering gadwall.

- Dumsey Meadow SSSI (water dependent); unimproved pasture consisting of mainly crested dog's tail *Cynosurus cristatus* and common knapweed *Centaurea nigra* and marshy depressions present along the river bank.
- Knight and Bessborough Reservoirs SSSI (water dependent); Site of national importance for wintering Northern shoveler.
- Bushy Park and Home Park SSSI (not water dependent); Site consists of woodland and grassland that support nationally important saproxylic invertebrate assemblages associated with heartwood decay, bark and sapwood decay. Veteran trees are predominantly lime and Pedunculate oak.
- A desk based assessment of the PHI for the River Thames between Culham and Teddington identified 293 areas of water dependent priority habitat (within 500m of the impacted reach) with potential hydrological connectivity including: coastal and floodplain grazing marsh (221 areas with a total area of 464.23 ha), lowland fens (38 areas with a total area of 41.83 ha), reedbeds (three areas with a total area of 3.07 ha), purple moor grass and rush pasture (four areas with a total area of 3.9 ha), mudflats (four areas with a total are of 1.56 ha), and areas of "No main habitat but additional habitats present" which included areas of water dependent habitats (lowland fens, CFGM, reedbeds, and mudlfats) (27 area with a total area of 36.11 ha).

3.9.2 Relevant impact pathways

Considering the baseline designated and protected water dependent habitats and the operational pattern, the support releases could therefore result in changes in water quality, hydrology and hydraulics (in-stream habitat) which could result in the following:

- Change in river levels altering water levels in adjacent habitats including groundwater and water level in ditches
- Change in seasonality, duration, or frequency of periodic inundation of saltmarsh or intertidal mudflats
- Change in periodic inundation altering distribution or duration of temporary pools in saltmarsh
- Change in water chemistry in river altering nutrient availability or altering habitat suitability for aquatic and periodically inundated communities
- Change in velocity altering supporting processes

3.9.3 STT operation – current conditions

3.9.3.1 Change to flow, velocity and depth

In this reach, the STT solution would augment flow via the STT interconnector. The flow augmentation regime is dependent on the maturity of the STT solution.

3.9.3.1.1 Early phase (Unsupported)

Flow augmentation at Culham in the early phase STT scheme is when the flow in the River Severn is above the HoF and water is required for the River Thames. In scenario A82, this occurs from the 30th of September - 30th November and in Scenario M96 from the 31st of October - 9th January. In both of these scenarios, flows have also begun to increase in the River Thames at time of unsupported transfer and the higher rate of flow augmentation of 500 Ml/d does not coincide with periods of lowest river flow in the River Thames. As such, there is no other pattern of introduced flow peaks in the River Thames in either scenario, with the reference condition patterns of flow increases and decreases retained. Flow augmentation leads to an increase in the flow in the River Thames downstream of Culham typically around 20-25 %, but by up to 40 % depending on the flow in the river. Upstream of the confluence with the River Pang, the increase in the flow in the River Thames is lower as a proportion of river flow, typically 20 %, but by up to 34 % depending on the flow in the river. Upstream of the Datchet intake the increase in the flow in the River Thames is lower still as a proportion of river flow, typically 10-15 %, but by up to 32 % depending on the flow in the river. Outside of these operating periods the pipeline maintenance flow of 20 Ml/d or a Netheridge Transfer supported rate of 35 Ml/d would be discharged to the River Thames at all other times, both of which are small proportion (less than 10%) flow increases at Culham.

The long profile of flow for A82 on the 23rd of October shows a 25 % increase in river flow at Culham from 500 Ml/d flow augmentation with that flow increase held to upstream of the Datchet intake ~100 km downstream and then re-abstracted. The long profile of flow for M96 on the 5th of December shows a 20 % increase in river flow at Culham from 500 Ml/d flow augmentation with that flow increase again held to upstream of the Datchet intake ~100km downstream and then re-abstracted.

3.9.3.1.2 Full STT

Flow augmentation at Culham in the Full STT scheme is more frequent than the Early Phase STT. In scenario A82, this occurs from the 30th of June - 30th November and in Scenario M96 from the 15th of June - 9th January. The supported period of abstraction (in the modelled scenario is a 330 Ml/d flow increase) leads to a steady increase in the flow in the River Thames downstream of Culham by 60-86 % in A82, depending on the flow in the river, and in the lower flow year M96 an increase of 65-103 % depending on flow in the river . Apart from the initial flow increase when flow augmentation commences, there are no other patterns of introduced flow peaks in the River Thames in either scenario, with the reference condition patterns of flow increases and decreases retained. Upstream of the confluence with the River Pang, the increase in the flow in the River Thames is lower as a proportion of river flow, typically 33-48 % for the A82 scenario and 35-45 % for the M96 scenario depending on the flow in the river. Upstream of the Datchet intake, the increase in the flow in the River Thames is lower still as a proportion of river flow, typically 22-33 % for both the A82 and M96 scenarios depending on the flow in the river. Outside of these operating periods the pipeline maintenance flow of 20 Ml/d would be discharged to the River Thames at all other times which are small proportion (less than 5%) flow increases at Culham.

The long profile of flow for the A82 scenario on the representative low flow date 18th July shows a 67 % increase in river flow at Culham from 330 Ml/d flow augmentation with that flow increase again held to upstream of the Datchet intake ~100km downstream and then re-abstracted.

The 1D hydraulic model output for water depth variability in the River Thames has not been used in this assessment. This is because water levels in the River Thames are managed for navigation, with the normal operating level varying within 1 m. For example, at Culham Lock 90 % of gauged river levels in the last year have varied within in a 0.3 m range; at Whitchurch Lock (local to the River Pang confluence) by approximately 0.2 m; at Romney Lock (local to the Datchet intake) by 0.40 m. This is in contrast to the differences in water depth which have been greater than 1 m during the scenario periods reported for the River Thames at Culham; upstream of the River Pang; and upstream of the Datchet intake.

The 1D hydraulic model output for depth-average velocity variability in the River Thames is considered more reliable. The key summary of the modelled velocity change is that the STT solution would reduce the extent of average velocity reduction within the channel during summer periods of low flow in the River Thames. With the STT solution, average velocity at Culham would not fall below 0.2 m/s; and upstream of the River Pang and upstream of the Datchet intake average velocity would not fall below 0.2 m/s at times of operation of the STT solution.

Impact assessment

Based on the modelling results above, during early phase STT it is evident that the change in flow is not discernible and as the River Thames channel is managed for navigation, limited impacts on water depth as a result of the STT SRO are anticipated. Therefore, there would be no discernible change in the hydrological connectivity or seasonality, duration, or frequency of periodic inundation in areas of priority habitat or potentially hydrologically connected water dependent habitats in SSSIs adjacent to the impacted reach.

However, during full STT downstream of Culham outfall flows are predicted to increase from 60 – 103 % depending on whether it is a moderate - low flow year or a very low flow year. This will reduce to 22 – 33 % at the Datchet intake. The increase in flow rate may alter supporting processes with potential for change in distribution or condition of hydrologically connected priority habitat or potentially hydrologically connected water dependent habitats in SSSIs adjacent to the impacted reach. No flood modelling has been completed for the potential impacts of STT SRO on the River Thames. The River Thames channel is managed for navigation, limited impacts on water depth as a result of the STT SRO are anticipated. So, it is unlikely that would be no discernible change in the hydrological connectivity or seasonality, duration, or frequency of periodic inundation in areas of priority habitat or potentially hydrologically connected water dependent habitats in SSSIs adjacent to the impacted reach but this will be assessed in greater detail at Gate 3.

Changes to water quality

Similar changes in water quality are generally predicted for both the A82 and M96 scenarios under the fully supported STT scheme.

During periods of scheme operation in early summer (June and July) when River Thames water temperatures are at their highest (17°C), flow augmentation from the STT solution could cool river temperatures by up to 1°C. As river temperatures fall in late summer and early autumn (September and October) there is a slight pattern that the STT solution could shift water temperature decline by 1-4 days. As the model does not allow for any heat exchange with the atmosphere, a temperature change pattern is retained for the remainder of the model extent, although this is considered to be an over-representation.

Dissolved oxygen saturation in both scenarios is increased by 4 %sat at times of STT solution augmenting low flows in the River Thames at Culham. However, as this is at times of super-saturation, this may be an over-representation. At higher river flows, the effect of flow augmentation is less. The modelling identifies a potential zone of influence of the increase in saturation as far as the River Thame confluence, 12 km downstream of the STT interconnector outfall.

Ammoniacal nitrogen is predicted to increase during the scheme operation by around 0.03 mg/l (from a baseline of 0.02 – 0.06 mg/l) at Culham downstream of the STT interconnector outfall.

Phosphorus is predicted to increase during the scheme operation by around 0.05 mg/l (from a baseline of 0.12 – 0.35 mg/l) at Culham downstream of the STT interconnector outfall with a lower rate of increase downstream. Downstream of Culham, the River Thame is modelled to increase pressure on phosphorus concentrations and the Rivers Pang and Kennet to reduce pressure. Increases are greatest at times of low flow in the River Thames, which, in the modelled scenarios, coincide with 353 Ml/d supported transfer from the River Severn (Full STT solution). At times of up to 500 Ml/d unsupported transfer (both early phase and full STT solution), baseline river flows in the River Thames are modelled as higher and as such, phosphorus concentrations are modelled to increase by around 0.03 mg/l.

The pH change was calculated from pan-SRO monitoring data. Those spot monitoring data identify a pH range in the lower Severn at Deerhurst of 7.5 – 8.7 (mean 8.1). Although there is greater variability in the range of pH in the lower Severn than the middle Thames, the difference in mean value is indiscernible.

3.9.3.1.3 Impact assessment

Based on modelled outputs, no discernible impacts from changes in water quality are anticipated on hydrologically connected protected habitats as the increases in ammoniacal nitrogen, phosphorus and dissolved oxygen saturation are minor and will not impact on the WFD status of the watercourse and consequently are unlikely to have discernible impacts to hydrologically connected protected habitats.

3.9.4 STT operation - future climate

This section sets out the findings of the effects of the STT operation during future climate conditions.

3.9.4.1 Change to flow, velocity and depth

In comparison with the M96 scenario the M96 Future scenario would include a 22 % longer period of flow augmentation releases - with extension both 24 days earlier, to include late May and all of June; and 21 days later, to include most of January. Flow augmentation would be at peak rate of 500 Ml/d for 53, non-continuous days from late September. Between the end of June and late September flow augmentation would be at the supported rate of 353 Ml/d. The M96 scenario would include a period of flow augmentation for 208 days from mid-June to early January, including flow augmentation at peak rate of 50 0Ml/d for 88 continuous days from early November. Between mid -June and early November flow augmentation would be at the supported rate of 353 Ml/d.

Flow augmentation at Culham in the M96 Future scenario would occur from the 22nd of May to the 29th of January. This leads to an increase in the flow in the River Thames downstream of Culham by 16 % to 132 % depending on the flow in the river. Apart from the initial flow increase when flow augmentation commences, there is no other pattern of introduced flow peaks in the River Thames, with the reference condition pattern of flow increases and decreases retained. Upstream of the confluence with the River Pang the increase in the flow in the River Thames is lower as a proportion of river flow, typically 10 - 61 % depending on the flow in the river. Upstream of the Datchet intake the increase in the flow in the River Thames is lower still as a proportion of river flow, typically 5 - 40 % depending on the flow in the river. Outside of these operating periods, the pipeline maintenance flow of 20 Ml/d would be discharged to the River Thames at all other times: this is a small proportion (less than 5 %) of the flow increase at Culham.

3.9.4.1.1 Impact assessment

Based on the modelling results above, during early phase STT it is evident that the change in flow is not discernible and as the River Thames channel is managed for navigation, limited impacts on water depth as a result of the STT SRO are anticipated. Therefore, there would be no discernible change in the hydrological connectivity or seasonality, duration, or frequency of periodic inundation in areas of priority habitat or potentially hydrologically connected water dependent habitats in SSSIs adjacent to the impacted reach.

However, during full STT downstream of Culham outfall flows are predicted to increase from 16 – 132 % during a very low flow year. This will reduce to 5 - 40 % at the Datchet intake. The increase in flow rate may alter supporting processes with potential for change in distribution or condition of hydrologically connected priority habitat or potentially hydrologically connected water dependent habitats in SSSIs adjacent to the impacted reach. No flood modelling has been completed for the potential impacts of STT SRO on the River Thames. The River Thames channel is managed for navigation, limited impacts on water depth as a result of the STT SRO are anticipated. So, it is unlikely that would be no discernible change in the hydrological connectivity or seasonality, duration, or frequency of periodic inundation in areas of priority habitat or potentially hydrologically connected water dependent habitats in SSSIs adjacent to the impacted reach but this will be assessed in greater detail at Gate 3No flood modelling has been completed for the potential impacts of STT SRO on the River Thames.

3.9.4.2 Changes to water quality

The futures assessment of general water quality is an assessment of the change in dilution only. It does not account for future climate temperature changes nor changes to pollutant load in the future. Note that the simulations only changed the River Thames and tributary flows; the water quality data for all inputs, including the STT interconnector discharge and sewage works flows remained the same in all simulations.

Under the M96 Future scenario, the predicted water quality in the River Thames is only a minor change from predicted under M96. The main difference is that the period of the operation of the scheme is longer, starting in late May and ending in late November. Although the change in concentrations described for M96F in the middle Thames at Culham occurs over a longer period, the peak changes in concentrations are very similar to M96 for all parameters.

3.9.4.2.1 Impact assessment

Based on modelled outputs, no discernible impacts from changes in water quality are anticipated on protected species as the increases in ammoniacal nitrogen, phosphorus and dissolved oxygen saturation are minor and will not impact on the WFD status of the watercourse and consequently are unlikely to have discernible impacts to hydrologically connected protected habitats.

4. CONCLUSIONS

4.1 SUMMARY OF THE EFFECT UNDER CURRENT CONDITIONS

From the results it is evident that the potential changes in flow (as associated with either supported or unsupported STT operation) are not considered discernible and will likely be within the inter annual variations that would be observed under reference conditions.

As a result, the potential changes in flow (as associated with either a supported or unsupported STT) will not impact on the water dependent habitats of the identified SSSIs and protected habitats as there is not predicted to be a significant change in water level or velocity within impacted reaches of the River Vyrnwy, River Severn , River Avon or River Thames and the relative height difference between the protected habitats and the baseline river levels. The hydrological modelling and flood assessment did not identify changes in the frequency, extent or duration of winter inundation that could have potential to alter the extent, quality or distribution or the priority habitats (coastal and floodplain grazing marsh, lowland fens, wet woodland, and purple moor grass and rush pastures) or the associated species or habitats of interest for the identified hydrologically connected/potentially hydrologically connected SSSIs (Rectory Farm Meadows SSSI, Racecourse Meadows SSSI, Welford Field SSSI, Tiddesley Wood SSSI, Upham Meadow and Summer Leasow SSSI, Severn Ham, Tewkesbury SSSI, Old River Severn, Upper Lode SSSI), Upper Severn Estuary SSSI, and Severn Estuary SSSI.

No impacts that could lead to adverse effects from water quality were identified for the protected and designated habitats with potential hydrological connectivity to the impacted reaches of the River Vyrnwy, River Severn, River Avon, and River Thames. The reduction in soluble reactive phosphate associated with the impacted reaches of the River Avon and the Severn (from the Avon confluence to the tidal limit at Gloucester) has the potential for beneficial impacts to the priority habitats and wetland and aquatic vegetation associated with the designated sites within these reaches (Rectory Farm Meadows SSSI, Racecourse Meadows SSSI, Welford Field SSSI, Tiddesley Wood SSSI, Upham Meadow and Summer Leasow SSSI, Severn Ham, Tewkesbury SSSI, and Old River Severn, Upper Lode SSSI), Upper Severn Estuary SSSI, and Severn Estuary SSSI. Potential impacts from exposure of protected habitats to increased concentrations of nonylphenols, cypermethrin, perfluorooctane sulfonic acid and its derivatives and permethrin will be further reviewed at Gate 3.

4.2 SUMMARY OF THE EFFECTS UNDER FUTURE CONDITIONS

Under Future scenarios, the STT SRO would have a longer period of flow augmentation. As future baseline conditions typically have longer periods where low flow years occur, it is anticipated that the operation of STT SRO will have beneficial impacts on protected habitats that rely on surface water to supply supporting habitat. Limited changes to water quality were identified under future conditions. However, the high increases in flow downstream of Culham outfall could impact on condition or distribution of protected habitats and the supporting processes although due the level control for navigation in the Thames there is limited potential for changes in water depth. There is uncertainty surrounding potential changes to periodic inundation due to no flood modelling being undertaken for the River Thames at Gate 2.

4.3 UNCERTAINTY AND CONFIDENCE DATA GAPS

The available evidence and data are considered sufficient to inform the assessment of the potential changes to water dependent designated sites and protected habitats with hydrological connectivity to waterbodies associated with the STT solution for Gate 2. Furthermore, the additional evidence collected by the STT group has reduced the uncertainty in the conclusion of the Gate 1 assessments by identifying/confirming the extent of protected habitats with potential hydrological connectivity to the impacted reaches.

There remains some uncertainty in the assessments completed in Gate 2 and further recommendations have been made below to address the uncertainty. The uncertainty is summarised as follows:

- Much of the assessment work is based on ADCP data and does not take into account the influence of the river level on groundwater level in the adjacent protected habitats; and
- The assessment of hydrological connectivity did not take into account groundwater connectivity and was based on presence of connecting channels and the relative height difference using open source elevation data and average river levels to determine survey locations.

- There is uncertainty surrounding potential changes to periodic inundation due to no flood modelling being undertaken for the River Thames at Gate 2. Recommendations for Gate 3

The following recommendations are made for Gate 3 in order to further bolster the habitat assessment and to provide this with a more robust empirical framework:

- If possible, use a more detailed model to provide higher resolution outputs at sections of velocity and depth. This would be beneficial in broadening the hydraulic information available to characterise the simulated range of changes at each cross-section within a channel and allow development of a better understanding of these changes, particularly in areas in direct hydrological connectivity or in areas with highly sensitive water dependent habitats;
- Undertaking Common Standards monitoring, macrophyte surveys and ADCP surveys within the Old River Severn Upper Lode SSSI if changes to the scheme identify the potential for change in river levels and confirm potential for changes from water quality; and
- Borehole surveys are due to be undertaken prior to Gate 3. The results of the investigations should be reviewed to provide further information on the potential hydrological connectivity from impacted reaches to protected habitats through groundwater.