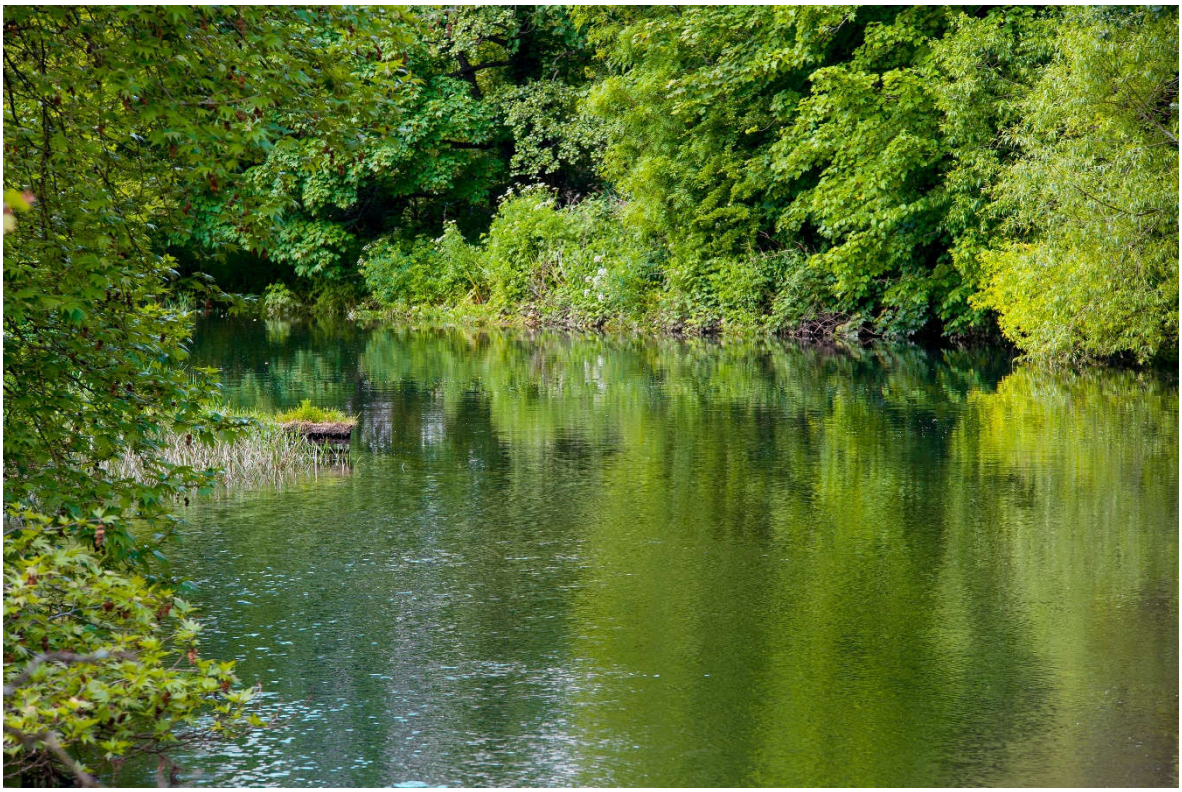
Strategic Regional Water Resource Solutions: Annex C Water Quality Assessment Report

Standard Gate Two Submission for Thames to Southern Transfer (T2ST)

Date: November 2022



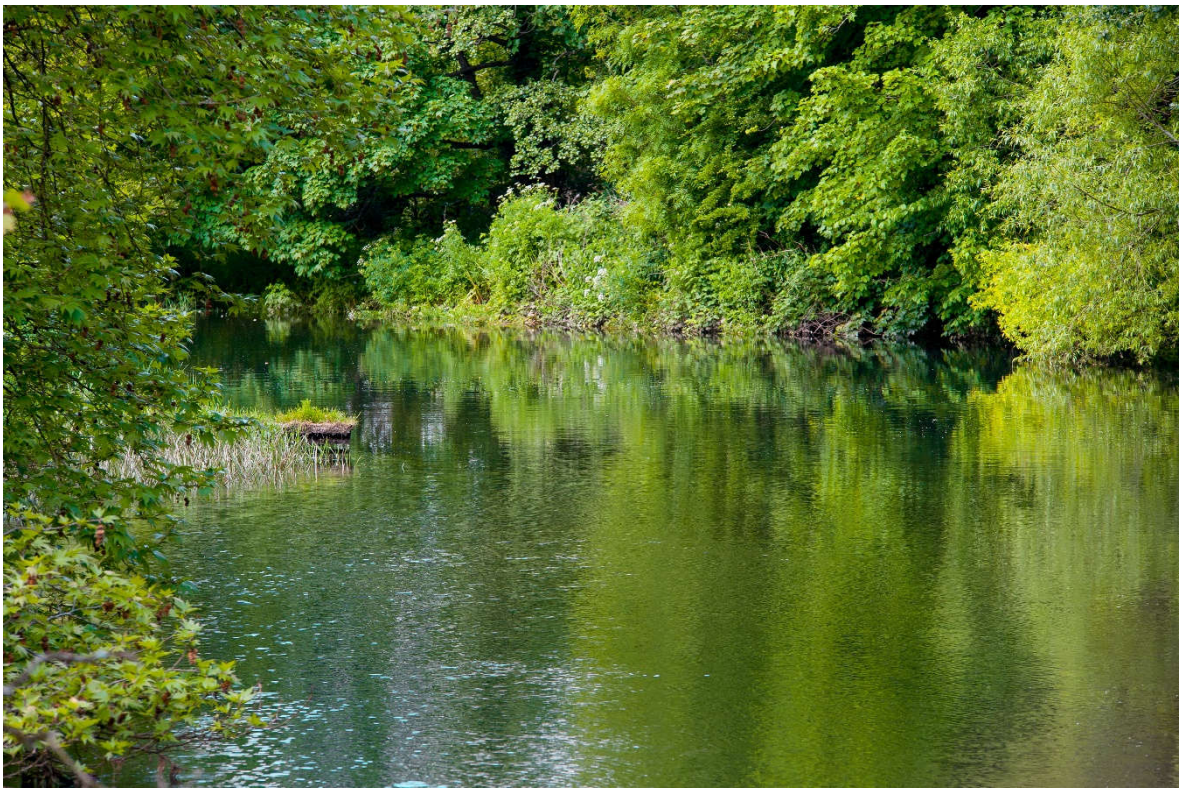
Notice

Position Statement

- *This document has been produced as the part of the process set out by RAPID for the development of the Strategic Resource Options (SROs). This is a regulatory gated process allowing there to be control and appropriate scrutiny on the activities that are undertaken by the water companies to investigate and develop efficient solutions on behalf of customers to meet future drought resilience challenges.*
- *This report forms part of suite of documents that make up the 'Gate 2 submission.' That submission details all the work undertaken by Thames Water and Southern Water in the ongoing development of the proposed SROs. The intention of this stage is to provide RAPID with an update on the concept design, feasibility, cost estimates and programme for the schemes, allowing decisions to be made on their progress and future funding requirements.*
- *Should a scheme be selected and confirmed in the Thames Water and Southern Water final Water Resources Management Plans, in most cases it would need to enter a separate process to gain permission to build and run the final solution. That could be through either the Town and Country Planning Act 1990 or the Planning Act 2008 development consent order process. Both options require the designs to be fully appraised, and in most cases an environmental statement to be produced. Where required that statement sets out the likely environmental impacts and what mitigation is required.*
- *Community and stakeholder engagement is crucial to the development of the SROs. Some 'high level' activity has been undertaken to date. Much more detailed community engagement and formal consultation is required on all the schemes at the appropriate point. Before applying for permission Thames Water and Southern Water will need to demonstrate that they have presented information about the proposals to the community, gathered feedback and considered the views of stakeholders. We will have regard to that feedback and, where possible, make changes to the designs as a result.*
- *The SROs are at a very early stage of development, despite some options having been considered for several years. The details set out in the Gate 2 documents are still at a formative stage and consideration should be given to that when reviewing the proposals. They are for the purposes of allocating further funding not seeking permission.*

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 and Southern Water's 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 and Southern Water will be subject to the statutory duties pursuant to the necessary consenting process, including environmental assessment and consultation as required. This document should be read with those duties in mind.



THAMES TO SOUTHERN TRANSFER (T2ST)

Annex C Water Quality Assessment Report

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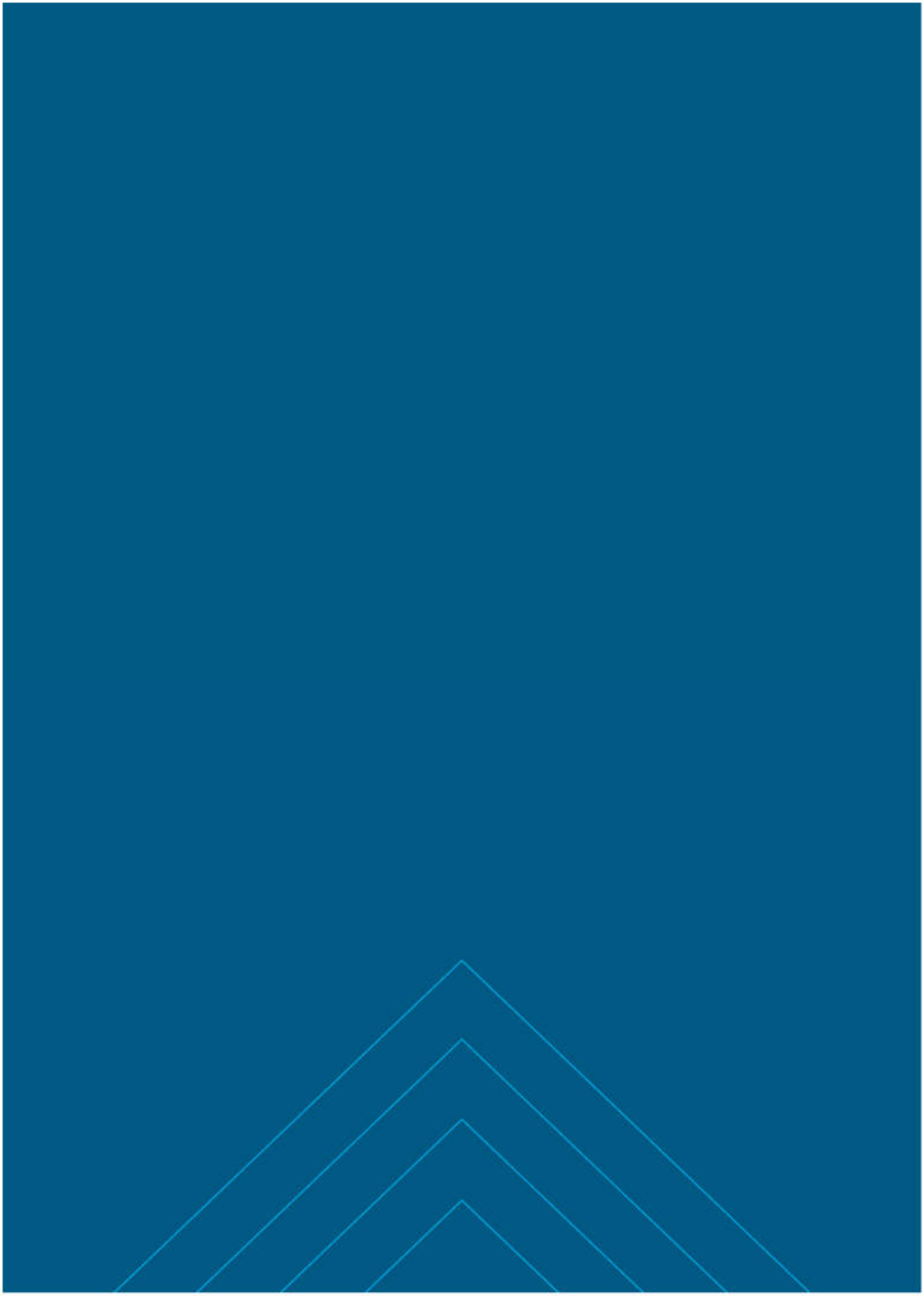

Executive Summary

This draft report summarises the water quality assessment that has been undertaken to date as part of the Thames to Southern Transfer (T2ST) Strategic Resource Option (SRO) for Gate 2. The approach for this water quality assessment follows the All Companies Working Group (ACWG) methodology to ensure a consistent process of reviewing the strategic water quality risks. This methodology has been created in accordance with the Drinking Water Inspectorate (DWI) planning requirements, to follow global best practice in Drinking Water Safety Planning in alignment with the UK Regulatory framework and emerging water quality considerations.

The Water Quality Risk Assessment (WQRA) forms the third stage of the five steps of the ACWG Methodology. As part of the Gate 1 submission to RAPID in July 2021 WQRA spreadsheets were produced and reviewed through a workshop with stakeholders from Thames Water (TW) and Southern Water (SRN) on the 13th and 15th April 2021. These spreadsheets follow a 'source-to-tap' approach for water safety planning through abstraction, treatment and distribution to customers for the T2ST SRO, identifying the key 'limiting hazards' and control measures to reduce these hazards.

The Gate 2 workshop for T2ST was held on the 19th and 26th May 2022 undertaking the water quality risk assessment process for all water source scenarios by reviewing limiting hazards and likelihood scores. The workshops were attended with stakeholders from Thames Water and Southern Water and followed the ACWG methodology. These workshops took place after the SESRO SRO Gate 2 WQRA workshop held on the 16th May 2022 and receipt of the Severn to Thames Transfer (STT) SRO Gate 2 WQRA, where a workshop was held on 7th March 2022 with an additional workshop with the DWI present on the 28th April 2022. These two 'upstream' SRO assessments form the potential sources for the T2ST scheme.

This report summarises the progress of the Gate 2 WQRA based on available information to date, and identifies control measures (in particular, water treatment) to manage the limiting hazards for each of the preferred water source options taken forward into Gate 2 of the T2ST SRO.

SRO Options - Gate 2 Options Appraisal

At Gate 1, six options for implementing the T2ST transfer were identified. Options 2,3,5 and 6 comprised raw water transfers over significant distances from the point of abstraction, with treatment (to potable standard) located at the end of the transfer pipelines close to the point of supply. Conversely, Options 1 and 4 comprised treatment close to the point of abstraction with transfer of potable water to the point of supply. All T2ST options are dependent on the prior development and commissioning of a water resource option to provide additional raw water yield in the River Thames (STT or SESRO).

Following commencement of Gate 2 work in August 2021, an options appraisal was completed to address key questions concerning the viability and operation of the six options identified at Gate 1. The options appraisal was completed in December 2021 and involved a number of workshops with representatives from TW, SRN and the T2ST project team. The options appraisal methodology and conclusions of this work are documented within the Gate 2 Options Appraisal Report, Annex A1 (doc ref: T2ST-REP-G2-01). The report concluded that the two potable transfer options (Option 1: Culham to Otterbourne and Option 4: Reading to Otterbourne) should be taken forward into concept design. The four raw water transfer options (2,3,4 and 5) were screened out as part of the Gate 2 options appraisal process, due to the need for pre-treatment to control INNS risk, multiple downstream water treatment sites, and associated increase in CAPEX, OPEX and environmental impact compared to potable options.

Hence only the potable water transfer options (Options 1 and 4) were taken forward into Gate 2 concept design as follows:

- Option 1: A potable water transfer from either SESRO or STT from a water treatment works located to the west of the A34 near Drayton in Oxfordshire to the SRN water supply network in Hampshire.
- Option 4: A potable water transfer from a water treatment works following a direct river abstraction from the River Thames near Pangbourne to the SRN network in Hampshire.

Following identification of the two preferred T2ST potable transfer options to take forward into the Gate 2 concept design (Options 1 and 4), a route and site selection process was undertaken to establish preferred route corridors for both options. This work is documented within the Route and Site Assessment - Preferred Option Report, Annex A2 (doc ref: T2ST-G2-REP-02). As part of this work, two variants of Option 1 were identified, and named as "Option B and C". Options B and C have the same points of abstraction from either SESRO or STT, the same WTW location and the same points of delivery to the SRN network in Hampshire -

but follow different pipeline corridors. As part of the route and site selection process Option 4 was also renamed as “Option E”.

The route and site selection work also established that Option E should be held back at this stage of the SRO assessment, due to high planning risk associated with the construction of a new direct river abstraction from the River Thames between Pangbourne and Reading within the North Wessex Downs AONB, and other planning constraints concerning the location of the associated water treatment works.

Hence only Options B and C have been taken forward as preferred options into concept design and water quality risk assessment for T2ST Gate 2. These options comprise treatment of raw water from either SESRO or STT at a WTW located to the west of the A34 near Drayton in Oxfordshire, then potable water transferred to the SRN water supply network in Hampshire. Further background information on the options selection process is set out in the Concept Design Report. Annex A3, (doc ref: T2ST-REP-G2-07).

Through discussion and agreement with TW and SRN, 50Ml/d, 80Ml/d and 120Ml/d scheme capacities have been considered for each of the two preferred options at Gate 2. This is considered to be an appropriate range of scheme capacity for T2ST at Gate 2, given the current uncertainties in the WRSE Regional plan modelling and is the same range of scheme capacity assessed for Gate 1 in July 2021.

T2ST spur connections

As detailed in the concept design report Annex A3, (doc ref: T2ST-REP-G2-07), the T2ST spine main connects to existing service reservoirs to the northwest and west of Winchester in Hampshire, within the Southampton East water resource zone (WRZ). Spur connections are also provided from the T2ST main to the SRN Highclere WRZ at Beacon Hill service reservoir and to the SRN Andover WRZ at an existing service reservoir located to the south-east of Andover on Micheldever Road.

A connection point from the T2ST scheme to the South East Water (SEW) Basingstoke WRZ (at Northgate) may also be provided subject to the final outcome of the WRSE Regional plan. A connection to SEW is however currently outside the scope of this SRO and is not discussed further in this document. Similarly, there may also be a requirement for a spur connection from T2ST to the TW Kennet Valley WRZ depending on the final Regional plan.

Water Source Scenarios- Gate 2 WQRA

The T2ST SRO preferred options B and C may each be supplied by several different water sources, each with differing water quality risk profiles. These include raw water from abstracted directly from SESRO or from the Severn to Thames Transfer (STT) SRO. Therefore, to undertake a source-to-tap water safety risk assessment, four water source scenarios have been defined for Gate 2 as follows:

1. Abstraction from **SESRO** – sourced from the River Thames at Culham at high flow;
2. Abstraction from **STT transfer** – flows sourced directly from the River Severn through the Severn to Thames Transfer SRO scheme **(STT) with pipeline** conveyance;
3. Abstraction from **STT transfer** – flows sourced directly from the River Severn through the Severn to Thames Transfer SRO scheme **(STT) with canal** conveyance;
4. Abstraction from **STT transfer** – flows sourced directly from River Severn through the Severn to Thames Transfer SRO scheme **(STT) with support from WwTW effluent** (conveyance by either pipeline or canal)

The key drinking water quality risks (‘limiting hazards’) associated with each source scenario 1-4 were initially identified through a workshop with Thames Water and Southern Water in Gate 1, as per the ACWG methodology. WQRAs for each water source scenario were developed during Gate 1 based on information available at the time (including drinking water safety plans (DWSP), historic water quality monitoring data, and the upstream SESRO and STT WQRAs. The T2ST WQRAs for all relevant water source scenarios have been fully updated in Gate 2 using the water quality monitoring data gathered to date from the latest Gate 2 monitoring programme, and the Gate 2 updates to the upstream SESRO and STT WQRAs. This includes the modification to the STT scenarios in light of the changes to the proposal of the options, e.g. abstraction direct from the STT transfer main rather than discharge and re-abstraction from the River Thames. These are summarised in Section 4.

All STT scenarios include flow support to ensure that design flows can be maintained during periods of low flow within the River Severn. Water source scenarios 2 and 3 are supported by flow releases from Lake Vyrnwy to the upper River Severn catchment. Water source scenario 4 receives flow support from both Lake Vyrnwy and treated effluent from Minworth WwTW. Only ‘supported’ options have been considered for the T2ST source to ensure continuity of supply for operation of the transfer.

The risk assessments for source scenarios 2, 3 and 4 at Gate 1 were informed by the WQRA produced by the STT SRO as well as the existing River Thames DWSP. At Gate 1 it was assumed that water from STT would be released into the Thames north of Culham at Lechlade, for re-abstraction to SESRO and T2ST at Culham. Hence a combined River Thames and River Severn risk profile was developed for the STT sources at Gate 1. The STT options for Gate 2 have now developed to exclude the option to discharge upstream of Culham due to capacity constraints within the upper Thames, with all STT discharge now located at Culham for all source options. The T2ST source scenarios for STT are now based on a direct abstraction from the STT transfer main prior to discharge to the Thames at Culham, and hence the risk profile for Gate 2 for the STT options have been updated from Gate 1 to reflect this.

Control Measures and Treatment

A proposed potable water treatment process for each water source scenario 1 to 4 has been identified. The source water scenarios result in differing risks and limiting hazards, which drive different selections of treatment processes in order to mitigate the expected limiting hazards associated with each water source. These treatment processes have been reviewed following the Gate 2 WQRA workshop, with changes made to the proposed treatment to reflect the latest understanding of the risk profiles and are summarised in Section 5.

Based on the Revised Gate 2 WQRAs the highest risk water source remains water source scenario 4 (STT), which includes planned indirect support from treated wastewater effluent. This may give rise to increased microbiological risk as well as increased risks of emerging substances such as endocrine disrupting compounds from pharmaceutical and personal care products.

Water sources 2 and 3 (STT) are slightly more favourable than water source 4 due to a reduced microbiological risk that is associated with the Minworth WwTW effluent, however there will still be similar risks due to other wastewater treatment works discharging upstream in the River Severn. It is noted that the Minworth WwTW effluent will undergo an additional advanced water treatment process (AWTP) which may impact the risks associated with the Minworth WwTW effluent – however at the time of the Gate 2 T2ST WQRA workshop, the proposed treatment was unknown due to the maturity of the scheme, and so any credit for control by the proposed AWTP against limiting hazards could not be quantified during the Gate 2 assessment. As such, the water quality risks associated with the Minworth WwTW effluent were assessed using the current available water quality monitoring data, without advanced treatment, taking a conservative approach. Further details of the Minworth AWTP are expected to be provided at Gate 3, at which time the risks will be reassessed.

Water source 1 from SESRO carries a slightly different risk profile to River Severn water and requires full treatment to manage turbidity from source (compared with the revised River Severn pipeline transfer – source scenario 2). However, water source 1 from SESRO is likely to carry a reduced risk compared to source scenarios 3 and 4 (STT via canal and with WwTW effluent support respectively).

In all options and water source scenarios, treated water from new surface water sources will be introduced to new regions, including the currently groundwater-fed area of Andover and Kingsclere. Changes in water source can affect aesthetic risks such as taste and odour, as well as corrosivity. These risks will require closer investigation during subsequent phases of work after the scheme matures to have a known water source and receiving zone, to allow for blending and customer acceptability impact assessments. Pre-mitigated aesthetic and corrosivity risks are expected to be high due to the nature of a change of source. Potential control measures include pro-active consumer engagement, however there may also be a requirement for additional chemical conditioning prior to entering supply and blending when treated T2ST water is blended with existing water sources in the supply network. Further work to establish the need for, and nature of, such conditioning will be required in future phases. Customer engagement is expected to follow the guidance provided by the Britain Thinks customer engagement methods study as presented to the ACWG, which focused on the timescales of engagement with consumers around a source change, as well as customer attitudes to acceptability of source water changes in the supply network. Southern Water have not yet begun direct consumer engagement, in line with recommendations of the Britain Thinks customer engagement study which recommends timely engagement closer to the point of implementation.

It is noted that a cost comparison of each water source scenario has not been undertaken at this stage. Further work has been undertaken using Atkins Water Treatment Modeller (AWTM) to aid with high level concept design and sizing of the water treatment works.

1. Introduction

1.1. T2ST SRO

The Thames to Southern Transfer (T2ST) option has been identified as a Strategic Regional Water Resource Option (SRO) in the PR19 Final Determination, with funding allocated between Thames Water (TW) and Southern Water (SRN).

The aim of the T2ST study is to investigate options for transferring available water from the Severn to Thames Transfer (STT) and/or SESRO from the Thames Water Swindon and Oxfordshire (SWOX) water resource zone to SRN's Hampshire area. T2ST is dependent on the prior development and commissioning of a water resource option to provide additional water in the River Thames (STT or SESRO), and hence is unlikely to be available until the late 2030s or 2040s depending on the timing of SESRO or STT, to be determined by the WRSE Regional plan. T2ST is a long-term resilience option that could form a key strategic link within the south-east region of England.

The SROs need to progress through a formal gate process of review and approval. The Gate 1 report for T2ST and supporting annexes was submitted to RAPID in July 2021. The assessment process for Gate 1 was overseen by RAPID, with input from the partner regulators Ofwat, the Environment Agency and the Drinking Water Inspectorate. The Environment Agency together with Natural England also reviewed the environmental sections of the submissions and provided feedback to RAPID. The Consumer Council for Water also provided input to the assessment on customer engagement. The final decision by RAPID was published in December 2021 and concluded that further funding should be allowed for T2ST to progress to Gate 2.

1.2. Water Quality Risk Assessment Gate 2

This draft report summarises the water quality assessment that has been undertaken to date as part of the Thames to Southern Transfer (T2ST) Strategic Resource Option (SRO) for Gate 2. The approach for this water quality assessment follows the All Companies Working Group (ACWG) methodology to ensure a consistent process of reviewing the strategic water quality risks. This methodology has been created in accordance with the Drinking Water Inspectorate (DWI) planning requirements, to follow global best practice in Drinking Water Safety Planning in alignment with the UK Regulatory framework and emerging water quality considerations.

This Water Quality Risk Assessment (WQRA) forms the third stage of the five steps of the ACWG Methodology. As part of the Gate 1 submission to RAPID in July 2021 WQRA spreadsheets were produced and reviewed through a workshop with stakeholders from Thames Water (TW) and Southern Water (SRN) on the 13th and 15th April 2021. These spreadsheets follow a 'source-to-tap' approach for water safety planning through abstraction, treatment and distribution to customers for the T2ST SRO, identifying the key 'limiting hazards' and control measures to reduce these risks.

The T2ST Gate 2 water quality risk assessment workshop was held with representatives from Thames Water and Southern Water on 19th May 2022, with a follow up session held on 26th May 2022, after the upstream STT and SESRO SRO workshops had been held on 7th March and 16th May 2022 respectively. The STT SRO team also held a workshop in which the DWI were present on 28th April 2022. Follow-up information was requested from the STT team in response to queries raised at the workshop and has been incorporated into this report and final WQRA spreadsheets.

This report summarises the output of the Gate 2 WQRA based on available information to date, and outlines control measures (in particular, water treatment) to manage the limiting hazards for each of the preferred water source options taken forward into Gate 2 of the T2ST SRO.

2. SRO Options

2.1. Gate 2 Options Appraisal

At Gate 1, six options for implementing the T2ST transfer were identified. Options 2,3,5 and 6 comprised raw water transfers over significant distances from the point of abstraction, with treatment located downstream at the end of the transfer pipelines and close to the point of supply. Options 1 and 4 conversely comprised of treatment close to the point of abstraction and potable transfer to the point of supply. All T2ST options are dependent on the prior development and commissioning of a water resource option to provide additional water in the River Thames (STT or SESRO).

Following commencement of Gate 2 work in August 2021 an options appraisal was completed to address key questions concerning the viability and operation of the six options identified at Gate 1. The options appraisal was completed in December 2021 and involved a number of workshops with representatives from TW, SRN and the T2ST project team. The options appraisal methodology and conclusions of this work are documented within the Gate 2 Options Appraisal Report, Annex A1 (doc ref: T2ST-REP-G2-01). The report concluded that the two potable options (Option 1: Culham to Otterbourne and Option 4: Reading to Otterbourne) should be taken forward into concept design. The four raw water transfer options (2,3,4 and 5) were screened out as part of the Gate 2 options appraisal process, due to the need for pre-treatment to control invasive non-native species (INNS) risk, multiple downstream water treatment sites, and associated increase in CAPEX, OPEX and environmental impact compared to potable options.

Hence only the potable options (Options 1 and 4) were taken forward into Gate 2 concept design as follows:

1. Option 1: A potable water transfer from either SESRO or STT from a water treatment works located to the west of the A34 near Drayton in Oxfordshire to the SRN water supply network in Hampshire.
2. Option 4: A potable water transfer from a water treatment works following a direct river abstraction from the River Thames near Pangbourne to the SRN network in Hampshire.

Following identification of the two preferred T2ST potable options to take forward into the Gate 2 concept design (Options 1 and 4), a route and site selection process was undertaken to establish preferred route corridors for both options. This work is documented within the Route and Site Assessment - Preferred Option Report, Annex A2 (doc ref: T2ST-G2-REP-02). As part of this work, two variants of Option 1 were identified, and named as “Option B and C”. Options B and C have the same points of abstraction from either SESRO or STT and the same points of delivery to the SRN network in Hampshire - but follow different pipeline corridors. As part of the route and site selection process Option 4 was also renamed as “Option E”.

The route and site selection work also established that Option E should be held back at this stage of the SRO assessment, due to high planning risk associated with the construction of a new direct river abstraction from the River Thames between Pangbourne and Reading within the North Wessex Downs AONB, and other planning constraints concerning the location of the associated water treatment works.

Hence only Option B and C have been taken forward as preferred options into concept design and water quality risk assessment for T2ST Gate 2. These options comprise a potable water transfer from either SESRO or STT from a site located to the west of the A34 near Drayton in Oxfordshire to the SRN water supply network in Hampshire. Further background information on the options selection process is set out in the Concept Design Report. Annex A3, (doc ref: T2ST-REP-G2-07).

Through discussion and agreement with TW and SRN, 50Ml/d, 80Ml/d and 120Ml/d scheme capacities have been considered for each of the two preferred options at Gate 2. This is considered to be an appropriate range of scheme capacity for T2ST at Gate 2, given the current uncertainties in the WRSE Regional plan modelling. This is the same range of scheme capacity as assessed for Gate 1 in July 2021.

2.2. T2ST Spur Connections

As detailed in the concept design report Annex A3, (doc ref: T2ST-REP-G2-07), the T2ST treated water spine main connects to existing service reservoirs to the northwest and west of Winchester in Hampshire, within the Southampton East water resource zone (WRZ). Spur connections are also provided from the T2ST main to the SRN Highclere WRZ at Beacon Hill service reservoir and to the SRN Andover WRZ at an existing service reservoir located to the south-east of Andover on Micheldever Road.

A connection point from T2ST scheme to the South East Water (SEW) Basingstoke WRZ (at Northgate) may also be provided subject to the final outcome of the WRSE Regional plan. A connection to SEW is however

currently outside the scope of this SRO and is not discussed further in this document. Similarly, there may also be a requirement for a spur connection from T2ST to the TW Kennet Valley WRZ depending on the final Regional plan.

3. Basis of Water Quality Assessment

3.1. Identified Water Sources

The T2ST SRO preferred Options B and C may each be supplied by several different water sources, each with differing water quality risk profiles. These include raw water abstracted directly from SESRO or from the Severn to Thames Transfer (STT) SRO. Therefore, to undertake a source-to-tap water safety risk assessment, four water source scenarios have been defined for Gate 2 as follows, each with varying risk profiles:

1. Abstraction from **SESRO** – sourced from the River Thames at Culham at high flow
2. Abstraction from **STT transfer** – flows sourced directly from the River Severn through the Severn to Thames Transfer SRO scheme **(STT) with pipeline** conveyance
3. Abstraction from **STT transfer** – flows sourced directly from the River Severn through the Severn to Thames Transfer SRO scheme **(STT) with canal** conveyance
4. Abstraction from **STT transfer** – flows sourced directly from the River Severn through the Severn to Thames Transfer SRO scheme **(STT) with support from WwTW effluent** (conveyance by either pipeline or canal)

During Gate 1 it was assumed that water from STT would be released into the Thames north of Culham at Lechlade, for re-abstraction to SESRO and/or T2ST at Culham. The STT options for Gate 2 have now developed to exclude the option to discharge upstream of Culham due to capacity constraints within the upper Thames, with all STT discharge now located at Culham for all source options. The T2ST source scenarios for STT (2, 3 and 4) are now based on a direct abstraction from the STT transfer main prior to discharge to the Thames at Culham, and hence the risk profile for Gate 2 for the STT options have been updated from Gate 1 to reflect this.

All STT scenarios include flow support to ensure that design flows can be maintained during periods of low flow within the River Severn. Water source scenarios 2 and 3 are supported by flow releases from Lake Vyrnwy to the upper River Severn catchment. Water source scenario 4 receives flow support from both Lake Vyrnwy and treated effluent from Minworth WwTW. Only ‘supported’ options have been considered for the T2ST source to ensure continuity of supply for operation of the transfer.

The key drinking water quality risks (‘limiting hazards’) associated with each water source scenario 1-4 were initially identified through a workshop with Thames Water and Southern Water in Gate 1, per the ACWG methodology. WQRAs for each water source scenario were developed during Gate 1 based on information available at the time (including DWSP, historic water quality monitoring data, and the upstream SESRO and STT WQRAs). The T2ST WQRAs for all relevant water source scenarios have been fully updated during Gate 2 using the water quality monitoring data gathered to date from the latest Gate 2 monitoring programme, and the Gate 2 updates to the upstream SESRO and STT WQRAs. The WQRAs were updated in Gate 2 following the ACWG methodology in a workshop with representatives from both Southern and Thames Water. The limiting hazards and updates from Gate 2 are summarised in Section 4.

Figure 3-1 on the following page shows the preferred T2ST Options B and C in Block Flow Diagram (BFD) form, showing spurs to all receiving supply zones. The diagram also shows the location of the new proposed WTW, which water source scenarios are viable for each option, and with a key indicating which treatment process is applicable, with treatment processes described in Section 5. Section 3.1 gives further information regarding the water source scenarios.

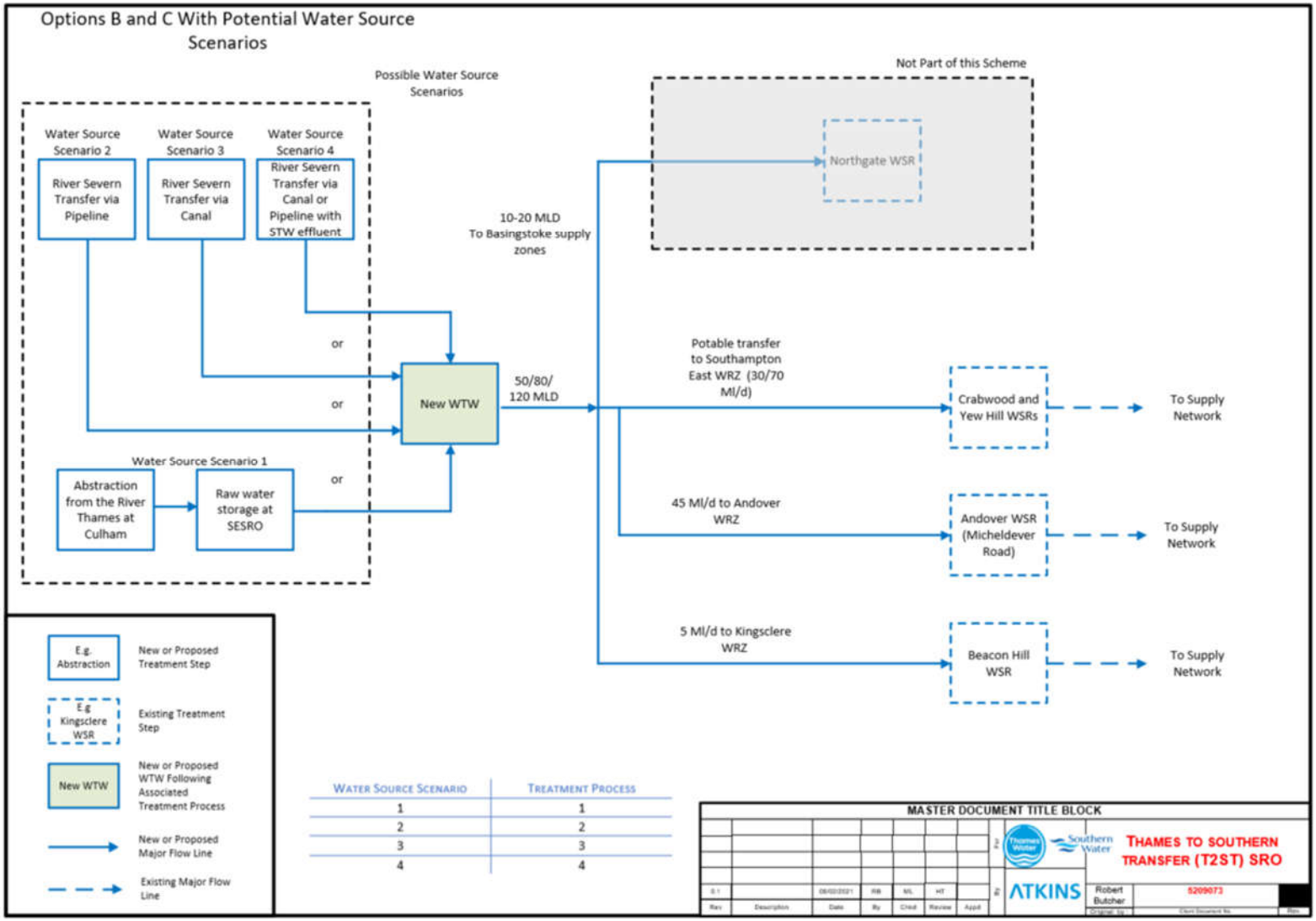

Figure 3-1 - Options B and C Block Flow Diagram

SESRO Source (Scenario 1). The proposed location of SESRO is to the west of the A34 near Drayton. For water source scenario 1, stored water within SESRO would be abstracted from the reservoir and treated at the SESRO source prior to transfer to Hampshire through the T2ST transmission pipeline.

SESRO has a planned storage capacity of between 75-150 Million m3. Although the actual turnover period of SESRO will depend on the rate of draw down for T2ST and other schemes, it is expected that the retention time in the reservoir will be sufficiently large to alter the water quality of the water at the outlet of the reservoir compared to the inlet of the reservoir. For example, the large retention time will allow heavy suspended solids such as silt to settle, reducing the expected average turbidity. However, reservoir storage can result in an increase in the risk of algal blooms and associated by-products.

SESRO would be fed by the River Thames when at high flows, with discharge back to the River Thames when the river is at low flows to supplement other downstream SRO schemes.

The risk assessment for source scenario 1 is informed by the Water Quality Risk Assessment (WQRA) produced by the SESRO SRO. Additionally, existing River Thames Drinking Water Safety Plans (DWSP) have been referred to as part of the Gate 1 assessment - particularly that for Farmoor WTW, which is located upstream of the proposed abstraction point for SESRO and is based on the most recent 5 years of water quality monitoring data.

The water quality monitoring data provided by the Gate 2 monitoring scheme, as discussed in Section 4.2.2, provides quantifiable data to assist in updating the Water Quality Risk Assessments for Gate 2.

STT Source (Scenarios 2, 3 and 4)

The Severn to Thames Transfer (STT) SRO is a potential source for T2ST. In this scenario a connection from the STT transfer main would supply T2ST, located upstream of the proposed STT discharge to the River Thames at Culham. At this stage it is assumed that the connection to T2ST from the STT main would be to the west of the A34 near Abingdon. The T2ST water treatment works would be located in the same location as proposed for the SESRO source option, on land to the west of the A34 near Drayton. Treated water would then be pumped to Hampshire through the T2ST transmission main as for the SESRO source option.

Within the STT SRO there are a number of sources of water currently being assessed, each of which present different water quality risks to T2ST, including:

- River Severn raw water transfer via pipeline (water source scenario 2) with a water quality risk profile of the River Severn
- River Severn raw water transfer via canals (water source scenario 3), which may increase risks including pesticides, oil and fuels which are related to a canal transfer etc. It is assumed however that the canal will not be navigable and so may not substantially increase the hydrocarbon risk.
- River Severn supported by treated wastewater effluent (e.g. from Minworth Wastewater Treatment Works) described as water source scenario 4, which would be expected to increase microbiological risks.

Note that the risk assessments for source scenarios 2,3, and 4 at Gate 1 were informed by the WQRA produced by the STT SRO as well as the existing River Thames DWSP. At Gate 1 it was assumed that water from STT would be released into the Thames north of Culham at Lechlade, for re-abstraction to SESRO and T2ST at Culham. Hence a combined River Thames and River Severn risk profile was developed for the STT sources at Gate 1. The STT options for Gate 2 have now developed to exclude the option to discharge upstream of Culham due to capacity constraints within the upper Thames, with all STT discharge now located at Culham for all source options. The T2ST source scenarios for STT are now based on a direct supply from the STT transfer main prior to discharge to the Thames at Culham, and hence the risk profile for Gate 2 for the STT options have been updated. Information from the latest STT WQRAs were provided prior to the T2ST workshop on 19th May 2022.

It is understood that Minworth WwTW effluent will undergo an advanced water treatment process (AWTP), however at the time of the T2ST WQRA workshop, the proposed treatment was unknown due to the maturity of the scheme and so the benefit of future control measures against limiting hazards due to the AWTP could not be quantified. As such, the water quality risks associated with the Minworth WwTW effluent were assessed using the current available water quality monitoring data, without advanced treatment, to provide a conservative approach. Further details of the Minworth AWTP are expected to be provided at Gate 3, at which time the risks will be reassessed.

Receiving areas T2ST will supply water to the Southampton East WRZ, which is supplied from a combination of surface water sources (River Itchen) and groundwater sources. T2ST will also supply water to the Kingsclere WRZ and Andover WRZ which are both groundwater zones. Hence, irrespective of the source scenario, T2ST will supply treated water from a new source into a combination of groundwater fed and surface water fed regions.

The water quality risk assessments for T2ST are based on the four source water scenarios. Drinking water risks for each of these source scenarios have been reviewed in Section 4 and proposed treatment strategies have then been developed for each water source scenario as presented in Section 4.4.

3.2. Conceptual Drinking Water Quality Risk Assessment Assumptions

For the Gate 2 concept design stage, a number of assumptions have been made to allow for a clear assessment of water quality risks and treatment needs, for the T2ST preferred options as shown below.

1. For water source scenario 1 it is assumed that there will be a direct reservoir abstraction from SESRO to a new WTW located at the SESRO site.
2. It is assumed that the SESRO intake on the River Thames at Culham will be located upstream of the Abingdon WwTW outfall.
3. It is assumed that Farmoor WTW DWSP, as the closest abstracting WTW on the River Thames, is a representative characterisation of the risk profile of the water in the Thames close to the proposed SESRO abstraction at Culham. The Thames Water DWSPs are understood to be based on 5 years of water quality monitoring data for existing abstraction points and are continually reviewed and updated with the most recent water quality monitoring data, with likelihood scores calculated based upon this data.
4. Only supply connections to SRN sites/customers within the Southampton East, Kingsclere and Andover WRZs are considered in this study. A range of maximum capacity for the T2ST is under consideration at this stage of reporting for Gate 2 (50,80 and 120Ml/d), due to uncertainties in the final outcome of the WRSE Regional plan. T2ST water will be delivered to existing service reservoirs near Winchester within the Southampton East WRZ. Supply connections will also be provided to the Andover WRZ (45Ml/d capacity) and Kingsclere WRZ (5Ml/d capacity) from offtakes from the T2ST spine main. Further information on T2ST transfer capacity and connectivity to the SRN supply network is provided within the Concept design Report, Annex A3 (doc ref: T2ST-REP-G2-07).
5. Supply connections to South East Water at Basingstoke or to the TW Kennet Valley are pending WRSE model outputs and are currently not included in this water quality risk assessment, or sizing of treatment assets. These supply connections will be included in further updates of this report if required.
6. Minworth WwTW effluent is assumed to have been treated to compliance with the requirements of the Water Framework Directive to achieve and maintain good status in water bodies, prior to discharge into the River Severn upstream of the Severn to Thames transfer.

4. Drinking Water Quality Risk Assessment (WQRA)

4.1. All Company Working Group (ACWG) Methodology

To ensure a consistent approach with all SROs, the All Companies Working Group (ACWG) methodology (supplied by Jacobs) has been adopted. The methodology has been based on existing UK and global regulation and policies. The primary source of regulations followed is from the Water Supply (Water Quality) Regulations (2016) – (S.I2016/614) as amended by the 2018 Amendment Regulations (S.I 2018/706) for England and the Water Supply (Water Quality) Regulations (Wales) (S.I 2018/647 (W.121)) for Wales including DWI Guidance on their implementation. Other guidance implemented can be found in the ACWG WQ Risk Framework Report produced by Jacobs, ref: "B19589BJ -DOC-001| 06". This guidance ensures the ACWG methodology follows the DWI water safety planning requirements. The framework concept includes 5 stages, with the water quality risk assessment being stage 3, and stage 4 & 5 producing outputs for the Gate documents.

Figure 4-1 - 5 Stages of the ACWG Methodology Framework

There is a 5-step process for the WQRA (stage 3 of the ACWG methodology) for each water source scenario, which is described below:

1. Agree likely limiting hazards for the SRO from the list of hazards included in the methodology. These are hazards which are likely to drive the development and/or acceptability and/or viability of the scheme. WQ Risk Assessment list contains approx.100 hazards.
2. Conduct/review hazard and hazardous event assessment with reference to likely limiting hazards.
3. Identify control measures. Check existing mitigation through control measures required is aligned with existing project considerations.
4. Agree pre and post control risk scores.
5. Identify residual risks and data gaps to be addressed during RAPID gated process.

Gate 1 workshops:

Collaborative review workshops with Thames Water and Southern Water to undertake the above process were held on 13th and 15th April 2021 for Gate 1.

Gate 2 workshops:

Workshops using water quality information gathered during Gate 2 were held on 19th and 26th May 2022 to review the limiting hazards and update any risk scores as necessary for T2ST. This followed the STT SRO Gate 2 workshop on 7th March 2022 and the SESRO SRO Gate 2 workshop held on 16th May 2022. The DWI Compliance Risk Index (CRI) (DWI, 2018) was used for guidance in updating the consequence scores (note, the full CRI methodology was not implemented as not all aspects are relevant). This follows the ACWG approach to ensure there is a common consequence scoring method across the SROs. Where consequence scores were not provided in the CRI (e.g. corrosivity, algae) consequence scores were updated based on the consequence scores provided in the existing TW DWSPs or as agreed collaboratively by TW and SRN during the ACWG workshop in line with other SROs (including the SESRO and STT SROs) to ensure consistent scoring across the schemes.

Likelihood scores were provided by the SESRO and STT Gate 2 WQRAs. These likelihood scores were reviewed at the T2ST workshop together with a review of water quality monitoring from the Gate 2 monitoring programmes and existing drinking water safety plans. Final likelihood scores were judged at the T2ST workshop via a qualitative assessment of the above information and guided by the scoring matrix provided in the WQRA spreadsheet (see Figure 4-2).

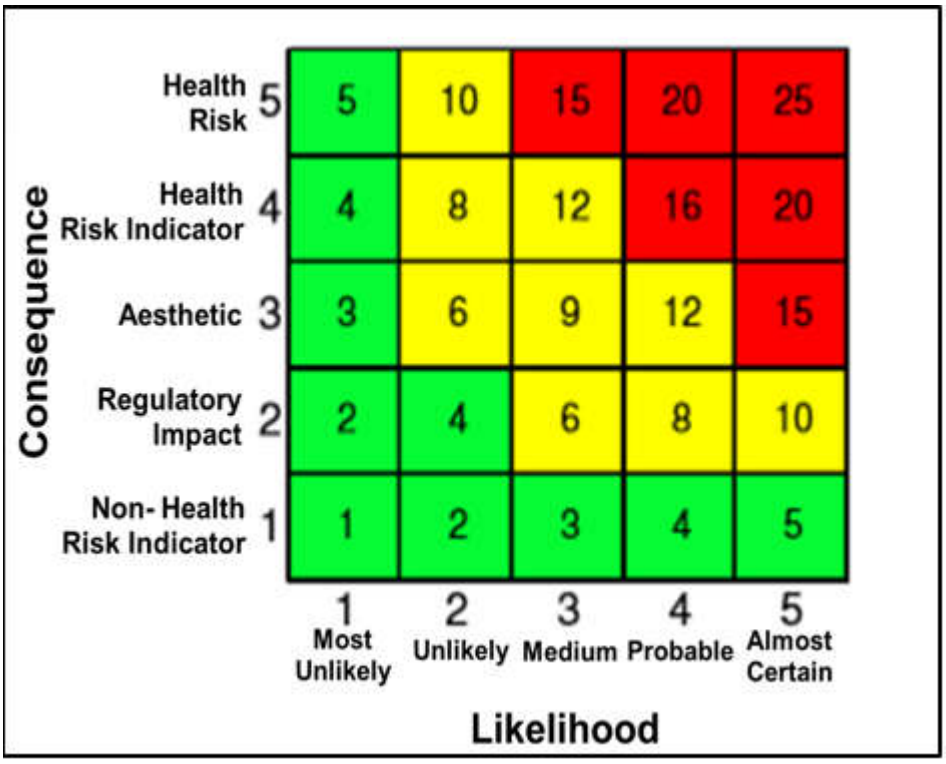

Figure 4-2 - Risk Matrix Provided in WQRA Spreadsheet

WQRA spreadsheets for each water source scenario have been updated following completion of the Gate 2 T2ST workshops.

The following sections of this report follow the ACWG methodology for developing a WQ risk assessment.

4.2. Existing Water Quality Information

4.2.1. Information provided for Gate 1

The output from the SESRO (Atkins) and STT SRO water quality risk assessments (Ricardo Energy and Environment) were used as a basis for the limiting hazards for the T2ST SRO prior to the T2ST Gate 1 WQRA workshop.

At the time of the Gate 1 workshop, the written SESRO and STT WQRA outputs were marked as draft, due to the concurrent timescales of all SROs. However, prior to the T2ST workshop on the 13th April 2021, workshops for both SESRO and STT SROs had been held to agree these risk assessments in accordance with the ACWG methodology.

The first T2ST SRO Gate 1 workshop was held on the 13th April 2021, with a follow up session held on 15th April 2021, both attended by stakeholders from Thames Water and Southern Water.

The Gate 1 T2ST workshops were attended by representatives who had been present at both the SESRO and STT workshops (Thames Water representatives) and therefore it is considered that inputs from these representatives to the T2ST process should capture the hazards identified by the full SESRO and STT ACWG methodology.

Thames Water provided a set of Drinking Water Safety Plans (DWSP) for a number of their sites. These DWSP provided the best insight into the known risks within the River Thames at the time, as they are based on knowledge of the catchment and historical data from the river at the various site abstraction points.

A review of the DWSP for Farmoor Intake Catchment, Reservoir and WTW and as well as Datchet Intake Catchment pre- and post-control scores was undertaken to support the identification of limiting hazards (see below).

These sites were chosen due to their locations being closest to the proposed intakes on the River Thames. Farmoor Reservoir and WTW is upstream of the proposed Culham / SESRO abstraction location, whilst the Datchet intake is downstream as illustrated in Figure 4-3.

Figure 4-3 - Location of Culham intake (SESRO), Farmoor and Datchet WTW

The high 'red' risks for Farmoor and Datchet WTW include many typical surface water risks including insoluble metals, turbidity, Cryptosporidium and a number of pesticides including metaldehyde. Other notable risks include nitrite and chromium - chromium was previously a red risk in the Farmoor catchment region, however it has been advised that the chromium risk has been reduced to an amber risk following ongoing monitoring of total chromium. These parameters are discussed further in the supporting ACWG water quality risk assessment (WQRA) spreadsheets.

Farmoor Reservoir DWSP provides a useful indication of risks which may be similar to that at SESRO (water source scenario 1) due to the inclusion of a reservoir before treatment. Comparison of the intake catchment and reservoir stages in the Farmoor DWSP identifies a number of risks which are reduced by storage in a reservoir, such as insoluble metals and turbidity.

Datchet abstraction point is downstream of a number of large WwTW discharge points (including Reading Wastewater treatment works) and industrial discharges as the river enters more heavily populated areas – this appears to be reflected by elevated risks in the DWSP, for example, of ammonium. As these contributors to the river are downstream, Datchet is considered to be less representative of the risks present at the SESRO abstraction location compared to Farmoor.

The existing DWSP information for the receiving SRN areas (Otterbourne, Andover and Kingsclere WTWs) were also reviewed to identify new or increasing residual risks resulting from treated T2ST water being introduced to the SRN distribution network. Risks due to this change in treated water source may impact on corrosivity, aesthetic properties, taste & odour issues in storage and distribution influencing customer acceptability.

4.2.2. Information Provided from Gate 2

4.2.2.1. SESRO Water Source Scenario

The ongoing water quality monitoring programme for Gate 2 began in December 2020 and involves spot monitoring of a suite of 331 chemical and microbiological determinands, as well as online monitoring of

Temperature, Conductivity and Dissolved Oxygen. The monitoring programme is set to run to September 2022 for Gate 2 and is expected to continue throughout Gate 3. The monitoring location relevant to the T2ST SESRO source option is upstream of the proposed SESRO abstraction location on the River Thames as seen in Figure 4-4, but close enough that there would not be expected to be a significant change of water quality between the sample location and proposed abstraction point.

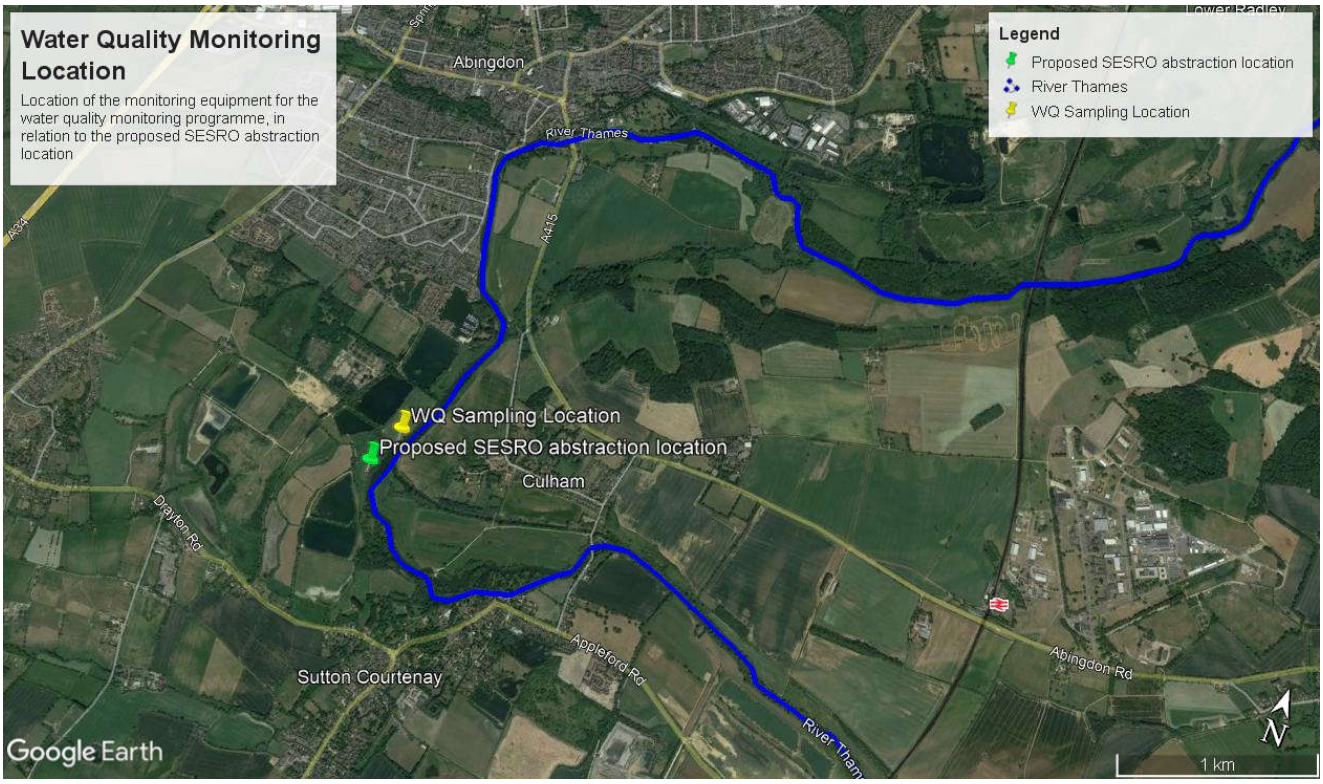

Figure 4-4 - Water Quality Monitoring Programme Location

The water quality monitoring programme is a data gathering exercise being undertaken by Atkins which will inform and allow further development of the water quality risk assessment spreadsheets, as well as informing future work scopes. The monitoring programme will allow for a more informed understanding of the likelihood of risks in the River Thames, as well as providing surveillance of parameters which may change from their historic likelihood/ consequence scores, for example due to regulatory changes. The water quality data is also used to inform a raw water envelope to inform concept treatment plant design and sizing.

Further review of the water quality information provided from the monitoring programme to date is provided in Section 4.4.1.

In addition to the data collected from the water quality monitoring programme, the output of the SESRO SRO WQRA was provided following the completion of the workshop on 16th May 2022. The risk assessment for the SESRO SRO was completed in line with the ACWG methodology in a workshop environment with the relevant stakeholders.

4.2.2.2. STT SRO Water Source Scenarios

Gate 2 WQRAs were provided from the STT SRO following the completion of the STT workshop held on 7th March 2022 and included updated limiting hazards and likelihood scores. These scores and limiting hazards were updated and agreed upon in the STT WQRA workshop following the ACWG methodology and it is understood that these limiting hazards were updated after a review of the Gate 2 water quality monitoring programme undertaken for the STT SRO.

Some water quality data has since been provided to the T2ST SRO water quality team by the STT SRO team to provide an insight into the magnitude of risks in the catchment. Monitoring occurred at several sites, including at Deerhurst, the Minworth WwTW final effluent and in the lower River Severn, and were used by the

STT team to inform the likelihoods of limiting hazards. The limiting hazards which were added during Gate 2 have been reviewed in Section 4.4.2.

4.3. Limiting Hazards Summary

Following the ACWG methodology, and using the sources of information identified above, limiting hazards for each of the water source scenarios for the T2ST schemes were initially identified during Gate 1.

Limiting hazards were agreed by picking the hazards which were most likely to drive the development, acceptability, or viability of the SRO, in accordance with the ACWG methodology.

The Gate 2 workshops held on 19th and 26th May 2022 reviewed the limiting hazards and their corresponding risk scores determined during the Gate 1 workshops and evaluated whether any new parameters should be added to the limiting hazards list following the review of the water quality monitoring programme. The outputs of the Gate 2 WQRA for SESRO and STT SROs were used to inform the T2ST WQRA and limiting hazards following the ACWG approach.

The agreed limiting hazards for Gate 2 for each water source scenario, along with a summary of the source information which led to this selection, are presented in Table 4-1.

Further details including the scoring of these limiting hazards is provided in the supporting ACWG water quality risk assessment (WQRA) spreadsheets with narrative around any new or adjusted limiting hazards in Section 4.4.

Table 4-1 shows the relevant limiting hazards for water source scenarios 1, 2, 3 and 4, selected during Gate 2, which are all possible water sources for the preferred T2ST Options B and C. A summary of any new or removed limiting hazards for each water source in Gate 2 is as follows:

Water Source Scenario 1: Bromate added as a new limiting hazard due to the risk of formation during treatment from bromide present in the River Thames. No Limiting Hazards were removed.

Water Source Scenario 2: Bromate, Polycyclic Aromatic Hydrocarbons (PAH), 1,4-Dioxane, N-Nitrosodimethylamine (NDMA), Total Organic Carbon (TOC), Endocrine Disrupting Compounds (EDCs) and PFAS substances were all added as new limiting hazards following a review of water quality data of the River Severn. Chromium was removed as a limiting hazard due to being associated as a potential risk only for the River Thames.

Water Source Scenario 3: Bromate, Polycyclic Aromatic Hydrocarbons (PAH), 1,4-Dioxane, N-Nitrosodimethylamine (NDMA), Total Organic Carbon (TOC), Endocrine Disrupting Compounds and PFAS substances were all added as new limiting hazards following a review of water quality data of the River Severn. Chromium was removed as a limiting hazard due to being associated as a potential risk only for the River Thames.

Water Source Scenario 4: Polycyclic Aromatic Hydrocarbons (PAH), 1,4-Dioxane, N-Nitrosodimethylamine (NDMA), Total Organic Carbon (TOC) and PFAS substances were all added as new limiting hazards following a review of water quality data of the River Severn and Minworth WwTW final effluent. Chromium was removed as a limiting hazard due to being associated as a potential risk only for the River Thames.

Table 4-1 - Limiting Hazards for Water Source Scenarios

		Water source scenario	1	2	3	4
Limiting hazard	**Source of risk info**	**Comment**	*SESRO reservoir*	*STT via pipeline*	*STT via canal*	*STT with WwTW support via canal or pipeline*
E. coli (bacteria limiting hazard)	SESRO WQRA + STT WQRA	Limiting hazard for bacteriological pathogens. Faecal pathogens derived from sewage, livestock, human activity, and wildlife in the catchment, present in both the River Thames and the River Severn.	Y	Y	Y	Y (highest risk noting planned WwTW support)
Cryptosporidium	SESRO WQRA + STT WQRA	Limiting hazard for chlorine tolerant pathogens. Derived from sewage, livestock, human activity, and wildlife in the catchment present in both the River Thames and the River Severn.	Y	Y	Y	Y (highest risk noting planned WwTW support)
Iron	SESRO WQRA + STT WQRA	Limiting hazard for metals. Iron & manganese within the source rivers are most likely to be in particulate form (rather than soluble), however dissolved metals can result from low DO conditions within reservoirs. Legacy mining in the catchment headwaters of R.Severn is also a potential source.	Y	Y	Y	Y
Manganese	SESRO WQRA + STT WQRA		Y	Y	Y	Y
Bromate	R. Thames monitoring programme, STT WQRA	High bromide in River Thames, River Severn & Minworth WwTW effluent flagged – risk this is converted to bromate (regulated parameter) if correct treatment and management not selected and practiced.	Y	Y	Y	Y
Nitrite	R. Thames Farmoor DWSP + STT WQRA	Noted as a red risk in the Farmoor Catchment DWSP, as well high levels in the River Severn.	Y	Y	Y	Y

		Water source scenario	1	2	3	4
Limiting hazard	**Source of risk info**	**Comment**	*SESRO reservoir*	*STT via pipeline*	*STT via canal*	*STT with WwTW support via canal or pipeline*
Pesticides: Total	SESRO WQRA + STT WQRA	Derived from agricultural and amenity applications of pesticides in the R.Thames & R.Severn catchment.	Y	Y	Y	Y
Metaldehyde	SESRO WQRA + STT WQRA	Important pesticide as it is difficult to treat, therefore included as a limiting hazard which may influence treatment. Historically high observed environmental levels in R.Thames & R.Severn derived from agricultural and amenity applications in the catchment. Concentrations will vary seasonally. Metaldehyde was banned for outdoor use in April 2022 and this has been considered in the risk assessment.	Y	Y	Y	Y
Polycyclic Aromatic Hydrocarbons (PAH)	STT WQRA	Limiting hazard for hydrocarbon contamination from combustion of wood and biofuels as well as from intrusion from industrial processes. High levels of PAH have been recorded in River Severn.	-	Y	Y	Y
Benzo(a)pyrene	STT WQRA	Benzo(a)pyrene, a polyaromatic hydrocarbon, has been noted as present within the River Severn and is considered a limiting hazard for hydrocarbon contamination, however included as a separate limiting hazard due to having a stricter PCV than PAH.	-	Y	Y	Y
Corrosivity	Southern Water receiving network assessment / workshop / STT WQRA	Treated R.Thames/Severn waters may have different corrosivity from that in existing receiving SRN network – limiting hazard covering associated risks e.g. metals compliance, aesthetic, alkalinity, turbidity issues, discolouration.	Y	Y	Y	Y

		Water source scenario	1	2	3	4
Limiting hazard	**Source of risk info**	**Comment**	*SESRO reservoir*	*STT via pipeline*	*STT via canal*	*STT with WwTW support via canal or pipeline*
Taste	SESRO WQRA	Limiting hazard for taste & odour derived from biological activity in the reservoir. Note that changes to customer perception due to change in source type are captured under Change in Source Type as the limiting hazard.	Y	-	-	-
Change in Source Type	Southern Water receiving network assessment / workshop / STT WQRA	T2ST involves introducing treated surface waters into a currently groundwater fed region (Andover & Kingsclere). Limiting hazard for any effects of introducing treated water from a new source into an existing network (including customer acceptability e.g. complaints due to change in perception of taste & odour, hardness, etc).	Y	Y	Y	Y
1,4-Dioxane	STT WQRA	Parameter of emerging concern associated with effluent from WwTW. Deemed to likely be present in the River Avon and Severn due to existing WwTW discharges.	-	Y	Y	Y
Pathogens - Bacteria, **Viruses**, Protozoa	STT WQRA	Limiting hazard for viruses (bacteria and protozoa risks are covered by the E. coli & Cryptosporidium limiting hazards above). Due to the population located around the Rivers Severn and Thames, pathogens are likely to be present including viruses. While viruses are expected to be present in the Thames source waters, they are not on the 'limiting hazard' list for source water scenario 1 as they were not included in the SESRO Gate 2 WQRA. They are not expected to be limiting in the sense of driving additional control measures, as the virus risk is expected to be managed (based on knowledge of existing R. Thames risk profile & controls) by the control measures/disinfection strategy required for E. coli & Cryptosporidium, which are	-	Y	Y	Y (highest risk noting planned WwTW support)

		Water source scenario	1	2	3	4
Limiting hazard	**Source of risk info**	**Comment**	*SESRO reservoir*	*STT via pipeline*	*STT via canal*	*STT with WwTW support via canal or pipeline*
		both limiting hazards for all T2ST source water scenarios. However, the STT WQRA included this parameter as a limiting hazard and thus it is included in the limiting hazard list for source scenarios 2,3 and 4, which may have a different virus risk profile from that in the R. Thames (particularly in source scenario 4 where WwTW effluent support is included). Note that somatic coliphages are expected to be included in future regulation (as they are included in the revised Drinking Water Directive). Somatic coliphages were monitored for in the Minworth WwTW final effluent chamber.				
N-Nitrosodimethylamine (NDMA)	STT WQRA	Produced as a by-product in processes using nitrites/nitrates and amines, particularly wastewater treatment among also being an industrial pollutant and considered a parameter of emerging concern. Noted to likely be present in River Severn water due to existing WwTW discharges upstream in the Severn.	-	Y	Y	Y
Total Organic Carbon (TOC)	SESRO WQRA / STT WQRA	Limiting hazard for disinfection byproduct precursors & potential natural colour risk due to peat influence in STT catchments. Derived from biological activity in the catchments and expected in all lowland surface waters.	Y	Y	Y	Y
Chromium	R. Thames Farmoor DWSP	Regulatory PCV change expected; previously noted as a red risk in Farmoor Catchment DWSP. Post workshop note: it has been advised by TW that the chromium risk for Farmoor Catchment DWSP has recently been reduced to an amber risk, following ongoing monitoring of total chromium, however no further chromium (VI) data is available. This parameter is subject to an action limit lower than the total chromium PCV,	Y	-	-	-

		Water source scenario	1	2	3	4
Limiting hazard	**Source of risk info**	**Comment**	*SESRO reservoir*	*STT via pipeline*	*STT via canal*	*STT with WwTW support via canal or pipeline*
		thus uncertainty around the chromium (VI) hazard remains and is recommended for review at Gate 3.				
Endocrine Disrupting Compounds (EDC)	Workshop	Emerging contaminants associated with WwTW discharges in source catchment. The Gate 2 monitoring programme for the River Thames included monitoring for nonylphenol, whilst monitoring in the Minworth final effluent included monitoring for all 3-benchmark endocrine-disrupting compounds mentioned in the revised DWD (nonylphenol, bisphenol A and 17β-oestradiol). EDCs expected to be present in the River Severn due to other upstream wastewater treatment works discharges. Included within the work shared by Thames Water (TW) project on emerging substances to the ACWG.	-	Y	Y	Y (highest risk noting planned WwTW support)
PFAS Substances (NOTE: changed from PFOA in Gate 1 to capture risk associated with PFOA, PFOS and other PFAS substances)	Workshop	Limiting hazard for perfluorinated substances, industrial contaminants of emerging concern for which legislative limits are expected to be introduced. DWI Information Letter 03/2022 provides a tiered approach to actions relating to concentrations of any PFAS substance in final water, for the requirment of monitoring, consideration of PFAS in risk assessments, as well as measures of reducing concentrations of PFAS in water supplied to consumers. The Gate 2 monitoring programme includes monitoring of PFAS substances in the River Thames and Minworth WwTW final effluent and is discussed in the following sections. Included within the work shared by TW project on emerging substances to the ACWG.	Y	Y	Y	Y

		Water source scenario	1	2	3	4
Limiting hazard	**Source of risk info**	**Comment**	*SESRO reservoir*	*STT via pipeline*	*STT via canal*	*STT with WwTW support via canal or pipeline*
Turbidity	Workshop	Design parameter – expected in surface water sources.	Y	Y	Y	Y
Algae	SESRO WQRA + STT WQRA	While algae may be present in all sources, speciation of algae (particularly relevant to potential types of algal toxins) and scale of risk is likely to differ between reservoir, river and canal sources, with eutrophication presenting a particular risk of high algal loads with associated algal toxin risks in the reservoir. STT DWSP flagged canal conveyance as a particular risk factor for algae and associated issues. Associated issues including algal toxins, taste & odour issues and influence on treatment processes e.g. increases to pH, are covered by this limiting hazard.	Y	-	Y	Y (canal option only)

4.4. Water Quality Information (Gate 2)

4.4.1. Monitoring Data from SESRO Source

Updates to the limiting hazards in water source scenario 1 were made following a review of the Gate 2 water quality monitoring programme, as well as the received Gate 2 WQRA from the SESRO SRO. The likelihood scores for E. coli, PFAS Substances, Iron, Manganese, Nitrite and Turbidity were all updated from Gate 1 to reflect an increased understanding of the magnitude of each risk having reviewed quantitative data from the monitoring programme. Bromate was the only new limiting hazard to this water source scenario due to the risk of formation during treatment, as bromide is noted as present in the River Thames at concentrations which would exceed the PCV for bromate if fully converted.

Other parameters which had been raised as potential limiting hazards in the SESRO SRO workshop such as nickel, cyanide and radioactivity were also discussed during the T2ST workshop. It was concluded however that these parameters did not warrant being added to the limiting hazard list following a review of water quality data.

The water quality monitoring data provides the most up-to-date quantitative information regarding the water quality of the source scenarios. Monitoring data on the River Thames at the proposed abstraction location of the T2ST SRO informs us of the raw water quality of the proposed water to be used in water source scenario 1. Table 4-2 summarises the 20 samples taken and made available to date between December 2020 and April 2022.

The monitoring programme is to continue for Gate 2 until September 2022, and so Table 4-2 will continue to be updated as and when new data is made available.

Table 4-2 - Water Quality Information from River Thames Monitoring

Parameter	Minimum	Mean	Maximum	95%ile	90%ile	10%ile	PCV / Limit / Future limit	Unit
E. coli	261	1551	2420	2420	2420	830	0	MPN/100ml
Cryptosporidium	0	0.1	1	1	0.2	0	0	no/litre
Iron (total)	72	193	590	438	331	99	200	µgFe/l
Manganese (total)	5.7	11.9	28	16.6	15.1	7.5	50	µgMn/l
Bromate	<2	<2	<2	<2	<2	<2	10	µgBrO_3/l
Bromide	<0.10	0.21	0.37	0.35	0.34	0.13	-[1]	mg/l
Nitrite	<0.1	0.5	1.1	1.0	0.9	0.1	0.1[2]	mgNO_2/l
Nitrate	5.42	20.02	60	37	35	5.88	50	mgNO_3/l
Pesticides: Total[3]	0.26	0.33	0.71	0.58	0.42	0.26	0.5	µg/l
Metaldehyde	<0.02	<0.02	0.07	0.02	<0.02	<0.02	0.1	µg/l

[1] Bromide does not have a PCV, however bromate has a PCV of 10µg/l.
[2] Nitrite limit 0.5mgNO_2/l at customers tap.
[3] 109 pesticides sampled for with majority of readings below LOD of <0.02µg/l. 11 representative pesticides used in determination of data for the table (propyzamide, mecoprop, MCPA, glyphosate, fluroxypyr, flufenacet, dicofol, clopyralid, carbetamide, bentazone, 2,4-dichlorophenoxyacetic acid (2,4-D)). Pesticides are likely present in elevated concentrations due to the nature of the surface water source. Review of Farmoor Catchment DWSP indicates high risk. It has been recommended that the Total Pesticide suite is reported as a dedicated parameter in future water quality monitoring data reports.

Parameter	Minimum	Mean	Maximum	95%ile	90%ile	10%ile	PCV / Limit / Future limit	Unit
Total Organic Carbon (TOC)	1.9	3.8	6.8	6.1	5.1	2.7	-[4]	mg/l
Chromium (III) dissolved	0	0.7	3.8	2.3	0.7	0.5	-	µg/l
Chromium (VI) dissolved	<7.0	<7.0	<7.0	<7.0	<7.0	<7.0	3[5]	µg/l
Chromium total	<0.25	0.84	4.1	2.87	2.53	<0.25	50[6]	µg/l
Nonylphenol (Endocrine Disrupting Compounds)	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	-[7]	µg/l
Perfluorooctane Sulfonic acid (PFOS) and its derivatives	0.004	0.007	0.011	0.009	0.009	0.004	≥0.1[8]	µg/l
Uranium Total	<10	<10	<10	<10	<10	<10	30[9]	µg/l
Lead	0.045	0.633	2.20	1.52	1.26	0.234	10[10]	µg/l
Turbidity	2	7.3	17	17	16.2	2.8	1[11]	NTU
Algae (as Chlorophyll)	<20	<20	31	<20	<20	<20	-	µg/l

The monitoring programme has also allowed for a review of the likelihood of emerging contaminants such as nonylphenol – an endocrine disrupting compound and PFOS and its derivatives, a perfluorinated compound and used as the indicator for the PFAS compounds.

Sample data for nonylphenol, shown in Table 4-2, indicated that all samples monitored were at the lower limit of detection, <0.04µg/l. Nonylphenol is currently on the DWD watchlist with a limit of 0.3µg/l and so these results currently do not indicate a high risk to drinking water quality. Nonylphenol is currently the only endocrine disrupting compound on the DWD watch list monitored for in the River Thames.

Information on sample data for bromide has been provided due to its potential to form bromate. Data for bromide shows a max recorded value of 0.37mg/l, which could pose a threat to the bromate PCV of 10µg/l if oxidised.

PFOS and its derivatives returned a max recorded value of 0.011µg/l shown in Figure 4-5, well below the DWI Tier 3 action limit of ≥0.1µg/l where further action is required to reduce concentrations below 0.1µg/l as soon as possible due to breaching the wholesomeness concentration in final water. It is however above the Tier 1 action limit (<0.01µg/l) and so falls into Tier 2 (<0.1µg/l) which includes a review of control measures, discussions with the Liaison Inspector if final water results exceed company's internal limits/ looks to be an increasing PFAS trend which could breach the wholesomeness level (Tier 3), prepare measures to prevent the supply of water to

[4] No abnormal change
[5] Action limit for Cr(VI) noted in Further Guidance on Chromium in Drinking Water Information Letter (DWI, 2017).
[6] New value of 25µg/l proposed in revised DWD for total chromium (which includes Cr(VI) and Cr(III)).
[7] No current PCV for nonylphenol, however added to the DWD watch list, with a World Health Organisation (WHO) recommended value of 0.3µg/l.
[8] Tier 3 Action Limit for PFOS in Final Water, DWI Information letter 03/2022 (DWI, 2022)
[9] Proposed new limit for uranium total in revised DWD.
[10] Current limit is 10µg/l, however proposed new limit in revised DWD is 5µg/l at point of supply.
[11] Current limit of 1 NTU at treatment works, and 4 NTU at customers tap. Proposed new limit in revised DWD limit to change to 0.3 NTU in 95% of samples. None to exceed 1 NTU at the treatment works.

consumers with >0.1µg/l PFAS and consult with UKHSA and local health authorities. PFOS and its derivatives has been used to represent the PFAS Substances limiting hazard, in lieu of data from all 47 PFAS substances named by the DWI. It is recommended for future monitoring that the suite is updated to include all 47 PFAS compounds.

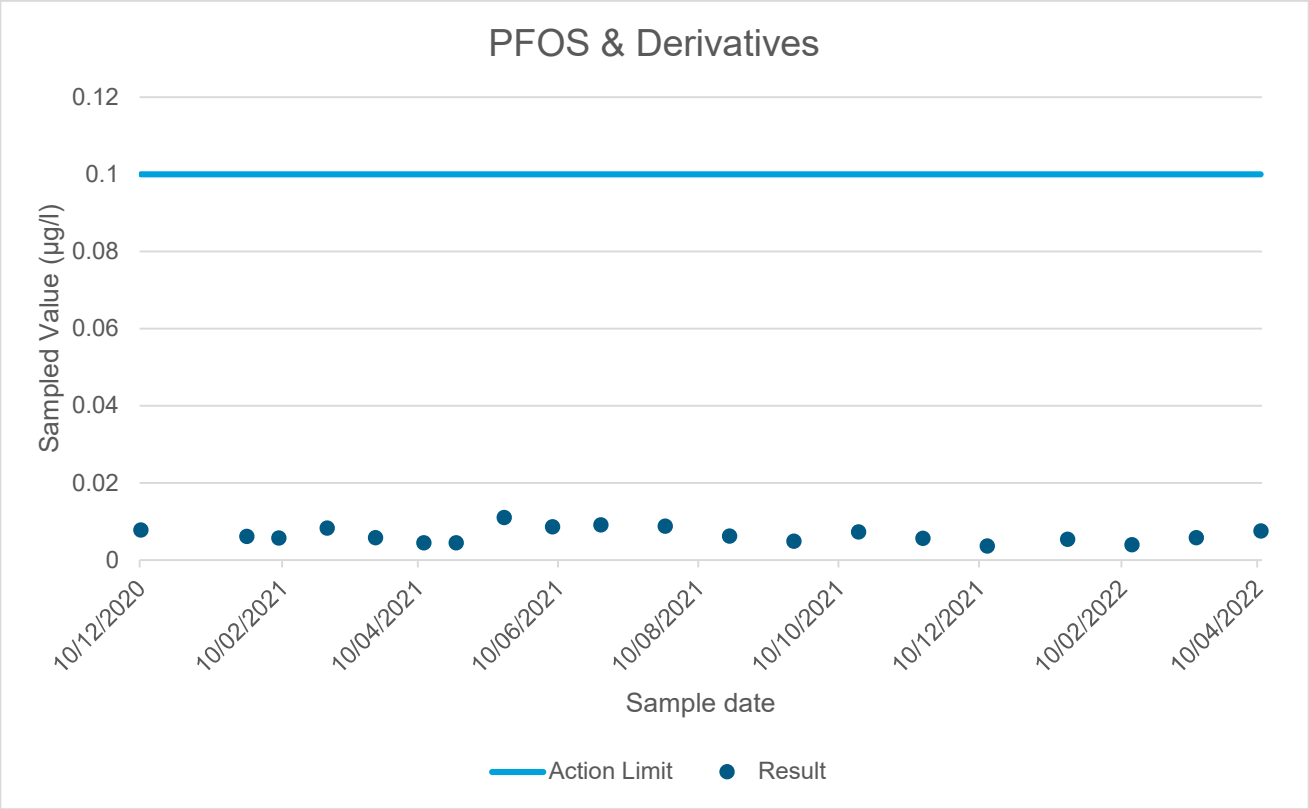

Figure 4-5 - Sampled Values for PFOS & Derivatives in the River Thames

Information on nitrite shows samples contained concentrations of nitrite above the PCV. Sample data for nitrate shows the maximum value at 60mg/l, above the nitrate PCV of 50mg/l. This is likely an outlier as otherwise the highest concentration is below the PCV at 46mg/l.

The revised Drinking Water Directive (DWD) of December 2020 and DWI guidance notes have identified parameters such as chlorite, uranium, lead, turbidity and chromium which require a new or updated limit. These limits have not yet been adopted by the UK but may become future Prescribed Concentration or Values (PCV). Elevated concentrations of these parameters may pose a risk against future regulatory changes, and so are highlighted as parameters of note for monitoring.

A summary of sample data for uranium, lead, turbidity and chromium which have either new or updated limits in the revised Drinking Water Directive, can be seen in Table 4-2.

All samples of chlorite were measured at the limit of detection of <3µg/l, and whilst chlorite does not currently have a PCV, it has been added to the Revised DWD with a limit of 250µg/l (0.25mg/l). Recorded values are well below this limit.

Data for uranium show sampled data at the lower limit of detection of 10µg/l. There is currently no PCV for uranium in the UK, however the updated Drinking Water Directive, which is not yet adopted in the UK, has a limit of 30µg/l for uranium. This would therefore not be likely to be a risk if a new limit is adopted.

Lead in the raw water is below the current PCV of 10µg/l, and also below the revised limit in the revised DWD of 5µg/l which may be adopted in the UK.

The total chromium prescribed value is also under review. The current UK limit is currently set at 50µg/l; however, a new value of 25µg/l has been proposed in the revised DWD (this value also remains under WHO review, and a transitional period until January 2036 should apply before the value becomes

more stringent). The sampled values for total chromium can be seen in Figure 4-6 below, with all bar two data points below 3µg/l, and all values below the proposed new limit for total chromium in the revised DWD. The recorded value at 20µg/l has been determined an error in the lab data, and so was removed from the summary information in Table 4-1.

The instances where total chromium (of which Cr (VI) is a constituent part) exceeded the Cr (VI) action limit are shown in Figure 4-6 below.

The DWI issued a letter to water companies to reiterate and expand on advice received from Public Health England (PHE) (see Further Guidance on Chromium in Drinking Water Information Letter, DWI, 2017) that where chromium (VI) samples regularly exceed an action limit of 3µg/l, water companies should conduct a catchment investigation to understand whether catchment solutions are possible, and if not, blending or treatment should be considered. Current sampling data has a limit of detection greater than this action limit (LOD 7µg/L), and so conclusions cannot be drawn yet. It is recommended for future monitoring that the limit of detection for chromium (VI) is reduced so the full extent of the risk can be quantified against DWI guidance provided in aforementioned Information Letter.

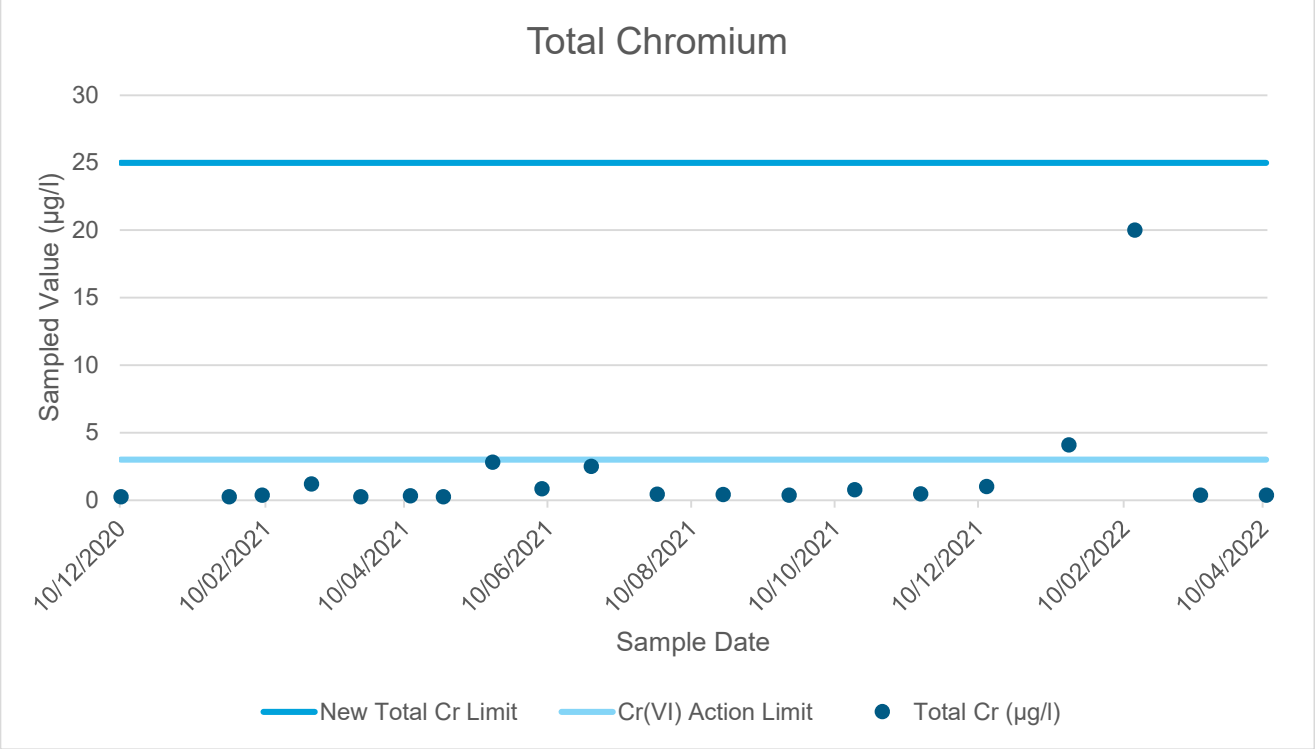

Figure 4-6 - Sampled Values for Total Chromium

At present, only 20 samples have been collected over a 16-month time period for all parameters from the Gate 2 water quality monitoring programme, which provides a small data set of the water quality in the River Thames at the proposed abstraction location. Other water quality data is available upstream at Farmoor WTW which is reported by TW to show similar trends. However, a greater sampling survey over a longer period of time at the proposed abstraction location will allow for trends to be determined, and a more accurate representation of the water quality issues at the proposed abstraction location will be available. The received monitoring data from the SRO monitoring programme so far provides an improved (but limited) data set for the water quality profile of the River Thames and has supported the review and update of scoring of the limiting hazard likelihoods in the Gate 2 workshop.

4.4.2. Monitoring Data from STT Source

Updates to water source scenarios 2, 3 and 4 were based on the Gate 2 revision of the WQRAs provided by the STT SRO team. The likelihood scores were also provided from the STT team following a review of the Gate 2 STT water quality monitoring programme. Likelihood scores in the catchment region for Cryptosporidium, nitrite, metaldehyde, benzo(a)Pyrene, corrosivity, pathogens and turbidity increased for all 3 STT water source

scenarios. Additionally, polycyclic aromatic hydrocarbons, 1,4-dioxane, NDMA, TOC, endocrine disrupting compounds and PFAS substances were added to the list of limiting hazards for all STT scenarios. Bromate has also been added as a limiting hazard to water source scenario 2 and 3 due to the high levels of bromide in the River Severn and the risk of bromate formation during treatment. Bromate was already considered a limiting hazard for water source scenario 4 due to the understanding that it was present in the Minworth WwTW final effluent.

The limiting hazards of chromium, temperature, INNS and conductivity were removed as limiting hazards during the T2ST workshop following that these risks were associated with the deployment and mixing of River Severn water and River Thames water, which no longer will occur/ impact the T2ST scheme.

The data gathered in the Gate 2 water quality monitoring programme has been used by the STT SRO team to inform on the likelihood and magnitude of the risks and limiting hazards in the catchment for the STT SRO scheme. At the time of writing, sample data from the lower River Severn and upstream of Gloucester Docks, has been provided and includes 16 spot samples between December 2020 and December 2021. This information has been used in conjunction with other sampling data along the River Severn and the upstream River Avon to inform the likelihood scores provided in the WQRAs. Water quality information for the Minworth final effluent includes 10 spot samples taken between April 2021 and December 2021 and has been used to inform the additional water quality risk from the support from Minworth WwTW effluent which affects water source scenario 4.

The following Table 4-3 and Table 4-4 provide a summary of the water quality data for a number of parameters sampled on the River Severn and in the Minworth WwTW effluent respectively.

Table 4-3 - Water Quality Sample data on the River Severn

Parameter	Minimum	Mean	Maximum	95%ile	90%ile	10%ile	PCV	Unit
Polycyclic Aromatic Hydrocarbons	<0.05	0.07	0.18	0.16	0.13	0.13	0.1	µg/l
Total Organic Carbon	3	5.4	8.5	7.8	7.3	3.8	No Abnormal Change	mg/l
E. coli	17	793	2420	2420	2420	71	0	MPN/100ml
Cryptosporidium	0	0.07	1	0.35	0	0	0	no/litre
Iron (total)	78	653	2000	1775	1550	205	200	µgFe/l
Manganese (total)	26	61	160	114	93	33	50	µgMn/l
Bromate	<2	<2	<2	<2	<2	<2	10	µgBrO_3/l
Bromide	<0.1	0.17	0.51	0.43	0.36	<0.1	-	mg/l
Nitrite	0.016	0.440	2.30	1.30	0.90	0.016	0.1[12]	mgNO_2/l
Pesticides: Total[13]	0.16	0.40	0.96	0.86	0.70	0.27	0.5	µg/l
Metaldehyde	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	µg/l
Benzo(a)Pyrene	<0.005	0.009	0.042	0.023	0.016	<0.005	0.01	µg/l

[12] Nitrite limit 0.5mgNO_2/l at customers tap

[13] 109 pesticides sampled for with majority of readings below LOD of <0.02µg/l. 11 representative pesticides used in determination of data for the table (propyzamide, mecoprop, MCPA, glyphosate, fluroxypyr, flufenacet, dicofol, clopyralid, carbetamide, bentazone, 2,4-dichlorophenoxyacetic acid (2,4-D)). Likely present in higher concentrations due to surface water source. Review of Farmoor Catchment DWSP indicates high risk. It has been recommended that the Total Pesticide suite is reported as a dedicated parameter in future water quality monitoring data reports.

Parameter	Minimum	Mean	Maximum	95%ile	90%ile	10%ile	PCV	Unit
Turbidity	7	30	85	70	60	8	1[14]	NTU
Algae (as Chlorophyll)	10	16.5	80	49.9	26.2	10	-	µg/l

The maximum value recorded for polycyclic aromatic hydrocarbons (PAHs) was recorded at 0.18µg/l, almost twice the current PCV. Total organic carbon has been added as quantitative component of being a differing source to the receiving SRN sites, and the differences between surface vs groundwater sites.

Table 4-4 - Water Quality Sampling Data for the Minworth WwTW Final Effluent

Parameter	Minimum	Mean	Maximum	95%ile	90%ile	10%ile	Proposed DWD Limit / Watch List Guidance Value	Unit
NDMA	<0.001	0.008	0.047	0.029	0.011	<0.001	-	µg/l
1,4-Dioxane	<1.0	1.2	5	3.9	2.8	<1.0	-	µg/l
Sum of PFAS Substances	0.038	0.060	0.073	0.072	0.070	0.048	0.5	µg/l
17β-oestradiol	<0.001	0.0012	0.0029	0.0024	0.0018	<0.001	0.001[15]	µg/l
Nonylphenol	<0.04	0.33	0.70	0.61	0.53	0.21	0.30[15]	µg/l
Bisphenol A	<10	30	137	110	83	<10	2.5	µg/l
Somatic Coliphages[16]	0	2.6	9	8.1	7.2	0	0.5	PFU/ml

Although NDMA does not have a PCV in the UK, it does have notification levels in some US states of a health-based value of 0.01µg/l (California Department of Public Health), which current concentrations in samples are exceeding.

1,4-Dioxane was added to the European Chemicals Agency candidate list of substances of very high concern (ECHA, 2021) due to carcinogenic properties, but does not currently have a PCV or regulated limit.

20 PFAS compounds were sampled for in the Minworth final effluent, with the majority of individual compound samples below the lower limit of detection of <0.005µg/l. The sum of the PFAS compounds was determined from each sample, and is shown that values were below the proposed DWD limit of the sum of PFAS substances of 0.5 µg/l. The current monitoring suite however does not cover all 47 PFAS compounds listed by the DWI as parameters of concern. Additional monitoring of this suite is proposed in light of the updated DWI guidance and availability of analysis by the monitoring labs, and thus the PFAS substance risk remains under a watching brief.

The endocrine disrupting chemicals of 17β-oestradiol, nonylphenol and bisphenol A as well as somatic coliphages all have maximum readings in Minworth final effluent well above the proposed watch list limits indicated in the Revised DWD. Although not monitored for in the River Severn, endocrine disrupting chemicals

[14] Current limit of 1 NTU at treatment works, and 4 NTU at customers tap. Revised limit to change to 0.3 NTU in 95% of samples. None to exceed 1 NTU at the treatment works.
[15] No current PCV for nonylphenol or 17β-oestradiol, however guidance values are stated as recommended by the World Health Organisation for assessing the occurrence of endocrine disrupting compounds.
[16] Somatic Coliphages were measured in the Minworth Final Effluent, and are a parameter of note for the Pathogens – Virus limiting hazard.

and viruses have been added as limiting hazards for water source scenario 2 and 3 due to the understanding that there are other wastewater treatment works upstream of the abstraction point on the River Severn, and therefore likely that these hazards will also be present in the River Severn, but in lower concentrations than the Minworth WwTW final effluent due to dilution in the rivers.

5. Treatment Requirements and Process Selection

5.1. Selected Processes

From the water quality assessment, limiting hazards for the four water source scenarios have been determined as outlined in Section 4. Following the ACWG methodology, control methods have been selected to mitigate the risks. Part of the basis for selection of the limiting hazards is that if the limiting hazards are controlled, all other risks in the water source will be controlled. As the limiting hazards differ slightly between the water source scenarios as well as differences in the magnitudes of those risks, one treatment process has been selected for each water source scenario to mitigate each risk profile through a conceptual design phase. The following tables explain the selected treatment processes against each of the limiting hazards.

Treatment processes were devised during Gate 1 to successfully mitigate the limiting hazards for each water source scenario. Following the review of the Gate 2 monitoring programme and water quality risk assessment workshops, the proposed treatment processes were reviewed and adapted to show a current best understanding of the control measures required.

Key alterations have included:

- The removal of the clarification stage for water source scenario 2 and scenario 4 where conveyance is via Deerhurst treatment plant and the pipeline.

  The STT SRO will include pre-treatment at Deerhurst (as part of the STT scope), involving ferric chloride dosing, coagulation, clarification and RGF, prior to conveyance and treatment as part of T2ST SRO, and discharge into the River Thames as part of the STT SRO. This pre-treatment is understood to be in place to prevent an INNS transfer risk to the River Thames. As the basis of design for the Deerhurst pre-treatment is unknown at this stage, but it is not a potable water treatment works, it will still provide some risk mitigation, and so the T2ST treatment process' include the control measures appropriate for the source risks. This includes subsequent filtration stages to ensure the water is fully prepared for downstream treatment including disinfection. Clarification is still included in water source 3 & 4 where conveyance is via canal, to indicate the differing risks. This approach is considered robust, and in line with best practices in water safety planning.
- The addition of an ozonation step in water source 4 is following a revised strategy to the bromate formation risk (see discussion in Section 5.3), with the previously proposed PAC dosing stage removed. The use of hydrogen peroxide alongside the ozonation step has also been proposed for water source 2,3 and 4 to create an advanced oxidation process (AOP), which provides the additional benefit of destroying organic compounds.

Minworth WwTW final effluent is assumed to have been treated to compliance with the Water Framework Directive prior to discharge into the River Severn upstream of the Severn to Thames transfer.

Block flow diagrams are provided in the following sections, alongside each water source, showing all proposed treatment processes for each water source scenario.

DAF has been selected in Process 1 (for water source scenario 1 – SESRO source) due to the expected higher algae loads, which are typically buoyant, and reduced silt due to pre-settlement in the reservoir.

GAC is included in all processes to control the wide range of organics such as taste and odour and pesticide risks. The empty bed contact times (EBCT) may differ between the water source scenarios and are dependent contaminant concentration, which is to be assessed in future design stages.

UV and chlorine contact tanks are included in all processes to provide multi-layered disinfection, managing protozoa, bacteria and virus risks.

5.1.1. Treatment for Water Source Scenario 1

Table 5-1 - Selected Treatment / Control Measure for Limiting Hazards of Water Source 1

Limiting Hazard	Treatment / Control Measure Selected
E. coli	Ozonation, UV and chlorine disinfection
Cryptosporidium	Ozonation, UV disinfection
Iron	Mixing within SESRO reservoir to prevent solubilisation of metals. Coagulation & clarification, Rapid Gravity Filtration (RGF)
Manganese	Mixing upstream in SESRO reservoir to prevent solubilisation of metals. Coagulation & clarification, use of hypochlorite for improved oxidation of soluble manganese prior to Rapid Gravity Filtration (RGF)
Bromate	Bromate strategy will be to reduce bromate formation via oxidation of Bromide via use of existing operating strategies demonstrated at existing treatment works to reduce the formation of bromate.
Nitrite	Ozonation, sodium hypochlorite (oxidation of nitrite to nitrate, which has a substantially higher PCV)
Pesticides: Total	Ozonation, Granular Activated Carbon (GAC) Adsorption
Metaldehyde	Metaldehyde risk expected to decrease due to the 2022 ban on outdoor – WQRA requires ongoing monitoring to confirm this. Catchment management control measures are expected to be ongoing and have been observed to considerably reduce risk presented to treatment in the existing Thames Water catchment. Therefore, no specific treatment step is proposed, however advanced oxidation (combined use of peroxide and ozone) and GAC adsorption may offer some reduction.
Corrosivity	Conditioning as required. TBC at later design stage
Taste	Ozonation & GAC Adsorption for reduction of organics which may affect taste, Customer engagement[17]
Change in Source Type	No specific treatment step - customer engagement required
Total Organic Carbon	Pre-ozonation, GAC Adsorption
Chromium	Chromium is noted as a limiting hazard as existing data indicates its presence in the River Thames. Total chromium does not indicate a challenge to the expected revised PCV, however current data is uncertain on the risk from Cr(VI) due to limitations on to the limit of detection. The WQRA requires ongoing and improved surveillance to confirm this. No specific treatment step is proposed, coagulation and RGF may offer some reduction, further monitoring is required to determine if a specific treatment step is required.
PFAS Substances	Further monitoring required to determine if specific treatment step required. GAC Adsorption may provide some benefit depending on species and concentrations.
Turbidity	Coagulation & clarification (Dissolved Air Flotation (DAF)), RGF, GAC Adsorption.
Algae	Coagulation & clarification (DAF), Pre-ozonation

[17] Customer engagement has begun regarding potential new water sources and the SRO schemes. Discussed further in Section 5.3.

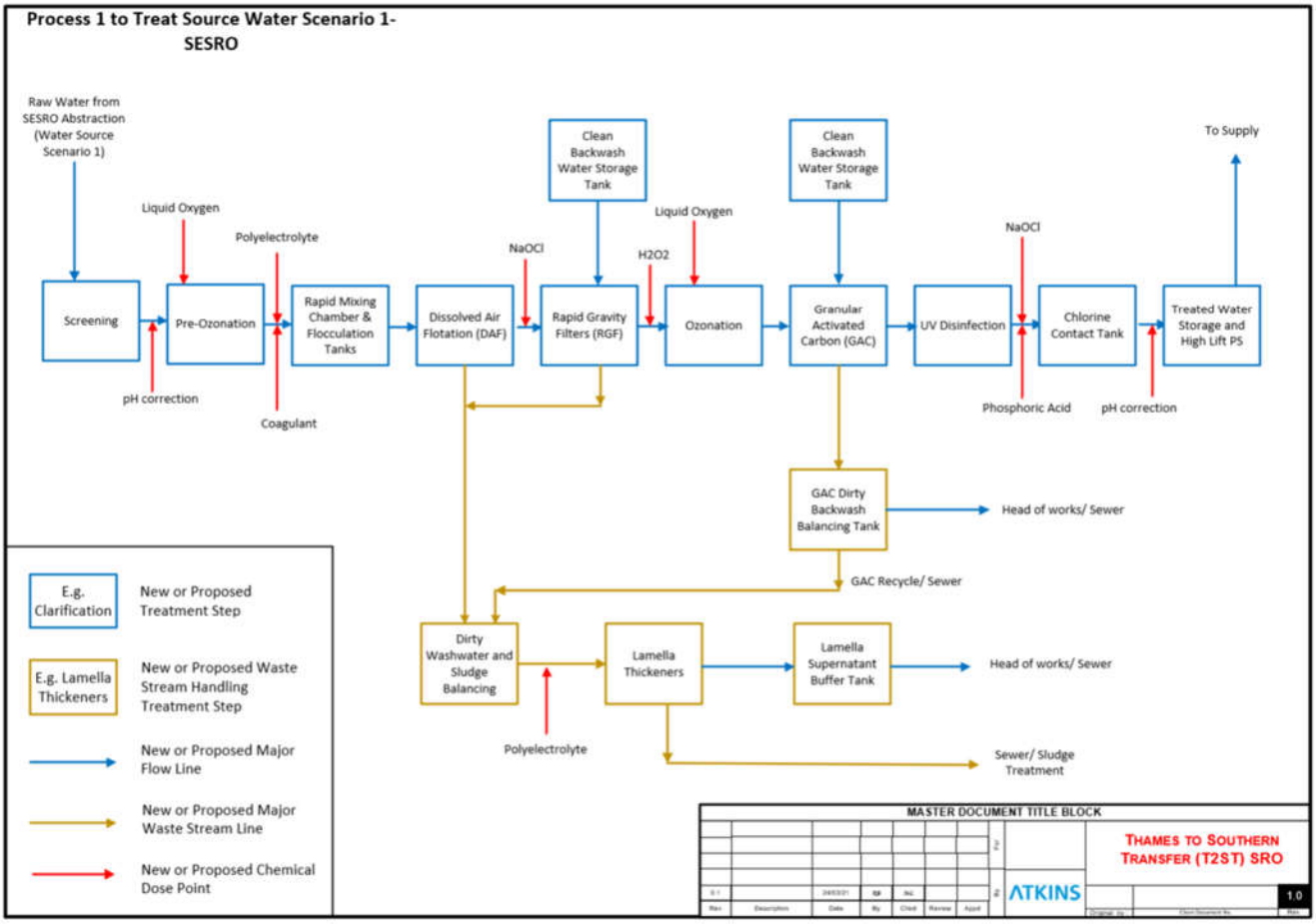

Figure 5-1 - Process 1 for Water Source Scenario 1

5.1.2. Treatment for Water Source Scenario 2

Table 5-2 - Selected Treatment/ Control Measures for Limiting Hazards of Source Water 2

Limiting Hazard	Treatment / Control Measure Selected
E. coli	Ozonation, UV and chlorine disinfection
Cryptosporidium	Ozonation, UV disinfection
Iron	Pre-Ozonation, Coagulation, RGF
Manganese	Pre-Ozonation, Coagulation, RGF
Bromate	Bromate strategy will be to reduce formation via oxidation of bromide. Use of operating strategies at existing treatment works to reduce the formation of bromate.
Nitrite	Ozonation, (oxidise nitrite to nitrate which has a substantially higher PCV)
Pesticides: Total	Ozonation, GAC Adsorption
Metaldehyde	Metaldehyde risk expected to decrease due to the 2022 ban on outdoor – WQRA requires ongoing monitoring to confirm this. Catchment management control measures are expected to be ongoing and have been observed to considerably reduce risk presented to treatment in the existing Thames Water catchment. Therefore, no specific treatment step is proposed, however advanced oxidation (combined use of peroxide and ozone) and GAC adsorption may offer some reduction.

Limiting Hazard	Treatment / Control Measure Selected
Polycyclic Aromatic Hydrocarbons	Ozonation, GAC Adsorption
Benzo(a)pyrene	Pre-Ozonation, Coagulation, RGF, GAC Adsorption
Corrosivity	Conditioning as required. TBC at later design stage
Change in Source Type	No specific treatment process- customer engagement required
1,4-Dioxane	Advanced Oxidation Process (AOP) (O_3 + H_2O_2), GAC Adsorption
Pathogens – Bacteria, **Viruses**, Protozoa	Ozonation, UV Disinfection, Chlorine Contact Disinfection
NDMA	AOP (O_3 + H_2O_2)
Total organic Carbon	Ozonation, GAC Adsorption
Endocrine Disrupting Compounds	AOP (O_3 + H_2O_2), GAC Adsorption
PFAS Substances	Further monitoring required to determine if specific treatment step required. GAC Adsorption may provide some benefit depending on species and concentrations.
Turbidity	Coagulation, RGF, GAC Adsorption

Due to the inclusion of a clarification and filtration pre-treatment stage at Deerhurst, as well as to reflect that abstraction is straight from the STT transfer main rather than from the River Thames, the clarification step has been removed from the proposed T2ST treatment. The decision to retain a filtration stage is to ensure turbidity is removed for downstream treatment effectiveness. At this stage it is expected the raw water will have sufficient hardness/alkalinity that a second stage of coagulation will be effective in forming a flocc and improving removal of remaining solids through RGF without unduly impacting the corrosivity of the water. It is noted though that that this would need to be further explored during design.

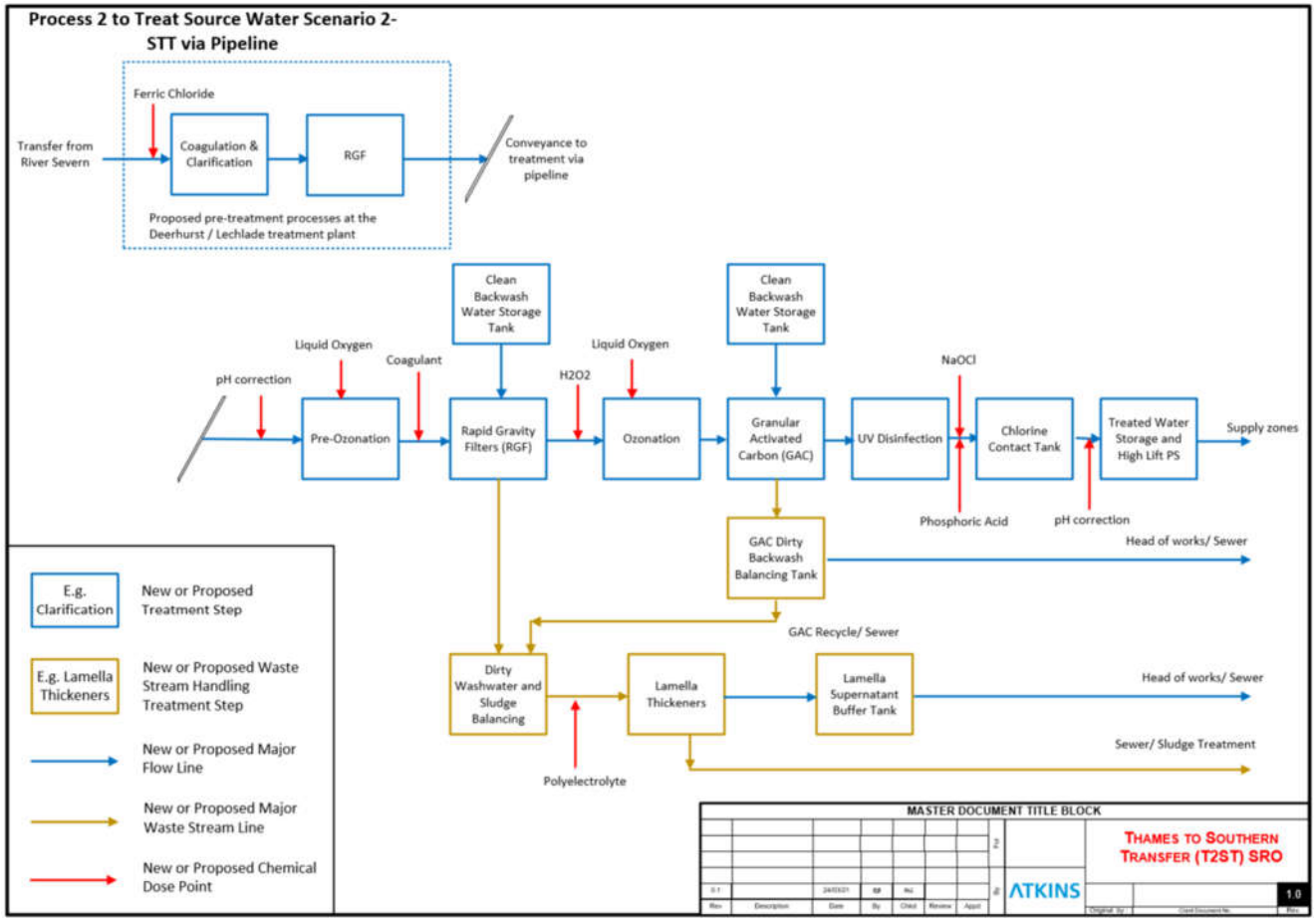

Figure 5-2 - Process 2 for Water Source Scenario 2

5.1.3. Treatment for Water Source Scenario 3

Table 5-3 - Selected Treatment/ Control Measures for Limiting Hazards of Source Water 3

Limiting Hazard	Treatment / Control Measure Selected
E. coli	Ozonation, UV and chlorine disinfection
Cryptosporidium	Ozonation, UV disinfection
Iron	Pre-Ozonation, Coagulation & Clarification, RGF
Manganese	Pre-Ozonation, Coagulation & Clarification, RGF
Bromate	Bromate strategy will be to reduce formation via oxidation of bromide. Use of operating strategies at existing treatment works to reduce the formation of bromate.
Pesticides: Total	Ozonation, GAC Adsorption
Nitrite	Pre-ozonation (oxidises nitrite to nitrate which has a substantially higher PCV)
Metaldehyde	Metaldehyde risk expected to decrease due to the 2022 ban on outdoor – WQRA requires ongoing monitoring to confirm this. Catchment management control measures are expected to be ongoing and have been observed to considerably reduce risk presented to treatment in the existing Thames Water catchment. Therefore, no specific treatment step is proposed, however advanced oxidation (combined use of peroxide and ozone) and GAC adsorption may offer some reduction.

Limiting Hazard	Treatment / Control Measure Selected
Polycyclic Aromatic Hydrocarbons	Ozonation, GAC Adsorption
Benzo(a)pyrene	Pre-Ozonation, Coagulation, Lamella Clarifiers, RGF, GAC Adsorption
Corrosivity	Conditioning as required. TBC at later design stage
Change in Source Type	No specific treatment process - customer engagement required
1,4-Dioxane	AOP (O_3 + H_2O_2), GAC Adsorption
Pathogens - Bacteria, **Viruses**, Protozoa	Ozonation, UV Disinfection, Chlorine Contact Disinfection
NDMA	AOP (O_3 + H_2O_2)
Total Organic Carbon	Ozonation, GAC Adsorption
Endocrine Disrupting Compounds	AOP (O_3 + H_2O_2), GAC Adsorption
PFAS substances	Further monitoring required to determine if specific treatment step required. GAC Adsorption may provide some benefit depending on species and concentrations.
Turbidity	Coagulation, Lamella Clarifiers, RGF, GAC Adsorption
Algae	Pre-Ozonation, Coagulation, Lamella Clarifiers, RGF

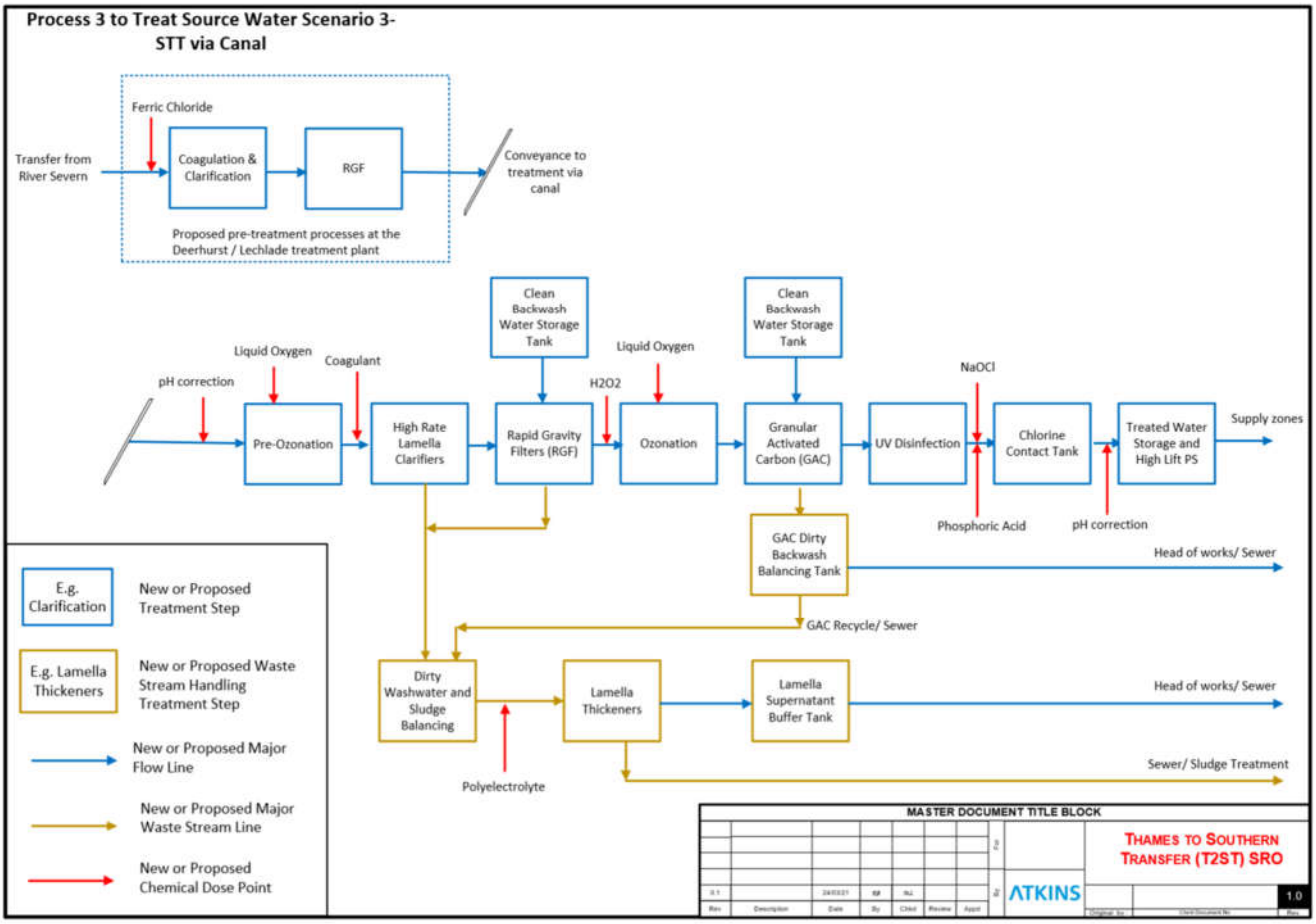

Figure 5-3 - Process 3 for Water Source Scenario 3

5.1.4. Treatment for Water Source Scenario 4

Table 5-4 - Selected Treatment/ Control Measures for Limiting Hazards of Source Water 4

Limiting Hazard	Treatment / Control Measure Selected
E. coli	Ozonation, UV and chlorine disinfection (potential for UF Membrane Filtration dependent on further study)
Cryptosporidium	Ozonation, UV disinfection, (potential for UF Membrane Filtration dependent on further study)
Iron	Coagulation & Clarification, Pre-ozonation, RGF
Manganese	Coagulation & Clarification, Pre-ozonation, RGF
Bromate	Bromate strategy will be to reduce formation via oxidation of bromide. Use of operating strategies at existing treatment works to reduce the formation of bromate.
Nitrite	Pre-ozonation (oxidise nitrite to nitrate which has a substantially higher PCV)
Pesticides: Total	GAC Adsorption
Metaldehyde	Metaldehyde risk expected to decrease due to the 2022 ban on outdoor – WQRA requires ongoing monitoring to confirm this. Catchment management control measures are expected to be ongoing and have been observed to considerably reduce risk presented to treatment in the existing Thames Water catchment. Therefore, no specific treatment step is proposed, however advanced oxidation (combined use of peroxide and ozone) and GAC adsorption may offer some reduction.
Polycyclic Aromatic Hydrocarbons	Ozonation, GAC Adsorption
Benzo(a)pyrene	Lamella Clarifiers, RGF, GAC Adsorption
Corrosivity	Conditioning as required. TBC at later design stage
Change in Source Type	No specific treatment process- customer engagement required
1,4-Dioxane	AOP (O_3 + H_2O_2), GAC Adsorption
Pathogens - Bacteria, **Viruses**, Protozoa	UV Disinfection, Chlorine Contact Tank, (potential for UF Membrane Filtration dependent on further study)
NDMA	AOP (O_3 + H_2O_2)
Total Organic Carbon	Lamella Clarifiers, GAC Adsorption
Endocrine Disrupting Compounds	AOP (O_3 + H_2O_2), GAC Adsorption
PFAS Substances	Further monitoring required to determine if specific treatment step required. GAC Adsorption may provide some benefit depending on species and concentrations.
Turbidity	Coagulation & Clarification, RGF, GAC Adsorption
Algae	Coagulation & Clarification, RGF

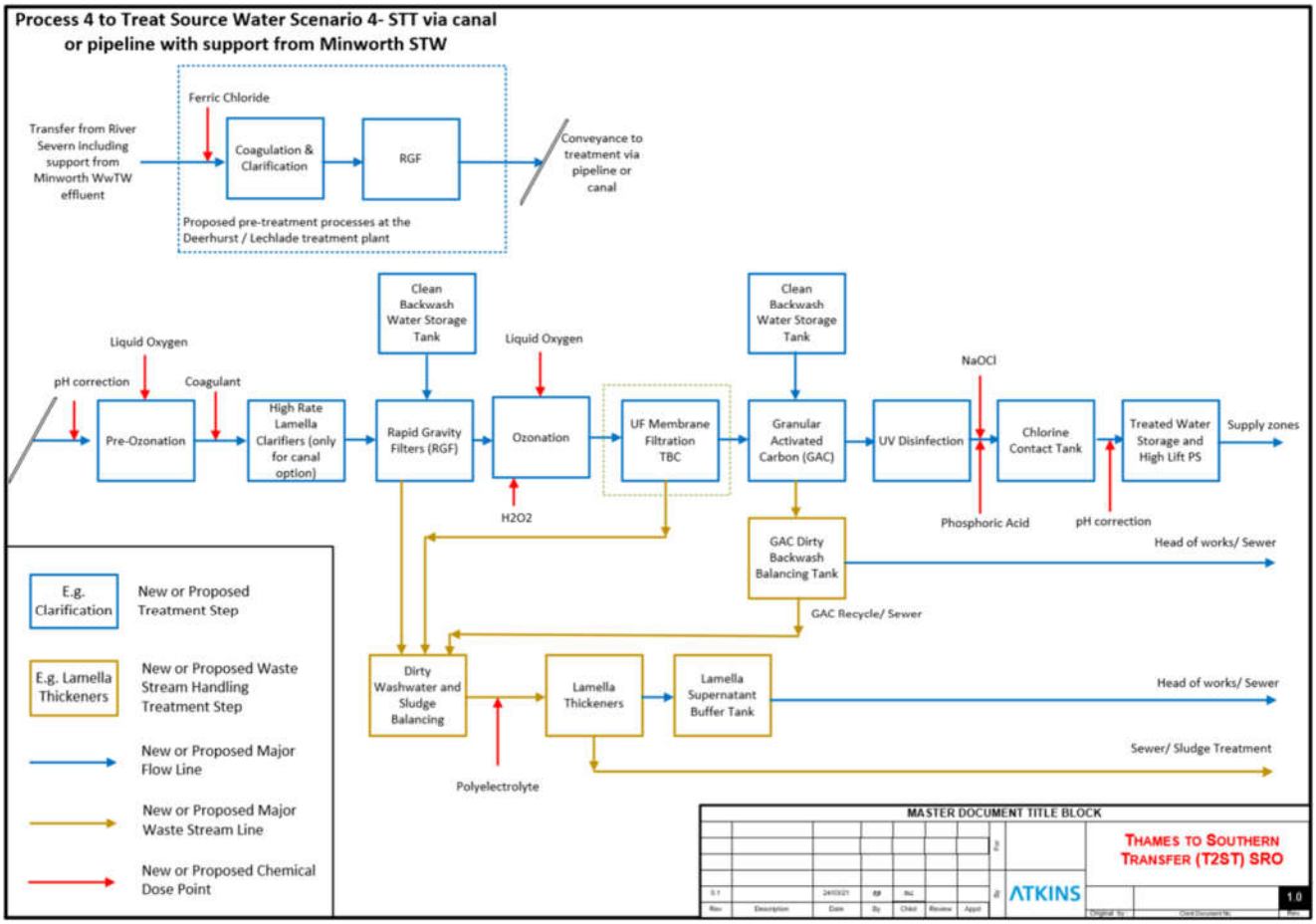

Figure 5-4 - Process 4 for Water Source Scenario 4

5.2. Chemical treatment

A number of chemicals are expected to be dosed to both processes and can be seen at dosing points on the above Figures. Specific chemicals used for coagulant and pH correction will be determined based on results from jar tests at a later design stage. However, experience and judgement have been used to estimate chemical consumption at this stage of conceptual design, to allow indicative operational costs to be estimated.

Thames Water include ozonation at many of their sites which currently treat River Thames water, as mitigation for taste and odour and pesticide risks. Ozonation has therefore been provided in Processes 1 to 4 as both pre-ozonation upstream of clarification or filtration, and post-ozonation downstream of filtration. As well as offering organics destruction, ozone also benefits coagulation and extends the period between regeneration of GAC media. Although the use of ozonation can oxidise bromide to bromate, other process controls as implemented at existing sites may be used to minimise this risk as discussed further in Section 5.3.

It is assumed at this stage that liquid oxygen (LOX) will be supplied for generation of ozone on site, with hydrogen peroxide (H2O2) to be provided to create an AOP for removal of endocrine disrupting compounds, NDMA and 1,4-dioxane in source scenarios 2,3 and 4.

Chlorine disinfection is included as a means of disinfection and to provide a free residual chlorine level (sodium hypochlorite dosing is currently assumed however evaluation of most appropriate chlorination product would be carried out at a later design stage). Contact tanks are included to provide contact time to ensure effective disinfection (in terms of a defined ‘Ct’ in mg.min/L).

5.3. Process Risks and Considerations

This section discusses uncertainty in the data provided up to Gate 2 and the assumptions that have been necessary to define a treatment strategy at this stage. As more monitoring data becomes available, selected

processes or operational methods may change to reflect a better understanding of the magnitude of risks of the water sources.

Metaldehyde has been identified as a risk in River Thames water and is expected to be present in all water source scenarios. Metaldehyde could warrant a separate treatment process to ensure removal, however it was banned for outdoor use in April 2022, hence the risk is likely to substantially reduce over the timeframe for implementation of the T2ST SRO. Current data from the Gate 2 monitoring programme shows that the maximum recorded value of metaldehyde is 0.07µg/l, which is below the PCV of 0.1µg/l. Although there may be some removal via conventional GAC, this is not expected to provide full mitigation. It is recommended to continue being monitored over the next gated stages to see whether a specific treatment stage for removal is warranted.

It is noted the inclusion of ozonation may increase bromate risks if bromide is present in the water source. It is known however that ozonation is employed at other River Thames WTWs. Bromate is considered a limiting hazard for all water source scenarios, with the main control method being to understand and manage the bromate formation risk from bromide which is present in the raw water. Discussions during the Gate 2 WQRA workshop were around methods of best practice to reduce bromate formation risks, including procedures in place at existing treatment works with bromate formation risks. Water Quality data for bromate show existing levels in the River Thames is <2µg/l (LOD) in all samples which do not pose a risk to the PCV of 10µg/l. Water quality data for bromide in the River Thames shows some samples below the limit of detection of <0.1mg/l, with the highest value 0.37mg/l. Bromide has also been noted in the River Severn for following the water quality monitoring programme, as well as in the Minworth WwTW effluent at levels which if converted, could breach the bromate PCV if fully oxidised. To mitigate this, the WTW will follow existing procedures and strategies at place at existing treatment works. Some of these strategies include reduced ozone dosing concentrations, suppressed pH when ozone dosing and the use of ultra-low bromate hypochlorite.

Water source 4 includes support from WwTW effluent, which may give rise to increased microbiological risks, increased bromate risk through formation during treatment, as well as an increased likelihood of emerging substances such as endocrine disrupting compounds from pharmaceutical and personal care products. This risk will be informed by the STT WQRA. Data for the River Thames shows nonylphenol, an endocrine disrupting compound, to have values lower than the action limit (max value <0.04µg/l). Appropriately sized activated carbon adsorption may be a suitable control measure for endocrine disrupting compounds.

A widened suite of monitoring for the 47 PFAS compounds is recommended to allow for a full understanding of the risk from PFAS compounds, so that it can be determined if specific treatment steps are required.

GAC is included as a treatment step for water source 4 with sizing to be considered in later stages. Ultrafiltration (UF) membrane filtration is also under consideration for inclusion in treatment for water source 4, as an additional microbiological barrier. The need for a further microbiological barrier in addition to the clarification, filtration, UV and chlorination steps is already part of the source 4 treatment strategy but will be reviewed in subsequent design stages and take into consideration data gathered from the ongoing monitoring programme.

Chromium is currently detected in the River Thames, and so is present as a limiting hazard in water source scenario 1 where the River Thames is the catchment. The maximum concentration recorded in the River Thames is 4.1µg/l, below the expected new maximum prescribed concentration and value (PCV) for chromium, which could potentially be reduced to 25µg/l following the revised DWD. Values for samples of Cr(VI), with an action limit of 3µg/l, have all been measured below the LOD of 7µg/l - at the current time, this does not provide a useful indication of whether Cr(VI) is indeed a risk or not due to the LOD being greater than the action limit. No conclusion can be drawn whether Cr(VI) is a risk or not at this time, and so specific treatment or mitigation methods cannot be ruled out, however it is recommended that continued surveillance keeps this under review.

The requirement for conditioning at the new water treatment works prior to distribution to the SRN supply zones for network compatibility and to manage corrosivity, change of source type and customer acceptability risks will require investigation in later stages once the scheme develops and the water source is known. Customer engagement and consultation will be required regarding new water sources. Customer engagement is expected to follow the guidance provided by the Britain Thinks customer engagement methods study as presented to the ACWG, which focused on the timescales of engagement with consumers around a source change, as well as customer attitudes to acceptability of source water changes in the supply network. This work highlighted that, consumers perceive water reuse schemes as the highest risk, whereas water sourced from reservoirs or other imported sources are of lower risk. The study also recommended timely engagement with consumers closer to the implementation of the scheme. As such, no direct consumer engagement regarding the T2ST SRO has yet been undertaken by Southern Water due to the timescales for implementation, however it is expected that

future engagement will follow the recommendations of the study. Continued customer engagement is considered a key control method and action required for successful implementation of this scheme.

5.4. Waste Handling Considerations

The water treatment process yields a waste stream. The provision of a waste management route – connection to the public sewerage system, frequency of vehicle movements for removal of dewatered cake solids, disposal of out-of-specification recovered washwater – can be a significant issue in the planning of a new water treatment works site.

The assumed waste treatment aims to produce a thickened sludge for disposal to public sewer, with recovered wash water returned to the head of the works to improve efficiency, with any risks associated with wash water recovery to be captured and controlled as part of the future design process, to prevent any risk from being passed to the consumer.

6. Recommendations for Further Work

Recommendations from Gate 1 focused on defining a monitoring programme for water quality data gathering, which would in turn would allow for further examination and review of water quality risks. This monitoring programme has continued throughout Gate 2, is proposed to continue throughout Gate 3, and will continue benefit the T2ST SRO design development by providing:

- Information to inform likelihood scores for emerging contaminants – in particular endocrine disrupting compounds, somatic coliphages and perfluorinated substances. Note: monitoring for somatic coliphages was implemented in Gate 2 but is likely to be included in future monitoring programmes.
- Information to inform the magnitude of expected pathogen risk from WwTW effluent supported source scenario.
- Surveillance of parameters which may change from their historic likelihood/consequence, for example due to regulatory changes – e.g. metaldehyde, chromium.
- Data to inform a quantitative design raw water quality envelope for treatment plant design and sizing.

The Gate 2 monitoring programme has provided a broader data set with more recent data and more parameters, allowing a review of likelihood scores for the limiting hazards during the Gate 2 T2ST workshop. Recommendations from Gate 2 can be summarised as below:

- Continued and improved monitoring to allow for a greater pool of quantitative data, to inform likelihood scores of emerging contaminants and track trends, and to also ensure monitoring accommodates for lower limits. E.g. increasing the suite of monitoring parameters for PFAS substances to include all 47 compounds named by the DWI; lowering the limit of detection for Cr(VI) to below the action limit, to allow for a better understanding of the risk to the proposed new limit in the revised DWD. Improved monitoring for pesticides as many values are below the limit of detection, to allow for a better understanding of the total pesticide risk.
- Continued surveillance of parameters which may change from their historic likelihood/consequence, for example, due to regulatory changes or for parameters which do not have a regulatory limit, e.g. NDMA or 1,4-dioxane.
- An investigation into change in source water risks:

  While the treatment processes identified in section 5 are expected to treat water to drinking water quality standards, residual risks which can result from the introduction of treated water from new sources into existing treated water networks must be considered. The receiving Southern Water water resource zone of Southampton East in Hampshire is currently fed by surface water from the River Itchen at Otterbourne, whereas the Andover and Kingsclere water resource zones are supplied by groundwater sources.

  The greatest residual risk to provision of acceptable drinking water quality lies with customer acceptability risks such as changes to the aesthetic qualities of water (including its colour, taste and odour); through modification of nitrate blending strategies; to changes to the corrosivity of water and impacts on the nature and concentration of corrosion by-products entering the water on route to the customer tap. The transfer of potable water over long distances also requires careful management of residual disinfectant and disinfection by-products.

  These risks are recognised as of key importance to a source-to-tap water safety planning approach and should be explored in subsequent phases of work should the scheme be taken forward. The water quality risk assessment process identified that the Andover and Kingsclere water resource zones are likely to be impacted the most due to the change in type of water source – from a ground to surface source. Pro-active consumer engagement is a planned control measure which will be taken to reduce the impacts of this risk, however there is a risk that additional conditioning treatment is required in addition to the treatment processes outlined in section 5. As the scope of the project has not yet been finalised, including confirmation of the final capacity and utilisation of the scheme and preferred water source, further work is required to establish the need for such control measures and to inform the design. Additional data will also inform the design going forward.
- Regarding the upstream STT SRO water sources, further information is required on the AWTP at Minworth and the pre-treatment at Deerhurst / Lechlade during Gate 3. For example, whether pre-treatment processes have been selected for the clarification and filtration stages, whether a treatment goal/basis of design has been defined, and if any bankside storage of any kind is to be used. This will

further inform the likely risk mitigation upstream of receipt of the water into the T2ST scheme, and thus development of the downstream control measures and treatment works design within the T2ST SRO.

7. Conclusions

The six SRO options initially identified for Gate 1 of the T2ST SRO have been further assessed during the Gate 2 options appraisal process and two preferred options have now emerged (Options B and C). These options comprise a potable water transfer from either SESRO or STT from a site located to the west of the A34 near Drayton in Oxfordshire to the Southern Water supply network in Hampshire. Further background information on the options selection process is set out in the Concept Design Report. Annex A3, (doc ref: T2ST-REP-G2-07).

The scope of the SRO options has been refined in Gate 2, to identify one preferred T2ST option (Options B and C).

Options B and C have four possible water source scenarios: 1, 2, 3 and 4, all with differing risks and limiting hazards, which drive different selections of treatment processes in order to successfully mitigate the risks associated with each water source. Risk assessments for each water source have been revised following the Gate 2 ACWG WQRA workshop and identify the limiting hazards and control measures in place for each risk. The Gate 2 process has identified new water quality risks for all water source scenarios having reviewed water quality monitoring data provided by the Gate 2 monitoring programme. The monitoring programme to date has provided a small sample of data to help quantify the magnitude and likelihood of risks in both the SESRO and STT scenarios. While continued monitoring is required to provide a full understanding of trends of the water quality profile, the data provided thus far does provide some indication of the risks and is at present the most up to date source of information.

All four water source scenarios for Options Band C are feasible as a preferred water source has not yet been determined. Water Quality Risk Assessment worksheets for each water source scenario were updated following the T2ST workshop on 19th and 26th May 2022 with information available at the time.

Water source scenario 1 assumes a direct abstraction from SESRO reservoir (the source to which is the River Thames).

Source scenarios 2, 3, and 4 are supplied from the River Severn via the STT SRO via pipeline, canal and with indirect support from WwTW effluent respectively.

As water source scenario 4 involves planned indirect support from WwTW effluent, it presents the highest risk to water quality due to an increased magnitude of risk from microbiological and endocrine disrupting compounds.

Water source scenario 3 involves conveyance of River Severn water via canal, which presents a lower risk to water quality than indirect WwTW effluent reuse but may result in higher turbidity and other environmental run-off related risks than conveyance direct by pipeline from the STT pre-treatment plant.

The Gate 2 revision of water source scenario 2 (River Severn water conveyed via STT pipeline from the STT pre-treatment plant) benefits most from pre-treatment within the STT scope, particularly in reducing turbidity risk, and as a result requires less intensive pre-treatment within the T2ST scope compared to the other STT source scenarios.

Water source 1 from SESRO carries a slightly different risk profile to River Severn water and requires full treatment to manage turbidity from source (compared with the revised River Severn pipeline transfer – source scenario 2). However, water source 1 from SESRO it is likely to carry a reduced risk compared to source scenarios 3 and 4 (STT via canal and with WwTW effluent support respectively).

The proposed treatment from Gate 1 for water source 2, 3 and 4 have been adapted following the Gate 2 workshop and in light of new limiting hazards to provide a revised view of appropriate control measures to manage each source scenario's water quality risk profile.

In all water source scenarios, treated water from new surface water sources will be introduced to new regions, including the currently groundwater-fed water resource zones of Andover and Kingsclere. Changes in water source can affect aesthetic risks such as taste and odour, as well as corrosivity. These risks will require closer investigation during subsequent phases of work – potential control measures include chemical conditioning prior to entering supply and pro-active consumer engagement. Further work to establish the need for, and nature of, such conditioning would be required in future phases.

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