Strategic Regional Water Resource Solutions: Annex 1.1: Interconnector Deerhurst to Culham Pipeline Conceptual Design Report

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

Date: November 2022

Severn to Thames Transfer

Interconnector Deerhurst to Culham pipeline conceptual design report

STT-G2-S3-303

November 2022

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Conceptual Design Report- Interconnector Pipeline Deerhurst to Culham

Severn to Thames Transfer (STT)

September 2022

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Executive summary

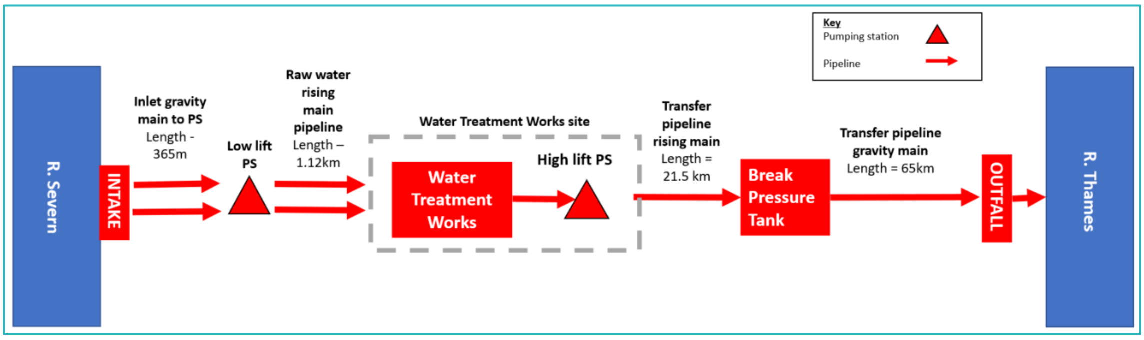
This report is an annex to the Gate 2 submission for River Severn to River Thames Transfer Strategic Resource Option (SRO). It builds on the work undertaken in Gate 1. At Gate 1 two different interconnector options were developed: 'Deerhurst to Culham', using a direct pipeline between the River Severn at Deerhurst and the River Thames at Culham, and; 'Cotswolds Canal' using a combination of pipelines and open water transfers via existing and reconstructed canals from the River Severn at Gloucester Docks and the River Thames at Culham.

At Gate 2, alternative options (including the two Gate 1 options) were evaluated, and a preferred Gate 2 option selected. This preferred option, consists of a revised pipeline option from Deerhurst to Culham. It is a viable option to transfer water, made available from the other aspects of the STT System, from the River Severn to the River Thames. The option has been developed at three, mutually exclusive alternative flow regimes – 300Ml/d, 400Ml/d and 500Ml/d.

The option consists of the following elements:

- Screened intake on the River Severn in the Deerhurst area
- Low Lift (raw water) Pumping Station to deliver flow to the treatment works also in the Deerhurst area
- Conventional Water Treatment Works to treat the water to ensure that it is suitable for release into the upper Thames, based on both quality parameters and invasive species constraints
- Transfer to the River Severn at Culham including a High Lift (treated water) Pumping Station, 86km pipeline, break pressure tank and outfall.

Figure 0.1: Gate 2 Interconnector Schematic



The key design changes from Gate 1 to Gate 2 are:

- Revised pipeline route, avoiding environmental constraints but no significant change in length
- Optimisation of pipe diameters typically resulting a 100mm reduction in diameter
- Revised intake, low lift pumping station, WTW and high lift pumping station locations
- Adjustment of WTW process sizes following water quality sampling data and further confirmation of INNS removal requirements
- Revised configuration of pumping stations resulting in a greater number of smaller pumps

- Reassessment of size of break pressure tank required (sized based on hydraulic requirements instead of nominal retention time at Gate 1 stage) resulting in a considerable reduction in size of break pressure tank.

An outline construction programme has been developed, detailing a construction duration of six years. This has not changed since Gate 1 and will be reviewed and refined in Gate 3 through early contractor involvement and a greater consideration of commissioning operations.

Risk and opportunity registers from Gate 1 have been reviewed and updated, key risks and opportunities have been detailed within the CDR in relation to their impact on the design and future design development activities. Further information on the costing of these risks can be found in the corresponding cost report.

Glossary

Acronym	Definition
AOD	Above Ordnance Datum
AONB	Area of Outstanding Natural Beauty
BPT	Break Pressure Tank
CAPEX	Capital Expenditure
CDR	Conceptual Design Report
DAF	Dissolved Air Flotation
DCO	Development Consent Order
DfMA	Design for Manufacture Assembly
DNO	Distribution Network Operator
DWI	Drinking Water Inspectorate
EA	Environment Agency
HAZOP	Hazard and Operability Study
ICA	Instrumentation, Control and Automation
MCC	Motor Control Centre
M&E	Mechanical and Electrical
MEICA	Mechanical, Electrical, Instrumentation, Control and Automation
OPEX	Operational Expenditure
PS	Pumping Station
RGF	Rapid Gravity Filter
SESRO	South East Strategic Resource Option
SRO	Strategic Resource Option
SSSI	Site of Special Scientific Interest
STT	Severn Thames Transfer
SWA	Slough, Wycombe and Aylesbury (a Thames Water water resource zone)
SWOX	Swindon Oxford (a Thames Water water resource zone)
T2ST	Thames to Southern
WFD	Water Framework Directive
WQ&E	Water Quality and Ecology
WRMP	Water Resource Management Plan
WRZ	Water Resource Zone
WTW	Water Treatment Works

1 Introduction

1.1 Background

The Deerhurst Pipeline forms a part of the River Severn to River Thames Transfer (STT) Strategic Resource Option (SRO). This report relates to a physical asset or 'interconnector' which conveys raw water from the River Severn to the River Thames. The interconnector itself has no resource benefit. Resource benefit comes from the natural flow in the River Severn (unsupported flow) and the related source SROs providing supported flow.

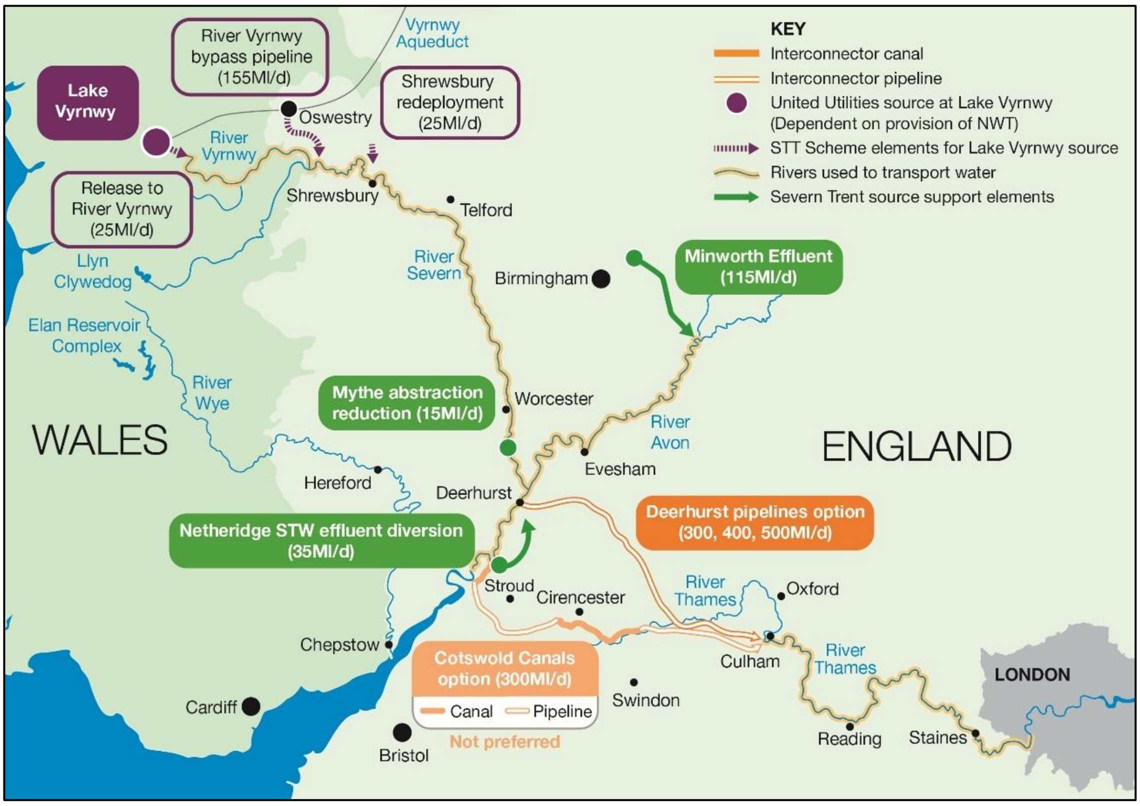
The source SROs are:

- North West Transfer SRO
- Minworth Effluent SRO
- Severn Trent Sources (this covers both Netheridge STW Effluent diversion and Mythe abstraction reduction).

Collectively these source SROs and the interconnector form the elements of the Severn Thames Transfer Scheme which is jointly promoted by Severn Trent Water, United Utilities and Thames Water.

The concept designs for each of the source elements are described in their own Gate 2 submissions. This Conceptual Design Report (CDR) forms part of the STT Gate 2 submission and covers the interconnector only.

Figure 1.1: Map Schematic Showing Gate 1 STT SRO Elements



The Interconnector will transfer treated river water (unsupported flow) from the River Severn to the River Thames when there is a need. When the flow in the River Severn is insufficient or is below the hands-off flow, then source discharges and Interconnector abstraction in line with the proposed permitting road map will operate.

At Gate 1, two different interconnector options were developed:

- 'Deerhurst to Culham', using a direct pipeline between the River Severn at Deerhurst and the River Thames at Culham
- 'Cotswolds Canal' using a combination of pipelines and open water transfers via existing and reconstructed canals from the River Severn at Gloucester Docks and the River Thames at Culham.

At Gate 2, alternative options (including the two Gate 1 options) were evaluated, and a preferred Gate 2 option selected. This preferred Gate 2 option, as detailed in this document, consists of a revised pipeline option from Deerhurst to Culham. It is a viable option to transfer water, made available from the other aspects of the STT System, from the River Severn to the River Thames. The option has been developed at three, mutually exclusive alternative flow regimes – 300Ml/d, 400Ml/d and 500Ml/d.

During Gate 3, further work and consultation will be carried out on the selection of a shortlisted option before a final decision is made.

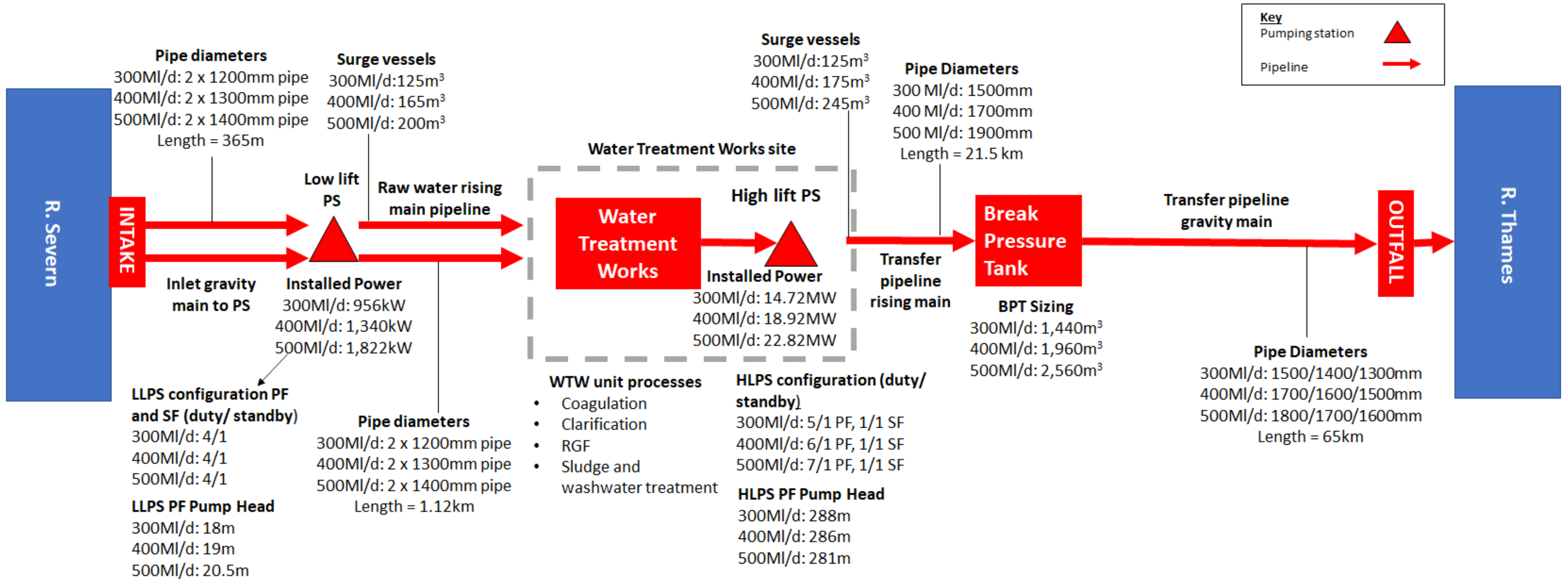
1.2 Option Overview and Location

This conceptual design has been developed to demonstrate that the scheme is a technically viable option and allow costing to be undertaken for Gate 2. A schematic of the solution which has been developed is shown in Figure 1.2.

Water is abstracted from the River Severn at Deerhurst, near Tewkesbury and transferred by a new rising main pipeline over the Cotswold Hills and before being discharged into the River Thames near Culham. The main components of the option are:

- Abstraction from the River Severn via a river intake structure at Deerhurst including inlet screens and a twin pipeline to a raw water pump station
- Low Lift (raw water) pumping station (LLPS) transferring raw water via a twin pipeline to treatment works
- Water treatment works (WTW) to improve the quality of the abstracted water, principally removing suspended solids, metals, and invasive non-native species.
- High lift PS (HLPS)
- A rising main to the break pressure tank
- A break pressure tank at the high point
- A gravity main to discharge point
- A discharge outfall at Culham with an actuated valve and an aeration cascade
- Washouts along the route provided with permanent discharge pipework to adjacent watercourses
- Air valves along the route for pipe drain down and refill during pipeline maintenance

Figure 1.2: Deerhurst to Culham Schematic



1.2.1 Gate 2 Development

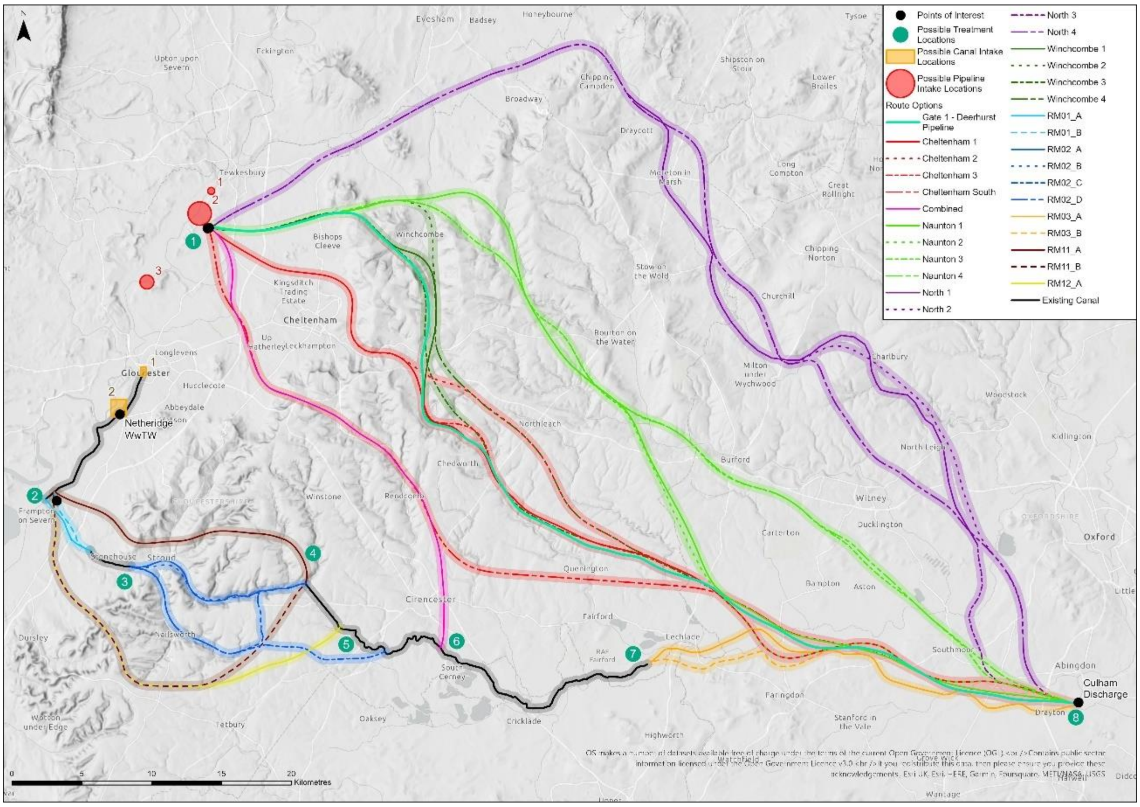
Gate 2 activities can be split into two different sections, options appraisal and design development.

1.2.1.1 Gate 2 – Interconnector Options Appraisal

The Severn Thames Transfer (STT) Interconnector options appraisal study sought to identify and assess alternative interconnector options, encompassing a wide range of options, progressing from simply a 'viable' option at Gate 1 to a preferred solution for Gate 2.

The option appraisal methodology had three stages: Longlist, Shortlist and Validation. The longlist and shortlist stages focussed on a 300 Ml/d capacity transfer for water supply, whereas the Validation stage considered a range of potential futures including larger capacity transfers and integration of the water supply scheme with restoration of the disused Cotswold Canals for boat navigation. Longlist appraisal was undertaken against qualitative environmental impact and engineering criteria. Shortlist appraisal and Validation considered costs and benefits, in a quantitative (monetised) and qualitative assessment. Figure 1.3 is an indicative map showing longlist options considered.

Figure 1.3: Indicative Map of Longlist Options

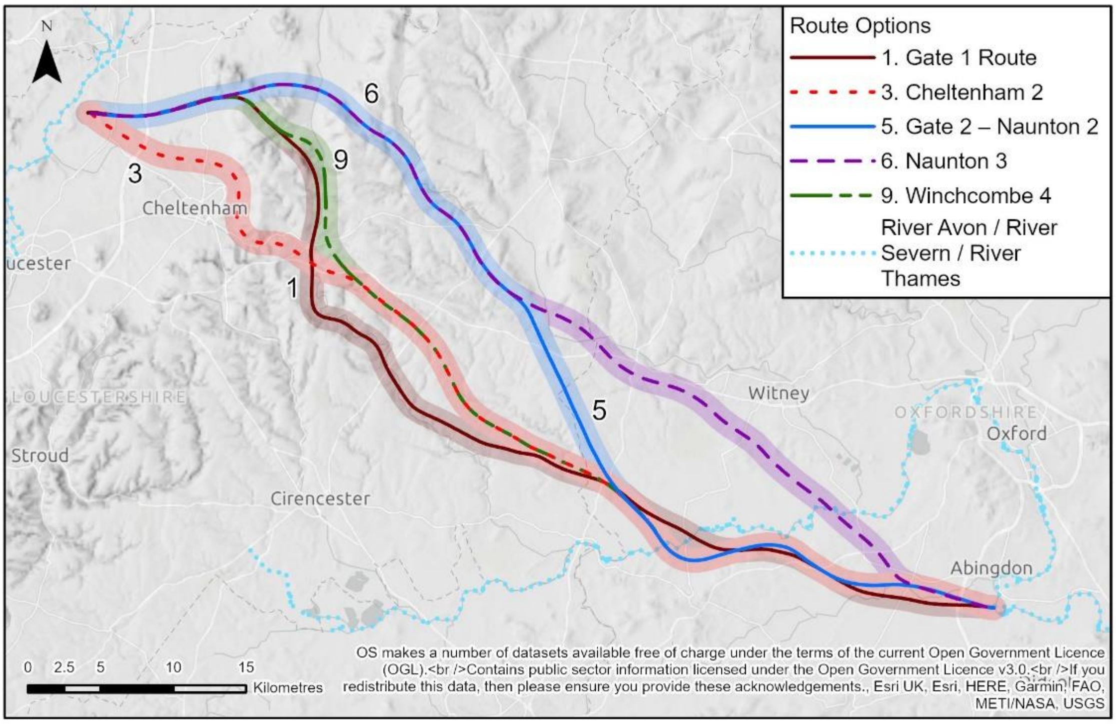


The study area is primarily defined by the reaches of the River Severn that can be used for abstraction, acceptable locations for the discharge into the River Thames and the topography of the Cotswold Hills. The longlist identified a number of potentially feasible direct pipeline routes and routes that would reconstruct sections of the Cotswold Canals for open water transfer. The shortlist was selected to include a direct pipeline option that characterised options of this type for comparison against materially different options that combined pipelines with partial restoration of the Cotswold Canal corridor. The longlist and shortlist stages selected a direct pipeline from the River Severn in the vicinity of Deerhurst to the River Thames at Culham as the preferred option for a 300 Ml/d water supply transfer. The Potential Futures Validation further concluded that any benefits gained by integrating canal restoration with a water supply transfer would be outweighed by the impacts and costs. Furthermore, a direct pipeline was shown to be the only cost-effective solution for transfers larger than 300 Ml/d.

At shortlist stage the Naunton 2 pipeline was selected to characterise the direct pipeline option. This route option has been developed further during Gate 2.

However, as shown in Figure 1.4, three other route options also passed the longlist stage. These should be reviewed at Gate 3, when land referencing and further desk top geotechnical studies should be completed to inform refinement of the pipeline route selection. In addition, an alternative treatment process of either a settlement lagoon or a nature based solution followed by pile cloth filters passed longlist stage and would warrant further investigation within Gate 3. At Gate 2 conventional treatment has been selected to ensure robustness of the solution.

Figure 1.4: Pipeline Route Options Passing Longlist Stage



1.2.1.2 Design Development Phase

The design development stage further developed the shortlist direct pipeline option. The intake and WTW locations and processes were broadly similar to the Gate 1 option but the pipeline route was significantly different.

The design development phase sought to further define and refine the selected shortlist option, to ensure greater confidence in cost and programme at this stage.

During design development, the key activities in Table 1.1 were undertaken, whose findings have resulted in changes and enhancements to the solution proposed in Gate 1.

Table 1.1: Design Development activities undertaken during Gate 2

	River Intake	Detailed review of river intake structure and screens
Option development	Pumping Stations	Sizing of low lift and high lift pump station, selection of pump station configuration (duty/stand-by), pump sizing and selection
	Water Treatment Works	Additional water quality sampling and INNS monitoring carried out at Deerhurst and Culham, whose results have informed WTW unit process design and sizing
	Raw water and Transfer Pipelines	Pipe diameter optimisation on whole life cost basis for raw water and transfer pipelines
		Outline surge analysis for Low Lift PS and High Lift PS
	Break Pressure Tank	Update to BPT design
	Electricity and Power Supply	Detailed review of site power supply requirements
	Geotechnical	Desktop geotechnical study

The key asset changes from the Gate 1 solution are shown Table 1.2 below.

Table 1.2: Summary of changes from Gate 1 solution to Gate 2 solution

STT Interconnector component	Gate 1 Solution	Gate 2 Solution
River intake	Two stage screening with bar and band screens	Two stage screening with bar and band screens
	300Ml/d: 3 duty/ 1 standby	300Ml/d: 10 duty/ 2 standby
	400Ml/d: 4 duty/ 1 standby	400Ml/d: 14 duty/ 2 standby
	500Ml/d: 5 duty/ 1 standby	500Ml/d: 16 duty/ 2 standby
Low lift PS (installed power)	4 duty/ 1 standby configuration for all capacity options	4 duty/ 1 standby configuration for all capacity options
	300Ml/d: 1.9MW	300Ml/d: 956kW
	400Ml/d: 2.5MW	400Ml/d: 1.34MW
	500Ml/d: 3.1MW	500Ml/d: 1.82MW
		Outline surge analysis carried out and surge vessels sized for 300, 400 AND 500Ml/d scenarios
Raw water pipeline	Inlet gravity pipe: Length = 400m	Inlet gravity pipe: Length = 365m
	Rising main to WTW: Length = 1.1km	Rising main to WTW: Length = 1.1km
	Inlet and delivery pipe diameters: Twin 1800mm diameter pipe for inlet pipe and delivery pipe	Inlet and delivery pipe diameters: 300Ml/d: Twin 1200mm pipe 400Ml/d: Twin 1300mm pipe 500Ml/d: Twin 1400mm pipe
Water Treatment Works	Treatment via coagulation, clarification, RGF, sludge and washwater treatment	Treatment train unchanged. Unit processes re-sized on the basis of water quality sampling data and INNS monitoring
High lift PS (installed power)	4 duty/ 1 standby configuration for all capacity options	5/1, 6/1 and 7/1 duty/ standby configuration for all 300, 400 and 500 Ml/d capacity options respectively
	300Ml/d: 14.5MW	300Ml/d: 14.7MW

STT Interconnector component	Gate 1 Solution	Gate 2 Solution
	400Ml/d: 19MW	400Ml/d: 18.9MW
	500Ml/d: 24MW	500Ml/d: 22.8MW
	Preliminary surge assessment carried out for 300Ml/d scenario only	Outline surge analysis carried out and surge vessels sized for 300, 400 AND 500Ml/d scenarios
Transfer pipeline rising main	Length: 19.8km	Length: 21.5km
	300Ml/d: 1600mm diameter	300Ml/d: 1500mm diameter
	400Ml/d: 1800mm diameter	400Ml/d: 1700mm diameter
	500Ml/d: 2000mm diameter	500Ml/d: 1900mm diameter
Break Pressure tank	Two cell BPT provided. Sized on basis of 1 hour storage volume	Single cell BPT provided. Sized as part of surge modelling, on basis of Pressure Sustaining Valve stroke closure of 800s
	Operating depth = 5m	Operating depth = 5m
	300Ml/d: V=12,600m^3	300Ml/d: V=1,440m^3
	400Ml/d: V=16,700m^3	400Ml/d: V=1,960m^3
	500Ml/d: V=20,900m^3	500Ml/d: V=2,560m^3
Transfer pipeline gravity main	Length: 66.6km	Length: 65km
	300Ml/d: 1500/1400mm diameter	300Ml/d: 1500/1400/1300mm diameter
	400Ml/d: 1800/1600mm diameter	400Ml/d: 1700/1600/1500mm diameter
	500Ml/d: 2000/1800mm diameter	500Ml/d: 1800/1700/1600mm diameter
Outfall Structure	Aeration cascade with actuated valve (dry inlet)	Aeration cascade with actuated valve (dry inlet)

1.2.2 WRSE Regional Modelling Output

The STT system has been modelled by the WRSE as part of their assessment for their regional water resource plan. The STT interconnector is one of the principal SROs in a portfolio of solutions. According to output based on Gate 1 information the STT unsupported flows would be required by 2040 with a phased implementation of the source supports thereafter. However, new information has been provided, consultation feedback received, and regional reconciliation is taking place prior to the WRSE finalising their plan. The Plan will not be finalised until early 2023.

1.3 Sizing and Phasing

1.3.1 Transfer Capacity

The interconnector option has been developed at three different capacities, 300Ml/d, 400Ml/d, and 500Ml/d. The details of sizing have been captured in Chapter 2.2.

The scheme is expected to be operated during periods of drought/ low flows (and low reservoir storage) in the River Thames catchment. Consequently, there are expected to be significant periods of time when the scheme will not be in full operation and will be operated with a sweetening flow, ensuring consistency of water released into the River Thames and to enable the scheme to be available for use at short notice (within a 20 day notice period).

A 24hr pumping regime has been assumed, with an allowance of 20Ml/d for sweetening flow. This regime may be adjusted during further investigations into the potential utilisation and operational regime in Gate 3.

1.3.2 Phasing

At this stage the operating regime has not yet been confirmed and as such the potential opportunities for phasing have only been considered at a high level and a detailed phasing plan has not been developed at this stage. As greater surety of the operational profile is developed, evaluation of the benefits of phasing and their impact on the cost and programme will be undertaken.

The potential opportunities for phasing of the key assets have been considered below:

- Intake works and pump stations: It is unlikely that it would be economical or desirable to phase the civil elements of the works, however the provision and installation of MEICA elements could be phased.
- Water treatment works: The proposed treatment design features multiple 100Ml/d streams to meet the desired design capacity, allowing the plant to ramp-up and down to cater for the anticipated range of flows. The streaming principally refers to the clarification and rapid gravity filtration stages. Dependent on the desired end capacity and utilisation profile streams could be constructed as required in a progressive manner. However, it is recommended that common elements such as the clean backwash tank and dirty washwater handling system are sized for the expected final design capacity.
- Pipeline: As with the intake works and pumping stations it would not be economical or desirable to phase the pipeline.
- BPT: The BPT has been designed to have only one cell, so there is no foreseen opportunity for phased delivery.
- Outfall structure: It is unlikely that these civil works would be beneficial to phase.

1.4 Links with other Options

1.4.1 STT Sources and dependencies

The flows abstracted from the River Severn via the intake of the STT interconnector consist of unsupported flows in the River Severn, and supported flows from related options and SROs. Where sufficient unsupported flows are not available to match demand requirements, resource elements could be implemented incrementally to supplement flows.

Further information on the STT Sources and the wider STT system can be found in Section 1.1.

1.4.2 Mutual Exclusivities

All STT interconnector options are mutually exclusive.

1.4.3 Potential interactions with other schemes

There are a number of potential interactions with other schemes, not within the scope of the STT scheme. These have the potential to change the operational requirements for the interconnector and would need to be considered at a later stage once it is decided which schemes are to progress.

1.4.3.1 South East Strategic Reservoir Option (SESRO)

The proposed location of SESRO is 4-5km west of the proposed outfall for Deerhurst Pipeline and the pipeline passes in close proximity to potential SESRO assets. Therefore, future design and planning for STT must take full account of the plans and development of the SESRO project. If both schemes progress careful planning will be required to ensure that the design and construction of these elements are aligned.

To date, consultation with SESRO has resulted in minor realignment of the pipeline adjacent to the proposed reservoir site and along the corridor between the reservoir and the River Thames. In addition, a common outfall location has been identified for both options. It is planned that, if both options progress, a shared outfall will be constructed to service both options.

At Gate 2 it has been assumed that both options will progress independently of each other, and full costs are included.

If both schemes were to progress there may be an opportunity to provide extra flexibility in operation by connecting the pipeline directly into the reservoir, as well as to the outfall.

1.4.3.2 Thames to Southern (T2ST)

There is a potential requirement for a connection to the T2ST scheme. This would be in the form of a cross connection approximately 3km west of the proposed outfall for Deerhurst Pipeline (Refer to the T2ST scheme for further details).

1.4.3.3 Thames to Affinity Transfer (T2AT)

STT has the potential to support T2AT which abstracts water from the River Thames in London. (Refer to T2AT Gate 2 for further information.)

1.4.3.4 Additional Spurs

In addition to those connections mentioned above, the STT Interconnector also has the potential to provide water to Thames Water's Swindon Oxford (SWOX) Water Resource Zone and Slough, Wycombe and Aylesbury (SWA) Water Resource Zone. These potential spurs are outside the scope of this SRO.

2 Conceptual Design

This section describes the design that has been included in the cost estimate. It is a conceptual design, that allows a costing exercise to be undertaken for the developed option, risks and opportunities to be understood and further work which should be carried out in subsequent gates of design to be identified.

2.1 Design Principles

The interconnector has been developed in alignment with the All Company Working Group (ACWG) design principles, which are, in turn, based on the National Infrastructure Commission (NIC) design principles of climate, people, place and value.

The ACWG principles are listed below with narrative on how they are reflected in the STT Interconnector Gate 2 design. (It is noted that the Gate 2 Options Appraisal and the selection of a preferred option will be further reviewed at Gate 3, with additional stakeholder and public consultation. This may result in an adjustment of the selected option and further review of the application of the design principles.) :

- *Climate - Nature knows no boundaries* - The interconnector provides a link between the River Severn and the River Thames, connecting the water resources in the North West with the South East, facilitating water trading between regions that has previously not been possible and enabling the sharing of this critical resource. Three water companies are working collaboratively to develop the STT scheme across two water resources planning regions.
- *Climate – Resource and carbon efficient* - Construction and operational carbon considerations over the whole life cycle of the scheme have been included as part of the option selection and development. During design development carbon hotspots have been identified, with the pipeline element resulting in the potential for the largest capital emissions. An initial optimisation of the pipeline diameter has been carried out, based on whole life cost and assumed utilisation, resulting in a reduction from Gate 1 diameters. Operational carbon has also been reviewed, with the development of the option of an energy recovery turbine to be installed at the end of the pipeline to capture residual energy when the pipeline is operating at low flows. Further work will continue into Gate 3, with the review of a nature based treatment solution that has potential to reduce operational carbon, both from process power and chemical use.
- *Climate – Resilient and Adaptable* – Options appraisal explicitly considered the resilience of the scheme in the decision making process. This will continue to be reviewed in the Gate 3 option refinement.
- *People – Understand and respond to your Community's needs* – The STT project seeks to meet the overarching need to provide a reliable supply of water to customers within the south east, however, there are potential opportunities to provide additional social value within the interconnector design. An assessment of social value has been central to the options appraisal stage, where a number of canal based transfer options were assessed, however, these were not selected for progression as the preferred Gate 2 solution. At Gate 3 there will be further consultation with stakeholders and the public on both on the preferred Gate 2 option and alternative options to determine the option for progression at Gate 3. Opportunities to provide additional social value will be sought such as the potential switch to a nature based treatment option or be linked to the provision of BNG requirements.
- *People – engage widely, early and meaningfully* – Through the options appraisal stage of the interconnector initial engagement has occurred with key stakeholders, such as CCT and

environmental regulators. A wider range of consultation is currently in progress including wider environmental and river focussed stakeholders, local authority officers and lobby groups. The option was included in the draft WRSE regional plan public consultation and will be included draft company WRMP public consultations later in 2022.

- *People – Improve access and inclusion* – Gate 2 has focussed on option selection and initial development of a preferred option. Access and inclusion will be considered further as the landscape, BNG and architectural concept emerges in Gate 3.
- *Place – Take care - understand and develop landscape, cultural heritage, health and sustainability* - Environmental assessments have informed key decisions in the option selection, with route options selected to minimise impact to environmental and heritage designations and high priority habitats.
- *Place – Protect and promote the recovery of nature* – Option appraisal considered BNG and natural capital. Further consideration will be given to the preferred scheme as the landscape and architectural concept develops in Gate 3.
- *Place – Design all features beautifully with honesty and creativity* – The interconnector consists of a long pipeline and number of discrete above ground assets, including the intake, WTW, BPT, outfall and a number of small valve chambers along the route. The BPT will be within the Cotswolds AONB and consideration has been given to the provision of visual screening/ burying the structure to reduce long term visual impact. The intake and WTW are located adjacent to the River Severn, in Gate 2, an emphasis has been placed on high level options appraisal and definition of the engineering components required. This will form the basis for further work in Gate 3 to develop engineering designs further, in tandem with review and assessment of potential visual impact and the best way to mitigate and negative impact.
- *Value – Maximise, capture and measure additional embedded value* – Options appraisal methodology incorporates a best value approach to options selection, thereby selection of the Gate 2 option has set a baseline value. As the interconnector advances into Gate 3, further opportunities will be sought to increase the baseline value through adapting the designs where appropriate. This may include opportunities to improve access to recreation through the improvement of existing footpaths or development of new routes aligned with the pipeline route; opportunities aligned to the provision of BNG, such as the creation of additional woodland recreation.

2.1.1 Scheme Requirements

The purpose of this scheme is to bolster regional water supply resilience in the South East by enabling the transfer of flows from disperse source options, via the River Severn, to the South East region via the River Thames, when there is a need in the River Thames and sufficient flow in the River Severn. The Interconnector will transfer treated river water (unsupported flow) from the River Severn to the River Thames when there is a need. When the flow in the River Severn is insufficient or is below the hands-off flow, then source discharges and Interconnector abstraction in line with the proposed permitting road map will operate.

The required capacity of the scheme is dependent on the WRSE regional modelling output, which will determine the eventual capacity option of the scheme which will be selected (300, 400 or 500Ml/d). This CDR covers these three capacity options. The capacity requirements are unknown at present and when established the opportunities for phasing will be examined.

2.1.2 Resilience Assumptions

As currently envisaged, this scheme is a drought relief scheme and would be operated during periods of drought / low flows in the River Thames catchment. As a result, there are likely to be significant periods of time when the scheme would not be in full operation and the interconnector would instead be operating with a sweetening flow. In addition, during operation, storage is available at downstream assets (abstracting and treating flow from the River Thames) to allow operation to be halted for a period of time without effect on downstream supply. However, consideration also needs to be made to the maximum acceptable residence time of flows within the pipeline during potential shutdowns. The acceptable level of resilience should be reviewed in more detail during Gate 3 to ensure an optimal balance is reached between resilience and cost effectiveness.

The following assumptions have been made at Gate 2:

- **Dual power supplies will be required to major assets**, ie intake, pumping stations and water treatment works. This will enable the water treatment works to continue operation during outage of the main supply. This should be reviewed at Gate 3 with further discussion with the DNO regarding the resilience of the supply network, further confirmation from water companies regarding the required resilience of the water supply, and further consideration of the risks of longer residence times in the pipeline during unplanned shutdowns. An opportunity to remove a second supply has been costed.
- **Major crossings will not be twinned.** It is assumed twin crossings will not need to be installed for major crossings. Maintenance works on crossings could be undertaken during periods when the main transfer is not in use.
- **Raw water main will be dualled.** There is a known risk of zebra mussel incrustation of the raw water pipeline which may require routine maintenance to remove. Dual raw water mains have been proposed to allow full operation to continue while cleaning and maintenance is undertaken with flow diverted through one pipe. However, further work should be undertaken during Gate 3 to further understand the level of risk posed and the required resilience of supply. An opportunity to remove the dualled pipe has been costed.
- **Standby pumps –** A single standby pump has been provided at each pumping station.

2.1.3 Utilisation Assumptions

As currently envisaged, this scheme is a drought relief scheme and would be operated during periods of drought / low flows in the River Thames catchment. At this stage, the operating regime of the interconnector is not known. The assumptions below have been used during the option development:

- 300Ml/d, 400Ml/d and 500Ml/d peak flow capacity options
- Percentage of time at peak flow is 20%
- Percentage of time at sweetening flow of 80%
- Sweetening flow rate is 20Ml/d
- Running time per day is 24 hours

Pipe diameters have been optimised on the basis of a whole life cost (WLC) comparison and the selected optimal diameters have been subjected to a sensitivity analysis against variation of the percentage of time at peak flow up to a maximum of 100%, to confirm the robustness of the diameter selection.

It is recommended that the operating regime is further investigated in Gate 3, and the sizing of key scheme components should be backchecked at this point, however, significant changes in sizing are not anticipated.

2.1.4 Applicable Standards

2.1.4.1 National and Water Company Standards

This conceptual design has been developed with reference to Thames Water Asset standards. Flow velocities in the raw water pipeline and the transfer pipeline have additionally taken into consideration UU and STW standards regarding flow velocity in transfer pipelines. The flow velocities in the selected pipe sizes are higher than those typically adopted in the above-mentioned standards, and the justification for this has been described below.

Section identifies the pipe diameters estimated during Gate 2 option development, and flow velocities associated with these sizes. Pipe diameters were chosen to accommodate the flow whilst keeping flow velocities at or below 2.0m/s for the rising main, due to surge pressure considerations and 3.0m/s for the gravity main, due to abrasion considerations. The gravity main upper limit for flow velocity is higher than the Thames Water asset standard of 2.5m/s[1]. This is considered as acceptable for gravity mains in this instance due to the fact that this is a partially treated pipeline and water will undergo further treatment prior to distribution and supply. Therefore, any resuspension of deposits and discolouration due to the high velocities will be subsequently removed. This was discussed and agreed with STW, UU and TW during the Gate 2 conceptual design.

During options appraisal and design development stages due consideration has been given to both construction and operational health and safety. Options appraisal buildability criteria included an assessment of whether an option is likely to be able to be built safely such as whether there is enough space available.

2.1.4.2 ACWG and SRO specific guidance

The All Company Working Group (ACWG) has developed design principles and guidance which should be adopted in all SROs which are a part of the STT scheme.

2.2 Scheme Components

The scheme has been divided into the following components:

- Intake
- Pumping stations
- Water treatment works
- Pipelines
- Break pressure tank
- Outfall

2.2.1 Intake

The intake consists of two stage screening; an initial coarse screen to exclude debris, protecting a finer screen that will prevent aquatic fauna (fish and eels) from entering the pipe. The intake will also need additional protection such as bollards to prevent accidental damage of the intake from river traffic.

Large bar screens in the river are positioned at the start of a twin gravity main[2]. These would be complimented by fine band screens, for further screening and fish / eel isolation, with screenings returned directly to the river. These screens operate in a compact footprint and can

[1] According to clause 1.7 of the Thames Water standard AM-DES-WN&T-WN02-SEC1 - Water Mains Design Standard- water mains design and construction shall, as a minimum, comply with BS EN 805. Clause A11 of BS EN 805 sets acceptable velocities between 0.5 to 2m/s and up to 3.5m/s in special circumstances.

[2] It may become single at later stages if confirmed that zebra mussels can be removed from the single pipe without impacting the operation of the system

be fitted with fish return channels to ensure any fish “caught” are returned safely to the river. An alternative to band screens is passive wedge wire screens, the benefits of which could be investigated further at Gate 3 (Section 4.3.2.3). The level of redundancy should be reviewed at Gate 3. The table below shows the number of screens included for costing purposes.

Table 2.1: Screen configuration

Required flow (Ml/d)	No of portals	Screens/portal	No of Screens	Size in plan
300	6	2	10duty/2Stand-by	40.8m x 8m
400	8	2	14duty/2Stand-by	53.6m x 8m
500	9	2	16duty/2Stand-by	60m x 8m

The number of screens required has been determined by the minimum water depth expected at the river and the maximum velocity for avoiding Eels to be trapped. The minimum river water depth has been assumed 1m and the maximum velocity through the filters has been set to 0.15m/s according to the latest recommendations of the Environment Agency. Further investigation should be undertaken in Gate 3 to assess the minimum design water depth at the intake location and confirm the screen requirement.

Isolation of the twin water mains will be made possible by the provision of a penstock chamber (approx. is 10m x 5.5m in plan, 5m depth) on each main close to the screens,

A small compound will be required on the river bank close to the screens to allow maintenance vehicle access and to allow maintenance of the screens and penstocks. This may require the alignment of the Severn Way footpath to be locally modified.

It is proposed that power to the intake, and its associated electrical controls, would be provided from the Low lift PS site, which is located outside of the flood plain.

2.2.2 Pumping stations

2.2.2.1 Low Lift Pumping Station

The conceptual design for the Low Lift Pumping Station includes 4 duty and 1 standby submersible pumps for each flow option, with pump lifts and installed power requirements shown in Table 2.2.

Table 2.2: Low Lift PS Key Data

Required flowrate (Ml/d)	No. of pumps	Pump lift required (m)	Total installed power (MW)
300	4 duty/1 standby	18	1
400	4 duty/1 standby	18.9	1.3
500	4 duty/1 standby	20.5	1.8

The conceptual design for the Low Lift Pumping station includes 4 duty and 1 standby submersible pumps for each flow option, with pump lifts and installed power requirements shown in Table 2.2. The design includes a circular wet well with an adjacent valve chamber and submersible pumps. It is estimated that the depth of the wet well would range between 8 and 10m. This will be confirmed in Gate 3, following a survey of river levels in the screen location and proposed intake screen level . The required area of the wet well including valve chamber ranges is between 195m^2 (for 300Ml/d option) and 285m^2 (for the 500Ml/d option), as detailed in Table 2.3.

Adjacent to the wet well, a dedicated building will be provided for the electrical plant with the rest of the plant installed on surface concrete slabs or kiosks. At present, surge vessels are located outside – this should be reviewed at Gate 3 to considered whether locating the vessels within a dedicated building would be more appropriate in this location. The design and external finishes for the building and screening provision will be confirmed in Gate 3, with consideration to the visual impact of the site on the surrounding area and specific planning requirements.

The electrical plant building will house the pumping station Motor Control Center (MCC), transformer, generator, switch gear and electrical controls for the intake screens, with an estimated building dimension of approximately 200m^2. This will also house the electrical control equipment for the water treatment works.

The access road to the proposed site would be from the adjacent minor road network with an overall length of approximately 1km. The site would be fenced. Planting would be provided as required to screen the site. The location selected allows the surplus excavated material from the pumping station and intake works to be reused locally to landscape around the pumping station to screen it from the river bank footpath as well as to modify the existing sloping ground profile on site to enhance screening of the pumping station and aid integration into the landscape. Any impact on the local trees would be compensated for in a post construction landscape planting plan.

The Low lift PS and all other MEICA plant for the option need to be further designed in later design stages to optimise operational efficiency at reduced flows to provide the sweetening flow, as well as having the capability of being isolated in sections for maintenance.

Table 2.3 includes additional assumptions on sizing of assets.

Table 2.3: Unit Sizes Low Lift PS

Item	Flow (Ml/d)	Total unit / building area (m^2)	Depth to invert (m)	Length / Diameter (m)	Width (m)	Height above ground (m)
Pumping Station Shaft -wet well and valve chamber-	300	195	8	12.5	-	-
	400	210	9	12.5	-	-
	500	285	9.6	15	-	
Electrical Plant Building	300 - 500	200	-	20	5	5
DNO Metering Kiosk	300 -500	20	-	5	4	5
Surge Vessels Area	300	162	-	18	9	5.5
	400	185	-	18.5	10	6
	500	205	-	20.5	10	6

2.2.2.2 High lift Pumping Station (HLPS)

The High Lift PS is located within the proposed water treatment works site. Key data for the High Lift PS is included in Table 2.4.

Table 2.4: High Lift PS Key Data

Required flowrate (Ml/d)	No. of pumps	Pump lift required (m)	Total installed power (MW)
300	Normal operational flowrates: 5 duty/1 standby	288	14.7
	Sweetening flow: 1 duty/1 standby	245	1
400	Normal operational flowrates: 6 duty/1 standby	286	18.9
	Sweetening flow: 1 duty/1 standby	245	1
500	Normal operational flowrates: 7 duty/1 standby	281	22.8
	Sweetening flow: 1 duty/1 standby	245	1

The conceptual design for the High Lift Pumping station includes a varying number (5/6/7) duty pumps for operational flow rates with a single standby. In addition, a separate sweetening flow pump and standby pump have been provided. This enables the selection of the most suitable and efficient pump for sweetening flow operation, given the differing duty points that will be required for this normal operation compared to peak transfer flow.

It is proposed that the High Lift pumping station will be a dry-well type with a building proposed to house the horizontal split case type pumps. The overall PS size with respect to flows are estimated and tabulated in Table 2.5.

A 1700 m³ pump sump will provide 2 hours of storage at sweetening flow (20Ml/d) and ensures an appropriate number of pump starts and stops per hour. Further investigation is recommended at Gate 3 to ensure adequate storage is provided to ensure continued operation of the WTW in case of short outages of the pump station, or alternatively the provision of recirculation pumps to return flows to the head of the works during outage.

The electrical control plant for the high lift pumping station will be housed in a common electrical building with the WTW equipment.

Table 2.5 details the proposed sizing of key assets.

Table 2.5: Unit sizes High lift PS

Item	Flow (Ml/d)	Total unit / building area (m^2)	Length (m)	Width (m)	Height above ground (m)
Pumping Station building	300	850	50	17	5.7
	400	1200	60	20	
	500	2100	70	25	
WTW and HLPS Electrical Building	300 - 500	1000	40	25	5
WTW and HLPS DNO Metering Kiosk	300-500	96	12	8	5
Surge Vessel Area	300	162	18	9	5.5
	400	185	18.5	10	6
	500	267	17	15.7	6

2.2.3 Pipelines

2.2.3.1 Pipeline routes

Raw Water Pipeline

The raw water pipeline route has been updated from the Gate 1 route, following minor changes in location of the river intake and the WTW. In Gate 1, the proposed route passed over a localised hill, increasing the pumping requirements for the Low Lift PS, and resulting in the need for an additional break pressure tank for operational purposes, as the portion of the pipeline downstream of the hill would operate as a gravity pipe.

The revised route avoids the hill, reducing the pumping head of the Low Lift PS and enabling the raw water pipeline to operate purely as a rising main, which is preferred for operational simplicity.

Bulk Transfer Pipeline

The top-ranked route options proposed in Gate 1 aimed to reduce the static head, and hence the pipeline operating pressure. A selection of the route to be progressed to option development was carried out. Other drivers in selecting the proposed route were:

As noted in Section 1.2.1, pipeline route options were assessed and reviewed during the Gate 2 options appraisal stage, and a new pipeline route was selected for further development during this Gate.

All routes reviewed transferred flow to the River Thames at Culham. An assessment was carried out to review the possibility of releasing flows further upstream and reducing the length/ diameter of the pipeline. Releasing the full transferred flows upstream of Culham is not considered promotable due to the potential environmental impact on the river particularly on the Oxford Meadows SAC. However, smaller discharges may be possible, allowing a reduction in pipe diameter between Lechlade and Culham. This would result in a small cost saving. This has been identified as a potential opportunity to be investigated further at Gate 3.

2.2.3.2 Pipe sizing

Optimised pipe diameter selection has been undertaken on the basis of minimising the whole life cost (TOTEX) over the life cycle of the asset. The utilisation assumed during the pipe diameter optimisation was 20% annual peak flow utilisation and 80% sweetening flow. Likewise, the pipe condition has been taken into account by considering the following pipe roughnesses:

Table 2.6: Pipe roughness

System[1]	New pipe roughness (mm)	Old pipe roughness
Treated Water	0.03	0.3
Raw Water	0.03	1.5[2]

1 Epoxy lining or similar has been considered to select the roughness
2 This value has been selected based on the zebra mussel incrustation and the slimming

A check was carried out to assess what impact a variation of the assumed utilisation would have on the optimal diameter proposed. This was done by increasing the assumed utilisation in increments of 20% until a maximum of 100% utilisation (which is an unlikely scenario). The optimal diameter proposed was found to increase by one pipe diameter size at approximately 50% utilisation and increased once more by one pipe diameter size at approximately 70%. For resilience schemes, such as this, which are operated at peak capacity less frequently and “normal operation” is likely to be a significantly lower sweetening flow, the pipe diameter selected usually tends towards the higher end of acceptable velocities.

The Gate 1 solution proposed considerations to reduce the pipe diameter part way along the gravity main. This has been evaluated in Gate 2, and the results of this have been reported in Table 2.7: Pipe Sizing and Figure 2.1, Figure 2.2 and Figure 2.3.

At this stage, a twin-pipe has been proposed for the raw water pipeline from the intake to the WTW, as this section of the pipeline is prior to treatment, and it is likely that additional maintenance will be required, particularly to deal with zebra mussel incrustation. Twin pipes allow operational flexibility to allow some water to be kept flowing if one of the pipelines requires maintenance. However, there is usually a cost premium for doing this, since two 1.6m diameter pipes are required to provide the same carrying capacity as one 2m pipe. Similarly, two 1.2m pipes are required to replace a 1.6m diameter pipe. As the raw water pipeline is relatively short (approximately 1.5km), and the future scheme utilisation is yet to be confirmed, a twin raw water pipeline has been proposed. It is recommended that the resilience requirements are investigated further in Gate 3, as this would allow this solution to be further refined.

Some alternative solutions to deal with zebra mussels incrustation that could be considered in lieu of twinning of the raw water pipeline include:

a) Provision of zebra mussel treatment, such as provision for bio bullet dosing, at the intake to help control mussel growth
b) Plug flow for sweetening to prevent the need for continuous operation
c) A dedicated sweetening flow pipeline sized specifically to accommodate the sweetening flow rate (two pipes, with one dedicated to peak flow and another dedicated to the sweetening flow).

It is proposed that these are explored further in Gate 3.

A single pipeline has been proposed for the bulk transfer pipeline from the WTW to the discharge point. Given that this is a drought relief scheme (resilience), and it is expected that its utilisation will only be partial at peak flow (currently 20% annual peak flow assumed), the peak transfer flow rate will not be required at all times. It is therefore likely that any maintenance operations could be undertaken outside of this period. This should be reviewed further at Gate 3 once the operational regime is further defined, to confirm the above outlined approach toward maintenance operations. A single pipe has been proposed as it will be a more cost-effective solution and the sweetening flow period provides ample opportunity for maintenance of the pipeline. The head loss calculations have been based on the Darcy Weisbach approach, using a pipe roughness 0.3mm, and minor losses have been calculated based on an estimation of the pipe horizontal and vertical bends. The minor losses equate to approximately 16% of the friction head loss.

The conveyance between the intake and the Low Lift PS is proposed as two gravity pipes assumed to both be fully operational, with flow channelled through one pipe during maintenance. Maintenance will be carried out during sweetening flow periods. The pipes are sized for 300, 400 and 500Ml/d capacity options and the respective diameters are shown in Table 2.7. Future maintenance requirements to remove mussel incrustation have been considered in the pipe sizing. Valves are proposed at both intake and at the pumping station, so that each pipe could be isolated and cleaned. In Gate 3, it is proposed that drain down of the pipes, human access and working in confined spaces during construction and maintenance activities is given further consideration, to assess its impact on positioning and sizing of valve chambers.

Table 2.7: Pipe Sizing

Pipeline Section	Pipeline Length (km)	Type of pipeline	Static Lift (m)	Flow (Ml/d)	Velocity (m/s)	Pumping Head (m)	Internal Diameter (mm)	Notes
Raw Water Pipeline Intake to Low Lift PS	0.4	A. Gravity main	N/A	300	1.53	N/A	2 No. 1200	Non-pressurised gravity flow
				400	1.74	N/A	2 No. 1300	
				500	1.88	N/A	2 No. 1400	
Raw Water Pipeline Low lift PS to WTW	1.1	B. Rising main	15.3	300	1.53	17.97	2 No. 1200	Low pressure rising main
				400	1.74	18.89	2 No. 1300	
				500	1.88	20.54	2 No. 1400	
Transfer Pipeline WTW to BPT	21.5	C. Rising main	243	300	1.96	288.03	1500	First 18km of the rising main is at high pressure (P>16bar)
				400	2.04	285.70	1700	
				500	2.04	281.35	1900	
Transfer Pipeline BPT to R. Thames Outfall	22.1	D. Gravity main Section 1	N/A	300	1.96	N/A	1500	Operated as a fully pressurised gravity main
	21.4	E. Gravity main Section 2			2.26	N/A	1400	
	20.2	F. Gravity main Section 3			2.62	N/A	1300	
	22.1	D. Gravity main Section 1	N/A	400	2.04	N/A	1700	
	21.4	E. Gravity main Section 2			2.30	N/A	1600	
	20.2	F. Gravity main Section 3			2.62	N/A	1500	
	22.1	D. Gravity main Section 1	N/A	500	2.27	N/A	1800	
	21.4	E. Gravity main Section 2			2.55	N/A	1700	
	22.1	F. Gravity main Section 3			2.88	N/A	1600	

2.2.3.3 River intake to Low Lift PS

The conveyance from the river intake to the Low Lift PS is proposed as two gravity pipes sized for the 300, 400, and 500Ml/d capacity options and their respective diameters are shown in . Both pipes are assumed be fully operational during peak flow; a single pipe can be used during low flow or sweetening periods to allow for maintenance to take place. Valves are proposed at both the pumping station and at the discharge, so that each pipe could be isolated, drained down and cleaned.

2.2.3.4 Low Lift PS to WTW

The conveyance from the Low Lift PS to the WTW is proposed as two rising main pipes sized for the 300, 400, and 500Ml/d capacity options and the respective diameters are shown in . Both pipes are assumed be fully operational during peak flow; a single pipe can be used during low flow or sweetening periods to allow for maintenance to take place. Similar to the intake pipes, valves are proposed at both the pumping station and at the discharge, so that each pipe could be isolated and cleaned. The Low Lift PS sizes for the different capacity options are shown in Table 2.3.

The conceptual design for the Low Lift Pumping Station includes 4 duty and 1 standby submersible pumps for each flow option, with pump lifts and installed power requirements shown in Table 2.2.

2.2.3.5 WTW to outfall

The transfer pipeline from the WTW to the outfall location is composed of two segments; a 21.5km rising main from the WTW to the break pressure tank (BPT), located at the high point, and a gravity main from the BPT to the outfall at Culham. The gravity main is proposed to be operated as pressurized, whereby a pressure sustaining valve controls discharge prior to the outfall to maintain the pipe full.

The steady state hydraulic profile of the 300Ml/d, 400Ml/d and 500Ml/d options are shown in Figure 2.1, Figure 2.2 and Figure 2.3 respectively. This shows the head loss along the pipeline based on the pipe sizes and lengths provided in Table 2.7.

As indicated in Section 2.2.3.6, the addition of the surge vessel to the rising main for mitigating severe transient pressures resulted in maximum pressure of 35bar approximately. The first 6km are predicted to be subjected to transient pressures between 35 to 30bar and steady state pressures between 28 to 25bar. The remainder of the pipeline is subjected to transient pressures of up to 30bar and steady state pressures of up to 25bar.

The structural design of the pipeline is recommended to be carried out in Gate 3, at which point the steel pipe wall thicknesses can be confirmed along with the nominal pressure of the fittings.

The High Lift PS lifts flows from the WTW to the BPT, and details of this have been captured in Section 2.2.2.2 and Table 2.4.

Figure 2.1: Transfer pipeline design details 300Ml/d capacity option

Figure 2.2: Transfer pipeline design details 400Ml/d capacity option

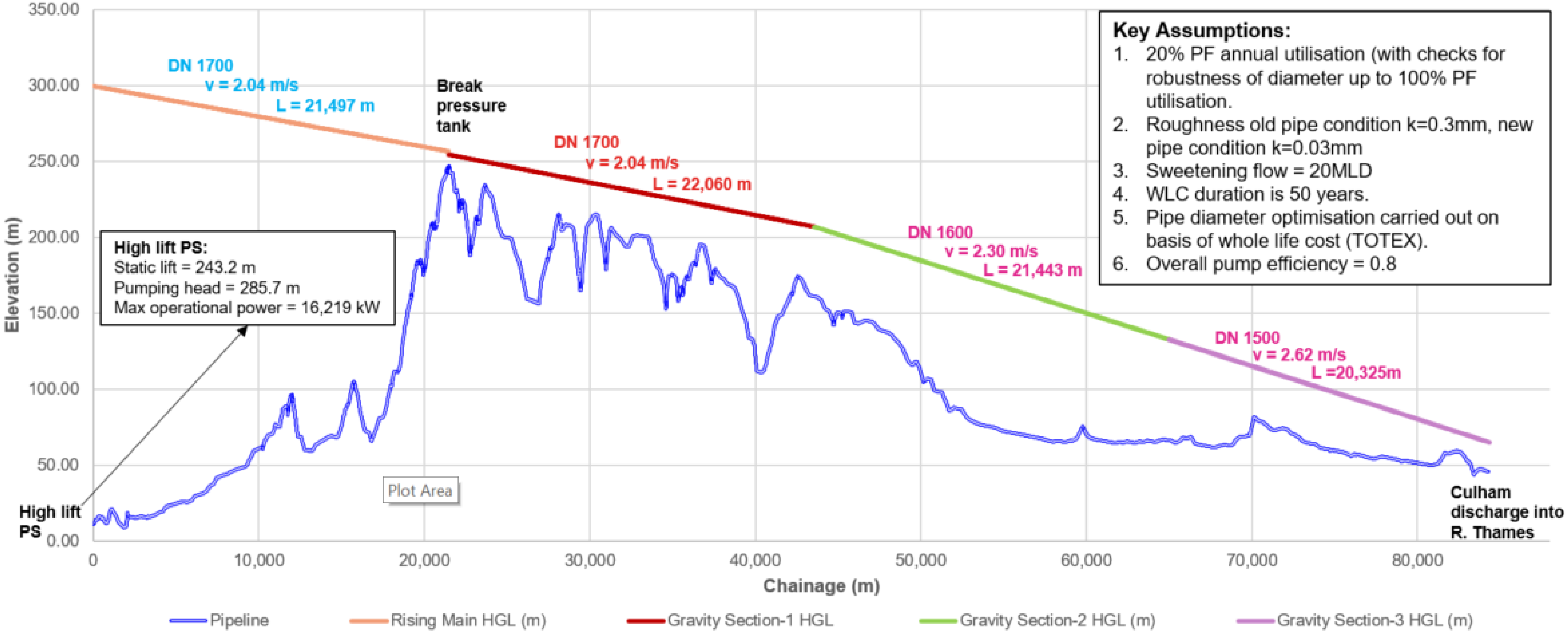
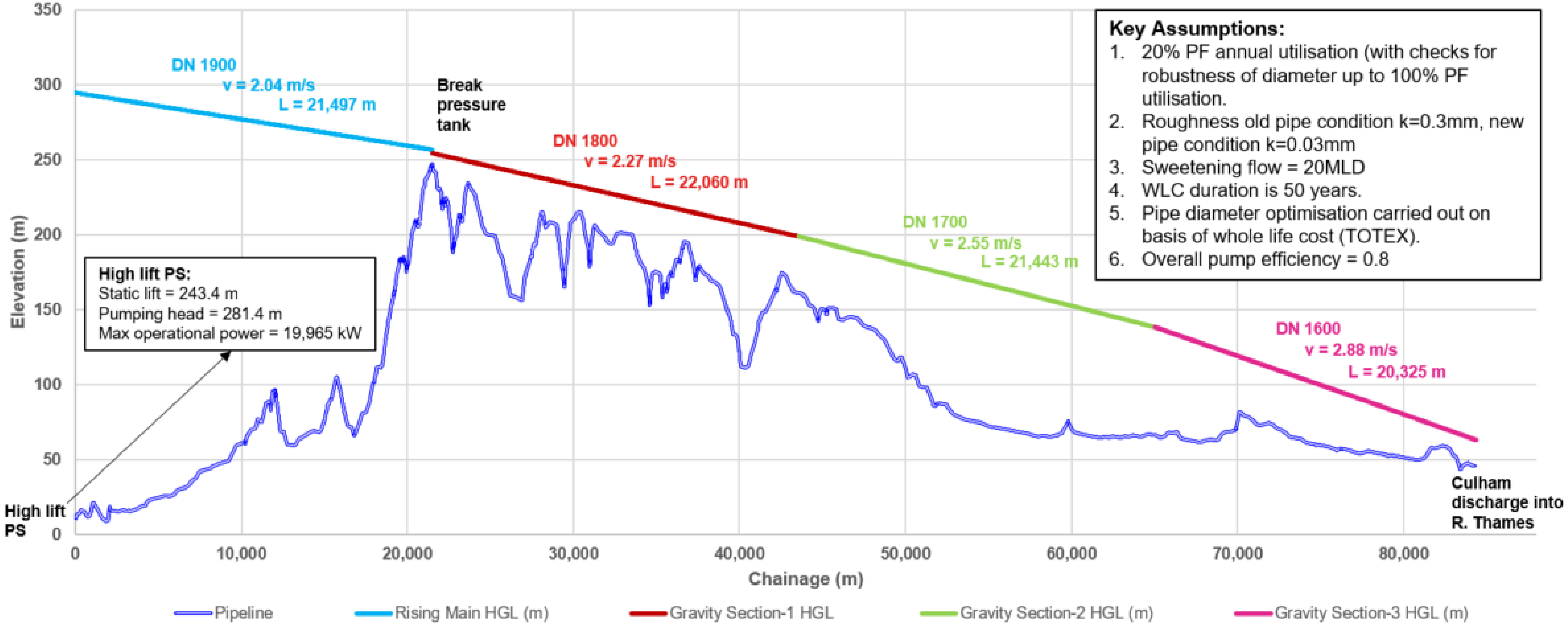


Figure 2.3: Transfer pipeline design details 500Ml/d capacity option



2.2.3.6 Surge assessment

A high-level surge assessment was carried out in order establish the need for surge protection. The only case analysed was pump trip, modelled to replicate sudden failure of the pumps, e.g. power failure.

Raw water System

The simulation without any surge mitigation in place resulted in maximum pressure of around 3bar and negative pressures or full vacuum along a significant length of the pipeline. This is well beyond the range of standard pipes and fittings and therefore surge mitigation has been included in the costs.

The addition of the surge vessel to the rising main resulted in transient pressures ranging between 4.5 bar and 0.0 bar.

The required surge vessel volumes are shown in Table 2.8. This volume includes a 20 to 25% additional allowance and additional volume for 1No. standby vessel.

Table 2.8: Low Lift PS Surge Vessel configuration

Flow (Ml/d)	No. of surge vessels	Surge vessel unit volume (m^3)	Total required Volume (m^3)
300	4duty / 1 standby	25	125
400	4duty / 1 standby	35	175
500	4duty / 1 standby	40	200

High Lift system

The simulation without a surge mitigation in place resulted in maximum pressure of around 53bar and negative pressures or full vacuum along a significant length of the pipeline. This is well beyond the range of standard pipes and fittings and therefore surge mitigation has been included in the costs.

The addition of the surge vessel to the rising main resulted in the maximum pressure dropping to 35bar approximately. The first 6km are predicted to be subjected to transient pressures between 35 to 30bar and steady state pressures between 28 to 25bar as detailed in Section 2.2.3.5. The remainder of the pipeline is subjected to transient pressures of less than 30bar and steady state pressures of less than 25bar. The minimum transient pressure is slightly above 0bar except for the last 400m where the minimum pressure is around -0.7bar[3] with the addition of 2 No. double orifice air valves.

The maximum and minimum transient pressure predicted at the gravity main considering a valve full stroke closing time of 800s at the PSV at the discharge, ranges between 31bar and 0.1bar.

The required surge vessel volumes are shown in . This volume includes a 20 to 25% additional allowance and additional volume for 1 No. standby vessel.

[3] The minimum allowable transient pressure is normally set to -0.8bar according to the water industry common practice

Table 2.9: High Lift PS Surge Vessel configuration

Flow (Ml/d)	No. of surge vessels	Surge vessel unit volume (m^3)	Total required Volume (m^3)
300	4 duty / 1 standby	25	125
400	4 duty / 1 standby	35	175
500	6 duty / 1 standby	35	245

2.2.3.7 Crossings

The scheme crosses a range of major obstacles as detailed in Table 2.10 below. It is envisaged that all crossings would consist of a single pipeline. The table below shows the assumed construction methodology subject to consultation with relevant stakeholders.

Table 2.10: Crossings

Crossing Type	Construction method	Raw water pipeline	Rising Main	Gravity Main			Total No. of crossings
				Sect 1	Sect 2	Sect 3	
Pipe Diameter (mm)							
300Ml/d		*1200*	*1500*	*1500*	*1400*	*1300*	
400Ml/d		*1300*	*1700*	*1700*	*1600*	*1500*	
500Ml/d		*1400*	*1900*	*1800*	*1700*	*1600*	
Motorway	Trenchless	-	1	-	-	-	1
Main road (Dual Carriageway)	Trenchless	-	1	-	-	1	2
Main road (Single carriageway)	Open cut	-	4	6	3	3	16
Minor road	Open cut	1	9	11	8	8	36
Dirt road	Open cut	-	1	2	1	-	4
Railway	Trenchless	-	2	-	-	-	2
Gas Mains	Trenchless	-	2	-	2	1	5
River	Trenchless	-	2	1	1	1	5
Stream	Open cut	-	1	3	5	16	25
High voltage electricity line	Open cut	2	12	5	4	1	22
Large Diameter Water Main	Open cut		-	1	-	3	4
Total		**3**	**35**	**29**	**24**	**34**	**125**

2.2.3.8 Pipeline fittings

Air valves will be located at every high point. Washouts will be located at every low point to allow drain down of the pipeline. Due to the size of the pipeline drain down volumes will be substantial therefore potential discharge locations may be limited. At Gate 3 the potential washout locations and required drain down pipework will be identified, including the need for any additional pumping, tankering and above ground assets.

Full bore line valves would be located approximately every 5km, in easily accessible locations to allow isolation of a short section of the pipeline in emergencies and to allow maintenance. It has been assumed that all major crossings require isolating valves at each side of the crossing. Further, more detailed assessments of number and location of fittings required will be carried out in later design stages. The line valves will require above ground kiosks.

It is proposed that duty and stand-by pressure sustaining valves (PSV) be located at the downstream end of the pipeline to maintain pressure and keep a constant water level at the break pressure tank (BPT). An instrumentation, control, and automation system (ICA) will be required between the BPT and the PSV to modulate the level at the BPT for the range of flowrates. This is the simplest and most common way of operating a pipeline such as this in order to keep the pipeline full, however, it is recognised that the static pressures are significant, and therefore alternative configurations may need to be investigated at Gate 3, e.g.: 2 no. PSV in series. An additional dedicated duty/standby PSV for the sweetening flow of a smaller diameter is proposed to be installed in parallel to the main PSVs. These PSVs are proposed to be housed in a dry chamber incorporated in the outfall cascade structure.

2.2.3.9 Break Pressure Tank (BPT)

A BPT is proposed at the highest point on the treated water pipeline. Its purpose is to provide hydraulic stability within the system and allow the pipeline to stay full should a pump trip occur. In the case of a pump trip prompted by a power outage, the discharge PSV will slowly close to avoid causing severe transient pressures, while ensuring that the water level at the BPT never goes below the set minimum water level to avoid air entrainment into the gravity section. In the case of the rising main, several duty surge vessels and one standby have been proposed to prevent severe transient pressures see section 2.2.3.6.

The BPT has been sized by means of a surge modelling. It has been sized based on a PSV at the discharge with a full stroke closing time of 800 seconds. The steady state water level at the BPT has been set 0.5m below the rising main discharge level. The minimum water level has been set 1.5 diameters above the outlet pipe to avoid air entrainment. The resultant BPT size meeting these conditions are shown in Table 2.11 below.

Table 2.11: Break Pressure Tank Design

Flow (Ml/d)	Total Volume (m^3)	Size	Operating depth (m)	High Integrity alarmed access covers?
300	1,440	12m x 12m x10m	5.2	Yes
400	1,960	14m x 14m x10m	5.2	Yes
500	2,560	16m x 16m x10m	5	Yes

A BPT with only one cell has been proposed with cleaning and maintenance being undertaken during planned stoppages. It is envisaged that it will be possible to schedule a number of days during sweetening flow operation when flow can be stopped to allow for routine maintenance. This will be reviewed during Gate 3 and consideration given to whether a second cell should be added to provide additional flexibility.

The concept design is for a reinforced concrete structure, partially buried and with grassed embankments to blend the tank into the surrounding landscape. The possibility of built offsite pre-cast wall panels to reduce the programme duration and impact on site would form part of later design development.

The potential visual impact of the BPT will require particular attention as it is located within the Cotswolds Area of Outstanding Natural Beauty (AONB). Further work will be undertaken during Gate 3 to review and minimise the visual impact and to ensure that planning and stakeholder considerations are adequately addressed. Measures such as a grassed roof could be considered to blend the BPT with the natural surroundings.

A valve chamber will be required at the outlet of the tank and an overflow pipe connected to the closest water course to be determined at Gate 3. A small kiosk will be required to house the electrical and control equipment.

The main access would be from the adjacent public road. Within the site, the conceptual design includes a hardstanding access road including a parking bay and a turning area, and an access track around the BPT. The site would be fenced.

2.2.4 River Thames outfall structure

The outfall structure would be constructed on the banks of the River Thames close to Culham and is similar to the proposal in Gate 1.

The outfall concept design includes a cascade outfall structure, incorporating a dry inlet chamber for the actuated valve, and a hardstanding area.

The cascade is included to oxygenate the water before discharge into the water course. The concept design is an in-situ curved concrete stepped gravity weir, approximately 10m, 14m and 17m long for the 300, 400 and 500Ml/d schemes respectively, based on a broad crested weir with 200mm head over the weir. Crest level at 2m above ground level has been assumed. The top of the structure would be 3m above the surrounding ground levels. Detailed consideration of the cascade will be carried out in later design phases to minimise the impact of the discharge on the local environment and river. Local landscaping will be considered and developed in subsequent design phases.

The proposed outfall site is flat at 50mAOD. A review of the EA flood maps indicates a flood level of 54 mAOD at this location which should be taken into consideration in Gate 3, and engagement with the EA will be required.

The valve chamber would be incorporated into the cascade structure and in this way the electrical plant related to the actuated valve would be protected from flooding. A hardstanding has been included for maintenance and access would be from the adjacent private road. The site would be fenced.

2.2.5 Water Treatment Works

2.2.5.1 Water quality

Treatment is required to improve the quality of the River Severn abstracted water before discharge into the River Thames. Total suspended solids (TSS) and other parameters, such as phosphorous and metals, need to be reduced to an acceptable level prior to discharge, with the aim to achieve “no deterioration” in the quality of the receiving body[4]. Additionally, the risk of invasive non-native species (INNS) transfer as a result of the introduction of a pathway between the Severn and the Thames catchments must be managed.

Water quality sampling was undertaken in the River Severn at Deerhurst and the River Thames at Culham throughout 2021. The outcome of this sampling was used to assess the level of treatment required and size the selected treatment process. Table 2.12: outlines the influent water quality conditions at Deerhurst, for the key design parameters.

[4] Defined as not more that an 10% change in the average or 95% percentile value for each parameter.

Table 2.12: Influent water quality at Deerhurst

Parameter	Unit	Minimum	Average	95%ile	Max
Turbidity	NTU	2	17.2	48.9	58
Colour	Hazen	4	15.2	26.2	32
Aluminium	mg/l	0.02	0.27	0.76	0.86
Iron	mg/l	0.77	0.38	1	1.1
Manganese	mg/l	0.01	0.05	0.07	0.08
Phosphorous (soluble reactive phosphorous)	mg/l	0.05	0.16	0.27	0.28
Suspended solids	mg/l	7	26.2	75.2	96
Total organic carbon	mg/l	2.6	5.8	8.8	9.4
Hardness as $CaCO_3$	mg/l	107	205.1	293.8	312
pH	pH units	7.5	8	8.5	8.7
alkalinity as $CaCO_3$	mg/l	72	127.5	183	190
Estimated solids load	**mg/l**	**5**	**39**	**107.2**	**127.1**

NoteSource: Estimated solids load is based on the raw water quality and calculated using the method in WRc document "Application Guide to Waterworks Sludge Disposal, Ref TT016". Solids (mg/l of treated water) = 2.0 x turbidity (NTU) + 0.2 x colour (°Hazen) + 2.9 x aluminium (mg/l) + 1.9 x iron (mg/l) + 1.58 x manganese (mg/l)

Several parameters were identified that had greater concentrations in the River Severn than the River Thames, and thus require either treatment to reduce the concentration, or blending to dilute, outlined in Table 2.13. Particulate metals should be removed with the coagulant floc. Dissolved ions cannot be removed easily, requiring blending to achieve suitable concentrations.

It is not proposed to target removal of pesticides and herbicides. Some of the identified organics could be removed using advanced treatment (such as ozone and granular activated carbon adsorption), however, others would require more advanced treatment processes. The pesticides are already present in the River Thames, and downstream water treatment works already have pesticide removal processes.

It has been assumed that these organic compounds would be removed at the water treatment works after blending with the River Thames water and no specific additional treatment would be required for them. Catchment management schemes in both the Severn and Thames catchments are encouraged to reduce the levels of pesticides entering the water bodies.

Table 2.13: Influent water quality at Deerhurst – parameters of concern

Parameter type	Parameter	Comments
Dissolved ions	Chloride	Unlikely to be removed by coagulation, settlement, and filtration. Require blending or reverse osmosis membranes
	Flouride	
	Sulphate	
	Boron	
	Bromine	
	Chlorine	
Metals	Arsenic	Likely to be associated with particles and removed with the coagulant floc.
	Chromium	
	Iron	
	Mercury	
	Tin	
Organics	Pesticides	Unlikely to be removed by coagulation, settlement and filtration. Some can be partially removed using advanced treatment (adsorption or oxidation) Blending and catchment management also suitable.
	Herbicides (ie. glyphosate, mecoprop, MCPA)	
	PFAS compounds	
	Hydrocarbons (ie benzo(a)pyrene)	

The risk of spreading INNS between the Severn and the Thames catchments as a result of the proposed transfer scheme was previously identified, and mitigation proposed for any raw water transfer scheme. The Environment Agency stated a need for a pathway-based risk assessment approach.

INNS monitoring was carried out in the Severn and Thames catchments to establish which species are currently known to be present within the waterbodies associated with the STT and identify those that are likely to be facilitated by a raw water transfer by becoming entrained and transported to new sites[5]. The monitoring then informed the proposed treatment selection.

Larger INNS such as birds and mammals are not likely to be transported by a raw water transfer, however, the risk of transfer of smaller INNS, including plants, aquatic invertebrates and their eggs/seeds requires mitigation. Additionally, molluscs such as Zebra Mussel and Asian Clams will need monitoring and controlling to mitigate bio-fouling of the intake structure and pipework. The size of each functional group and their juveniles was identified, to ensure the proposed treatment is suitable to remove.

Of the identified INNS in the River Severn catchment, the smallest juvenile units are ca. 70 micron (Zebra mussel). Both rapid gravity filtration and pile cloth media filters are effective (>90% removal efficiency) at removing particles of this size.

2.2.5.2 Water treatment process selected

The treatment works is proposed to be located in the Severn catchment, to reduce the risk of INNS transfer and potential for scouring of the pipeline from suspended solids.

The proposed treatment (Appendix A) at Deerhurst comprises a conventional WTW with chemical coagulant dosing, clarification and rapid gravity filtration (RGFs). The screened water from the Low Lift pump station will pass through an inlet mixing tank where it is dosed with ferric chloride for coagulation. The raw water will pass through the flocculation chamber and clarifiers,

[5] 'River Severn to River Thames Transfer (STT) strategic regional water resource solution. Environmental Evidence Report: INNS'. Published July 2021

with the clarified water then passing through the rapid gravity filters. Treated water will be discharged into the pipeline via the high lift pumping station.

Coagulation and flocculation destabilises and aggregates the suspended solids and prepares the water for the solid liquid separation stage, using lamella clarifiers. Rapid gravity filtration provides effective removal of small particles, also enabling effective removal of INNS (ca. >90% of 50-micron particles and >50% of 5 micron species, including larvae of invasive species). The RGFs will be operated with robust safeguards to prevent bypass of potentially contaminated water to the Thames catchment and minimise the spread of invasive species.

2.2.5.3 Treatment works site layout

Table 2.14 summarises the main process units and sizing, developed to calculate the required footprint of the works and enable the treatment works to be costed. In addition to the process units, the treatment works site includes a transformer compound, High Lift pump station building, an administrative building, a chemical dosing area, and provision for surge vessels.

Table 2.14: WTW process unit sizes

Item	Flow (Ml/d)	Total unit / building area (m^2)	Number of units	Active depth (m)	Total length (m)	Total width (m)
Inlet mixing tank	300	900	1	3	42.4	21.2
	400	1200	1	3	49	24.5
	500	1510	1	3	55	27.5
Coagulation / flocculation & clarifiers	300	6500	10	-	161.2	40.3
	400	8670	14	-	186.2	46.6
	500	10840	18	-	208.2	52.1
Rapid gravity filters	300	3980	26	-	126.2	31.5
	400	5310	32	-	145.7	36.4
	500	6640	40	-	163	40.7
Dirty washwater holding tank	300	1950	2	5	62.4	31.2
	400	2610	2	5	72.2	36.1
	500	3260	2	5	80.7	40.4
Sludge lamella thickeners	300	540	2	5.5	32.9	16.4
	400	720	2	5.5	37.9	19
	500	900	2	5.5	42.4	21.2
Lamella thickened sludge pump station	300	40	1	-	8.9	4.5
	400	60	1	-	11	5.5
	500	70	1	-	11.8	5.9
Thickened sludge holding tank	300	240	2	5	21.9	11
	400	320	2	5	25.3	12.6
	500	400	2	5	28.3	14.1
Supernatant return pumping station	300	80	1	-	12.6	6.3
	400	100	1	-	14.1	7.1
	500	130	1	-	16.1	8.1
Centrifuge building	300	100	1	-	14.1	7.1
	400	130	1	-	16.1	8.1

Item	Flow (Ml/d)	Total unit / building area (m^2)	Number of units	Active depth (m)	Total length (m)	Total width (m)
	500	160	1	-	17.9	8.9
Administrative building	300 - 500	400	1	-	28.3	14.1
Power compound	300 - 500	500	1	-	22.4	22.4
Chemical storage and dosing	300	280	1	-	16.7	16.7
	400	370	1	-	19.2	19.2
	500	460	1	-	21.4	21.4

It is proposed that the surplus excavated material from the construction of the treatment works, if suitable, would be re-used to modify the existing ground levels and help provide landscaping of the works. Re-profiling could be supplemented with planting to screen the proposed treatment works and aid integration into the landscape.

The building design and selection of materials will aim to minimise the visual impact and be appropriate to the scale of developments and farmsteads in the vicinity, rural character of the area and sympathetic to the setting of the nearby Cotswolds AONB. Similar schemes have been delivered, including the following:

- Brighton & Hove WwTW, Southern Water – includes a green living roof with grass and wildflowers, and a sunken site. The site is adjacent to the South Downs National Park.
- Williamsgate WTW, United Utilities – includes a green living roof. Additional earthworks were carried out to reshape the site and create a deeper valley for the works to sit. The site is adjacent to the Lake District National Park.
- Glencorse WTW, Scottish Water – treated water storage tank and treatment building is covered with a grass roof which harvests rainwater that is stored in bio-diverse wetlands. The site is sunken into the ground and shielded by landscaped bunds. The site is adjacent to the Pentland Hills Regional Park.
- Wear Valley WTW – buildings were constructed using natural stone, slate, and timber to mimic local farmsteads, two hectares of woodland were planted around the site, and a third of the facility is buried into the hillside. The site is located in the North Pennines AONB.
- Rivelin WTW, Yorkshire Water – buried treatment works, with excavated material used to backfill and landscape the site. Green roof with wildflowers and trees used to blend the site into surroundings. The site is located in the Peak District National Park.

2.2.5.4 Chemical requirements

Table 2.15 outlines the required chemicals for the proposed treatment process.

Table 2.15: List of chemicals used at the WTW

Chemical	Treatment Process
Ferric Chloride ($FeCl_3$)	Coagulation/Flocculation
Polymer	Sludge dewatering
Polymer	Sludge thickening

2.2.5.5 Waste stream

The waste streams originating from the clarifier desludging and backwashing of the RGFs will be treated on-site. Sludge will be blended, then thickened using lamella thickeners and dewatered using centrifuges. Supernatant from the thickeners will be recycled to the inlet mixing tank via a return pumping station. The centrate will be recycled to the dirty washwater holding tank and the dewatered sludge cake disposed of off-site.

Full sludge treatment and disposal has been proposed, both to maximise the recovery of water by minimising process losses.

2.2.5.6 Water Treatment Works – Alternative Options

During the long-list appraisal, an alternative nature-based treatment process was identified, featuring a hybrid settlement lagoon/constructed wetland, followed by pile cloth media filters. This option should be investigated at Gate 3. Further information can be found in section 4.3.2.2.

2.2.6 Power Supplies

Initial discussions have been undertaken with Distribution Network Operator (DNO) to confirm the ability to provide dual power supply for LLPS, WTW and HLPS.

Further consideration will be given in Gate 3 regarding both the requirement to provide dual supply, and if a dual supply is selected, whether a back up diesel generator is appropriate for the LLPS or whether a dual mains supply is preferred.

Total power consumption figures have been estimated for all sites. Table 2.16 shows the MW ratings for the pumping stations with the total installed power indicated.

Table 2.16: Summary of power requirements

	Power Supply Required (MW)		
	300Ml/d	**400Ml/d**	**500Ml/d**
LLPS	1	1.2	1.6
Intake screens	*Low power requirement. Incorporated into LLPS*	*Low power requirement. Incorporated into LLPS*	*Low power requirement. Incorporated into LLPS*
Low Lift Pumps	*1*	*1.2*	*1.6*
WTW & HLPS	13.5	17.1	20.8
WTW	*0.5*	*0.6*	*0.8*
High Lift Pumping Station	*13*	*16.5*	*20*

Small supplies will also be needed at the BPT and outfall to enable the operation of valves and control equipment.

2.2.6.1 Low Lift Pumping Station Power Supply

As detailed in sections above, the Low Lift Pumping station site will include power and controls for both the pumping station and the intake screens. A total 1.6MVA capacity supply (peak) will be provided from the local DNO network. A back up supply will be provided using a standby diesel generator.

Outdoor transformers (11/0.4kV) will be located in a transformer compound adjacent to the new electrical plant building.

Provision has been made for a separate DNO metering kiosk to house high voltage switchgears and metering to be maintained by DNO/Energy supply authority for accessing the equipment as required.

2.2.6.2 WTW/ High Lift Pumping Station Power Supply

As the WTW and high lift pumping station are situated on the same site, power will be provided for both in a single location. A total 21MVA capacity supply (peak) will be provided from the DNO network.

The HLPS and WTW shall receive power at high voltage level (preferably at 11kV). In order to provide resilience in the system and to meet high-power demand of HLPS and WTW (), dual 11kV power supplies from two independent power substation/grids are proposed.

Provision has been made for separate DNO metering kiosk to house high voltage switchgears including metering, current transformers etc. with estimated dimension of approximately 96m^2. DNO Metering kiosks shall be maintained by DNO/Energy supply authority for accessing the monthly readings.

Two oil type outdoor transformers will be located in a transformer compound adjacent to the new electrical building which will house switchgear and Motor Control Centres for both the HLPS and the WTW. The building is listed in the and is estimated to be approximately 40m x 25m.

2.3 Scheme Operation

This section details how the proposed scheme components will be operated during peak flow and sweetening flow conditions.

2.3.1 System Control

A robust methodology will be required to coordinate the volumetric requirements with the variety of sources and flows in the River Severn and associated sources. This system control is outside the scope of this concept design report which describes how the transfer of water is controlled from the River Severn to the River Thames.

It is anticipated that core elements of the scheme will require communications channels to facilitate system control between the River Severn intake at Deerhurst and the River Thames outfall at Culham. These elements include the water quality monitors at the River Severn, LLPS, WTW, HLPS, BPT levels and control valves at the Culham outfall. The details of these communication channels are proposed to be further investigated in Gate 3, to determine required communication infrastructure.

2.3.2 WTW Operational Philosophy

The treatment works will be comprised of multiple identical streams, each with a capacity of 100 Ml/d (i.e. 300Ml/d plant has 3 streams). Each stream would be capable of operating at a minimum flow of 20-30% of the streams' capacity, to facilitate the sweetening flow. A stream operating at the minimum flow of 20 Ml/d could be ramped up to full flow (100Ml/d) relatively quickly, (within 24 hours).

An offline stream would require a longer priming time to bring it online as the clarifiers would need to stabilise, and a sludge blanket form. The start-up of each stream would require the recirculation of water within the process for a few days before water can be produced at an acceptable quality and discharged to the transfer pipeline. It is expected this would take around 3 days per stream, plus an additional day to ramp up to full flow.

Once each stream is online and running at the minimum flow, the plant can be ramped up and down as required, with short notice. The minimum flow of the works is thus greater than the sweetening flow – to maintain all streams in service and in 'hot standby' would require 20% of the works design flow. For example, the 300 Ml/d scheme can operate between 60 – 300 Ml/d within 24 hours.

Reduction in flow can be carried out quickly if required, with each stream ramping down to 20 Ml/d. However, if a stream is reduced to 0 Ml/d throughput, it should be taken out of service and cleaned.

For optimum flexibility, it is recommended that the works is operated with as many streams online as possible to provide the required flow. For example, if 100 Ml/d is required for the 500Ml/d scheme, it is preferable for this to be provided by 3 to 5 streams at a reduced flow, rather than one stream at full flow.

At Gate 2 the treatment works has been sized based on the maximum suspended solids concentration, measured during the water quality sampling undertaken throughout 2021. However, there will likely be periods of poorer water quality or peaks in suspended solids concentrations in the River Severn, such as during spate conditions. These will be monitored, and when above the acceptable treatment level, the intake flow may need to be reduced to prevent overloading of the system.

Higher solids loading through the plant would require more frequent backwashing of the RGFs and greater solids handling in the washwater recovery system. As a result, the output of the works would be reduced to account for the increased process losses.

A monitoring programme, sampling raw water quality at Deerhurst is on going and will continue into Gate 3. This will further inform the selection of an appropriate design water quality envelope for the WTW to ensure the works is designed to operate at full flows when required for transfer, with reductions in flows only required in exceptional water quality events.

2.3.3 Pipeline Operational Philosophy

The operating philosophy for the pipeline from the WTW to outfall is summarised as follows:

2.3.3.1 Sweetening flow

Under certain operational scenarios the pipelines are not required to transfer flow but need to be available should a transfer be required. It is assumed that the pipeline will transfer a sweetening flow, to ensure that the discharge of the water from the pipeline to the environment doesn’t have any detrimental effect, particularly regarding the deoxygenation of the water in the pipeline.

There are operational and environmental issues concerning the de-oxygenation of water, including a reduction in dissolved oxygen levels and the emission of hydrogen sulphide. The required sweetening flow rate has been calculated based on the rate of dissolved oxygen reduction in the pipeline[6].

Based on the assumed conditions, a maximum retention time of approximately 11 days is required to maintain a final dissolved oxygen concentration of 0.5mg/l. This is equivalent to a sweetening flow of approximately 20Ml/d for the 500Ml/d option. The minimum flows through the treatment plant will also impact on the minimum sweetening flow required.

The outfall from the pipeline will pass through a reaeration cascade to reoxygenate the water discharge into the River Thames.

There is considerable uncertainty around the various conditions used to estimate the sweetening flows which should be refined as the project progresses to Gate 3. It is recommended that testing is carried out to determine the effects of storing the water in the pipeline and assess the suitability of the water for discharge to the environment.

[6] Further information on the sweetening flow calculation is provided in the technical note: ‘STT-G2-S3-306-STT STT Interconnector - Estimate of Sweetening Flows’

2.3.3.2 Normal Operation

When required to do so, the transfer volume will be able to be increased in discrete steps to meet the requirement to transfer flows.

During normal operation the required flowrate will be regulated by the pumps VSDs at both the raw and the high lift pumping stations.

Aiming to keep the gravity main full, it is proposed to set a constant level at the BPT which will be modulated by the PSV at the discharge end of the gravity section. Two sets of parallel duty/stand-by PSVs have been proposed for both the normal operation and the sweetening flowrates.

2.3.3.3 Fail mode

The rising main remains fully charged following a pump trip or not in operation for maintenance.

The BPT provides a small reservoir to prevent the pipeline dewatering in the event of a pump trip. Downstream flow out of the BPT would be controlled by means of a PSV located at the downstream end of the pipeline.

As indicated on the previous sections, duty/stand-by PSVs have been proposed ensuring the availability of one PSV in the case one fails.

Typically, sectional valves are required every 5km and in accessible locations, and all major crossings are likely to have isolation valves associated with them

The test pressure envelope in all operational scenarios should be set out and agreed.

2.3.4 Operational Maintenance Requirements

The key locations which will have ongoing maintenance requirements are anticipated to be:

- M&E infrastructure at the intake works
- M&E infrastructure at the pumping stations
- M&E infrastructure at the treatment works
- Cleaning of raw water pipeline due to zebra mussel incrustation
- Valves and valve chambers

2.3.5 Operational Resourcing Requirements

The mechanical & electrical aspects of the pipeline will require regular maintenance, but the quantum will depend on the frequency of operation. At this stage it has been assumed that one full time equivalent (f.t.e) would be required per 50Ml/d of installed treatment, for example, 6 f.t.e. will be provided for the 300Ml/d option.

2.3.6 Operational Power Usage

Operational power usage estimates are shown in Table 2.17.

Table 2.17: Power usage

Option component	Flow (Ml/d)	Full flow (kWh/day)	Sweetening flow (kWh/day)
Low Lift (raw water) PS	300	17,184	600
	400	24,384	600
	500	30,624	600
High Lift (treated water) PS	300	285,480	17,904
	400	365,616	17,904
	500	451,416	17,904
Water Treatment Works (excluding LLPS and HLPS)	300	4,400	300
	400	5,900	300
	500	7,300	300

2.3.7 Operational Chemical Usage and Vehicle Movements

Table 2.18 summarises the annual chemical consumption for the water treatment works and the estimated vehicle movements per year, for chemical deliveries to site and sludge cake removal from site. The calculations are based on the treatment works operating at its maximum design flow for 20% of the year, and a sweetening flow of 20 Ml/d for the remaining 80%.

Table 2.18: Chemical usage and vehicle movements

Delivery Type	Flow (Ml/d)	Average Consumption (Bulk) (kg/yr)	Size of Load (tonnes)	Average loads (loads / yr)	Comment
Main Treatment Chemicals					
Ferric Chloride	300	1,254,204	23	55	-
	400	1,584,257		69	-
	500	1,914,311		83	-
Sludge Treatment					
Polymer	300	3,787	6	1	Assume will be via 25kg bags. Less than 1 tanker needed at 300 & 400 Ml/d so rounded to 1 load.
	400	4,784			
	500	5,780			
Sludge Disposal					
Sludge Cake	300	1,078,161	13.6	79	13.6m^3 tanker - assume sludge has density of 1 kg/l
	400	1,361,887		100	
	500	1,656,614		121	

2.3.8 Operational Carbon

Capital and Operational carbon (tCo$_2$e) have been assessed and details can be found in the associated STT Cost, Carbon, and Benefits Report (STT-G2-S3-357).

2.4 Permanent Land Requirement

The estimated land requirements for this option are summarised in Table 2.19.

Table 2.19: Land requirements, ownership, and constraints

Option component	Land-take required m^2	Proposed location	Availability/ ownership	Site constraints
Intake at the River Severn	1,000 plus 2,660 access road to intake	At intake at the River Severn	In private ownership. Land will need to be purchased.	Public footpath to be diverted around intake
Low lift PS	3,150 plus 7,000 access road to LLPS	Approx. 0.4km Southeast of intake	In private ownership. Land will need to be purchased.	Greenfield site/ agricultural land.
Treatment works	76,000 plus 8,750 access road to WTW	Approx. 1.5km East of intake	In private ownership. Land will need to be purchased.	Greenfield site/ agricultural land.
Break Pressure Tank	10,000	At the high point of the route	In private ownership. Land will need to be purchased.	Needs to be at pipeline high point. Greenfield site/ agricultural land.
Outfall at the River Thames	750	Culham	In private ownership. Land will need to be purchased.	Needs to be on the River Thames

Wayleaves will be required for the entire pipeline length.

It is noted that the intake, pumping stations and WTW are within Landscape Protection Zone (Policy LND3).

2.5 Environmental Issues; mitigation and social benefits

For environmental issues, mitigation and social benefits related to this scheme, refer to reports listed in which are issued separately from this CDR.

Table 2.20 below details the key environmental issues and proposed mitigation for the construction and operation of the interconnector.

Table 2.20: Construction and Operational Environmental issues and mitigation

Issue	Mitigation
	Construction
General	*Mitigation measures would be set out in a detailed Construction and Environmental Management Plan that would accompany the planning application and any applications for environmental consents/permits.*
Traffic on local roads	*New access roads will be provided at start of construction. Wheel washes for truck deliveries to site will be provided. Approved traffic routes for construction traffic will be applied to minimise impacts on local roads. Haul routes from existing roads to compounds and working areas will be minimised and land reinstated following completion of the construction works.*
Noise	*Construction working hours will be limited as agreed during the planning process. Plant to be used will be modern and in good condition with silencers fitted when near to key noise receptors. Site temporary construction compounds will be away from residential areas. Any landscaping bunds around perimeter at permanent sites will be provided at the start of construction (which can provide noise barrier benefits).*
Air Quality (Dust / fumes)	*Well maintained plant to be used. Plant will be modern and in good condition to minimise emissions. Dust will be controlled through dampening haul roads and earthworks and aggregate processing plant.*
Water Quality	*Measures will be taken to protect any temporary exposure of bare soil from runoff during heavy rainfall events. Earthworks drainage will be controlled including use of temporary settlement ponds. Early diversion of watercourses will be carried out. All vehicle and chemical/oil storage will be fully bunded to prevent any accidental pollution of groundwater or watercourses. The*

	mitigation measures will be set out in the applications for Flood Defence Consents where these are required for any river construction works. *First flush water at commissioning will be tested and if required treated at the temporary lagoon.*
Land drainage	*Pre-construction land drainage will be installed as part of the enabling works and land drainage will be fully re-established during the reinstatement. Where land is sloping towards a watercourse, a buffer grass strip and straw bales will be provided as appropriate to stop sediment from the site running off-site untreated.*
Nature Conservation Designations (Ancient Woodland, Sites of Importance to Nature Conservation)	*If site specific ecological assessments identify any impacts to protected species or habitats associated with the construction work, appropriate mitigation measures including (where appropriate) relocation of such species will be undertaken in advance of the works being undertaken.* *Land designated as Ancient Woodland and Wood-Pasture (NERC) are near the proposed conveyance route. Use of non-dig construction techniques may be undertaken to minimise vegetation loss.* *Where soil stripping is undertaken, the soils are to be stored and reinstated following construction to maintain seedbanks.*
Heritage Assets or listed building proximity	*In places, the site is close to known heritage assets. In these locations, further advice will be sought and, if recommended, initial archaeological investigations will be undertaken prior to construction works and qualified archaeologists will provide a watching brief during the works. Buffer areas in relation to excavation and earth moving works between the works and heritage locations should be established, in addition to advice from the archaeologist.*
Flooding	*Flood compensation ponds will be constructed as part of the enabling works. Earthworks sequencing will include cofferdam formation to avoid flooding of borrow areas during construction.*
Vegetation	*Every effort will be made to ensure the final pipeline routes minimise the need for the removal of any trees, hedgerows or other important vegetation, or adverse effect on supporting root structures. Any affected hedgerows will be reinstated.*
Movement of Invasive Species	*Invasive species on site to be identified and removed in advance of construction. Main Deerhurst Pipeline commissioning to be with treated water.*
Public right of way	*All reasonable effort will be made to avoid temporary closure of public rights of way and diversions will be provided instead. Public right of way will be reinstated following construction completion. Careful siting and use of screening where work locations are in proximity to public rights of way will be undertaken.*
Visual Impact from key receptors around site	*Prior to construction tree surveys for locations affected by temporary and permanent above ground works, including permanent installations, temporary compounds, launch and reception pits, and construction routes, will identify tree constraints including protected trees and root protection areas.* *Tree retention, tree removal and pruning requirements will be identified and the extent of removal will be minimised. As part of site preparation tree pruning and clearance will be undertaken to accommodate construction. Construction exclusion zones will be identified, and tree protection fences will be installed. The fence is maintained for the duration of works.* *Ground protection opportunities will be identified and implemented to enable construction access in vicinity of existing trees to avoid removal.* *Where possible temporary compounds would be located on brownfield sites, hard surfacing, existing car parks or compounds to minimise disturbance to existing landscape features and visual amenity. If such locations are not available, they will be located to the edge of areas of public open space, preferably near roads where any new installations can be sited in relation to existing development.* *Temporary and permanent compounds, cabins and car parks will be sited away from sensitive receptors such as residential areas.* *The use of existing planting for screening will be maximised (tree constraints to be accommodated).*

	Existing hard landscape features will be retained, protected and stored for future reinstatement, where they form part of a distinctive setting or relate to the character of an area, for example stone walls. *Existing views or key viewpoints will be maintained where possible to minimise disturbance to visual amenity through appropriate siting of compounds and temporary access routes.* *Disturbance to or removal of key landscape features or amenity features that are distinctive, rare and/or are characteristic of the area will be avoided by appropriate siting and routing of temporary and permanent works.* *Land take for construction will be minimised to reduce landscape and visual impact and subsequent extent of area to be reinstated.* *Where appropriate, new plant and equipment, including chambers and valves will be provided at boundaries to avoid visual intrusion and minimise disturbance to current land use.* *Stockpiling of materials, or delivery of materials to be used in construction in areas of high landscape value or sensitivity, such as public parks, visitor attractions, residential areas, where visual amenity may be affected will be minimised.* *Traffic will be controlled, and deliveries and construction will be organised to minimise visual impact and disturbance to visual amenity during construction; for example, weekend working will be avoided.* *Temporary lighting will be strategically located for safe construction requirements and where possible, will be directional to minimise increase in light levels.*
Floodplain encroachment	*The intake and outfall sites would be located within the flood plain and as such compensation may be required for this development*
Operation	
Visual Impact from key receptors around site	*Landscaping / planting around the Deerhurst Pipeline LLPS site and treatment site has been allowed for to minimise visual impact. The break pressure tank is proposed with grassed earth embankments and planting to minimise visual impact.*
Traffic on local roads	*Traffic during operation expected to be limited to small operations vans, primarily visiting the LLPS and the treatment site. Occasional maintenance works of MEICA items for all sites may require larger trucks / mobile cranes to bring / install replacement parts or plant.*
Noise	*Limited noise will occur from pump operation and cleaning of screens at the river intake. This should be effectively mitigated using noise insulation.*

2.6 Geotechnics

A high-level geotechnical desk study was conducted ahead of Gate 2 to identify the main geotechnical risks associated with the preferred pipeline route.

The findings of the high-level geotechnical desk study were used to:

- update the project risk register;
- update the assumptions made in the cost estimates for the scheme, particularly around the ease of excavation assumed along the pipeline route; and
- inform future studies and investigations to aid the management of the geotechnical risks.

Using Mott MacDonald's Atlas system, supplemented with published geological maps from the British Geological Survey (British Geological Survey, 2022), the following geotechnical risks were assessed:

- geology along the route (risks of soft ground, difficult excavation)
- potential for ground instability and landslips;
- presence of landfills within 250m of pipeline;

- dissolution features; and
- aquifer designations.

Based on the methodology adopted, the following risks were excluded from the assessment:

- UXO risk
- risk associated with mining and quarries;
- Groundwater related issues (e.g. flotation risk); and
- presence of Made (Artificial) Ground.

The desk study identified a number of in-ground risks that will affect the proposed STT Interconnector scheme. The most significant of these identified to date are:

- risks associated with cambering and valley bulging;
  - This risk is most likely present in the north-western section of the proposed route where the strong Oolite Group overlies the weaker Lias Group. This occurs for approximately 32km of the route. These mass movement processes are common across the Jurassic escarpment of the Cotswolds across which the route is planned to cross. The potential engineering problems are not insurmountable but are serious and could increase engineering costs.
- landslip risks, often associated with the above cambering and valley bulging;
- soft ground, leading to instability and foundation issues, most often in river valleys;
  - This occurs where superficial deposits of Alluvium and River Terrace Deposits are present, approximately 21km of the route.
- dissolution potential within the Lias Group, Corallian Group, and Inferior and Great Oolite Groups;
  - This high impact-low probability risk occurs where limestone is present in the bedrock geology, which occurs for approximately 61km of the route.
- expected to cross at least five geological faults along the route mostly within the western extent of the route; and
- excavating in close proximity to landfill sites. It is likely that minor re-routing of the pipeline will be possible to mitigate this risk.

In addition to the risks excluded from the high-level desk study, the following aspects would need to be assessed as the design develops:

- suitability of excavated materials for re-use;
- stiffness of native soils (in relation to pipe support); and
- chemical aggressivity for pipeline materials.

In Gate 3 the following activities will be undertaken to further understand and review potential mitigation for these risks:

- more detailed literature review of additional information including but not limited to:
  - topographical maps;
  - aerial photographs of the site and surrounding area;
  - relevant British Geological Survey maps;
  - historic geological memoirs;
  - database of all recorded solution features; and
  - previous investigations at the site and in the surroundings.
- scoping of a Ground Investigation to gain further understanding of any areas that would be particularly of concern.

2.7 Interaction with other SROs / WRMP24 Options

This sub-section explains any interactions with other schemes which has been included in this design, and how consideration of these schemes has been built into costed solution to ensure compatibility.

2.7.1 SESRO

The horizontal alignment of the final approximately 3-4km of the Deerhurst to Culham pipeline has been routed along the proposed alignment of the auxiliary drawdown channel for the SESRO reservoir. The concept design assumes that the lower sections of the STT pipeline would be constructed at the same time as the SESRO auxiliary drawdown channel, located in the towpath of the canal. This would minimise construction disruption, avoid the need for multiple road crossings and reduce the land area required for the two schemes. Therefore, future design and planning for STT must take full account of the plans and development of the SESRO project. If both schemes progress careful planning will be required to ensure that the design and construction of these elements are aligned.

Further design optimisation of the auxiliary channel design and STT alignment in the final 3-4km will be required in subsequent design stages to maximise the benefits from this interaction.

3 Scheme Delivery

This section details how the proposed scheme components would be delivered.

3.1 Overview of construction process

The works required are not considered unusual for a major cross-country pipeline scheme, however the pipeline diameters for the 400Ml/d and 500Ml/d flow rates are larger and the pressures higher than commonly installed which may result in additional challenges in terms of design and the procurement of pipe and fittings.

3.1.1 Intake structures and low lift pumping station

3.1.1.1 Intake Structure

The main intake structure is located on the bank of the River Severn, with screens installed within the river. Therefore, construction will require a dewatered sheet piled cofferdam within the river to allow excavation for the intake pipework and screen installation. A temporary settlement lagoon will be needed to treat the water from the dewatering before discharging back into the river.

Construction of the intake valve chamber will also require a sheet piled / cofferdam excavated area. Where sheet piles have been used, once construction / installation is complete, the sheet piles would be removed, and the ground levels reinstated.

3.1.1.2 Low lift Pumping Station (LLPS)

The LLPS structure proposed is a circular shaft below ground wet well with submersible pumps installed and a rectangular valve chamber adjacent to the wet well. The estimated shaft depth to invert ranges between 8m to 10m and internal diameter between 12.5m and 15m. The overall sizes of the LLPS are referred in Table 2.3.

It is likely that this area will be in soft soils and a caisson method will be used. Caissons are either installed as a ‘wet caisson’ where the water level inside the caisson is slightly higher than the external ground water level, or as a ‘dry caisson’ where the inside of the caisson is open to the atmosphere. In the caisson method, the precast concrete elements are erected at the surface and are then lowered into the ground aimed by hydraulic jacks anchored to a concrete collar whilst excavation progresses.

The adjacent valve chamber can be either constructed in situ or with precast concrete elements for the walls and cover slab.

It is proposed that a site compound will be established at the LLPS site, this will be located outside of the flood plain and service both the intake and LLPS sites. Temporary compound access roads will be installed as appropriate.

3.1.2 WTW and High Lift Pumping Station (HLPS)

3.1.2.1 Water Treatment Works

It is proposed that the contractor’s compound adjacent to the permanent WTW site boundary would service both the treatment works, the HLPS and the first part of the pipeline corridor. Any archaeological and ecological constraints would be managed and mitigated in advance of site establishment and construction to minimise the impact on programme duration. Where there is an impact on habitat, enhancement works will be developed as part of further, more detailed, option design.

Once the site has been established, the key process elements would be constructed in accordance with a detailed programme, followed by testing and commissioning. Landscaping works would be the last site activity.

The flow through the works should be gravitational, with a gentle gradient of 1 in 10 to 1 in 15 most favourable. The hydraulic profile though the works, and the associated earthworks for landscape bunds, will be optimised through a cut and fill balance calculation. Final site selection will be critical to minimise earthworks and earthworks operations.

This type of treatment works would lend itself to “build off site” techniques, maximising the use of prefabrication to reduce programme time and local disruption whilst improving quality and safety.

The treatment works will operate in separate treatment streams (proposed 100 Ml/d capacity per stream). The streams will be commissioned sequentially to provide flow to commission each stream, and the transfer pipeline.

A detailed construction programme showing a clear commissioning pathway would drive the overall construction sequence across the whole scheme.

3.1.2.2 High Lift Pumping Station

The concept design includes a HLPS, located within the proposed water treatment works site. It is expected that horizontal split case type pumps will be the most appropriate, installed within a dry-well arrangement. It is envisaged that the pump room will be housed in a 2 to 4 m deep concrete basement, with pumps installed at a similar level to the invert of the pump sump. On top of the pump basement a building will be constructed to cover and protect the pump room. The overall PS sizes in respect to flows are estimated and tabulated in .

There is likely to be an opportunity to use precast elements during construction, reducing site construction processes, potentially providing opportunities for improved site health and safety and reductions in capital cost and carbon.

3.1.3 Pipelines

3.1.3.1 Intake to LLPS

The twin pipelines from the river intake to the LLPS are likely to be constructed using sheet piled open cut excavation. It is estimated the total depth of excavation is 5m on average which will be proportionally increased on the last 25m up to 8.5m at the PS. The sheet piled excavation width is estimated to be at least 9m wide for the twin intake pipes. The intake temporary settlement lagoon would be used for the dewatering.

3.1.3.2 LLPS to WTW

The twin pipelines from the LLPS to the treatment works is proposed to be constructed via an open cut method with depths to invert of between 3 to 4m.

3.1.3.3 WTW to Outfall

It is assumed that the majority of the main conveyance elements – the rising main from the HLPS and the gravity pipeline from the BPT to the outfall will be constructed in open cut. A 40m wide working width during construction has generally been assumed. Where there are specific constraints, the corridor has been reduced to 20m width. At larger diameters it is likely that this working width will need to increase to 50m, this will need to be reviewed and updated in Gate 3.

At major crossings, the pipeline would be laid via a no-dig method. Refer to Section 2.2.3.7.

For minor crossings, open cut methods have been assumed. Minor roads would either be closed with diversions in place or would be partially closed where land width allows for partial closure. Minor water courses would be temporarily flumed. Additionally, all smaller water courses would be flumed during construction to allow ease of construction traffic movement along the pipeline corridor to minimise the impact.

All archaeological and ecological constraints would be managed and mitigated in advance of pipeline construction to minimise the impact on the pipe laying programme duration. Where there is an impact on habitat, enhancement works would be developed as part of further, more detailed, option design.

Construction management is expected to be carried out via nine main construction compounds, available as required during the option construction, as well as several satellite compounds. For the main compounds an area of 150 x 200 m has been assumed. For the satellite compounds, it has been assumed that they would be required at approximately 2km intervals and that an area of 100 x 200m has been assumed. The satellite compounds will be reinstated as construction progresses, and it is estimated that three will be in use at any given time. Specific locations for the compounds will be selected at later project stages. Sites must have adequate access from an A and/or B road, and should be selected to minimise disturbance to local traffic and residents.

Power requirements for compounds would be in the order of 200kVA for the smaller compounds & 400kVA for the main compounds.

During construction, access to the whole length of the pipeline would generally be via the construction compounds and along the construction easement. The pipeline construction will progress along the pipeline in a linear manner, with topsoil stripping in advance of construction. Soil would be temporarily stored alongside the easement. It has been assumed that the majority of excavated material will be suitable for backfill of the pipeline trench. After each pipe section has been completed and successfully pressure tested, where possible additional spoil from the excavation will be distributed across the easement minimising the exportation of spoil material. Following that, the topsoil would be placed back, and the land would be reinstated to pre-construction conditions.

During construction, areas with high permeability and high groundwater levels would require permits to be obtained by the contractor from the relevant authorities for the disposal of the groundwater to a suitable location. There would also be a need for lagoons to intercept and treat the commissioning wastewater. The lagoons would need to be available prior to pressure testing and land would be fully reinstated after commissioning.

3.1.3.4 Major Crossings

A count of major crossings has been shown in Table 2.10. Major crossings have been assumed to be trenchless crossings (no dig) and are proposed as single crossings, in line with the resilience assumptions. Major crossings include the following:

- Railway crossings
- Motorway crossings
- River crossings
- Main Road (dual carriageway) crossings

All major crossings are likely to require isolation valves at each end.

Single carriageway main road crossings will be installed using open cut construction. However, by exception, some single lane A-roads may require non-dig construction by the corresponding authorities or night-time closures to minimise traffic disruption.

The following assumptions have been made for trenchless crossings:

- The pipeline route would cross as close to perpendicular as possible to all crossings and outside cuttings where possible
- Due to relatively short lengths tunnelling would be carried out in a single run, i.e. no need for intermediate shafts
- When pipe jacking a sleeve internal diameter of 200mm larger than the pipeline outside diameter will be installed
- Where the crossing is under infrastructure on an embankment, an additional 10m distance away from the toe of the embankment has been assumed
- Shafts would act as permanent works valve chambers where the specific authority requires isolation either side of the crossing in question e.g. Network Rail for railway crossings

The construction method and the arrangements will need to be agreed with the asset owner before construction.

3.1.4 Break Pressure Tank

The BPT is likely to be constructed of in-situ or precast reinforced concrete elements, although alternative, lower carbon construction methods should be investigated in further design stages. The tank should be partially buried to reduce the visual impact on the AONB , with a need for excavation, and the appropriate cut and fill balance calculation and detailed hydraulic review to determine the base slab level.

After construction, and testing, it is expected that the tank will be covered with earth, topsoil and seeded with grass minimising visual impact. However, since this is raw water, it is possible that the need to cover the tank could be challenged, this will be reviewed considered planning requirements and any additional health and safety issues that could result from an open tank.

3.1.5 Outfall

The main outfall structure is likely to be in-situ or precast concrete with the aeration cascade would either be of stepped concrete, or of rock (riprap) construction. Sheet piling would be required at the riverbank to allow construction. The aeration cascade would be of sufficient length to allow gentle entry of water into the River Thames.

Once the transfer has been commissioned, it is proposed that it will operate at a constant sweetening flow. As such, a permanent recommissioning lagoon is not required. For commissioning purposes, it is proposed that a temporary commissioning lagoon would be constructed near the outfall location, with three intermediate lagoons along the gravity section of the transfer pipeline, in accordance with Section 3.4.2.2.

A location for the temporary lagoon required at the outfall to treat the first flush at commissioning has not yet been selected. However, it should be located outside Flood Zones 2 and 3 nearest to the outfall for the selected route. The required size of the commissioning lagoon is based on a 5km section of the treated water pipeline. Selection of an appropriate land parcel should be carried out in Gate 3, following early contractor engagement.

Table 3.1: Commissioning Lagoon sizes

Flow rate (Ml/d)	Volume (m^3)
300	10,000
400	12,500
500	15,500

3.2 Construction Land Requirement

The table below lists additional land required to facilitate construction. It is noted that land is assumed to be within private ownership and will need to be rented for the duration of the corresponding site construction.

Table 3.2: Construction land requirements

Option component	Land take required m^2	Proposed location	Site constraints
Intake at the River Severn	2,500	50x50m construction area adjacent to permanent land boundaries	Flood zone 2 and 3
Low lift PS	20,000	LLPS shaft area adjacent to LLPS permanent site area	In close proximity to flood zones 2 and 3.
Intake and WTW	20,000	Materials handling and laydown area mid-way between the LLPS and WTW permanent site areas	In close proximity to flood zones 2 and 3.
Break Pressure Tank	6,900	Adjacent to permanent site area	-
Outfall at the River Thames	1,000 (plus additional 6200m^2 for temporary lagoon)		-
Main construction compounds along pipeline (temporary 3Nr)	Approximately 30,000 per compound (200m x 150m)	Good road access (at least two lanes) into the compound	-Location to be confirmed
Satellite construction compounds along pipeline includes laydown area (temporary, assumed 11Nr)	Approximately 20,000 per compound (200m x 100m)	Located every 6km along A/B road to allow for delivery. Reinstated as construction progresses, approx. 3 in use at a time	-Location to be confirmed -
Laydown areas (temporary, assumed 29Nr)	Approximately 20,000 per compound (200m x 100m)	Located every 2km along A/B road to allow for delivery. Reinstated as construction progresses, approx 3 in use at a time	-Location to be confirmed
Pipeline construction width	340ha (85km)	Along pipeline route	40m temporary working width. To be reviewed further in Gate 3.

Specific locations and resultant area of construction areas should be revised following early contractor consultation at Gate 3.

3.3 Construction Traffic

The estimated required construction traffic movement is shown in the table below.

Table 3.3: Construction traffic movements

Component	Flow (Ml/d)	Size of truck loads (tonnes)	Size of concrete truck (m^3)	Approx. Loads	Comments
Intake and LLPS	300 - 500	10	6	1,900	Loads during construction only. Includes the delivery of construction materials including rebar, concrete and road layers.
Pipeline	300	10	6	12,000 + 4,000	Assumes 10% of excavated material from trench to be removed from site. The remaining would be backfill or spread over the wayleave. Delivery of pipework in 6m lengths.
	400			16,000 + 4,000	
	500			20,000 + 4,000	
Treatment Site	300	10	6	7,250	Loads during construction only. Includes the delivery of construction materials including rebar, concrete and road layers.
	400			8,260	
	500			9,240	

3.4 Delivery Programme

3.4.1 Planning, development and enabling stages

The STT interconnector is categorised as a Nationally Significant Infrastructure Projects (NSIP), and as such will seek planning approval via a Development Consent Order. The planning, development and enabling stages, are detailed in Annex G in the Gate 2 report - STT-G2-S5-451-STT Planning, Consents, and Land Report.

3.4.2 Construction and commissioning stages

An indicative construction programme has been developed (Appendix B). The construction start date is a nominal date to align with the current best estimate of a likely start date based on the wider STT programme and the current results of the regional modelling. This programme is indicative only and gives a high level indication of the construction duration required. However, it is strongly recommended that this programme is further developed in Gate 3 through early contractor engagement to obtain greater certainty of construction and commissioning timescales.

3.4.2.1 Construction phase

Planning of the pipe laying teams will dictate the time required to lay the pipeline. If there are more pipe laying teams, the work can be carried out more quickly, but it will require a larger management effort and is likely to be constrained by how quickly pipe deliveries can be made. Further detailed planning is required to optimise the balance of work fronts and other constraints such as material delivery, seasonal influence on access to the temporary easement for the enabling works and the actual need to lay pipe and pipe jacks as part of an integrated programme of works to allow full consideration of overall commissioning and hand over.

The main long lead items include main power supplies, ICA units and specialist high lift high volume treated water pumps and large diameter pipes. Programming of these influences the overall timeframe, significant duration could be saved if long lead items could be procured in the pre-construction phase. Pipe procurement for example is shown on the critical path.

Deployment of Design for Manufacture and Assembly (DfMA) and Modern Methods of Construction to the structures and MEICA installations could significantly reduce the procurement and installation durations of these elements.

3.4.2.2 Commissioning phase

There are several key elements required to commission the new assets end to end and the way these are sequenced during the procurement and construction programme can help or hinder the overall project commissioning. At present, commissioning has not been planned in detail, a high-level review has been undertaken and a number of issues (as detailed below) identified that should be reviewed in Gate 3, along with a more detailed assessment of the impact of commissioning on programme. It has been assumed that the WTW would be commissioned before the pipeline to enable the use of treated water for elements of the pipeline commissioning. It is likely to also be necessary to identify alternative sources of commissioning water and acceptable discharge locations along the length of the pipeline.

Key elements and dependencies need consideration from the earliest possible stages and procurement of the construction scope needs to consider ownership of interfaces as the procurement strategy is developed. The key elements during commissioning have been identified at this stage to be:

- Water treatment works commissioning needs raw water from the River Severn in the right quantities. Therefore, the intake, LLPS and raw water pipeline to the head of the WTW need to be commissioned, and a power supply (temporary or permanent) is required.
- The raw water pipeline is relatively short and low pressure and can drain back to the LLPS and to the River Severn through the intake culverts.
- Three options for dealing with the treated water from the WTW during commissioning have been identified.
  - Recirculation
  - Discharge back to the River Severn
  - Used to commission the pipeline to the BPT and beyond
- The HLPS needs sufficient quantities of water to fully test the pumps, pipeline and BPT to test pressures. This needs to be treated water to eliminate the risk of INNS transfer.
- The BPT needs to be tested for water tightness for this volume of water. The required water could be tankered in or provided slowly off a local main and can be completed offline.
- Commissioning of the whole scheme also needs end to end SCADA and control testing

The scope of the commissioning process has been considered in three stages:

a) Raw water side and Treatment works

The test and commissioning strategy for the WTW includes off-site testing, installation and construction completion testing, dry testing, wet testing, commissioning and performance and takeover testing.

The WTW is comprised of streams which can be commissioned in stages, with the water from one stream used to commission subsequent streams, reducing the demands on external water being required. The treatment works commissioning sequence can be based on the operational ramp-up/down procedure outlined in Section 2.3.2. The key commissioning risks to consider include:

- Disposal options for commissioning water (can it be returned to the River Severn or a local water body?)
- Testing the treatment works at varying water quality conditions to ensure it can treat the range.

b) High Lift PS

The testing and commissioning strategy for the HLPS will include:

- Off-site / factory inspections and tests (prior to commissioning) - to ensure that acceptable equipment is delivered to site.
- Commissioning Tests (functional and operational) – to ensure that each item is properly installed and functions as required and that all items operate together to meet the performance requirements.

Given the high capacity and pressure requirements of the pumps, it would be expected that factory acceptance tests are carried out on the pumps, including a string test with the motors and variable frequency drives. In addition, Third Party Inspections may be considered for other critical items such as overhead travelling cranes and surge vessels as they are required to meet statutory requirements in relation to health and safety.

Functional (site acceptance) tests on the pump station would take place before any operational tests are carried out and these would include:

- safety checks on the equipment (including that all relevant warning and safety signage has been provided and security of fixings)
- a general inspection correct assembly and quality of installation
- non-running tests such as calibration tests
- checks on water, lubrication and air tightness of all services at the required pressures,
- checks for excess vibration or overheating of equipment under load conditions
- checks to ensure that the design parameters have been satisfied with respect to the light levels, noise levels, paint specifications, etc.
- in the case of electrically driven plant, a check on functionality, relay settings, earth continuity, earth loop resistance, direction of rotation, running current and insulation and also ensuring the correct test certificates have been provided
- in the case of instrumentation, a check on instrument loop integrity, functionality and calibration
- a demonstration of correct operation of PLC, communications and SCADA

Once functional tests have been carried out, operational tests would be carried out on equipment and systems that form part of the high lift pump station to demonstrate their operation under both manual and automatic control.

Some key considerations during commissioning and specifically when carrying out operational tests are:

- Ensuring the testing phasing correctly aligns with the WTW and pipeline commissioning, if the pump station is to be used to fill for the pipeline commissioning
- Significant volumes of water are needed to pressure test pipework and carry out performance testing of the pumps (it is recommended treated water is used to manage INNS risk)
- Phasing the power supply to the site to ensure suitable power is available for both functional and operational tests of the pumps, motors and drives and other key electrical equipment.

c) Pipeline commissioning

a. General

There are many things to be considered for the commissioning of such a strategic new pipeline asset and there are various phases of commissioning required before flows can be transferred to the River Thames. Pipe testing should be done sequentially and ideally the site team should plan their test sequence to pass the same test water with gravity from one section to the next one. As this may take many weeks water quality issues maybe need to be addressed as the water ages and stagnates. This may not be possible and defining water supplies for testing is required as the final route design is completed. Some key considerations during commissioning are:

- Very significant volumes of water are needed end to end. It will be required to identify where this water come from and how the volumes can be reduced as far as is practical.
- Appropriate and safe discharge of commissioning water to local water courses to match existing / seasonal flow regimes as the pipeline is sequentially brought into use.
- Water quality and INNS transfer risks upstream and downstream of the break pressure tank.
- Management and disposal of testing and commission water.
- Need for and use of sectional valves and test ends.
  - Sectional completion of water testing should be carefully planned to minimise the need for large volumes of water
  - If the water does need to be refreshed – pre-treatment and disposal of water in all possible water courses and discharge rates need to be discussed with the EA.
- The need for flushing and swabbing vs visual inspection and good work practice for a raw water main – as this is a raw water main and of large diameter the need for swabbing needs to be challenged.
- It is proposed that commissioning should include water testing for planning purposes.
- During pipe laying high standards of quality control are required both for storage at pipe dumps, transport to the work front and installation including use of secure end caps at the end of every shift for every pipelaying squad (there are likely to be multiple work fronts to deliver the pipeline element
  - Risks of pipes in flood plains getting flooded
  - Poor quality control and workmanship needing more cleaning
- For a pipeline of this size and length as pipelaying progress is made sectional pressure testing should be specified very carefully within an overall and detailed commissioning programme.

b. Pipeline to BPT

This section of the pipeline remains in the River Severn catchment and so can be pressure tested and flushed without full WTW commissioning, but careful consideration of INNS transfers and the potential risk of INNS remaining in the pipeline following testing is required. The planning of flow rates, drain down time and water quality controls prior to discharge into local water courses needs careful consideration, as these flows flow back eventually to the River Severn.

This section of pipe is 21 km long and is likely to require 1 intermediate lagoon to flush to. The first section can be successfully drained back to the WTW site and space required for managing these flows should also be taken into consideration.

c. Downstream of BPT to outfall

This section requires treated water for commissioning to prevent any INNS transfer risk. If the proposed STT WTW and HLPS are not available to provide commissioning water alternative supplies will be required and as is this is a relatively rural area, large flows are unlikely to be readily available. Existing large diameter trunk mains in close proximity to the route may be a source of commissioning water in this scenario, however, this requires further investigation.

This pipeline section is 65km long and for initial planning should consider 4 lagoons in total between the BPT and the outfall at circa 15-20km intervals with an absolute requirement for a lagoon immediately upstream of the outfall to ensure water quality is satisfactory before turning flows to the receiving waters in the River Thames. The vertical profile should be used to determine the best locations for these along with the consideration of access to and from the lagoons and local water courses, their characteristics and capacity to receive treated commissioning flows.

It is suggested that after the WTW, HLPS and pumped rising main section of pipe to the BPT the gravity section is sequentially commissioned from pressure testing and flushing to lagoons until the water is flowing clear and water quality is accepted. This would allow each lagoon to be decommissioned as you approach the discharge point.

This process needs a detailed commissioning plan that also ties in fully with an overall procurement and construction programme

d) Crossings – general.

It is likely that piped crossings of major existing linear infrastructure will require no-dig crossings and will be installed using a micro tunnelled sleeve and then the permanent pipe installed within this. All key crossings are also likely to require isolation valves at each end. Water to pressure test each crossing will be required and is likely to be sourced from either local supplies or tankering depending on the location. All crossings should be independently pressure tested and accepted in advance of connecting into the overall pipeline for sectional and then end to end pressure testing.

3.5 Construction Carbon

Construction carbon (tCO_2e) has been estimated for the 300, 400 and 500Ml/d options. Refer to Annex A3 – Carbon report for details on construction carbon.

4 Assumptions, Risks and Opportunities

4.1 Key assumptions

Key assumptions that have been made in this conceptual design report are listed below:

- **Permitting** It has been assumed that the permitting strategy is implemented in a timely fashion to facilitate the commissioning phase of construction.
- **Level of treatment required**: The level of treatment required has been determined based on the water quality sampling data discussed in section 2.2.5 and summarised in Table 2.12: and Table 2.13: .
- **Raw water quality**: It is assumed that operation could be stopped for short durations if high suspended solids readings are detected, or other pollution incidents occur at the intake.
- **Washwater and sludge**: It has been assumed that there will not be a sufficiently sized sewer connection for the wastewater, so a wastewater treatment system is proposed that would treat the washwater and produce sludge cake. Treated washwater will be recycled back to the inlet.
- **Flood plain levels**: There is no detailed information about the flood levels at both intake and outfall. These have been estimated from the publicly available EA flood maps.
- **Standby Generation**: Dual mains power supplies have been provided for the WTW and HLPS site. A single mains power supply with standby generation has been provided for the Intake and LLPS.
- **Sweetening flow**: It has been assumed that the rising mains will be continuously running at sweetening flows of 20Ml/d, therefore no permanent provision has been made to enable full shut-down of the pipeline.
- **Temporary commissioning lagoon**: It has been assumed that the first flush of water during commissioning would require treatment and temporary commissioning lagoons are proposed for this purpose.
- **Major crossings**: It has been assumed that all major crossings will be constructed by pipe jacking or boring a carrier pipe 200mm larger than the pipeline. This carrier pipe will then be used as a sleeve for the product pipe to be laid through it. It has been assumed that no twin crossings will be required.
- **Pipeline construction corridor**: A standard 40m construction corridor has been assumed along the length of the pipeline, with a reduction to 20m over short sections where required due to constraints. This should be reviewed in Gate 3 following early contractor engagement and further stakeholder engagement with the view that a 50m width may be desirable for the larger diameter pipelines.
- **Pipeline**:
  - A single pipeline has been specified for the main transfer pipeline section.
  - It is assumed that pipelines upstream of the WTW are required to be dualled due to the increased risk of zebra mussel incrustation prior to treatment. There exists an opportunity to utilise a single pipe, following further investigation into the risk posed by zebra mussels. This should be reviewed at Gate 3.
- **Washouts**: It has been assumed that at each low point there would be a watercourse in proximity, so that most of the pipeline could be drained by gravity. (i.e. there has been no allowance for permanent pumping stations at any location) or discharge to land would be acceptable.

- **Discharge consents for washouts**: It has been assumed that discharge consents will be granted for washouts where required.

4.2 Key Risks

4.2.1 Costed Risks

The following key risks have been identified and are costed within the costed risk:

- **Ground conditions -** there is a risk that the ground conditions encountered are worse than assumed, leading to increased structural requirements or increased construction complexity
- **Land agreement** – consultation has not yet been carried out with landowners and third parties and there is a risk that the current pipe route alignment is not acceptable within their land and a realignment is required.
- **The availability of power**, particularly for the HLPS which has a high-power requirement – initial contact has been made with the local DNO which suggests the provision of power in this location would be achievable, however, detailed discussions have not yet taken place regarding costs so there is a risk that costs are higher than currently estimated.
- **Archaeological discoveries** – there are known archaeological features in the vicinity of the WTW and the pipeline route, so there is a risk that additional archaeology is discovered during construction.
- **Third party engagement** for major crossings may be more extensive than currently assumed, and the requirements more onerous
- **Service diversions** – whilst a high-level review of major services has been undertaken during Gate 2 development, there is still a risk that additional services will need diversion to enable construction of the transfer.
- **Contaminated material** excavated from uncharted landfill sites – the route has avoided all charted landfill sites but, there is a risk that uncharted landfill or contaminated land will be encountered.
- **Compensation for crop loss** etc. – route has not yet been surveyed for land use so risk that higher levels of compensation are required than have currently been included.
- **Trenchless Crossings –** it is currently assumed that all major crossings are undertaken using trenchless techniques, however, this may not be possible in all instances.
- **Construction working area and permanent land acquisition –** There is a risk that insufficient land has been costed or that rates for leasing and land purchase are inadequate.

Additional risks included within costed risk include:

- **Environmental risks** – including consents, discovery of protected species, accidental silt pollution incidents, INNS spread prevention measures and the provision of compensatory habitats
- **Planning risks** – timescales and cost of gaining planning consent, additional work required to fulfil requirements of planning
- **Procurement risks –** including delays to key items
- **Construction risks –** availability of commissioning water and additional restrictions on construction.

4.3 Key Opportunities

4.3.1 Costed Opportunities

Three main opportunities have been included within costed opportunities due to the assumption that there is a high chance that they could be realised following further design work at Gate 3. These are detailed below:

- **Removal of dual intake pipes** – Due to the likelihood that the interconnector will not be required for water supply all the time, significant periods of time will be available for maintenance activities such as the removal of a build up of zebra mussels making the provision of dual pipes unnecessary. As the project progresses into Gate 3, greater understanding will be gained of likely utilisation and further agreement will be reached as to the level of resilience required.
- **Split release locations** – There is a possibility to release part of the flow into the River Thames upstream of Culham, reducing the diameter of the pipeline downstream of the early release location. Further discussion is needed with environmental regulators to fully understand the acceptability of this proposal.
- **Removal of dual power supply** – A review of the resilience requirements of the interconnector may result in the removal of the requirement for a back up power supply. The interconnector releases flows into the River Thames, where they are subsequently abstracted. Existing downstream storage may enable the shutdown of the interconnector for a number of days before and it has an impact on supply.

4.3.2 Other Design Opportunities

A number of further opportunities have been identified that could benefit the design and operation of the interconnector. These have not been fully developed but should be looked at during or prior to Gate 3 to ascertain both their feasibility and merit to confirm whether they should be included as part of the Interconnector going forward.

4.3.2.1 Energy Recovery and Renewable Energy Opportunities

Energy recovery potential has been estimated for the 300, 400 and 500Ml/d options. Refer to Annex A3 – Carbon report for details on energy recovery opportunities.

4.3.2.2 Alternative treatment opportunity

During the long-list appraisal, an alternative nature-based treatment process was identified, featuring a hybrid settlement lagoon/constructed wetland, followed by pile cloth media filters.

Constructed wetlands are nature-based systems that mimic the processes observed in natural wetlands. The proposed design would feature multiple cells in series, some acting as settlement lagoons, and some fitted with floating wetlands.

Wetlands have a proven efficiency for removal of organic matter and suspended solids. Additionally, they can reduce the pollutant load in water, by removing contaminants such as nitrogen, ammonia, phosphorous, suspended solids, heavy metals and some pesticides. The settlement cells would further encourage the colloidal silt solids present in the River Severn to settle out.

Pile cloth media filters offer comparable particulate removal to rapid gravity filters, with a smaller footprint, and would provide effective removal of INNS. Dirty backwash water from the pile cloth media filters would be recycled back to the lagoon/wetland, negating the need for sludge handling equipment or sludge tankering off-site.

Constructed wetlands and settlement lagoons require minimal operator intervention. The wetland/lagoon cells would require desludging; however, deep cells would reduce the frequency of this to a target 2 - 3 year regularity. In comparison to a conventional treatment works, the operation and maintenance costs are lower, as there is no chemical dosing, less internal pumping and less equipment to maintain. Additionally, no chemical deliveries or sludge cake tankers would be required. There are additional benefits from this option, including biodiversity gains, social benefits, and carbon sequestering.

However, wetlands are typically land intensive and the removal mechanisms are still not fully understood, making an accurate size estimation difficult. Typically, wetlands are operated at a steady influent flow rate, and it is not known what impact the stop-start process would have on the wetland chemistry – contaminants could be re-released after a sudden flow change.

Nature-based solutions are growing in popularity, and more research is being undertaken in this area. The following next steps are recommended:

- Engage a wetland-specialist to model the solids removal and estimate required footprint to determine opportunity feasibility.
- Review similar schemes to determine feasibility of operating at changing flowrates.
- Engage with pile cloth media filter suppliers to determine what flexibility there is in filter feed conditions.

4.3.2.3 Alternative intake screening solution (passive wedge-wire screens)

Band screens (such as Hydrolox Screens) have been specified at this stage as these have previously been accepted by environmental regulators in locations where there is a requirement to meet the guidance detailed in the Environment Agency Eel Manual (Screenings at Intakes and Outfalls: Measures to Protect Eels). These operate in a compact footprint and can be fitted with fish return channels to ensure any fish “caught” are returned safely to the river. However, these screens are visually intrusive and require a power supply for operation. The screens will need to be located adjacent to the river, within the flood plain, resulting in potential problems with the installation of electrical equipment.

An alternative to band screens is passive wedge (PWWC) wire screens. They have a lower visual impact, are simple to operate and can work effectively in shallow water. The cleaning of the screens is carried out through the injection of compressed air and the compressors can be housed in the LLPS site away of the flooding zone. However, further work will need to be carried out to confirm the acceptability of these screens in relation to the eel guidance.

4.3.2.4 Combined Efficiencies with SESRO

As detailed in section 1.4.3.1, if both SESRO and STT progress to construction there are potential efficiencies that could be gained at the end of the interconnector such as:

- Combining the outfalls from STT and SESRO, reducing total engineering works required and overall costs,
- Aligning the final 3-4km of the interconnector pipeline to share the land corridor for the SESRO auxiliary channel.
- Connecting the interconnector directly to SESRO to potentially enhance the combined benefit of the two schemes and potentially negate the need for the final section of pipeline.

These opportunities should be reviewed as further understanding becomes available on the likely construction timelines.

Regular ongoing liaison will be required with the SESRO team due to the potential proximity of assets within the outfall area.

4.3.2.5 Optimisation of sweetening flow requirements

During Gate 2 an estimation has been made of the minimum sweetening flow to ensure the quality of transferred water at the end of the pipe and to enable the required ramp up times from minimum flow to full operation.

There is the possibility that this flow could be further optimised, reducing operational costs and carbon. It is suggested that the following activities be undertaken at Gate 3.

- Investigate the potential to reduce sweetening flows by the re-aeration of flows at the break pressure tank
- Desktop research to review any formal research into the requirement and calculation of sweetening flows
- Consultation with water companies to ascertain existing knowledge in the operation of long raw water pipelines
- Further consultation with other raw water transfer SRO design teams to compare approaches with the intention of developing a combined approach throughout the SRO programme.
- Investigate the requirements for ramp up times and how they might be achieved with a lower sweetening flows.

5 Future Scheme Development

Future scheme development has been divided into three main stages:

- Further Option Definition
- Engineering Design Development
- Development for Planning Approval.

At each stage of development as the project progresses, through Gate 3 and beyond, it will be important to review additional information that comes available and to review whether it could be material to the option selection process. Where relevant, a back check will be undertaken to confirm the ongoing validity of the decisions made at the options appraisal stage.

Further consultation will be undertaken on options appraisal and, where appropriate, feedback will be included in a back checking exercise. The scope detailed below assumes that the conclusions of the Gate 2 Options Appraisal remain valid through backchecking exercises. This will need further review and revision if significant changes occur in option selection.

5.1 Further Option Definition

The Gate 2 options appraisal study recommended that a direct pipeline option should be taken forward for design development and a representative option has been developed for Gate 2 as described in the sections above.

However, further refinement of the option is required to confirm all components of the option for DCO examination.

Further option definition seeks to confirm the key components of the option to move forward to Gate 3 engineering design development, preparation for the DCO submission and preparation of tender information for the delivery phase. Further work will focus on:

- Confirmation of option capacity (through regional and company planning)
- Confirmation of interconnector route (based on increased understanding of ground conditions, land ownership etc)
- Confirmation of treatment type (based on initial desktop study and pilot trials) and location (a localised site selection study)
- Confirmation of intake location (based on a localised site selection study).

The works required is further described below.

5.1.1 Finalise Capacity of Option

To date three capacity options have been developed in parallel, however, it is envisaged that, at Gate 3, this will be refined to a single option. This will be determined by selection of the option within the draft WRSE regional water resource management plan and the surety of the plan.

It is therefore assumed that the scope of Gate 3 design development will focus on a single capacity option.

5.1.2 Finalise Interconnector Route Selection

Four Deerhurst to Culham interconnector options passed the Stage 1 Longlist appraisal stage of options appraisal. They were all considered viable and are technically similar (ie. they utilise the same transfer facilities but have differing routes). Naunton 2 route was selected at that time as a preferred option for the Gate 2 submission, but it was recommended that the four potential interconnector options should be further compared and a final route selected during Gate 3 Further Option Definition.

The following activities are recommended to enable the selection of the preferred route:

- Complete a more detailed geological and geotechnical desk study and risk assessment (for all route options passing the longlist stage). Some of the risks identified may be relatively minor, but others, especially the ground movement (cambering, landslipping, etc), backfilling and chemical aggressivity may be significant enough to alter the route selection;
- Land referencing to identify any particular land issues that may differentiate between remaining route options
- Liaison with environmental regulator to confirm acceptability of early release (upstream of Culham) into the River Thames for a proportion of the flow – and confirm option requirements

These activities should be undertaken prior to the non-statutory DCO consultation planned to take place in Summer 2023 to enable informed consultation to be undertaken.

5.1.3 Finalise WTW Treatment Technology

The Gate 2 Option includes conventional treatment technology but the option of a settlement lagoon followed by pile cloth filters also passed longlist appraisal. Subsequently an option of a more nature based solution has also been proposed (as detailed in Section 4.3.2.2).

Initially a desk top study of the potential nature based/ settlement lagoon hybrid solution for treatment should be undertaken. It is recommended that this includes the following:

- Engage a wetland-specialist to model the solids removal and estimate required footprint to determine opportunity feasibility.
- Review similar schemes to determine feasibility of operating at changing flowrates.
- Engage with pile cloth media filter suppliers to determine what flexibility there is in filter feed conditions.
- Engagement with environmental regulators to confirm requirements and acceptability of INNS treatment and to confirm quality requirements for release flow
- If required, commencement of a pilot trial to model the impact of the required varied operation of the treatment and to gain greater understanding of the potential removal of solids and other contaminants.

This work will be undertaken prior to Gate 3, enabling sufficient time to instigate pilot trials if required.

5.1.4 Finalise WTW and Intake Location

The options appraisal stage concluded that the intake and WTW should be located in the Deerhurst area. However, a localised site selection is needed to confirm the specific location for these key assets.

Sites will be identified and appraised prior to non-statutory consultation, to allow for engagement on the final choice of sites.

5.1.5 Project Wide Activities

A number of additional activities, as outlined below, should also be undertaken or progressed during further option definition stage:

- Confirm resilience requirements to inform the following:

- Removal of dual power supply
- Removal of dual intake pipes
- Maintenance and standby provision assumptions

5.2 Engineering Design Development

Engineering design development will take place following the further definition of the option. At Gate 3 this will seek to further develop the chosen option, increasing definition and reducing risk thereby increasing confidence in cost estimates, and to provide sufficient engineering information to inform the application for the Development Consent Order and documents required to tender the delivery phase through the Direct Procurement for Customers process. This is likely to include the following.

5.2.1 Refinement of Engineering Design

- Further assessment of geology and geotechnics of the site area, developed in phases, targeted on key sites and areas of concern identified during desktop studies:
  - Determine whether pipeline will traverse through the superficial deposits or bedrock geology to validate ease of excavation ratings assigned along the route
  - Subject to the findings of studies undertaken during option definition stage, perform targeted investigations to confirm ground and groundwater conditions along the route and at proposed structures. These can be supplemented with previous ground investigation records which are available on the British Geological Survey Onshore Geoindex (British Geological Survey, 2022). Geophysical surveys and a review of geomorphological mapping to identify any potential landslides may also be specified.
  - Limited targeted trial pits to confirm the potential for reuse of excavated material as pipe surround. This will be used to inform planning regarding requirements for removal of excavated material and possibilities to re-use as-dug material.
- Further investigation to identify and define services that cross site area, including liaison with owners of high risk services such as high pressure gas mains, to confirm required specifications for crossing design
- Determine locations of washouts and air valves to determine the requirement for, and location of, additional above ground structures.
  - Develop pipeline long section to identify outline pipe profile and required washout locations
  - Identify feasible washout discharge locations and any requirements for additional pumping, tankering or long lengths (or large diameters) of washout pipework
- Further review of hydraulic design and control philosophy including a high level failure modes and effects analysis (FMEA) to ensure the provision of sufficient buffer storage and overflow facilities
- Liaison with SESRO and further development and confirmation of the outfall location and alignment of the final section of the pipeline to the River Thames
- Review possibilities for phased construction of WTW
- Further outline design of assets to define building sizes and heights, including development of intake screening solution
- Identify and review further opportunities such as:
  - Additional carbon reduction opportunities
  - Additional energy recovery and renewable energy opportunities

  - Potential opportunities for the provision of enhanced environmental and social outcomes alongside the key components of the project and biodiversity net gain requirements to maximise social value.

5.2.2 Refinement of Programme and Construction Methodology

- At this stage it is suggested that it would be appropriate to establish Early Contractor Involvement to assist in the following tasks
  - Develop more detailed construction programme including more detailed commissioning plan
  - Develop compound area requirements and identify locations
  - Confirm width of easement for pipeline along complete length of easement
  - Develop outline delivery plan for large diameter pipes
- Develop Commissioning plan
  - Identify requirements and locations for commissioning lagoons
  - Identify water supply for commissioning as required

5.2.3 Development of Operating Strategy

Further development of operating strategy, including:

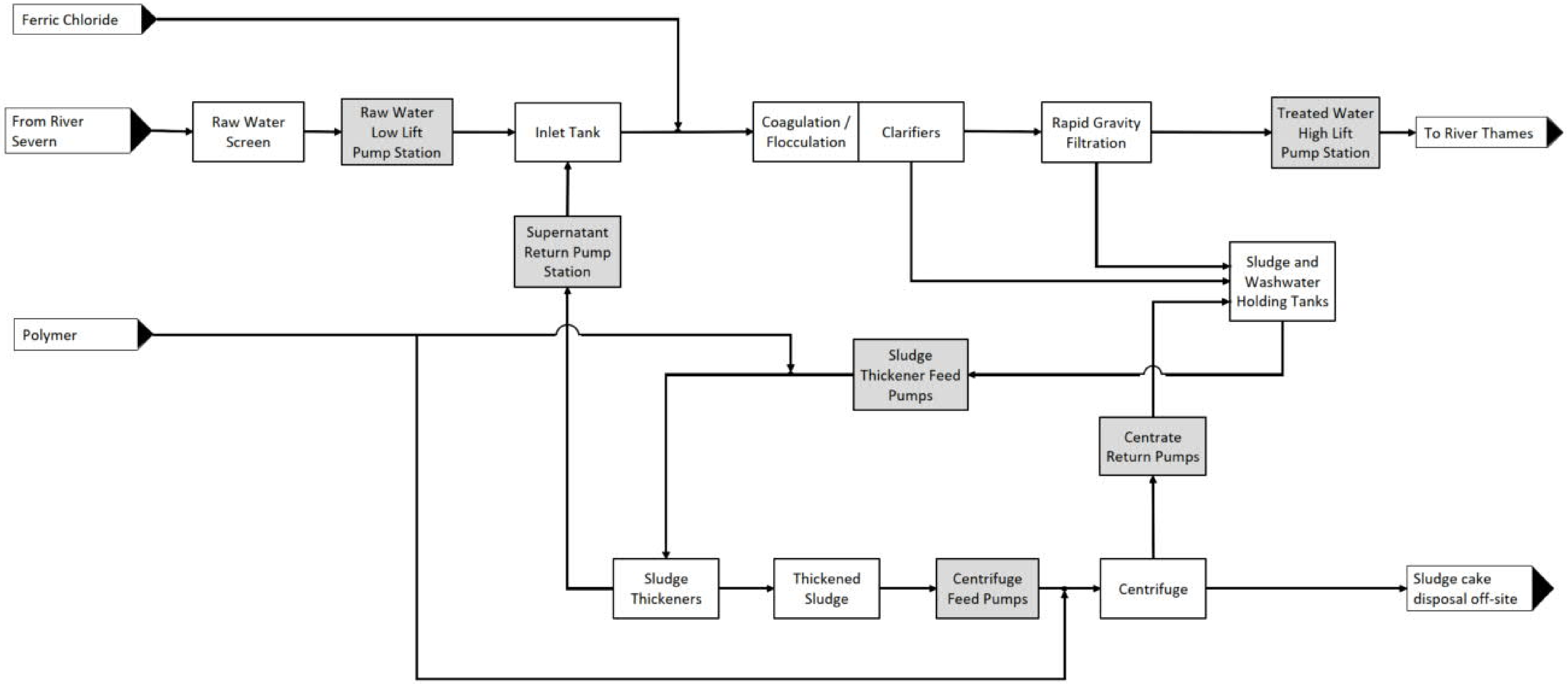
- Further optimisation of sweetening flows
  - Investigate the potential to reduce sweetening flows by the re-aeration of flows at the break pressure tank
  - Desktop research to review any formal research into the requirement and calculation of sweetening flows
  - Consultation with water companies to ascertain existing knowledge in the operation of long raw water pipelines
  - Further consultation with other raw water transfer SRO design teams to compare approaches with the intention of developing a combined approach throughout the SRO programme.
  - Investigate the requirements for ramp up times and how they might be achieved with a lower sweetening flows.
- Define allowable ramp up and ramp down periods, and the corresponding impact on the design of the WTW and operating strategy
- Review outage implications and develop appropriate mitigation as required.

5.3 Development for Planning

Further documentation will be required to support preparation for a DCO submission and examination. This is likely to include, but not be limited to, the following:

- Development of a landscape and architectural concept and design for the scheme (including provision of Biodiversity Net Gain)
- Develop information to support informal and formal consultations with stakeholders and the public
- Develop site layouts to inform red line drawings showing required extent of permanent sites (and the pipeline route)
- Develop information required to inform Environmental Impact Assessment scoping (and later the full EIA), such as confirmation of material for disposal, construction traffic movements

A. Process Flow Diagram



Key to Symbols

Notes

Rev	Date	Drawn	Description	Ch'k'd	App'd
01	10/05/22	HP	First Issue	JB	JT

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SEVERN TRENT · Thames Water · United Utilities

Title

Severn to Thames Transfer SRO
Gate 2
Water Treatment Works
Process Flow Diagram

Designed	E Cook	Eng Check	J Bishop
Drawn	H Prasath	Coordination	J Bishop
GIS Check	N Waldron	Approved	J Tayor

Scale at A3	Status	Rev	Security
	PRE	P1	STD

Drawing Number
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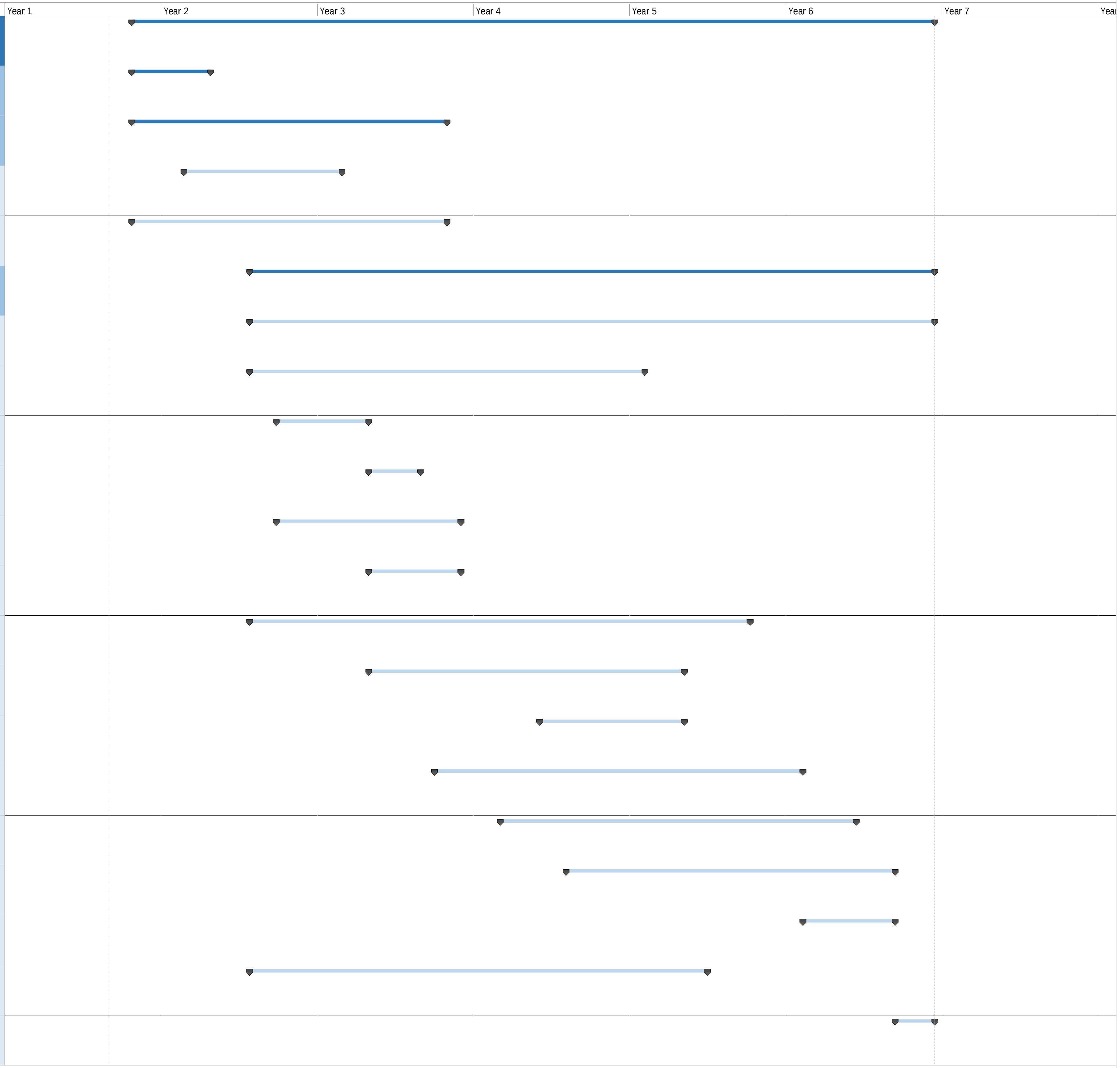
B. Programme

Gate 2 Option

Strategic Resource Option STT Interconnector Construction Programme - Gate 2

ID	WBS	Package	Task Name	Start	Finish
1	1		Severn Thames Transfer	Tue 24/10/28	Wed 14/12/33
2	1.1		Pre-construction activities	Tue 24/10/28	Wed 25/04/29
5	1.2		Mobilisation and Enabling	Tue 24/10/28	Thu 31/10/30
6	1.2.1		Site mobilisation and enabling works	Fri 23/02/29	Wed 27/02/30
10	1.2.2		Procurement of long-lead items	Tue 24/10/28	Thu 31/10/30
16	1.3		Main Construction	Thu 26/07/29	Wed 14/12/33
17	1.3.1		Milestones	Thu 26/07/29	Wed 14/12/33
21	1.3.2	Pipelines	Establish Compounds	Fri 27/07/29	Thu 05/02/32
32	1.3.3	Structures	Intake at Deerhurst	Thu 27/09/29	Tue 30/04/30
37	1.3.4	Pipelines	Pipeline Section A - 400m Twin 1.4m Dia	Wed 01/05/30	Fri 30/08/30
43	1.3.5	Structures	Raw Pump Station	Thu 27/09/29	Mon 02/12/30
49	1.3.6	Pipelines	Pipeline Section B - 1.1km Twin 1.8m Dia	Wed 01/05/30	Mon 02/12/30
55	1.3.7	Structures	Water Treatment Works & HLPS	Fri 27/07/29	Fri 08/10/32
73	1.3.8	Pipelines	Pipeline Section C - 21.5km 1.5 to 1.9m Dia Rising Main	Wed 01/05/30	Fri 07/05/32
79	1.3.9	Structures	Break Pressure Tank	Thu 05/06/31	Fri 07/05/32
87	1.3.10	Pipelines	Pipeline Section D - 22.1km 1.5 to 1.8m Dia Gravity Main	Wed 02/10/30	Wed 09/02/33
93	1.3.11	Pipelines	Pipeline Section E - 21.4km 1.4 to 1.7m Dia Gravity Main	Wed 05/03/31	Mon 13/06/33
99	1.3.12	Pipelines	Pipeline Section F - 20.2km 1.3 to 1.6m Dia Gravity Main	Wed 06/08/31	Tue 13/09/33
105	1.3.13	Structures	Discharge at Culham	Thu 10/02/33	Tue 13/09/33
110	1.3.14	Crossings	Crossings	Fri 27/07/29	Wed 30/06/32
131	1.3.15		Commissioning Acitivities	Tue 13/09/33	Wed 14/12/33



Project: Thames Water Strategic | Task | Milestone | Summary | Project Summary | Critical | Manual Progress

Thu 13/10/22

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