Thames to Affinity Transfer SRO

Technical Supporting Document A1a

Concept Design Report

Lower Thames Reservoir Option

Notice

Position Statement

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

Disclaimer

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

Contents

Figures and Tables

List of Abbreviations

(Not all are used in this annex)

Abbreviation	Definition
ACWG	All Company Working Group
ADO	Average Deployable Output
AFW	Affinity Water
AIC	Average Incremental Cost
AMP	Asset Management Plan
BRI	Beckton Reuse Indirect (identifier for one of the T2AT options)
Capex	Capital Expenditure
CDR	Concept Design Report
CEMP	Construction Environmental Management Plan
CESWI	Civil Engineering Specification for the Water Industry
CSF	Chalk Streams First
DAPWL	Deepest Advisable Pumped Water Levels
D/A/S	Duty/Assist/Standby
DCO	Development Consent Order
DICL	Cement Lined Ductile Iron
DNO	Distribution Network Operator (Electrical Power Supplier)
DO	Deployable Output
DPC	Direct Procurement for Customers
DRA	Direct River Abstraction
DWI	Drinking Water Inspectorate
EA	Environment Agency
EAR	Environmental Assessment Report
FDC	Flow-Duration Curve
FTE	Full Time Equivalent
fWRMP19	Final Water Resources Management Plan for PR19
GAC	Granular Activated Carbon
GUC	Grand Union Canal
H&S	Health and Safety
HLPS	High Lift Pumping Station
HRA	Habitats Regulation Assessment
HS2	High Speed 2
IBC	Intermediate Bulk Containers
INNS	Invasive Non-Native Species

Abbreviation	Definition
LNR	Local Nature Reserves
LTR	Lower Thames Reservoir (Identifier for one of the T2AT options, refers to a group of strategic raw water storage reservoirs situated to the west of London)
LRMC	Long Run Marginal Cost
MCC	Motor Control Centre
MDO	Minimum Deployable Output
Ml/d	Megalitres per Day
NEUB	Non-Essential Use Ban
NIC	National Infrastructure Commission
NNR	National Nature Reserves
NPV	Net Present Value
OB	Optimism Bias
Opex	Operational Expenditure
PR19	Price Review 2019
PR24	Price Review 2024
PS	Pumping Station
QCRA	Quantified Costed Risk Assessment
RAPID	Regulators' Alliance for Progressing Infrastructure Development
RGF	Rapid Gravity Filtration
RMU	Ring Main Unit
RSS	Regional System Simulation
RWPS	Raw Water Pumping Station
RWTM	Raw Water Transfer Main
SAC	Special Areas of Conservation
SCADA	Supervisory Control and Data Acquisition
SEA	Strategic Environmental Assessment
SESRO	South East Strategic Reservoir Option
SPA	Special Protection Areas
SR	Service Reservoir (drinking water storage)
SRO	Strategic Regional Option
SSSI	Site of Special Scientific Interest
STT	Severn Thames Transfer
STW	Sewage Treatment Works
T2AT	Thames to Affinity Transfer
TOC	Total Organic Carbon
TUB	Temporary Use Ban

Abbreviation	Definition
TW or TWUL	Thames Water
TWTM	Treated Water Transfer Main
UV	Ultraviolet
WFD	Water Framework Directive
WIMES	Water Industry Mechanical and Electrical Specification
WRMP19	Water Resource Management Plan for PR19
WRMP24	Water Resource Management Plan for PR24
WRPG	Water Resources Planning Guidelines
WRSE	Water Resources South East
WTW	Water Treatment Works
WRZ	Water Resource Zone
WQRA	(Drinking) Water Quality Risk Assessment

1. Introduction

1.1 Background

1.1. The Thames to Affinity Transfer (T2AT) scheme is a prospective project with the objective of abstracting available raw water from the Thames Water catchment in west, south, and east London; treating it to drinking water standards; and delivering to Affinity Water customers in the area to the north-west, north and north-east of London.

1.2. T2AT is one of the Strategic Resource Options (SROs) identified by Ofwat in its Price Review 2019 (PR19) final determination which are being investigated as potential solutions to meet the forecast water supply requirements across England over the next forty to eighty years.

1.3. Affinity Water and Thames Water are developing the T2AT scheme under the guidance of the Regulators' Alliance for Progressing Infrastructure Development (RAPID). RAPID was formed to help accelerate the development of new water infrastructure and design future regulatory frameworks, with collaboration between Ofwat, the Environment Agency (EA) and the Drinking Water Inspectorate (DWI).

1.4. RAPID has defined a gated process for developing the SROs to identify the optimum set of solutions through which each region will meet their future water supply challenge:

- Gate 1 – Initial feasibility, design and multi-solution decision making (Completed in July 2021).
- Gate 2 – Detailed feasibility, design and multi-solution decision making.
- Gate 3 – Finalised feasibility, pre-planning investigations and planning applications.
- Gate 4 – Planning applications, procurement strategy and land purchase.

1.5. In order to foster consistency in approach across all of the SROs, and drive efficiency through collaboration, the water companies involved have formed an All Company Working Group (ACWG). The ACWG has prepared guidance, in consultation with RAPID, for the teams working on individual SROs on each of the significant topics which need to be covered in the gated submissions.

1.6. Eight options for achieving the objectives of the T2AT scheme were presented at Gate 1. These options were also included within the water resources planning process carried out by Water Resources South East (WRSE); the regional water resource planning alliance that covers the South East of England and comprises the six water companies that operate in this region.

1.7. Further to an option appraisal process, two of the options have been identified as preferential for development to Gate 2, namely the Lower Thames Reservoir (LTR) option and the Beckton Reuse Indirect (BRI) option. The preference for these two options reinforces the selection made in the emerging regional plan prepared by WRSE.

1.8. This concept design report (CDR) sets out the working solution at Gate 2 of the T2AT LTR option. The CDR forms part of a suite of technical documents that support the main T2AT RAPID Gate 2 report. The list of documents that make up the submission, along with a short synopsis of the contents, may be found in the main T2AT RAPID Gate 2 report.

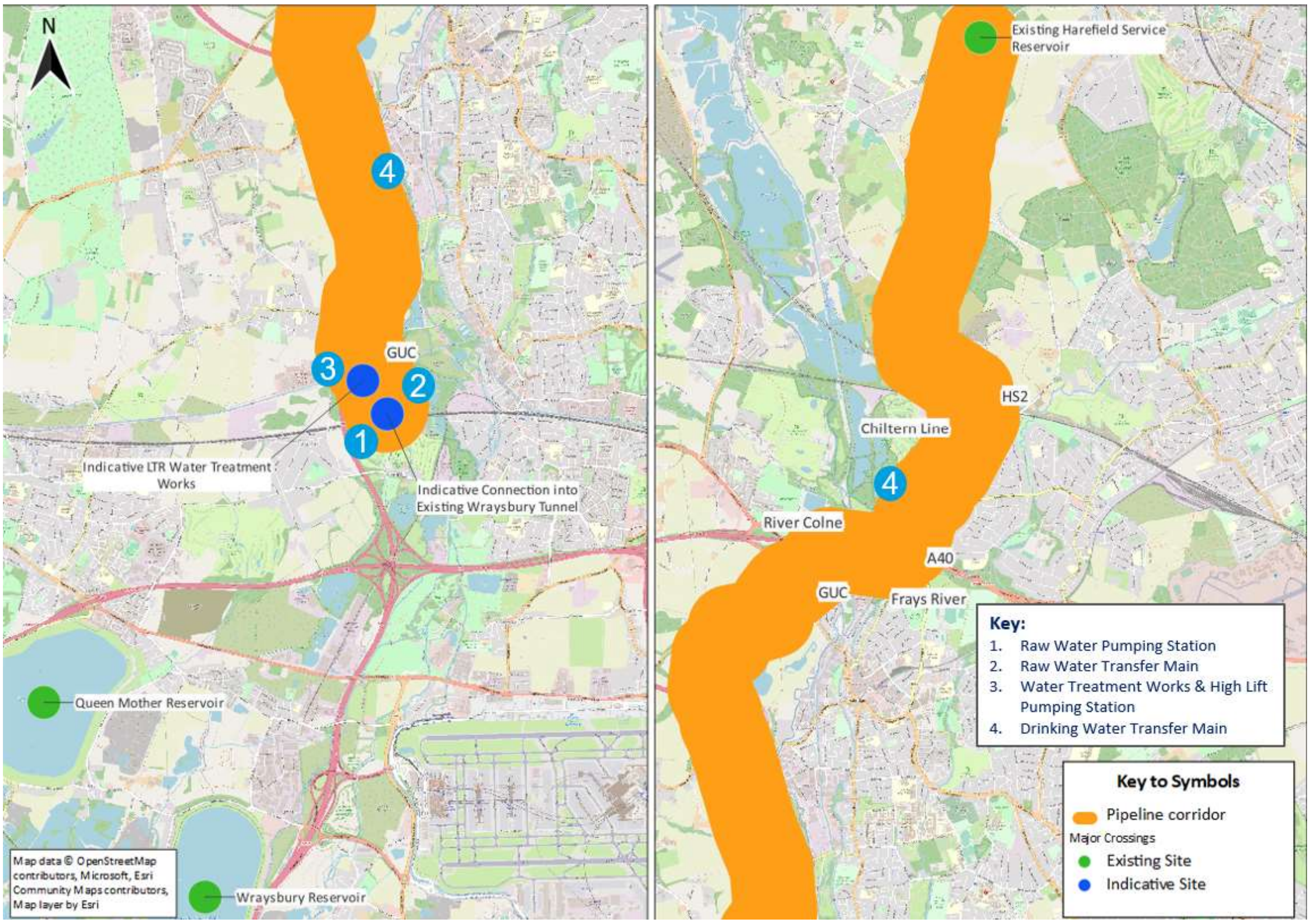
1.9. Readers are asked to bear the following points in mind:

- The working solutions are not fixed and final solutions, they are used for the purposes of modelling and assessing the scheme for the RAPID gated process; there are alternatives to the selected corridors and sites which are available to be consulted upon at a later stage in the project life.
- Consultation with stakeholders will be key to finalising the sites and pipeline routes.
- The working solutions are not the detailed design; there are still numerous studies that will have to be undertaken prior to finalising design decisions if the T2AT scheme is to be implemented.
- The concept design report applies to the T2AT LTR option on its own; the transfer scheme will require enabling infrastructure to be built both upstream and downstream to create a complete system.

1.2 Scheme overview and location

1.10. An overall view of the scheme location is provided in Figure 1.1.

Figure 1.1 LTR option location map



1.11. The source of water for the LTR option is the River Thames. The natural flow in the river will need to be supported, especially during drought years, by the South East Strategic Reservoir (SESRO) SRO and possibly the Severn Thames Transfer (STT) SRO. SESRO is a pre-requisite for the LTR option because without SESRO the LTR option would leave Thames Water with a reduced volume of strategic storage.

1.12. Raw water for the LTR option will be abstracted using the existing Thames Water intake to the Queen Mother and Wraysbury bankside storage reservoirs. These are part of the Lower Thames Reservoir system, hence the name of this T2AT option.

1.13. There is an existing tunnel which allows the afore mentioned reservoirs to provide an alternative source of water to Affinity Water's existing Iver WTW in abnormal circumstances. Under the LTR option it is proposed that a new connection is made into this tunnel, with a raw water pumping station (LTR-RWPS) in an adjacent shaft within the boundary of the existing Iver WTW site.

1.14. The raw water will be conveyed in a new buried transfer main (LTR-RWTM) to a new water treatment works (LTR-WTW).

1.15. Drinking water produced by the WTW will pass through a storage tank before entering a high-lift pumping station (LTR-HLPS) from where it will be conveyed via a buried drinking water transfer main (LTR-DWTM) to the existing service reservoir (SR) in the vicinity of Harefield.

1.16. The LTR-DWTM corridor will be routed to the side of the Colne Valley, crossing it in the vicinity of the A40 corridor. There are several major crossings along the route including the A40 dual carriageway, the HS2 railway, the Chiltern line railway and the Grand Union Canal and other major watercourses that follow the Colne Valley.

1.17. The delivery point for the LTR option is the existing SR in the vicinity of Harefield which is a distribution hub within the Affinity Water network. The scheme will make use of existing, unused SR capacity to provide the necessary strategic storage. Modifications to the network downstream from the SR to distribute the increased inflow are currently being determined by Affinity Water and form part of their wider water resources planning and investment programme.

1.3 Sizing and phasing

1.18. Two alternative capacities have been considered for the LTR option which are sized to provide an increase of 50Ml/d and 100Ml/d of average deployable output (ADO) to Affinity Water respectively.

1.19. For the 50Ml/d alternative it is assumed that the different components of the scheme would be built to come on stream at the same time. For the 100Ml/d alternative it is assumed that while the pipelines and major civil structures would be constructed to accommodate the ultimate capacity, investment would be delayed wherever possible on the process units and mechanical plant, half of which would be built in a second phase.

1.4 Links with other options, schemes and elements

1.20. The LTR option is dependent on additional water resource being made available for abstraction from the River Thames as the current availability is fully accounted for by existing abstraction licences. As mentioned in paragraph 1.11 above, the additional resource availability will be created by implementing the SESRO, and possibly the STT, scheme(s). The overall ADO generated by these “source” schemes, and how it is distributed between T2AT and the other “transfer” schemes which depend upon them, such as the Thames to Southern Transfer SRO, is reported in the submissions associated with those SROs.

1.21. SESRO is a pre-requisite for the LTR scheme because Thames Water consider that without the new reservoir, the scheme would leave Thames Water with an unacceptable reduction in the volume of strategic storage available to them. Further information on the proposed sequencing of the T2AT delivery to meet this constraint and to reflect the timing of the need for the T2AT implementation in the WRSE draft Regional Plan may be found in Supporting Document F-1: Project Delivery Plan.

1.22. The anticipated earliest completion date of the SESRO project is 2040. It is anticipated that the time required to plan, develop, construct and commission the transfer scheme would be 11 years. This means that the next stage of development of T2AT does not need to start in earnest until 2029. This aspect of the project is covered in more detail in Technical Supporting Document F, the project Delivery Plan.

1.23. The LTR option will deliver additional drinking water into the existing SR in the vicinity of Harefield. The scheme will make use of existing reservoir capacity, some of which is currently surplus to requirements and out of service.

1.24. In order to distribute the additional water to customers, enhancements to the existing network downstream from Harefield will be required. The nature and timing of these enhancements will be dependent on the implementation of other schemes, such as the Grand Union Canal (GUC) SRO. Affinity Water is undertaking a long-term planning exercise (Connect 2050) to determine their bulk water transfer needs (within and between Affinity Water supply zones). Investments required to implement these strategies over the next AMP period (AMP8) will be included in Affinity Water's Water Resources Management Plan for the 2024 period review (WRMP24).

1.25. The LTR option is compatible with the water resources management concept proposed by Chalk-Streams First initiative. The organisation highlights that reductions in groundwater abstractions will allow the aquifers to recharge allowing flows to recover, T2AT in combination with SESRO help to facilitate this. A proportion of the flow increase in chalk streams surrounding London, will be available for abstraction as a water supply resource further downstream i.e. the River Thames. Affinity Water are currently determining what that proportion would be under different scenarios but, although it may provide a resource for some towns and villages currently served by groundwater abstraction, it would not be sufficient on its own to reliably meet the full requirements of T2AT, especially under drought conditions, hence T2AT's reliance on SESRO.

2. Conceptual Design

2.1 Design principles

2.1.1 Scheme requirements

2.1. In order to cover the range of new resources that are envisaged to be required by AFW, two capacities for the T2AT scheme have been developed, a 50Ml/d and a 100Ml/d ADO variant. The ongoing water resources modelling and assessment that feed into the WRSE regional modelling shall determine which of these two variants is required, further details of this analysis are in Section **Error! Reference source not found.**.

2.2. Potential sources of water for the scheme are the SESRO SRO and the STT SRO. The process of selecting the LTR option for development out of a long list of 33 potential options is described in the Technical Supporting Document A4: the Options Appraisal Methodology Report. The majority of that process took place prior to Gate 1.

2.3. It is a requirement that the scheme will assure the supply of water to customers during drought conditions of a severity which is only expected once in 500 years. Further details of how this has been analysed are provided in chapter **Error! Reference source not found.**.

2.4. The LTR option will draw water from the existing Lower Thames Reservoirs, specifically the Queen Mother Reservoir and the Wraysbury Reservoir. The ability to abstract must be reliable across the full range of operating levels in the reservoirs and must not jeopardise the existing supply infrastructure between the reservoirs and Iver WTW. The proposed scheme should not interfere unduly with the current ability of Iver WTW to obtain part of its supply from the Lower Thames Reservoirs.

2.5. Water abstracted from the reservoirs needs to be treated to Affinity Water's drinking water quality standards without undue risk of failure or undue risk of generating customer complaints.

2.6. The scheme should be designed such that its implementation, commissioning and operation does not cause a breach of any regulatory requirements or otherwise cause an unacceptable impact to the environment or affected communities. In fact, where practical, the design should identify areas where the scheme could create positive impacts on the environment (for instance improving the setting of a listed building) and benefits to the community beyond the basic objective of assuring the supply of safe drinking water to the public.

2.7. The design of the scheme should take into account the need to optimise the use of natural resources and energy, and to minimise greenhouse gas emissions, both in its implementation and operational phases.

2.1.2 Anticipated operational regime and utilisation

2.8. To meet the required alternative capacities of 50Ml/d and 100Ml/d of ADO to Affinity Water, a higher volume of raw water abstraction capacity needs to be provided to account for losses in the system.

2.9. An allowance for operational losses in the WTW process of 5% (of the required increase in ADO) has been allowed.

2.10. As explained in chapter **Error! Reference source not found.**, in order to provide an increase in ADO of 50Ml/d or 100Ml/d, the maximum drinking water output capacity of the scheme has to be approximately 10% higher.

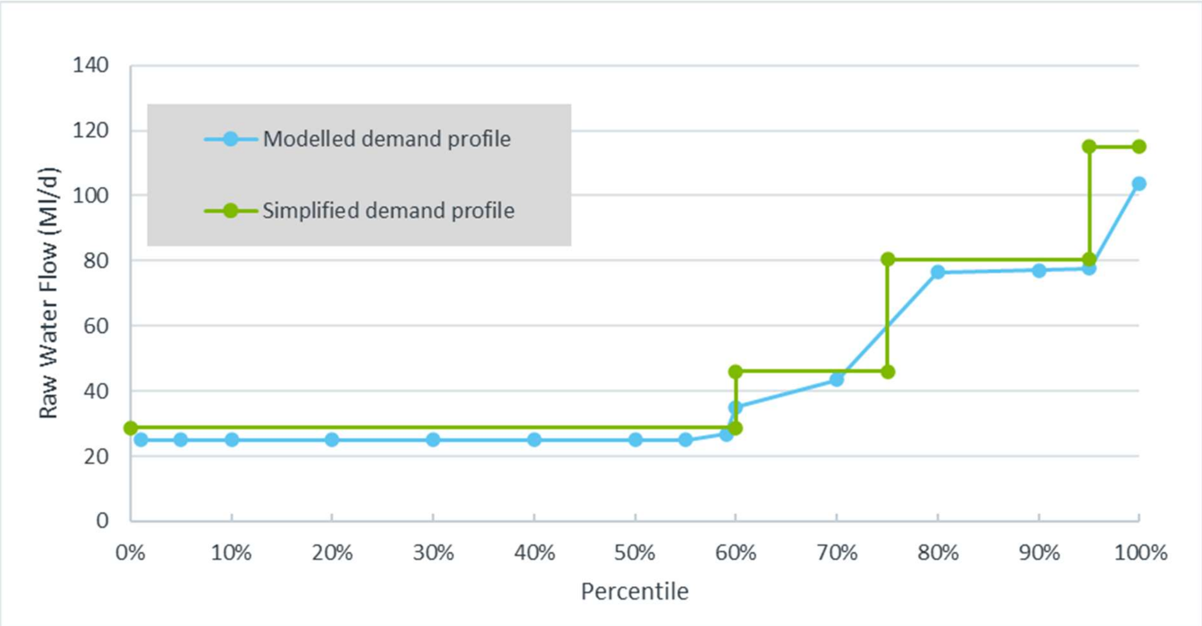
2.11. The concept design is therefore based on the capacities shown in Table 2.1 below.

Table 2.1 Raw and drinking water capacities

Required increase in ADO	Drinking water output required	Raw water capacity required
50	55	57.5
100	110	115

2.12. As described in chapter **Error! Reference source not found.**, it is not expected that the scheme will be used at 100% capacity for 100% of the time. If the T2AT scheme is modelled as the last source to be utilised, then there are significant periods during which the scheme is not called on at all. However, the nature of water treatment processes is that it takes a significant amount of time and cost to recommission a WTW from a complete standstill. Therefore, the scheme will always be operated at a minimum throughput of 25% of its full capacity. For the 100 Ml/d alternative this gives the utilisation frequency profile shown by the blue line in Figure 2.1 below.

Figure 2.1 Utilisation frequency profile for the 100Ml/d ADO alternative



2.13. For the purposes of calculating Opex for the T2AT scheme, the profile has been simplified as shown by the green line in Figure 2.1. The simplified utilisation profile for each alternative is shown in tabular form in Table 2.2.

Table 2.2 Simplified utilisation profile for 50Ml/d ADO and 100Ml/d ADO alternatives

Utilisation (% of Capacity)	Proportion of time spent at utilisation (% of time)	Raw water flow for 50Ml/d ADO alternative (Ml/d)	Raw water flow for 100Ml/d ADO alternative (Ml/d)
0%	0%	0	0
25%	60%	14.4	28.8
40%	15%	23	46
70%	20%	40.3	80.5
100%	5%	57.5	115

2.14. Note that the average utilisation is 40% for both alternatives, giving a long-term average raw water flow of 23Ml/d for the 50Ml/d ADO alternative and 46Ml/d for the 100Ml/d ADO alternative.

2.15. In practice, once the scheme is in place, it is likely that the operators will find that there is a cost-efficiency to be gained by sharing the demand for water between the existing facilities and the new scheme. For this reason, the concept design has optimised pipe diameters for the scheme running at 100% capacity. There is some scope to refine this, through further study of how the scheme might actually be used in the future, once there is an understanding of the cost of raw water obtained from the Lower Thames Reservoirs.

2.1.3 Applicable national and water company standards

2.16. The scheme will be designed to comply with applicable national standards and good practice guidelines. The main categories of standard are outline in this section.

2.17. The engineering work will be designed in accordance with the most recent British Standards, many of which are still aligned with European Standards.

2.18. The design will follow regulations and guidance produced by national regulators, such as the Environment Agency, the Drinking Water Inspectorate and Natural England. This includes statutory regulations, such as the Water Supply (Water Quality) Regulations as well as best practice guidance on how to comply with regulations, such as the Environment Agency document; Screening at intakes and outfalls: measures to protect eel.

2.19. The water industry in the UK has developed specifications that have been agreed across water companies. These include the Civil Engineering Specification for the Water Industry (CESWI) and the Water Industry Mechanical and Electrical Specification (WIMES). Each Water Company has generated their own amendments to these documents. In the case of T2AT, it is the Affinity Water amendments that will be applicable.

2.20. Affinity Water have also developed their own suite of detailed standard specifications and design standards to supplement CESWI and WIMES. For some items a suitable standard specification was not available from Affinity Water. In these cases, Thames Water standard specifications have been used for guidance.

2.1.4 ACWG and other SRO specific guidance

2.21. The ACWG has set high-level design objectives for the SRO projects[1]. These objectives have been derived from the National Infrastructure Commission's (NIC) Design Principles structure, which considers design under four headings: Climate, People, Places and Value. They have been arrived at through discussion, policy review and precedent study to represent best practice for the SRO projects.

2.22. The design objectives fall under the following categories:

- Cross Cutting Design Principles; including health and safety in design
- Climate; Mitigate greenhouse gas emissions and adapt to climate change
- People; Reflect what society wants and share benefits widely
- Place; Provide a sense of identity and improve our environment
- Value; Achieve multiple benefits and solve problems well

2.23. The guidance outlines nine steps in an iterative process towards completing the project design:

1. Understand the nature, objectives, requirements and components of the project
2. Understand the places that the project will affect
3. Understand the people that will be affected by the project
4. Identify the opportunities arising from the project
5. Identify the key considerations, constraints and opportunities
6. Develop the project design vision and principles
7. Embed the design principles into the host organisation
8. Design to maximise benefits and minimise adverse effects
9. Capture important design decisions

[1] Design Principles, Process and Gate 2 Interim Guidance – ACWG - December 2021

2.24. These iterations take place across the following design stages

A. Site/corridor optioneering

B. Identification of the preferred site/corridor

C. Concept design and options testing

D. Design development to Development Consent Order (DCO) / planning application

E. Design development post-planning

F. Technical design for construction

G. Management plans, maintenance, specifications etc.

2.25. During Gate 2 development the multidisciplinary project team (including environmental, planning and engineering specialists) held workshops framed around the design principles to develop the concept design.

2.26. In accordance with the ACWG guidance, the Gate 2 option development has focussed on steps 2 to 6 of the iterative process and, also in line with the guidance note, has passed through design maturity stages A and B and is presented at Gate 2 while it is within stage C.

2.27. The scheme is likely to be progressed as a DCO under the Planning Act 2008 (PA2008) rather than via a conventional planning application under the Town and Country Planning Act 1990 (TCPA1990). The planning strategy is described in Technical Support Document G; Planning, consenting and land acquisition strategy.

2.1.5 Risk Management

2.28. As at Gate 1, we have continued to consider risk across the project. We have a qualitative risk register, which is used to record, track and manage pre-construction phase risks, mostly associated with consenting and delivery programme. This risk register informs the quarterly reporting to RAPID. We have also developed a Quantitative Costed Risk Assessment (QCRA), which has been used to help derive estimates of construction phase financial risks for Gate 2. Finally, we have the Water Quality Risk Assessment (WQRA) which has been compiled using the All Companies Working Group (ACWG) approved spreadsheet tool. Both the WQRA and QCRA were reviewed via workshops.

2.29. Details of the qualitative risk register are provided in Supporting Document 1 - RAPID Gate 2 Report, whilst details of the WQRA are provided in Supporting Technical Document Ca: Drinking Water Risk Assessment, with details of the QCRA being provided in Supporting Technical Document A2a: Cost Report. To ensure a degree of consistency across the different SROs, the ACWG has provided guidance and a spreadsheet template for capturing the Quantitative Costed Risk Assessment (QCRA) and calculating Optimism Bias (OB)[2].

2.30. Throughout the WQRA process, the list of limiting hazards for each option has been reviewed and refined to give a representative, high-level view of the parameters which are likely to need treatment at this early stage of design. The WQRA process has also identified data gaps and residual risk considerations that can now be addressed moving forward into the next phase of works, and through to the development of a Drinking Water Safety Plan (DWSP) for any option to be progressed to scheme promotion.

2.31. In order to further develop our risk understanding, a number of Gate 3 activities have been identified, the proposed work breakdown is detailed in Supporting Document F: Project Delivery Plan. The Supporting Document F: Project Delivery Plan focuses on the key aspects of the risk registers, discussing the highest priority risks and what activity is being undertaken to mitigate the major cost and programme risks during future phases of the project.

2.32. Below are examples of the future activities, which would likely be used to inform future risk assessments;

- Environmental and engineering site surveys, including:
  - Walkover surveys
  - Ground investigations
  - Groundwater and surface water monitoring
  - Asset location and condition surveys
  - Geophysical survey and planning archaeological evaluation surveys
  - Ecological, biodiversity and arboriculture surveys
  - Further raw water quality sampling
- Topographical survey, especially of watercourses and river structures
- Initial non-statutory consultations and liaison with affected stakeholders
- Further early contractor engagement
- Further modelling of need and alternatives, as required, using WRSE regional system simulator and investment model, to reflect commentary from public consultations on WRSE and WRMP strategic plans.

2.2 Scheme components and operating philosophy

2.2.1 WTW site selection

2.33. The working solution location for the new WTW, which has been adopted as the working solution for Gate 2 development, is to the north of the existing Iver WTW.

[2] ACWG (2021), Appendix A-1 - Optimism Bias and QCRA Template - Rev C.xlsx

This location was identified through a thorough review of several potential sites and was found to be the best match to the technical, environmental, community and planning criteria considered. In particular, the working solution location is considered to have the lowest impact within the designated green belt area and minimises the risk associated with long raw water pipelines. The identification and review process are described in Technical Supporting Document A5, the Options Refinement Report.

2.34. The site is of sufficient size to accommodate the necessary treatment units and supporting buildings and infrastructure, including power supply, chemical storage and sustainable surface water drainage. There is also space for the necessary sludge treatment and storage, six hours of drinking water storage and the high lift pumping station. The components of the WTW will be arranged and designed in a manner which will enhance the setting of the listed building which is surrounded by the suggested site.

2.35. The site is adjacent to the Colne Brook, which currently accepts overflow discharges from the Grand Union Canal. It is considered that it will be possible to negotiate a consent for emergency discharges into this watercourse provided that adequate provision is made to guarantee that;

- discharges will be treated to a suitable standard as agreed with the regulatory authority and
- discharge flow will be less than the agreed maximum rate, so as not to cause any adverse impacts to the receiving water body.

2.2.2 Pipeline corridor selection

2.36. The Gate 2 working solution for the drinking water transfer main corridor is shown in Figure 1.1. The pipeline corridor will be routed along the east side of the M25, and the west side of the Colne Valley, before crossing the valley in the vicinity of the A40 corridor. The corridor then passes to the west of Ickenham before heading north to cross the Chiltern line railway and the HS2 high speed railway near to Harvil Road. From this point to the SR, the corridor crosses open countryside.

2.37. There are several major crossings along the route including the A40 dual carriageway, the HS2 railway, the Chiltern line railway and the Grand Union Canal and other major watercourses that follow the Colne Valley.

2.38. The working solution corridor was determined through a process of identifying a series of small segments and assessing them against a schedule of technical, environmental, community and planning criteria. The selected chain of segments which constitutes the working solution at Gate 2 is the corridor which best matches the criteria across all disciplines.

2.39. The main challenge for selecting the pipeline corridor was identifying the best place to cross the Colne Valley. In practice there were only two viable alternatives, the A40 corridor (as selected) and an alternative corridor through Denham and Harefield Villages, passing through the narrow strip adjacent to Widewater Lock. This alternative would involve considerably more disruption to the public.

2.40. The identification process is described in Technical Supporting Document A5, the Options Refinement Report. The final choice of pipeline corridor for the option will be subject to further appraisal, environmental survey and consultation. The working solution documented within this CDR is not a fixed and final solution as noted in paragraph 1.9 above.

2.2.3 Drinking water quality and process design

2.41. The proposed process for the WTW has been determined through a review of the risks associated with the key water quality parameters associated with the raw water source, the downstream distribution network, and ultimately the product delivered to customers. Essentially, the approach, which has been outlined by the ACWG, identifies the "Limiting hazards" and then determines the most appropriate means of reducing that hazard to below the level required by Affinity and Thames Water's standards.

2.42. The drinking water risk assessment process is described fully in Technical Support Document Ca; Drinking Water Risk Assessment Report - Lower Thames Reservoir Option.

2.43. Further raw water quality monitoring is being undertaken, both in the River Thames and in the Wraysbury Reservoir, to increase the confidence in the available data set upon which the risk assessment is based.

2.44. A conventional water treatment process is proposed consisting of fine screens, clarification, rapid gravity filtration (RGF), ozone conditioning, granular activated carbon (GAC) filtration and chlorination to provide residual disinfection as shown in Table 2.3.

Table 2.3 Proposed treatment processes

Process	Details
Pre-ozonation	For treatment of pesticides, to control the formation of trihalomethanes and to control taste and odour. Additionally, to aid in downstream coagulation.
Clarification	Consisting of coagulation, flocculation, and settlement. This process helps to remove colloidal material from water and reduce its turbidity, reducing the number of microorganisms and other organic matter passing to downstream treatment processes.
Rapid gravity filtration	For removal of residual floc and residual turbidity,

Process	Details
Ozonation	For treatment of pesticides, to control the formation of trihalomethanes and to control taste and odour. Additionally, to aid effectiveness of downstream GAC filters.
Granular activated carbon	For the removal of pesticides, taste and odour forming components and colour.
Disinfection	Via chlorination for pathogen kill.

2.45. Consideration was given to including an Ultraviolet (UV) disinfection stage to provide 4-log removal or inactivation of cryptosporidium. However, this was discounted as it was decided that raw water storage in the Wraysbury and Queen Mother reservoirs would provide sufficient attenuation of cryptosporidium in conjunction with the conventional treatment process outlined above to achieve 4-log removal without the need for enhanced treatment.

2.46. Clarifier sludge, as well as RGF and GAC dirty backwash water, will go into a wastewater system, which will consist of a wastewater holding tank, sludge thickening and sludge centrifuge.

2.47. Supernatant from the wastewater system will be recycled through to the head of the works. As cryptosporidium is low risk in the system, the supernatant will be internally recycled at up to 10% of the works flow. If for any reason there is a raw water quality event that causes it to be high risk, and it has not been possible to obtain an emergency discharge consent to the local watercourse, then an arrangement will need to be made with Thames Water to discharge it to a sewer as trade effluent.

2.48. It is anticipated that the sludge cake will be taken off site by road, to a licenced waste disposal facility.

2.2.4 Design of connection and raw water pumping station at Iver

2.49. It is proposed that a new shaft is sunk adjacent to the existing standby pumping shaft at Iver WTW and a heading driven to connect the two shafts at low level. These are “dry” shafts, meaning that the flow is contained within pipework within the shafts and there is no free water surface. A piped connection will be made to the existing feed from the raw water reservoirs such that the existing alternative feed routes to Iver WTW will be retained.

2.50. The concept design anticipates a lined segmental shaft. The Great Western Main Line is potentially within the zone of influence for ground movement arising from shaft construction. Design of the shaft will need to ensure that anticipated ground movement is well within the allowable limits, and a suitable monitoring programme, to detect actual movement against pre-agreed trigger levels will need to be agreed well in advance with Network Rail.

2.51. The method of construction of the cross-connecting header will depend on the ground conditions identified during the geotechnical investigation.

2.52. The new shaft will contain the low lift pumps, installed at a sufficiently low level that there will always be a positive pressure on the suction side of the pumps.

2.53. For the 50Ml/d ADO alternative, the required 57.5Ml/d of raw water delivery to the WTW will be achieved by installing four (three duty plus one standby) pumps.

2.54. For the 100Ml/d ADO alternative, the required 115Ml/d flow rate will be achieved by installing six (five duty plus one standby) pumps. These pumps will be installed in two phases, with only four (three duty plus one standby) pumps being installed in the first phase.

2.55. Surge vessels will be needed to ensure that transient pressures in the raw water rising main remain within acceptable limits. It is proposed to install three (two duty plus one standby) vessels for the first alternative, or for the first phase of the larger alternative, and to add a further vessel in the second phase if the larger alternative is required.

2.2.5 Raw water transfer main

2.56. The raw water will be conveyed along a 0.5km long buried pipeline to the new WTW. For the 50Ml/d ADO alternative, the concept design is based on a DN900 cement lined ductile iron (DICL) pipeline, for the 100Ml/d ADO alternative a DN1200 DICL pipeline is proposed.

2.57. As mentioned in section 2.1.3, there is scope for optimising the pipeline diameter once the utilisation of the scheme in conjunction with other drinking water sources is better understood. Selection of the most appropriate pipe material will need to be left as late as possible in the procurement process as the relative price, and embedded carbon emissions, of ductile iron, steel and other materials is volatile.

2.58. It is expected that the raw water transfer main will be laid entirely in open-cut trench.

2.2.6 Proposed modifications at Laleham Intake

2.59. Thames Water abstract water from the River Thames at Datchet to feed the Queen Mother and Wraysbury reservoirs. At Gate 1 the LTR option included an allowance for providing enhancements at Thames Water's Laleham Intake, which is downstream from Datchet. It was envisaged that additional abstraction capacity into the Lower Thames Reservoirs system would be required to compensate Thames Water for abstraction capacity at Datchet now "given" to Affinity Water. On further consideration it has been seen that this is an over-simplification of the situation; the additional water that passes through the Queen Mother and Wraysbury reservoirs on its way to feed T2AT will be replaced by abstracting for longer periods, rather than increasing the abstraction rate. The longer pumping duration is likely to take place at both Datchet and Laleham. This means that no enhancement is required at either intake under the T2AT scope of work. Nevertheless, a risk allowance has been included in case some enhancement measures, such as additional water quality monitoring, are brought back into the project in future.

2.60. There is a possibility that low-rate pumps will be required at Laleham to make optimum use of the water stored in SESRO, and an appropriate risk allowance has been included in SRO to cover this eventuality.

2.2.7 Civil design of LTR-WTW and LTR-HLPS

2.61. The main civil structures which will be required for the WTW are as follows:

- Inlet chamber, flocculation and clarifiers
- Rapid gravity filters (RGF) including clean washwater holding tanks
- Interstage pumping station
- Ozonation chamber
- Granulated activated carbon (GAC) filters including clean washwater holding tanks
- Chlorine contact tank
- Treated water storage tanks
- High lift pumping station and surge vessels
- Sludge and dirty washwater holding tanks
- Sludge thickeners
- Thickened sludge holding tank
- Sludge dewatering building
- Sludge cake storage and sludge truck loading facility
- Supernatant holding tank and supernatant return pumping station
- Chemical storage and dosing building (including sodium hypochlorite for chlorination)
- Ozone generator including liquid oxygen storage
- Step-down transformer and ring main unit bases and compounds.
- Administration and control building
- Site pipework
- Electrical duct network
- Surface water drainage including detention lagoon
- Foul drainage
- Emergency overflow and discharge pipework including attenuation storage (if required) and conditioning facility
- Site access roads, car park, paths and security fencing

- Hard and soft landscaping

2.62. The ACWG guidance on design requires a high quality of design for the WTW structures, and previous experience at Iver suggests that the structures will need to be of similar appearance to the existing works. If the working solution site is selected, then the architectural treatment of the plant will be of particular interest around the listed building which lies within the site. A high quality of architectural finish does not necessarily mean a large increase in cost, but value for money will need to be demonstrated by Thames and Affinity Water, especially where there are no sensitive receptors to visual impact.

2.2.8 MEICA design of LTR-WTW and LTR-HLPS

2.63. The main MEICA elements of the WTW are as follows:

- Pre-ozone static mixer (may be within the inlet pipework)
- Flocculation mixers
- Lamella Clarifiers
- RGF air scour blowers and backwash pumps
- Interstage pumps with variable speed drives (for 50Ml/d ADO 2 duty +1 standby, for 100Ml/d ADO 4 duty + 1 standby)
- GAC filters air scour blowers and backwash pumps
- High lift pumps with variable speed drives (for 50Ml/d ADO 2 duty +1 standby, for 100Ml/d ADO 4 duty + 1 standby)
- Surge vessels and associated compressors (for 50Ml/d ADO 1 duty +1 standby, for 100Ml/d ADO 2 duty + 1 standby)
- Sludge processing equipment including feed pumps, scrapers, centrifuges and sludge handling
- Chemical storage, fill point, preparation and dosing plant. In particular:
    - Ozone generation equipment including liquid oxygen storage, ozone generators, vaporisers, refrigeration and destructors.
- Service water and wash-down ring main
- Motorised valves for isolation and modulating flow, and other process control devices
- Incoming Distribution Network Operator (DNO) supply switchgear and metering – twin feeds 1 duty + 1 standby
- Motor Control Centre (MCC) feeding high lift pumps via variable speed drive units
- Ring main feeding three ring main units (RMUs) each equipped with a step-down transformer feeding the following MCCs:
    - RMU1

    - Raw water pumping station
  - RMU2
    - Clarifiers
    - RGF
    - Ozone generator
  - RMU3
    - Interstage pumps / GAC
    - Sludge treatment centre
    - High lift pumping station ancillary equipment
- Heating, ventilation and air conditioning
- Internal and external building services and lighting
- Supervisory control and data acquisition (SCADA) system communicating with distributed control in each MCC
- Plant instrumentation including water quality, level and flow monitoring
- Communication, telemetry and security systems

2.64. At Gate 2 the concept design is proposing dual electrical power feeds in lieu of a single feed with on-site standby generation. This avoids the operating costs and security risks associated with maintaining the generator units, purchasing and storing fuel, and managing unused, aging fuel. On the downside it means that Thames and Affinity Water cannot take advantage of the commercial benefits of on-site standby generators such as triad avoidance and spinning reserve.

2.65. Initial enquiries are being made with UK Power Networks, the DNO for the Iver area, to establish the extent of network reinforcement that will be required to provide the dual supplies proposed.

2.66. The duty point of the high lift pumps proposed in the concept design requires 690kW motors. These are supplied at 11kV as would normally be the case for motors of this rating. However, Affinity Water prefer equipment to be supplied at 400V which does not require the attendance of HV qualified technicians. It would be possible to specify that the motors are designed to operate on 400V, or a higher number of smaller pumps could be provided, but there would be an associated capital cost penalty.

2.2.9 Drinking water transfer main

2.67. The drinking water produced by the WTW will be conveyed along a 14km long buried pipeline to the existing SR in the vicinity of Harefield. The pipeline corridor is described in section 2.2.2. For the 50Ml/d ADO alternative, the concept design is based on a DN800 cement lined ductile iron (DICL) pipeline, for the 100Ml/d ADO alternative a DN1200 DICL pipeline is proposed.

2.68. As with the raw water pipeline there is scope for optimising the pipeline diameter once the strategy for use of the scheme in conjunction with other drinking water sources is further developed. Similarly, selection of the most appropriate pipe material will need to be left as late as possible in the procurement process as the relative price of ductile iron, steel and other materials is volatile.

2.69. The transfer main will generally be buried with a minimum depth of cover of approximately 900mm in open land and 1,200mm under roads and trafficked areas. Once the ground has been reinstated, buried pipelines are generally non-intrusive with few visual clues to their whereabouts. The most significant permanent visual impact is where the corridor passes through a wooded area or line of trees where it is normal to leave a grass swathe, it not being acceptable practice to reinstate trees close to the pipe. For this reason, the working solution pipe corridor avoids such areas as far as possible.

2.70. Isolation valves will be provided at regular intervals along the route. A drain valve and chamber or flushing point with hydrant will be provided at each low point on the pipeline and an air valve will be provided at each high point.

2.2.10 Modifications at Harefield Reservoir

2.71. Harefield service reservoir is not fully utilised at present by Affinity Water; one compartment of reservoir number 3 is out of service to ensure that water is not retained in storage for too long, as this could give rise to water quality deterioration.

2.72. It is therefore proposed that the T2AT pipeline feeds into reservoir number 3 and when the throughput of the reservoir rises sufficiently, the unused compartment is brought back into service.

2.73. The configuration of the existing inlet and outlet at SR has been assessed against good practice guidance and a new connection arrangement proposed. The final arrangement will need to be confirmed via modelling when flow rates are finalised, including an assessment of the possible impact on the existing system.

2.74. The flow required at Harefield is determined by the downstream demand. Affinity Water are investigating how best to configure changes to the distribution network that is fed from Harefield via the Connect 2050 programme. This reconfiguration will require further consideration during future project stages to ensue T2AT demand is fully understood, and how the utilisation of T2AT will interact with the utilisation of other sources.

2.2.11 Control Summary

2.75. Raw water will be drawn from the existing tunnel by using variable speed pumps within the new LTR-RWPS. LTR-RWPS will pump flows at a controlled rate to LTR-WTW.

2.76. The speed of the raw water pumps will vary automatically to control the delivery flow to match a set point as monitored on a local flowmeter. The RWPS output becomes the flow into the treatment works. The flow set point will be adjusted incrementally should the water level in the treated water tank rise above or fall below a defined “dead band” for a set period of time.

2.77. Fluctuations in the output of the works arising from filter backwashing and other events will be buffered by the storage volume in the treated water tank.

2.78. The water level at strategic points in the WTW and in the treated water tank will be monitored. High levels will trigger a reduction in the raw water set point flow. High-High levels or overflows will initiate a controlled shutdown of the raw water pumps and consequently the WTW.

2.79. In line with instructions received from Affinity Water’s control centre, the WTW operator will set the required flowrate from the LTR-HLPS to meet the demand for water into the SR. The WTW operator will also have the option to transfer this function to the Affinity Water control centre.

2.80. The speed of the high lift pumps will vary automatically to control the delivery flow, as monitored on a local flowmeter, to match the required flow set point. A secondary trim function will adjust the flow set point incrementally below that set by the operator if the water level in the SR rises above a pre-determined level for a set period of time. If the level falls below a pre-determined level for a predetermined time the set point will return incrementally back to the original flow rate set by the operator. A High-High level or overflow at the SR, or a loss of signal, will trigger a controlled shutdown of the high lift pumps. Should the reduced flow or shutdown condition persist then the water level in the treated water storage tank will rise, leading to a reduction in the raw water pumped flow and ultimately a WTW shutdown.

2.81. The control of flow into the SR will need to be integrated with existing control systems governing the current inflow.

2.3 Alternative options and opportunities

2.82. The working solution documented within this CDR is not a fixed and final solution as noted in paragraph 1.9 above, therefore the options and alternatives presented below are not discounted. We shall continue to develop our thinking and our approach managing scheme risks and if appropriate adjust the concept design during future gateways.

2.3.1 Cross connection to Sunnymeads tunnel

2.83. At Gate 1, it was suggested that an enhancement to the LTR option would be to provide a resilience connection from the Sunnymeads tunnel to the LTR raw water pumping station. Whilst this would undoubtedly provide some resilience benefit, it would introduce the following complications:

- The drinking water risk assessment for the LTR WTW is based on a degree of Cryptosporidium risk reduction being provided by the raw water reservoirs. If a direct river water feed was provided from Sunnymeads then consideration would have to be given to introducing an additional treatment stage in the new WTW.
- The concept design takes advantage of the hydraulic head available in the raw water reservoirs. A resilience connection to the Sunnymeads tunnel would require the pumps to be installed at a lower level to ensure that sufficient head was available at the pump inlet. The concept design connection arrangement would need to be significantly altered, potentially with a deeper shaft and a lower-level cross-connection adit to provide the right hydraulic conditions.

2.3.2 Alternative locations for LTR-WTW

2.84. During the process of option refinement, several possible WTW locations were identified. One possibility was a brownfield site that is not within the green belt, but this was discounted because it is earmarked for residential development within the local plan. The working solution site was selected from the remaining options on the basis that it had the least adverse impact on the green belt. The final selection of the WTW site will need to be made through a process of engagement with the public and other stakeholders.

2.85. Whilst the working solution for the site appears to be the most practical and the one with lowest adverse impact in the light of current knowledge, further information may arise during project development which challenges this conclusion. If the ground is severely contaminated as a result of its industrial history, then this would make the site less feasible. Given the site's position close to Heathrow Airport and the motorway network, affordability could also be a factor driving re-consideration of alternative locations.

2.3.3 Drinking water transfer to Harrow and Arkley

2.86. The LTR concept design is based on all the drinking water produced being supplied to Harefield SR for onward distribution. This will allow a greater proportion of the existing Iver output to be directed towards areas served by the Harrow and Arkley SRs, which are forecast to have a significant deficit if no action is taken. A potential transfer main running from Iver to Harrow SR and then on to Arkley SR is included in Affinity Water's Water Resources Plan for PR19 (Scheme AFF-CTR-WRZ4-0707). If this scheme was linked to the LTR WTW instead of Iver then it could be possible to reduce the capacity of the T2AT drinking water transfer main to Harefield. The relative merits of different options for the transfer and distribution of water within the Affinity Water supply zones are being investigated under Affinity Water's Supply 2050 strategy.

2.3.4 Carbon saving opportunities

2.87. Opportunities for reducing the embedded and operational carbon dioxide emissions associated with the T2AT scheme are discussed in detail in technical supporting document A3a: Carbon Strategy - LTR Option.

2.88. The main opportunities for reducing embedded carbon emissions lie in the materials selected for construction, particularly for the pipeline. The main opportunities for reducing operational carbon emissions lie in reducing energy consumption. There is a tension between these two opportunities in selecting the correct pipe diameter to provide the optimum whole life carbon “cost”, which in turn is dependent on how the scheme will be utilised. As stated in paragraphs 2.57 and 2.68, further study will be required to determine the optimum pipeline material and diameter.

3. Scheme Delivery

3.1 Overview of construction process

3.1.1 Raw water pumping station construction

3.1. Civil construction of the raw water pumping station will need to be undertaken by a specialist contractor with experience in completing similar works. The principal areas of difficulty are that the zone of influence of shaft construction will include the existing adjacent standby pumping shaft and the Great Western Main Line. Construction work will take place within the boundary of the live Iver WTW in an area where there are frequent movements of articulated 40t tipper trucks collecting sludge. Access and egress to the WTW site is subject to security checks.

3.2. Indications are that there is three to four metres of made ground overlying natural superficial deposits at the site overlying some 28metres depth of London Clay. This is likely to result in the need to sink the upper 4-5m as a caisson or within a sheet pile cofferdam, before switching to underpinning techniques to construct the lower section and base within the clay.

3.3. The short connection to the existing standby pumping station shaft will be via a horizontal tunnel from the new shaft.

3.4. Excavation of the shaft will result in approximately 4,000m^3 of arisings. It is not expected that contaminated ground will be found in this area, but a precautionary allowance has been made for a further 2% to be treated and disposed of as potentially hazardous material.

3.1.2 LTR WTW and high lift pumping station construction

3.5. Prior to commencement of work on the new LTR WTW, the site will require clearance. On the working solution site there are a number of existing commercial buildings to be demolished and there may be historical pockets of contaminated ground that have to be treated and disposed of off-site.

3.6. The geotechnical desk study suggests that the majority of the working solution site is covered by a variable thickness of made ground overlying superficial deposits with London Clay encountered from a depth of around 5m below ground level.

3.7. This means that for the deeper and more heavily loaded structures it is likely that a piled foundation combined with an anti-heave material in between the pile caps will be required to both support the structure and limit uplift forces due to ground heave.

3.8. For shallower foundations it is likely that ground improvement will be required to stabilise the made ground and superficial deposits.

3.9. Excavation for the WTW will produce an estimated 21,000m^3 of non-hazardous arisings which cannot be re-used for construction or in landscaping. This is in addition to an estimated 5,000m3 of hazardous material that will need to be treated and safely disposed of. This is based on assumptions regarding how much of the spoil can be absorbed in landscaping on site and the proportion of excavation that will be contaminated.

3.10. There is limited space on the working solution site to accommodate temporary accommodation for the construction staff, plant and laydown areas for storage of materials. Additional area will be required for this, and it is suggested that the nearest suitable location is to the west side of the M25.

3.1.3 Pipeline construction

3.11. The two elements of pipeline construction which will have the biggest impact on programme are (a) ensuring that the environmental controls and mitigations are implemented correctly and (b) completing the major crossings.

3.12. Minor crossings will be carried out in open cut. For roads, this will usually be achieved in two halves with a traffic light system in place for a few days. For minor water courses it is normal to channel the water through a length of pipe and cut the trench underneath.

3.13. There are six significant watercourses which will need to be crossed, including the Grand Union Canal (twice), the Colne Brook (twice) the River Colne and Fray's River. The crossings for these watercourses ranges from 10m to 25m in length. In these locations the concept design is for the pipe to be twinned to ensure resilience and installed in micro-tunnels bored under the watercourse.

3.14. An alternative to be considered for some of the major water course crossings is pipe bridges. There are several existing pipe bridges next to the Grand Union Canal and River Colne T2AT crossing points so the visual impact would be lessened. However, there are security issues with exposed pipes which may preclude this as an option on T2AT.

3.15. Although it is classified as a major crossing, it has been assumed that the A4007 will be crossed in open cut. If this is permitted it is likely that significant conditions will be stipulated by the highway authority, such as only being allowed to work and institute traffic control at night. If no form of traffic control is allowed, then the crossing will have to be undertaken by micro-tunnelling.

3.16. The other major road crossing is the A40 dual carriageway. The concept design envisages that the crossing will pass underneath the highway where it is raised on a viaduct section. The pipeline would be installed in open cut between two viaduct piers. The open trench will need to be design such that it does not encroach upon the zone of influence of the pier foundations. A suitable monitoring programme, to provide early warning should unexpected movement occur, will need to be agreed well in advance with National Highways.

3.17. For the Chilterns Line railway crossing, the concept design is for the pipe to be twinned to ensure resilience and installed in micro-tunnels bored under the railway and adjacent land owned by Network Rail.

3.18. Affinity and Thames Water is still negotiating with the promotors of the HS2 railway line for provision to be made for the future T2AT pipeline. As well as the main HS2 running line, there is a maintenance siding proposed at the crossing point. Assuming that no provision is made by HS2, the concept design is for a twin-bore micro-tunnel to be constructed under the Chiltern Line, HS2 and the maintenance siding.

3.2 Delivery programme

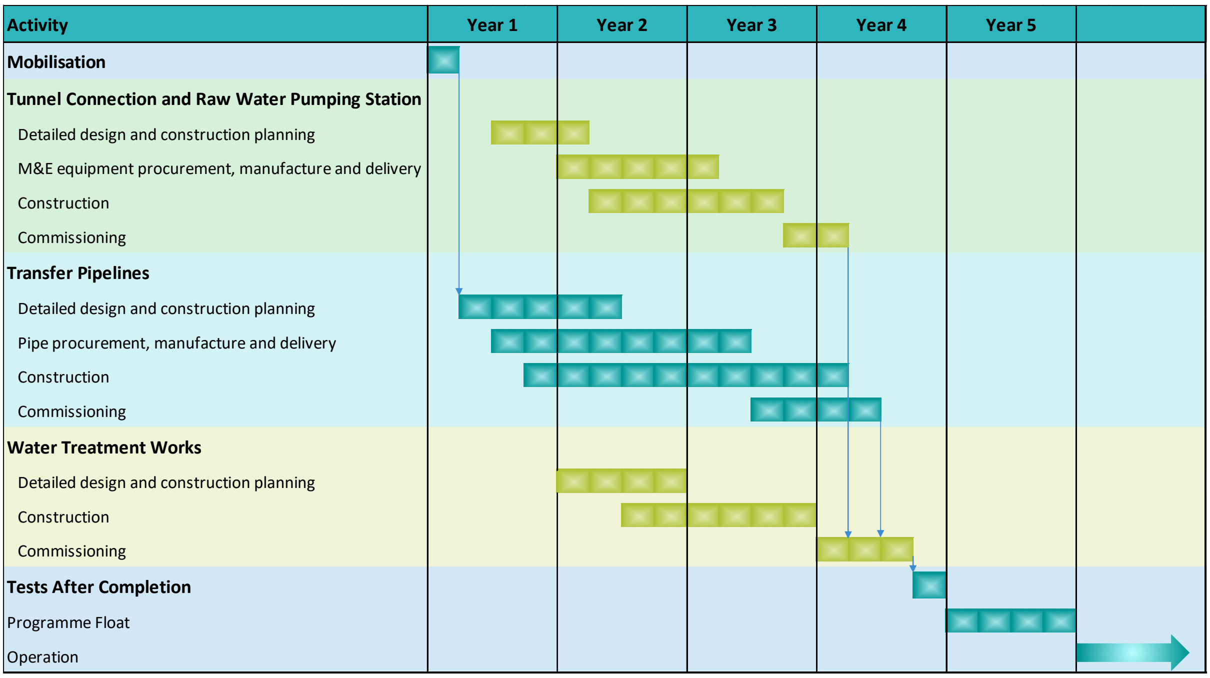
3.19. Because the long-term ADO generated by the LTR option is derived from implementation of the SESRO or STT schemes, and because Thames Water are not able to allocate raw water storage capacity to Affinity Water until the SESRO scheme is operational, the assumption has been made that the LTR option will not be required until SESRO water is available. At gate 2, the expectation is that the earliest completion date for SESRO will be 2040 and therefore the earliest completion date for the LTR option is also 2040.

3.20. The transfer scheme could potentially operate without additional resource being available, as long as it operated within Thames Water's existing abstraction licence limits and did not draw upon Thames Water's strategic raw water reserves. However, the key benefit of the investment in T2AT is the resilience that the scheme will provide under drought conditions, and so there is limited value in making this capital outlay until SESRO comes on stream.

3.21. It is anticipated that the remainder of the RAPID gated process, obtaining a DCO, and establishing a project delivery organisation will take approximately six years. This will be followed by a detailed design, construction and commissioning period of approximately five years, making a total of eleven years. The equivalent time frame for SESRO is considerably longer meaning that there is likely to be a reduction in activity on T2AT until a minimum of eleven years before the anticipated date for availability of SESRO water.

3.22. An indicative programme for detailed design, construction and commissioning of the LTR option is shown in Figure 3.1.

Figure 3.1 Indicative Implementation Programme



4. Capacity and Utilisation Assessment

4.1 Introduction

4.1. This section describes the modelling and assessment that has been undertaken for T2AT, as part of the Gate 2 investigations, to better understand the required capacity and utilisation of the transfer scheme and hence feed into the asset concept design process. This modelling has also informed the representation of options within the WRSE regional modelling and WRMP24 options appraisal processes.

4.2. The work consists of the following main elements:

- Analysis of the infrastructure requirements to deliver the 1 in 500 year dry year ADO.
- Analysis of the long-term utilisation of the transfer scheme, to provide information on the likely operational requirements of the option and the minimum and maximum expected flows.
- Validation of the conjunctive use benefit of operating the transfer in combination with Thames Water's London supply zone.

4.2 Overview and context of planning problem

4.3. The analysis completed to explore the utilisation profile for the T2AT used the PyWR water resources platform to consider the demand profiles that are generated when new resource is introduced into the system.

4.4. Because the Affinity Water system does not contain any significant raw water storage, the calculation of Deployable Output (DO) is complex and reflects a single value that captures the combination of various modes of system failure that can occur in a drought year, including low groundwater levels, high peak week demands and prolonged high summer demands. These implications are conceptually illustrated in Figure 4.1 below.

4.5. As shown, because demand will be higher during the summer critical period, achieving a given ADO requires that the capacity of a new scheme is higher than the ADO. The ratio of scheme capacity to ADO will tend to reflect the ratio of average annual demand: summer period demand. Similarly, because the point of failure tends to be during the summer, there is spare capacity in existing sources outside of that summer period. This spare capacity can be utilised when demand increases or supply is lost, which means that new sources of water only tend to have to be fully utilised during the summer.

Figure 4.1 Illustration of Supply/Demand Stress and Need in the Affinity Central System

4.3 Infrastructure Capacity Analysis

4.6. The baseline DO for Affinity Water's system was derived using the WRSE regional system simulation model.

4.7. For each of the model runs completed to explore the DO of the T2AT system, and the associated peak capacity required to deliver that level of ADO, the following assumptions were applied:

- The standard 2018 demand profile and demand savings were used, along with the WRSE stochastic groundwater data set (i.e. 400*48 years)
- The 'Company Alternative' Environmental Destination scenario used in the WRSE Jan '22 emerging plan was incorporated by reducing or turning off the relevant groundwater sources. This reduced the effective 1 in 200 year minimum deployable output (MDO) capability within the model by approximately 128Ml/d compared with the 2025 position.

- Other key assumptions were retained as per the baseline WRSE DO model.

4.8. The T2AT transfer was simulated as a fixed rate transfer, at either 50 or 100 Ml/d (noting that a larger 200 Ml/d transfer was also simulated for sensitivity), which then enabled the overall change in ADO to be established and the ratio of the ADO gain to the transfer scheme capacity (or efficiency of the transfer) to be calculated. The results of this DO analysis are shown in Table 4.1 below.

Table 4.1 Analysis of T2AT transfer efficiency

Transfer Capacity	Increase in ADO (Ml/d)	Transfer efficiency (%)
50	43	87%
100	85	85%
200	183	91%

4.9. This result is as expected. With temporary use bans (TUBs) and Non-essential use bans (NEUBs) in place, peak period demands for AFW tend to be higher than the dry year annual average. This can be seen in the graphs in Figure 4.1 above. The 30 day rolling average demand during a 'dry year' (2018) summer is around 10% - 14% higher than the annual average (depending on when the TUBs and NEUBs are introduced within the year). This is reflected in the modelling as a dry year annual average DO that is approximately 15% lower than peak transfer capacity. Essentially, this means that the capacity of the transfer needs to be approximately 15% higher than the effective dry year annual average DO to meet this higher peak demand.

4.10. As a result, the raw water infrastructure capacity of the T2AT working solutions that are required to deliver an ADO of 50 and 100 Ml/d are set at 57.5Ml/d and 115Ml/d respectively.

4.4 Utilisation Analysis

4.4.1 Model set-up

4.11. To generate a realistic utilisation profile for the transfer scheme, it was necessary to modify modelled demand profiles to reflect operational reality. This was done to the PyWR model set-up, building on the approach taken to derive the baseline and transfer DO figures.

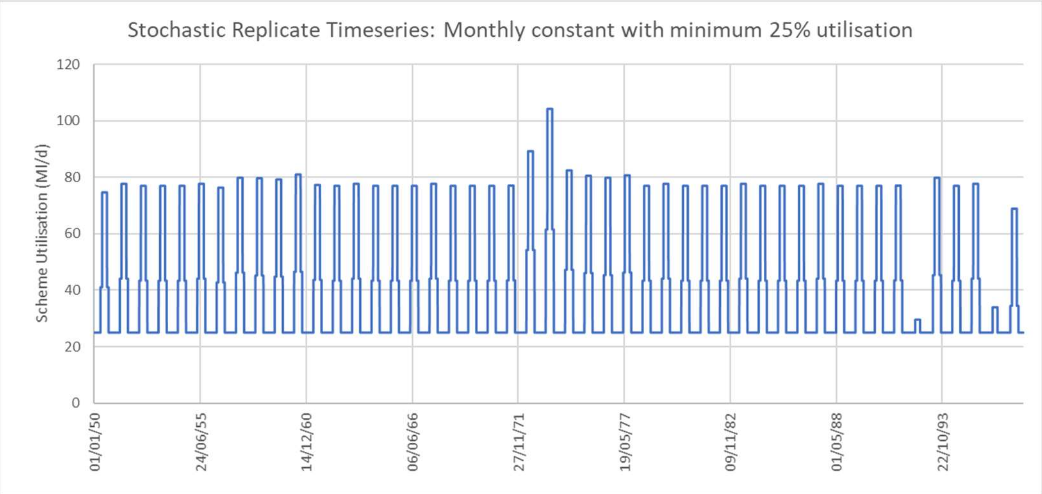
4.12. Because the drought vulnerability in the Affinity Water system relates to groundwater, there is uncertainty in the performance and availability of groundwater during drought events. Although new sources are relatively expensive, they would be managed pro-actively to avoid unexpected problems and failures of groundwater. Therefore, the demand profile used assumes maximum operation between June and August, ramped up and down to the summer peak during May and September and a 25% minimum flow October to April. Sources with annual volumetric constraints could be operated at increased rates during the summer peaks, but it is assumed that annual allowances were not exceeded through pro-active management.

4.13. It is very unlikely that the schemes that are proposed could be operated on a complete on/off basis during the year. To produce a more operationally realistic profile at lower levels of demand it is assumed that scheme utilisation could not reduce below 25% of the ADO for the scheme. This maintains a reasonable level of operational throughput or sweetening flow and enables timely 'ramp up' of treatment and pumping capacity during a drought event.

4.4.2 Results

4.14. Once the 'operationally realistic' modifications are applied, then a utilisation time series is derived. An example of this, for one of the stochastic replicates, can be seen in Figure 4.2 below.

Figure 4.2 Final T2AT operationally realistic utilisation profile



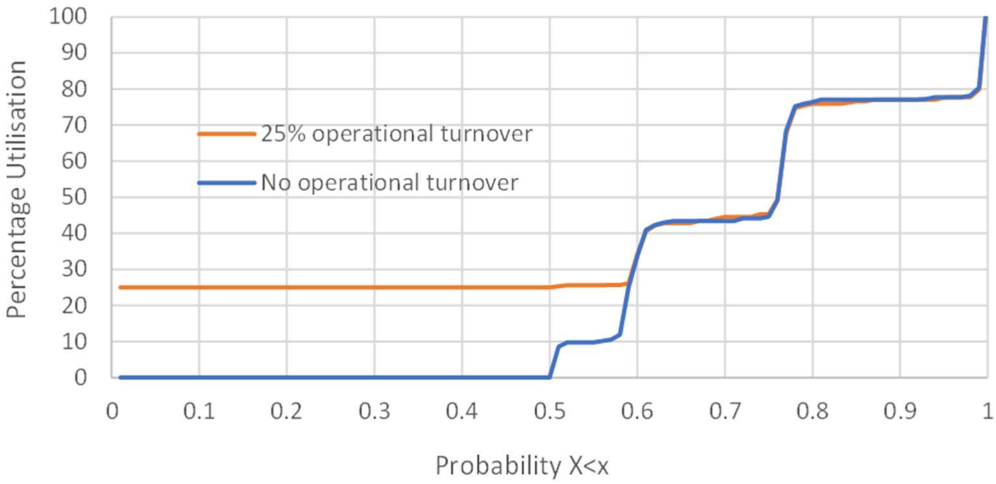
Note: It should be noted that the above timeseries is for an example stochastic replicate (nominal years – the stochastic data runs multiple sets of 50 year 'what if' climate analysis), and not the historic record

4.15. As expected, this shows that the majority of years are 'normal' with utilisation dictated by the level of demand. Five years show exceptional utilisation, three significantly below the 'normal' requirement and two significantly higher than the 'normal' requirement.

4.16. The resultant utilisation profiles are then used to inform the engineering design of the scheme, the appraisal of operational costs and the feasibility of different commercial and procurement models.

4.17. Based on the full stochastic analysis, the probability of expected daily usage of the scheme is as shown in Figure 4.3 below. This shows that outside of the May to September period, expected use is likely to be dictated by operational turnover. During May to September the usage is a balance of groundwater level versus the demand management impacts of TUBs and NEUBs. Typical utilisation is in the order of 80% in summer, only increasing with significant droughts beyond 1 in 50 years.

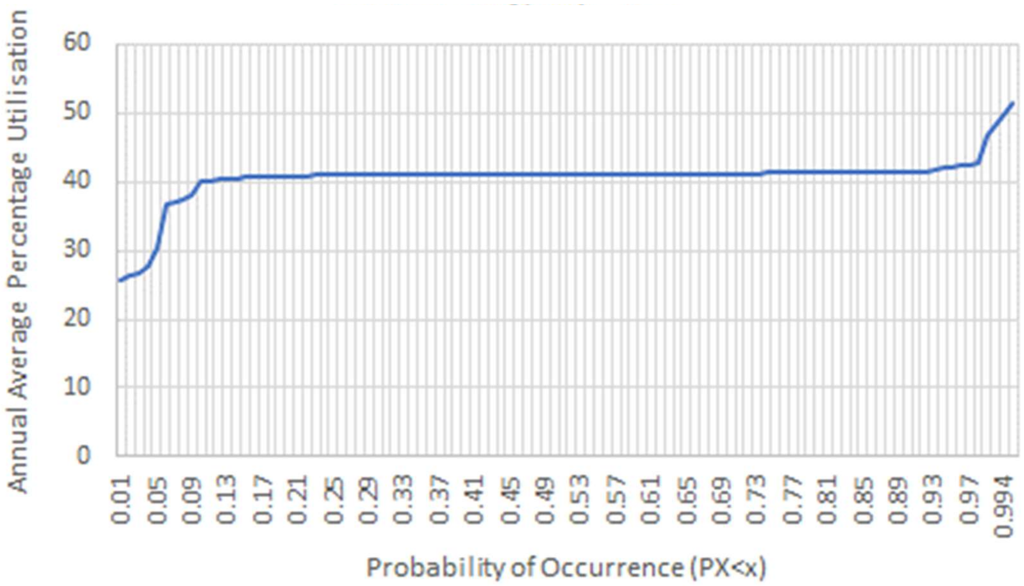
Figure 4.3 Cumulative Probability Distribution for Daily Scheme Utilisation



4.18. These data have also been transformed into annual average utilisation rates. These figures demonstrate that normal 'dry year' utilisation (i.e. prolonged summer not associated with a groundwater drought) are typically around 40% annual average utilisation. Most drought years will actually result in a reduction in overall utilisation as the application of TUBS and NEUBs reduces demand, with only droughts worse than around 1 in 50 years generating a significant increase above a 'normal' dry year.

4.19. The corresponding cumulative probability plot for a 100Ml/d scheme is shown in Figure 4.4 below:

Figure 4.4 Cumulative duration frequency curve of T2AT utilisation, 25% minimum turnover



4.20. Therefore, for the purposes of volumetric storage, even under severe droughts with a 25% operational minimum turnover, the required utilisation is very unlikely to exceed 50% of DO. A 100 Ml/d DO scheme therefore only requires 18,250Ml (=

365*100/2) per annum of water to support the scheme.

4.5 Validation of utilisation analysis and resulting conjunctive use benefits

4.21. Validation analysis was undertaken to explore the combined or conjunctive use impact of supplying the T2AT transfer from Thames Water's London WRZ, to explore the impact on the supplying zone and validate the 50% utilisation conclusion noted previously.

4.22. Modelling the conjunctive use of the T2AT with the London system was undertaken using the operational realistic demand profiles previously discussed. The analysis looked at the total annual average DO for London, with and without the T2AT in operation.

4.23. The model results for the 1 in 200 year and the 1 in 500 year droughts are shown in table 4.2 below.

Table 4.2 T2AT, conjunctive use modelling results

Return period	AFW DO increase from T2AT (Ml/d)	London DYAA DO (Ml/d)	Net loss of DO to London due to T2AT (Ml/d)
500	100	1,937	30
200	100	2,076	37

4.24. The impact on London DO of a transfer providing a 50 Ml/d to Affinity Water is generally low. This is because the duration of deficit tends to be very small as there is surplus groundwater availability outside of the summer period (see Figure 4.1) and because droughts are not necessarily consistent between the two companies. Hence, the two systems do not generally need to supply peak demands at the same time during a drought event.

4.25. Overall, the modelling shows that operating the 100 Ml/d T2AT transfer scheme during a 1 in 500 year drought results in a relatively small loss of DO. A loss of only between 30 and 37 Ml/d is seen for London, even with a 25% minimum flow. This accords well with the volumetric requirement of 50% ADO from the utilisation analysis discussed previously.

4.26. This means that if an additional 100Ml/d DO is transferred to Affinity Water from London in a 1 in 500 year drought (e.g. DO which originated at a new resource in the Upper Thames, either STT or SESRO or another resource), then 70Ml/d of that DO is returned to London, which represents a benefit gained from conjunctive use of the resource. Overall, the modelling suggests a net benefit to London of up to 70% of the transfer DO. Given the uncertainty inherent in the modelling, we have treated this as a guide and an indication of maximum benefit.

4.27. Based on the above, in order for supply to be resilient it would be necessary for Affinity Water to reserve enough storage to support approximately a 50% average utilisation. Effectively that water becomes unavailable to Thames during a drought (it is reserved by contract), so the operationally realistic reduction for Thames is equal to half the DO gained by Affinity Water. We have therefore modelled this within the WRSE and WRMP24 modelling systems as a 50% conjunctive use benefit to London when the T2AT is operated using any new resource in the upper Thames catchment. This means that if 100 Ml/d is transferred to Affinity Water from the London WRZ, using new resources from the upper Thames catchment, then this only results in a net loss of 50 Ml/d to the London DO.

5. Future Scheme Development

5.1 Engineering design development

5.1. Following submission of the Gate 2 submission for the LTR option it is envisaged that only a limited extent of further development will take place before the project enters a deferral period. For the reasons described in section 3.2. the end of the deferral period will be dependent on the anticipated date on which SESRO can supplement the wate resource available within the river Thames.

5.2. The scope of work and anticipated schedule for work carried out before and following the deferral period is described fully in technical supporting document F; Project Delivery Plan.

5.2 Integrated planning

5.3. Further development of the T2AT SRO will require close liaison with the SESRO scheme and the other SROs which draw upon it to ensure that the water resource management and associated licencing arrangements with the Environment Agency are fully coordinated. Compiling the operational agreement for the LTR option will be complex as it will need to integrate with Thames Water's management strategy for the Lower Thames reservoirs, which in turn is integrated with management of water level, flows and water quality in the affected reaches of the river itself. The strategy itself, and associated licence agreements, will be radically altered as a result of SESRO.

5.4. Subsidiary to the agreement of resource management and abstraction licences with the Environment Agency, a protocol and pricing structure will need to be established for water sharing between Thames Water and Affinity Water.

5.5. The Connect 2050 strategy being prepared by Affinity Water will both be influenced by the expected implementation of the LTR option and influence the way in which the scheme feeds into the distribution network. It is anticipated that further study will be required to estimate the extent to which the scheme will be utilised when working in parallel with other sources, which will also interact with the Connect 2050 proposals.

5.6. In the shorter term, Affinity Water's WRMP24 programme of work will include enhancements to the network, some of which will need to take into account the additional water made available by the LTR option. One example is provided in section 2.3.3.

6. Conclusion

6.1. The LTR option for fulfilling the requirements of the T2AT scheme has been selected for further development by the WRSE regional modelling programme.

6.2. Two alternatives of the option have been developed to provide 50Ml/d and 100Ml/d of ADO to Affinity Water. These require raw water capacity of 57.5Ml/d and 115Ml/d and drinking water capacity of 55Ml/d and 110Ml/d respectively to achieve the required ADO.

6.3. The choice of the LTR option from amongst the other T2AT options has been confirmed through detailed options appraisal.

6.4. A working solution for the LTR option has been identified through a cross-discipline refinement process. The concept design for the LTR option has been developed on the basis of this working solution in order that the costs, challenges and risks associated with implementing the scheme can be better understood. It is recognised that the working solution will change and be further refined in the light of public consultation as the scheme progresses.

6.5. The main components of the working solution concept design are:

- A connection into the raw water tunnel leading from the Queen Mother and Wraysbury Reservoirs to Iver WTW.
- LTR-RWPS; A raw water pumping station to lift water from the tunnel and pump it to the LTR-WTW
- LTR-RWTM; A 500m long raw water transfer main from the pumping station to the WTW
- LTR-WTW; A new WTW with a working solution location just to the north of Iver WTW. A conventional WTW process is proposed with:
  - Clarifiers
  - Rapid gravity filters
  - Ozone
  - Granulated activated carbon filters
  - Chlorine disinfection
  - Treated water storage
  - Sludge thickeners and dewatering plant
- LTR-HLPS; A high lift pumping station to pump water from LTR-WTW to Harefield SR
- LTR-DWTM; A 14km transfer pipeline from LTR-WTW to Harefield SR

6.6. The drinking water pipeline will require several major crossings including:

- Six major watercourses
- The A40 dual carriageway
- The Chilterns Line railway
- The HS2 high speed railway and maintenance siding.

6.7. For the transfer pipes the material selected for the concept design is cement lined ductile iron.

6.8. The selected diameters for the raw water pipeline are DN900 and DN1200 for the two flow alternatives. For the drinking water pipeline, the selected diameters are DN800 and DN1200. Further study of how the LTR option is used in combination with other sources will be required to determine whether a whole life cost and carbon saving can be achieved by selecting a smaller diameter.

6.9. Modelling indicates that, if the LTR option is the least preferred source relative to other sources available to Thames and Affinity Water, then average utilisation will be about 40%. However, it is likely that it will not be the least preferred source under all conditions and so average utilisation will be higher than 40%.

6.10. If the scheme was developed without a break, then it is estimated that it could be brought on stream in approximately eleven years; the first six years of which would be planning and development and the following five years dedicated to detailed design, construction and commissioning. However, since completion of SESRO is a pre-requisite for deriving maximum benefit from the LTR option, and SESRO has a delivery period of more than eleven years, a deferral period is proposed so that the conclusion of both projects is coordinated.

6.11. Development of the scheme will need to take place in association with development of the water resource sharing agreement with Thames Water. This in turn will be related to agreements on how SESRO is operated and revised abstraction agreements from the River Thames.

6.12. On the downstream side of the scheme, network enhancements will be required to distribute the additional drinking water. Over the longer term these are being developed by Affinity Water as part of their Connect 2050 strategy. More immediately, network enhancements that will interact with the LTR option are being proposed under Affinity Water's WRMP24 submission to Ofwat

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