Thames to Affinity Transfer

Technical Supporting Document B1a

Environmental Appraisal 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 had 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

Glossary

Term	Definition
Agricultural Land Classification (ALC)	ALC provides a framework for classifying land according to the extent to which its physical or chemical characteristics impose long-term limitations on agricultural use. It classifies agricultural land in five categories according to versatility and suitability for growing crops: • Grade 1 – excellent quality agricultural land • Grade 2 – very good quality agricultural land • Grade 3 – split into Subgrade 3a of good quality agricultural land, and Subgrade 3b of moderate quality agricultural land • Grade 4 – poor quality agricultural land • Grade 5 – very poor quality agricultural land Grades 1, 2 and 3a are classed as best and most versatile (BMV) and greater consideration of these soil resources are made during planning applications.
Ancient and veteran trees	An ancient tree is one that has passed beyond maturity and is old, or aged, in comparison with other trees of the same species. Veteran is a term describing a tree with habitat features such as wounds or decay. All ancient trees are veteran, but not all veterans are old enough to be ancient. An ancient tree is exceptionally valuable. Attributes include its: 1) great age; 2) size; 3) condition; 4) biodiversity value as a result of significant wood decay and the habitat created from the ageing process; 5) cultural and heritage value. (Sources: https://www.gov.uk/guidance/ancient-woodland-ancient-trees-and-veteran-trees-advice-for-making-planning-decisions and https://www.woodlandtrust.org.uk/media/1836/what-are-ancient-trees.pdf)
Ancient Tree Inventory	An inventory database of ancient, veteran, and notable trees identified across the UK.
Ancient Woodland	Any area that's been wooded continuously since at least 1600 AD, or a date otherwise specified by the Overseeing Organisation including: 1) ancient semi-natural woodland mainly made up of trees and shrubs native to the site, usually arising from natural regeneration plantations on ancient woodland sites; 2) replanted with conifer or broad-leaved trees that retain ancient woodland features, such as undisturbed soil, ground flora and fungi; 3) wood pastures identified as ancient;

Term	Definition
	4) historic parkland, which is protected as a heritage asset in the relevant planning policy. (Source: https://www.gov.uk/guidance/ancient-woodland-ancient-trees-and-veteran-trees-advice-for-making-planning-decisions)
Area of Outstanding Natural Beauty (AONB)	Land protected by the Countryside and Rights of Way Act 2000 on account of factors such as landscape or scenic quality, relative wildness or tranquillity, and / or natural or cultural heritage features. It protects the land to conserve and enhance its natural beauty. (Source: Natural England)
Background noise level	Prevailing noise level in a specified environment measured in the absence of the noise being studied
Baseline data	Data used to describe the current conditions of the environment, against which future predictions can be made.
Benefits	Positive impacts on wellbeing.
Best and Most Versatile (BMV)	Defined as Grades 1, 2 and 3a by policy guidance. This is the land which is most flexible, productive and efficient in response to inputs and which can best deliver future crops.
Biodiversity Net Gain (BNG)	Biodiversity Net Gain is an approach to development that leaves biodiversity in a measurably better state than before.
Carbon Sequestration	The uptake and storage of carbon, for instance by absorption of carbon dioxide by trees and plants which then release the oxygen.
Conceptual Model (CM)	A written or pictorial representation of sources, pathways, and receptors at potentially contaminated sites, in line with LCRM guidance.
Conservation Area	Defined by the Planning (Listed Buildings and Conservation Areas) Act 1990 as an area 'of special architectural or historic interest, the character of which it is desirable to preserve or enhance'.
Construction	Any activity involved with the provision of a new structure (or structures), its modification or refurbishment. A structure will include a residential dwelling, office building, retail outlet, road, etc.
Construction Environmental Management Plan (CEMP)	A document which sets out site-specific procedures and mitigation measures to monitor and control environmental impacts throughout the construction phase of the project.

Term	Definition
Contaminated land	Defined in Part 2A of the Environmental Protection Act 1990 as land where significant harm is being caused or there is a significant possibility of such harm being caused; or significant pollution of controlled waters is being or is likely to be caused.
Disbenefits	Negative impacts on wellbeing.
Discounting	A method for translating future costs or benefits into present values using a discount rate.
Dust	Solid particles that are suspended in air or have settled out onto a surface after having been suspended in air. The terms dust and particulate matter (PM) are often used interchangeably, although in some contexts one term tends to be used in preference to the other. In this assessment the term 'dust' has been used to include the particles that give rise to soiling, and to human health (i.e. PM_{10} or $PM_{2.5}$) and ecological effects. Note: this is different from the definition given in BS 6069-2:1994, where dust refers to particles up to 75µm in diameter.
Earthworks	Covers the processes of soil-stripping, ground-levelling, excavation and landscaping.
Ecosystem	A dynamic complex of living things (animals, plants and micro-organisms) and their physical environment interacting as a functional unit.
Ecosystem Services	Functions of the natural environment, that directly or indirectly provide benefits for people.
Environmental Impact Assessment (EIA)	Statutory process under e.g. Town and Country Planning (EIA) Regulations 2017 (as amended), consisting of: 1. Preparation of an Environmental Statement 2. Consultation 3. Examination by the competent authority of the information contained within the Environmental Statement 4. The reasoned (justified or evidenced) conclusion by the competent authority on the significant effects of the project on the environment 5. The reasoned (justified or evidenced) decision by the competent authority to grant or refuse development consent.
Eutrophic	Rich in organic and mineral nutrients and supporting an abundant plant life, which in the process of decaying depletes the oxygen supply for animal life.
GDP (Gross Domestic Product)	The value of output or national income of a country over a 12 month period.
GDP Deflator	An index of the general price level in the economy, measured by the ratio of Gross Domestic Product (GDP) in nominal terms to GDP at constant prices.

Term	Definition
Habitat	A place where an organism or community of organisms normally live.
Heavy Duty Vehicle (HDV)	Goods vehicles and buses greater than 3.5 tonne (t) gross vehicle weight.
Historic Landscape Character	Historic Landscapes are defined by perceptions that emphasise the evidence of the past and its significance in shaping the present landscape. The definition encompasses all landscapes, including the countryside, townscapes and industrial landscapes as well as designed landscapes, such as gardens and parks.
Key characteristics (landscape)	The elements or combination of elements that are particularly important to the current distinctive character of the landscape and help to give an area its particularly distinctive sense of place. (Source: GLVIA3)
LAeq	A steady noise level (weighted) which over a period of time has the same sound energy as the time varying noise
Landscape Character	A distinct, recognisable and consistent pattern of elements in the landscape that makes one landscape different from another, rather than better or worse. (Source: GLVIA3)
Landscape Character Area (LCA)	A discrete geographical area of a particular landscape type. (Source: GLVIA3)
Landscape Character Assessment	Process of identifying and describing variation in character of the landscape - the unique combination of elements and features that make landscapes distinctive - to assist in managing change in the landscape. (Source: GLVIA3)
Landscape Value	Relative value or importance attached to different landscapes by society on account of their landscape qualities, including natural and cultural heritage, landscape condition, associations, distinctiveness, recreational value, perceptual value (scenic/wildness and tranquillity) and functionality. (Source: GLVIA3 and Landscape Institutes Technical Guidance Note; TGN 02/21 'Assessing landscape value outside national designations')
Light Duty Vehicle (LDV)	Cars and small vans less than 3.5 t gross vehicle weight.
Listed building	A building or structure designated under section 69 of the Planning (Listed Building and Conservation Areas) Act 1990 as being of 'special architectural or historic interest'.

Term	Definition
Mineral Safeguarding Areas (MSA)	Areas of known mineral resources that are of sufficient economic or conservation value (such as building stones) to warrant protection for generations to come.
National Nature Reserve (NNR)	A statutory designation afforded to land declared under the National Parks and Access to the Countryside Act 1949 or Wildlife and Countryside Act (1981), as amended, and include some of the best examples of wildlife and geology.
National Planning Policy Framework (NPPF)	Sets out the Government's economic, environmental and social planning policies. A revised National Planning Policy Framework was published by the Ministry of Housing, Communities and Local Government in July 2021 which replaced the previous NPPF published in March 2012 and revised in February 2019.
Natural Capital	Stocks of the elements of nature that have value to society, such as forests, fisheries, rivers, biodiversity, land and minerals. Natural capital includes both the living and non-living aspects of ecosystems. Stocks of natural capital provide flows of environmental or 'ecosystem' services over time. These services, often in combination with other forms of capital (human, produced and social) produce a wide range of benefits
Particulate matter	Airborne particulate matter is made up of a collection of solid and/or liquid materials of various sizes that range from a few nanometres in diameter (about the size of a virus) to around 100 microns (about the thickness of a human hair).
Phase 1 habitat survey	The Phase 1 habitat classification and methodology is a widely used and industry accepted technique for habitat survey across the UK.
PM_{10}	Particulate matter with an aerodynamic diameter of 10 microns or less.
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 2.5 microns or less.
Present Value	The sum of a stream of future values discounted at an appropriate discount rate (such as the Green Book social discount rate) to bring them to today's value.
Public Right of Way (PRoW)	A public right of way is a right by which the public can pass along linear routes over land at all times. Although the land may be owned by a private individual, the public have a legal right across that land along a specific route. (Source: https://www.devon.gov.uk/prow/what-are-public-rights-of-way/
Replacement Cost	The cost of providing a substitute good or engineering solution that performs a similar function to the environmental good. For example, wetlands that provide flood protection may be valued on the basis of the cost of building man-made defences of equal effectiveness. Since wetlands provide a range of

Term	Definition
	ecosystem services, this costing would be a minimum estimate of the value of a wetland.
Risk	The likelihood of an adverse event occurring.
Scheduled Monument	A monument which has been scheduled is protected against disturbance. The Secretary of State must be informed about any work which might affect a monument above or below ground, and English Heritage gives advice to the Government on each application. In assessing each application the Secretary of State will try to ensure that damage done to protected sites is kept to a minimum.
Sensitivity	Term applied to specific receptors, combining judgements of the susceptibility of the receptor to specific type of change proposed and the value related to that receptor. (Source: GLIVA3)
Setting	Contribution of the surroundings to the appearance of an area or feature and the interrelationship of the area or feature to the wider context and sense of place. (Source: LA107)
Silencer	A device used for reducing noise within air and gas flow systems. Can be fitted to exhausts of construction plant
Site of Special Scientific Interest (SSSI)	Sites of Special Scientific Interest represent the best examples of habitats present within the UK, and the designation provides statutory protection and a duty for the landowner to maintain the habitats
Special Area of Conservation (SAC)	Special Areas of Conservation are strictly protected sites designated under the EC Habitats Directive.
Study area	Study areas are used to define the spatial extent of environmental assessments. Each environmental factor defines its own study area(s) individually, taking account of relevant guidance.
Susceptibility	Ability of a defined landscape or visual receptor to accommodate the specific proposed change without negative consequences. (Source: GLIVIA3)
Visual amenity	Overall enjoyment of a particular area, surroundings, or views in terms of people's activities - living, recreating, travelling through, visiting, or working. (Source: GLIVIA3)

Term	Definition
Visual receptor	Individuals and/or defined groups of people who potentially could be affected by a project. (Source: GLIVIA3)
World Heritage Site	A site which has been listed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) due to its cultural or physical significance.
Zone of theoretical visibility (ZTV)	Map produced (usually digitally) to specific criteria to illustrate the area(s) from which a project can theoretically be visible. (Source: GLIVIA3)

Abbreviations

Abbreviation	Full term
AA	Appropriate Assessment
ACWG	All Companies Working Group
AEP	Annual Probability Event
ALC	Agricultural Land Classification
AOD	Above Ordnance Datum
AONB	Area of Outstanding Natural Beauty
APA	Archaeological Priority Area
AQMA	Air Quality Management Area
BAP	Biodiversity Action Plan
BEIS	Business, Energy and Industrial Strategy
BGS	British Geological Survey
BOA	Biodiversity Opportunity Areas
BMERC	Buckinghamshire and Milton Keynes Environmental Records Centre
BMV	Best and Most Versatile
BNG	Biodiversity Net Gain
BPM	Best Practicable Means

Abbreviation	Full term
BRC	Biological Record Centres
BS	British Standard
BU	Biodiversity Units
CAZ	Clean Air Zone
CCD	Check, clean, dry
CCRA	Climate Change Risk Assessment
CEH	Centre for Ecology and Hydrology
CEMP	Construction Environmental Management Plan
CIRIA	Construction Industry Research and Information Association
CM	Conceptual Site Model
CO_2	Carbon Dioxide
CRT	Canal and River Trust
cSAC	Candidate Special Area of Conservation
DBA	Desk-Based Assessment
Defra	Department for Environment, Food and Rural Affairs
DI	Ductile Iron
DRA	Direct River Abstraction
EAR	Environmental Appraisal Report
ECoW	Ecological Clerk of Works
EIA	Environmental Impact Assessment
ELMS	Environmental Land Management System
EMS	Environmental Management System
ENCA	Enabling a Natural Capital Approach guidance
EPA	Environmental Protection Act
EPUK	Environmental Protection UK
EU	European Union
GCN	Great Crested Newts
GDP	Gross Domestic Product

Abbreviation	Full term
GiGL	Greenspace Information for Greater London
GIS	Geographical Information System
GHG	Greenhouse Gas
GLHER	Greater London Historic Environment Record
GLVIA3	Guidelines for Landscape and Visual Impact Assessment Third Edition
GRP	Glass Fibre Reinforced Plastic
GVA	Gross Value Added
GWDTE	Groundwater Dependant Terrestrial Ecosystem
HDV	Heavy Duty Vehicle
HGV	Heavy Goods Vehicles
HER	Historic Environment Record
HERC	Hertfordshire Environmental Records Centre
HRA	Habitats Regulations Assessment
IAQM	Institute of Air Quality Management
IEMA	Institute of Environmental Management and Assessment
IMD	Index of Multiple Deprivation
INNS	Invasive Non-Native Species
JNCC	Joint Nature Conservation Committee
LAQM	Local Air Quality Management
LCRM	Land Contamination Risk Management
LCA	Landscape Character Area
LDV	Light Duty Vehicle
LFRMS	Local Flood Risk Management Strategy
LLFA	Lead Local Flood Authority
LNP	Local Nature Partnership
LNR	Local Nature Reserve
LOAEL	Lowest Observed Adverse Effect Level
LSOA	Lower Layer Super Output Areas

Abbreviation	Full term
LWS	Local Wildlife Site
NaFRA	National Flood Risk Assessment
NAP	National Adaption Programme
NAU	National Appraisal Unit
NBN	National Biodiversity Network
NC	Natural Capital
NCA	Natural Capital Assessment
NCN	National Cycle Network
NEP	Natural Environment Partnership
NERC	Natural Environment and Rural Communities
NEVO	Natural Environment Valuation Online tool
NFM	Natural Flood Management
NHLE	National Heritage List for England
NNR	National Nature Reserve
NOEL	No Observed Effect Level
NOx	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NPPF	National Planning Policy Framework
NPS	National Policy Statement
NPSE	National Policy Statement for England
NRMM	Non-Road Mobile Machinery
NRN	Nature Recovery Network
NWG	Northumbrian Water Group
ONS	Office for National Statistics
ORVal	Outdoor Recreational Valuation
OS	Ordnance Survey
PEA	Preliminary Ecological Appraisal
PPG	Pollution Prevention Guidance

Abbreviation	Full term
PM	Particulate Matter
PPE	Personal Protective Equipment
PROW	Public Right of Way
pSPA	Potential Special Protection Area
PTAL	Public Transport Accessibility Level
RAPID	Regulators' Alliance for Progressing Infrastructure Development
REGO	Renewable Energy Guarantees of Origin
RIGS	Regionally Important Geological Sites
RMNI	River Macrophyte Nutrient Index
RPA	Root Protection Area
RSBP	Royal Society for Protection of Birds
RWT	Raw Water Transfer
SAC	Special Area of Conservation
SAI-RAT	SRO Aquatic INNS Risk Assessment Tool
SEA	Strategic Environmental Assessment
SEPA	Scottish Environment Protection Agency
SESRO	South East Strategic Reservoir Option
SFRM	Strategic Flood Risk Management
SINC	Sites of Importance for Nature Conservation
SOAEL	Significant Observed Adverse Effect Level
SPA	Special Protection Area
SPZ	Source Protection Zone
SRN	Strategic Route Network
SRO	Strategic Resource Options
SSSI	Site of Special Scientific Interest
STT	Severn Thames Transfer
STW	Sewage Treatment Works
SuDs	Sustainable Drainage Systems

Abbreviation	Full term
SWMP	Surface Water Management Plan
T2AT	Thames to Affinity Transfer
TfL	Transport for London
TPO	Tree Preservation Orders
TVERC	Thames Valley Environmental Records Centre
UK	United Kingdom
UK Hab	UK Habitat Classification
UKTAG	UK Technical Advisory Group
WACA	Wildlife and Countryside Act 1981
WFD	Water Framework Directive
WRMP	Water Resources Management Plan
WRSE	Water Resources South East
WTW	Water Treatment Works
ZoI	Zone of Influence
ZTV	Zone of Theoretical Visibility

Executive summary

Introduction

The Environment Assessment Report (EAR) is a technical supporting document prepared to support the Gate 2 submission report to the Regulators' Alliance for Progressing Infrastructure Development (RAPID) for the Thames to Affinity Transfer (T2AT) Strategic Resource Option (SRO).

This EAR presents the environmental appraisal work for the Lower Thames Reservoir Option and has been informed by desk based assessments using publicly available information in line with the requirements of the Gate 2 submission. The work is at a preliminary stage and establishes an initial appraisal that can be built on during subsequent project stages. In future, this will also be informed by the undertaking of site surveys and collection of additional information and data that will inform an Environmental Impact Assessment (EIA) likely to be required as part of any future consenting process.

This EAR does not definitively scope potential environmental effects in or out at this stage and the recommendations for further technical work outlined within this EAR are subject to change as further information becomes available at subsequent project stages. Future work will be carried out in conjunction with relevant stakeholders to inform the approach to the EIA.

The details set out in this EAR are still at a formative stage and consideration should be given to that when reviewing the proposals. They are for the purposes of making decisions on progress and further funding not seeking permission.

Overview of the Lower Thames Reservoir Option

The Lower Thames Reservoir Option involves the abstraction of raw water from Thames Water's Wraysbury and Queen Mother reservoirs via a proposed connection into Affinity Water's existing tunnel at the existing Iver Water Treatment Works (WTW). This raw water would then be diverted to a new WTW then drinking water would be subsequently conveyed to an existing service reservoir in the vicinity of Harefield.

The key components of the Lower Thames Reservoir Option are summarised below.

- A connection into the existing Wraysbury tunnel at the existing Iver WTW, and raw water pumping station (within this report referred to as the ‘Wraysbury Tunnel Connection’).
- A raw water transfer pipeline from the existing Iver WTW to a new WTW (within this report referred to as the ‘Raw Water Transfer Main’). The indicative route corridor identified for the Raw Water Transfer Main is referred to as the ‘Raw Water Transfer Main Route Corridor’.
- A new WTW (within this report referred to as ‘the new WTW’) to the north of the existing Iver WTW (within this report referred to as the ‘Indicative WTW Site’).
- A drinking water transfer pipeline from the new WTW to an existing service reservoir in the vicinity of Harefield (within this report referred to as the ‘Drinking Water Transfer Main’). The indicative route corridor identified for the Drinking Water Transfer Main is referred to as the ‘Drinking Water Transfer Main Route Corridor’.
- A connection into the existing service reservoir in the vicinity of Harefield (within this report referred to as the ‘Harefield Service Reservoir Connection’).

A more detailed scheme description is provided in Technical Supporting Document A1a, Concept Design Report.

Informal regulatory assessments

Three informal regulatory assessments have been completed for the Lower Thames Reservoir Option. The informal Habitats Regulations Assessment (HRA) and Water Framework Directive (WFD) compliance assessment are summarised in this report and presented as separate Technical Supporting Documents (B2 and B3 respectively). The Strategic Environmental Assessment (SEA) prepared for the Water Resources South East (WRSE) Regional Plan has also been reviewed in light of the design development at Gate 2 and desk based assessment work undertaken across the topics, with any updates to the SEA presented in Technical Supporting Document B4, Strategic Environmental Assessment Review.

Habitats Regulations Assessment

The HRA Stage 1 Screening Assessment identified potential Likely Significant Effects on the South West London Waterbodies Special Protection Area (SPA) and Ramsar, but the Stage 2 Appropriate Assessment (AA) did not identify any transmission pathways by which a Likely Significant Effect could reasonably occur. Therefore, no adverse effects on the integrity of the Habitats Sites are considered likely either alone or in-combination.

As no residual effects are expected from the implementation of this option, an in-combination assessment is not required for the Lower Thames Reservoir Option. As the option progresses, this should be reviewed and if residual effects are identified, the option should go through an in-combination effects assessment as part of a formal HRA will be completed pursuant to the consenting stage.

Water Framework Directive Compliance Assessment

The WFD Level 1 – basic screening assessment identified thirteen water bodies in relation to the Lower Thames Reservoir Option made up of six surface water rivers, two lakes, two canals and three groundwater bodies. As a result of the WFD Level 1 – basic screening assessment, one surface water river (the Thames (Cookham to Egham)) and two lakes (Queen Mother Reservoir and Wraysbury Reservoir) were taken through to the Level 2 – detailed impact assessment. The Level 2 assessment determined that impacts associated with the new or increased abstraction do not have the potential to deteriorate the WFD elements of the Thames (Cookham to Egham), Queen Mother Reservoir and Wraysbury Reservoir or prevent the attainment of Good status in the future. All other waterbodies were determined to have an impact score of less than 1 and were scoped out of further assessment at the Level 1 stage. Therefore, at this stage, the Lower Thames Reservoir Option is considered to be compliant with the WFD.

Strategic Environmental Assessment Review

Technical Supporting Document B4, Strategic Environmental Assessment Review, presents an update to the SEA level option assessment prepared by WRSE, in-line with the methodology in the WRSE Regional Plan Environmental Assessment Methodology Guidance[1]. This involved the identification of potential effects for each SEA objective at both the construction and operational phases, pre and post mitigation, with each SEA objective scored against an eight-point scale.

Major positive effects were identified for the SEA objective on delivering reliable and resilient water supplies given the Lower Thames Reservoir Option improves the transfer of water across regions.

Moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for biodiversity, flora and fauna for the construction of the Lower Thames Reservoir Option due to potential for indirect effects on nationally designated sites, and potential impacts on priority habitat, protected species and woodland for both options during the construction phase.

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[1] Mott MacDonald (2020). Water Resources South East (WRSE) Regional Plan Environmental Assessment Methodology Guidance. https://www.wrse.org.uk/media/lb0g0tsr/wrse_file_1347_wrse-regional-plan-environmental-assessment-methodology-guidance.pdf [Accessed April 2022]

Carbon would be generated as a result of construction as well as during operation. The SEA identified minor negative effects associated with carbon emissions during the construction phase and moderate negative effects during the operational phase.

Moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were also identified for the construction phase for the SEA objective on soil given the potential for disturbance and permanent loss of agricultural land (Grades 2 and 3) and there is potential for disturbance of contaminants given the Lower Thames Reservoir Option intersects or is within close proximity to historic and authorised landfill sites. The construction phase also has the potential to cause disruption to material assets therefore moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) identified.

The Lower Thames Reservoir Option passes through Air Quality Management Areas (AQMAs) with moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) identified for the SEA objective on air quality at the construction phase for. Given the Lower Thames Reservoir Option passes through community or recreational facilities, moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for both objectives related to population and human health at the construction phase.

For the historic environment objective, moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for the Lower Thames Reservoir Option at the construction phase given there is a Grade II listed building within the Indicative WTW Site.

The Lower Thames Reservoir Option is identified to have moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) as a result of potential construction related flood risk as it passes through Flood Zones 2 and 3.

Minor negative or neutral effects were identified for the remaining SEA objectives.

Mitigation measures to prevent, reduce or off-set adverse environmental effects have been identified as part of the SEA. These measures do not always completely eliminate effects or result in the downgrading of effects, from moderate to minor for example, however, if implemented, they would contribute to reducing the effects identified for the SEA objective.

It is recommended that the environmental assessment information from the SEA is fed into the WRSE Regional Plan and the Thames Water and Affinity Water WRMP24s (Water Resource Management Plan 24) so that the Lower Thames Reservoir Option is more appropriately assessed for SEA purposes as part of the SEA for the WRMP24s and WRSE Regional Plan.

Environmental appraisal outcomes by topic

Biodiversity, flora and fauna

Terrestrial ecology

No statutory designated sites or ancient woodland are likely to be directly impacted by works to construct the Lower Thames Reservoir Option.

The Lower Thames Reservoir Option has the potential to indirectly impact Kingcup Meadows and Oldhouse Wood, Fray's Farm Meadows, Denham Lock Wood, Ruislip Wood SSSIs, Frays Valley and Denham Quarry Park Local Nature Reserves (LNR) during construction.

The London's Canals Site of Importance for Nature Conservation (SINC), Southlands Manor Local Wildlife Site (LWS), Mid Colne SINC, Shepherd's Hill Woods and Fields SINC and Newyears Green SINC would potentially be directly impacted due to open cut excavation for the Drinking Water Transfer Main.

No other statutory or non-statutory sites are likely to be negatively impacted due to the distance from the pipeline route and the lack of an impact pathway.

Where open cut excavation is proposed, several priority habitats could be bisected including good quality semi-improved grassland and deciduous woodland, which all have the potential to be directly impacted by construction works.

The Lower Thames Reservoir Option has the potential to impact protected and priority species, including where the Drinking Water Transfer Main Route Corridor crosses watercourses, including the River Colne, Alder Bourne, Fray's River and Colne Brook. Notable species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice, reptiles, GCN, and breeding birds. If present, these species may be adversely affected by construction works through disruption to commuting opportunities and routes. There could also be indirect effects due to disturbance from construction plant and machinery, the presence of people, lighting, creation of dust etc.

Other protected species with the potential to be present include otter and water vole. These species have the potential to be present at the river crossing locations. Trenchless techniques are proposed to cross the watercourses, which is likely to reduce impacts during construction. However, works are likely be required to facilitate this, and as such, potential negative impacts via disturbance and local habitat loss may occur if these species are present.

Planned maintenance or replacement of pipeline sections during operation have the potential to impact habitats and protected species, however impacts are likely to be highly localised and likely to be sufficiently mitigated by Ecological Method Statements and ecological supervision.

During operation, the new WTW could cause disturbance to protected and priority species through increasing lighting to the surrounding habitats, which could affect bats and barn owls, and potential increases in noise and disturbance to the surrounding habitats.

In order to mitigate potential issues arising from construction of the Lower Thames Reservoir Option on biodiversity, the Drinking Water Transfer Main should be routed to avoid non-statutory designated nature conservation sites, priority habitats and those habitats that provide higher/better potential for protected and priority species. If this cannot be accommodated, trenchless techniques should be employed to allow the pipeline to cross under these protected areas. Where this is not possible, compensatory habitat would be required.

It should be noted that the protected and priority species suggested as being present are likely to be amended following completion of surveys and should not be considered final. Surveys are recommended at a subsequent project stage both to refine habitat mapping and identify the presence of protected species. Surveys should be phased in nature and proportionate to the level of design.

A Preliminary Ecological Appraisal is recommended to assess the likelihood of protected species and habitats being present. As part of this, site visits should be undertaken to ground truth the findings of the desk based habitat mapping before a survey programme for protected species and habitats is established. The timing of surveys would vary depending on the protected species in question, as optimum windows for differing species vary.

Aquatic ecology

During construction, there is a risk of construction related impacts on the aquatic communities. The construction related impacts include localised impacts on water quality due to increased sediment loads and/or pollution incidents and temporary disturbance of fish communities. Overall, the aquatic communities associated with the construction activities are considered to be tolerant and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term with, no or negligible change in aquatic ecological community receptors are expected.

Based on currently available information, the majority of identified operational effects on the aquatic environment are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity of affected reaches.

Identified adverse effects with risks to the overall ecological integrity during operation of the Lower Thames Reservoir Option include potential primary productivity/food-chain effects within the River Thames, upstream of the abstraction point for the Lower Thames Reservoir Option. Flow changes within the River Thames as a result of the South East Reservoir Option (SESRO) SRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected reaches.

Soils

Soil resources

The Lower Thames Reservoir Option is within developed and undeveloped land. The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor and Indicative WTW Site are within non-agricultural land and the Drinking Water Transfer Main Route Corridor crosses agricultural fields, non-agricultural land and urbanised areas.

Soil along the southern half of the Drinking Water Transfer Main Route Corridor is anticipated to predominantly be comprised of a shallow calcareous and non-calcareous loamy soil over flint gravel or a deep stoneless silty soil, which are seasonally waterlogged by fluctuating groundwater. In the northern half of the Drinking Water Transfer Main Route Corridor, soil is anticipated to predominantly be comprised of a slowly permeable seasonally waterlogged loamy over clayey or silty over clayey soil.

Ground disturbance in the form of topsoil/subsoil stripping may adversely affect soil quality during the construction process through inappropriate handling during stripping, stockpiling and reinstatement. This can impact soil function which could ultimately affect crop/vegetation growth.

For temporary works, it is anticipated that the majority of stripped topsoil/subsoil resource would be reinstated. A volume of subsoil may be permanently loss from the volume of strip that is associated with space occupied by underground pipelines. These soils should be appropriately stockpiled and managed prior to reinstatement upon the completion of pipe installation for a particular section.

For permanent land-take, topsoil/subsoil strip is anticipated to precede construction works and would present a permanent loss of topsoil/subsoil resource (where present) from the stripped area.

Soil resource from areas where reinstatement is not possible should firstly be considered for reuse within the scheme. If this is not viable and/or there are excess soil quantities, topsoil/subsoil may be sold for use in other construction projects or industries. It should be stated that landfilling of soil resource should be the last resort, as this would represent a permanent loss of topsoil/subsoil resource from the stripped area.

Based on the provisional Agricultural Land Classification (ALC) data, the Lower Thames Reservoir Option components are situated in Grade 3 land, non-agricultural land or urban land. Note that the provisional ALC data does not subdivide Grade 3 into 3a (representing best and most versatile land) and 3b (not presenting best and most versatile land). Where detailed ALC survey is available, agricultural land has been classified as Grade 2 and 3a.

Where detailed ALC survey is available, some areas of the Drinking Water Transfer Main Route Corridor have been classified as Grade 2 and 3a (in the New Denham area between the M25 and M40) and 4 (in the southern section of the route corridor immediately east of the M25).

It is recommended that a detailed soil survey (soil resource survey and/or ALC survey) is undertaken at a subsequent project stage to confirm soil resources present. The findings should inform a soil management plan which would provide guidance for stripping, stockpiling, maintenance, reinstatement and after care of soil resources. During construction activities, it is recommended that a qualified soil scientist undertake on-site monitoring visits to ensure the best practice and guidance as stated in the soil management plan is followed.

Land quality

Based on the identified historical and current land uses within the components of the Lower Thames Reservoir Option and within the surrounding areas, there is the potential for contamination to be present within the ground and groundwater underlying the sites as well as potential ground gas, particularly within the southern extent of the Drinking Water Transfer Main Route Corridor where the route passes through or adjacent to a number of historical landfill sites, as well as through an Environment Agency Designated Contaminated Land site.

It is considered that the risks identified in the Conceptual Site Models for the Indicative WTW Site and the Wraysbury Tunnel Connection would be adequately mitigated using the process in the Model Procedures for the Management of Land Contamination (LCRM)

(Defra/ Environment Agency). There may be significant negative impacts to land quality and human health where the Drinking Water Transfer Main Route Corridor passes through existing landfill sites, particularly in the area of the Environment Agency Designated Contaminated Land site. Impacts may include creating preferential pathways for contaminants to groundwater or surface water as well for ground gas away from existing landfills, impacts on human health due to direct contact with contaminated material and inhalation of landfill gas, production of waste requiring treatment and/ or removal. Temporary impacts during construction would include production of potentially contaminated dust from excavation of waste.

Consultation would be required with the landowner, local authorities and the Environment Agency, at a subsequent project stage, with regard to potential routing through landfill and associated risks. Once further assessments have been carried out, detailed geotechnical and geo-environmental Preliminary Risk Assessments should be completed, and the envisaged land quality mitigation measures reviewed, to understand whether these are sufficient to mitigate the potential impacts to acceptable levels and therefore confirm the feasibility or not of the preferred route. As part of the Preliminary Risk Assessments, ground investigation aims would be determined.

A site-specific geotechnical and geo-environmental ground investigation would be the key mitigation in reducing the uncertainty associated with the majority of the identified risks for the preferred route. It is envisaged that a preliminary phase of ground investigation works would provide initial information to assist in the development and delivery of the next project stage which includes finalised feasibility, pre-planning investigations and planning applications. A detailed phase of ground investigation would be required at a later stage in the project delivery.

Water

Aquatic environment appraisal

The majority of identified effects on the aquatic environment are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity of affected reaches. Flow changes within the River Thames as a result of SESRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected reaches. However, the potential impacts associated with the new or increased surface water abstraction would not be of a magnitude to result in the potential to deteriorate the WFD elements of the Thames

(Cookham to Egham), Queen Mother Reservoir and Wraysbury Reservoir or prevent them from the attainment of Good status in the future.

Groundwater

To the north of Ickenham, the Drinking Water Transfer Main Route Corridor passes through areas defined as Source Protection Zone (SPZ) 1 and SPZ 2. The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor and Indicative WTW Site are not located within SPZs. Construction within SPZs requires additional assessment and potentially mitigation to ensure no adverse impacts on public water supplies. Prior to construction, a hydrogeological risk assessment would be required for works within SPZ1 or 2.

None of the three groundwater bodies considered in the Level 1 – basic screening assessment were carried through to the Level 2 – detailed screening assessment. This has resulted in no further requirements for assessment of groundwater flow under the WFD at this stage. If any of the design assumptions or mitigation measures change, this will be reconsidered at subsequent project stages.

Flood risk

Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the site of the Wraysbury Tunnel Connection is at low risk of fluvial flooding. Although at very low risk of surface water flooding, a sustainable drainage system would be required for the raw water pumping station at the Wraysbury Tunnel Connection. The site of the Wraysbury Tunnel Connection is considered to be at extremely low risk of groundwater flooding and is not at risk of flooding from reservoir, canal and or other sources of artificial flooding.

Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the Raw Water Transfer Main Route Corridor is at low risk of fluvial and surface water flooding. The Raw Water Transfer Main Route Corridor is considered to be at extremely low risk of groundwater flooding and is not at risk of flooding from reservoir, canal and or other sources of artificial flooding.

Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the Indicative WTW Site is at low risk of fluvial flooding. A small part of the Indicative WTW Site is considered to be at high risk of surface water flooding. A sustainable drainage system would therefore be required for the Indicative WTW Site and the raw water pumping station at the Wraysbury Tunnel Connection, and it is recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process.

The indicative temporary construction compound for the WTW is considered to be at medium to low risk of surface water flooding. Care should be taken with the storage of equipment and materials to ensure stockpiled materials and other items are not washed into local drains to prevent blockages which could lead to localised flooding.

The Indicative WTW Site is considered to be at extremely low risk of groundwater flooding and is not at risk of flooding from reservoir, canal and or other sources of artificial flooding.

The Drinking Water Transfer Main Route Corridor is considered to be at risk of fluvial flooding from the River Colne and associated tributaries where the pipeline crosses the watercourses. It is assumed that no-dig methods would be utilised for major river crossings and that there would be no displacement of fluvial flooding as the pipeline would be underground. There is still a risk of flooding during the construction phase near any watercourse and it is recommended that works within the river during forecasts of wet weather or issued flood warnings should be avoided. Therefore, construction timings should be considered during the design development stage. Pipeline maintenance access points should be located in areas where there is low risk of flooding to ensure that they are accessible at all times and ensure pipe design and cover is enough to withstand seepage from flooding into the pipes.

North of Uxbridge, the Drinking Water Transfer Main Route Corridor bedrock geology is chalk. It is recommended that a groundwater model is requested at a subsequent project stage to assess the risk of groundwater flooding on the development of the Drinking Water Transfer Main Route Corridor within chalk bedrock areas. It is also recommended that groundwater risk is taken into consideration during design of the Drinking Water Transfer Main, and groundwater designs are implemented to assist with protection the asset.

Parts of the Drinking Water Transfer Main Route Corridor are shown to be at risk from reservoir, canal and or other sources of artificial flooding. The consequences of flooding from reservoirs are very high, however the inspection and maintenance regime under the Reservoirs Act (1975) means that the probability of occurrence of flooding from these sources is considered low. The Grand Union Canal has been identified as a potential flood risk due to its course running parallel with the River Colne. The main risk would be due to a breach of the canal during the construction period. It is considered that this risk would be very low.

The Harefield Service Reservoir Connection is considered to be at low risk of fluvial and surface water flooding, at low risk of groundwater flooding and is not considered to be at risk of flooding from reservoir, canal and or other sources of artificial flooding.

Air quality

All of the Lower Thames Reservoir Option components except the Harefield Service Reservoir Connection are either entirely or partly located within an Air Quality Management Area (AQMA). There are no Clean Air Zones in their vicinity.

The assessment indicates that the annual mean nitrogen dioxide (NO_2) objective may be exceeded in sections of the Drinking Water Transfer Main Route Corridor that are located close to the roadside within Buckinghamshire Council's 'South Bucks District Council AQMA No. 2' AMQA, which was declared for exceedances of the annual mean NO_2 objective. However, exceedances of the NO_2 objectives are unlikely to occur in suburban and urban background locations, where the Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor, Indicative WTW Site, the majority of the Drinking Water Transfer Main Route Corridor and Harefield Service Reservoir Connection are located. Further to this, exceedances of particulate matter (PM_{10} and $PM_{2.5}$) objectives are not expected to occur in any location.

There are sensitive human and ecological receptors within 350m of the Lower Thames Reservoir Option, which could be impacted as a result of construction activities. Therefore, a number of construction dust mitigation measures have been recommended in accordance with Institute of Air Quality Management (IAQM) guidance[2]. A dust risk assessment should be undertaken at a subsequent project stage, once more information is available to determine the construction dust risk at these sensitive receptors and whether additional construction dust mitigation is required.

The air quality impacts associated with vehicle traffic during the construction phase and the impacts from the standby generators should also be assessed once further details of these activities are available. If significant effects are predicted as result of these activities, additional mitigation may be required.

The impacts on air quality associated with vehicles during operation are not anticipated to be significant as, based on current information, the Lower Thames Reservoir Option would generate an additional annual average flow of one to three Heavy Goods Vehicles (HGVs)

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[2] Institute of Air Quality Management, Guidance on the assessment of dust from construction and demolition (2014)

per day throughout its operation, which is well below the Environmental Protection UK /IAQM screening threshold of 25 Heavy Duty Vehicles[3] (HDVs) per day on average each year.

The impacts associated with standby generators during operation have not been assessed, in part because it has been assumed that the impact on air quality would be mitigated within their design. Specifically, it is assumed that the generators would be designed to optimise dispersion of pollutants. For example, the generators should be designed with a sufficient stack height and should not have rain caps or cowls attached, which could impede the exhaust flow.

Climatic factors

Climate change risk assessment

The main climatic risks are:

- Flood risk being exacerbated by climate change and negatively impacting the pipeline.
- Higher temperatures and drought, leading to desiccation of soil, loss of strength, ground movement and damage to WTW/pumping station foundations and pipeline bedding.
- New WTW and raw water pumping station operational temperature limits being exceeded leading to shut downs.

It is recommended that these measures are mitigated by considering the changes in climate in the designs of the pipeline and assets. This includes planning for a higher range of thermal variation, increased flood risk and ground movement.

Carbon footprinting assessment

The Lower Thames Reservoir Option would have both capital and operational carbon emissions. The majority of the capital carbon sits within the construction associated with the transfer pipelines and WTW. The capital carbon emissions associated with pipeline construction result predominantly from the embodied carbon of the pipe material itself, with backfill/reinstatement and excavation also contributing to emissions. The capital carbon emissions for the WTW were driven by aspects of the treatment process that comprise of predominantly civil components such as potable water storage, clarifiers and filtration. Power consumption for pumping is the significant contributor to operational emissions with emissions.

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[3] HDVs are defined as freight vehicles of more than 3.5 tonnes (trucks) or passenger transport vehicles of more than 8 seats (buses and coaches).

Capital carbon mitigation opportunities include material selection, optimising the design of the WTW to reduce use of high carbon materials, reducing pipe size diameter, consideration given to not installing dual tunnels at every trenchless crossing, reviewing backfill and reinstatement to reduce the amount of imported material required, consideration given to single rather than dual supply for pumping stations and waste minimisation, e.g. through use of modular or off-site manufacture options.

Operational carbon mitigation opportunities include reducing operational carbon at carbon hotspot areas such as optimising energy efficiency and maintenance activities to prolong asset life/ performance, low carbon power generation and decarbonised electricity procurement choices and renewable energy generation.

Landscape

Construction of both the Raw Water Transfer Main and Drinking Water Transfer Main has the potential to result in the loss of vegetation both in the working corridor and where compounds are located. This is of particular concern along watercourses, field boundaries and where vegetation has a screening effect, for example in screening existing roads (the M25) and infrastructure. Perceptual and experiential value may be adversely affected in the vicinity of public rights of way (PRoWs) and residential properties as a result of the presence of construction activity which may result in a reduction in tranquillity of the landscape.

Construction of the Drinking Water Transfer Main would result in a temporary change to land use within the generally flat low-lying recreational landscape of the River Colne valley, due to large scale excavation and stockpiling of materials within the working corridor, most of which lies within the London Green Belt. The temporary diversion or closure of footpaths, including the Colne Valley Trail, Grand Union Canal Walk and London Loop, would temporarily reduce recreational connectivity across a proportion of the Colne Valley.

There is potential for permanent loss of waterside vegetation along the River Colne, Colne Brook, Grand Union Canal, Alder Bourne and Fray's River and the introduction of man-made culverts at the intersection of the pipeline and these watercourses, which unless designed sympathetically, would locally detract from the character of the river corridors. Removal of roadside vegetation, most notably along the M25 corridor and vegetation around existing areas of industrial development/ infrastructure has the potential to open up views of detracting elements for residential and recreational receptors.

Although the pipeline would be buried below the surface of the ground, the pipeline corridor may be evident where vegetation is lost during construction along watercourses and PRoW, in particular where vegetation, such as trees and woodland, cannot be replaced because it falls within the pipeline easement. This may result in a permanent change to the character along stretches of watercourses and PRoW, which may in turn affect their perceptual and experiential value for users of the PRoW and waterside footpaths.

The Indicative WTW Site is a site of existing industrial use and provides an opportunity to reduce the extent of hardstanding in comparison to the existing land use.

The indicative location of the temporary construction compound for the WTW may require clearance of existing woodland and scrub woodland and as a result there could be localised, adverse landscape effects.

The study area lies on the western edge of greater London and, as such, visual receptors are typical of the urban/rural interface and include (but are not limited to) residential receptors; recreational receptors, including users of public rights of way, cyclists, visitors to country parks, recreational users of the waterways and people engaging in outdoor recreation at formal sports facilities; transport receptors, including users of the road and rail networks; and employment and education receptors. These types of visual receptors would be considered and potentially taken through to assessment at a subsequent project stages, once more detailed design information is available.

Construction of the Drinking Water Transfer Main has the potential to impact protected trees including those within Harefield Village Conservation Area and with Tree Preservation Orders (TPO) in the Ickenham area.

There are wider opportunities within the Lower Thames Reservoir Option to enhance landcover value and strengthen the blue-green network, for example through use of re-wilding techniques in the restoration of temporary compound areas and use of mitigation planting to link existing green infrastructure elements across the wider Colne Valley landscape.

Recommended future technical work to be undertaken at a subsequent project stage includes the following:

- Refining the pipeline construction corridor and location of above ground structures to reduce the likely loss of vegetation and impact to sensitive landscape features.
- Once the location of above ground structures has been refined, a Zone of Theoretical Visibility (ZTV) should be produced to aid identification of possible visual receptors.
- Site visits should be to be carried out along the refined pipeline route corridor to confirm the findings of this EAR and the ZTV.

- Design landscape mitigation to integrate the above ground structures into the landscape and replace any vegetation removed during construction within the working corridor.
- To support to the detailed design phase of the Lower Thames Reservoir Option, it is recommended that a full BS5837:2012 survey is conducted, and an arboricultural impact assessment and tree protection plan produced. Where sensitive sites cannot be avoided, extra mitigation is likely to be required to minimise impacts during the construction phase.

Historic environment

There are 67 Listed Buildings, two Scheduled Monuments and seven conservation areas within 500m of the Lower Thames Reservoir Option. There are no World Heritage Sites or Registered Parks or Gardens within this area. There are 98 non-designated heritage assets within 500m of the Lower Thames Reservoir Option, as mapped by the Greater London Historic Environment Record, Buckinghamshire Historic Environment Record (HER) and Hertfordshire HER. Data within these HERs, along with several archaeological investigations, has identified a generally high potential for archaeological remains, particularly dating to the prehistoric period.

The excavation required for the Raw Water Transfer Main and Drinking Water Transfer Main would severely truncate, or remove entirely, potential archaeological remains. There is no anticipated impact to the two Scheduled Monuments in the study area and no Scheduled Monument Consent is anticipated to be required.

The construction of the WTW at the Indicative WTW Site could adversely affect the setting of the Grade II Iver Court Farmhouse however there is an opportunity to enhance the setting of this listed building, which should be investigated at a subsequent project stage. A Listed Building Consent may be required for the WTW if the Indicative WTW Site is taken forward and the proposals involve a direct impact to Iver Court Farmhouse.

Further assessment, at a subsequent project stage would refine the need for archaeological investigation and in consultation with local archaeological advisors. A programme of geophysical survey in undeveloped areas and test pitting in developed areas would help identify the presence of archaeological remains. Should remains of potential high significance be identified, a diversion of the pipeline route should be considered, to facilitate preservation in situ. The results of the survey or test pitting would enable a programme of targeted archaeological investigation to be developed at a subsequent project stage, such as targeted trial trench evaluation, to ensure no significant archaeological remains are removed without adequate record.

Noise

By careful design, noise impacts from constructing the Lower Thames Reservoir Option could be minimised. Noise impacts from construction of the Wraysbury Tunnel Connection and Raw Water Transfer Main are likely to be minimal due the distance from noise sensitive receptors.

The alignment of the Drinking Water Transfer Main should be chosen to be at least 85m from noise sensitive receptors (130m where trenchless techniques occur) in order to minimise significant adverse noise impacts. It is considered that this can be achieved along the vast majority of the Drinking Water Transfer Main Route Corridor.

Once the final alignment of the Drinking Water Transfer Main has been agreed, the areas where residual construction noise impacts may occur should be identified and the noise mitigation options to be included in a Construction Noise Management Plan considered.

At this stage, it is considered unlikely that baseline noise surveys and construction noise assessments would be required for the Indicative WTW Site, since it is anticipated that significant adverse noise impacts could be avoided through design, although this should be kept under review as the design is developed at subsequent project stages, in particular the construction access routes.

All operational noise impacts for above ground infrastructure should be designed out through a number of methods including acoustic enclosure of plant, acoustic louvres, ducts silencers and plena for ventilation paths to enclosures and buildings, vibration isolation of plant and acoustic barriers, where required. All of these means of noise mitigation have been used extensively and are well understood and therefore any potential adverse noise impacts can be designed out.

At this stage, it is considered likely that baseline noise surveys and operational noise assessments would be required at a subsequent project stage to determine the background noise levels and inform detailed design. If required, baseline noise monitoring should be undertaken in order to set noise limits in accordance with BS4142:2014 for operational noise in the area of all of the above ground facilities. Once the noise baseline has been established use the derived criteria as design constraints for these facilities.

Population and human health

The Lower Thames Reservoir Option is located within 500m of housing and private property, businesses, community facilities and areas of open space and recreation. The Wraysbury Tunnel Connection and Raw Water Transfer Main Route Corridor are within the existing Iver WTW and the Indicative WTW Site is on existing industrial land. The Drinking Water Transfer Main Route Corridor crosses agricultural land and bisects areas of open space and recreation, including a golf course and several PRoWs, before terminating at an existing service reservoir in the vicinity of Harefield.

Health indicators for the population within the three local authority areas in which the Lower Thames Reservoir Option is located were also analysed. Life expectancy (for both genders) is slightly higher across all areas in which the Lower Thames Reservoir Option is located, compared to the England average. The under-75 mortality rates (from all causes, cardiovascular diseases and cancer) for all the local authorities are also less than the national rates. A large proportion of residents living within 500m of the Lower Thames Reservoir Option live in the least or second least deprived deciles in the country.

There are anticipated to be a range of community and human health impacts affecting housing and private property, businesses and open space and recreation as a result of the Lower Thames Reservoir Option during both construction and operation. These impacts include land requirements for the Indicative WTW Site affecting existing businesses and temporary land requirements affecting a golf course, PRoW closure and travel disruption. Depending on the construction methodologies, there may also be a change in environmental conditions as a result of a combination of noise, air quality, visual impacts or presence of Heavy Goods Vehicles (HGVs).

To avoid or mitigate potential disruption and disturbance to communities during construction and operation of the Lower Thames Reservoir Option, best practice mitigation should be implemented during construction.

Further assessment is recommended at a subsequent project stage to understand the timing and extent of the population and human health impacts and whether the impacts are temporary or permanent.

Material assets

The Lower Thames Reservoir Option has the potential to affect other material assets during construction and operation including transport, energy, water and wastewater, waste and minerals infrastructure.

Based upon high level estimates of HGVs and staff vehicles that may be required during the construction and operational phases of the Lower Thames Reservoir Option, at this stage, it is not considered that the vehicles volumes generated would present additional constraints to the road network, and the majority of roads are anticipated to provide practical options such as the dual carriageway of Denham Road and the single carriageways of Bangor Road South, Thorney Lane Street and Slough Road. Potential issues have been identified in some areas, for example, access difficulties from both Harvil Road and Skip Lane where the current landscape may require trees and hedges to be removed. These access issues would need to be investigated at a subsequent project stage.

The Drinking Water Transfer Main Route Corridor intersects with PRoWs and there are PRoWs in proximity to the indicative locations for temporary construction compounds and the Indicative WTW Site. Although this provides a potential opportunity in terms of adequate public accessibility to these sites, it also provides a constraint when undergoing development works where construction areas may impact on nearby PRoWs. Consideration would need to be given to maintaining walking routes around temporary construction compounds and ensuring they are accessible and safe to use.

The Drinking Water Transfer Main Route Corridor intersects with National Cycle Network (NCN) routes 6 and 61. NCN route 61 is in close proximity to one of the indicative locations for temporary construction compounds and, while this would be beneficial in terms of connectivity, this road would likely be used for vehicle access to the pipeline construction works. Consequently, appropriate mitigation for NCN route 61 is likely to be required, potentially including a temporary diversion. NCN route 61 offers good connections for cycling to the Indicative WTW Site.

The Drinking Water Transfer Main Route Corridor crosses the Chiltern Railway, HS1 Phase 1 route, Grand Union Canal and highways and local roads. Engagement would be required with the relevant stakeholders including National Highways, Network Rail and Canal and River Trust at a subsequent project stage.

The Lower Thames Reservoir Option has the potential to affect other material assets during construction including potential safety hazards from overhead powerlines, existing operational assets including licensed waste sites and strategic areas of minerals. During operation, there is potential for temporary disruption during maintenance work.

Recommended areas for future technical work at a subsequent project stage are summarised below:

- Review any changes to the conceptual design following Gate 2 in terms of access routes to the indicative locations for temporary construction compounds, pipeline crossings and HGV/workforce access for the new WTW.
- Review construction HGV and workforce numbers and programme once known to determine construction flows to assess future potential impact on roads.
- Review construction vehicle types once known to enable access roads and site access point suitability to be assessed.
- Collect baseline traffic data, depending on the expected volume of vehicles and the programme. Traffic surveys are only likely to be required at specific junctions. The scope of traffic surveys and need for modelling would be subject to engagement with the highway authorities.
- Update review of local authority local plans / transport schemes to understand potential cumulative effects from other projects to determine the modelling extents and junction analysis required.
- Engage with highway authorities where opportunities to create access routes access have been highlighted.
- Review alignment of the Drinking Water Transfer Main to ensure avoidance of existing and allocated minerals and waste sites and undertake engagement with relevant stakeholders including Minerals and Waste Authorities.
- Pursuant to the consenting process, a Transport Assessment would be undertaken and supporting documents such as a Construction Traffic Management Plan, Travel Plan and Servicing and Delivery Plan would be produced detailing how transport impacts are mitigated and managed.

Potential cumulative effects

An initial cumulative effects assessment has been undertaken. It is understood that if the Lower Thames Reservoir Option is selected as an option in the WRSE Regional Plan, as well as Thames Water WRMP24 and Affinity Water WRMP24, it will be subject to an in-combination effects assessment with the other selected options, neighbouring water companies plans and neighbouring regional plans. Until the WRSE Best Value Regional Plan has been developed and agreed, it is not known when the Lower Thames Reservoir Option would be implemented, and therefore, which other developments could act in-combination with it.

No other SROs are geographically near to the Lower Thames Reservoir Option and therefore effects during construction are unlikely to occur. Cumulative operational effects are unlikely.

From the review of the plans, programmes and projects, five developments were identified that have the potential for cumulative effects due to overlapping construction periods. These include a residential development at Batchworth Golf Course within the Three Rivers District Council New Local Plan – Sites for potential Allocation and two allocated sites for mineral extraction that are adjacent to the Drinking Water Transfer Main Route Corridor. The construction programmes for these developments and the Lower Thames Reservoir Option potentially overlap, with potential for minor cumulative construction effects arising from visual intrusion, traffic disruption, noise, vibration and air quality on receptors. No cumulative impacts resulting from operation are anticipated. No cumulative effects were identified for the other two developments, which are a sand and gravel extraction from King George VI reservoir and a site allocation within the borough of Spelthorne.

From the review of the plans, programmes and projects, three other developments were considered as part of the cumulative effect assessment:

- UK Government Hybrid Bill HS2 Phase One
- Planning Inspectorate, Western Rail Link to Heathrow
- Buckinghamshire Council, Buckinghamshire Council (CM/0049/21), Land At Sutton Court Farm North Park Langley SL3 8AU

All three developments are located within 1km of the Lower Thames Reservoir Option. These developments are likely to be fully built out before construction of the Lower Thames Reservoirs Option commences; however, they would need to be considered as part of a future cumulative effects assessment in terms of temporal effects, for example on local communities, and the potential deterioration of the environment as a result of successive developments. These developments would also need to form part of the future baseline for the Environmental Impact Assessment (EIA). In particular, the future baseline in relation to area north and south of the crossing of the HS2 Phase One would need to be considered at a subsequent project stage.

Invasive non-native species risk assessment

The invasive non-native species (INNS) risk assessment identified that the Lower Thames Reservoir Option would not introduce a new hydrological connection between previously isolated catchments. Although a number of aquatic INNS have been identified within the study area, including several High Impact species, there is a very low risk that the Lower Thames Reservoir Option would facilitate their spread as water transfer is through a closed system.

The main risk associated with the water transfer component of the Lower Thames Reservoir Option was identified as raw water movement between the source at the Wraysbury and Queen Mother Reservoirs and the new WTW. Although biosecurity measures have been identified, there would be minimal benefit from their implementation in reducing the risk relating to the rare event of water leakage and implementation of these measures may be considered disproportionate in relation to the risk. There would be negligible risk of INNS transfer for the Drinking Water Transfer Main and further biosecurity/mitigation measures would have no tangible benefit.

The INNS risk associated with the proposed new assets (raw water pumping station at the Wraysbury Tunnel Connection and the new WTW) was assessed as being low. The assets are designed to move water within a sealed system, therefore it is considered unlikely that additional biosecurity measures would reduce the risk further.

Natural capital and biodiversity net gain

Natural Capital Assessment (NCA) and biodiversity net gain (BNG) calculations were undertaken for the Lower Thames Reservoir Option.

Natural capital refers to the elements of the natural world that provide benefits to society and includes aspects such as woodland, grassland, freshwater, marine, urban greenspace and wetland habitats. The benefits that are provided to humans by the natural environment vary from regulating services such as natural flood management to cultural services such as recreational value.

BNG refers specifically to the combination of habitats present within a site and their ability to support biodiversity. Each habitat is given a distinct score that relates to its area, condition, distinctiveness and connectivity. The change in habitat due to the construction and operation of the regional plan options informs the overall BNG score and whether they are likely to contribute to a net gain in biodiversity.

The T2AT SRO is committed to achieving a minimum 10% BNG, which would be reviewed when the precise regulatory and legislative requirements are known (e.g. under the Environment Act 2021[4]). Opportunities were identified to achieve this for the Lower Thames Reservoir Option, however specific habitat mitigation and enhancement proposals would be set out at a subsequent project stage.

The NCA identified that the Lower Thames Reservoir Option would likely cause the temporary and permanent loss of natural capital stocks during construction. Stocks that are likely to be permanently lost include pasture, woodland priority habitat and active floodplain. However, best practice mitigation (including the use of trenchless techniques) and reinstatement/compensation of habitat means that most natural capital stocks post construction should have no to little change and would likely have no permanent impact on the provision of ecosystem services.

The NCA identified that the transfer routes could be optimised within the current transfer route corridors to reduce the loss of natural capital stocks. An optimised route could result in a reduction in the total quantity of permanently lost and avoided the permanent loss of active floodplain that would be permanently lost as a result of the scheme, and in greater value retained for ecosystem services. The feasibility of an optimised route should be further investigated, at a subsequent project stage, against engineering, environmental, social, and planning constraints, as well as against potential opportunity areas and proposals for environmental net gain.

The assessment of BNG calculates that approximately 77 BNG habitat units could be lost due to the temporary removal of habitats during construction. This could be reduced to 57 BNG habitat units through optimisation of the transfer routes.

Opportunities identified in the NCA and BNG assessments have the potential to contribute to government ambitions for environmental net gain. This could take the form of habitat compensation, creation and/or species relocation schemes. Any schemes would need to be taken forward based on a comprehensive understanding of the interaction between natural systems and between natural systems and social uses of land.

At a subsequent project stage, it is recommended that the underlying data sources are confirmed and refined with on-site surveys to provide a more-detailed understanding of habitat condition. Opportunities should also be considered to create and improve habitat

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[4] Environment Act 2021, c.30. Available at: https://www.legislation.gov.uk/ukpga/2021/30/contents/enacted [Accessed: April 2022]

on-site and off-site through local schemes, Nature Recovery Networks and wildlife corridors in order to achieve a minimum 10% net gain in BNG units and increase the provision of ecosystem services, therefore aiding in developing more resilient options for the future provision of water for T2AT SRO.

Wider benefits

Wider benefits are those areas of environmental and social value that are associated with constructing and operating the scheme. Areas of disbenefit are also considered.

The consideration of wider benefits draws on the findings of other assessment work to inform the Gate 2 submission, as well as introducing additional information where material in the context of the Lower Thames Reservoir Option.

The main findings from a review of the wider benefits associated with the Lower Thames Reservoir Option are as follows.

Beneficial economic impacts associated with new operational phase jobs are anticipated to generate approximately £13 million (over a 30 year appraisal period).

Proposals to enhance green infrastructure links and local footpaths could lead to health and well-being benefits. Further work to develop these opportunities and incorporate into the scheme design could be undertaken at a subsequent project stage.

A draft partnership strategy has been developed as a basis for future engagement with stakeholders in order to help deliver some of the benefits and enhancements from changes to land use and provision of BNG.

Summary of main findings

A number of constraints and issues for further investigation and work have been identified however, the preliminary desk-based environmental appraisal undertaken at this stage, based upon the conceptual design, did not identify any environmental risks which could affect the viability of the Lower Thames Reservoir Option. As stated above, the recommendations outlined in this environmental appraisal do not definitively scope potential environmental effects in or out at this stage; this would be done as part of an

Environmental Impact Assessment (EIA) scoping process to be undertaken at the appropriate time and based on up to date information at that time.

The table below presents a summary of the environmental appraisal for the Lower Thames Reservoir Option.

Assessment / topic	Environmental appraisal summary
Informal Habitats Regulations Assessment	Stage 1 Screening: Potential Likely Significant Effects on South West London Waterbodies SPA/Ramsar. Stage 2 AA: No adverse effects on the integrity of South West London Waterbodies SPA/Ramsar are expected. In-combination effects assessment not required as no residual effects are expected.
Water Framework Directive Compliance Assessment	Level 1 Screening: One surface water river (the Thames (Cookham to Egham)) and two lakes (Queen Mother Reservoir and Wraysbury Reservoir) had an impact score greater than 1 due to new or increased abstraction. No groundwater bodies were taken forward to a Level 2 assessment. Level 2 Screening: It was determined that the new or increased surface water abstraction activity does not have the potential to deteriorate the WFD elements of the water body or prevent them from attaining Good status. The Lower Thames Reservoir Option is therefore considered to be compliant with the WFD.
Strategic Environmental Assessment Review	Major positive effects identified on delivering reliable and resilient water supplies. Moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for biodiversity, flora and fauna, soil, flood risk, air quality, and population and human health for the construction of the Lower Thames Reservoir Option. Moderate negative effects on carbon emissions during the operational phase. Minor negative or neutral effects were identified for the remaining SEA objectives.
Biodiversity, flora and fauna	No direct impacts on statutory designated sites. Potential for indirect effects on statutory designated sites including Kingcup Meadows and Oldhouse Wood, Fray's Farm Meadows, Denham Lock Wood, Ruislip Wood SSSIs, Frays Valley and Denham Quarry Park LNRs during construction.

Assessment / topic	Environmental appraisal summary
	Direct and indirect negative effects on non-statutory designated sites, including Southlands Manor LWS, Mid Colne SINC, Shepherd's Hill Woods and Fields SINC and Newyears Green SINC. No loss of ancient woodland. Potential loss of deciduous woodland priority habitat and potential impacts on protected and priority species. Based on currently available information, the majority of identified effects on the aquatic environment are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity of affected reaches. Identified adverse effects with risks to the overall ecological integrity of affected reaches include potential primary productivity/food-chain effects within the River Thames, upstream of the abstraction point for the Lower Thames Reservoir Option. Flow changes within the River Thames as a result of SESRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected reaches.
Soils	No direct or indirect impacts on designated geological sites. No permanent loss of best and most versatile agricultural land as above ground infrastructure is on non-agricultural land. Potential for temporary loss of Grade 2 and 3 (including 3a) agricultural land due to pipeline construction within the Drinking Water Transfer Main Route Corridor. Potential for contamination due to construction works within historic landfills and other contaminated land.

Assessment / topic	Environmental appraisal summary
Water	The majority of identified effects on the aquatic environment are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity of affected reaches. Sections of pipeline pass through SPZs, with potential risk of pollution during construction. No further requirements for assessment of groundwater flow under the WFD at this stage, as neither of the groundwater bodies considered in the Level 1 – basic screening assessment were carried through to the Level 2 – detailed screening assessment. Permanent infrastructure is in flood zone 1; low surface water flood risk for Indicative WTW Site, closed loop sustainable drainage system required for raw water pumping station at Wraysbury Tunnel Connection and new WTW to capture potential contaminants from the treatment process. Fluvial flood risk along the Drinking Water Transfer Main Route Corridor near watercourse crossings would need to be managed during construction.
Air	Majority of Lower Thames Reservoir Option is within AQMAs. Annual mean NO_2 objective may be exceeded during construction in areas that are located close to the roadside within Buckinghamshire Council's 'South Bucks District Council AQMA No. 2' AQMA. Exceedances of the PM_{10} and $PM_{2.5}$ objectives are not expected to occur. Operational effects associated with traffic and standby generators for the new WTW are unlikely to exceed air quality objectives.
Climatic factors	Climatic risks include exacerbation of flood risk, higher temperatures and drought leading to change in ground conditions, and exceedance of operational temperature limits leading to shutdowns. Construction carbon emissions associated with the transfer pipelines and WTW. Operational carbon emissions primarily associated with power consumption for pumping.

Assessment / topic	Environmental appraisal summary
Landscape	Potential for permanent change in landscape character along the pipeline route where vegetation, such as trees and woodland, is lost during construction and cannot be replaced because it falls within the pipeline easement. Indicative WTW Site is proposed on a site of existing industrial use and provides an opportunity to reduce the extent of hardstanding in comparison to the existing land use. Potential visual receptors identified include residential, recreational (including users of PRoW and cyclists), users of transport networks and employment and education receptors. Potential impacts on protected trees within proximity to the Drinking Water Transfer Main Route Corridor including within Harefield Village Conservation Area and TPOs in the Ickenham area. Opportunities to enhance landcover value and strengthen the blue-green network, for example through use of re-wilding techniques in the restoration of temporary compound areas and use of mitigation planting to link existing green infrastructure elements across the wider Colne Valley landscape.
Historic environment	No permanent impacts on designated heritage assets with exception of Iver Court Farmhouse, a Grade II Listed Building, which, depending on the layout for the Indicative WTW Site, could be directly impacted. Construction of the new WTW could also adversely affect the setting of the Grade II listed Iver Court Farmhouse however there is an opportunity to enhance the setting of this listed building. A Listed Building Consent may be required if the Indicative WTW Site is taken forward. High potential for archaeological remains, particularly dating to the prehistoric period. Excavation during construction would severely truncate, or remove entirely, potential archaeological remains.
Noise	Construction and operational noise impacts from the Wraysbury Tunnel Connection, Indicative WTW Site and Raw Water Transfer Main Route Corridor are likely to be minimal due the distance from noise sensitive receptors. Pipeline alignment should be chosen to be at least 85m from noise sensitive receptors (130m where trenchless techniques occur) in order to minimise significant adverse noise impacts. This could be achieved along the vast majority of the Drinking Water Transfer Main Route Corridor and should be factored into refinement of the pipeline route alignment.

Assessment / topic	Environmental appraisal summary
Population and human health	Community and human health impacts affecting housing and private property, businesses and open space and recreation during both construction and operation, including permanent and temporary land requirements, PRoW closure, travel disruption and a change in environmental conditions as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles. No permanent loss of housing and private property, community facilities or recreational assets.
Material assets	It is not considered that the vehicles volumes generated during construction and operation would present additional constraints to the road network. The majority of roads are anticipated to provide practical options for construction access. There are some localised construction access issues to be investigated in further detail at a subsequent project stage. Major infrastructure crossings including A40, Chiltern Line, HS2 Phase 1 route and Grand Union Canal would require further investigation and agreement with stakeholders at a subsequent project stage. Opportunity for a closer access and egress from the M25, which could provide a more direct route to construction sites. Potential impacts on existing utilities and minerals and waste sites.
INNS Risk Assessment	Lower Thames Reservoir Option would not introduce a new hydrological connection between previously isolated catchments. Very low risk that the Lower Thames Reservoir Option would facilitate spread of INNS as water transfer is through a closed system. Main risk identified is raw water movement between the source / intake and the new WTW. Minimal benefit from implementation of biosecurity measures and implementation of these measures may be considered disproportionate in relation to the risk. Negligible risk of INNS transfer of drinking water and further biosecurity/mitigation measures would have no tangible benefit. Low risk associated with the new assets as they are designed to move water within a sealed system; unlikely that additional biosecurity measures would reduce risk further.

Assessment / topic	Environmental appraisal summary
Natural Capital Assessment and Biodiversity Net Gain	Potential for temporary loss of natural capital and ecosystem services as a result of the pipeline and permanent loss as a result of above ground components. Transfer routes could be optimised within the current transfer route corridors to reduce the loss of natural capital stocks. Approximately 77 BNG habitat units could be lost due to the temporary removal of habitats during construction. This could be reduced to 57 BNG habitat units through optimisation of the transfer routes.

Taking into account the key legislation and national planning policy outlined in this EAR, and with the information available at this stage, it is not considered that there any insurmountable environmental issues that should prevent the Lower Thames Reservoir Option from progressing. A summary of key risks is outlined below.

- Potential indirect effects on statutory designated sites and direct and indirect effects on non-statutory designated sites, priority habitat and protected species would require further consideration in terms of draft National Policy Statement[5] (NPS) Section 4.3 and National Planning Policy Framework[6] (NPPF) Section 15 (paragraph 180), which states that *'as a general principle, and subject to the specific policies below, development should avoid significant harm to biodiversity and geological conservation interests and contribute overall to net biodiversity gain. Where significant harm cannot be avoided or mitigated, as a last resort, appropriate compensation measures should be sought to provide net gains for biodiversity.'* Further technical work, including surveys, is recommended at a subsequent project stage to investigate potential impacts, proposed mitigation and proposals for biodiversity net gain.
- Potential direct effects on the Grade II listed Iver Court Farmhouse would require further consideration in terms of draft NPS Section 4.7 (paragraphs 4.7.11 to 4.7.25 and NPPF Section 16 (paragraphs 199-202) , which states that *'substantial harm to or loss of a Grade II Listed Building…should be exceptional,'* and *'any harmful impact on the significance of a designated heritage asset should be weighed against the public benefit of development, recognising that the greater the harm to the significance of the heritage asset, the greater the justification that will be needed for any loss.'* It is considered that in the case of the Grade II Listed Iver Court Farmhouse, the Lower Thames Reservoir Option could provide an opportunity to enhance its setting and restore value to the asset that has been lost

[5] Department for Environment, Food & Rural Affairs (2018) Draft National Policy Statement for Water Resources Infrastructure. Available at: https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents/draftnpswaterresourcesinfrastructure.pdf [Accessed April 2022]
[6] Ministry of Housing, Communities & Local Government (2021) National Planning Policy Framework. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2 [Accessed April 2022]

through the surrounding unsympathetic development. Further technical work is recommended at a subsequent project stage to investigate if the public benefit would outweigh the potential harm, or if the tests in Paragraph 4.7.19 of the NPS[7] would apply.

Recommendations for future technical work

Recommendations for future technical work at a subsequent project stage are presented in this section. It is recommended that the following activities are prioritised ahead of commencing formal environmental assessment pursuant to the consenting process.

- Stakeholder engagement on the transfer routes and sites, including with statutory environmental stakeholders (Natural England, Environment Agency and Historic England), Local Planning Authorities, including County Archaeologists, and non-statutory environmental stakeholders including Wildlife Trusts.
- Further work on pipeline routing and siting of above ground infrastructure to avoid constraints such as non-statutory designated sites and priority habitats; this includes investigating the engineering feasibility of the Natural Capital Optimised Route and determining future environmental baseline, particularly in relation to the HS2 Phase 1 crossing.
- Informing the design to review biosecurity measures and improve resilience to physical climate change risks.
- Further work to understand contamination risks including a geotechnical and geo-environmental ground investigation and a hydrogeological risk assessment to identify risks to SPZs and likely mitigation.
- Further work to investigate risks and impacts to the setting of affected features could be undertaken. In particular, a feasibility study for the Grade II listed building within the Indicative WTW Site could be undertaken should this site be taken forward following stakeholder engagement and public consultation.
- Targeted surveys of macroinvertebrate, fish and macrophyte/phytobenthos is required for several of the tributaries of the River Colne and Aldbourne as there is currently no data available to inform the sensitivity of these water bodies.
- Investigate the opportunity to gain direct access from the M25 to the Drinking Water Transfer Main Route Corridor.

[7] *'Where the proposed development will lead to substantial harm to or the total loss of significance of a designated heritage asset, the Secretary of State will refuse consent unless it can be demonstrated that the substantial harm or total loss of significance is necessary in order to deliver substantial public benefits that outweigh that loss or harm, or alternatively that all of the following apply: the nature of the heritage asset prevents all reasonable uses of the site; no viable use of the heritage asset itself can be found in the medium term through appropriate marketing that will enable its conservation; conservation by grant funding or some form of not for profit charitable or public ownership is demonstrably not possible; and the harm or loss is outweighed by the benefit of bringing the site back into use.'*

- Scope and undertake surveys and investigations in order to inform design development and EIA scoping, including:
  - Preliminary Ecological Appraisal to identify the targeted ecology surveys required.
  - Continued aquatic ecology and water quality monitoring.
  - Targeted walkovers of the watercourse crossings the inform the need for and scope for additional mitigation measures.
  - Preparation of a ZTV to identify visual receptors followed by site visits to confirm the ZTV and identify viewpoints and locations for visually verified views.
  - Initial arboricultural survey to inform ahead of a full BS5837:2012 survey.
  - Historic environment walkovers and engagement with local archaeological advisors to determine the programme of geophysical and intrusive survey required.
  - Transport Assessment Scoping to identify the traffic surveys and assessment required.
- Undertake optioneering on delivering BNG, including identifying specific locations for opportunities and investigating the merits of the timing of interventions, and developing partnerships to help deliver some of the benefits and enhancements from changes to land use and provision of BNG.

1 Introduction

1.1 Purpose of this report

1.1. The Environmental Assessment Report (EAR) is a technical supporting document prepared to support the Gate 2 submission report to the Regulators' Alliance for Progressing Infrastructure Development (RAPID) for the Thames to Affinity Transfer (T2AT) Strategic Resource Option (SRO).

1.2. This EAR presents the environmental appraisal work for the Lower Thames Reservoir Option. This option would enable the transfer of water from Wraysbury and Queen Mother reservoirs in the Thames region to an existing service reservoir in the vicinity of Harefield in the Affinity region.

1.3. The purpose of this EAR is to meet the requirements for the RAPID Gate 2 guidance[8], and to draw together the conclusions of all the Gate 2 environmental appraisal work into a single document.

1.4. This EAR has been informed by desk based assessments using publicly available information in line with the requirements of the Gate 2 submission. The work is at a preliminary stage and establishes an initial appraisal that can be built on during subsequent project stages. In future, this will also be informed by the undertaking of site surveys and collection of additional information and data that will inform an Environmental Impact Assessment (EIA) likely to be required as part of any future consenting process.

1.5. This EAR does not definitively scope potential environmental effects in or out at this stage and the recommendations for further technical work outlined within this EAR are subject to change as further information becomes available at subsequent project stages. Future work will be carried out in conjunction with relevant stakeholders to inform the approach to the EIA.

1.6. The details set out in this EAR are still at a formative stage and consideration should be given to that when reviewing the proposals. They are for the purposes of making decisions on progress and further funding not seeking permission.

[8] Regulators' Alliance for Progressing Infrastructure Development (RAPID) Strategic Regional Water Resource Solutions Guidance for Gate Two. Available at: https://www.ofwat.gov.uk/wp-content/uploads/2022/02/Strategic-regional-water-resource-solutions-guidance-for-gate-two_Feb_2022.pdf [Accessed April 2022]

1.2 Scope of environmental appraisal

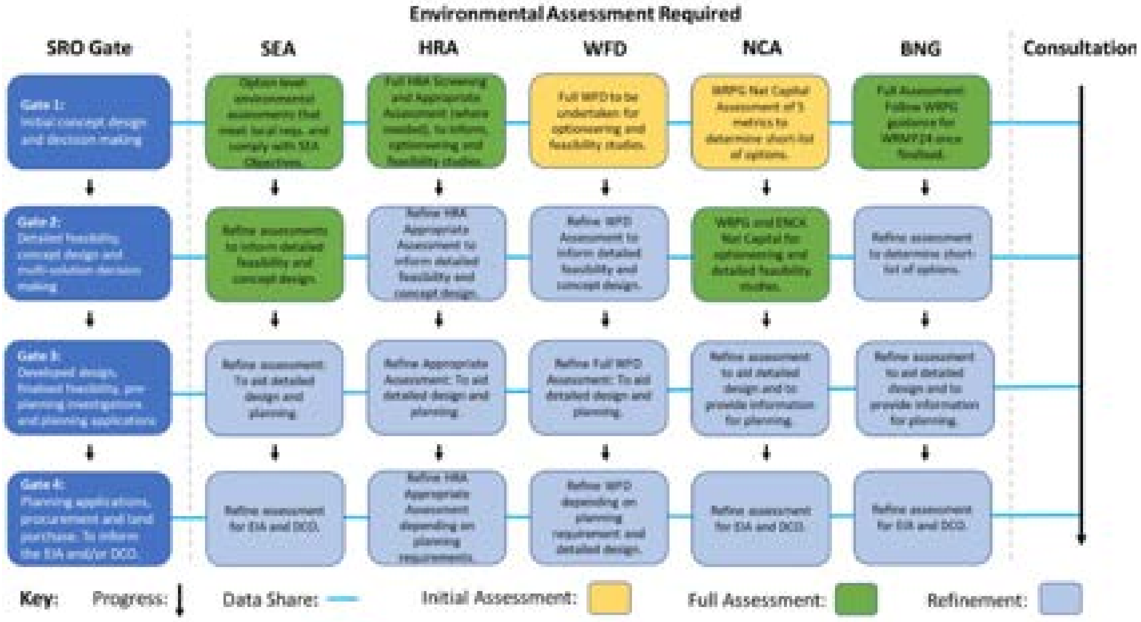
1.7. For the purpose of the Gate 2 Submission, the Lower Thames Reservoir Option has been subject to a desk-based environmental appraisal, building on the work undertaken at Gate 1, to identify potential environmental and social impacts, potential mitigation measures and enhancement opportunities. The following have been undertaken.

- Informal Habitats Regulations Assessment (HRA), updating the Gate 1 HRA.
- Informal Water Framework Directive Assessment (WFD), updating the Gate 1 WFD assessment.
- Review and update of the Strategic Environmental Assessment (SEA) undertaken for the purpose of aligning with the Water Resources South East (WRSE) Regional Plan and reported at Gate 1.
- Topic-based desk-based assessments, updating Gate 1 work on baseline and assessment of effects.
- Invasive non-native species (INNS) risk assessment, updating the Gate 1 risk assessment.
- Natural capital assessment (NCA), updating the Gate 1 assessment.
- Biodiversity net gain (BNG) calculations, undertaken using Biodiversity Metric 3.0.
- Wider benefits assessment.

1.8. Figure 1.1 below shows the integration of the environmental assessments (i.e. SEA, HRA, WFD, NCA/BNG) within the RAPID gated process. This schematic is taken from the All Companies Working Group (ACWG) guidance that was released in Gate 1[9]. While this is still largely relevant and followed, it has been somewhat superseded by the RAPID Gate 2 guidance[8], which the Gate 2 assessments have followed.

[9] All Companies Working Group, WRMP environmental assessment guidance and applicability with SROs, Mott MacDonald, October 2020.

Figure 1.1: Environmental assessment integration with SRO Gates



1.9. The environmental appraisal is based upon currently available desk-based information, which is considered to be an appropriate approach for Gate 2 (which, as shown in Figure 1.1: Environmental assessment integration with SRO Gates, is a detailed feasibility and conceptual design stage). Information provided by third parties, including publicly available information and databases, is considered correct at the time of assessment (April/May 2022).

1.10. The following Technical Supporting Documents have informed the EAR and are referred to within this report:

- A1a, Concept Design Report (Lower Thames Reservoir Option)
- A3a, Carbon Report (Lower Thames Reservoir Option)
- A4, Options Appraisal Methodology Report
- A5, Options Refinement Report
- B2, Habitats Regulations Assessment
- B3, Water Framework Directive Compliance Assessment
- B4, Strategic Environmental Assessment Review

1.3 Stakeholder engagement

1.11. The principles for our approach to environmental engagement are as follows:

- To build on the engagement undertaken to date, taking account of any issues and concerns raised by local communities or stakeholders, ensuring discussions are timely.
- To fit within the regulatory process established under the guidance to understand and agree expectations.
- To be integrated with regional/company water resource planning.

1.12. Engagement during Gate 2 has focused on development of the pipeline route corridor and location of above ground infrastructure.

1.13. Regular engagement has been undertaken with the National Appraisal Unit (NAU) (comprising the Environment Agency and Natural England) through a series of Technical Liaison Forums during Gate 2. The NAU has had opportunity to comment on development of the design and the outcomes of the environmental appraisal.

1.14. Initial engagement has also been undertaken with Local Planning Authorities, as set out in Technical Supporting Document A4, Options Appraisal Methodology Report, with a focus on introducing the options appraisal process and providing an overview of the Lower Thames Reservoir Option.

1.4 Structure of the report

1.15. This EAR is structured as follows.

- Chapter 2 (Summary scheme description) presents an overview of the Lower Thames Reservoir Option and signposts to other Technical Supporting Documents where further information can be found.
- Chapter 3 (Informal regulatory assessments) presents information on the regulatory assessments (informal HRA, WFD assessment and updates to the WRSE SEA as part of the Gate 2 submission).
- Chapters 4-13 present the topic-based desk-based assessments undertaken to inform the Gate 2 submission.
- Chapter 14 (Potential cumulative effects) presents an initial local, SRO-specific cumulative effects assessment undertaken to inform the Gate 2 submission.
- Chapter 15 (Invasive non-native species risk assessment) presents the INNS risk assessment undertaken to inform the Gate 2 submission.

- Chapter 16 (Natural capital and biodiversity net gain) presents the NCA and BNG assessments undertaken to inform the Gate 2 submission.
- Chapter 17 (Wider benefits) presents a summary of the potential wider benefits associated with the Lower Thames Reservoir Option.
- Chapter 18 presents a summary of the main findings and recommendations for future technical work to be undertaken at a subsequent project stage.

2 Summary scheme description

2.1 Scheme overview

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

2.2. Two alternative capacities have been considered for the Lower Thames Reservoir Option, which are sized to provide an increase of 50Ml/d and 100Ml/d of average deployable output to Affinity Water respectively.

2.3. Raw water for the Lower Thames Reservoir Option would 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 option.

2.4. There is an existing tunnel which allows the aforementioned reservoirs to provide an alternative source of water to Affinity Water's existing Iver Water Treatment Works (WTW) in abnormal circumstances. Under the Lower Thames Reservoir Option, it is proposed that a new connection is made into this tunnel, with a raw water pumping station in an adjacent shaft within the boundary of the existing Iver WTW site.

2.5. The raw water would be conveyed in a new buried transfer main to a new WTW. An indicative route corridor has been identified through an options refinement process (see Section 2.2).

2.6. Drinking water produced by the new WTW would pass through a storage tank before entering a high-lift pumping station from where it would be conveyed via a buried drinking water transfer main to an existing service reservoir in the vicinity of Harefield.

2.7. The drinking water transfer main would 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. An indicative route corridor has been identified through an options refinement process (see Section 2.2).

2.8. The delivery point for the Lower Thames Reservoir Option is an existing service reservoir in the vicinity of Harefield, which is a distribution hub within the Affinity Water network. The Lower Thames Reservoir Option would make use of existing, unused service reservoir capacity to provide the necessary strategic storage. Modifications to the network downstream from the service reservoir to distribute the increased inflow are currently being determined by Affinity Water and would form part of their wider water resources planning and investment programme.

2.9. The key components of the Lower Thames Reservoir Option are summarised below and shown on Figure 2.1: Lower Thames Reservoir Option – key components.

- A connection into the existing Wraysbury tunnel at the existing Iver WTW, and raw water pumping station (within this report referred to as the 'Wraysbury Tunnel Connection').
- A raw water transfer pipeline from the existing Iver WTW to a new WTW (within this report referred to as the 'Raw Water Transfer Main'). The indicative route corridor identified for the Raw Water Transfer Main is referred to as the 'Raw Water Transfer Main Route Corridor'.
- A new WTW (within this report referred to as the 'new WTW') to the north of the existing Iver WTW (within this report referred to as the 'Indicative WTW Site').
- A drinking water transfer pipeline from the new WTW to an existing service reservoir in the vicinity of Harefield (within this report referred to as the 'Drinking Water Transfer Main'). The indicative route corridor identified for the Drinking Water Transfer Main is referred to as the 'Drinking Water Transfer Main Route Corridor'.
- A connection into an existing service reservoir in the vicinity of Harefield (within this report referred to as the 'Harefield Service Reservoir Connection').

2.10. A more detailed scheme description is provided in Technical Supporting Document A1a, Concept Design Report (Lower Thames Reservoir Option).

2.2 Alternatives considered

2.11. Technical Supporting Document A4, Options Appraisal Methodology Report provides a description of the options identification, appraisal and screening process that has been undertaken to identify the constrained and currently preferred options for the T2AT SRO.

2.12. An unconstrainted list of 33 options was compiled in consultation with Affinity Water and Thames Water and screened against a set of initial screening criteria, which included consideration of impacts on statutory designated sites. Options which passed the initial screening stage were then screened against secondary screening criteria, which included consideration of environmental designations and features, impact on natural capital stocks, impact on Water Framework Directive no-deterioration objectives and impact on European Sites[10]. Consideration was also given to whether the option offered opportunities for biodiversity improvement and/or chalk stream enhancement, and whether any of the potential environmental impacts identified could be mitigated, and the level of mitigation that would be required.

2.13. Eight options remained after screening:

- Maidenhead: abstraction of raw water at a new Maidenhead intake, conveyance to a new WTW at an existing service reservoir in the vicinity of Harefield, and utilisation of available storage capacity at the existing service reservoir.
- Sunnymeads 1: abstraction of raw water at the existing Affinity Water Sunnymeads intake, conveyance to a new WTW at an existing service reservoir in the vicinity of Harefield, and utilisation of the available storage capacity at the existing service reservoir.
- Teddington Direct River Abstraction (DRA): Abstraction of raw water at a new intake at Teddington, upstream of Teddington weir and upstream of the proposed London Effluent Reuse SRO Teddington DRA option outfall (treated effluent from Mogden Sewage Treatment Works (STW)); conveyance to a new WTW in the vicinity of Harefield; and utilisation of the available storage capacity at an existing service reservoir in the vicinity of Harefield.
- Sunnymeads 2a: abstraction of raw water at the existing Affinity Water Sunnymeads intake and conveyance to a new WTW at Iver (Iver 2), near to the existing Iver WTW. The drinking water is then conveyed to an existing service reservoir in the vicinity of Harefield to utilise the available storage capacity at the existing service reservoir.
- Walton 2b: abstraction of raw water via an extension to the existing Affinity Water Walton intake and conveyance to the proposed Iver 2 WTW. The drinking water is then conveyed to an existing service reservoir in the vicinity of Harefield to utilise the available storage capacity at the existing service reservoir.
- Mogden Reuse Indirect 3: this option comprises the same infrastructure as Walton 2b but utilises water from the proposed London Effluent Reuse SRO Mogden effluent reuse option. For the Mogden Reuse Indirect 3 option in T2AT, an extension of the London Effluent Reuse SRO Mogden effluent reuse option outfall pipeline is required from the reach containing the Thames Water Walton intake, to the reach containing the Affinity Water Walton intake i.e. to a point upstream of Sunbury weirs.
- Lower Thames Reservoir 2a: Water from Thames Water's Wraysbury and Queen Mother reservoirs is abstracted via a proposed connection into Affinity Water's

[10] This includes Special Protection Areas (SPAs) and Special Areas of Conservation (SACs), proposed and candidate SPAs and SACs (pSPAs and cSACs). The network also extends to wetland sites of international importance (Ramsar sites).

existing Wraysbury (100" inch) tunnel at the existing Iver WTW site. This raw water is then diverted to the proposed Iver 2 WTW. The drinking water is subsequently conveyed to an existing service reservoir in the vicinity of Harefield to utilise the available storage capacity at the existing service reservoir.

- Beckton Reuse Indirect: Indirect transfer of recycled water from Beckton STW to a new WTW and new service reservoir near North Mymms. The proposed abstraction point would be located on the River Lee, downstream of the outfall from the proposed Beckton Water Recycling option (including extension from Lockwood shaft), within the London Effluent Reuse SRO. Another potential source for this option is water abstracted as part of the London Effluent Reuse SRO Teddington DRA option, which abstracts river water upstream of the recycled water discharge from Mogden STW and utilises the existing Thames-Lee Tunnel (with an extension), which would discharge in a similar location to the proposed Beckton Water Recycling option (London Effluent Reuse SRO). N.B. In the period since option selection, modelling by both WRSE and Affinity Water has identified a constraint in the distribution network between the proposed import point at North Mymms and a service reservoir in the vicinity of Brookmans Park in WRZ3. This option has therefore been extended to include a drinking water conveyance component from North Mymms to Brookmans Park. Furthermore, since Gate 1, the Beckton Reuse Indirect Option has been extended to feed an existing service reservoir in the vicinity of Brookmans Park due to the limited existing transfer capacity from North Mymms to Brookmans Park.

2.14. The eight options were assessed by WRSE in January 2021, in-line with the methodology in the WRSE guidance[11]:

- Habitats Regulations Assessment (HRA) Stage 1: Test of Likely Significance (Screening Assessment)
- WFD Assessment Level 1: Basic Screening
- SEA
- Natural Capital Assessment and Biodiversity Net Gain

2.15. Environmental assessments carried out prior to the Gate 1 submission, which followed further refinement of infrastructure siting and pipeline route optimisation included:

- Updated Stage 1 HRA and Stage 2 Appropriate Assessment, if required, in accordance with the WRSE guidance.
- Updated Level 1 WFD Basic Screening and Level 2 Detailed Impact Screening, if required, in accordance with the WRSE guidance.

[11] Mott MacDonald (2020). Water Resources South East (WRSE) Regional Plan Environmental Assessment Methodology Guidance. Available at: https://www.wrse.org.uk/media/lb0g0tsr/wrse_file_1347_wrse-regional-plan-environmental-assessment-methodology-guidance.pdf [Accessed April 2022]

- Consideration of local level data (Local Wildlife Sites (LWS) and Tree Preservation Orders (TPO)) in-line with the methodology in the ACWG guidance12.
- Review of SEA against refined options to confirm any changes to the WRSE metrics.
- INNS risk assessment.
- Assessment of opportunities for net zero carbon contributions.
- Consideration of wider benefits including societal benefits and environmental net gain.

2.16. Technical Supporting Document A4, Options Appraisal Methodology Report provides a comparison of the eight options taken forward against the following themes: technical challenge, carbon footprint, environment and community, and planning complexity.

2.17. Maidenhead, Teddington DRA and Walton 2b / Mogden Reuse Indirect 3 did not perform as well under the environment and community theme due to WFD risks and in the case of Teddington DRA and Walton 2b / Mogden Reuse Indirect 3, higher loss of ecosystem services and biodiversity than other options, potentially due to the length of pipeline, which was longer than other options, also resulting in higher carbon emissions. Maidenhead also performed poorly due to proximity of the Chilterns Area of Outstanding Natural Beauty (AONB) to construction work and the pipeline intersecting with two historic parks and gardens.

2.18. The Lower Thames Reservoir Option compared well under all the themes considered within the options appraisal, including environment and community, and hence would be a favourable option for development to Gate 2. The Beckton Reuse Indirect Option also compared well to the other transfer options, and in particular the other two options which rely on reuse water. This is the most favourable reuse option for development to Gate 2 and is the only T2AT option which feeds directly into the eastern side of Affinity Water's Supply area.

2.19. Which, if any, of the T2AT options are carried past Gate 2 will be determined by the further outputs of the WRSE regional modelling, the best value plan which it informs, and the outcomes of the resultant public consultation processes on the emerging and draft plans. The process will consider and compare the merits of whole solutions, of which the transfer scheme would be just one component in a system which ensures continuity of supply to customers. Of particular relevance is the choice of option (or other SRO) to provide the source of new raw water for the T2AT scheme, whether linked to additional effluent reuse, new raw water storage or an inter-regional transfer. The optimisation of the whole system relies on the WRSE best value planning and modelling process, but the choice will also be informed by the relative merits of the different options. The model also considers consequential benefits such as reductions in groundwater abstraction and additional water discharges into the environment. The assessments of the T2AT options are therefore

[12] WRMP Environmental Assessment Guidance and Applicability with SROs – ACWG - October 2020.

to be considered within the larger context of the overall solutions which constitute the best value plan.

2.20. The preferred options for the T2AT SRO are the Lower Thames Reservoir Option and the Beckton Reuse Indirect Option.

2.21. Technical Supporting Document A5, Options Refinement Report provides a description of how the preferred options for the T2AT SRO have been developed since Gate 1, including the options appraisal process that has been undertaken to select indicative route corridors for the Raw Water Transfer Main and Drinking Water Transfer Main and an Indicative WTW Site.

2.22. The routes and sites were developed based on series of criteria that consider engineering, environmental, social, and planning constraints. The route for each option has been identified within a wider corridor that meets a majority of the criteria and therefore avoids a large number of environmental designations and communities. This report presents the assessment of the indicative route corridors and indicative sites for above ground infrastructure for the purpose of the Gate 2 submission.

2.23. This EAR presents the assessment of the indicative route corridors for the Raw Water Transfer Main and the Drinking Water Transfer Main, and the Indicative WTW Site for the purpose of the Gate 2 submission. Those alternatives discounted through the options appraisal process are not considered within this EAR; Technical Supporting Document A5, Options Refinement Report should be referred to for further information on these alternatives and the reasons for discounting them at this stage. It should be noted that the indicative route corridors and Indicative WTW Site, along with the alternatives considered, would be subject to stakeholder engagement and a public consultation exercise.

2.3 Key assumptions

2.24. The following key assumptions have been used within the assessments.

2.25. Abstraction from the Queen Mother Reservoir and Wraysbury Reservoirs would be in line with licence agreements from the Environment Agency, which are dependent on the additional volumes being provided by the STT and SESRO Schemes.

2.26. As stated in Paragraph 2.22, the EAR is based upon the route corridors for the Raw Water Transfer Main and the Drinking Water Transfer Main, as shown in Figure 2.1: Lower Thames Reservoir Option – key components. These corridors are up to 500m wide in unconstrained locations and it has been assumed for the purpose of the desk based assessments that pipeline construction works could be undertaken anywhere within the route corridors.

2.27. At this stage, it is assumed that construction would require a maximum 50m working width in unconstrained locations along the Raw Water Transfer Main and Drinking Water Transfer Main pipeline routes, and topsoil would be stripped to accommodate excavations, site haul roads and other construction features. An indicative route has been identified within the route corridors based upon engineering, environmental and planning considerations and forms the basis of calculations for agricultural landtake, indicative estimates of HGVs and staff vehicles, NCA and BNG, to enable a realistic scenario to be assessed.

2.28. It is assumed that temporary construction compounds would be required and indicative locations for these have been identified approximately every 2km within the route corridors.

2.29. As stated in Paragraph 2.21, an Indicative WTW Site has been identified following an options appraisal process. An indicative site for a temporary construction compound has also been identified. The EAR is based upon these indicative locations.

2.30. A construction period of 2035 – 2039 has been assumed based the WRSE emerging draft plan that was issued for consultation in January 2022[13]. The Lower Thames Reservoir Option is anticipated to be operational from 2039.

2.31. The following assumptions have been made in relation to construction methodology:

- Below ground structures would be constructed such that they would not form a preferential pathway for pollution to groundwater or cause alterations in groundwater flow or levels.
- Risk assessments would be undertaken for excavation works and dewatering to ensure no adverse impact on watercourses, wetland habitats or abstractions. Dewatering discharge would be treated before discharge.
- The pipe network would not be buried any deeper than 8m below existing ground level. The exceptions to this are transitions into micro-tunnelled crossings and the shaft required for Wraysbury Tunnel Connection, which is expected to be approximately 14 m below existing ground level.
- Water extracted from the ground during construction would be treated to a standard agreed with the regulatory authority before discharging at less than the agreed maximum rate to the water environment.
- Any discharge from the new WTW would be to the WFD waterbody which the new WTW is situated in and would be treated to a standard agreed with the regulatory authority at less than the agreed maximum rate, so as to not cause any potential impacts to water quality of the receiving water body.

[13] Water Resources South East (2022) Our Regional Plan. Available at: https://wrse.uk.engagementhq.com/our-regional-plan [Accessed April 2022]

- Any discharge from commissioning lagoons would be treated to a standard agreed with the regulatory authority at less than the agreed maximum rate so as to not cause any potential impacts to water quality of the receiving water body.
- The majority of crossings, including main rivers and the HS2 Phase 1 route, would be via micro-tunnel. The A4007 and A40 would be crossed using an open cut method under the road, and other roads would be crossed using an open cut method across the road with traffic management in place. Where watercourses would not be micro-tunnelled, it is assumed they would be flumed during construction. This would be a short term construction activity (i.e. less than seven days), which would ensure the watercourse is returned to its natural function following installation of the pile section.

2.32. It is assumed that a Construction Environmental Management Plan (CEMP) would be developed at an appropriate stage to ensure that environmental risks such as uncontrolled discharges from construction are minimised and that Emergency Response Plans are in place in the event of an incident. Best practice pollution prevention would be followed for all construction works with reference to:

- CIRIA C741 Environmental Good Practice on Site Guide (Charles and Edwards, 2015)[14]
- CIRIA C532 Control of water pollution from construction sites (Masters-Williams *et al.* 2001)[15]
- Environment Agency's Pollution Prevention Guidance Notes[16] including PPG1: General Guide to Prevention of Pollution (July 2013); PPG5: Works and maintenance in or near water (October 2007), PPG6: Pollution prevention guidance for working at construction and demolition sites (April 2010); PPG21: Pollution incident response planning (March 2009); PPG22: Dealing with spillages on highways (April 2011).

2.33. Thames Water and Affinity Water have Environmental Management Systems (EMS) in place for their assets. The EMS aims to identify and implement the necessary actions to avoid adverse effects to the environment during the operational phase. For example, the EMS would include standard measures relating to pollution control and control of disturbance from light or noise. As such, it is expected that these would be updated to incorporate the requirements of new assets commissioned as part of the Lower Thames Reservoir Option, and it is assumed that the appropriate EMS would be followed in order to avoid adverse effects to the environment.

[14] Charles P. and Edwards P (2015) *Environmental good practice on site guide.* CIRIA C741, 260p.
[15] Masters-Williams H., Heap A., Kitts H. *et al.* (2001) *Control of water pollution from construction sites*. CIRIA C532, 27p.
[16] Note, the Environment Agency Pollution Prevention Guidance Notes have been withdrawn by the Government, although the principles within them are robust and still form a reasonable basis for pollution prevention measures.

3 Informal regulatory assessments

3.1. Three informal regulatory assessments have been undertaken to support the Gate 2 submission and are presented as standalone Technical Supporting Documents. This section of the EAR presents a summary of these assessments.

3.1 Habitats Regulations Assessment

3.2. Technical Supporting Document B2, Habitats Regulations Assessment, contains the results of the informal HRA undertaken for the Lower Thames Reservoir Option. It provides information on the HRA screening (HRA Stage 1) and the further Appropriate Assessment (AA) (HRA Stage 2) undertaken to assess the potential effects of the option on European Sites[17].

3.3. The HRA Stage 1 Screening Assessment identified potential Likely Significant Effects on the South West London Waterbodies Special Protection Area (SPA) and Ramsar site. There is a potential for adverse effects on the South West London Waterbodies SPA and Ramsar site, located approximately 4.5km away, as these sites are hydrologically connected to the indicative transfer main route corridors, and they are located downstream of the works. Adverse effects may occur as a result of construction-related disturbance on qualifying species, such as noise, light, dust pollution, sediment discharge and pollution events.

3.4. The HRA Stage 2 AA did not identify adverse effects on the integrity of the South West London Waterbodies SPA and Ramsar.

3.5. Following the application of best practice measures, no adverse effects on the integrity of European Sites were identified for the Lower Thames Reservoir Option during construction or operation. It should be noted however that the assessment for the Lower Thames Reservoir Option is based on the conclusion that there would be no change to the current abstraction regime at Wraysbury Reservoir. This assessment must be revised if further investigations lead to a different conclusion in relation to possible impacts to surface water levels and flows at the reservoir and a formal HRA will be completed pursuant to the consenting stage.

3.6. As no residual effects are expected from the implementation of this option, an in-combination assessment is not required for the Lower Thames Reservoir Option. As the option progresses, this should be reviewed and if residual effects are identified, the option should go through an in-combination effects assessment as part of a

[17] This includes Special Protection Areas (SPAs) and Special Areas of Conservation (SACs), proposed and candidate SPAs and SACs (pSPAs and cSACs). The network also extends to wetland sites of international importance (Ramsar sites).

formal HRA completed pursuant to the consenting stage

3.7. It should be noted that Technical Supporting Document B2, Habitats Regulations Assessment, presents the results of an informal HRA assessment based upon a conceptual design. The conclusions should therefore be considered preliminary. The HRA should be reviewed as the design is developed and a full assessment carried out at a subsequent project stage, pursuant to the consenting process.

3.2 Water Framework Directive compliance assessment

3.8. Technical Supporting Document B3, Water Framework Directive Compliance Assessment, contains the results of the informal WFD compliance assessment undertaken for the Lower Thames Reservoir Option.

3.9. The Level 1 basic screening assessment was completed to determine which activities have the potential to impact the surface water bodies.

3.10. The Level 1 – basic screening assessment identified thirteen water bodies in relation to the Lower Thames Reservoir Option: six surface water rivers, two lakes, two canals and three groundwater bodies.

3.11. One surface water river (the Thames (Cookham to Egham)) and two lakes (Queen Mother Reservoir and Wraysbury Reservoir) had an impact score greater than 1 due to new or increased abstraction. These water bodies were carried through to the Level 2 – detailed screening assessment

3.12. The remaining five surface water rivers, two canals and three groundwater bodies assessed as part of the Level 1 assessment were not determined to have an impact score greater than 1 and were scoped out of further assessment.

3.13. The Level 2 assessment determined that impacts associated with the new or increased surface water abstraction do not have the potential to deteriorate the WFD elements of the Thames (Cookham to Egham), Queen Mother Reservoir and Wraysbury Reservoir or prevent them from the attainment of Good status in the future.

3.14. The Lower Thames Reservoir Option is therefore considered to be compliant with the WFD at this stage.

3.15. It should be noted that Technical Supporting Document B3, Water Framework Directive Compliance Assessment, presents the results of an informal WFD assessment based upon a conceptual design. The conclusions should therefore be considered preliminary. The WFD assessment will be reviewed as the design is developed and a full assessment will be carried out at a later stage pursuant to the consenting process.

3.3 Strategic Environmental Assessment

3.16. Technical Supporting Document B4, Strategic Environmental Assessment Review, presents an update to the SEA level option assessment prepared by WRSE, in-line with the methodology in the WRSE Regional Plan Environmental Assessment Methodology Guidance[18]. This involved the identification of potential effects for each SEA objective at both the construction and operational phases, pre and post mitigation, with each SEA objective scored against an eight-point scale. The SEA objectives are presented in the table below.

Table 3.1: SEA objectives

SEA topic	SEA objective
Biodiversity, flora and fauna	Protect and enhance biodiversity, priority species, vulnerable habitats and habitat connectivity (no loss and improve connectivity where possible)
Soil	Protect and enhance the functionality, quantity and quality of soils
Water	Increase resilience and reduce flood risk
	Protect and enhance the quality of the water environment and water resources
	Deliver reliable and resilient water supplies
Air	Reduce and minimise air emissions
Climatic factors	Reduce embodied and operational carbon emissions
	Reduce vulnerability to climate change risks and hazards
Landscape	Conserve, protect and enhance landscape, townscape and seascape character and visual amenity
Historic environment	Conserve, protect and enhance the historic environment, including archaeology
Population and human health	Maintain and enhance the health and wellbeing of the local community, including economic and social wellbeing
	Maintain and enhance tourism and recreation
Material assets	Minimise resource use and waste production
	Avoid negative effects on built assets and infrastructure

[18] Mott MacDonald (2020). Water Resources South East (WRSE) Regional Plan Environmental Assessment Methodology Guidance. https://www.wrse.org.uk/media/lb0g0tsr/wrse_file_1347_wrse-regional-plan-environmental-assessment-methodology-guidance.pdf [Accessed April 2022]

3.17. It should be noted that the SEA update presented in Technical Supporting Document B4, Strategic Environmental Assessment Review, is not a formal SEA under The Environmental Assessment of Plans and Programmes Regulations 2004 as it is a project not a plan/programme and is therefore outside the scope of the SEA Regulations[19]. The SEA has been carried out as best practice and to help inform the regional planning and Water Resource Management Plan 2024 (WRMP24) SEAs. Technical Supporting Document B4, Strategic Environmental Assessment Review does not constitute an Environmental Report under the Regulations and therefore, does not contain all of the information as set out in Schedule 2. A compliant Environmental Report will be produced for the WRMP24.

3.18. Major positive effects have been identified for the SEA objective on delivering reliable and resilient water supplies given the options improve the transfer of water across regions.

3.19. Carbon would be generated as a result of construction as well as during operation. The SEA identified minor negative effects associated with carbon emissions during the construction phase and moderate negative effects during the operational phase.

3.20. Moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for biodiversity, flora and fauna for the construction of the Lower Thames Reservoir Option due to potential for indirect effects on nationally designated sites, and potential impacts on priority habitat, protected species and woodland for both options during the construction phase. A HRA Stage 1 Screening and Stage 2 AA has been undertaken (see Technical Supporting Document B2, Habitats Regulations Assessment), which identified no adverse effects on the integrity of the South London Waterbodies SPA and Ramsar site.

3.21. Moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were also identified for the construction phase for the SEA objective on soil given the potential for disturbance and permanent loss of agricultural land (Grades 2 and 3) and there is potential for disturbance of contaminants given the Lower Thames Reservoir Option intersects or is within close proximity to historic and authorised landfill sites. The construction phase also has the potential to cause disruption to material assets therefore moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) identified.

3.22. The Lower Thames Reservoir Option passes through Air Quality Management Areas (AQMAs) with moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) identified for the SEA objective on air quality at the construction phase for. Given the Lower Thames Reservoir Option passes through community or recreational facilities, moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for both objectives related to population and human health at the construction phase.

[19] UK Government (2004). The Environmental Assessment of Plans and Programmes Regulations 2004. Available at: https://www.legislation.gov.uk/uksi/2004/1633/contents/made [Accessed April 2022]

3.23. For the historic environment objective, moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for the Lower Thames Reservoir Option at the construction phase given there is a Grade II listed building within the Indicative WTW Site.

3.24. The Lower Thames Reservoir Option is identified to have moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) as a result of potential construction related flood risk as it passes through Flood Zones 2 and 3.

3.25. Minor negative or neutral effects were identified for the remaining SEA objectives.

3.26. Mitigation measures to prevent, reduce or off-set adverse environmental effects have been identified as part of the SEA. These measures do not always completely eliminate effects or result in the downgrading of effects, from moderate to minor for example, however they do contribute to reducing the effects identified for the SEA objective.

3.27. It is recommended that the environmental assessment information from the SEA is fed into the Regional Plan and the Thames Water and Affinity Water WRMP24s so that the Lower Thames Reservoir Option is more appropriately assessed for SEA purposes as part of SEA for the WRMP24s and WRSE Regional Plan.

4 Biodiversity, flora and fauna

4.1 Introduction

4.1. This chapter presents a desk-based assessment undertaken to identify the potential impacts on ecological features from the transfer corridors and above ground infrastructure including the intake and WTW. The objectives of the desk-based assessment were to identify the key ecological features, constraints and opportunities and the issues and features that may require further investigation at a subsequent project stage.

4.2. The need to consider biodiversity, flora and fauna is driven by legislation (including the Conservation of Habitats and Species Regulations 2017 (as amended), Wildlife and Countryside Act 1981 (as amended) and Natural Environment and Rural Communities Act 2006) and national planning policy (draft National Policy Statement (NPS) for Water Resource Infrastructure[20], Sections 3.3 (Habitats Regulations Assessment) and 4.3 (biodiversity and nature conservation), and National Planning Policy Framework (NPPF)[21] (Section 15 (conserving and enhancing the natural environment), paragraphs 174-175, 179-182).

4.2 Terrestrial ecology

4.2.1 Methodology

4.2.1.1 Study area and sources of information

4.3. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within a 2km study area for statutory designated nature conservation sites and a 1km study area for non-statutory designated nature conservation sites and habitats. Where it was recognised that impacts could extend beyond the proposed study areas due to potential pathways being present, the assessment boundaries were extended

[20] Department for Environment, Food & Rural Affairs (2018) Draft National Policy Statement for Water Resources Infrastructure. https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents/draftnpswaterresourcesinfrastructure.pdf [Accessed April 2022]
[21] Ministry of Housing, Communities & Local Government (2021) National Planning Policy Framework. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2 [Accessed April 2022]

accordingly to address the geographic extent of the potential impacts.

4.4. Table 4.1 outlines the baseline data sources which were collated and considered in the desk-based assessment.

Table 4.1: Sources of information (terrestrial ecology)

Data collected	Source
Greenspace sites; open map local roads; surface water; woodland	Ordnance Survey (OS) Open Data
Land cover data including statutory designated sites, ancient woodland and priority habitat inventory.	Multi-Agency Geographic Information for the Countryside (www.magic.gov.uk) [22]
Descriptions / designations of statutory designated nature conservation sites (and candidate designated sites)	Natural England/Joint Nature Conservation Committee (JNCC)
Important Bird Areas	Royal Society for Protection of Birds (RSPB)
Habitats	Derived from OS MasterMap
Biodiversity Action Plan (BAP) priority habitats	UK Government - MAGIC Maps Website[22] / the National Biodiversity Network (NBN) Atlas[23] / local authority information on BAP priority habitats and species
Non-statutory designated nature conservation site data	Local Biological Record Centres (BRCs) – Greenspace Information for Greater London (GiGL), Buckinghamshire and Milton Keynes Environmental Records Centre (BMERC) and Hertfordshire Environmental Records Centre (HERC)

4.2.1.2 Approach to impact appraisal

4.5. A qualitative approach was undertaken to evaluate the biodiversity of the study area and assess where there was potential for the Lower Thames Reservoir Option to result in impacts on key ecological features. Where there was potential for impact to protected and priority habitats and species, recommendations have been made for

[22] Defra, Multi-Agency Geographic Information for the Countryside. Available at: https://magic.defra.gov.uk/ [Accessed April 2022]
[23] National Biodiversity Network (NBN) Atlas. Available at: https://nbnatlas.org/ [Accessed April 2022]

further surveys that may need to be undertaken at a subsequent project stage, as appropriate.

4.6. An initial desk-based habitat mapping exercise was undertaken using key desktop sources of information including GIS mapping systems, OS mapping and available land cover datasets. Available data was used to produce GIS maps using the ESRI ArcGIS system that correspond to Phase 1 habitat survey (JNCC, 2010[24]), the standardised system for classifying and mapping wildlife habitats in all parts of Great Britain, including urban areas. (Note that it is recommended that this is converted to UKHabs classification system at a subsequent project stage).

4.7. The habitat maps were used to determine the potential for key ecological features present in the study area. The potential for protected and/or priority species to be present was evaluated using experience and professional judgement, based on the habitats present and using open web-based sources such as the UK government's MAGIC website[22], the NBN Atlas[23] and local authority information on UK BAP priority habitats and species, where available.

4.8. Online sources of aerial photography, where the quality/resolution was of sufficiently high quality, were also used where appropriate. Sources included, but were not limited to, Google and Bing aerial photography, Google Streetview, and the various aerial photography suites in Esri ArcPro (which itself sources from Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community).

4.9. Once the key ecological features were defined, an assessment as to the potential for these features to be affected by the Lower Thames Reservoir Option during construction and operation was undertaken. Positive impacts were identified as well as negative ones. Ecological constraints and opportunities associated with the Lower Thames Reservoir Option were identified, and any recommendations for further survey or investigation, to be undertaken at a subsequent project stage, highlighted.

4.2.1.3 Assumptions and limitations

4.10. This chapter presents a purely desk-based assessment, and as such, site visits have not been undertaken at this stage to map and classify habitats present or identify potential evidence of protected or priority species. Protected or priority species records were not collected and instead, the potential for protected species to be present was determined through a review of habitat types.

4.11. Chapter 15 presents the INNS risk assessment in relation to potential spread of INNS

[24] Joint Nature Conservation Committee (2010) Handbook for Phase 1 habitat survey: A technique for environmental audit. Available at: https://data.jncc.gov.uk/data/9578d07b-e018-4c66-9c1b-47110f14df2a/Handbook-Phase1-HabitatSurvey-Revised-2016.pdf [Accessed April 2022]

as a result of the abstraction and transfer of raw water. It has not been possible to assess the scope for INNS from construction-related activities, as data from online and desk-based sources is generally very limited. It is recommended that a construction phase INNS assessment is undertaken once specific habitat mapping and INNS surveys have been undertaken at a subsequent project stage. Where INNS are identified, best practice procedures within Construction Industry Research and Information Association (CIRIA) Manual C679 'Invasive species management for infrastructure managers and the construction industry'[25] and 'The Knotweed Code of Practice – managing Japanese Knotweed on development sites'[26] should be followed to reduce the spread of INNS for all construction works derived from these options, as a minimum standard.

4.2.2 Understanding of the baseline

4.2.2.1 Statutory designated nature conservation sites

4.12. There are no SPAs or potential SPAs (pSPAs), Special Areas of Conservation (SACs) or candidate SACs (cSACs) or Ramsar sites within the study area. Technical Supporting Document B2, Habitats Regulations Assessment, contains the results of the HRA undertaken for the Lower Thames Reservoir Option; no adverse effects on the integrity of European Sites were identified and these have not been considered further.

4.13. There are seven biological Sites of Special Scientific Interest (SSSIs) within the study area, as presented in Table 4.2 below and shown on Figure 4.1: Statutory designated nature conservation sites.

[25] CIRIA (2008), Invasive species management for infrastructure managers and the construction industry (C679). Authors Wade, M, Booy, O, and White, V.

[26] Environment Agency (2013), Managing Japanese knotweed on development sites (version 3) – The Knotweed Code of Practice. Withdrawn in 2016, but still outlines best practice.

Table 4.2: Sites of Special Scientific Interest

SSSI name	Closest distance to Lower Thames Reservoir Option components	Summary description
Kingcup Meadows and Oldhouse Wood	0km (Drinking Water Transfer Main Route Corridor)	Kingcup Meadows and Oldhouse Wood constitutes a mosaic of habitats adjacent to the River Alderbourne, which includes woodland, unimproved pastures and semi and unimproved meadowland. The fields are comprised of dry grassland, wet grassland and areas of fen and swampy vegetation. Unimproved grassland and wetland habitats have declined nationally.
Denham Lock Wood	0.46km (Drinking Water Transfer Main Route Corridor)	Denham Lock Wood is a diverse area of open mire and wet woodland which shows a zonation of wetland habitats occurring rarely in Greater London. The woodland flora is particularly varied supporting assemblages of epiphytic mosses, ferns and herbs. The open areas of flood plain mire are characterised by plant communities typical of a rich fen habitat.
Fray's Farm Meadows	0km (Drinking Water Transfer Main Route Corridor)	Fray's Farm Meadows are one of the last remaining examples of relatively unimproved wet alluvial grassland in Greater London and the Colne Valley. The meadows also provide good cover for waders and wildfowl throughout the year and wintering species include jack snipe (*Lymnocryptes minimus*), snipe (*Gallinago gallinago*), lapwing (*Vanellus vanellus*), teal (*Anas crecca)* and shoveler (*Anas clypeata*).

SSSI name	Closest distance to Lower Thames Reservoir Option components	Summary description
Mid Colne Valley	1.03km (Drinking Water Transfer Main Route Corridor)	The Mid Colne Valley is a site of significant ornithological interest, particularly for the diversity of breeding woodland and wetland birds, and for the numbers of wintering wildfowl. The site also contains one of the last remaining examples of unimproved chalk grassland in Greater London. Ornithological interest of site is high with 70 breeding and 80 wintering species being recorded. Breeding woodland birds include kestrel (*Falco tinnunculus*), lesser whitethroat (*Sylvia curruca*), nuthatch (Sitta *europaea*), tawny owl (*Strix aluco*) and three species of woodpecker. The gravel pits and River Colne attract one of the most important wetland breeding bird communities in Greater London and the Colne Valley: coot (*Fulica atra*), greylag goose (*Anser anser*), little ringed plover (*Charadrius dubius*), kingfisher (*Alcedo atthis*), mute swan (*Cygnus olor*) and tufted duck (*Aythya fuligula*) nest regularly, while others such as gadwall (*Anas strepera*) and shoveler are resident and occasionally breed. Many species of wintering wildfowl are attracted to the extensive water areas; the numbers of tufted duck frequently reach levels of national importance.
Old Park Wood	1.5km (Drinking Water Transfer Main Route Corridor)	Old Park Wood comprises some of the most floristically rich ancient woods in Greater London and contains complex transitions through examples of widely differing woodland types.
Ruislip Woods	0km (Drinking Water Transfer Main Route Corridor)	Ruislip Woods form an extensive example of ancient semi-natural woodland, including some of the largest unbroken blocks that remain in Greater London. A diverse range of oak and hornbeam woodland types occur, with large areas managed on a traditional coppice-with-standards system. The site is also unusual in Greater London for the juxtaposition of extensive woodland with other semi-natural habitats, mostly notably acidic grass-heath mosaic and areas of wetland. These habitats and especially the woodland contain several plant and insect species that are rare or scarce in a national or local context.

SSSI name	Closest distance to Lower Thames Reservoir Option components	Summary description
Black Park	1.98km (Drinking Water Transfer Main Route Corridor)	Black Park consists of a variety of habitats comprising dry and wet heath, alder carr, mixed and coniferous woodland and small areas of acid grassland. The heathland and alder carr are of particular importance, as both habitats are very rare in Buckinghamshire. They support specialised communities of plants and animals, including many that are rare or uncommon in the county.

4.14. The SSSI Impact Risk Zone of one SSSI that is not within the study area, and not mentioned in Table 4.2, intersects with the study area. This is listed below in Table 4.3.

Table 4.3: SSSI Impact Risk Zones

SSSI	Summary Description	Relevant Criteria
Wraysbury Reservoir	An artificially embanked reservoir constructed around 1970. Wraysbury reservoir regularly supports nationally important numbers of wintering cormorant (*Phalacrocorax carbo*), great crested grebe (*Podiceps cristatus*) and shoveler. The reservoir also support notable numbers of wintering gadwall.	Discharge – Any discharge of water or liquid waste of more than 20m³/day to ground (i.e. to seep away) or to surface water, such as a beck or stream.

4.15. There is one National Nature Reserve (NNR) within the study area (Ruislip Woods, located immediately adjacent to the Drinking Water Transfer Main Route Corridor). Ruislip Woods NNR forms an extensive example of ancient semi-natural woodland, including some of the largest unbroken blocks that remain in Greater London. A diverse range of oak and hornbeam woodland types occur, with large areas managed on a traditional coppice-with-standards system. The site is also unusual in Greater London for the juxtaposition of extensive woodland with other semi-natural habitats, mostly notably acidic grass-heath mosaic and areas of wetland.

4.16. There are five Local Nature Reserves (LNRs) within the study area as presented in Table 4 4 below and shown on Figure 4.1: Statutory designated nature conservation sites.

Table 4.4: Local Nature Reserves

LNR	Closest distance to Lower Thames Reservoir Option components	Summary description
Batchworth Heath	0.96km (Drinking Water Transfer Main Route Corridor)	Batchworth Heath is a small ancient common. Consists of heathland, a pond with diverse marginal flora, unimproved acid grassland, neutral grassland, and secondary woodland.
Black Park	1.74km (Drinking Water Transfer Main Route Corridor)	Black Park consists of a variety of habitats comprising dry and wet heath, alder carr, mixed and coniferous woodland and small areas of acid grassland. The heathland and alder carr are of particular importance, as both habitats are very rare in Buckinghamshire. They support specialised communities of plants and animals, including many that are rare or uncommon in the county.
Frays Valley	0km (Drinking Water Transfer Main Route Corridor)	A series of lakes, ancient wet-woodland and meadows beside the Grand Union Canal. Includes the London Wildlife Trust's reserves of Fray's Farm Meadows SSSI and Denham Lock Wood SSSI plus Harefield Place Nature Reserve and several lakes.
Northmoor Hill Wood	2km (Drinking Water Transfer Main Route Corridor)	Consists of a variety of woodland, with both drier and wetter. South-west of the site is more open and scrubby with birch-dominated woodland. The field contains a varied ground flora, with the flora in the southwest and southeast corners being typical of more acidic woodland. A record of the nationally scarce coralroot bittercrest (*Cardamine bulbifera*) was recorded at the edge of deep quarry pits in the north-east.
Denham Quarry Park	0.4km (Drinking Water Transfer Main Route Corridor)	Denham Country Park comprises meadows, rivers and woodland. Nesting birds on the site have included kestrels, and kingfishers are known to use the River Colne here.

4.2.2.2 Non-statutory designated nature conservation sites

4.17. There are 17 non-statutory designated nature conservation sites within the study area comprising Sites of Importance for Nature Conservation (SINCs) and Local Wildlife Sites (LWSs). They are listed below in Table 4.5 and shown on Figure 4.2: Non-statutory designated nature conservation sites.

Table 4.5: Non-statutory designated nature conservation sites

Site	Closest distance to Lower Thames Reservoir Option components	Designation	Summary Description
London's Canals	0km (Raw Water Transfer Main Route Corridor and Drinking Water Transfer Main Route Corridor)	SINC – Metropolitan Importance	London's Canals support a wide range of aquatic flora, amongst which are found a number of locally uncommon species. These include narrow-leaved water plantain (*Alisma lanceolatum*), rigid hornwort (*Ceratopyllum demersum*) and shining pondweed (*Potomageton lucens*).
Little Britain	0.14km (Raw Water Transfer Main Route Corridor)	SINC – Metropolitan Importance	Section of the Colne Valley with a remarkable variety of habitats including lakes, rivers, scrub, areas of wasteland, woodland and neutral grassland. Of particular importance are the areas of unimproved floodplain grassland, which support a lush flora including the nationally scarce tasteless water-pepper (*Polygonum mitis*).
Frays River at Uxbridge Moor	0.6km (Drinking Water Transfer Main Route Corridor)	SINC – Borough I Importance	Section of the Fray's River flowing through urban Uxbridge and Cowley. Supports a reasonable diversity of wetland plants and waterfowl.
Southlands Manor	0km (Drinking Water Transfer Main Route Corridor)	LWS	Consists of semi-improved neutral grassland, rough grassland, ponds, bank of the River Alderbourne and a damp rank grassland. Supports a range of invertebrate fauna.
Mid Colne Valley	0km (Drinking Water Transfer Main Route Corridor)	SINC – Metropolitan Importance	A section of the Colne Valley with a remarkable range of high-quality wetland habitats, including three SSSIs. Contains ancient woodland, marshes and wet grassland.

Site	Closest distance to Lower Thames Reservoir Option components	Designation	Summary Description
Common Plantation and Park Wood	0.1km (Drinking Water Transfer Main Route Corridor)	SINC – Borough II Importance	Two areas of woodland, containing remnants of ancient woodland. The River Pinn runs through the woodland, providing an excellent route between areas to the north and those to the south of the A40.
Mad Field Covert, Railway Mead and the River Pinn	0.2km (Drinking Water Transfer Main Route Corridor)	SINC – Borough II Importance	Railway Mead is an area of herb-rich grassland to the south of the railway, bounded by mature hedgerows of mainly pedunculate oak (*Quercus robur*) and blackthorn (*Prunus spinosa*). Shallow and slow-flowing section of the River Pinn runs through here.
Harefield Hall and The Lodge	0.03km (Drinking Water Transfer Main Route Corridor)	SINC – Borough II Importance	The gardens of a large country house with a variety of habitats, including ancient woodland, hedge, orchard, ponds and planted shrubbery.
Brackenbury Railway Cutting	0.2km (Drinking Water Transfer Main Route Corridor)	SINC – Borough II Importance	This broad, wooded railway cutting provides pleasant, rural views for passengers. The dense tree and scrub cover is dominated by pedunculate oak, elder (*Sambucus nigra*), and English elm (*Ulmus procera*) with abundant ivy (*Hedera helix)*.
Newyears Green	0km (Drinking Water Transfer Main Route Corridor)	SINC – Borough I Importance	Woodland surrounded by fields and hedges. Contains the locally scarce buckthorn (*Rhamnus catharticus*), and a good range of mammals and birds are known to frequent the site.
Dew's Dell	0km (Drinking Water Transfer Main Route Corridor)	SINC – Borough I Importance	An old quarry that has great wildlife potential. The southern and middle areas are mostly woodland with some grassland at the woodland edges. Northern section of the site is a nature reserve managed by the London Wildlife Trust.
Shepherd's Hill Woods and Fields	0km (Drinking Water Transfer Main Route Corridor)	SINC – Borough I Importance	A large mosaic of fields and small woods with thick inter-connecting hedges. Locally scarce species such as wild service-tree (*Sorbus torminalis*) are present.

Site	Closest distance to Lower Thames Reservoir Option components	Designation	Summary Description
Long Spring	0.92km (Drinking Water Transfer Main Route Corridor	LWS	Ancient semi-natural woodland with numerous woodland indicators. Woodland springs with associated streams and wet areas add habitat diversity.
White Hill Wood	0.9km (Raw Water Transfer Main Route Corridor	LWS	Old secondary woodland with a semi-natural canopy and varied structure. Supports ancient woodland indicators.
Bishop's Wood	0km (Raw Water Transfer Main Route Corridor	LWS	Consists of ancient woodland, supporting a very rich and diverse flora. The site has been extensively replanted with conifers and broadleaved species, but there are relic stands of ancient woodland consisting predominantly of hazel (*Corylus avellana*) coppice with pedunculate oak/*ash* (*Fraxinus excelsior*) standards.
Knightscote Farm Ponds	0.12km (Drinking Water Transfer Main Route Corridor	SINC – Borough II Importance	Two ponds separated by an area of woodland, one used for fishing. Contains bracken, marsh, ponds, ruderal and wet woodland.
Breakspear House Wood	0km (Drinking Water Transfer Main Route Corridor	SINC – Borough II Importance	A small ancient woodland. The ancient woodland indicator plants present include, include Midland hawthorn (*Crataegus laevigata*), black bryony (*Tamus communis*), field maple (*Acer campestre*) and holly (*Ilex aquifolium*).

4.2.2.3 Important Bird Areas

4.18. There are no Important Bird Areas within the study area.

4.2.2.4 Ancient woodland

4.19. There are a total of 73 ancient and ancient replanted woodland sites within the study area, 11 of which are immediately adjacent to but excluded from the Drinking Water Transfer Main Route Corridor. Ancient woodland is shown on Figure 4.3: Ancient woodland and priority habitats.

4.2.2.5 Priority habitats

4.20. The following priority habitats are present within the study area: Deciduous woodland, good quality semi-improved grassland, lowland fens, lowland meadows, purple moor grass and rush pastures, traditional orchard and no main habitat but additional habitats present.

4.21. There is deciduous woodland priority habitat within the Raw Water Transfer Main Route Corridor, the Indicative WTW Site and the indicative construction compound for the new WTW, and deciduous woodland and good quality semi-improved grassland priority habitat within the Drinking Water Transfer Main Route Corridor. Priority habitats are shown on Figure 4.3: Ancient woodland and priority habitats.

4.2.2.6 Nature Recovery Network

4.22. The Lower Thames Reservoir Option overlaps with Natural England's Nature Recovery Network (NRN), with two Natural England Network Enhancement Zones and one Network Expansion Zone. These do not carry any specific protection designations but do represent networks of habitats that can be complemented and contributed to, with any mitigation, compensation or enhancement proposals.

4.2.2.7 Desktop habitat mapping

4.23. Within the 1km study area, the Phase 1 habitats presented in Table 4.6 were deemed to be present based upon desktop habitat mapping, which is based on aerial imagery as described in Section 4.2.1.2.

Table 4.6: Phase 1 habitat types identified from desktop mapping

Component	Phase 1 habitats identified
Wraysbury Tunnel Connection	J1.2 – Cultivated/disturbed land - amenity grassland
Raw Water Transfer Main Route Corridor	A1.1.1 – Broadleaved woodland – semi-natural J1.2 – Cultivated/disturbed land – amenity grassland

Component	Phase 1 habitats identified
Indicative WTW Site	A1.1.1 – Broadleaved woodland – semi-natural J1.2 – Cultivated/disturbed land – amenity grassland J3.6 – Buildings J5 – Hardstanding
Indicative WTW temporary construction compound	A1.1.1 – Broadleaved woodland – semi-natural A2.1 – Scrub – dense/continuous B6 – Poor semi-improved grassland G2 – Running water J1.2 – Cultivated/disturbed land – amenity grassland
Drinking Water Transfer Main Route Corridor	A1.1.1 – Broadleaved woodland – semi-natural A1.2.2 - Coniferous woodland – plantation A2.1 – Scrub – dense/continuous B6 – Poor semi-improved grassland G2 – Running water J1.2 – Cultivated/disturbed land – amenity grassland J3.6 – Buildings J5 – Hardstanding
Harefield Service Reservoir Connection	J1.2 – Cultivated/disturbed land – amenity grassland

4.2.2.8 Protected and priority species potential

4.24. The components of the Lower Thames Reservoir Option include a range of habitat types, with varying levels of suitability for protected and priority species. In the following sections the habitats with potential to support protected species are described. Note that this is not a definitive list, and all areas should be assessed as appropriate as the scheme progresses.

Bat habitat assessment

4.25. Bats use a wide range of different habitats throughout the year as they feed, roost and commute through the landscape. They use foraging habitats to find food and commuting habitats (often linear features) to travel between roosts and foraging habitats. These habitats are vital for bats.

4.26. Bats commonly use a wide range of habitats for foraging throughout the landscape ranging from semi-natural to urban environments. Wooded areas are commonly used by foraging, roosting, hibernating, and breeding bats, especially areas that provide a mosaic of open and closed canopies. Grasslands provide important habitat for foraging bats, especially those with reduced or no arable inputs, e.g. lowland calcareous grassland. Riparian areas are commonly used by bats for foraging and commuting with some species having a strong affinity for foraging above flowing and stagnant water bodies, e.g. Daubenton's bat (*Myotis daubentonii*). Common foraging habitats within arable landscapes include hedgerows, treelines, scattered residential dwellings and gardens, arable ponds, set aside margins and headlands.

4.27. Bats roost and breed in a wide range of features, including features within trees such as woodpecker and rot holes, tear outs, crevices beneath loose bark, ivy cover and hazard beams. Trees can be used within a variety of habitats including woodlands, arable and urban environments. Features within buildings such as loft voids, crevices between roof tiles and batons and ill-fitting soffits, and in structures (bridges etc) like cracks, expansion joints, voids etc, all have the potential to support roosting bats. Any feature that is likely to allow ingress by a particular species of bat has the potential to support a roosting bat.

4.28. Bats are considered likely to be present across the Lower Thames Reservoir Option with potential roosting, foraging, and commuting habitats present including habitats such as woodland, grassland, riparian, rivers, streams and arable field margins with associated ditches and hedgerows. For example, the Drinking Water Transfer Main Route Corridor intersects the Fray's River, River Colne, the Grand Union Canal and the associated woodland and hedgerows to the southwest of Ickenham. All of these are likely to have bats present, as there are a high number of potential roost sites and features suitable for foraging and commuting activities. There is also potential for bats within the indicative site for the WTW temporary construction compound.

Badger habitat assessment

4.29. Badgers (*Meles meles*) are found across the UK, with the highest numbers in southern England[27]. Ideal badger habitat is comprised of a mixture of woodland and open country. Each badger territory typically includes a main sett and several smaller setts of differing type and function. Badgers are opportunistic foragers that make use of a range of habitats, including for example woodlands, arable margins, grassland and terrestrial margins of riparian habitats forage over a large area and as a result need a relatively large area of habitat for their home range.

4.30. Badgers have the potential to be present across the Lower Thames Reservoir Option. As badgers often use a mixture of woodland and grassland habitats they may reside anywhere where there is a woodland stand with some adjacent foraging habitat. Furthermore, badgers can make their setts and home range on nearly entirely arable

[27] Mammal Society (2022) Species – Badger. Available at: https://www.mammal.org.uk/species-hub/full-species-hub/discover-mammals/species-badger/ [Accessed August 2022]

landscapes, therefore they have the potential to reside at any point.

Great crested newt habitat assessment

4.31. Great crested newts (*Triturus cristatus*) (GCN) are found throughout the UK. GCN are primarily terrestrial but use ponds and other waterbodies such as ditches for breeding, foraging and shelter. Adult GCN generally hibernate on land (juveniles and sub-adults remain in ponds for up to five years), and therefore require hibernacula such as logs, log piles and rubble to hibernate in or under. Woodland, scrub, grassland and other habitat would also be used for dispersal and foraging. These habitats, along with a number of ponds and ditches, are present across the Lower Thames Reservoir Option. Where these habitats are present, there is the potential for GCN to be present.

Hazel dormouse habitat assessment

4.32. Hazel dormice (*Muscardinus avellanarius*) occur mainly in the southern counties of England[28] and are commonly associated with areas of deciduous woodland and overgrown hedgerows but, where large areas of woodland are present in the landscape, hazel dormice have been found in other habitats such as reedbed. Hazel dormice often live in low population densities living amongst tree branches and rarely come down to ground level.

4.33. Hazel dormice have the potential to be present across the across the Lower Thames Reservoir Option, especially in areas with high densities of deciduous woodland and where there are healthy networks of hedgerows. For example, the northern section of the Drinking Water Transfer Main Route Corridor to the east and northeast of South Harefield has relatively large patches of deciduous woodland present, with associated hedgerows networks. There is also potential for hazel dormice within the indicative site for the WTW temporary construction compound.

Reptile habitat assessment

4.34. Widespread reptile species (grass snake (*Natrix natrix*), adder (*Vipera berus*), slow worm (*Anguis fragilis*) and common lizard (*Zootoca vivipara*)), are most widely distributed on large areas of habitat such as heathland, rough grassland, calcareous grassland and sand dunes. They are often present locally in a range of other land covers such as railways and disused railway lines, roadside embankments and verges, churchyards/ cemeteries, allotments, derelict/brownfield areas, neglected/ overgrown land, rough pasture, scrub, quarries and woodland glades. Localised features and suitable vegetation cover/structure are important for reptile species to be present.

[28] Mammal Society (2022) Species – Hazel Dormouse. Available at: https://www.mammal.org.uk/species-hub/full-species-hub/discover-mammals/species-hazel-dormouse/ [Accessed August 2022]

4.35. Sand lizard (*Lacerta agilis*) is far less common and widespread but is known to exist in localised areas in the midlands. It prefers heathland and dunes (the latter of which is not likely to be present in or around the study area).

4.36. A number of habitats across the Lower Thames Reservoir Option are suitable for reptile utilisation. For example, the extensive area of dense scrub interspersed with deciduous woodland between Iver Heath and Cowley has the potential to support widespread reptile species. This area would be bisected by the Drinking Water Transfer Main Route Corridor. There is also potential for reptiles within the indicative site for the WTW temporary construction compound.

Breeding bird habitat assessment

4.37. Breeding birds are found in nearly all UK habitats. Breeding birds in the UK are split into species assemblages. For example, farmland species assemblage, woodland species assemblage and wetland bird species.

4.38. Breeding birds, being found in nearly all UK habitats, are a potential constraint anywhere there is suitable nesting habitat such as hedgerows, trees, ditches, grassland, scrub, woodland, and structures, e.g. bridges, walls and buildings. Breeding birds are likely to be ubiquitous across the whole of the Lower Thames Reservoir Option study area, including natural, semi-natural and built-up areas.

Other protected species

4.39. Otters (*Lutra lutra*) use a broad variety of watercourses and waterbodies including rivers, lakes, canals, and ditches. They have the potential to be present anywhere where there is suitable aquatic and terrestrial habitat. For example, the Drinking Water Transfer Main Route Corridor passes through the Frays River, River Colne, Alder Bourne, Grand Union Canal Slough Arm, and Colne Brook, along with minor watercourses and ditches connected to the rivers mentioned. All of these have the potential to provide suitable habitat for otters.

4.40. Water vole (*Arvicola amphibius*) also use a variety of watercourses but generally prefer sites with earth banks for burrowing, and with significant swathes of vegetation for foraging. They generally prefer slower flowing watercourses. Any habitat present within the pipeline route that offers slower moving watercourses, appropriate gradient embankment, appropriate vegetative food sources and low levels of predation, have the potential to support water voles. Areas within the Lower Thames Reservoir Option that may offer these habitats, and as a result have the potential for water vole to be present include (but are not limited to) the Frays River, River Colne, Alder Bourne, Grand Union Canal Slough Arm, and Colne Brook, which the Drinking Water Transfer Main would pass, along with minor watercourses and ditches connected to the rivers mentioned.

4.41. White-clawed crayfish (*Austropotamobius pallipes*) live in a diverse variety of clean aquatic habitats, but especially favour hard-water streams and rivers with large densities of refuge sites, available food sources and contact with other white-clawed crayfish populations, i.e. natural rivers not affected by dams and weirs. They also prefer high water quality with suitable levels of dissolved oxygen and calcium and absence of the non-native North American signal crayfish (*Pacifastacus leniusculus*) and associated crayfish plague (*Aphanomyces astaci*). There appears to be suitable habitat present within the Lower Thames Reservoir Option that has the potential to support this species, especially in more isolated streams. White-clawed crayfish populations are adversely affected by the presence of North American signal crayfish, and hence the associated crayfish plague, so this species also requires consideration. It is acknowledged, however, that white-clawed crayfish are unlikely to be present within the study area and therefore they are not considered further at this stage.

4.2.3 Appraisal outcomes

4.2.3.1 Wraysbury Tunnel Connection

Construction

4.42. No statutory designated nature conservation sites or ancient woodland would be directly or indirectly impacted by works to construct the Wraysbury Tunnel Connection. The Little Britain SINC – Metropolitan Importance is located 0.36km to the east of the Wraysbury Tunnel Connection but is unlikely to be negatively impacted due to the distance from the proposed works area and the lack of an impact pathway.

4.43. Construction works have the potential to impact protected species at the connection point to the Wraysbury Tunnel within the existing Iver WTW. The current indicative location for this is within amenity grassland, surrounded by hardstanding and buildings, and within close proximity to an area of broadleaved woodland, ponds and running water (e.g. Colne Brook and River Colne, which are located to the east). This area has the potential to support some protected species including but not limited to badgers, bats, widespread reptiles, GCN and breeding birds.

4.44. Other protected species with the potential to be present include otter and water vole; these species have the potential to be present in the nearby River Colne and Colne Brook. There is the potential for these species to utilise the area of proposed works for foraging activities. If present, these species may be adversely affected by construction works through disruption to commuting opportunities and routes. There could also be indirect effects due to disturbance from construction plant and machinery, the presence of people, lighting, creation of dust, etc.

Operation

4.45. Planned maintenance has the potential to impact habitats and protected species, most likely in the form of habitat maintenance/control. However, impacts would be highly localised and should be mitigated by Ecological Method Statements and in person Ecological Clerk of Works (ECoW).

4.2.3.2 Raw Water Transfer Main Route Corridor

Construction

4.46. No statutory designated nature conservation sites or ancient woodland would be directly impacted by works to construct the Raw Water Transfer Main. The Little Britain SINC – Metropolitan Importance is located 0.14km to the east of the Raw Water Transfer Main Route Corridor but is unlikely to be negatively impacted due to the distance from the route corridor and the lack of an impact pathway.

4.47. Works to construct the Raw Water Transfer Main have the potential to impact deciduous woodland priority habitat and protected and priority species. Protected species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice, widespread reptiles, GCN, breeding birds, water voles and otters. Habitat loss, habitat severance and fragmentation, and disturbance, as described in Paragraph 4.44, could affect these protected species, if present.

Operation

4.48. During operation, impacts upon habitats and protected species are likely to be low. Planned maintenance or replacement of pipeline sections have the potential to impact habitats and protected species, most likely in the form of habitat maintenance/control. However impacts are likely to be highly localised and should be mitigated by Ecological Method Statements and in person ECoW.

4.2.3.3 Indicative Water Treatment Works Site

Construction

4.49. No statutory designated nature conservation sites or ancient woodland are likely to be impacted by works to construct the new WTW. The Little Britain SINC – Metropolitan Importance is located to the 0.42 km to the east of the Indicative WTW Site but is unlikely to be negatively impacted due to the distance from the Indicative WTW Site and the lack of an impact pathway.

4.50. Works to construct the new WTW have the potential to impact deciduous woodland Priority Habitat and protected and priority species, both within the Indicative WTW Site and the indicative site for the temporary construction compound. Protected species with a potential to be present within these sites include (but may not be limited to) badgers, bats, hazel dormice, reptiles, GCN and breeding birds, and may all be negatively impacted by construction works. Since the Indicative WTW Site is on a previously developed site, the potential for protected and priority species may be reduced. There is also the potential for species such as water vole and otter to be present within proximity to the Indicative WTW Site and indicative site for the temporary construction compound due to the proximity of the Grand Union Canal Slough Arm and Colne Brook and the presence of potential foraging habitat. Habitat loss, habitat severance and fragmentation, and disturbance, could affect these protected species, if present.

Operation

4.51. During operation, the new WTW would potentially increase lighting to the surrounding habitats, with exterior lights being installed. This could have adverse effects on crepuscular and nocturnal species, for example bats, barn owl etc. There would also be a potential increase in noise and disturbance to the surrounding habitats. These forms of disturbance could act to deter protected and priority species from the immediate area, causing further loss of usable habitat and hence increasing habitat loss, fragmentation and severance.

4.2.3.4 Drinking Water Transfer Main Route Corridor

Construction

4.52. Kingcup Meadows and Oldhouse Wood, Ruislip Woods, Denham Lock Wood, Mid Colne Valley and Fray's Farm Meadow SSSIs, along with Frays Valley and Denham Quarry Park LNRs, have the potential to all be indirectly impacted by works to construct the Drinking Water Transfer Main. Ruislip Woods SSSI, Fray's Farm Meadow SSSI and Frays Valley LNR are in close proximity to the Drinking Water Transfer Main Route Corridor.

4.53. Open cut excavation pipe installation could negatively impact all of these sites via indirect effects. Indirect effects associated with the planned construction method include disturbance from construction plant and machinery, the presence of people, lighting, and creation of dust. Disturbance from machinery could impact breeding and wintering bird assemblages present within sites. Creation of dust and NO_X via heavy plant movement could negatively impact the flora of low nutrient sites such as calcifuge communities present within Ruislip Woods SSSI.

4.54. Open cut excavation pipe installation could negatively impact the Fray's Farm Meadow SSSI and Fray's Valley LNR via indirect effects. The wader and waterfowl assemblage present within site is likely to negatively impacted by indirect effects associated with construction, including disturbance from construction plant and machinery and the presence of people.

4.55. Construction activity may have negative impacts on the rare and scare invertebrate species supported within Ruislip Woods SSSI due to potential disturbance. Pollution generated during construction such as dust and $NO_{x,}$ have the potential to negatively impact the calcifuge communities present within site.

4.56. As described in Section 2.3, below ground structures would be constructed such that they would not form a preferential pathway for pollution to groundwater or cause alterations in groundwater flow or levels.

4.57. A number of non-statutory SINCs could be directly impacted during construction, with many being directly bisected by the Drinking Water Transfer Main Route Corridor. These include the London's Canals SINC, Southlands Manor LWS, Mid Colne SINC, Shepherd's Hill Woods and Fields SINC and Newyears Green SINC. Any vegetation removal during the construction phase could potentially have a negative impact on these sites. Disturbance due to excessive noise, vibration, lighting and the presence of people, and pollution events could also adversely affect these habitats.

4.58. No other statutory or non-statutory designated sites are likely to be negatively impacted due to the distance from the Drinking Water Transfer Main Route Corridor (see Table 4.5) and the lack of an impact pathway.

4.59. Where open cut excavation is proposed, several priority habitats could be bisected including good quality semi-improved grassland and deciduous woodland, which all have the potential to be negatively impacted by construction works.

4.60. Works to construct the Drinking Water Transfer Main have the potential to impact protected and priority species along the length of the route corridor, including where the Drinking Water Transfer Main Route Corridor crosses watercourses, including the River Colne, Alder Bourne, Fray's River and Colne Brook. Protected species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice, widespread reptiles, GCN and breeding birds. Habitat loss, habitat severance and fragmentation, and disturbance, could affect these protected species, if present. Other protected species with the potential to be present along the pipeline route include otter and water vole. These species have the potential to be present at the river crossing locations. As described in Section 2.3, trenchless techniques are proposed to cross major watercourses, which is likely to reduce impacts during construction. However, works are likely be required to facilitate this, and as such, potential negative impacts via disturbance and local habitat loss may occur if these species are present.

Operation

4.61. Planned maintenance or replacement of pipeline sections have the potential to impact habitats and protected and priority species, however impacts are likely to be highly localised and should be mitigated by Ecological Method Statements and in person ECoW.

4.2.3.5 Harefield Service Reservoir Connection

Construction

4.62. No designated sites, ancient woodland or priority habitat would be directly impacted by works to construct the Harefield Service Reservoir Connection. The existing Harefield Service Reservoir immediately adjacent to the Shepherd's Hill Woods and Fields SINC, with potential negative impacts via disturbance during construction works for the Harefield Service Reservoir Connection.

4.63. Construction works have the potential to impact protected and priority species within the existing Harefield Service Reservoir site. Notable species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice, widespread reptiles, GCN and breeding birds. Depending on the nature of the construction works, these species may all be negatively impacted by construction works. Habitat loss, habitat severance and fragmentation, and disturbance could all affect protected species if present.

Operation

4.64. The Harefield Service Reservoir Connection would take place within an existing service reservoir, therefore, during operation, it is not expected that there would be any adverse impacts on species or habitats in its vicinity.

4.2.4 Recommended mitigation and enhancement opportunities

4.65. Good practice is to apply the mitigation hierarchy. That is to first avoid, mitigate and, finally as the last option, compensate for biodiversity losses. If compensating for losses within the development footprint is not possible or does not generate the most benefits for nature conservation, then biodiversity losses can be offset by providing gains elsewhere. This is the first principle in the Biodiversity Net Gain Good

Practice Principles for Development[29].

4.66. In order to mitigate potential issues arising from the Lower Thames Reservoir Option on biodiversity, where possible, the Drinking Water Transfer Main should be routed to avoid non-statutory designated nature conservation sites and priority habitats, and those habitats that are of higher potential for protected and priority species. If this cannot be accommodated, trenchless techniques should be considered to allow the pipeline to cross under these protected areas. Where this is not possible, compensatory habitat would be required.

4.67. As described in Section 2.3, it is assumed that a CEMP would be developed at an appropriate stage to ensure that environmental risks are managed. Once more information is known about the ecological constraints on site through survey work undertaken at a subsequent project stage, detailed mitigation and enhancement measures should be developed to reduce disturbance during the construction stage, and protected species licences should be obtained, where required.

4.68. The Lower Thames Reservoir Option falls partially within an NRN with two Natural England Network Enhancement Zones and one Network Expansion Zone. Therefore, there are opportunities to incorporate the network enhancement zone into the landscape and ecology post-construction enhancement/habitat creation and restoration proposals within these locations. Biodiversity enhancements are considered within Chapter 16, Natural capital and biodiversity net gain and Chapter 17, Wider benefits.

4.3 Aquatic ecology

4.3.1 Methodology

4.3.1.1 Study area and sources of information

4.69. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surface water bodies within a 1km area (see Figure 4.1: Statutory designated nature conservation sites and Figure 4.2: Non-statutory designated nature conservation sites). Where it was recognised that impacts could extend beyond the proposed study areas due to potential indirect impacts, the assessment boundaries were extended accordingly to address the geographic extent

[29] Chartered Institute of Ecology and Environmental Management (CIEEM) Biodiversity Net Gain: Good Practice Principles for Development. Available at: https://cieem.net/resource/biodiversity-net-gain-good-practice-principles-for-development/ [Accessed April 2022]

of the potential impacts.

4.70. The Lower Thames Reservoir Option, in particular the transfer route corridors, interact with ten surface water bodies including two WFD lakes, and two canals. Only one WFD waterbody, Thames (Cookham to Egham) (GB106039023231), is directly associated with the abstraction of raw water from the River Thames for the Lower Thames Reservoir Option. Three groundwater bodies are also associated with the construction activities.

4.71. The study area for the aquatic ecology topic excludes the footprint of SESRO as this is considered within the EAR for SESRO. As described in Section 2.1, SESRO is a pre-requisite for the Lower Thames Reservoir Option because without SESRO the Lower Thames Reservoir Option would leave Thames Water with a reduced volume of strategic storage. The operational effects associated with SESRO are also discussed in the SESRO EAR and are only summarised in the section below.

4.72. The relevant components, the associated receptors (waterbodies) and the potential pathways are summarised in Table 4.7.

Table 4.7: Summary of the waterbodies and the relevant components as associated with the Lower Thames Reservoir Option

Component	Receptor(s)	Pathway
Wraysbury Tunnel Connection	Colne Brook (GB106039023010) Grand Union Canal, Uxbridge to Hanwell Locks, Slough Arm, Paddington Arm (GB70610078)	Construction related impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc.
Raw Water Transfer Main Route Corridor	Colne Brook (GB106039023010) Grand Union Canal, Uxbridge to Hanwell Locks, Slough Arm, Paddington Arm (GB70610078) Grand Union Canal, Maple Lodge to Uxbridge (Rivers Colne and Chess plus canal) (GB70610252) Newyears Green Bourne	Construction related impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc. It is unknown whether the component requires washout/maintenance points. Should these be required, this could result in water quality and flow changes during maintenance.
Indicative WTW Site	Colne Brook (GB106039023010) Grand Union Canal, Uxbridge to Hanwell Locks, Slough Arm, Paddington Arm (GB70610078)	Construction related impacts such as pollution incidents, local increases in sediment/siltation, temporary

Component	Receptor(s)	Pathway
		disturbance as a result of noise and vibration, etc. Changes to flow and water quality as a result of a new / increased discharge from the WTW. It is unknown whether the component requires washout/maintenance points. Should these be required, this could result in water quality and flow changes during maintenance.
Drinking Water Transfer Main Route Corridor	Colne Brook (GB106039023010) Alderbourne (GB106039023080) Colne (Confluence with Chess to River Thames) (GB106039023090) Unnamed tributary of the Alderbourne Tributaries of the River Colne, including the Sand River, Shire Ditch and Fray's River. Grand Union Canal, Maple Lodge to Uxbridge (Rivers Colne and Chess plus canal) (GB70610252)	Construction related impacts such as pollution incidents, local increases in sediment/siltation, temporary disturbance as a result of noise and vibration, etc. It is unknown whether the component requires washout/maintenance points. Should these be required, this could result in water quality and flow changes during maintenance.
Harefield Service Reservoir Connection	None identified. This is an existing service reservoir, with no surface water bodies identified in the vicinity of the structure.	None identified.

4.73. Table 4.8 outlines the baseline data sources which were collated and considered in the assessment. As summarised in Table 4.8, the desk-based assessment was informed by monitoring data collected in 2020 and 2021 for the SESRO SRO for the River Thames. Due to uncertainty around the scheme's pipeline corridor, no such targeted monitoring has been completed for the water bodies associated with the construction components and the baseline was mostly informed by open-source data in these instances.

Table 4.8: Sources of information (aquatic ecology)

Data collected	Source
Aquatic ecology features and species (including protected species)	Environment Agency Ecology and Fish Data Explorer data[30] and Fisheries Classification Scheme 2 (FCS2)[31] data Monitoring Programme data; including fish, invertebrates, macrophytes, diatoms, specialist depressed river mussel (*Pseudanodonta complanata*) surveys, multi-purpose eDNA [32]monitoring and bespoke INNS surveys within the study area / Supplementary data from Thames Water AMP7 WINEP investigations into INNS
Descriptions / designations of statutory designated nature conservation sites (and candidate designated sites)	Natural England/Joint Nature Conservation Committee (JNCC)
Habitats	Derived from OS MasterMap
Biodiversity Action Plan (BAP) priority habitats and species	UK Government - MAGIC Maps Website[22] / the NBN Atlas[23] / local authority information on BAP priority habitats and species

4.3.1.2 Approach to impact appraisal

4.74. A qualitative approach was undertaken to evaluate the aquatic ecology of the study area and assess where there was potential for the Lower Thames Reservoir Option (infrastructure and transfer corridor) to result in impacts on key ecological features. Where there was potential for significant impacts, recommendations have been made for further surveys, as appropriate.

4.75. Multiple data sources (see Table 4.8) were reviewed to identify available baseline ecological data within the study area and further develop the baseline understanding developed at Gate 1.

[30] Environment Agency (2021) *Ecology and Fish Data Explorer* [online]. Available at: https://environment.data.gov.uk/ecology/explorer/ [Accessed on: 25/11/2021].
[31] WFD-UKTAG (2008) *Rivers Assessment Methods Fish Fauna: Fisheries Classification Scheme 2*. Available at: https://wfduk.org/resources%20/river-fish [Accessed on: 22/02/2022].
[32] eDNA monitoring focussed on watercourses associated with the Scheme footprint, where access for conventional survey methods was restricted. This was supplemented by INNS eDNA sampling on the River Thames.

4.76. Two types of data were used to build an understanding of the baseline aquatic ecology; community data and population sensitivities across the study area. This included community biological metrics and species records.

4.77. The predicted direction and magnitude of receptor change associated with each pathway is reported within the assessment, based on the definitions outlined in Table 4.9. The assessment of effects considers the likely mitigation measures (see Section 2.3), prior to any further mitigation and/or compensation.

Table 4.9: Gate 2 assessment of potential effects for aquatic ecology

Description of potential effect
Major beneficial change in aquatic ecological community receptors, with the potential to improve the overall ecological integrity of the reach.
Minor beneficial change in aquatic ecological community receptors, unlikely to affect the overall ecological integrity of the reach.
No or negligible change in aquatic ecological community receptors.
Minor adverse change in aquatic ecological community receptors, unlikely to affect the overall ecological integrity of the reach.
Major adverse change in aquatic ecological community receptors, with the potential to reduce the overall ecological integrity of the reach.

4.3.1.3 Assumptions and limitations

4.78. Whilst there is a significant volume of baseline data within the study area and potential sensitivities of the major water bodies are relatively well understood, the main limitation of the baseline assessment is the uneven spatial and temporal distribution of the data. As such, no data were available for the smaller tributaries and watercourses associated with the various components. Additional information regarding the baseline data limitations are provided in Section 4.3.3.

4.79. This chapter presents a purely desk-based assessment, and as such, it does not include any field-based evidence of sensitivity of any watercourses. Protected species records were also informed by open-source data.

4.80. As noted in Section 2.1, the source of water for the Lower Thames Reservoir Option is the River Thames. However, the natural flow in the river is insufficient and so operation of the scheme will be dependent on raw water being fed into the river from the SESRO SRO. Any impacts related to the provision of the source water are considered in the EAR for the SESRO SRO.

4.81. Abstraction from the Queen Mother Reservoir and Wraysbury Reservoirs would be in line with licence agreements from the Environment Agency, which are dependent on the additional volumes being provided by the STT and SESRO SROs. It has therefore been assumed that there will be no change in water level or water quality within the Wraysbury Reservoir as the source of the water will be unchanged.

4.82. Any discharge from the new WTW should be treated to a standard agreed with the regulatory authority at less than the agreed maximum rate so as to not cause any potential impacts to water quality of the receiving water body.

4.83. Assumptions regarding the construction methodology and embedded mitigation measures (including measures related to INNS and biosecurity) are provided in Section 2.3.

4.3.2 Understanding of the baseline

4.3.2.1 Statutory designated nature conservation sites

4.84. While several statutory designated nature conservation sites have been identified as being associated with the construction components, most of the sites are designated for terrestrial habitats and species. The relevant sites are listed in Section 4.2.2 and are presented in Figure 4.1: Statutory designated nature conservation sites. Only two statutory designated nature conservation sites associated with the construction components are considered to be designated for aquatic features. These are Denham Lock Wood SSSI and the Wraysbury Reservoir SSSI (noting the construction activities are within the SSSI Impact Risk Zone of the latter).

4.85. Where internationally designated terrestrial habitat and species are dependent on aquatic features, these have been assessed in more detail within Technical Supporting Document B2, Habitats Regulations Assessment.

4.86. A screening exercise was also undertaken for all statutory and non-statutory sites associated with the River Thames to identify those that are designated on account of aquatic features and that could conceptually be at risk of change as a result of the operation of SESRO in support of the Lower Thames Reservoir Option. The results of the assessment are provided in the SESRO EAR.

4.3.2.2 Non-statutory designated nature conservation sites

4.87. Several non-statutory designated nature conservation sites have been identified in the study area as associated with the construction activities. This includes several SINCs and LWSs that are designated for aquatic features. The relevant sites are listed in Section 4.2.2 and are presented in Figure 4.2: Non-statutory designated nature conservation sites.

4.3.2.3 Protected/notable species

4.88. A number of aquatic species of conservation importance have been identified from available datasets. These are listed in the sections below. This includes several fish species that are considered as being of national importance such as brown / sea trout (*Salmo trutta*), bullhead (*Cottus gobio*), European eel (*Anguilla anguilla*) and brook lamprey (*Lampetra planeri*).

4.3.2.4 Fish community and notable species

4.89. Baseline data for the fish community were available for several sites within the study area from the Environment Agency's Fish and Ecology data explorer. The draft River Basin Management Plan 3 (RBMP3) WFD status of the waterbodies range from Poor to Moderate (also see Technical Supporting Document B3, Water Framework Directive Compliance Assessment). Baseline descriptions of the fish community and associated with the study area are outlined in Table 4.10.

4.90. The fish community within the study area consisted mostly of coarse fish species with more than 20 species observed from Environment Agency survey data. This includes dace (*Leuciscus leuciscus*), chub (*Squalius cephalus*), barbel (*Barbus barbus*) bleak (*Alburnus alburnus*), gudgeon (*Gobio gobio*), pike (*Esox Lucius*), roach (*Rutilus rutilus*), perch (*Perca fluviatilis*), tench (*Tinca tinca*) and stone loach (*Barbatula barbatula*).

4.91. Several species of conservation importance have also been recorded historically, including brown / sea trout, bullhead, European eel and brook lamprey.

4.92. The available baseline data suggest a fish community that is fairly tolerant to environmental change when considering the tolerances of the fish community as identified as part of the Fisheries Classification Scheme (FCS2)[33].

4.93. The River Thames supports a species-rich fish community due to its size and concomitant fisheries habitat provision. The River Thames supports between 18 and 24 species with a community dominated (both in terms of species and abundance) by coarse fish. The highest densities apparent from the underpinning survey data across all reaches are associated with roach and bleak, both known for their shoaling behaviour. Notable species recorded in the Thames include European eel (recorded in every study reach), as well as other, less abundant, notable species including

[33] WFD UK Tag (2008). UKTAG Rivers Assessment Methods Fish Fauna (Fisheries Classification Scheme 2 (FCS2)) by Water Framework Directive - United Kingdom Technical Advisory Group (WFD-UKTAG). ISBN: 978-1-906934-09-5

Atlantic salmon (*Salmo salar*), barbel, brown/sea trout, bullhead, and lamprey.

4.94. The INNS ruffe (*Gymnocephalus cernuus*) and common carp (*Cyprinus carpio*) varieties have been recorded in the River Colne. These species have also been recorded in the River Thames along with sunbleak and zander (*Sander lucioperca).* It is noted that some of these species such as ruffe and carp are considered naturalised within South East England.

4.95. The INNS assessment is detailed in Chapter 15, Invasive non-native species risk assessment. It is noted that some species of INNS are considered "naturalised" throughout the UK.

Table 4.10: Baseline fish community within the study area

Receptor	Baseline summary
Colne Brook (GB106039023010)	The fish element has been classified as Poor. The fish community consist mostly of coarse fish species and have a preference for slow flowing water. The fish community is considered to be generally tolerant to environmental changes. There are numerous historical surveys available to inform the baseline of this water body. There are historical records of brown trout, European eel, brook lamprey and bullhead within this water body.
Grand Union Canal, Uxbridge to Hanwell Locks, Slough Arm, Paddington Arm (GB70610078)	The ecology element has been classified as Moderate (overall). There were no fisheries data available for this water body.
Grand Union Canal, Maple Lodge to Uxbridge (Rivers Colne and Chess plus canal) (GB70610252)	The ecology element has been classified as Moderate (overall). There were no fisheries data available for this water body. One survey location was available for this water body, upstream of the study area. The site was survey on one occasion and the data indicates that the community consists mostly of coarse fish. European eel was observed during the survey.
Newyears Green Bourne (a tributary of the River Colne)	The fish element for this watercourse has not been classified. There are no survey data available to inform the baseline fish community.
Alderbourne (GB106039023080)	The fish element has not been classified for this water body. The fish community consist mostly of coarse fish species and have a preference for slow flowing water. There are numerous historical surveys available to inform the baseline of this water body. The fish community is considered to be generally tolerant to environmental changes. There are historical records of brown trout, European eel, brook lamprey and bullhead within this water body.

Receptor	Baseline summary
Colne (Confluence with Chess to River Thames) (GB106039023090)	The fish element has been classified as Poor. Only one survey locations (near the confluence with the Colne Brook) was available to inform the baseline fish community. The site was last surveyed in 2006. Only two species were sampled during the surveys including chub and perch. The fish community was considered to be generally tolerant to environmental changes.

4.3.2.5 *Macroinvertebrate community and notable species*

4.96. Baseline data for the macroinvertebrate community were made available for several sites within the study area from the Environment Agency's Fish and Ecology data explorer. The RBMP3 WFD status of the waterbodies ranged from Moderate to High (also see Technical Supporting Document B3, Water Framework Directive Compliance Assessment). Baseline descriptions of the macroinvertebrate community associated with the study area are outlined in Table 4.11.

4.97. Data from the biological metrics for the macroinvertebrate community indicated that the communities across all the associated watercourses were dominated by taxa with a moderate to high tolerance for pollution. There was some variation in the metrics with the results indicating slightly higher sensitivities in larger watercourses (such as the River Colne).

4.98. Several INNS species have also been identified within the study area. This includes the Florida crangonyctid (*Crangonyx floridanus*), freshwater bivalves (*Dreissenidae spp.*), New Zealand mud snail (*Potamopyrgus antipodarum*) and Northern river crangonyctid (*Crangonyx pseudogracilis*).

Table 4.11: Baseline macroinvertebrate community within the study area

Receptor(s)	Baseline summary
Colne Brook (GB106039023010)	The macroinvertebrate element has been classified as High. Data were available for numerous survey locations in the vicinity of the Drinking Water Main Transfer Corridor, noting that nearby survey locations were last surveyed in 2005. The Whalley Hawkes Paisley Trigg (WHPT) Average Score Per Taxon (ASPT) scores for the survey locations range from 4.3-4.9. Lotic Invertebrate Flow Evaluation (LIFE) scores range from 6.3-7.1 and Proportion of Sediment-sensitive Invertebrates (PSI) scores range from 24.1–44.1. Overall, the macroinvertebrate community is considered tolerant to moderately sensitive to pollution with a preference for slow flowing water and are indicative of a heavily to moderately silted riverbed.

Receptor(s)	Baseline summary
Grand Union Canal, Uxbridge to Hanwell Locks, Slough Arm, Paddington Arm (GB70610078)	The ecology element has been classified as Moderate (overall). There were no macroinvertebrate data available for this water body.
Grand Union Canal, Maple Lodge to Uxbridge (Rivers Colne and Chess plus canal) (GB70610252)	The ecology element has been classified as Moderate (overall). Data were available for two survey locations in the vicinity of the proposed canal crossing, noting that the most recent surveys were in 2009. The WHPT ASPT scores for the survey locations range from 3.8-4.1, LIFE scores range from 5.7-6.2 and PSI scores range from 7.5-13.8. Overall, the macroinvertebrate community is considered to be tolerant to pollution with a preference for slow to flowing water and indicative of a heavily sedimented bed.
Newyears Green Bourne (a tributary of the River Colne)	The macroinvertebrate element for this watercourse has not been classified. There are no survey data available to inform the baseline macroinvertebrate community.
Alderbourne (GB106039023080)	The macroinvertebrate element has been classified as High for this water body. Data are available for two survey locations. The WHPT ASPT scores for the survey locations range from 4.5-5.2, LIFE scores range from 6.2-6.5 and PSI scores range from 26.8 – 46.0. Overall, the macroinvertebrate community is considered to be moderately sensitive to pollution with a preference for slow to moderately fast flowing water and indicative of a slightly to moderately sedimented bed.
Colne (Confluence with Chess to River Thames) (GB106039023090)	The macroinvertebrate element has been classified as High for this water body. Data were available for numerous survey locations in the vicinity of the Drinking Water Main Transfer Corridor with surveys as recent as 2019. The WHPT ASPT scores for the survey locations range from 3.9-5.7, LIFE scores range from 5.6-6.8 and PSI scores range from 13.8-44.1. Overall, the macroinvertebrate community is considered to be tolerant to moderately sensitive to pollution with a preference for slow to moderately fast flowing water and indicative of a heavily to moderately sedimented bed.

4.3.2.6 Macrophyte community and notable species

4.99. Baseline data for the macrophyte community were available for several sites within the study area from the Environment Agency's Fish and Ecology data explorer. The WFD status of the waterbodies was Moderate (also see Technical Supporting Document B3, Water Framework Directive Compliance Assessment). Baseline descriptions of the macroinvertebrate community associated with the study area are outlined in Table 4.12.

4.100. Broadly, the macrophyte communities within the study area were typical of large base-rich, lowland rivers, with high River Macrophyte Nutrient Index (RMNI) scores indicative of communities which prefer nutrient enriched conditions. The N taxa and number of functional groups were indicative of diverse habitat, although these indexes are very variable between reaches.

Table 4.12: Baseline macrophyte community and notable species by study area reach

Receptor(s)	Baseline summary
Colne Brook (GB106039023010)	The macrophyte and phytobenthos element (combined) has been classified as Moderate. Data are limited to two survey location near the Drinking Water Main Transfer Corridor, noting that extensive data sets are available for the reaches upstream. The RMNI scores (7.7-8.2) are indicative of eutrophic conditions.
Grand Union Canal, Uxbridge to Hanwell Locks, Slough Arm, Paddington Arm (GB70610078)	The ecology element has been classified as Moderate (overall). There were no macrophyte data available for this water body.
Grand Union Canal, Maple Lodge to Uxbridge (Rivers Colne and Chess plus canal) (GB70610252)	The ecology element has been classified as Moderate (overall). There were no macrophyte data available for this water body.
Newyears Green Bourne (a tributary of the River Colne)	The macrophyte and phytobenthos element (combined) for this watercourse has not been classified. There are no survey data available to inform the baseline macrophyte community.
Alderbourne (GB106039023080)	The macrophyte and phytobenthos element (combined) has been classified as Moderate. Data are limited to two survey location with surveys as recent as 2020. The RMNI scores (7.6-7.7) are indicative of eutrophic conditions.
Colne (Confluence with Chess to River Thames) (GB106039023090)	The macrophyte and phytobenthos element (combined) has been classified as Moderate. Data are limited to one survey location with surveys as recent as 2019. The RMNI scores (8.0-8.2) are indicative of eutrophic conditions.

4.3.2.7 Phytobenthos and phytoplankton communities

4.101. Baseline data for the phytobenthos community were limited within the study area, with no phytobenthos data available for waterbodies at locations that are directly associated with the Lower Thames Reservoir Option. The WFD status of the waterbodies was Moderate (see Technical Supporting Document B3, Water

Framework Directive Compliance Assessment).

4.102. Data were only available for one survey location located on the River Colne, upstream of the Drinking Water Main Transfer Route Corridor. The Trophic Diatom Index (TDI) at this site is indicative of diatom (phytobenthos) assemblages that prefer nutrient enriched watercourses.

4.103. Data were also available for two survey locations on the Grand Union Canal, upstream of the Drinking Water Main Transfer Route Corridor. The TDI at these sites is indicative of diatom (phytobenthos) assemblages that prefer nutrient enriched watercourses.

4.3.3 Appraisal outcomes

4.3.3.1 Wraysbury Tunnel Connection

Construction

4.104. During construction there is a risk of construction related impacts on the aquatic communities associated with the Colne Brook and the Grand Union Canal (Uxbridge to Hanwell Locks), Slough Arm, and Paddington Arm.

4.105. The construction related impacts include localised impacts on water quality due to increased sediment loads and/or pollution incidents. Temporary disturbance of fish communities (including migratory species such as European eel) could also occur.

4.106. Overall, the aquatic communities of the water bodies associated with the construction activities are considered to be tolerant and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term with, no or negligible change in aquatic ecological community receptors are expected.

Operation

4.107. As noted in Section 2.1, SESRO is a pre-requisite for the Lower Thames Reservoir Option because without SESRO the Lower Thames Reservoir Option would leave Thames Water with a reduced volume of strategic storage. The potential changes in flow/level/habitat within the River Thames in relation to abstraction to support the Lower Thames Reservoir Option has, therefore, considered the potential changes as assessed in the SESRO EAR.

4.108. The SESRO EAR concluded that, overall, flow changes within the River Thames as a result of SESRO discharges in support of a Lower Thames Reservoir Option have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected reaches. Whilst flow augmentation removes drought and very low flow years conceptually provides an overall benefit for ecological communities; the influence of SESRO (whilst proportionally smaller at higher baseline flow scenarios) would be to move average or typical lower flow (but non-drought) hydrological years into more average and above-average flow years.

4.109. This change could realise more adverse than beneficial effects for the baseline ecological communities of the River Thames and requires further consideration (i.e. assessment of other such hydrological scenarios) at subsequent project stages.

4.110. Considering direct effects; as a level-dependent system, velocity and depth on the River Thames are significantly influenced by how level control structures are operated at a given discharge. Therefore, conceptually, with no change in existing level control operating procedures, velocity and depth during SESRO augmentation in support of an abstraction for the Lower Thames Reservoir Option would simply reflect existing velocity and depth associated with the equivalent discharge under existing baseline conditions (to which the baseline ecology is adapted).

4.111. The potential mechanisms of impact associated with flow augmentation are therefore a longer period of higher summer flow conditions relative to the stochastic baseline (and associated increases in both level and velocity during those periods, assuming no amendment to existing level-control operations), and a reduction in the frequency of low flow and drought year hydrology within the system.

4.112. Increased summer discharge has the potential for direct effects, for example mortality of fish during a critical period in the life stages of particular species. Increased discharge also has the potential for indirect effects such as changes in water quality (including temperature) and food availability (such as changes in phytoplankton and zooplankton dynamics). Different fish and life stages have different optimal flow and level preferences and the magnitude of change predicted, whilst small in most instances, may well provide a competitive advantage and favour certain fish species over others.

4.113. Preliminary modelling indicates that the impacts of SESRO operational discharges are largely positive, in that it will reduce or make no change in river concentrations for both the options modelled (75Mm^3 and 150Mm^3).

4.114. One exception to this is a change in ammonia immediately downstream of the reservoir related to the increase in river velocities and consequent reduced travel time. However, this increase in concentration is predicted to only materialise for a relatively short distance in the context of the River Thames (it disappears by the Kennet confluence i.e. 50 km downstream from SESRO) and whilst proportionally large, is very small in absolute terms and would not cause a change from High WFD status for ammonia as baseline River Thames concentrations are typically extremely low.

4.115. The reduction in nutrient concentrations could alter phytoplankton and phytobenthos growth and dynamics with implications on primary productivity and algal blooms (see sections below).

4.116. Conceptually, the predicted decrease in nutrients (especially ortho-phosphate) downstream of SESRO has the potential to limit phytoplankton growth. However, monitoring data suggest that nutrient concentrations in the River Thames are typically at high concentrations and are poorly correlated with chlorophyll a. Microcosm experiments completed by Centre for Ecology and Hydrology (CEH) on behalf of Thames Water found that the growth rate of Thames algae was unaffected (or slightly reduced) by the addition of reservoir water, suggesting that the change in water quality would have negligible impact on Thames algae.

4.117. Eutrophication Risk Modelling completed by CEH on behalf of Thames Water for SESRO investigated the effects of SESRO operation (in terms of increased flow and decreased temperature) on phytoplankton growth in the Thames. They predict relatively minor changes in the relative abundance of phytoplankton groups under SESRO scenarios (with and without climate change), with virtually no change in chlorophyll concentration, and a reduction in the number of days of suitable cyanobacteria growth conditions. The results therefore suggests that SESRO is unlikely to affect most phytoplankton groups, but that it could partially mitigate the risk of problematic cyanobacteria blooms, which are predicted to increase under future

4.118. Scientific understanding of these complex interrelationships is low, and so there remains a high level of uncertainty as to what the effect of a change in primary productivity would be, and whether the predicted change would be enough to drive measurable responses in the community structure or function.

4.3.3.2 Raw Water Transfer Main Route Corridor

Construction

4.119. During construction there is a risk of construction related impacts on the aquatic communities associated with the Colne Brook Grand Union Canal (Uxbridge to Hanwell Locks, Slough Arm and Paddington Arm, the Grand Union Canal (Maple Lodge to Uxbridge section) and the Newyears Green Bourne.

4.120. The construction related impacts include localised impacts on water quality due to increased sediment loads and/or pollution incidents. Temporary disturbance of fish communities (including migratory species such as European eel) could also occur.

4.121. Overall, the aquatic communities of the water bodies associated with the construction activities are considered to be tolerant and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term with, no or negligible change in aquatic ecological community receptors are expected.

Operation

4.122. Operational impacts are not considered likely following construction. During maintenance of the infrastructure, there is a risk that washout from the Raw Water Transfer Main could discharge into nearby water bodies resulting in changes in water quality and flow. It has been assumed that maintenance work will be completed with consideration of the Environment Agency's Pollution Prevention Guidance Notes[16]. Any changes are therefore considered temporary and reversible and negligible overall.

4.3.3.3 Indicative Water Treatment Works Site

Construction

4.123. During construction, there is a risk of construction related impacts on the aquatic communities associated with the Colne Brook and the Grand Union Canal (Uxbridge to Hanwell Locks, Slough Arm, and Paddington Arm). The construction related impacts include localised impacts on water quality due to increased sediment loads and/or pollution incidents. Temporary disturbance of fish communities (including migratory species such as European eel) could also occur.

4.124. Overall, the aquatic communities of the water bodies associated with the construction activities are considered to be tolerant and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term with, no or negligible change in aquatic ecological community receptors are expected.

Operation

4.125. The operation of the new WTW could impact the Colne Brook. During operation, any effluent discharge could impact on the receiving environment and the associated aquatic communities. Overall, the aquatic communities associated with the operational activities are considered to be tolerant to changes in water quality.

4.126. Any discharge (during commissioning and operation) will be treated to a standard agreed with the regulatory authority at less than the agreed maximum rate so as to not cause any potential impacts to water quality of the receiving water body.

4.127. It is recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process. As such, there is no impact pathway applicable to the operation of this component.

4.128. Overall, the potential impact during operation is considered negligible. During maintenance of any infrastructure impacts are likely to be negligible.

4.3.3.4 Drinking Water Transfer Main Route Corridor

Construction

4.129. During construction, there is a risk of construction related impacts on the aquatic communities associated with numerous water bodies. This includes the Colne Brook, Alderbourne, River Colne and the Grand Union Canal (Maple Lodge to Uxbridge section). This also includes an unnamed tributary of the Alderbourne and tributaries of the River Colne.

4.130. As noted in Section 2.3, main rivers would be crossed via micro-tunnel. All other rivers would be crossed using an open cut method across the road with traffic management. Where watercourses would not be micro-tunnelled, it is assumed they will be flumed during construction. However, works are likely be required to facilitate this, and as such, potential negative impacts via disturbance and local habitat loss may occur. This would include localised impacts on water quality due to increased sediment loads and/or pollution incidents. Below ground structures will be constructed such that they would not form a preferential pathway for pollution to groundwater or cause alterations in groundwater flow or levels.

4.131. Overall, the aquatic communities of the water bodies associated with the construction activities are considered to be tolerant and impacts are considered temporary and reversible. Any impacts on the aquatic communities are therefore expected to be short term with, no or negligible change in aquatic ecological community receptors are expected.

Operation

4.132. Operational impacts are not considered likely following construction. During maintenance of the infrastructure, there is a risk that washout from the Drinking Water Transfer Main could discharge into nearby water bodies resulting in changes in water quality and flow. It has been assumed that maintenance work will be completed with consideration of the Environment Agency's Pollution Prevention Guidance Notes[16]. Any changes are therefore considered temporary and reversible and negligible overall. It is noted that any water discharged from the washout / maintenance points will be treated.

4.3.3.5 Harefield Service Reservoir Connection

Construction

4.133. This component is not associated with any surface water bodies. Impacts during construction are considered to be negligible.

Operation

4.134. Operational impacts are not considered likely following construction. During maintenance of any infrastructure impacts are likely to be negligible.

4.3.4 Recommended mitigation

4.135. As stated in paragraph 4.65, good practice is to apply the mitigation hierarchy. That is to first avoid, mitigate and finally as the last option compensate for biodiversity losses. If compensating for losses within the development footprint is not possible or does not generate the most benefits for nature conservation, then biodiversity losses can be offset by providing gains elsewhere. This is the first principle in the Biodiversity Net Gain Good Practice Principles for Development.

4.136. Appropriate precautions should be taken when working in any channels or adjacent to watercourses, to appropriately manage flood risk and the potential for deposition of silt or release of other forms of suspended material or pollution within the water column.

4.137. Water extracted from the ground during construction should be treated to a standard agreed with the regulatory authority before discharging at less than the agreed maximum rate to the water environment.

4.138. It is recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process.

4.139. Any discharge from commissioning lagoons should be treated to a standard agreed with the regulatory authority at less than the agreed maximum rate so as to not cause any potential impacts to water quality of the receiving water body.

4.140. Crossings of main rivers should be via micro-tunnel. Where watercourses cannot be micro-tunnelled, it is recommended that they are flumed during construction. This will be a short term construction activity (i.e. less than seven days), which will ensure the watercourse is returned to its natural function following installation of the pile section.

4.141. It is assumed that a CEMP would be developed at an appropriate stage to ensure that environmental risks such as uncontrolled discharges from construction are minimised and that Emergency Response Plans are in place in the event of an incident. Best practice pollution prevention will be followed for all construction works

4.142. There is still a risk of flooding during the construction phase near any watercourse and it is recommended that works within the river during forecasts of wet weather or issued flood warnings should be avoided.

4.4 Summary of main findings and recommendations for future technical work

4.4.1 Terrestrial ecology

4.143. No statutory designated sites or ancient woodland are likely to be directly impacted by works to construct the Lower Thames Reservoir Option.

4.144. The Lower Thames Reservoir Option has the potential to indirectly impact Kingcup Meadows and Oldhouse Wood, Fray's Farm Meadows, Denham Lock Wood, Ruislip Wood SSSIs, Frays Valley and Denham Quarry Park LNRs during construction.

4.145. The London's Canals SINC, Southlands Manor LWS, Mid Colne SINC, Shepherd's Hill Woods and Fields SINC and Newyears Green SINC would potentially be directly impacted due to open cut excavation for the Drinking Water Transfer Main.

4.146. No other statutory or non-statutory sites are likely to be negatively impacted due to the distance from the pipeline route and the lack of an impact pathway.

4.147. Where open cut excavation is proposed, several priority habitats could be bisected including good quality semi-improved grassland and deciduous woodland, which all have the potential to be directly impacted by construction works.

4.148. The Lower Thames Reservoir Option has the potential to impact protected and priority species, including where the Drinking Water Transfer Main Route Corridor crosses watercourses, including the River Colne, Alder Bourne, Fray's River and Colne Brook. Notable species with the potential to be present include (but are not limited to) badgers, bats, hazel dormice, reptiles, GCN, and breeding birds. If present, these species may be adversely affected by construction works through disruption to commuting opportunities and routes. There could also be indirect effects due to disturbance from construction plant and machinery, the presence of people, lighting, creation of dust etc.

4.149. Other protected species with the potential to be present include otter and water vole. These species have the potential to be present at the river crossing locations. Trenchless techniques are proposed to cross the watercourses, which is likely to reduce impacts during construction. However, works are likely be required to facilitate this, and as such, potential negative impacts via disturbance and local habitat loss may occur if these species are present.

4.150. Planned maintenance or replacement of pipeline sections during operation have the potential to impact habitats and protected species, however impacts are likely to be highly localised and likely to be sufficiently mitigated by Ecological Method Statements and ecological supervision.

4.151. During operation, the new WTW could cause disturbance to protected and priority species through increasing lighting to the surrounding habitats, which could affect bats and barn owls, and potential increases in noise and disturbance to the surrounding habitats.

4.152. In order to mitigate potential issues arising from construction of the Lower Thames Reservoir Option on biodiversity, the Drinking Water Transfer Main should be routed to avoid non-statutory designated nature conservation sites, priority habitats and those habitats that provide higher/better potential for protected and priority species. If this cannot be accommodated, trenchless techniques should be considered to allow the pipeline to cross under these protected areas. Where this is not possible, compensatory habitat would be required.

4.153. It should be noted that the protected and priority species suggested as being present are likely to be amended following completion of surveys and should not be considered final. Surveys are recommended at a subsequent project stage both to refine habitat mapping and identify the presence of protected species. Surveys should be phased in nature and proportionate to the level of design.

4.154. A Preliminary Ecological Appraisal (PEA) is recommended to assess the likelihood of protected and priority species and habitats being present. As part of this, protected species data should be obtained from biological records centres and site visits undertaken to ground truth the findings of the desk based habitat mapping before a survey programme for protected species and habitats is established to inform an Ecological Impact Assessment to assess impacts to the qualifying features of designated sites, habitats and protected species, and inform scheme design evolution and mitigation measures. The timing of surveys would vary depending on the protected species in question, as optimum windows for differing species vary.

4.4.2 Aquatic ecology

4.155. Considering the micro-tunnelling technique proposed for the construction process, and the mitigation measures proposed, no or negligible change in aquatic ecological community receptors are expected.

4.156. Walkovers of the potential crossing points are recommended to further inform the scope of the mitigation measures that may be required. Limited data was available for the desktop assessment of selected aquatic features, notably macrophyte and phytobenthos communities.

4.157. Flow changes within the River Thames as a result of SESRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected reaches.

4.158. No data were available to inform the sensitivity of the minor water bodies such as the tributaries of the Alderbourne and the River Colne and further surveys may be required. This includes the Newyears Green Bourne (a tributary of the River Colne) which will be associated with large sections of the Drinking Water Transfer Main Corridor.

4.159. It is also recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process.

4.160. As stated in Paragraph 4.154, a PEA is recommended to assess the likelihood of protected species and habitats being present before a survey programme is established to inform an Ecological Impact Assessment.

4.161. Whilst the assessment at subsequent project stages will seek to improve certainty around the trajectory of change that may be anticipated relative to baseline in the aquatic environment; a key challenge will resolving the subjectivity and philosophy of whether a potential change (for example, changes in the relative abundance of different fish species) is considered to be adverse or beneficial, particularly in the context of the extensive existing anthropogenic modifications of the river and its flow regime which has shaped the baseline ecological communities.

5 Soils

5.1 Introduction

5.1. This chapter presents a desk-based assessment undertaken to identify potential impacts on soils from the transfer route corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to establish the soils baseline associated with the Lower Thames Reservoir Option, identify constraints and opportunities, and identify the issues that may require further investigation at a subsequent project stage. Land quality has also been considered in relation to potential land contamination.

5.2. The need to consider soils and land quality is driven by legislation (Part II A of the Environmental Protection Act (EPA), 1990, although numerous other subsidiary Regulations are also relevant) and national planning policy (draft NPS for Water Resource Infrastructure[20] (Section 4.10, Land use including open space, green infrastructure and Green Belt) and NPPF[21] (Section 15, conserving and enhancing the natural environment), paragraphs 174 and 183-184).

5.3. Impacts on food production as a result of the loss of agricultural land are considered in the NCA presented in Chapter 16, Natural capital and biodiversity net gain.

5.2 Methodology

5.2.1 Study area and sources of information

5.4. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within 200m.

5.5. Table 5.1 outlines the baseline data sources which were collated and considered in the desk-based assessment.

Table 5.1: Sources of information (soils)

Data collected	Source
Land use	MAGIC map[22]
Agricultural Land Classification (ALC)	Provisional ALC data (Natural England)[34] Post-1988 publicly available ALC data (Natural England)[35] Predictive Best and Most Versatile (BMV) Land Maps (Natural England)[36]
Soil type and properties	Soilscapes viewer, Land Information System (LandIS)[37] British Geological Survey (BGS) Onshore GeoIndex – borehole data[38]
Geology and superficial deposits	British Geological Survey of England and Wales, 1:50,000, Sheet 255, Beaconsfield, Solid & Drift, 2005 British Geological Survey of England and Wales, 1:50,000, Sheet 269, Windsor, Solid & Drift, 1999 BGS Onshore GeoIndex[38]
Climatological data	Climatological Data for ALC handbook (1989)[39]
Soil hydrology	Cranfield University, UK[40]
Flood risk	Information on flood risk was derived from Section 6.3, Flood Risk, to ensure consistency in data collection and subsequent assessment.

[34] Natural England. (2020) Provisional Agricultural Land Classification (ALC). Available at: https://data.gov.uk/dataset/952421ec-da63-4569-817d-4d6399df40a1/provisional-agricultural-land-classification-alc [Accessed April 2022]
[35] Natural England. (2021) Agricultural Land Classification (ALC) Grades - Post 1988 Survey (polygons). Available at: https://data.gov.uk/dataset/c002ceea-d650-4408-b302-939e9b88eb0b/agricultural-land-classification-alc-grades-post-1988-survey-polygons [Accessed April 2022]
[36] Natural England. (2017) Likelihood of Best and Most Versatile Agricultural Land. Available at: http://publications.naturalengland.org.uk/category/5208993007403008 [Last accessed October 2022]
[37] Cranfield Soil and AgriFood Institute. Soilscapes. Available at: http://www.landis.org.uk/soilscapes/index.cfm [Accessed April 2022]
[38] British Geological Survey. (2022) GeoIndex Onshore. Available at: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.129380744.505609546.1642073666-2029197738.1642073666 [Accessed April 2022]
[39] The Meteorological Office. (1989) Climatological Data for Agricultural Land Classification. Available at: http://publications.naturalengland.org.uk/publication/6493605842649088 [Accessed April 2022]
[40] Cranfield University. Soil Data. Available at: Soil Data - Cranfield Mapshop (blueskymapshop.com) [Accessed April 2022]

Data collected	Source
Land quality	Groundsure Reports & GIS data pack

5.2.2 Approach to impact appraisal

5.2.2.1 Land use

5.6. Using data from MAGIC map[22], current land uses of potentially affected areas were reported to identify features pertinent to soil resources and soil management planning.

5.7. A summary of recent and historical industrial land uses is provided in Section 5.3.1, based on review of the Groundsure Reports and GIS data pack obtained.

5.2.2.2 Agricultural land classification

5.8. Soils are considered a natural non-renewable resource that has relevance to water holding capacity, agricultural output, habitat and biodiversity capital, construction, carbon store, climate change and more.

5.9. Fundamental to this is the ALC framework[41], which categorises agricultural land quality in England and Wales into five provisional grades based on local climatological data and anticipated soil properties (from soil association mapping[42]). This provides a basis for retaining land of higher quality for agricultural use where possible (grades 1-3), whilst prioritising lower quality land (grades 4 and 5) for construction. Provisional ALC maps are based on sparse soil data and are useful as a strategic guide, but can be inaccurate, particularly at the local level. A detailed ALC survey would provide evidence for refining provisional ALC mapping and for subdividing grade 3 into grades 3a and 3b. This is a significant step as grades 1-3a are classed as BMV land, defined by the ALC framework as land which is considered 'the most flexible, productive and efficient in response to inputs and which can best deliver future crops for food and non-food uses.' In line with the NPPF[21], the Government and planning authorities have a commitment to retain within agricultural use wherever possible.

5.10. ALC defines cropping potential of land depending on physical and chemical

[41] Ministry of Agriculture, Fisheries and Food. (1988) Agricultural Land Classification of England and Wales Revised guidelines and criteria for grading the quality of agricultural land.
[42] Cranfield University. (2021) Soils guide. Available at: https://www.cranfield.ac.uk/themes/environment-and-agrifood/landis/soils-guide [Accessed April 2022]

properties:

- Grade 1 (excellent quality agricultural land)
- Grade 2 (very good quality agricultural land)
- Grade 3 (good or moderate quality agricultural land)
- Subgrade 3a (good quality agricultural land)
- Subgrade 3b (moderate quality agricultural land)
- Grade 4 (poor quality agricultural land)
- Grade 5 (very poor quality agricultural land)

5.11. Provisional ALC data from Natural England was used in conjunction with ALC data collected post-1988 if available to predict the grade of land impacted by the Lower Thames Reservoir Option.

5.12. Use of BMV agricultural land (ALC Grades 1, 2, 3a) should be minimised where possible, in favour of land in areas of poorer soil quality (ALC Grades 3b, 4 and 5).

5.13. It is important to note that the provisional Natural England ALC dataset, does not differentiate between Grades 3a and 3b as this is can only be established by a detailed ALC survey.

5.2.2.3 Soil type and properties

5.14. Digitised soil type and properties data from Cranfield University (e.g. texture, permeability) inform soil profile depth and resilience to damage during handling. The information aids assessment of design options, further investigative requirements such as field surveys, and contributes to soil management planning during construction activities.

5.15. Geological borehole data from the BGS Onshore GeoIndex[38] can corroborate information on soil properties from the Land Information System (LandIS)[37].

5.2.2.4 Geology

5.16. Site geology influences soil formation and characteristics. As above, this information aids assessment of design options, further investigative requirements such as field surveys, and contributes to soil management planning during construction activities.

5.2.2.5 Climatological data

5.17. Climate influences soil formation, properties and the agricultural potential of land. Key factors include altitude, average annual rainfall and field capacity days. Climatological data is key for providing guidance on soil handling and ALC grade assessment.

5.2.2.6 Flood risk

5.18. Flood risk is relevant because soils function as water stores for flood attenuation. The requirement for contractors to monitor and manage flood risk may affect agriculture and soil resources during construction. Areas were categorised into flood zones 1-3, flood storage areas and areas benefiting from flood defences.

5.2.2.7 Land quality

5.19. A high-level land quality assessment has been undertaken for the Raw and Drinking Water Transfer Mains, Wraysbury Tunnel Connection and the Indicative WTW Site. This involved review of readily available information in the form of Groundsure reports and GIS data packs, including recent and historical industrial land use, as well as geological mapping and publicly available borehole records.

5.20. The assessment of potential land contamination is based on current guidance documents related to Part II A of the EPA. Particular reference is made to Construction Industry Research and Information Association (CIRIA) Report C552 and to the Model Procedures for the Management of Land Contamination (LCRM) (Defra/ Environment Agency). Following procedure in the LCRM, a key element of a Preliminary Risk Assessment is development of a conceptual model. The conceptual model is described in terms of the contaminant sources, transport pathways and possible receptors that may be present, and the potential 'pollutant linkages' between them, as defined in the relevant legislation and guidance. These activities are described in CIRIA C552 as 'hazard identification'.

5.21. Based on the historical and current industrial land uses, the potential sources of contaminants and contaminants of concern have been identified. Initial conceptual site models (CSMs) have been developed whereby potential sources, pathways, receptors and potential pollutant linkages have been identified. Where a source, relevant pathway and receptor are present, a pollutant linkage is considered to exist, whereby there is a circumstance through which environmental harm could occur and a potential environmental liability is considered to exist.

5.22. The following CSM assumptions have been made with regards to construction:

- Management of waste materials on site will be in accordance with the Definition of Waste: Code of Practice (DoW CoP), which may require a Materials Management Plan (MMP) if material re-use is proposed on site.
- A robust CEMP will be developed and adopted during the construction works to manage any leaks, spills or potential dust generation.
- Risks to construction workers from contact with contaminated soils, groundwater or leachate (dermal or inhalation of dust/ vapours) will be addressed through Construction Design Management (CDM) process and potential Control of Substances Hazardous to Health (COSHH) risk assessments.
- Stockpiling of contaminated soils will be avoided where possible. Where stockpiling is necessary, the material will be segregated and stockpiled on impermeable hardstanding or sheeting and covered to prevent spreading. Risk assessment will then be undertaken to establish whether materials can be re-used or require treatment or off-site disposal.

5.23. Preliminary Qualitative Risk Assessments should be carried out at a subsequent project stage whereby for each potential pollutant linkage identified within the conceptual models, the potential risk is evaluated for ecological receptors, construction/maintenance workers and the final end users. This is based on the probability of the pollution event, and the severity it may have on site users and the environment. The Preliminary Qualitative Risk Assessments should be updated at subsequent project stages, as more information and understanding is obtained through the risk assessment process.

5.2.3 Assumptions and limitations

5.24. Site surveys were not undertaken as part of the desk-based assessment and confirmation of such desk study outputs would be achieved through a subsequent detailed field survey if required.

5.25. The outputs of the desk-based assessment were limited without the detailed data provided by an ALC or Soil Resources Survey but informed the need for future surveys and a Soil Management Plan, where required at a subsequent project stage.

5.3 Understanding of the baseline

5.3.1 Current and historical land use

5.26. The predominant current and historical industrial land uses for the components of the Lower Thames Reservoir Option are summarised in the following sections.

5.27. The Wraysbury Tunnel Connection and Raw Water Transfer Main Route Corridor are located on a developed brownfield site within the existing Iver WTW site with an electricity substation, pylons, WTW and gas governor located within 250m of the site. Historical industrial land use/ surface ground workings on site include cuttings, unspecified pit, brick works, unspecified works, refuse heap and WTW. Within 250m of the site, historical industrial land use includes railway sidings, cuttings, brickworks, tanks, unspecified tank, unspecified ground workings, refuse heap, electricity substation and landfills. A number of historical landfills are located to the south, the closest being 87m south, and two historical waste sites are located approximately 200m west/ northwest. The indicative site for the temporary construction compound for the new WTW is on Thorney Lane Landfill South historical landfill site which otherwise remains undeveloped.

5.28. The Indicative WTW Site is located on a developed brownfield site with historical industrial land use/ surface ground workings on site including railway/ tramway sidings and building, Iver Court brick works, unspecified wharf/ works, refuse heap and gravel pit. Historically, Iver Court Gravel Pit was also located on the site. Within 250m, historical industrial land uses include WTW, unspecified tank, brickworks, STW, unspecified pit, sand and ballast works, oil extracting mills, gravel pit, unspecified ground workings, refuse heap/ unspecified heap and landfills. Recent industrial land use includes hire services, breakers yard, recycling service, engineering services, repair and servicing, infrastructure and facilities and industrial features. A The Three Valleys Water historic landfill is located adjacent to the south of the site (although the logs for two boreholes located to the immediate east of the site refer to Made Ground of the Three Valleys Landfill) and the Thorney Land North historic landfill approximately 50m northwest of the site. The existing Iver WTW is located to the south of the Indicative WTW Site.

5.29. The Drinking Water Transfer Main Route Corridor, particularly the southern extent between Iver and New Denham but also around South Harefield, passes through developed land that has been heavily shaped by recent and historical surface ground workings, predominantly sand and gravel extraction, which has then been subsequently filled (landfill). The Drinking Water Transfer Main Route Corridor passes through or adjacent to a number of historical landfills as well as an Environment Agency Designated Contaminated Land site. There are several further historical landfills, authorised landfills and Environment Agency licensed waste sites located within 500m of the Drinking Water Transfer Main Route Corridor. Historical industrial land use/ surface ground working on site includes cuttings, unspecified tanks, WTW, brickworks, refuse heap, unspecified works, unspecified pits, electricity substation, STW, railway/ tramway sidings, unspecified wharf, nursery, sand and ballast works, sand pit, gravel pit, hospital and disused workings. Recent industrial land uses along the route include electricity substations, pylons/ masts, recycling businesses, STW and concrete company. To the north of Breakspear Road North, the Drinking Water Transfer Main Route Corridor is predominantly undeveloped and passes through agricultural fields.

5.30. The Harefield Service Reservoir Connection is within an existing facility and therefore within developed land. Battlers Wells Farm historic landfill site is located to the east of the site.

5.3.2 Designated geological sites

5.31. There is one geological SSSI within 2km of the Drinking Water Transfer Main Route Corridor, as shown on Figure 4.1 Statutory designated nature conservation sites. Harefield Pit SSSI provides a key section in the London Basin for a sequence through the Upper Chalk, Reading Beds and London Clay in the Reading Beds. This SSSI would not be impacted during construction and is not considered further in this appraisal.

5.32. No Regionally Important Geological Sites (RIGS) have been identified.

5.3.3 Geology

5.33. Table 5.2 and Table 5.3 summarise the identified bedrock and superficial deposits for the Lower Thames Reservoir Option components, with the anticipated ground conditions detailed in the following sections. The aquifer classification is also presented in the tables in accordance with the classifications in Table 5.4. Bedrock geology is shown on Figure 5.1 and superficial geology is shown on Figure 5.2.

Table 5.2: Identified bedrock

Component	Bedrock	Description	Aquifer classification
Wraysbury Tunnel Connection Raw Water Transfer Main Route Corridor Indicative WTW Site Drinking Water Transfer Main Route Corridor Harefield Service Reservoir Connection	London Clay Formation	Mainly comprises bioturbated or poorly laminated, blue-grey or grey-brown, slightly calcareous, silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay.	Unproductive
Drinking Water Transfer Main Route Corridor	Lambeth Group	Vertically and laterally variable sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate.	Secondary A
Drinking Water Transfer Main Route Corridor	Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated)	Seaford Chalk Formation: Firm white chalk with conspicuous semi-continuous nodular and tabular flint seams. Newhaven Chalk Formation: Soft to medium hard, smooth white chalks with numerous marl seams and flint bands, including abundant Zoophycos flints (notably at levels near the base).	Principal

Table 5.3: Identified superficial deposits

Component	Superficial deposits	Description	Aquifer classification
Wraysbury Tunnel Connection Raw Water Transfer Main Route Corridor Indicative WTW Site Drinking Water Transfer Main Route Corridor	Lynch Hill Gravel Member	Sand and gravel, with possible lenses of silt, clay or peat.	Principal
Raw Water Transfer Main Route Corridor Indicative WTW Site Drinking Water Transfer Main Route Corridor	Langley Silt Member	Varies from silt to clay, commonly yellow-brown and massively bedded.	Unproductive
Raw Water Transfer Main Route Corridor Indicative WTW Site Drinking Water Transfer Main Route Corridor	Alluvium	Unconsolidated clay, silt, sand and gravel deposited by a river, stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a mountain slope.	Secondary A
Drinking Water Transfer Main Route Corridor	Shepperton Gravel Member	Gravel with clay and sand.	Principal / Secondary A
Drinking Water Transfer Main Route Corridor	Boyn Hill Gravel Member	Sand and gravel, with possible lenses of silt, clay or peat.	Secondary A
Drinking Water Transfer Main Route Corridor	Taplow Gravel Member	Sand and gravel, with possible lenses of silt, clay or peat.	Secondary A

Component	Superficial deposits	Description	Aquifer classification
Drinking Water Transfer Main Route Corridor	Black Park Gravel Member	Sand and gravel, with possible lenses of silt, clay or peat.	Secondary A
Drinking Water Transfer Main Route Corridor	Gerrards Cross Gravel	Sand and gravel, locally with lenses of silt, clay or peat and organic material.	Secondary A

5.34. The anticipated ground conditions at the Wraysbury Tunnel Connection have been determined on a review of existing available ground investigation reports for the existing Iver WTW site and geological mapping. A thin layer of Made Ground is expected overlying the natural superficial Langley Silt Member and Lynch Hill Gravel Member. The bedrock London Clay Formation is expected at approximately 4.7m bgl and the Lambeth Group at around 33m bgl which overlies the White Chalk Subgroup. Shallow groundwater, within the top 2 to 5m bgl, is likely within the Lynch Hill Gravel Member.

5.35. A review of existing available BGS borehole logs and geological mapping for the Indicative WTW Site indicate the anticipated ground conditions to comprise Made Ground, approximately 2m thick, across most of the site overlying the natural superficial Langley Silt Member and Lynch Hill Gravel Member, with Alluvium potentially underlying the eastern extent of the site. The bedrock London Clay Formation is expected at approximately 5m bgl which overlies the Lambeth Group and White Chalk Subgroup. Shallow groundwater, within the top 2 to 5m bgl, is likely within the Lynch Hill Gravel Member.

5.36. The anticipated ground conditions underlying the Raw and Drinking Water Transfer Main Route Corridors have been determined based on geological mapping and existing BGS borehole logs. A variable thickness of Made Ground/ Worked Ground/ Infilled Ground is expected where recent and historical development has taken place. Superficial deposits comprising Alluvium, River Terrace Deposits and Glacial Sand and Gravel underlie most of the route from the existing Iver WTW to the A40. Langley Silt is also present at the southern extent of the route. Minimal superficial cover is mapped along the majority of the route north of the A40 overlying the bedrock London Clay Formation or Lambeth Group.

Table 5.4: Aquifer classification summary

Aquifer designation	Definition
Principal	Layers of rock or drift deposits with high fracture permeability, which allows them to store and procure high amounts of water.
Secondary A	Permeable layers that can support local water supplies and may contribute to base flow in rivers.
Secondary B	Lower permeability layers that may store and yield limited amounts of groundwater through fissures and openings.
Secondary (undifferentiated)	Not possible to be designated Secondary A or Secondary B status. Have minor value.
Unproductive	Largely unable to procure usable water and are unlikely to have any associated Groundwater Dependent Ecosystems.

Source: British Geological Society (2022)

5.3.4 Climatological data

5.37. Published climatological data shows a similar average annual rainfall across the Lower Thames Reservoir Option with rainfall slightly increasing from south (676mm) to north (689mm) and field capacity days[43] also increasing from south (139) to north (145).

5.3.5 Soil type and properties

5.3.5.1 Soil association and hydrology

5.38. Digitised soil type data was obtained from Cranfield University. The soil associations identified within the components of the Lower Thames Reservoir Option are presented in Table 5.5.

[43] The term 'field capacity days' refers to the number of days per year that agricultural land is at field capacity i.e. near saturation point.

Table 5.5: Identified soil associations

Component	Soil association	Description	Soil type hydrology
Drinking Water Transfer Main Route Corridor (near M25 and M40) Harefield Service Reservoir Connection	Essendon	Slowly permeable seasonally waterlogged coarse loamy over clayey soils. Associated with similar fine loamy over clayey and fine silty over clayey soils.	Slowly permeable, seasonally waterlogged soils over slowly permeable substrates with negligible storage capacity.
Wraysbury Tunnel Connection Raw Water Transfer Main Route Corridor Drinking Water Transfer Main Route Corridor (near M40)	Fladbury 3	Stoneless clayey, fine silty and fine loamy soils affected by groundwater. Flat land. Risk of flooding.	Soils seasonally waterlogged by fluctuating groundwater and with relatively slow lateral saturated conductivity.
Wraysbury Tunnel Connection Raw Water Transfer Main Route Corridor Indicative WTW Site Drinking Water Transfer Main Route Corridor (section south of M40)	Frome	Shallow calcareous and non-calcareous loamy soils over flint gravel affected by groundwater. Small areas of peat. Risk of flooding.	Soils seasonally waterlogged by fluctuating groundwater and with relatively rapid lateral saturated conductivity.
Wraysbury Tunnel Connection Raw Water Transfer Main Route Corridor Indicative WTW Site	Park Gate	Deep stoneless silty soils variably affected by groundwater.	Soils seasonally waterlogged by fluctuating groundwater and with relatively slow lateral saturated conductivity.

Component	Soil association	Description	Soil type hydrology
Drinking Water Transfer Main Route Corridor (section south of M40)			
Drinking Water Transfer Main Route Corridor (section north of M40) Harefield Service Reservoir Connection	Wickham 4	Slowly permeable seasonally waterlogged fine loamy over clayey and fine silty over clayey soils associated with similar clayey soils often with brown subsoils.	Slowly permeable, seasonally waterlogged soils over impermeable clay substrates with no storage capacity.

5.3.5.2 Soil organic carbon

5.39. Digitised average soil organic carbon data was obtained from Cranfield University, which presented carbon (%) at depths of 0-30cm, 30-100cm and 100-150cm for the Lower Thames Reservoir Option components.

5.40. Across the majority of the Lower Thames Reservoir Option, the soil organic carbon is very low to high within 0-30cm and very low to normal between 30cm and 150cm. No peaty soils were identified.

5.3.6 Agricultural land classification

5.41. Provisional ALC data and detailed ALC records (from soil surveys undertaken post-1988) along the transfer route corridors and the Indicative WTW Site is summarised as follows and shown on Figure 5.3: Agricultural Land Classification.

5.42. The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor and Indicative WTW Site (including the indicative site for temporary land-take required for construction) are within non-agricultural land according to the provisional ALC.

5.43. In its southern section, the Drinking Water Transfer Main Route Corridor is within non-agricultural land according to the provisional ALC with some areas classed as Grade 4 according to the detailed ALC. As the Drinking Water Transfer Main Route Corridor travels northwards, the provisional ALC becomes grade 3 with some areas of Grade 2, Subgrade 3a and 3b, according to the detailed ALC, in the New Denham area between the M25 and M40. Beyond the M40, the ALC is grade 3 according to the provisional ALC.

5.4 Appraisal outcomes

5.4.1 Potential impacts on function or quality of soil resource

5.44. The Lower Thames Reservoir Option would predominantly involve the installation of an underground water transfer pipeline, with the construction of a new WTW. To facilitate this, areas for temporary construction compounds would also be needed along the route, as well as for associated above ground infrastructure including the WTW. The transfer route corridors are situated in agricultural land predominantly classified as ALC Grade 3 (provisional), or in undeveloped non-agricultural land, and developed non-agricultural and urban land. The Indicative WTW Site is on non-agricultural land.

5.45. For the construction of the Raw Water Transfer Main and Drinking Water Transfer Main and any associated temporary compounds, it is not anticipated that there would be a permanent loss of topsoil/subsoil resource (from agricultural and non-agricultural land where present). It is anticipated that topsoil/subsoil strip would be conducted prior to trenching works to install the pipelines, or construction works for the compounds. These soils should be appropriately stockpiled and managed prior to reinstatement upon the completion of pipe installation for a particular section or the use of a temporary compound.

5.46. Should the pipeline be installed by trenchless techniques, topsoil/subsoil stripping is not anticipated. Topsoil/subsoil resource may not be present where the pipeline and temporary construction compounds are constructed in non-agricultural land/urban area or along a road, as it may have been previously stripped off and/or Made Ground is present.

5.47. Permanent land-take is anticipated within the Indicative WTW Site. Topsoil/subsoil strip is anticipated to precede construction works and would present a permanent loss of topsoil/subsoil resource (where present) from the stripped area. Soil resource from areas of permanent land-take should firstly be considered for reuse within the scheme, which may be areas of landscape planting or use as landscape bunds. If this is not viable and/or there is excess soil quantities, topsoil/subsoil may be sold for use in other construction projects or industries. It should be stated that landfilling of soil resource should be the last resort, as this would represent the permanent loss of stripped topsoil/subsoil resource from the scheme.

5.4.2 Potential impact on agricultural land classified as 'best and most versatile'

5.48. Based on the provisional ALC data, the Lower Thames Reservoir Option components are situated in Grade 3 land, non-agricultural land or urban land. Note that the provisional ALC data does not subdivide Grade 3 into 3a (representing best and most versatile land) and 3b (not presenting best and most versatile land). Where detailed ALC survey is available, agricultural land has been classified as Grade 2 and 3a.

5.49. Where detailed ALC survey is available, some areas of the Drinking Water Transfer Main Route Corridor have been classified as Grade 2 and 3a (in the New Denham area between the M25 and M40) and 4 (in the southern section of the route corridor immediately east of the M25).

5.50. Based on the available ALC data, the anticipated length (L) and area (A) of ALC classifications associated with the Raw Water Transfer Main, Indicative WTW Site and Raw Water Transfer Main, including indicative temporary compound areas are presented in Table 5.6 below. This high-level assessment assumes a working width of 50m following the alignment of the transfer route corridors. As the Wraysbury Tunnel Connection and Harefield Service Reservoir Connection are on existing operational sites, and not likely to result in loss of agricultural land, these have not been included in this table.

Table 5.6: Total landtake of agricultural land

Total ALC landtake	ALC grades									
	2		3		3a		Agricultural land total		Non-agricultural or urban	
	L (km)	A (ha)	L (km)	A (ha)	L (km)	A (ha)	L (km)	A (ha)	L (km)	A (ha)
Raw Water Transfer Main	0	0	0	0	0	0	0	0	0.3	1.5
Indicative WTW Site	0	0	0	0	0	0	0	0	4.8	17.6
Drinking Water Transfer Main	0.4	2	8.9	44.5	0.1	0.5	9.4	47.0	4.8	24.0
TOTAL	0.4	2	8.9	44.5	0.1	0.5	9.4	47.0	5.1	43.1

5.4.3 Potential land quality impacts (Conceptual Site Models)

5.51. Based on the identified historical and current land uses within the components of the Lower Thames Reservoir Option and within the surrounding areas, potential sources of contaminants and contaminants of concern have been identified. The potential sources, pathways and receptors of contamination have been identified in CSMs. These are summarised in the following sections for each component.

5.4.3.1 Wraysbury Tunnel Connection

5.52. Potential sources of contaminants and contaminants of concern identified for the Wraysbury Tunnel Connection are detailed in Table 5.7 below.

Table 5.7: Potential contaminants of concern – Wraysbury Tunnel Connection

Source	Potential contaminants of concern
Current on-site sources: Made Ground/ Infilled Ground • Made ground associated with historical uses of the site, including WTWs. • BGS mapping indicates infilled ground on site.	Heavy metals, inorganics, organics, total petroleum hydrocarbons (TPH) poly-aromatic hydrocarbons (PAHs), volatile and semi-volatile organic compounds (SVOCs and VOCs), asbestos containing material (ACM), microbial contaminants (e.g., pathogens), PFAS.
Historic on-site sources: Industrial land uses • Cuttings, unspecified pit, brick works, unspecified works, refuse heap, WTW, historical tank (unspecified), historical waste sites.	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs and VOCs, ACM. Elevated concentrations of carbon dioxide (CO_2) and methane (CH_4), and depleted concentrations of oxygen (O_2).
Current off-site sources: Light industrial land uses • Electricity substation, pylons, Iver WTW, gas governor. • Thorney Farm, Iver landfill (87m south). Inert, commercial and household waste.	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs / VOCs, Polychlorinated biphenyl (PCBs), ACM, microbial contaminants (e.g., pathogens). Elevated concentrations of carbon dioxide (CO_2) and methane (CH_4), and depleted concentrations of oxygen (O_2).

Source	Potential contaminants of concern
Historic off-site sources: Industrial land uses • Railway sidings, cuttings, brick works, unspecified pit, unspecified tank, unspecified ground workings, refuse heap, electricity substation, landfills with several historical tanks.	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs / VOCs, PCBs.
Pollution incident • Significant incident (category 2) to water recorded in 2015. The impact was recorded as inorganic chemicals / product.	Heavy metals, nitrates, nitrites, fluoride

5.53. Sources, pathways and receptors for the Connection into the raw water network are summarised below.

On-site sources

- S1: Potentially contaminated made ground / infilled ground associated with historical and current on and offsite land uses (WTWs, tanks, offsite landfill, reworked ground, brick works, cuttings, railway sidings, substation, unspecified pit and ground workings, refuse heap)
- S2: Ground gas generation from made ground and infilling

Off-site sources

- S3: Ground gas generation from made ground and infilling of Thorney Park landfill (87m south)

Pathways

- P1: Human uptake pathways

  Direct soil and dust ingestion

  Skin contact with soils and dust

  Inhalation of outdoor vapours and ground gas
- P2: Horizontal and vertical migration of any volatile vapours resulting from potential on/off site fuel spillages and/or made ground
- P3: Horizontal and vertical migration of any ground gas resulting from potential on/off site infilled ground and/or landfills
- P4: Horizontal and vertical migration of contaminants in the unsaturated zone
- P5: Horizontal and vertical migration of contaminants in the saturated zone
- P6: Migration of contaminants along engineered preferential pathways (shaft, deep tunnel, buried pipelines and service trenches)

- P7: Surface run-off along roads, pavements and other surfaces

Receptors

- R1: Construction workers
- R2: Final end users (maintenance workers)
- R3: Final end users (off site residential / commercial / recreational)
- R4: Groundwater in the Lynch Hill Gravel (Principal superficial aquifer)
- R5: Surface water features (Colne Brook and Farlows Lakes to the east)
- R6: Buried structures and infrastructure

5.4.3.2 Indicative WTW Site

5.54. Potential sources of contaminants and contaminants of concern identified for the Indicative WTW Site are detailed in Table 5.8 below.

Table 5.8: Potential contaminants of concern – Indicative WTW Site

Source	Potential contaminants of concern
Current on-site sources: Made Ground/ infilled ground • Iver Court Gravel Pit (NW) Industrial on-site uses • Recycling services, repair and servicing works, engineering services, electricity substations.	Heavy metals, inorganics, organics, total petroleum hydrocarbons (TPH) poly-aromatic hydrocarbons (PAHs), volatile and semi-volatile organic compounds (SVOCs and VOCs) and asbestos containing material (ACM). Elevated concentrations of carbon dioxide (CO_2) and methane (CH_4), and depleted concentrations of oxygen (O_2). Heavy metals, inorganics, organics, TPH, PAHs, SVOCs, VOCs
Historic on-site sources: Industrial land uses • Sewage works, brick works, refuse heap, ground workings, railway and tram sidings, water treatment works, unspecified tanks, sludge beds, oil extracting mills. Pollution incidents (significant (category 2) land impact) – 2004	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs, VOCs

Source	Potential contaminants of concern
• Waste materials from vehicles and vehicle parts.	Heavy metals, inorganics, organics, TPH, PAHs
Current off-site sources: Landfills • Three Valleys Water (4m S) • Thorney Lane North (49m NW) • Thorney Lane Landfill (182m W)	Heavy metals, inorganics, organics, total petroleum hydrocarbons (TPH) poly-aromatic hydrocarbons (PAHs), volatile and semi-volatile organic compounds (SVOCs and VOCs) and asbestos containing material (ACM) and elevated concentrations of carbon dioxide (CO_2) and methane (CH_4), and depleted concentrations of oxygen (O_2).
Industrial land uses • Sewage works, haulage and distribution, unspecified works active discharge consent (trade discharge to Grand Union Canal), M25 motorway.	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs, VOCs

5.55. Sources, pathways and receptors for the Indicative WTW Site are summarised below:

On-site sources

- S1: Potentially contaminated made ground associated with historical and current land uses (substation, scrap metal merchants, vehicle repair, recycling centres, sewage works, railway sidings)
- S2: Potentially infilled ground associated with Iver Gravel Pit and Three Valleys Water landfill
- S3: Ground gas generation from made ground and infilling of Iver Gravel Pit (and offsite landfills).

Off-site sources

- S4: Industrial land uses (sewage works, refuse heap, railway and tram infrastructure, oil extracting mills, unspecified tanks)
- S5: Pollution incident to land (significant risk) in 2004.
- S6: Adjacent historical landfill sites (Three Valleys Water (4m), Thorney Lane North (49m), Thorney Lane Landfill (182m)) and associated ground gas risk.

Pathways

- P1: Human uptake pathways
  - Direct soil and dust ingestion (outdoors)
  - Skin contact with soils and dust

  - Inhalation of outdoor vapours and indoor gas/ vapours
- P2: Horizontal and vertical migration of any volatile vapours resulting from potential on/off site fuel spillages and/or made ground / landfills
- P3: Horizontal and vertical migration of any ground gas resulting from potential on/off site infilled gravel pits and/or landfills
- P4: Horizontal and vertical migration of contaminants in the unsaturated zone
- P5: Horizontal and vertical migration of contaminants in the saturated zone
- P6: Migration of contaminants along engineered preferential pathways (piles, buried pipelines and service trenches)
- P7: Surface run-off along roads, pavements and other surfaces

Receptors

- R1: Construction workers
- R2: Final end users (WTW site staff)
- R3: Final end users (off site residential / commercial / recreational)
- R4: Groundwater in the Lynch Hill Gravel (Principal Superficial aquifer)
- R5: Groundwater in the Alluvium (Secondary A aquifer)
- R6: Surface water features (Grand Union Canal and Colne Brook)
- R7: Buried Structures and infrastructure

5.4.3.3 Raw and Drinking Water Transfer Main Route Corridors

5.56. Potential contaminants and contaminants of concern identified for the Raw and Drinking Water Transfer Main Route Corridors detailed in Table 5.9 below.

Table 5.9: Potential contaminants of concern – Raw and Drinking Water Transfer Main Routes Corridors

Source	Potential contaminants of concern
Current on-site sources: Made Ground/ Infilled Ground/ Landscaped Ground • Surface ground workings	Heavy metals, inorganics, organics, total petroleum hydrocarbons (TPH) poly-aromatic hydrocarbons (PAHs), volatile and semi-volatile organic compounds (SVOCs and VOCs) and asbestos containing materials (ACMs). Elevated concentrations of carbon dioxide (CO_2) and methane (CH_4), and depleted concentrations of oxygen (O_2).
Industrial on-site uses • Substations, pylons/ masts/ gantries, recycling business, sewage works, concrete products, M25, A40, railway line.	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs, VOCs, PCBs.
Historic on-site sources: Historical landfill • Woodlands Park • Woodlands Park No. 2 • Slough Road A • Dews Farm • Park Lodge Farm	Heavy metals, inorganics, organics, total petroleum hydrocarbons (TPH) poly-aromatic hydrocarbons (PAHs), volatile and semi-volatile organic compounds (SVOCs and VOCs) and asbestos containing material (ACM) and elevated concentrations of carbon dioxide (CO_2) and methane (CH_4), and depleted concentrations of oxygen (O_2).
Local Authority Site Determined as Contaminated Land (EPA 1990): • Park Lodge Farm Landfill (although GIS object ID refers to New Years Green Landfill Site).	Heavy metals, inorganics, organics, TPH PAHs, SVOCs and VOCs, ACM and elevated concentrations of CO_2 and CH_4, and depleted concentrations of O_2.
Industrial land uses • WTW, unspecified tanks, historical tanks, STW, cuttings, refuse heaps, disused workings, brickworks, unspecified works, unspecified pit, electricity substation, railway sidings/ tramway sidings, unspecified wharf, nursery, sand and ballast works, sand and gravel pits, hospital.	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs, VOCs.

Source	Potential contaminants of concern
Pollution incidents • Significant incidents (Category 2) to land recorded in 2004 and 2017. The pollutant was recorded as vehicles and vehicle parts (2004) and not identified (2017).	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs, VOCs
Current off-site sources: Historical landfills • Thorney Farm • Three Valleys Water • Thorney Lane North • Palmers Moor Farm • Lane North of Iver Lane • Elks Meadows Estate • Slough Road B • New Year Farm • Land off Harvil Road • Breakspear Road North • Battlers Wells Farm Authorised landfill: • Summerleaze	Heavy metals, inorganics, organics, TPH PAHs, SVOCs and VOCs, ACM and elevated concentrations of CO_2 and CH_4, and depleted concentrations of O_2.
Licensed Waste Sites: • Metal recycling sites	Heavy metals, inorganics, organics, TPH, PAHs, SVOCs, VOCs.

5.57. Sources, pathways and receptors for the Raw and Drinking Water Transfer Main Route Corridors are summarised below.

On-site sources

- S1: Potentially contaminated Made Ground associated with historical and current land uses (substations, recycling business, WTW, STW, tanks, concrete products, M25, A40, railway line, railway/ tramway sidings, brickworks)
- S2: Potentially Infilled Ground/ Landscaped Ground/ Worked Ground associated with historical surface ground workings (unspecified pit, sand and ballast works, sand and gravel pits, cuttings, unspecified works, disused workings) and historical landfill (Woodlands Park, Woodland Park No. 2, Slough Road A, Dews Farm and Park Lodge Farm)

- S3: Contaminants and ground gas generation associated with LA Site Determined as Contaminated Land (EPA 1990) – Park Lodge Farm (although GIS object ID refers to New Years Green Landfill Site)
- S4: Pollution incident (significant) to land 2004 and 2017
- S5: Ground gas generation from historical landfill on-site (Woodlands Park, Woodland Park No. 2, Slough Road A, Dews Farm and Park Lodge Farm) and off-site landfills
- S6: Ground gas generation associated with Alluvium

Off-site sources

- S7: Adjacent historical landfill sites – Thorney Farm (110m S), Three Valleys Water (250-450m W), Thorney Lane North (190-310m W), Palmers Moor Farm (<10m-100m W), Land North of Iver Lane (<20m E), Elk Meadows Estate (<20m E), Slough Road B (90-250m E), New Years Farm (320m NE), Land off Harvil Road (480m SW), Breakspear Road North (100-150m E), Battlers Wells Farm (175m E) and authorised landfill site – Summerleaze (<10m N) and associated ground gas risk
- S8: Contaminants associated with Environment Agency Licensed Waste Sites (metal recycling)

Pathways

- P1: Human uptake pathways
  - Direct soil and dust ingestion (outdoors)
  - Skin contact with soils and dust
  - Inhalation of outdoor vapours
- P2: Horizontal and vertical migration of any volatile vapours resulting from potential on/ off site fuel spillages and/ or made ground/ landfills
- P3: Horizontal and vertical migration of any ground gas resulting from potential on/off site infilled ground/ landscaped ground and/or landfills
- P4: Horizontal and vertical migration of contaminants in the unsaturated zone
- P5: Horizontal and vertical migration of contaminants in the saturated zone
- P6: Migration of contaminants along engineered preferential pathways (buried pipeline and service trenches)
- P7: Surface run-off along roads, pavements and other surfaces

Receptors

- R1: Construction workers
- R2: Final end users (maintenance workers)
- R3: Adjacent site users (off site residential / commercial / recreational)
- R4: Groundwater in the Lynch Hill Gravel Member/ Shepperton Gravel Member/ Sand and Gravel of Uncertain Age and Origin (Principal Superficial Aquifers),

Alluvium/ Boyn Hill Gravel Member/ Taplow Gravel Member/ Black Park Gravel Member (Secondary A Superficial aquifers)

- R5: Groundwater in the Lambeth Group (Secondary A Bedrock Aquifer with a small section of Principal Bedrock Aquifer)
- R6: Surface water features (Grand Union Canal, Colne Brook, Alder Bourne, River Colne, Fray's River, un-named watercourses and drainage ditches)
- R7: Source Protection Zone II (Outer Protection) or Zone III (Total Catchment)
- R8: Buried Structures and infrastructure i.e. pipeline material

5.4.3.4 Main identified impacts to land quality

5.58. It is considered for the Indicative WTW Site and the Wraysbury Tunnel Connection the risks identified in the CSM could be adequately mitigated using the process in LCRM.

5.59. There may be significant negative impacts to land quality and human health where the Raw and Drinking Water Transfer Main Route Corridors pass through existing landfill sites, particularly in the area of the Environment Agency Designated Contaminated Land site. Impacts may include creating preferential pathways for contaminants to groundwater or surface water as well for ground gas away from existing landfills, impacts on human health due to direct contact with contaminated material and inhalation of landfill gas, production of waste requiring treatment and/ or removal. Temporary impacts during construction would include production of potentially contaminated dust from excavation of waste.

5.60. It is currently unknown if there are any proposals for remediation of the Environment Agency Designated Contaminated Land site, however, installation of the Drinking Water Transfer Main across this area may inhibit future works to improve the land quality in the area. This would need to be discussed with the local authority at a subsequent project stage.

5.5 Recommended mitigation

5.5.1 Soils

5.61. Recommended measures to mitigate potential issues with regards to soils are as follows:

- A detailed soil survey (soil resource survey and/or agricultural land classification survey) to confirm the soil resources present, maps the distribution of soil types and establish the land grade (if ALC survey is chosen), and informs a soil management plan.

- A soil management plan:
  - Provides guidance for the stripping, stockpiling, maintenance, reinstatement and aftercare of the soil resources in accordance with Defra[44] and British Standards soil guidance[45] [46]; and
  - The soil management plan should include pre-construction planning, site preparation, field tests, and the methodology, monitoring and guidance for soil stripping, stockpiling, reinstatement and aftercare.

5.5.2 Land quality

5.62. Recommended measures to mitigate potential issues with regards to land quality are as follows:

- The assessment and possibly the remediation of land contamination would be a requirement of the planning process to ensure that the site is suitable for its proposed use under the NPPF. The LCRM guidance details the steps that would need to be followed as the scheme is progressed through the development and planning process. These steps include the production of a Preliminary Risk Assessment and completion of an appropriate ground investigation, tiered stages of risk assessments together with an assessment of unacceptable pollutant linkages. Where such linkages are found then a remediation options appraisal and strategy will be produced.
- Any remediation works required to manage contamination risk will be agreed with the relevant Local Planning Authority and Environment Agency. Remediation will need to be completed and verified before completion of the project.
- Risks during construction will also be mitigated through use of a CEMP which details the measures that will need to be taken to ensure that construction works themselves do not introduce new contamination into the site; and also how to manage pre-existing contamination that could be encountered. Together the CEMP and LRCM process comprise embedded mitigation measures that deal with temporary and permanent effects respectively.

[44] Department for Environment, Food & Rural Affairs. (2009) Construction Code of Practice for the Sustainable Use of Soils on Construction Sites. London: Defra.
[45] British Standards Institution. (2015) BS 3882:2015 Specification for topsoil. London: BSI Standards Limited.
[46] British Standards Institution. (2013) BS 8601:2013 Specification for subsoil and requirements for use. London: BSI Standards Limited.

5.6 Summary of main findings and recommendations for future technical work

5.6.1 Soil resources

5.63. The Lower Thames Reservoir Option is within developed and undeveloped land. The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor and Indicative WTW Site are within non-agricultural land and the Drinking Water Transfer Main Route Corridor crosses agricultural fields, non-agricultural land and urbanised areas.

5.64. Soil along the southern half of the Drinking Water Transfer Main Route Corridor is anticipated to predominantly be comprised of a shallow calcareous and non-calcareous loamy soil over flint gravel or a deep stoneless silty soil, which are seasonally waterlogged by fluctuating groundwater. In the northern half of the Drinking Water Transfer Main Route Corridor, soil is anticipated to predominantly be comprised of a slowly permeable seasonally waterlogged loamy over clayey or silty over clayey soil.

5.65. Ground disturbance in the form of topsoil/subsoil stripping can adversely affect soil quality during the construction process through inappropriate handling during stripping, stockpiling and reinstatement. This can impact soil function which could ultimately affect crop/vegetation growth.

5.66. For temporary works, it is anticipated that the majority of stripped topsoil/subsoil resource would be reinstated. A volume of subsoil may be permanently lost from the volume of strip that is associated with space occupied by underground pipelines. These soils should be appropriately stockpiled and managed prior to reinstatement upon the completion of pipe installation for a particular section.

5.67. For permanent land-take, topsoil/subsoil strip is anticipated to precede construction works and would present a permanent loss of topsoil/subsoil resource (where present) from the stripped area.

5.68. Soil resource from areas where reinstatement is not possible should firstly be considered for reuse within the scheme. If this is not viable and/or there are excess soil quantities, topsoil/subsoil may be sold for use in other construction projects or industries. It should be stated that landfilling of soil resource should be the last resort, as this would represent the permanent loss of topsoil/subsoil resource from the stripped area.

5.69. Based on the provisional ALC data, the Lower Thames Reservoir Option components are situated in Grade 3 land, non-agricultural land or urban land. Note that the provisional ALC data does not subdivide Grade 3 into 3a (representing best and most versatile land) and 3b (not presenting best and most versatile land).

5.70. Where detailed ALC survey is available, some areas of the Drinking Water Transfer Main Route Corridor have been classified as Grade 2 and 3a (in the New Denham area between the M25 and M40) and 4 (in the southern section of the route corridor immediately east of the M25).

5.71. It is recommended that a detailed soil survey (soil resource survey and/or ALC survey) is undertaken at a subsequent project stage to confirm soil resources present. The findings should inform a soil management plan which should provide guidance for stripping, stockpiling, maintenance, reinstatement and after care of soil resources. During construction activities, it is recommended that a qualified soil scientist undertake on-site monitoring visits to ensure the best practice and guidance as stated in the soil management plan is followed.

5.6.2 Land quality

5.72. Based on the identified historical and current industrial land uses within the components of the Lower Thames Reservoir Option and within the surrounding areas, there is the potential for contamination to be present within the ground and groundwater as well as potential ground gas, particularly within the southern extent of the Drinking Water Transfer Main Route Corridor where the route passes through or adjacent to a number of historical landfill sites as well as through an Environment Agency Designated Contaminated Land site.

5.73. It is considered that the risks identified in the Conceptual Site Models for the Indicative WTW Site and the Wraysbury Tunnel Connection would be adequately mitigated using the process in LCRM. There may be significant negative impacts to land quality and human health where the Water Transfer Main route passes through existing landfill sites, particularly in the area of the Environment Agency Designated Contaminated Land site. Impacts may include creating preferential pathways for contaminants to groundwater or surface water as well for ground gas away from existing landfills, impacts on human health due to direct contact with contaminated material and inhalation of landfill gas, production of waste requiring treatment and/ or removal. Temporary impacts during construction would include production of potentially contaminated dust from excavation of waste.

5.74. Consultation would be required with the landowner, local authorities and the Environment Agency, at a subsequent project stage, with regard to potential routing through landfill and associated risks. Design details of the historical landfill should be requested from the Local Authority (if these exist) to enable further assessments to be carried out to ensure that risks from the pipeline acting as an additional pathway to human health and controlled waters are mitigated. In addition, early consultation should be initiated to determine options for discharge/ treatment of potentially contaminated groundwater.

5.75. Where the Drinking Water Transfer Main Route Corridor passes through landfill sites, the feasibility of undertaking ground investigation should be considered. Additional health and safety/ chemical and geotechnical testing and aquifer protection measures will be required along with other requirements for drilling and/ or construction on a site where landfilling is present.

5.76. Once further assessments have been carried out at a subsequent project stage, detailed geotechnical and geo-environmental Preliminary Risk Assessments should be completed, and the envisaged land quality mitigation measures reviewed, to understand whether these are sufficient to mitigate the potential impacts to acceptable levels and therefore confirm the feasibility or not of the preferred route. As part of the Preliminary Risk Assessments, ground investigation aims would be determined.

5.77. A site-specific geotechnical and geo-environmental ground investigation would be the key mitigation in reducing the uncertainty associated with the majority of the identified risks for the preferred route. It is envisaged that a preliminary phase of ground investigation works would provide initial information to assist in the development and delivery of the next project stage which includes finalised feasibility, pre-planning investigations and planning applications. A detailed phase of ground investigation would be required at a later stage in the project delivery.

5.78. Management of waste materials on site would be in accordance with the DoW CoP which may require a MMP if material re-use is proposed on site. Further risk assessment would be required at subsequent project stages to determine the materials suitability for use. Some waste materials may not be suitable for reuse and will require disposal to landfill.

5.79. Consideration would need to be given to the potential requirement for pre-treatment of excavated material should existing landfill material be excavated as part of the construction works requiring disposal.

6 Water

6.1 Introduction

6.1. This chapter presents a desk-based assessment undertaken to identify potential impacts on water from the transfer route corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to establish the baseline associated with the Lower Thames Reservoir Option, identify constraints and opportunities, and identify the issues that may require further investigation at a subsequent project stage.

6.2. The need to consider water is driven by national planning policy (draft NPS for Water Resource Infrastructure[20] (Section 4.15, Water quality and resources and 4.8, Flood Risk) and NPPF[21] (Section 14, Meeting the challenge of climate change, flooding and coastal change), paragraphs 159-169, and Section 15, Conserving and enhancing the natural environment, paragraph 174).

6.3. Technical Supporting Document B3, Water Framework Directive Compliance Assessment contains the results of the WFD assessment undertaken for the Lower Thames Reservoir Option. This has formed the basis of the aquatic environment appraisal. Consideration has been given to groundwater in Section 6.3 and a desk-based assessment on flood risk is presented in Section 6.4.

6.2 Aquatic environment appraisal

6.4. As described in Section 3.2, Technical Supporting Document B3, Water Framework Directive Compliance Assessment, contains the results of the WFD assessment undertaken for the Lower Thames Reservoir Option.

6.5. The Level 1 basic screening assessment was completed to determine which activities have the potential to impact the surface water bodies. The Level 1 – basic screening assessment identified thirteen water bodies in relation to the Lower Thames Reservoir Option: six surface water rivers, two lakes, two canals and three groundwater bodies.

6.6. One surface water river (the Thames (Cookham to Egham)) and two lakes (Queen Mother Reservoir and Wraysbury Reservoir) had an impact score greater than 1 due to new or increased abstraction. These water bodies were carried through to the Level 2 – detailed screening assessment.

6.7. The remaining five surface water rivers, two canals and three groundwater bodies assessed as part of the Level 1 assessment were not determined to have an impact score greater than 1 and were scoped out of further assessment.

6.8. The results of the Level 2 assessment are supported by the more detailed appraisal that was undertaken as part of the SESRO SRO and documented in the SESRO EAR. As noted in Section 2.1, SESRO is a pre-requisite for the Lower Thames Reservoir Option because without SESRO the Lower Thames Reservoir Option would leave Thames Water with a reduced volume of strategic storage.

6.9. Based on currently available information, the majority of identified effects on the aquatic environment are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity of affected reaches.

6.10. Flow changes within the River Thames as a result of SESRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected reaches.

6.11. However, the potential impacts associated with the new or increased surface water abstraction would not be of a magnitude to result in the potential to deteriorate the WFD elements of the Thames (Cookham to Egham), Queen Mother Reservoir and Wraysbury Reservoir or prevent them from the attainment of Good status in the future.

6.12. The Lower Thames Reservoir Option is therefore considered to be compliant with the WFD at this stage.

6.3 Groundwater

6.13. Bedrock geology and superficial deposits are provided in Section 5.3.3, with the Lower Thames Reservoir Option affecting Principal, Secondary A, Secondary B and Unproductive aquifers. Risks to groundwater during construction were considered in Section 5.4.3.

6.14. Source Protection Zones (SPZ) are defined by the Environment Agency around large groundwater abstractions. They are zones which show the level of risk to the source from contamination, from any activity in these areas. Construction within SPZs requires additional assessment and potentially mitigation to ensure no adverse impacts on public water supplies. To the north of Ickenham, the Drinking Water Transfer Main Route Corridor passes through areas defined as SPZ1 and SPZ2. The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor and Indicative WTW Site are not located within SPZs. Prior to construction, a hydrogeological risk assessment would be required for works within SPZ1 or 2.

6.15. Groundwater Dependent Terrestrial Ecosystems (GWDTE), like wetlands, flushes and fens are environments reliant upon groundwater for their continued success and health. This makes them particularly sensitive to hydrological and ecological changes caused as a result of new developments that disrupt existing groundwater flow, such as pipelines. Kingcup Meadows & Oldhouse Wood SSSI, Denham Lock Wood SSSI, Fray's Farm Meadows SSSI and Ruislip Woods SSSI are GWDTE that would potentially be impacted during construction of the Drinking Water Transfer Main. However, as stated in Section 4.2.3.4, and as described in Section 2.3, below ground structures would be constructed such that they would not form a preferential pathway for pollution to groundwater or cause alterations in groundwater flow or levels.

6.16. Groundwater has been considered as part of the WFD assessment with three WFD groundwater bodies being considered at the Level 1 – basic screening assessment. None of the three groundwater bodies were carried through to the Level 2 – detailed screening assessment as the activities associated with the option did not result in an impact score greater than 1. This is a result of the embedded mitigation and design assumptions. Namely:

- The pipe depth will not exceed be 8 m below existing ground level;
- Any below ground structures will be constructed to ensure no impact to groundwater flow or quality; and,
- Any shafts or retaining walls which extend further than 8 m below existing ground level are in excess of 500 m from any GWDTEs.

6.17. This has resulted in no further requirements for assessment of groundwater flow under the WFD at this stage. If any of the design assumptions or mitigation measures change, this will be reconsidered at subsequent project stages.

6.4 Flood risk

6.4.1 Methodology

6.18. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within 1km. Where impacts could extend beyond 1km, the study area was extended.

6.19. The watercourses included in the study area are the River Colne, River Misbourne and River Pinn and the following tributaries of the River Colne, as shown on Figure 6.1: Flood risk and main river network interactions.

- Frays River – An offshoot of the Grand Union Canal, approximately 8km long watercourse flowing north to south from the A40 to the M4 where the watercourse joins the River Colne.

- Alder Brook/Alder Bourne – Approximately 7km watercourse that flows east to west from Pickeridge Wood to the M25 where it joins the Colne Brook.
- The Colne Brook – Approximately 13km watercourse that flows north to south from the M25 at Uxbridge to the River Thames at Egham.

6.20. Table 6.1 outlines the baseline data sources which were collated and considered in the desk-based assessment.

Table 6.1: Sources of information (flood risk)

Data collected	Source
Surface Water	
Detailed river network	Environment Agency
Groundwater	
Geology of bedrock and superficial deposits	British Geological Society
Aquifer properties	British Geological Society
Interactive groundwater vulnerability map	Defra
Flood risk	
Flood map for planning	Environment Agency
Historical flooding incidents	Lead local flood authorities, Environment Agency
Long term flood risk information (surface water, river flooding)	Environment Agency
Flood risk from reservoirs	Environment Agency
Flood protection infrastructure/ measures	Environment Agency
Lower River Colne modelling and mapping study	Environment Agency
Upper River Colne modelling and mapping study	Environment Agency
Topography	
LiDAR data	Environment Agency

6.21. The assessment on flood risk was limited by the availability of the data in the study area. The quality of the model results available for the study area also limited the understanding on the risk from flooding. The assumptions inherent in the models used to produce flood risk information, such as flood extents, flood depths, levels and flows followed through to the model outputs used for the study. These assumptions needed to be understood and considered when assessing the data.

6.22. Historical records on flooding and anecdotal information can be limited and it cannot be assumed that where there is no historical information available, flooding has not occurred in the past. Likewise photographs and records of flooding may not always capture the peak of a flood event or give a clear indication on the cause of flooding, and this was considered when reviewing the information.

6.23. When considering the impacts of climate change there are assumptions in the projections used and how this translates to an impact on peak flow, sea level rise and rainfall rates.

6.4.2 Understanding of the baseline

6.4.2.1 Environment Agency Flood Zones

6.24. The Environment Agency provides the 'Flood Map for Planning'[47] which displays the Environment Agency Flood Zones as defined in Table 6.2. It should be noted that the boundaries of the Flood Zones are indicative and do not consider any man-made structures such as railway embankments, roads and flood defences.

Table 6.2: Flood Zone descriptions

Flood Zone	Description	Annual Exceedance Probability
Flood Zone 1 – Low Probability	Land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year.	<0.1% sea or river flooding
Flood Zone 2 – Medium Probability	Land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding, or between a 1 in 200 and 1 in 1000 annual probability of sea flooding in any year.	1% - 0.1% river flooding 0.5% - 0.1% sea flooding

[47] Environment Agency Flood Map for Planning. Available at: https://flood-map-for-planning.service.gov.uk/ [Accessed May 2022]

Flood Zone	Description	Annual Exceedance Probability
Flood Zone 3a – High Probability	Land assessed as having a 1 in 100 or greater annual probability of river flooding, or a 1 in 200 or greater annual probability of flooding from the sea in any year.	>1% river flooding >0.5% sea flooding
Flood Zone 3b – Functional Floodplain	Land where water has to flow or be stored.	Identified in the Strategic Flood Risk Assessment as the 5% AEP or Flood Zone 3a where detailed modelling is not available.

Source: Environment Agency (2022) Flood Warning Information Service: Long term flood risk information.

6.25. Table 6.3 provides a summary of the fluvial flood risk for each of the components of the Lower Thames Reservoir Option according to the Environment Agency's Flood Map for Planning[47].

Table 6.3: Fluvial flood risk from Environment Agency Flood Map for Planning

Component	Fluvial Flood Risk
Wraysbury Tunnel Connection Raw Water Transfer Main Route Corridor	The Wraysbury Tunnel Connection and Raw Water Transfer Main Route Corridor are located within Flood Zone 1 and are therefore considered to be at low risk from fluvial flooding.
Indicative WTW Site	The Indicative WTW Site is not located within the Environment Agency's Flood Zone 3 and 2 and is considered to be in Flood Zone 1. Flood Zone 3 and 2 in this context is based on both detailed modelled data and historical flood data.
Drinking Water Transfer Main Route Corridor	The main sources of fluvial flood risk along the Drinking Water Transfer Main Route Corridor are the River Colne and its associated tributaries; Fray's River, River Misbourne and Alder Bourne. The most noticeable interaction with Flood Zone 3 is where the Drinking Water Transfer Main Route Corridor crosses any watercourses along the route corridor.
Harefield Service Reservoir Connection	The Harefield Service Reservoir Connection is located within Flood Zone 1 and therefore considered to be at low risk from fluvial flooding.

6.4.2.2 Historical flooding

6.26. The Environment Agency has provided information on recorded historical flood events in the area. Historical flooding has been identified in the area between the years of 1977 to 2014, the most noticeable occurring along the River Pinn with events being recorded in 1977, 1987 and 1988.

6.27. A review of online news and anecdotal evidence has highlighted examples of several key flood events in Uxbridge (2020), Harefield (2014) Rickmansworth (2021) and Watford (2021).

6.28. Table 6.4 provides a summary of historical flooding for each of the components of the Lower Thames Reservoir Option.

Table 6.4: Recorded historical flooding

Component	Historical flooding
Wraysbury Tunnel Connection Raw Water Transfer Main Route Corridor	There is no recorded flood history from the Environment Agency.
Indicative WTW Site	The online evidence does not identify instances of flooding at the Indicative WTW Site or the respective reach of River Colne but does identify periods of fluvial and pluvial flood risk in the wider catchment. There have been no anecdotal reports of flooding at the Indicative WTW Site.
Drinking Water Transfer Main Route Corridor	The online evidence does not identify instances of flooding within the route corridor but does identify periods of fluvial and pluvial flood risk in the wider catchment. There have been no anecdotal reports of flooding for the Drinking Water Transfer Main Route Corridor.
Harefield Service Reservoir Connection	There is no recorded flood history from the Environment Agency at the Harefield Service Reservoir Connection. There have been no anecdotal reports of flooding for Harefield Service Reservoir Connection.

6.4.2.3 Modelled river levels

6.29. Modelled water levels from the Lower and Upper River Colne have been obtained from the Environment Agency.

6.30. Mott MacDonald was commissioned in 2012 to undertake the 1D-2D Lower Colne modelling and mapping study. The aim of the study was to create a revised calibrated hydraulic model of the River Colne downstream of Denham functioning up to the 0.1% annual probability event (AEP).

6.31. The modelled flood extents include the 50% AEP, 20% AEP, 10% AEP, 5%AEP, 2%AEP, 1%AEP, 1%AEP+25%CC and 0.1%AEP events for the baseline scenario.

6.32. Halcrow was commissioned in 2010 to undertake the 1D-2D Upper Colne Strategic Flood Risk Management (SFRM) study. The principal objective of the study was to develop a robust hydrological and hydraulic model for the Upper Colne and its tributaries. The key outputs were peak channel water levels and flood maps, which are to be used in strategy studies including National Flood Risk Assessment (NaFRA).

6.33. The modelled flood extents include the 50% AEP, 20% AEP, 10% AEP, 5%AEP, 2%AEP, 1%AEP, 1%AEP+25%CC, 0.5% AEP and 0.1%AEP events for the baseline scenario.

6.34. The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor and Indicative WTW Site are not shown to be at risk of fluvial flooding from the Lower Colne for the design events modelled.

6.35. The Drinking Water Transfer Main Route Corridor is at risk of fluvial flooding where it crosses watercourses. This is described in more detail in Section 6.4.3.2.

6.4.2.4 Surface water flood risk

6.36. Surface water (pluvial) flooding happens when rainwater does not drain away through the normal drainage systems or soak into the ground, but ponds or flows over the ground instead. Managing the risk of flooding from surface water is the responsibility of Lead Local Flood Authorities (LLFAs). In this instance, the LLFAs are Buckinghamshire Council and London Borough of Hillingdon.

6.37. Each council has a published Strategic Flood Risk Assessment (SFRA) which examines different aspects of flooding including surface water flooding. All councils have requirements to assess, management and mitigate surface water flooding in respect to new development.

6.38. The Environment Agency's 'Long term flood risk' map[48] includes information regarding the risk of flooding from surface water, indicating areas with a 'high', 'medium', 'low' and 'very low' flood risk. These are defined in Table 6.5.

[48] GOV.UK Check the long term flood risk for an area in England. Available at: https://www.gov.uk/check-long-term-flood-risk [Accessed May 2022]

Table 6.5: Surface water flood risk categories

Category	Description	Annual Exceedance Probability
Very low risk	Each year the area has a chance of surface water flooding of less than 0.1%.	<0.1% (1 in 1000 year) of surface water flooding.
Low risk	Each year the area has a chance of surface water flooding of between 0.1 and 1%.	1% -0.1% (1 in 100 –1 in 1000 year) surface water flooding.
Medium risk	Each year the area has a chance of surface water flooding of between 1 and 3.3%.	3.3 –1% (1 in 75 -1 in 100 year) surface water flooding.
High risk	Each year the area has a chance of surface water flooding of greater than 3.3%.	>3.3% (up to 1 in 75 year) surface water flooding.

Source: Environment Agency (2022) Flood Warning Information Service: Long term flood risk information.

6.39. Table 6.6 provides a summary of the surface water flood risk for each of the components of the Lower Thames Reservoir Option according to the Environment Agency's Long term flood risk map. Figure 6.2: Surface water flood extents shows the surface water flood extents in relation to the Lower Thames Reservoir Option.

Table 6.6: Surface water flood risk

Component	Surface water flood risk
Wraysbury Tunnel Connection	Low
Raw Water Transfer Main Route Corridor	Low
Indicative WTW Site	High (approx. 6%) to very low (majority)
Drinking Water Transfer Main Route Corridor	High to very low
Harefield Service Reservoir Connection	Low

6.4.2.5 Sewer flood risk

6.40. Sewer flooding can be caused by blocked pipes, extreme weather and prolonged rainfall, insufficient land drainage and surcharges from private sewers or drains.

6.41. Buckinghamshire County Council[49] has identified that a typical sewer system design is constructed to accommodate rainfall events with a 3.3%AEP or greater (i.e. storm events up to the 30-year return period). Therefore, rainfall events with a return period greater than 30-years (3.3% AEP) would be expected to result in surcharging of some of the sewer systems.

6.42. Climate change is anticipated to increase the potential risk from sewer flooding as summer storms become more intense and winter storms more prolonged.

6.43. Buckinghamshire County Council's Local Flood Risk Management Strategy (LFRMS)[49] also states that to manage and maintain the existing sewer network is the responsibility of the risk management authority, in this case Affinity Water.

6.44. The transfer mains would be under the jurisdiction of Affinity Water. The transfer mains have been sized to maintain velocities and minimise the deposition of sediment. It is unlikely that in the future the transfer mains would require flushing or swabbing. The transfer mains would be inspected and maintained through the use of access chambers.

6.4.2.6 Groundwater flood risk

6.45. Groundwater flooding occurs when groundwater levels rise above surface elevations and is most likely to occur in low-lying areas underlain by permeable rocks (aquifers).

6.46. Bedrock geology and superficial deposits (see Section 5.3.3) can be useful indicators of available groundwater. Geological formations have varying ability to store and procure water due mostly to the permeability of the rock or unconsolidated deposit in question and these are classified as shown in Table 5.4.

6.47. In co-operation with the Environment Agency, Defra has produced UK coverage of groundwater vulnerability[50,38]. The Drinking Water Transfer Main Route Corridor spans across most categorisations of groundwater vulnerability with 'high' vulnerability located towards the north of the route corridor at Harefield. South of this, the classification of groundwater vulnerability is 'medium-low,' including the Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor and

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[49] Buckinghamshire County Council (2017) Local Flood Risk Management Strategy. Available at: https://buckinghamshire-gov-uk.s3.amazonaws.com/documents/bcc-lfrms-final-version-may-2017.pdf [Accessed October 2022]

[50] Defra (2022) Interactive groundwater vulnerability map. Available at: https://magic.defra.gov.uk/MagicMap.aspx [Accessed April 2022]

Indicative WTW Site.

6.48. As defined by the BGS, areas of 'medium' vulnerability are 'areas that offer some groundwater protection.' The definition for medium can also be applied to 'medium-low.' Unproductive areas are 'comprised of rocks that have negligible significance for water supply or baseflow to rivers, lakes and wetlands.'

6.49. The London Borough of Hillingdon's LFRMS (2015)[51] states 'areas identified from some basic groundwater susceptibility mapping within SWMP (Surface Water Management Plan), generally fall along the gravel river corridors.' The Groundwater Emergence Map referred to in Buckinghamshire's Preliminary Flood Risk Assessment (2011)[52] indicates 'groundwater rise within consolidated aquifers (Chalk etc.) but not permeable superficial deposits.'

6.50. Shallow groundwater is likely to be present at the existing Iver WTW and Indicative WTW Site with a moderate risk of groundwater flooding. It is considered that groundwater flooding could also pose a risk in the north section of the Drinking Water Transfer Main Route Corridor where chalk aquifers have been identified.

6.51. There are no known incidents of groundwater flooding within any of the components of the Lower Thames Reservoir Option. London Borough of Hillingdon has provided evidence of groundwater flooding in Ruislip in 2014[51], to the east of the Drinking Water Transfer Main Route Corridor, where ponding was spotted in open spaces.

6.4.2.7 Reservoir, canal and other sources of artificial flooding

6.52. Artificial flood sources include raised channels, canals, or storage features such as ponds and reservoirs.

6.53. The failure of a reservoir has the potential to cause catastrophic damage due to the sudden release of large volumes of water. The local planning authority would need to evaluate the potential damage to buildings or loss of life in the event of dam failure, compared to other risks, when considering development downstream of a reservoir.

6.54. The Environment Agency has produced 'Reservoir Flood Maps' based on hydraulic modelling to deliver a 'Dry day' and 'Wet day' scenario.

- The 'Dry-day' scenario predicts the flooding that would occur if the dam or reservoir failed when rivers are at normal levels.

[51] London Borough of Hillingdon (2016) Local Flood Risk Management Strategy 2015. Available at: https://www.hillingdon.gov.uk/media/4499/Local-Flooding-Risk-Management-Strategy/pdf/Appendix_A_-_Local_Flood_Risk_Management_Strategy_2016_1.pdf?m=1610451478887 [Accessed October 2022]

[52] Jacobs (2011) Buckinghamshire County Council Preliminary Flood Risk Assessment Report. Available at: https://www.buckscc.gov.uk/media/4517642/pfra_prelim_assessment_report_final.pdf [Accessed October 2022]

- The 'Wet day' scenario predicts how much worse the flooding might be if a river is already experiencing an extreme natural flood.

6.55. Artificial sources and reservoir flood risk outlined by the Environment Agency is limited to only the River Colne. A 'Wet day' scenario was therefore examined.

6.56. The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor and Indicative WTW Site are located outside the extent of artificial sources of flooding. Parts of the Drinking Water Transfer Main Route Corridor are shown to be at risk from artificial sources and reservoir flooding. This is illustrated on Figure 6.3: Risk of flooding from reservoirs.

6.57. The Grand Union Canal flows north to south through Buckinghamshire, parallel with the River Colne. The Grand Union Canal is under the jurisdiction of the Canal and River Trust (CRT) which is the navigation authority. CRT inspects, maintains and operates the water control structures within its ownership primarily to meet its statutory obligation to maintain navigation. CRT is not a Risk Management Authority. Primary responsibility for land drainage and flood prevention rests with private parties. CRT does not have any specific statutory responsibilities in relation to flooding and, therefore, its responsibilities are those of an owner and operator of its canals and other waterways.

6.4.3 Appraisal outcomes

6.4.3.1 Sequential Test

6.58. As set out in the NPPF[21], the aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. Annex 3 of the Flood risk and coastal change Planning Practice Guidance (PPG)[53] defines water treatment works as 'less vulnerable,' and it is considered that the Wraysbury Tunnel Connection, associated raw water pumping station and the transfer mains would be defined as 'water compatible.' These are defined in the PPG as follows.

- 'Less vulnerable' developments can be constructed in Flood Zone 3a without the application of an Exception Test. Construction in Flood Zone 3b is strictly prohibited.
- 'Water compatible' developments are appropriate in Flood Zone 3b, and application of the Exception Test is not required. It should be noted however that:

[53] GOV.UK, Flood risk and coastal change. Available at: https://www.gov.uk/guidance/flood-risk-and-coastal-change [Accessed April 2022]

'Water-compatible developments in Flood Zone 3b, should be designed and constructed to:

- remain operational and safe for users in times of flood.
- result in no net loss of floodplain storage.
- not impede water flows and not increase flood risk elsewhere.'

6.59. The aim therefore is to assess the asset locations with respect to flood risk for their planned lifetime, taking account of the vulnerability of its users, without increasing flood risk elsewhere.

6.4.3.2 Fluvial flood risk

6.60. The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor, Indicative WTW Site, the indicative site identified for the temporary construction compound and the Harefield Service Reservoir Connection are located within Flood Zone 1, and not shown to be at risk of fluvial flooding from the Lower and Upper River Colne for the design events modelled. They are therefore considered to be at low risk of fluvial flooding.

6.61. The Drinking Water Transfer Main Route Corridor is at risk of fluvial flooding where it crosses watercourses. It is assumed that micro-tunnelling would be utilised for major river crossings and that there would be no displacement of fluvial flooding as the pipeline would be located underground. The key crossing points are as follows:

- Colne Brook adjacent to the M25 near Iver and Iver Heath (micro-tunnelled).
- Alder Bourne to the north of the M25 (micro-tunnelled).
- River Colne and Frays River immediately to the south of the A40 (micro-tunnelled).

6.62. It is assumed that the placement of the Drinking Water Transfer Main would not have consequential impact on the displacement of fluvial flooding as the Drinking Water Transfer Main would be located underground. Care should be taken when installing the Drinking Water Transfer Main as to not impact upon the watercourses they cross.

6.63. It is recommended that during construction any excavated material is located away from areas of flood risk, especially if it is spoiled, so it does not block local drains or potentially lead to contamination.

6.64. It is also recommended that works within the river during forecasts of wet weather or issued flood warnings should be avoided. Therefore, construction timings should be considered in greater detail during the design development stage.

6.65. It is noted that Alder Bourne and the upper reaches of Frays River are not included in either the Mott MacDonald's 2012 Lower Colne study or Halcrow's 2010 Upper Colne study, therefore it is not possible to examine the extent of flooding, modelled water levels or flows at these locations where fluming would be required. Both watercourses are shown to exhibit flooding at these crossing locations according to the Environment Agency's Flood Zones. It is recommended that if available models of these watercourses exist, they should be examined at a subsequent project stage to understand the full hydrological risk during construction, and the impact these watercourses, if flumed, would have on localised flooding. Access to these models would also provide more detail in understanding the water levels for the different AEP events and assist in identifying potential constraints to development.

6.4.3.3 Surface water flood risk

6.66. New developments have the potential to cause an increase in downstream flood risk due to increased runoff rates and volumes. All above ground infrastructure would result in land use changes resulting from installation of impermeable surfaces. The change in surface water would need to be assessed at a subsequent project stage and, if appropriate, controlled.

6.67. The site of the Wraysbury Tunnel Connection is considered to be at very low surface water flood risk. It is assumed that the existing Iver WTW site already has surface water drainage systems in place, however it is recommended that this is assessed to understand its current capacity.

6.68. The Raw Water Transfer Main Route Corridor is considered to be at low surface water flood risk.

6.69. A small proportion of the Indicative WTW Site is shown to have a high surface water flood risk. It is assumed that the Indicative WTW Site already has surface water drainage systems in place, however these may not be suitable for use as a drainage system for the operation of a WTW. As the Environment Agency surface water flood mapping assesses how water moves across the ground and does not take into consideration already established drainage systems, it is recommended that a drainage assessment is undertaken for the Indicative WTW Site at a subsequent project stage to examine the current drainage capabilities against the current surface water flood risk.

6.70. The indicative site for the temporary construction compound for the new WTW is located on a greenfield site with no drainage networks to capture surface water flooding. The indicative site is shown to have surface water flood risk of medium to low. The extent of surface water flooding is minor across the indicative site location, however, most prevalent at the northwest boundary and south-central part of the compound. It is recommended that materials are stored outside the zones of surface water flood risk to prevent materials being washed into local drains, as they could cause blockages which could lead to localised flooding.

6.71. It is noted that the majority of the underlying bedrock in the south of the Drinking Water Transfer Main Route Corridor has the inclusion of clay. The presence of clay would result in slower infiltration rates and could result in pooling of surface water flooding.

6.72. Buckinghamshire Council's LFRMS[49] states three aims of surface water flood risk management

- New development must manage its own flood risk, not contribute to flood risk in the local area and must take into account the effects of climate change.
- New development must make appropriate arrangements for the management and maintenance of features put in place to manage local flood risk.
- Where possible, new development should contribute to reducing any existing flood risk within the local area.

6.73. Buckinghamshire Council guidance[54] states that the proposal for sustainable drainage systems (SuDs) must follow the discharge hierarchy. The discharge hierarchy should be appropriately assessed and the selected discharge point for proposed SuDS must be justified in accordance with the SuDS standard requirement for runoff destination using a methodology acceptable to Buckinghamshire Council.

6.74. It is recommended that to maintain a greenfield runoff rate that a sustainable drainage system is put in place in accordance with the guidance set out by Buckinghamshire Council[54].

6.75. The indicative site for the temporary construction compound for the new WTW is located on a greenfield site with no drainage networks to capture surface water flooding. The indicative site is shown to have surface water flood risk of medium to low. The extent of surface water flooding is minor across the indicative site location however most prevalent at the northwest boundary and south-central part of the compound. It is recommended that materials are stored outside the zones of surface water flood risk to prevent materials being washed into local drains, as they could cause blockages, which could lead to localised flooding.

6.76. It is noted that the majority of the underlying bedrock in the south of the Drinking Water Transfer Main Route Corridor has the inclusion of clay. The presence of clay would result in slower infiltration rates and could result in pooling of surface water flooding. During operation, surface water flood risk would not be impacted as the pipeline is underground.

6.77. The Harefield Service Reservoir Connection is shown to be at a very low risk of surface water flooding. No impacts are anticipated during construction or operation.

[54] Buckinghamshire County Council (2017) Developer Advice for Surface Water Drainage Strategies: Major Applications. Available at: https://www.buckscc.gov.uk/media/4511876/170403-revised-developer-packver2-1.pdf [Accessed October 2022]

6.4.3.4 Groundwater flood risk

6.78. Groundwater flooding would not preclude development of the raw water pumping station within the existing Iver WTW or the new WTW unless there was a demonstrated history of relatively frequent and problematic flooding. As described in Section 6.4.2.2, there have been no incidents of flood events at the existing Iver WTW or Indicative WTW Site. As there is no evidence of groundwater flooding, it is assumed that the risk of groundwater flooding is low.

6.79. North of Uxbridge, the bedrock geology within the Drinking Water Transfer Main Route Corridor is identified by BGS as chalk and may be susceptible to groundwater flooding. It is recommended that a groundwater model is requested at a subsequent project stage to assess the risk of groundwater flooding on the development of the Drinking Water Transfer Main Route Corridor at the chalk bedrock areas.

6.4.3.5 Reservoir, canal and other sources of artificial flooding

6.80. As described in Section 6.4.2.7, parts of the Drinking Water Transfer Main Route Corridor are shown to be at risk from artificial sources and reservoir flooding. The consequences of flooding from reservoirs are very high, however the inspection and maintenance regime under the Reservoirs Act (1975) means that the probability of occurrence of flooding from these sources is considered low.

6.81. The Grand Union Canal has been identified as a potential flood risk due to its course running parallel with the River Colne. No information has been provided about the operation of the canal and therefore cannot be examined as part of this assessment, however the main risk would be due to a breach of the canal during the construction period. It is considered that this risk would be very low.

6.4.4 Recommended mitigation

6.4.4.1 Management of fluvial flood risk during construction

6.82. The indicative site for a temporary construction compound to store materials and equipment for the development of the WTW is not at fluvial flood risk and is therefore considered to be suitable for the storage of materials and equipment.

6.83. There are Flood Alert Areas on the watercourses of the River Colne, Colne Brook, Alder Bourne and Frays River, and it is recommended that construction teams sign up to the Environment Agency's flood alert system. An alert through the system warns of the possibility of flooding and make the necessary preparations.

6.84. Sections of the Drinking Water Transfer Main Route Corridor are at fluvial flood risk, and there is a risk of flooding during the construction phase. It is recommended that measures are implemented when working next to watercourses and works within the river during forecasts of wet weather or issued flood warnings should be avoided. This should inform construction timings during the design development stage.

6.85. Preparation should be taken during the receipt of a flood alert to secure all construction locations and the equipment from the possibility of severe flooding. On site personnel should be made aware of flood risk and an evacuation plan directing staff away from areas where there is a flood risk should be implemented on receipt of a flood alert or warning.

6.4.4.2 Management of fluvial flood risk during operation

6.86. Pipeline maintenance access points should be located in areas where there is low risk of flooding to ensure that they are accessible at all times and ensure pipe design and cover is enough to withstand seepage from flooding into the pipes.

6.87. Assessment of fluvial flood risk at the existing Iver WTW and Indicative WTW Site showed that these locations neither have a history of flooding nor are at risk of fluvial flooding up to the 0.1%. It is therefore not considered at this stage that mitigation of fluvial flood risk is required.

6.4.4.3 Management of surface water flood risk during construction

6.88. It is recommended that care is taken during construction when storing equipment and materials to prevent stockpiled materials and other items being washed into local drains, as these could cause blockages, which could lead to localised flooding.

6.4.4.4 Management of surface water flood risk during operation

6.89. In accordance with the NPPF[21], paragraph 167, point C, new assets would need to incorporate sustainable drainage systems, unless there is clear evidence that this would be inappropriate.

6.90. Buckinghamshire Council[54] identifies the discharge hierarchy for new developments, stating that discharge hierarchy should be appropriately assessed and the selected discharge point for proposed SuDS must be justified. The primary aim is that runoff should be first restricted to the greenfield 1 in 1-year runoff rate during all events up to and including the 1 in 100-year rainfall event with climate change.

6.91. A sustainable drainage system would therefore be required for the Indicative WTW Site and the pumping station at the Wraysbury Tunnel Connection. It is recommended that the implemented drainage system is capable of capturing all excess surface water as a result of the scheme.

6.92. It is also recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process.

6.4.4.5 Management of groundwater flood risk

6.93. For the Drinking Water Transfer Main Route Corridor north of Uxbridge, it is recommended that a request is placed for an available groundwater model at a subsequent project stage to determine the groundwater risk of a chalk aquifer on underground pipe equipment. It is also recommended that groundwater risk is implemented into the design of the Drinking Water Transfer Main at this location to ensure that equipment is not affected.

6.5 Summary of main findings and recommendations for future technical work

6.5.1 Aquatic environment appraisal

6.94. The majority of identified effects on the aquatic environment are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity of affected reaches. Flow changes within the River Thames as a result of SESRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected reaches. However, the potential impacts associated with the new or increased surface water abstraction would not be of a magnitude to result in the potential to deteriorate the WFD elements of the Thames (Cookham to Egham), Queen Mother Reservoir and Wraysbury Reservoir or prevent them from the attainment of Good status in the future.

6.5.2 Groundwater

6.95. The Lower Thames Reservoir Option affects Principal, Secondary A, Secondary B and Unproductive aquifers. The Wraysbury Tunnel Connection and Indicative WTW Site are both underlain by Principal Superficial Aquifers.

6.96. To the north of Ickenham, the Drinking Water Transfer Main Route Corridor passes through areas defined as SPZ1 and SPZ2. The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor and Indicative WTW Site are not located within SPZs. Construction within SPZs requires additional assessment and potentially mitigation to ensure no adverse impacts on public water supplies. Prior to construction, a hydrogeological risk assessment would be required for works within SPZ1 or 2.

6.97. None of the three groundwater bodies considered in the Level 1 – basic screening assessment were carried through to the Level 2 – detailed screening assessment. This has resulted in no further requirements for assessment of groundwater flow under the WFD at this stage. If any of the design assumptions or mitigation measures change, this will be reconsidered at subsequent project stages.

6.5.3 Flood risk

6.98. Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the site of the Wraysbury Tunnel Connection is at low risk of fluvial flooding. Although at very low risk of surface water flooding, a sustainable drainage system would be required for the raw water pumping station at the Wraysbury Tunnel Connection. The site of the Wraysbury Tunnel Connection is considered to be at extremely low risk of groundwater flooding and is not at risk of flooding from reservoir, canal and or other Sources of artificial flooding.

6.99. Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the Raw Water Transfer Main Route Corridor is at low risk of fluvial and surface water flooding. The Raw Water Transfer Main Route Corridor is considered to be at extremely low risk of groundwater flooding and is not at risk of flooding from reservoir, canal and or other sources of artificial flooding.

6.100. Examination of fluvial flood risk from the Environment Agency's Flood Zone maps and modelled river levels indicates that the Indicative WTW Site is at low risk of fluvial flooding. A small part of the Indicative WTW Site is considered to be at high risk of surface water flooding. A sustainable drainage system would therefore be required for the Indicative WTW Site and the raw water pumping station at the Wraysbury Tunnel Connection, and it is recommended that a closed loop system be put into place for the new WTW to capture any potential contaminants from the treatment process.

6.101. The indicative temporary construction compound for the WTW is considered to be at medium to low risk of surface water flooding. Care should be taken with the storage of equipment and materials to ensure stockpiled materials and other items are not washed into local drains to prevent blockages which could lead to localised flooding.

6.102. The Indicative WTW Site is considered to be at low risk of groundwater flooding and is not at risk of flooding from reservoir, canal and or other sources of artificial flooding.

6.103. The Drinking Water Transfer Main Route Corridor is considered to be at risk of fluvial flooding from the River Colne and associated tributaries where the pipeline crosses the watercourses. It is assumed that no-dig methods would be utilised for major river crossings and that there would be no displacement of fluvial flooding as the pipeline would be underground. There is still a risk of flooding during the construction phase near any watercourse and it is recommended that works within the river during forecasts of wet weather or issued flood warnings should be avoided. Therefore, construction timings should be considered during the design development stage. Pipeline maintenance access points should be located in areas where there is low risk of flooding to ensure that they are accessible at all times and ensure pipe design and cover is enough to withstand seepage from flooding into the pipes.

6.104. North of Uxbridge, the Drinking Water Transfer Main Route Corridor bedrock geology is chalk. It is recommended that a groundwater model is requested at a subsequent project stage to assess the risk of groundwater flooding on the development of the Drinking Water Transfer Main Route Corridor within chalk bedrock areas. It is also recommended that groundwater risk is taken into consideration during design of the Drinking Water Transfer Main, and groundwater designs are implemented to assist with protection the asset.

6.105. Parts of the Drinking Water Transfer Main Route Corridor are shown to be at risk from reservoir, canal and or other sources of artificial flooding. The consequences of flooding from reservoirs are very high, however the inspection and maintenance regime under the Reservoirs Act (1975) means that the probability of occurrence of flooding from these sources is considered low. The Grand Union Canal has been identified as a potential flood risk due to its course running parallel with the River Colne. The main risk would be due to a breach of the canal during the construction period. It is considered that this risk would be very low.

6.106. The Harefield Service Reservoir Connection is considered to be at low risk of fluvial and surface water flooding, at low risk of groundwater flooding and is not considered to be at risk of flooding from reservoir, canal and or other sources of artificial flooding.

7 Air quality

7.1 Introduction

7.1. This chapter presents a desk-based assessment undertaken to identify potential air quality impacts on sensitive receptors from the construction and operation of the transfer corridors and above ground infrastructure including the WTW associated with the Lower Thames Reservoir Option. The objectives of the desk-based assessment were to establish the baseline air quality associated with the Lower Thames Reservoir Option, identify constraints and opportunities, and identify the issues and features that require further investigation.

7.2. The need to consider air quality is driven by legislation[55] and national planning policy (draft NPS for Water Resource Infrastructure[20] (Section 4.2, Air Quality) and NPPF[21] (Section 15, conserving and enhancing the natural environment), paragraph 186).

7.2 Methodology

7.2.1 Study area and sources of information

7.3. For possible dust generating activities during construction, the desk-based assessment identified the number of sensitive receptors in the area surrounding the Raw Water and Drinking Water Transfer Main Route Corridors and associated infrastructure (Wraysbury Tunnel Connection, Indicative WTW Site and Harefield Service Reservoir Connection) up to a distance of 350m. This is in line with the Institute of Air Quality Management (IAQM) construction dust guidance[56].

7.4. The review of baseline conditions considered publicly available air quality data up to a distance of 1km from the Raw Water and Drinking Water Transfer Main Route Corridors, anticipated construction works areas and associated infrastructure. If no representative data was found within this distance, data from a wider area was

[55] Air Quality Standards Regulations 2010, Air Quality Standards (amendment) Regulations 2016, Air Quality (Amendment of Domestic Regulations) (EU Exit) Regulations 2019 Environment (Miscellaneous Amendments) (EU Exit) Regulations 2020, Air Quality (England) Regulations 2000, Air Quality (England) (Amendment) Regulations 2002, Environment Act 1995 (Part IV)
Environment Act 2021 (Schedule 11), Environmental Protection Act 1990 (section 79(1)(d))

[56] Institute of Air Quality Management (2014) Guidance on the assessment of dust from construction and demolition. Available at: http://iaqm.co.uk/wp-content/uploads/guidance/iaqm_guidance_report_draft1.4.pdf [Accessed April 2022]

reviewed and presented if it was considered representative.

7.5. Table 7.1 outlines the baseline data sources collated and considered in the desk-based assessment.

Table 7.1: Sources of information (air quality)

Data collected	Source
Locations of AQMA and Clean Air Zones (CAZ)	Local authority and Defra mapping
Publicly available air quality data (Local authority and Defra air quality monitoring data, Defra background maps, Pollution Climate Mapping (PCM) model)	Local authority monitoring data (published in Annual Status Reports) Defra air quality monitoring data Defra PCM model/background maps
Human health, dust soiling and ecological receptor locations within 350m of transfer route corridors and associated infrastructure	OS mapping (AddressBase) Natural England mapping

7.2.2 Approach to impact appraisal

7.6. The desk-based assessment used a qualitative approach to appraise the Lower Thames Reservoir Option and identify where there is potential for air quality impacts. This included consideration of existing pollutant concentrations (from publicly available sources) in the vicinity of the Lower Thames Reservoir Option as well as its proximity to:

- AQMAs and CAZs
- Sensitive human health receptors
- Sensitive receptors to dust soiling
- Sensitive ecological receptors (relevant designated nature conservation sites)

7.7. Based on these findings, high-level mitigation measures were identified.

7.8. The sensitivity of receptors based on dust soiling and risks to human health within this appraisal has been based on the definitions provided with the IAQM guidance[56], which are presented in Table 7.2 below.

Table 7.2: Sensitivities of human health receptors to dust soiling effects and health effects

Receptor sensitivity	Dust soiling	Human health
High sensitivity receptor – surrounding land where:	• Users can reasonably expect enjoyment of a high level of amenity; or • the appearance, aesthetics or value of their property would be diminished by soiling; and • the people or property would reasonably be expected to be present continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. • Indicative examples include dwellings, museums and other culturally important collections, medium and long term car parks and car showrooms.	• Locations where members of the public are exposed over a time period relevant to the air quality objective (for example, in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day). • Indicative examples include residential properties. Hospitals, schools and residential care homes should also be considered as having equal sensitivity to residential areas for the purposes of this assessment.
Medium sensitivity receptor	• Users would expect to enjoy a reasonable level of amenity, but would not reasonably expect to enjoy the same level of amenity as in their home; or • the appearance, aesthetics or value of their property could be diminished by soiling; or • the people or property wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land. • Indicative examples include parks and places of work.	• Locations where the people exposed are workers, and exposure is over a time period relevant to the air quality objective (for example, in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day). • Indicative examples include office and shop workers.

Receptor sensitivity	Dust soiling	Human health
Low sensitivity receptor	• The enjoyment of amenity would not reasonably be expected; or • property would not reasonably be expected to be diminished in appearance, aesthetics or value by soiling; or • there is transient exposure, where the people or property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. • Indicative examples include playing fields, farmland (unless commercially-sensitive horticultural), footpaths, short term car parks and roads.	• Locations where human exposure is transient. • Indicative examples include public footpaths, playing fields, parks and shopping streets.

7.9. Table 7.2 above provides examples of high, medium and low sensitivity human health receptors. However, at this stage, only the following receptor types have been considered and included in this assessment, due to data availability:

- Residential properties
- Medical centres
- Education facilities
- Places of worship
- Allotments / community growing spaces
- Offices
- Golf courses
- Leisure centres
- Public gardens/parks
- Play spaces
- Playing fields
- Farm buildings
- Industrial properties

7.10. The presence of any other types of human health receptors would be considered at a later stage.

7.11. The following sensitive ecological receptor types have also been considered:

- SAC
- SPA
- Ramsar sites
- SSSI
- NNR
- LNR
- Ancient woodland
- Non-statutory designated nature conservation designations

7.12. Priority Habitats have not been considered as they are not classified as a designated site, in accordance with IAQM guidance[57].

7.13. Of the ecological receptor types listed above, five (SSSI, NNR, LNR, ancient woodland and non-statutory designated nature conservation sites) are located within 350m of the Lower Thames Reservoir Option and are therefore included in this assessment.

7.2.3 Assumptions and limitations

7.14. No formal construction dust assessment (following the methodology outlined in the IAQM guidance[56]) has been undertaken at this stage and therefore only high-level construction dust mitigation measures have been identified. No assessment of potential construction traffic effects has been undertaken as information on vehicle numbers or access routes are not available at this stage.

7.15. The most recent year of monitoring data available from local authorities is for 2020, however data from 2020 has the potential to be impacted by effects associated with the coronavirus (Covid-19) pandemic, such as a reduction in traffic movements resulting in reduced monitored pollutant concentrations. Therefore, data from 2020 may not be representative of existing concentrations so 2019 data has been used to inform the baseline for this assessment. It is therefore assumed that 2019 data is representative of current conditions.

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[57] IAQM (2020) A guidance to the assessment of air quality impacts on designated nature conservation sites. Available at: https://iaqm.co.uk/text/guidance/air-quality-impacts-on-nature-sites-2020.pdf [Accessed April 2022]

7.16. The desk-based assessment was qualitative and therefore no atmospheric dispersion modelling or scheme-specific monitoring surveys was undertaken.

7.17. The following elements were excluded from the desk-based assessment:

- Identification of potential construction traffic effects as a result of the Lower Thames Reservoir Option – as construction vehicle numbers and access routes have not yet been finalised at this stage. The Environmental Protection UK (EPUK)/IAQM guidance[58] indicates that an assessment of traffic emissions is likely to be required where a development generates an additional annual average flow of greater than 25 Heavy Duty Vehicles[59] (HDV) per day or greater than 100 Light Duty Vehicles (LDV) per day on local roads within an AQMA. Considering the nature of the scheme and the number of staff required, it is likely that the LDV and/or the HDV flows would exceed these thresholds during the construction phase and that an assessment of traffic emissions would be required. However, this should be confirmed at a subsequent project stage, once construction vehicle numbers have been finalised and are available.
- Identification of potential construction effects associated with Non-road Mobile Machinery (NRMM) and site traffic. It is stated in IAQM guidance[56] that "they are unlikely to make a significant impact on local air quality, and in the vast majority of cases they would not need to be quantitatively assessed". Therefore, given the nature of the scheme, it is unlikely that emissions from NRMM and site traffic would affect local air quality and as such their impacts on air quality have not been considered in this appraisal. Nonetheless it should be noted that NRMM would still be required to meet the relevant emission standards for NRMM.

  Identification of potential operational traffic effects as a result of the Lower Thames Reservoir Option – as, based on current information, the scheme is anticipated to generate an additional annual average flow of one to three HDVs per day throughout its operation, which is well below the EPUK/IAQM screening threshold of 25 HDVs per day on average each year. As such, the impacts on air quality associated from vehicles associated with the Lower Thames Reservoir Option during its operation are unlikely to require an assessment of traffic emissions and have not been considered further at this stage. This should be confirmed at a subsequent project stage, once operational vehicle numbers have been finalised and are available.
- Identification of potential operational effects associated with standby generators required for the associated infrastructure (pumping station for the Wraysbury Tunnel Connection and new WTW) as these are unlikely to result in air quality impacts during normal operation since the generators would only be used for emergencies (i.e. during periods when mains electricity supply to the respective sites (pumping station and WTW) was disrupted). If an emergency were to occur,

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[58] Environmental Protection UK and Institute of Air Quality Management (2017), 'Land-Use Planning and Development Control: Planning for Air Quality'

[59] HDVs are defined as freight vehicles of more than 3.5 tonnes (trucks) or passenger transport vehicles of more than 8 seats (buses and coaches).

the generators would likely operate for a short period of time until the power supply to the respective sites was restored. Outside emergency operation, the standby generators would only operate during maintenance/testing, which is anticipated to have a duration of less than 50 hours a year. Therefore, given the limited number of operating hours associated with the standby generators during normal operation, the impacts on air quality are likely to be minimal so have not been considered in this appraisal. However, this should be reviewed once the location, operating profile and design of the associated infrastructure for the Lower Thames Reservoir Option has been finalised.

7.3 Understanding of the baseline

7.3.1 Air Quality Management Areas

7.18. The closest AQMAs to each of the Lower Thames Reservoir Option components are detailed in Table 7.3.

Table 7.3: Closest AQMAs to the Lower Thames Reservoir Option

AQMA name	Details
South Bucks District Council AQMA No. 2 (Buckinghamshire)	The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor, Indicative WTW Site and southern section of the Drinking Water Transfer Main Route Corridor are located with this AQMA, which is a parish-wide AQMA located within Buckinghamshire Council's administrative area. The AQMA was declared in 2018 for exceedances of the annual mean NO_2 objective.
South Bucks AQMA (Buckinghamshire)	Part of the Indicative WTW Site and sections of the Drinking Water Pipeline Route Corridor are located within this AQMA, which is located within Buckinghamshire Council's administrative area. The AQMA comprises the M4, M25 and M40 and adjacent land, and was declared in 2004 for exceedances of the annual mean NO_2 objective.
Hillingdon AQMA	The central regions of the Drinking Water Transfer Main Route Corridor are located within this AQMA, which is a borough wide AQMA within the London Borough of Hillingdon's administrative area. The AQMA was declared in 2003 for exceedances of the annual mean NO_2 objective.

AQMA name	Details
Harrow AQMA	Approximately 3.8km to the east of the Harefield Service Reservoir Connection at its closest point, this borough wide AQMA is located within the London Borough of Harrow's administrative area. The AQMA was declared in 2002 for exceedances of the annual mean NO_2 and 24-hour mean PM_{10} objectives.

7.3.2 Clean Air Zones

7.19. The Lower Thames Reservoir Option passes through the administrative areas of Buckinghamshire Council, London Borough of Hillingdon and is in proximity to the administrative area of Three Rivers District Council. None of these local authorities have, or are currently proposing to have, a CAZ. However, it should be noted that there are proposals for the Ultra Low Emission Zone in London to cover the whole of Greater London from August 2023, which includes the London Borough of Hillingdon.

7.3.3 Local authority monitoring data

7.3.3.1 Nitrogen dioxide monitoring

7.20. Monitoring of NO_2 is undertaken within the administrative area of each of the three local authorities that the Lower Thames Reservoir Option passes through.

7.21. The following NO_2 monitoring is undertaken by each of the local authorities:

- Buckinghamshire Council undertakes NO_2 monitoring at two automatic monitoring station and 51 diffusion tube sites.
- London Borough of Hillingdon undertakes NO_2 monitoring at 11 automatic monitoring stations and 44 diffusion tube sites.
- Three Rivers District Council undertakes NO_2 monitoring at nine diffusion tube sites.

7.22. Local authority monitoring sites within the study area (within approximately 1km of the Lower Thames Reservoir Option) include 19 diffusion tubes, of which 14 are within Buckinghamshire Council's administrative area, and five within London Borough of Hillingdon.

7.23. Data from the diffusion tube sites show that between 2018 and 2020, NO_2 concentrations were below the annual mean objective at two urban background monitoring sites, which are located within and approximately 1km away from the Drinking Water Transfer Main Route Corridor. This is the type of location that is representative of areas where the Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor, Indicative WTW Site, the majority of the Drinking Water Transfer Main Route Corridor and Harefield Service Reservoir Connection are located.

7.24. Further to this, between 2018 and 2020, annual mean NO_2 concentrations were below the annual mean objective at all but two of the roadside sites. These two roadside sites are located in urban areas approximately 90m to 550m away from the Drinking Water Transfer Main Route Corridor. Of these two monitoring sites, only one exceeded the annual mean NO_2 objective in 2019, which is the latest year with representative monitoring data available. A monitoring site, which is located within Buckinghamshire Council's 'South Bucks District Council AQMA No.2' AQMA, and approximately 90m away from the Drinking Water Transfer Main Route Corridor, recorded an annual mean NO_2 concentration of 43.7µg/m^3 in 2019.

7.3.3.2 Particulate matter monitoring

7.25. There is no particulate matter (PM) monitoring data available within 1km of the Lower Thames Reservoir Option, however there is representative PM monitoring data available within 3km.

7.26. Representative monitoring sites have been considered as those that are not located at a kerbside location since the majority of the Lower Thames Reservoir Option is located in a rural/urban background area away from roads. There are, however, some smaller areas of the Lower Thames Reservoir Option that are located close to roads and industrial sites. Therefore, roadside and industrial monitoring sites have been considered, in addition to monitoring sites in rural/urban background locations.

7.27. Data from PM monitoring shows that PM concentrations are below the annual mean PM_{10} and $PM_{2.5}$ objectives as well as the 24-hour mean PM_{10} objective at all of the automatic monitoring stations between 2018 and 2020.

7.3.4 Defra background mapping

7.28. Defra provides mapped future year projections of background pollution concentrations for NO_X, NO_2, PM_{10} and $PM_{2.5}$ for each 1 km grid square across the UK for all years between 2018 to 2030[60]. Future year projections have been developed from the base year of the background maps, which is currently 2018. The maps

[60] Defra Background maps (2018) [Online] Available at: https://uk-air.defra.gov.uk/data/laqm-background-maps [Accessed April 2022]

include a breakdown of background concentrations by emission source, including road and industrial sources, which have been calibrated against 2018 (the baseline year) UK monitoring data.

7.29. Table 7.4 presents the minimum and maximum background concentrations across the 1 km grid squares containing the Lower Thames Reservoir Option for the current year of 2022. The minimum and maximum background concentrations are all below the relevant objectives.

Table 7.4: Defra projected background concentrations of NO_2, NO_x, PM_{10} and $PM_{2.5}$ for the Lower Thames Reservoir Option components in 2022 (ug/m^3)

Component	Minimum and maximum 2022 background concentrations (µg/m^3)			
	NO_2	NO_x	PM_{10}	$PM_{2.5}$
Wraysbury Tunnel Connection	24.4	36.6	17.1	11.2
Raw Water Transfer Main Route Corridor	24.4	36.6	17.1	11.2
Indicative WTW Site	18.5- 24.4	26.4- 36.6	15.4- 17.1	10.4- 11.2
Drinking Water Transfer Main Route Corridor	11.2- 24.4	14.9- 36.6	13.4- 17.1	9.2- 11.2
Harefield Service Reservoir Connection	11.2	14.9	13.4	9.2

Source: https://uk-air.defra.gov.uk/data/laqm-background-maps?year=2018 [Accessed April 2022]

7.3.5 PCM model

7.30. The PCM model presents the projected roadside NO_2 concentrations for approximately 9,000 modelled road links across UK and is used by Defra to report compliance with limit values transposed into UK law from EU Directive 2008/50/EC[61]. The PCM model provides NO_2 concentrations at locations 4m from the road, and projections are available for all years from 2019 to 2030 from the base year of 2018.

7.31. In general, predicted NO_2 concentrations decline into the future, mainly in response to cleaner vehicles and technologies, and actions in Air Quality Action Plans by local and combined authorities. The most recent PCM model was published in 2020 and

[61] European Union. (April 2008) Directive on Ambient Air Quality and cleaner Air for Europe, Directive 2008/50/EC Official Journal, vol. 152, pp. 0001-0044

the projections represent the projected concentrations assuming no further action beyond the air quality measures that were committed by the reference year (2018).

7.32. The closest PCM link to each of the Lower Thames Reservoir Option components has been presented below in Table 7.5. The greatest 2022 annual mean NO_2 concentration of 42.8µg/m^3 is predicted on the A40, which intersects the Drinking Water Transfer Main Route Corridor. This concentration exceeds the annual mean limit value of 40µg/m^3 for NO_2.

Table 7.5: Predicted annual mean NO_2 concentrations on PCM links closest to the Lower Thames Reservoir Option components

Component	PCM road link	Details
Wraysbury Tunnel Connection	A408 Census ID (802056742)	The predicted concentration at this link for 2022 is 24.8µg/m^3.
Raw Water Transfer Main Route Corridor		
Indicative WTW Site		
Drinking Water Transfer Main Route Corridor	A4020 Census ID (802037720)	The predicted concentration at this link for 2022 is 23.8µg/m^3.
	A40 Census ID (802078346)	The predicted concentration at this link for 2022 is 42.8µg/m^3.
Harefield Service Reservoir Connection	A404 Census ID (802037106)	The predicted concentration at this link for 2022 is 24.9µg/m^3.

7.4 Appraisal outcomes

7.4.1 Nitrogen dioxide

7.33. The annual mean NO_2 objective may be exceeded in regions of the Drinking Water Transfer Main Route Corridor that are located close to the roadside within Buckinghamshire Council's 'South Bucks District Council AQMA No. 2' AMQA, which was declared for exceedances of the annual mean NO_2 objective.

7.34. However, significant impacts on air quality are not expected in these regions. Any adverse effects from construction works on receptors in these regions can be minimised with the implementation of a CEMP such that they would not have a material impact, and the number of operational vehicle flows generated by the development is anticipated to be below the screening threshold of 25 HDVs.

7.35. Further to this, exceedances of the NO_2 objectives are unlikely to occur in suburban and urban background locations, where the Wraysbury Tunnel Connection, Indicative WTW Site, Raw Water Transfer Main Route Corridor, the majority of the Drinking Water Transfer Main Route Corridor and Harefield Service Reservoir Connection are located.

7.4.2 Particulate matter

7.36. Exceedances of the PM_{10} and $PM_{2.5}$ objectives are not expected to occur in any location.

7.4.3 Dust soiling and health effects

7.37. Table 7.6 provides a summary of the human health and ecological receptors within 350m of the components of the Lower Thames Reservoir Option. These receptors could be impacted as a result of construction activities.

Table 7.6: Dust soiling and health effects – sensitive human health and ecological receptors within 350m of the Lower Thames Reservoir Option components

Component	Human health receptors within 350m	Ecological receptors within 350m
Wraysbury Tunnel Connection	High sensitivity: Less than 10 residential properties Medium sensitivity: golf course Low sensitivity: industrial properties	One non-statutory nature conservation site
Raw Water Transfer Main Route Corridor	High sensitivity: Between 10 and 100 residential properties Medium sensitivity: offices, leisure centres and golf courses Low sensitivity: industrial properties	Two non-statutory designated nature conservation sites

Component	Human health receptors within 350m	Ecological receptors within 350m
Indicative WTW Site (including indicative site for the temporary construction compound)	High sensitivity: Over 100 residential properties Medium sensitivity: offices, leisure centres, allotments, public parks/gardens, play spaces and golf courses Low sensitivity: industrial properties	Two non-statutory designated nature conservation sites
Drinking Water Transfer Main Route Corridor	High sensitivity: Over 100 residential properties and less than 10 education facilities, places of worship and medical facilities Medium sensitivity: offices, leisure centres, allotments, public parks/gardens, play spaces and golf courses Low sensitivity: playing fields, industrial properties and farm buildings	16 areas of ancient woodland Four SSSIs One LNR One NNR 17 non-statutory designated nature conservation sites
Harefield Service Reservoir Connection	High sensitivity: between 10 and 100 residential properties Medium sensitivity: offices and a public park/garden Low sensitivity: industrial properties and farm buildings	Three areas of ancient woodland Five non-statutory designated nature conservation sites

7.5 Recommended mitigation

7.38. The following generic mitigation measures should be implemented for the Lower Thames Reservoir Option, as a minimum, to reduce adverse impacts on air quality associated with construction dust. These mitigation measures are based on highly recommended measures for low-risk sites in the IAQM guidance[56]. More stringent mitigation measures may be proposed at a subsequent project stage once a more detailed air quality assessment has been undertaken:

- Communication and site management
  - Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary.
  - Display the head or regional office contact information.
  - Record all dust and air quality complaints, identify causes and take appropriate measures to reduce emissions in a timely manner and record the measures taken.
  - Make a complaint log available to the planning authority, when requested.
  - Record any exceptional incidents that cause dust and or air emissions, either on or off site, and the action taken to resolve the situation in the log book.
- Monitoring
  - Carry out regular site inspections, record inspection results and make an inspection log available to the planning authority, when requested.
  - Increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.
- Preparing and maintaining the site
  - Plan site layout so that machinery and dust causing activities are located away from receptors as far as possible.
  - Erect solid screens or barriers around dusty activities or the construction site boundary that are at least as high as any stockpiles.
  - Avoid site runoff of water or mud.
  - Ensure all vehicles switch off engines when stationary – no idling vehicles.
  - Avoid the use of diesel- or petrol-powered generators and use mains electricity or battery powered equipment, where practicable.
- Operations
  - Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction.
  - Ensure an adequate water supply on the site for effective dust/ particulate matter suppression/ mitigation using non-potable water, where possible and appropriate.
  - Use enclosed chutes and conveyors and covered skips.
  - Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever available.
  - No bonfires and burning of waste materials.

7.39. As discussed in Section 7.2.3, the impacts associated with standby generators have not been assessed at this stage, in part because it has been assumed that the impact on air quality would be mitigated within their design. Specifically, it is assumed that the generators would be designed to optimise dispersion of pollutants. For example, the generators should be designed with a sufficient stack height and should not have rain caps or cowls attached, which could impede the exhaust flow.

7.6 Summary of main findings and recommendations for future technical work

7.40. All of the Lower Thames Reservoir Option components except the Harefield Service Reservoir Connection are either entirely or partly located within an AQMA. There are no CAZs in their vicinity.

7.41. The assessment indicates that the annual mean NO_2 objective may be exceeded in sections of the Drinking Water Transfer Main Route Corridor that are located close to the roadside within Buckinghamshire Council's 'South Bucks District Council AQMA No. 2' AMQA, which was declared for exceedances of the annual mean NO_2 objective. However, exceedances of the NO_2 objectives are unlikely to occur in suburban and urban background locations, where the Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor, Indicative WTW Site, the majority of the Drinking Water Transfer Main Route Corridor and Harefield Service Reservoir Connection are located. Further to this, exceedances of the PM_{10} and $PM_{2.5}$ objectives are not expected to occur in any location.

7.42. There are sensitive human and ecological receptors within 350m of the Lower Thames Reservoir Option, which could be impacted as a result of construction activities. Therefore, a number of construction dust mitigation measures have been recommended in accordance with the IAQM guidance[56]. A dust risk assessment should be undertaken at a subsequent project stage, once more information is available to determine the construction dust risk at these sensitive receptors, and whether additional construction dust mitigation is required.

7.43. The air quality impacts associated with vehicle traffic during the construction phase and the impacts from the standby generators should also be assessed once further details of these activities are available. If significant effects are predicted as result of these activities, additional mitigation may be required.

7.44. The impacts on air quality associated with vehicles during operation are not anticipated to be significant as, based on current information, the Lower Thames Reservoir Option would generate an additional annual average flow of one to three HDVs per day throughout its operation, which is well below the EPUK/IAQM[58] screening threshold of 25 HDVs per day on average each year.

7.45. The impacts associated with standby generators during operation have not been assessed, in part because it has been assumed that the impact on air quality would be mitigated within their design. Specifically, it is assumed that the generators would be designed to optimise dispersion of pollutants. For example, the generators should be designed with a sufficient stack height and should not have rain caps or cowls attached, which could impede the exhaust flow.

8 Climatic factors

8.1 Introduction

8.1. This chapter presents a desk based assessment undertaken to identify potential climatic risks from the construction and operation of the transfer corridors and above ground infrastructure including the WTW.

8.2. The need to consider climatic factors is driven by legislation (Paris Agreement 2015 and Climate Change Act 2008), Government policy (National Adaptation Programme[62]) and national planning policy (draft NPS for Water Resource Infrastructure[20] (Section 3.7, Climate change adaptation) and NPPF (Section 14, Meeting the challenge of climate change, flooding and coastal change[21]).

8.3. Technical Supporting Document A3a, Carbon Strategy Report, should be referred to for estimated capital and operational carbon impacts, whole life carbon emissions and carbon mitigation strategies. A summary is provided in Section 8.3 of this chapter.

8.2 Climate change risk assessment

8.2.1 Methodology

8.4. The climate change risk assessment presented in this chapter is intended to be a high-level screening exercise, which assesses the main risks to the scheme assets based on climate projections for a time horizon of 2080-2099. The hazards included in this stage of assessment include; high temperatures, low temperatures, high rainfall, flooding and drought. Hazards such as extreme events (snowfall) have not been considered at this screening stage. Further assessment should be completed at subsequent project stages to include a full range of hazards.

8.5. The construction phase has not been fully assessed as the construction methods are unknown at this stage. A high-level overview of construction impacts has been provided in Section 8.2.3. Further climate related impacts on construction due to extreme weather events should be considered and addressed by measures in the

[62] Defra (2018) The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting: Making the country resilient to a changing climate. Available at: https://www.gov.uk/government/publications/climate-change-second-national-adaptation-programme-2018-to-2023 [Accessed April 2022]

CEMP at a subsequent project stage.

8.2.1.1 Study area and sources of information

8.6. The climate change risk assessment focused on the area surrounding the route transfer corridors and associated infrastructure including the WTW. Current climate data describes the wider region surrounding the Lower Thames Reservoir Option and future climate identifies changes to the climate.

8.7. Table 8.1 outlines the baseline data sources collated and considered.

Table 8.1: Sources of information (climatic factors)

Data collected	Source
Current climate conditions	Met Office UKCP18 Land Observations (Regional) Met Office Regional Climates UK[63]
Future climate projections (temperature and precipitation)	Met Office UKCP18 Probabilistic Projections (Regional) Met Office UKCP18 Global Projections (Regional) (applicable to wind speed only)
Flood risk maps	Environment Agency Flood Risk Maps (see Chapter 6)

8.2.1.2 Approach to impact appraisal

8.8. A qualitative approach was taken to appraise the Lower Thames Reservoir Option and identify where there is potential for physical climate risks to affect the scheme. This included consideration of future climate conditions in the area surrounding the options up to the end of the century based upon operation starting in 2039 and a design horizon to 2100 as planned for in the WRSE Regional Plan.

8.9. Potential climate risks relevant to the Lower Thames Reservoir Option were identified and the likelihood and severity of each climate risk scored. The combination of likelihood and severity provides a risk rating for each climate impact (risk = likelihood x severity). Where the risk rating is greater than five, mitigation measures are identified to reduce the risk, and the residual likelihood and severity of the climate risk is re-rated after mitigation to ensure the residual risk is at an

[63] Met Office Regional Climates UK, Southern England. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/regional-climates/southern-england_-climate---met-office.pdf [Accessed April 2022]

acceptable level. The method is based on the Environment Agency Climate Change Risk Assessments (CCRAs)[64] for permitting purposes and has been used for similar schemes. This is a sound approach for conducting a high level physical climate change risk assessment and is good practice.

8.10. The scoring criteria for severity and likelihood of impact are below:

- Severity of impact:
  - Severe risk: short-term, acute risk to operations resulting in permanent compliance breach(es)
  - Medium risk: short-term, acute risk to operations resulting in multiple temporary compliance breaches
  - Mild risk: short-term, acute risk to operations resulting in single temporary compliance breach
  - Minor risk: short or long-term risk resulting in additional measures for compliance
- Likelihood of impact:
  - Highly likely: event appears very likely in the short term and almost inevitable over the long term, or there is evidence of the event already happening.
  - Likely: it is probable that an event will occur, or circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term.
  - Low likelihood: circumstances are such that an event could occur, but it is not certain even in the long term that an event would occur, and it is less likely in the short term.
  - Unlikely: circumstances are such that it is improbable the event would occur even in the long term.

Table 8.2: Climate risk score calculation

	Severe risk (Score= 4)	Medium risk (Score = 3)	Mild risk (Score = 2)	Minor risk (Score = 1)
Highly likely (Score = 4)	16	12	8	4
Likely (Score = 3)	12	9	6	3
Low likelihood (score = 2)	8	6	4	2

64 Environment Agency Climate Change Risk Assessment. Available at: https://www.gov.uk/guidance/adapting-to-climate-change-risk-assessment-for-your-environmental-permit [Accessed April 2022]

	Severe risk (Score= 4)	Medium risk (Score = 3)	Mild risk (Score = 2)	Minor risk (Score = 1)
Unlikely (Score = 1)	4	3	2	1

8.11. The risk categories are as follows:

- 12 to 16: high
- 8 to 9: moderate to high
- 4 to 6: moderate to low
- 1 to 3: low

8.2.1.3 Assumptions and limitations

8.12. The baseline for the future climate relies on the outputs from climate models, referred to as projections and obtained from a third-party source (the UK Met Office). Climate projections are not predictions or forecasts but projections of future climate under a range of hypothetical emissions scenarios and assumptions. The results, therefore, from the experiments performed by climate models cannot be treated as exact or factual, rather they are projections. Projections exclude outlying 'surprise' or 'disaster' scenarios in the literature and any scenario necessarily includes subjective elements. Generally, there is a higher level of confidence in temperature projections than those for precipitation and other variables and the degree of uncertainty associated with all climate change projections increases for projections further into the future. The climate change risk assessment would need to be updated periodically throughout the project lifecycle to ensure that all data is valid and the most up to date version.

8.13. The assessment is based on an operational design horizon to 2100, which is common across the WRSE Regional Plan. This may not be the same as the operational life of the specific assets that will be constructed and appraised in other parts of the Gate 2 feasibility work. However, the period to 2100 is considered appropriate for the assessment of climatic factors relevant to the scheme.

8.14. Cumulative assessment of climate change impacts is not covered at this stage. The assessment focuses on identifying and screening the high level physical climate risks to the main assets of the scheme. Further assessment will be carried out at subsequent project stages, including in-combination impacts of climate change with other topics.

8.2.2 Understanding of the baseline

8.2.2.1 Current climate

8.15. The Lower Thames Reservoir Option is located within both the Met Office south eastern region and the southern (London) region. The southern (London) region has been selected for the assessment, as it has marginally higher temperatures and is therefore a more conservative approach. The region is subject to continental weather influences that bring cold spells in winter and hot, humid weather in summer. High level qualitative climate observations for this region[63] over a 30-year period between 1981-2010 are presented in Table 8.3.

Table 8.3: Observed climate conditions

Climate variables	Climate observations
Temperature	Mean annual temperatures vary from about 11.5 °C in central London and along the south coast to about 9.5°C over higher ground well inland. January is the coldest month, with mean daily minimum temperatures over 3 °C in London. July is the warmest month, with mean daily maximum temperatures in the London area of 23.5 °C, the highest in the UK. Extreme maximum temperatures can occur in July or August and are usually associated with heat waves lasting several days. An 'air frost' occurs when the temperature at 1.25 metres above the ground falls below 0 °C, whereas incidence of a 'ground frost' refers to a temperature below 0 °C measured on a grass surface. The average number of days with air frost in Southern England is less than 30 a year in London. There is an urban heat-island effect associated with London, caused by the fabric of the buildings retaining heat from day time insolation. This is most conspicuous overnight in cold spells with light winds from late autumn to early spring, when temperatures in central London can be over 5 °C higher than in the outer suburbs and surrounding rural areas. The heat-island is also evident in summer heat waves.
Rainfall	The Thames Valley, London and the north Kent coast normally receive less than 650 mm of rain per year, and less than 550mm around the Thames Estuary. These values can be compared with annual totals around 500 mm in the driest parts of eastern England and over 4000 mm in the western Scottish Highlands. Rainfall is generally well-distributed throughout the year but with an autumn/early winter maximum. In London and the Thames Valley, there

Climate variables	Climate observations
	are also significant amounts in the summer associated with showery, convective rainfall. In winter (December to February) there are 30 wet days (>1mm) around the Thames Estuary. In summer (June to August) there are about 25 wet days. Periods of prolonged rainfall can lead to widespread flooding, especially in winter and early spring when soils are usually near saturation. The region can be subject to dry periods that place demands upon water supplies and require conservation measures such as summer hosepipe bans. If a period with below average rainfall includes winter months as well as the high-demand summer months, then conditions can become severe as the winter is the normal recharge time not only for reservoirs but the chalk aquifers upon which much of the region relies for water supplies.
Wind	Southern England is one of the more sheltered parts of the UK, the windiest areas being in western and northern Britain, closer to the Atlantic. Over most inland areas of the region the average is around 1-2 days per year. Wind speed is sensitive to local topographic effects and land use. Places sheltered by hills or in extensive urban areas will have lower mean wind speeds and fewer days of gale but can have strong gusts. Coastal areas experience sea breezes from late spring through the summer, caused by the temperature differential between the sea and the warmer land. These sea breezes will often reach London, originating from either the North Sea or, occasionally, the English Channel.
Sunshine	In general, December is the dullest month and June the sunniest. Southern England includes the sunniest places in mainland UK, these being the coastal resorts of Sussex and Hampshire. The Isle of Wight also features in the list of high sunshine averages. On the coast average annual sunshine durations can exceed 1800 hours, but 1550-1600 hours is typical of most of the region with a decrease towards the north (e.g. less than 1500 hours over the higher Chilterns).
Snowfall	On average, the number of days with snow falling is about 12-15 per year over the lower lying areas but about 20 days over the higher ground. The number of days with snow lying has a similar distribution, with 5 days per year in most inland areas but over 10 days on the higher ground particularly to the east and north.

8.16. Table 8.4 shows the observed climate baseline for the southern (London) region for 1981-2000. These are determined using the observations from the Met Office UKCP18 database at a regional level. Summer is defined as the months of June, July and August. Winter is defined as the months of December, January and February.

Table 8.4: Observed climate baseline

Climate variables	Baseline (1981-2000)
Mean annual temperature (°C)	10.9
Mean summer temperature (°C)	17.1
Maximum summer temperature (°C)	21.9
Mean winter temperature (°C)	5.1
Minimum winter temperature (°C)	2.3
Mean summer precipitation (mm/ summer month)	48.2
Mean winter precipitation (mm/ winter month)	52.3
Mean annual wind speed (m/s)	3.5

8.17. The Environment Agency flood maps were used to determine the extent of current flooding. The Drinking Water Transfer Main Route Corridor passes through areas of existing Flood Zone 2 and 3, in the west of Uxbridge Moor (M25), Alder Bourne crossing, North of New Denham (A40), Harvil Road, and west of Bayhurst Wood Country Park. The raw water pumping station at the Wraysbury Tunnel Connection and Indicative WTW Site are not located in Flood Zones 2 or 3 (see Section 6.4.2.1).

8.18. Historic weather events that have occurred in the region include:

- Drought in 2010-2012 in southern England resulting in difficult farming conditions, low river and groundwater levels and fires.
- Snow and low temperatures in February 2018 resulting in travel disruption and power cuts.
- Eight named storms over the 2018/2019 winter bringing high winds and heavy rainfall, resulting in travel disruption, flooding and power cuts.
- Heatwave in August 2020 with temperatures reaching 34°C, resulting in fires, heat-related health issues, and thunderstorms.
- Storm Eunice in February 2022 resulting in damages to buildings, fallen trees and flooding.

- Heatwave in July 2022 with temperatures reaching 38.9°C in Iver, resulting in heat-related health issues, fires, and travel disruption.
- Drought in July/August 2022 resulting in difficult farming conditions, low river and groundwater levels, untreated sewer discharges to water bodies, and fires.

8.2.2.2 Climate projections

8.19. The UKCP18 probabilistic projection dataset[65] developed by the Met Office Hadley Centre has been used to obtain future climate projections for southern (London) region. A baseline period of 1981-2000 has been used and the RCP8.5[66] emission scenario has been selected based on a precautionary approach. Three probabilities of change have been selected to show the ranges of outcomes; low, central and high change corresponding to 10th percentile, 50th percentile and 90th percentile, respectively.

8.20. The project is anticipated to be operational from 2039 and the WRSE Regional Plan considers a design life to 2100, so therefore the assessment presents projections to the end of the century, covering the period 2080-2099. Climate projections for London are presented in Table 8.5.

Table 8.5: Climate projections

Climate variables	Baseline (1981-2000)	Projected change 10th % 2080-2099 (RCP8.5)	Total projected (RCP8.5)	Projected change 50th % 2080-2099 (RCP8.5)	Total projected (RCP8.5)	Projected change 90th % 2080-2099 (RCP8.5)	Total projected (RCP8.5)
Mean annual temperature (°C)	10.9	+2	12.9	+4.3	15.2	+6.5	17.4

[65] The UKCP18 product selected for use in this assessment is the probabilistic projections. Probabilistic projections present a range of values for climate variables, based on the output of multiple runs of multiple climate models. Met Office, UKCP18 Guidance: How to use the UKCP18 land projections. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---how-to-use-the-land-projections.pdf. [Accessed April 2022]

[66] Representative Concentration Pathways (RCP8.5) are a method for capturing the assumptions about the economic, social and physical changes within a set of scenarios. Different pathways result in a different range of global mean temperature increases over the 21st century. Met Office, UKCP18 Guidance: Representative Concentration Pathways. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---representative-concentration-pathways.pdf. [Accessed April 2022]

Climate variables	Baseline (1981-2000)	Projected change 10th % 2080-2099 (RCP8.5)	Total projected (RCP8.5)	Projected change 50th % 2080-2099 (RCP8.5)	Total projected (RCP8.5)	Projected change 90th % 2080-2099 (RCP8.5)	Total projected (RCP8.5)
Mean summer temperature (ºC)	17.1	+2.9	20	+5.7	23.8	+8.6	25.7
Maximum summer temperature (ºC)	21.9	+3	24.9	+6.4	28.3	+10.1	32
Mean winter temperature (ºC)	5.1	+1.5	6.6	+3.6	8.7	+5.8	10.9
Minimum winter temperature (ºC)	2.3	+1.4	3.7	+3.6	5.9	+6.3	8.6
Mean summer precipitation (mm/summer month)	48.2	-76.1%	84.9	-40%	8.7	-1.7%	47.4
Mean winter precipitation (mm/winter month)	52.3	-2.7%	50.9	+24%	64.9	+55.4%	81.3

Climate variables	Baseline (1981-2000)	Projected change 2080-2099 (RCP8.5)[67]	Total projected (RCP8.5)
Mean annual wind speed (m/s)	3.5	-0.18	3.32

[67] Wind speed projections are only accessed at the global projections (regional) dataset up to 2100 (cannot be accessed using the probabilistic projections). There are no percentage probabilities with this dataset, and so is

8.21. The UKCP18 projections indicate that in the period 2080-2099, temperatures in London are projected to increase across the year. Precipitation is projected to vary seasonally, with an increase in winter and decrease in summer. Although summers are projected to become drier overall, more intense rainfall events are anticipated. Although winters are projected to become warmer overall, extreme low temperature events are anticipated to still occur. These projections are generally aligned to those identified across the UK where summers are projected to be hotter and drier, and winters wetter and warmer.

8.2.3 Appraisal outcomes

8.22. Appendix B presents the results of the risk assessment for a range of physical climate risks for the Lower Thames Reservoir Option. A summary of the highest scoring risks is provided below.

8.23. Impacts of higher summer temperatures include the potential that pipe / cabling material would be exposed to increased solar radiation (UV) and may deteriorate at a faster rate, cracking, strength loss and more rapid deterioration of concrete due to high temperatures. Additionally, there is the potential for pipejack / microtunnels crossings made from concrete to face cracking, strength loss and rapid deterioration due to high temperatures. As well as this, there is the potential that chemical and mechanical processes/equipment may exceed their operational temperature limit resulting in shut down and brake pressure tank capacity not able to cope with increased demand in the future due to increases in temperature.

8.24. Impacts of extreme low-temperature events include the potential that pipe and cabling material would be exposed to air frost and extreme cold temperatures/ice leading to deterioration of materials.

8.25. Higher annual and winter rainfall and more extreme rainfall events throughout the year may impact the Lower Thames Reservoir Option as high rainfall levels can cause swelling of the ground surrounding the pipe and lead to instability, risk of corrosion of pipe and cable materials. The Drinking Water Transfer Main Route Corridor through areas of existing Flood Zone 2 and 3 in the west of Uxbridge Moor (M25), Alder Bourne crossing. North of New Denham (A40), Harvil Road, and west of Bayhurst Wood Country Park. Flood risk in this area is likely to be exacerbated with higher winter rainfall and more extreme rainfall events throughout the year and may cause ground instability and issues with access to the pipes. Flood water may seep

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presented in a separate table to the rest of the climate variables. Met Office, UKCP18 Factsheet: Wind. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-wind_march21.pdf [Accessed April 2022] into the pipe and contaminate supply, however this is low risk as it is a buried pipe. It is also possible that flooding events could raise river levels and damage the pipe jack/micro tunnelling if there is not enough clearance. Additionally, capacity at the Indicative WTW Site may be exceeded due to increased incoming flows during periods of heavy rain leading to discharge into nearby watercourses.

8.26. Drier summers can impact soil, drought may have an impact on the stability/properties. There is a risk of ground cracking/shrinkage due to drought and can cause instability issues. Shrinkage and desiccation of ground leading to cracks, strength loss and instability, which may affect the foundations of the microtunnel crossings and the Indicative WTW Site. If there is a drought, site operations at the Indicative WTW Site may be affected as the site uses potable water.

8.27. The construction phase of the scheme will be impacted by climate change and as such consideration of the impacts and mitigations are to be included in the CEMP. As the construction methods are unknown at this stage, it is not possible to provide a detailed assessment of impacts and mitigation. A high-level list of potential construction impacts and mitigation for all assets (transfer pipelines, new WTW and raw water pumping station) are provided in Table 8.6.

Table 8.6: Potential construction impacts and mitigation measures

Potential impact	Potential mitigation measures
Flooding and heavy rain	
Programme delays due to increased frequency of site shutdowns	Contractor to be on Flood Watch at all times and to have a Flood Response Plan prepared for the construction phase Contingency plans for situations where flooding leads to restricted site access or key staff being unable to get to work, leading to construction delays.
Damage to equipment (plant, power generators, site cabins) and construction	Contingency plans for situations where storms, high winds or flooding lead to loss of mains power supply or communications, and the identification of safety critical and construction programme consequences.
Dangerous working conditions for staff (ground instability)	Workforce health and safety plans and welfare management systems to be put in place by the contractor, including details to be outlined within works plans and task briefs as appropriate. These should consider flooding which may lead to injury to construction staff due to slips and falls, especially for construction staff working in exposed locations at a distance from welfare facilities.
Site surface run-off (pollutants) contaminating rivers and groundwater	Procedures and precautions to be implemented in case of flooding, including temporary demobilisation plans. These procedures should consider prolonged and intense rainfall events that may lead to staff safety risks or pollution risks where construction materials (e.g. dust,

Potential impact	Potential mitigation measures
	contaminants, metals, or oils) have potential to runoff into watercourses. This should consider likely surface water runoff routes and plans for the protection of plant such as fuel storage and materials stockpiles or demobilisation of vehicles and items of mobile plant.
Additional costs to repair damages following flooding/heavy rainfall	Procedures and precautions to be implemented in case of flooding, including temporary demobilisation plans. Ensuring that all plant is stored in an area of site that is less susceptible to flooding to limit the equipment damage. Utilise sand bags on site and temporary flood prevention.
Wet conditions causing issues with earthworks and compaction methods	Flooding and high rainfall will affect the earthworks. Ensure that procedures are in place to demobilise construction vehicles. Use trenchless technology where possible to install the pipeline to minimise the impacts of a flood/heavy rainfall on the construction. This will also limit the impact of the scheme on the flood risk in the area.
Heatwaves and drought	
Dry conditions causing issues with earthworks and compaction methods	Hot temperatures and drought causes the soil moisture content of the soil to decrease, leading to issues with earthworks and compaction. Ensure that bowsers are on site to enable compaction works to continue.
Lack of potable water on site due to increase in demand	Prepare contingency plans for water shortages to ensure that a supply of water is available.
Dangerous working conditions for staff (heat-related injuries)	Workforce health and safety plans and welfare management systems to be put in place by the contractor, including details to be outlined within works plans and task briefs as appropriate. These should consider high temperatures, which may lead to risks of heatstroke, especially for construction staff working in exposed locations at a distance from welfare facilities.
Operating temperatures of construction equipment exceeded (plant, power generators)	Ensure cooling procedures are in place and utilised to enable continued operation of machinery (coolant, air circulation, shade).
Extreme weather (storms, wind, ice)	
Additional costs to repair damages following storms/wind	Procedures and precautions to be implemented in case of extreme weather, including temporary demobilisation plans.

Potential impact	Potential mitigation measures
	Ensuring that all plant is stored in an area of site that is less susceptible to wind to limit the equipment damage.
Site equipment (plant, power generators) freezing	Contingency plans for situations where freezing temperatures including battery warmers and oil heaters.
Icy/snow conditions causing issues with earthworks and compaction methods	Icy and snowy conditions will affect the earthworks. Ensure that procedures are in place to demobilise construction vehicles.
Programme delays due to increased frequency of site shutdowns	Contingency plans for situations where extreme weather leads to restricted site access or key staff being unable to get to work, leading to construction delays.
Dangerous working conditions for staff (risk of airborne debris)	Workforce health and safety plans and welfare management systems to be put in place by the contractor, including details to be outlined within works plans and task briefs as appropriate. These should consider both low temperatures, snow and ice which may lead to injury to construction staff due to slips and falls, especially for construction staff working in exposed locations at a distance from welfare facilities.

8.2.4 Recommended mitigation

8.28. It is recommended that the risks identified above are mitigated by considering the changes in climate in the designs of the pipeline and assets at a subsequent project stage. This includes planning for a higher range of thermal variation, increased flood risk and ground movement.

8.29. Construction mitigation measures are provided in Section 8.2.3. Design related mitigation measures could be implemented to reduce the impact of the Lower Thames Reservoir Option on the climate including the following.

- Structural elements to be designed to include thermal expansion and greater thermal variation specification to account for climate change.
- Pipe design and choice of materials to consider temperature variation.
- Materials selection and specification to consider future temperatures. Monitor and adjust the curing process of the concrete accordingly in order to minimise the risk of high temperatures on the deterioration rate of the structure.

- Consider nature based solutions to provide shade and reduce temperature.
- Locate pipeline access points in areas where there is low risk of flooding. Ensure pipe design and cover is enough to withstand seepage from flooding into the pipes.
- Ensure that ground movements are monitored and repaired when necessary to avoid further damage. Consider the changes in soil moisture in the pipe bedding material specification.
- Additional protective measures to be implemented to ensure that the pipes and cabling are sufficiently protected to reduce the corrosion rates. Selection of materials to consider future rainfall regime.
- Ensure that drainage capacity is designed to limit the flooding at the structure and account for future increased rainfall. Ensure that the foundations are not susceptible to seepage due to poor drainage.

8.3 Carbon footprinting assessment

8.30. Technical Supporting Document A3a, Carbon Strategy Report, should be referred to for estimated capital and operational carbon impacts, whole life carbon emissions and carbon mitigation strategies. A summary is provided in this section.

8.3.1 Methodology

8.31. Technical Supporting Document A3a, Carbon Strategy Report sets out the methodology for the carbon assessment undertaken for Gate 2. In summary, PAS 2080 principles were used in the approach to carbon management, which included understanding the baseline carbon impact of the scheme through quantifying its carbon impact, using a quantified assessment to establish carbon hotspots and then prioritising design mitigation efforts at the carbon hotspot areas. All carbon footprints presented are in CO_2 equivalents, meaning that the global warming potential of all six greenhouse gasses have been allowed for.

8.32. Efforts have been prioritised to reduce emissions rather than focus on an emissions mitigation plan. It is acknowledged that a significant proportion of emissions in construction and operation are considered Scope 3 emissions and outside of the direct control of the companies and designers delivering the Lower Thames Reservoir Option. However, it is also acknowledged that there is a significant opportunity to work with the supply chain prior to the delivery of the scheme to support accelerated decarbonisation of external systems and supply chains to help reduce the carbon impact of the scheme. The IEMA emissions reduction hierarchy[68] has been followed to identify opportunities to mitigate carbon impacts of the scheme. This aligns well with the carbon reduction hierarchy from PAS2080 and helps focus efforts on reducing emissions rather than offsetting them.

8.33. The carbon mitigation strategy has focussed efforts during Gate 2 on areas where the largest and most efficient reductions can be made. This has been informed through updating the baseline quantification with the latest design information for the scheme to identify the key capital and operational carbon hotspots for the scheme.

8.34. The mitigation efforts have been split into two areas:

- Opportunities directly under the control of the design team, including areas which can reduce emissions through design decisions that can be embedded and costed into the scheme.
- Longer term opportunities where the scheme and sector can influence external systems and supply chains to decarbonise major components of the scheme – these longer-term mitigation opportunities have been covered by a collaborative project commissioned by the All Company Working Group (ACWG) which has identified a consistent view across SROs how these external systems may decarbonise in the future to inform future decarbonisation potential and engagement priorities for individual SROs.

8.35. An assessment of carbon contributions and opportunities for net zero was undertaken at Gate 1, which resulted in identifying the options with the highest carbon footprints. For RAPID Gate 2, the following have been undertaken:

- Develop overall evidence-based carbon reduction strategy, that will continue to update assessments and challenge hotspots at later Gate stages
- Carbon design challenge workshops
- Identification of carbon mitigation measures to embed into current design
- Develop carbon mitigation plan for subsequent project stages

8.3.2 Appraisal outcomes

8.36. Whole life carbon emissions were assessed over 80 years, to include a 6-year planning and development period followed by a 5-year construction period ending in 2038. Operational carbon and capital carbon replacement emissions are assumed to start after the 5-year construction period. Table 8.7 summarises the estimated

[68] Institute of Environmental Management and Assessment (2020) Pathways to Net Zero: Using the IEMA GHG Management Hierarchy. Available at: https://www.iema.net/resources/reading-room/2020/11/26/pathways-to-net-zero-using-the-iema-ghg-management-hierarchy-november-2020 [Accessed August 2022]

whole life carbon impacts of the Lower Thames Reservoir Option.

8.37. Full details of the carbon values are reported in Technical Supporting Document A3a, Carbon Strategy Report.

Table 8.7: Summary of the whole life carbon emissions of the Lower Thames Reservoir Option

	50Ml/d	% of total emissions*	100Ml/d	% of total emissions*
Capital (tCO2e)	25,800	46%	43,700	45%
Capital replacements (tCO2e)	18,400	33%	35,500	37%
Operational power (tCO2e)	10,500	19%	16,000	17%
Operational chemicals (tCO2e)	160	0.3%	340	0.4%
Land use change (tCO_2e)	880	1.6%	880	0.9%
Total (tCO2e)	55,740		96,420	

* Columns do not add up to 100% due to rounding of values

8.38. The majority of the capital carbon sits within the construction associated with the transfer pipelines and WTW. The capital carbon emissions associated with pipeline construction result predominantly from the embodied carbon (Scope 3) of the pipe material itself, with backfill/reinstatement (Scope 3) being the next hotspot followed by the emissions from excavation (Scope 1 for the contractor), all contributing less than 20% of emissions. The capital carbon emissions for the WTW were driven by aspects of the treatment process that comprise of predominantly civil components such as potable water storage, clarifiers and filtration. These assets are dominated by concrete and steel reinforcement in the structures, at this stage the embodied carbon of these materials (Scope 3) has been estimated based on typical UK concrete mixes and standard reinforcement quantities. Power consumption for pumping is the significant contributor to operational emissions.

8.39. Full details of the carbon hotspots are reported in Technical Supporting Document A3a, Carbon Strategy Report.

8.3.3 Recommended mitigation

8.40. Capital and operational carbon mitigation strategies are presented in Technical Supporting Document A3a, Carbon Strategy Report, and a summary is provided below.

8.3.3.1 Capital carbon mitigation opportunities

8.41. The Lower Thames Reservoir Option has varying opportunities for carbon reduction in the design of the scheme notably, material selection, dimensions, crossings, installation method and treatment processes, which are outlined below.

- [Substitute] Material selection: This accounts for around half of capital emissions. Ductile Iron (DI) has a relatively high carbon intensity per metre unit length of pipe material compared to steel and composite pipes, such as glass fibre reinforced plastic (GRP). This should be explored at subsequent project stages.
- [Reduce] Water treatment works: Processes have been optimised from Gate 1 to reduce the land footprint, such as use of lamella clarifiers from dissolved air flotation. However, there is opportunity to optimise the design of chosen construction material to reduce use of high carbon materials such as concrete or allow for lower carbon materials at subsequent project stages.
- [Reduce] Pipe size (diameter): The pipeline diameter has been calculated and optimised and selected based on 100% utilisation at 100% capacity. There is the opportunity for further review with additional optimisation profiles at subsequent project stages, if the expected utilisation were different. This could result in a smaller diameter pipe and lead to capital carbon savings through both material and installation savings.
- [Reduce] Infrastructure crossings: The number of open cut crossings has been minimised predominantly to reduce disruption to the traffic network and the riverine environment. Major crossings would be trenchless (micro-tunnelling) with shafts at either end of the crossing. Based on current information, there are deemed to be no feasible alternative installation methods. However, consideration could be given at subsequent project stages to not installing dual tunnels at every trenchless crossing.
- [Substitute] Backfill and reinstatement: Where possible, use of as-dug material will be used for backfilling. To not overstate the carbon savings, the Gate 2 carbon assessment has assumed imported backfill for the pipe surround and as-dug material for the remaining trench, except where traversing through contaminated ground (where all backfill is assumed to be imported). Once further detail is known at subsequent project stages, an updated assessment of the imported material required for the pipeline can be made and could potentially lead to carbon savings.
- [Substitute] Electricity supply provision: At Gate 2, pumping stations have been designed to have dual supply. There is the opportunity to optimise this to single

supply for the high and low-lift pump stations along the pipelines. This could be explored at a subsequent project stage where discussions need to account for the risk to the operation of the scheme and the balance of carbon emissions associated with bringing standby generation capacity as required.

- [Reduce] Waste minimisation: Adopting construction techniques, e.g. modular or off-site manufacture options could help reduce the amount of waste associated with construction projects, whilst potentially reducing carbon emissions, improving health and safety and overall operational performance of assets. Having a robust waste management plan and engaging other potential users of surplus excavations could help reduce emissions associated with waste disposal.

8.42. The route of the Lower Thames Reservoir Option pipeline is deemed to be the shortest practicable and is unlikely to change significantly in subsequent project stages and has therefore not been relied upon for carbon savings.

8.3.3.2 Operational carbon mitigation opportunities

8.43. Operational carbon mitigation will largely depend on procurement partners and supply chain. As with the capital carbon, hotspot analysis was conducted at Gate 1 based on various assumptions.

8.44. Reducing operational carbon will be based on the following hotspot mitigation areas.

- Sweetening flow scenario: Testing low flow scenarios to allow for a reduction in minimum flow could offer carbon savings through reduction in chemical and energy requirements. However, any reduction in the minimum flow to supply provided by the Lower Thames Reservoir Option would need to be made up for by increasing the supply from other sources. The net reduction in operational carbon or the network, would therefore be less than the savings presented for the Lower Thames Reservoir Option.

  Optimising energy efficiency and maintenance activities to prolong asset life/ performance: Capital replacements form a sizeable proportion of the carbon footprint, and therefore exploring materials and plants which last longer could provide carbon savings. For example, consideration could be given to utilising new LED UV lamps, which have a lower energy consumption and longer design lives.

- Low carbon power generation and decarbonised electricity procurement choices: Organisations can also procure green electricity through their suppliers, which when market-based reporting can be used to zero out the power generation emissions of grid electricity. This requires the purchase of Renewable Energy Guarantees of Origin (REGO) certificates and comes at a premium over standard electricity tariffs in most cases.

- Renewable energy generation: There are opportunities to generate renewable energy through installation of solar panels and wind turbines across the Lower Thames Reservoir Option. Areas considered to date have been:
  - Solar panels installed on the process units of the water treatment works provided the technology improves to reduce leakage issues with tank roofs as has been noticed in previous projects. Hence this relies on technology developments to enable the opportunity.
  - Wind turbines at the service reservoir in the vicinity of Harefield since it is on elevated ground however this is not a prospect solely for T2AT and should explored with other stakeholders at subsequent project stages.

8.4 Summary of main findings and recommendations for future technical work

8.4.1 Climate change risk assessment

8.45. The main climatic risks are:

- Flood risk being exacerbated by climate change and negatively impacting the pipeline.
- Higher temperatures and drought, leading to desiccation of soil, loss of strength, ground movement and damage to WTW/pumping station foundations and pipeline bedding.
- WTW/pumping station operational temperature limits being exceeded leading to shut downs.

8.46. It is recommended that these measures are mitigated by considering the changes in climate in the designs of the pipeline and assets. This includes planning for a higher range of thermal variation, increased flood risk and ground movement.

8.47. The assessment carried out is a high-level risk screening exercise. Further assessment should be carried out at a subsequent project stage and will include a greater range of climate variables and assets and a more detailed assessment of the risks and mitigation measures.

8.4.2 Carbon footprinting assessment

8.48. The Lower Thames Reservoir Option would have both capital and operational carbon emissions. The majority of the capital carbon sits within the construction associated with the transfer pipelines and WTW. The capital carbon emissions associated with pipeline construction result predominantly from the pipe material itself, with backfill/reinstatement and excavation also contributing to emissions. The capital carbon emissions for the WTW were driven by aspects of the treatment process that comprise of predominantly civil components such as potable water storage, clarifiers and filtration. Power consumption for pumping is the significant contributor to operational emissions with emissions from chemicals result in less than 1% of operational emissions. It is recommended that these opportunities are investigated further at a subsequent project stage.

8.49. Opportunities that could be taken to decarbonise and drive towards net zero for capital carbon include material selection, optimising the design of the WTW to reduce use of high carbon materials, reducing pipe size diameter, consideration given to not installing dual tunnels at every trenchless crossing, reviewing backfill and reinstatement to reduce the amount of imported material required, consideration given to single rather than dual supply for pumping stations and waste minimisation, e.g. through use of modular or off-site manufacture options. For operational carbon, opportunities include optimising energy efficiency and maintenance activities to prolong asset life/ performance, low carbon power generation and decarbonised electricity procurement choices and renewable energy generation.

9 Landscape

9.1 Introduction

9.1. This section presents a desk-based assessment undertaken to describe the landscape baseline for the Lower Thames Reservoir Option based on published data. On the basis of the baseline, potential landscape impacts were identified for the transfer corridors and above ground infrastructure including the WTW. Potential impacts on protected trees were also considered.

9.2. The need to consider landscape and arboriculture is driven by national planning policy (draft NPS for Water Resource Infrastructure[20] (Section 4.9, Landscape and visual impacts) and NPPF (Section 15, Conserving and enhancing the natural environment, paragraphs 174 and 180[21]).

9.2 Methodology

9.2.1 Study area and sources of information

9.3. The landscape desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within a maximum 1km distance of the Lower Thames Reservoir Option. It is considered that 1km is sufficient for this stage as the desk based assessment focusses on landscape.

9.4. Protected trees were considered within 100m of the transfer route corridors and associated above ground infrastructure to identify potential design conflicts with arboricultural features.

9.5. The baseline data sources which were collated and considered in the desk-based assessment include, but are not limited to, those set out in Table 9.1 below.

Table 9.1: Sources of information (landscape)

Data collected	Source
Designations including National Park, Area of Outstanding Natural Beauty (AONB), Ancient woodland, agricultural land classifications, areas of high landscape value	Natural England, local planning authorities

Data collected	Source
Historic environment including conservation areas, listed buildings, scheduled monuments, Registered Parks and Gardens Parks Historic landscape characterisation historic hedgerows, historic field patterns	Information on the assets that are relevant to the historic environment desk based assessment (DBA) were sourced from the historic environment DBA team, to ensure consistency. Information on assets not relevant to the historic environment DBA team were sourced from aerial photography, historic maps, published historic landscape character documentation.
Public rights of way (PRoWs) including footpaths, bridleways, cycle paths	Local planning authorities, SUSTRANS, OS mapping
Published landscape and townscape character assessments and National Landscape Character Area Profiles	Local planning authorities, GOV.UK
Topography	LiDAR data from the Environment Agency database
Tranquillity and light pollution data	Council for Protection of Rural England
Existing vegetation	Aerial photography, OS mapping
Green infrastructure including country parks, formal parks, areas of recreation green space	OS Mapping, Local plans and local planning authorities
Ancient and Veteran Trees	Ancient Tree Inventory
Tree Preservation Orders (TPOs)	Local Planning Authorities

9.2.2 Approach to impact appraisal

9.6. The methodology was based on the Guidelines for Landscape and Visual Impact Assessment Third Edition (GLVIA 3), published by the Landscape Institute and Institute of Environmental Management and Assessment in 2013.

9.7. The desk based landscape baseline study considered the constituent elements, features and other factors that contribute to existing landscape character within the study area including:

- the physical influences on the landscape resource, including topography, geology, soils, microclimate, water bodies and water courses;
- the influence of human activity, including land use, open space, transport routes, PRoWs, national trails, historic green lanes, land management, the character of settlement and buildings and the pattern and type of fields and enclosure;
- the aesthetic and perceptual aspects of the landscape, including scale, complexity, openness, tranquillity, and wildness; and
- heritage features, including conservation areas, listed buildings, registered parks and gardens and other elements contributing to historic landscape character.

9.8. The findings were reviewed in conjunction with published landscape character assessments, to identify local landscape character areas.

9.9. The appraisal recognised the difference between impacts occurring at the construction phase and those occurring at the operational phase

9.10. Where appropriate, high-level mitigation measures were suggested to avoid or reduce potential impacts.

9.2.3 Assumptions and limitations

9.11. The information presented within this desk based assessment was sourced via the most up-to-date online records and from project data available at the time of writing. TPO data was sourced from Local Planning Authorities and where this was not possible, via the most up-to-date online records. Since this is a desk-based study, the findings can only be based on the information available at the time of the study and it is assumed that the information sourced is accurate.

9.12. The TPO for South Buckinghamshire was not available at the time of this desk-based assessment. Therefore, proximity and potential impacts on TPOs by the proposed works within this district have not been assessed.

9.13. A site survey was not undertaken as part of this desk-based assessment.

9.14. A Zone of Theoretical Visibility (ZTV) map was not produced as part of this desk-based assessment as there is insufficient design information to model the ZTV at this stage.

9.15. Consideration of visual amenity in this desk based assessment identified protected and designated views within the study area. A high level visual baseline is given in

Section 9.3.4 to identify the nature of visual receptors in the study area. However, visual amenity for individual and groups of receptors including residential, recreational and workplace receptors has not been considered. An assessment of visual amenity to inform a more detailed assessment would require more detailed design information, production of a ZTV and confirmation by site survey would follow at a subsequent project stage.

9.3 Understanding of the baseline

9.3.1 Landscape assets and designations

9.16. There are no statutory landscape designations within the study area. There are a number of nature conservation and heritage designations within the study area including registered parks and gardens, conservation areas, sites of special scientific interest and scheduled monuments. Landscape assets and designations relevant to defining landscape character are presented on Figure 9.1: Landscape Assets and Designations and where relevant, referred to in the local landscape character area descriptions in the sections below. Descriptions of the other designations within the study area can be found in Chapter 4, Biodiversity, Flora and Fauna, Chapter 10, Historic Environment, Chapter 12, Population and Human Health and Chapter 13, Material Assets.

9.3.2 National Character Areas

9.17. The Lower Thames Reservoir Option lies within the Thames Valley National Character Area (NCA 115: Thames Valley)[69].

9.18. The Thames Valley is a mainly low-lying, wedge-shaped area, widening from Reading, which includes Slough, Windsor, the Colne Valley and the southwest London fringes. The River Thames provides a unifying feature through a very diverse landscape of urban and suburban settlements, infrastructure networks, fragmented agricultural land, historic parks, commons, woodland, reservoirs and extensive minerals workings. Hydrological features dominate the Thames Valley, and include the Thames and its tributaries, part of the Grand Union Canal and the reservoirs which form the South-West London Waterbodies SPA and Ramsar site. These features provide essential water supply services for London and the surrounds, as well as being important areas for wildlife and recreation in an essentially urban landscape.

[69] National Character Area Profile 115: Thames Valley – NE379. Available at: https://nationalcharacterareas.co.uk/thames-valley/ [Accessed October 2022]

Flows and water levels in the River Thames are managed by a series of locks and structures upstream of Teddington. Flood defence and water quality improvement measures, such as the restoration of wetlands for flood management, provide opportunities for biodiversity and recreation.

9.19. Despite its urban character, the area is environmentally important and 6 per cent of it is covered by its 38 SSSIs. It has significant amounts of broadleaved woodland, much of it ancient, including Burnham Beeches, Windsor Forest and Great Park, and the Richmond Park SAC.

9.20. The following key characteristics are identified in the National Character Area description.

- Flat and low-lying land, rising to low, river-terraced hills, which include the prominent local outcrop of chalk on which Windsor Castle sits.
- The underlying geology is dominated by the London Clay which, over much of the area, is overlain by river-lain sands and gravels.
- The numerous hydrological features provide unity to an area which otherwise lacks homogeny; these features include the River Thames and its tributaries, streams, lakes, canals and open waterbodies (the result of restored gravel workings).
- Woodlands characterise the north-western area, with the wooded character extending up to the southern edge of the Chiltern Hills.
- Farming is limited. Where it survives, grazed pasture is the major land use within a generally open, flat and featureless landscape. The field pattern is medium-scale and irregular, with smaller fields to the west. Localised areas of species-rich hay meadows provide a splash of colour in summer.
- Although densely populated and developed, pockets of woodland, open grassland, parkland, wetlands and intimate meadows provide escape and tranquillity, and include a variety of habitats supporting important populations of many species, notably stag beetle, shoveler, gadwall and other invertebrates and wildfowl.
- Towards London in the east, the natural character of the area is overtaken by urban influences: a dense network of roads (including the M25 corridor), Heathrow Airport, railway lines, golf courses, pylon lines, reservoirs, extensive mineral extraction and numerous flooded gravel pits.
- There are small but biologically important areas of lowland heathland – especially on higher sandy ground in the north – and a small area to the south falls within the Thames Basin Heaths SPA buffer zone.
- To the south, the open Thames flood plain dominates, with its associated flat grazing land, becoming characterised by a number of formal historic landscapes on higher ground. Between Hampton and Kew, the River Thames forms the focus of a series of designed landscapes;

- The area has an urban character, and there are very few villages of more traditional character, although almost half of the area is green belt land and development has been restricted in areas like Crown Estate land.
- The river is closely associated with numerous historic places and cultural events, such as the signing of Magna Carta at Runnymede. Tourists from all over the world are drawn to the rich heritage of the area, flocking to attractions like Hampton Court Palace and Windsor Castle;
- The area is important for recreation, both for residents and visitors. Historic parkland and commons provide access to green space, the Thames Path National Trail runs the length of the National Character Area, and a variety of activities are enjoyed on the river and other waterbodies.

9.3.3 Local landscape character assessments

9.21. Local landscape character assessments were reviewed for South Buckinghamshire[70], London Natural Signatures[71] and the Colne Valley[72]. The landscape character areas relevant to the Lower Thames Reservoir Option are presented in Table 9.2, Table 9.3 and Table 9.4 respectively, and shown on Figure 9.2: South Buckinghamshire and London Natural Signatures Landscape Character Areas, and Figure 9.3: Colne Valley Landscape Character Assessment.

Table 9.2: South Bucks District Landscape Character Assessment (2011)

Landscape Character Area	Key characteristics
Iver Heath	• Transitional lowland topography, gradually rising towards the north. A sloping landscape, ranging approximately between 40m to 70m. • Underlain by Thames River Terrace Deposits, with Boyn Hill Gravel Formation covering the lower southern section. • Mixed land cover highly influenced by development and dominated by settlement such as the villages of Iver and Iver Heath.

[70] South Bucks District Landscape Character Assessment, prepared for Buckinghamshire County Council and South Bucks District Council by Land Use Consultants, October 2011. Available at: https://www.buckinghamshire.gov.uk/planning-and-building-control/planning-policy/landscape-character-assessments/ [Accessed April 2022]
[71] Natural England (2011) London's Natural Signatures. Available at: http://publications.naturalengland.org.uk/publication/6540238365130752 [Accessed April 2022]
[72] Colne Valley Landscape Character Assessment, , prepared by Alison Farmer Associates on behalf of Colne Valley Landscape Partnership, August 2017. Available at https://www.colnevalleypark.org.uk/wp-content/uploads/2019/05/Landscape-Character-Assessment-FinalReport-21Sept2017.pdf [Accessed April 2022]

Landscape Character Area	Key characteristics
	• Between settlements there are large open arable fields divided by a network of hedgerows and hedgerow trees. Smaller subdivisions are used for horse paddocks. • Fields are 20th Century enclosures, and pre 18th Century irregular enclosure. • Some dispersed archaeological remains include; a ploughed moat, Roman and Iron Age crop marks, and Thorney Lane Bridge (built 1835-38). • The landscape is cut by roads including the M25 creating local audible and visual impacts with a strong sense of movement. • Land use is varied with some industrial and business areas located in the south, a high voltage pylon line running along the railway line, and Pinewood Studios in the north, occupying the grounds of Heatherden Hall, a Grade II Victorian Country House. • This is a discordant landscape which often lacks unity. • Long extensive views across open fields, particularly south, over lower landscapes. Settlement sometimes limits and fragments views.
Colne Valley	• Flat, wide lowland floodplain, with very little topographic variation, on alluvium and loamy/clayey floodplain soils, with naturally high groundwater levels. • Dominated by rough grazing and pasture, interspersed with arable fields and paddocks. Predominantly geometric field patterns, enclosed by low hedgerows. • Tree cover is sparse, and largely confined to field boundaries. Small ancient woodlands are occasionally found in the north, close to settlement. • Three small settlements, Denham village, New Denham/Willowbank and Denham Green, are located in the north of the area. Denham has retained a strong historical character with numerous vernacular building. Elsewhere settlement density is low, comprising isolated farmsteads and occasional small, nucleated hamlets. • Gravel extraction has shaped the landscape, with former gravel pits restored into a string of water bodies. A network of meandering rivers and streams, occupy the floodplain, and the River Colne runs largely along the east boundary. These provide a valuable wildlife resource and recreational opportunity. • Fields are a mix of pre 18th century irregular and 20th century regular enclosures. • Grade II listed historic parkland located at Denham Place, north of Denham, a late 17th century country house surrounded by an 18th century landscaped park.

Landscape Character Area	Key characteristics
	• Numerous archaeological remains, including a Roman cemetery, and a number of Upper Palaeolithic and Mesolithic remains are located within the north of the area, closely associated with Denham. • Transport corridors cut the landscape including the M25, M40, which have a strong visual and audible influence. Screening earthworks are associated with these in places. Two railway lines also cross the area. • The area lies within the Colne Valley Regional Park and a well-established network of PRoWs exists, including the Colne Valley Way, the Grand Union Canal Walk, the Beeches Way and the South Bucks Way. • A number of golf courses are located along the floodplain, including Denham Court, within the site of a former 18th century manor house. • Intermittent long views are afforded across open fields and across the Colne Valley; however views are often interrupted by roads. Extensive views towards this landscape from the adjacent Hillingdon District. • Roads and pylons fragment an otherwise simple landscape and generate a discordant and busy character. Away from these areas, pockets of tranquillity remain associated with water and woodland.

Table 9.3: London Natural Signatures Landscape Character Assessment (2011)

Landscape Character Area	Key characteristics
Ruislip Plateau	• Remnant ancient woodlands with subtle variations in the mix of species and woodland structure which echo the underlying geology and history of the area. • Hornbeam coppice, glades and bluebell – the product of years of traditional woodland management – reflecting links between local culture and economy. • Wildflower meadows enclosed by species-rich hedgerows. • Field ponds. • Ancient, gnarled hedgerow oak trees. • Shady woodland paths, with carpets of moss. • Decaying fallen trees – a reminder of slow, gradual natural change.
Colne River Valley	• Opportunities for river restoration, particularly within water meadows and wet woodlands. • Seasonal transition – between wet and dry areas, as water ebbs and flows. • Meandering waterways, traces of former channels and oxbows.

	• Views across the river floodplain – water, meadow and woodland. • Effects of quarrying. • Chalk streams – rare, exceptionally diverse flora and fauna.

Table 9.4: Colne Valley Landscape Character Assessment (2017)

Landscape Character Area	Key characteristics
Misbourne and Alder Bourne Tributaries – Valley Sides	• Narrow and small scale valleys with gentle valley sides and narrow floodplain. • London Clay on upper slopes, chalk on middle slopes and alluvium on valley floor. • River deposits on higher land between the valleys gives rise to loamy/clayey soils. • Small scale landscapes comprising a mosaic of woodland and farmland and some patches of acidic vegetation on the terrace between the valleys. • Important areas of wet meadow and small water bodies on the floodplain reflecting the slowly permeable loamy/clayey soils. • Farmed landscape comprising rough grazing, pasture and paddock with some arable. • Notable areas of deciduous broadleaved woodland on the middle and upper slopes, sometimes ancient, and along watercourses. • Extensive network of hedgerows and hedgerow trees delineate field boundaries. • Settlement of Gerrards Cross, Higher Denham and Tattling End with some development extending onto the floodplain. • Isolated farmsteads and villages occur along the valley sides. • Area is dissected by major routes including M25, A428, M40 and A413. • Rural lanes, field enclosures, woodland areas and remnant parkland give rise to a strong time depth in this landscape, despite modern infrastructure. • Occasional long views from the valley sides and higher land between the valleys. • Valleys are accessed primarily via PRoWs but are difficult to perceive due to development and road/rail infrastructure which disrupts the unity of the landscape.
Rickmansworth to Uxbridge Wooded Farmland	• Elevated, gently rolling farmland east of the Colne Valley, dissected by small streams. • Complex superficial geology of clays and gravels overlaying chalk bedrock.

Landscape Character Area	Key characteristics
	• Mix of 18th and 19th century field enclosures, with areas of larger 20th/21st century fields defined by hedgerows and scattered trees (oak in south). • Mixed farming but predominately pasture with some rough grazing and arable. • Substantial ancient woodland including Ruislip National Nature Reserve. • Settlement density is low comprising scattered farmsteads (many listed) and larger settlements on the edges of the area often with historic centres e.g. Harefield. • Remnant parkland landscape and features e.g. Breakspear Park and Harefield Place. • Open views across farmland to wooded skylines. • Sparse network of rural lanes with extensive areas of agricultural land in between. • Landfill in the Newyears area gives rise to verge erosion and litter. • Hillingdon Trail passes through the northern and southern parts of this landscape.
Colne Valley: A412 to Iver	• Narrow valley floodplain between rising valley sides - Uxbridge on eastern slopes and historic rural pastures on western slopes. • Alluvial deposits over Thames Group comprising clay, slit, sand and gravel. • Numerous waterways have developed in the valley - Colne Brook flows along western side of valley floor while the River Colne flows along eastern edge - other waterways (Grand Union Canal, Fray's River and Duke of Northumberland's River) flow through the Uxbridge built up area. • Land use is dominated by pasture although there are some arable lands, active gravel extraction sites and small lakes. • Veteran infield trees reflect remnant historic parkland e.g. Huntsmoor Park and Dromenagh. • Historic villages of Iver (on valley slopes) and Thorney (on valley floor) with dispersed pattern of historic farmsteads. • Mixed and broadleaved woodland occurs on valley sides while the valley floor is more open particularly in the east. • Strong visual and physical connection between western valley sides and valley floor. • M25 audible but visually well concealed due to vegetation. • Lines of pylons are visually intrusive on valley floor along and south of Iver Lane. • Long views eastwards and northwards across the Colne Valley floor.

Landscape Character Area	Key characteristics
Iver Heath Terrace	• Transitional landscape sitting above and immediately east of the Colne Valley generally above the 40m contour and sloping in a southerly direction. • River terrace deposits of gravel and sand over London Clay give rise to acidic loamy soils with patches of slowly permeable seasonally wet clayey soils. • Mixed land use, highly influenced by 20th century development and dominated by extensions to Iver village and Iver Heath as well as the small hamlets, Shreding Green and Love Green. • Between settlements there are pastures and paddocks divided by a network of hedgerows and hedgerow trees. • 20th century enclosure pattern and long straight roads reflect the former open heath/common character of this landscape in the north. 18th century small scale sinuous enclosure dominates in the south. • Place names reflect former heath land use e.g. Iver Heath, Warren House, Heatherden Hall, and Heath Lodge. • Large scale buildings associated with Pinewood Studios are dominant in this landscape and from wider afield. • Busy roads and settlement give rise to an active and populated character.
Richings Lowland	• Lowland topography, gently sloping southwards between 40-25m above ordnance datum (AOD). • London Clay geology overlain with river terrace deposits including Boyn Hill Gravel. • Watercourses or waterbodies are scarce in this landscape except for the east/west arm of the Grand Union Canal and Horton Brook which feeds lakes in former Richings Parkland. • Varied land use including paddocks close to settlement, large arable fields and horse grazing pastures (former landfill south of M4). • Area of former orchards at the turn of the 20th century - still evident in land use today. • Tree cover is sparse, scattered along field boundaries or roads or within former parkland areas giving rise to an open expansive character. • Strong east west grain to this landscape reflected in transport routes e.g. railway, Grand Union Canal. pylons, M4, and A4. • Distinctive Victorian architecture evidenced in bridges and workers' cottages associated with Grand Union Canal and railway. • Encroachment of urban edge of Langley and Brands Hill with abrupt hard urban edge to east. • Several golf courses including the Iver, Richings Park and Thorney Park. • Pylons are visually prominent in this open landscape. • Long extensive views across open fields or former landfill sites.

Landscape Character Area	Key characteristics
Denham Valley Floor	• Open valley floor with little topographic variation. • Alluvium and loamy/clayey floodplain soils overly London Clay mudstone geology. • Rough grazing and pasture is dominant interspersed with arable fields and paddocks. • Geometric 18th and 20th century field patterns enclosed by low hedges. • Tree cover is limited to field boundaries and small ancient woodland. • Settlement comprises Denham Green (where it extends onto the floodplain), Denham village and New Denham. • Linear development along the major roads including A4020, A142 and A40 coupled with signage and lighting give this area an urban fringe character. • Denham village contains numerous listed buildings many comprising vernacular cottages faced in red brick. • Grade II historic parkland, Denham Place, to the north Dedham village. • Significant visual and audible disruption/fragmentation to the landscape from major infrastructure associated with M40 Junction 1, and pylons. • Recreational land uses include Buckinghamshire Golf Course.

9.3.4 Visual baseline

9.22. The study area lies on the western edge of greater London and, as such, visual receptors are typical of the urban/rural interface and include (but are not limited to) the following:

- Residential receptors: residents within Greater London, in outlying settlements, villages and in isolated properties.
- Recreational receptors: users of public rights of way, long distance footpaths, promoted routes, cycle ways (including local routes and those within the National Cycle Network), visitors to country parks, recreational users of the waterways including boaters, and people engaging in outdoor recreation at formal sports facilities.
- Transport receptors: users of the local and national road network including motorways, and people travelling by rail.
- Employment and education receptors: people working and those attending education establishments in the study area.

9.23. These are the types of visual receptors that would be considered and potentially taken through to assessment at subsequent project stages, once more detailed design information is available. The scoping of visual receptors to be included in the assessment would be informed through the production of a ZTV, site visit and in consultation with key stakeholders.

9.3.5 Protected trees

9.24. As described in Section 4.2.2.4, the Drinking Water Transfer Main Route Corridor is adjacent to several areas of ancient woodland. There is no ancient woodland within 100m of the Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor, Indicative WTW Site or Harefield Service Reservoir Connection.

9.25. No ancient or veteran trees were identified based on the information available.

9.26. As described in Section 10.3.1, there are several conservation areas within proximity to the Lower Thames Reservoir Option. Harefield Village Conservation Area is within the Drinking Water Transfer Main Route Corridor. There are no conservation areas within 100m of the Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor, Indicative WTW Site or Harefield Service Reservoir Connection.

9.27. There are several TPOs within the Drinking Water Transfer Main Route Corridor in the Ickenham area. Based on the information available, there are no TPOs within 100m of the Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor, Indicative WTW Site or Harefield Service Reservoir Connection.

9.4 Appraisal outcomes

9.4.1 Wraysbury Tunnel Connection

9.28. The Wraysbury Tunnel Connection lies within the existing Iver WTW. Landscape effects during construction and operation are likely to be contained by existing boundary fencing, vegetation and infrastructure elements on the site. Table 9.5 presents the potential landscape effects during construction and operation for the Wraysbury Tunnel Connection.

9.29. Based on the information available, no arboricultural constraints in relation to protected trees have been identified for the Wraysbury Tunnel Connection.

Table 9.5: Potential landscape effects – Wraysbury Tunnel Connection

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation	Additional notes
Scattered groups and individual trees within the existing Iver WTW. Colne Valley Trail Lies within the Richings Lowland LCA (Colne Valley) and Colne Valley LCA (South Buckinghamshire)	Potential loss of trees within Iver WTW.	Potential permanent loss of trees within the pipeline easement and at the siting of the new raw water transfer pumps.	The Wraysbury Tunnel Connection would be located within the existing Iver WTW and would be screened by existing boundary vegetation and the railway. Therefore, it is unlikely to impact the experience of and connectivity of the Colne Valley Trail.

9.4.2 Raw Water Transfer Main Route Corridor

9.30. Table 9.6 presents the potential landscape effects during construction and operation for the Raw Water Transfer Main Route Corridor.

9.31. Based on the information available, no arboricultural constraints in relation to protected trees have been identified for the Raw Water Transfer Main Route Corridor.

Table 9.6: Potential landscape effects – Raw Water Transfer Main Route Corridor

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Landform		
NCA 115: Thames Valley • Flat and low-lying land, rising to low, river-terraced hills. South Buckinghamshire LCA • Colne Valley: Flat, wide lowland floodplain, with very little topographic variation. Colne Valley LCA • Richings Lowland: Lowland topography, gently sloping southwards. • A412 to Iver: Narrow valley floodplain between rising valley sides.	• The flat low-lying landform would be altered by the excavation of a wide corridor of land and the presence of temporary soil stockpiles.	• It is assumed that land would be reinstated following construction.
Land Cover / Use		
NCA 115: Thames Valley • The route corridor is located within London's Green Belt.	• Construction activity would be in keeping with the character of the existing land use within the route corridor.	• Potential permanent loss of trees within the pipeline easement.
Vegetation and water		
NCA 115: Thames Valley • Numerous hydrological features provide unity to an area which otherwise lacks homogeny. • Woodlands characterise the north-western area.	• Potential loss of woodland between the River Colne, Colne Brook, Grand Union Canal (Slough Arm) and the existing WTW boundary.	• Permanent loss of vegetation within the pipeline easement.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Pockets of woodland, open grassland, parkland, wetlands and intimate meadows. South Buckinghamshire LCA (Colne Valley) • Tree cover is sparse, and largely confined to field boundaries. • A network of meandering rivers and streams, occupy the floodplain, and the River Colne runs largely along the east boundary. These provide a valuable wildlife resource and recreational opportunity. Colne Valley LCA (A412 to Iver) • Numerous waterways have developed in the valley - Colne Brook flows along western side of valley floor while the River Colne flows along eastern edge - other waterways (Grand Union Canal, Fray's River and Duke of Northumberland's River) flow through the Uxbridge built up area.	• Potential loss of trees within the existing Iver WTW.	
Perceptual and experiential qualities		
NCA 115: Thames Valley • Although densely populated and developed, pockets of woodland, open grassland, parkland, wetlands and intimate meadows provide escape and tranquillity. • The area is an important for recreation, both for residents and visitors. South Buckinghamshire LCA (Colne Valley) • The area lies within the Colne Valley Regional Park and a well-established network of PRoWs exists, including the Colne Valley	• Construction activity has the potential to temporarily reduce tranquillity in the vicinity of the construction work, including the Colne Valley Regional Park, PRoWs, Thorney Park Golf Club, Thorney Weir (fishing lake) and the Grand Union Canal (Slough Arm).	

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Way, the Grand Union Canal Walk, the Beeches Way and the South Bucks Way. • Roads and pylons fragment an otherwise simple landscape and generate a discordant and busy character. Away from these areas, pockets of tranquillity remain associated with water and woodland. Colne Valley LCA (A412 to Iver) • M25 audible but visually well concealed due to vegetation. • Existing detracting elements in the area include the M25, railway line, existing WTW and depot.	• Loss of vegetation within the river corridor might reduce the visual screening of the M25.	
Landscape assets/designations		
PRoWs, including: • Colne Valley Trail • Grand Union Canal Walk	• Potential temporary diversion or closure of footpaths and cycleways that intersect with the route corridor. • Potential loss of vegetation alongside footpaths.	• Loss of vegetation has the potential to alter the setting of the long distance footpaths.

9.4.3 Indicative Water Treatment Works Site

9.32. Table 9.7 presents the potential landscape effects during construction and operation for the Indicative WTW Site.

9.33. Based on the information available, no arboricultural constraints in relation to protected trees have been identified for the Indicative WTW Site.

Table 9.7: Potential landscape effects – Indicative Water Treatment Works Site

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation	Additional notes
• London's Green Belt. • The Indicative WTW Site lies within the Richings Lowland LCA (Colne Valley) and Colne Valley LCA (South Buckinghamshire). • The indicative site for the temporary construction compound lies within the Richings Lowland LCA (Colne Valley) and Iver Heath LCA (South Buckinghamshire). • Mature trees within the Indicative WTW Site. • Woodland west of Thorney Lane North between the railway and the Grand Union Canal.	• Loss of woodland and scrub vegetation within the indicative site identified for the temporary construction compound, particularly along the northern boundary close to the PRoW. • Loss of mature trees within the Indicative WTW Site. • Potential loss of vegetation from the Colne River corridor and Grand Union Canal on the boundary of the Indicative WTW Site. • A potential reduction in tranquillity associated with recreational spaces and PRoWs	• Loss of vegetation within the permanent site • Permanent loss of vegetation within the area previously occupied by the indicative temporary construction compound. • Alteration to the setting of Iver Court Farmhouse Grade II listed building.	• The Indicative WTW Site would be in-keeping with the existing industrial/ infrastructure character and scale of the existing land use on the permanent site and is unlikely to give rise to notable changes to landscape character or the character of local views.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation	Additional notes
• Woodland in the Colne River corridor. • Woodland along the Grand Union Canal. • Grand Union Canal users including boaters. • Grand Union Canal Walk and PRoWs along the Slough Arm.	e.g. along the Slough Arm of the Grand Union Canal.		

9.4.4 Drinking Water Transfer Main Route Corridor

9.34. Table 9.8 presents the potential landscape effects during construction and operation for the Raw Water Transfer Main Route Corridor.

9.35. Construction of the Drinking Water Transfer Main would either conflict with or be in close proximity to several TPOs in the Ickenham area and could directly impact trees within Harefield Village Conservation Area. Trees in this area should be physically inspected via a walkover assessment by a qualified arboriculturist to determine the level of impact, if any, to the trees.

Table 9.8: Potential landscape effects – Drinking Water Transfer Main Route Corridor

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Landform		
NCA 115: Thames Valley • Flat and low-lying land, rising to low, river-terraced hills. Colne Valley LCA • A412 to Iver: Narrow valley floodplain between rising valleys. • Denham Valley Floor: Open valley floor with little topographic variation. • Misbourne and Alder Bourne Tributaries: Narrow and small scale valleys with gentle valley sides and narrow floodplain. • Rickmansworth to Uxbridge Wooded Farmland: Elevated, gently rolling farmland. South Buckinghamshire LCA • Colne Valley: Flat, wide lowland floodplain, with very little topographic variation.	• The flat low-lying landform of the river floodplain would be altered by the excavation of a wide corridor of land and the presence of temporary soil stockpiles.	• It is assumed that land would be reinstated following construction.
Land cover / use		
NCA 115: Thames Valley • Farming is limited, field pattern is medium-scale and irregular. • The area is densely populated and developed. • The area is important for recreation, both for residents and visitors. • Infrastructure includes a dense network of roads (including the M25 corridor), Heathrow Airport, railway lines, golf courses, pylon lines,	• The introduction of construction compounds, machinery (including pipe jacks), fencing, lighting in the winter months and construction activity have the potential to temporarily change the existing	• Permanent loss of vegetation within historic parkland landscapes, including Huntsmoor Park Farm, Harefield Place and Round Coppice Farm which would reduce landcover value.

<table>
<tr><th>Key landscape sensitivities</th><th>Potential effects on landscape character during construction</th><th>Potential effects on landscape character during operation</th></tr>
<tr><td>reservoirs, extensive mineral extraction and numerous flooded gravel pits.
There are a number of formal historic landscapes on higher ground.
Within London’s Greenbelt.
Colne Valley LCA
A412 to Iver:
Land use is dominated by pasture although there are some arable lands, active gravel extraction sites and small lakes.
Dispersed pattern of historic farmsteads.
Denham Valley Floor: Geometric 18th and 20th century field patterns enclosed by low hedges.
Misbourne and Alder Bourne Tributaries:
Small scale landscapes comprising a mosaic of woodland and farmland.
Farmed landscape comprising rough grazing, pasture and paddock with some arable.
Isolated farmsteads and villages occur along the valley sides.
Rickmansworth to Uxbridge Wooded Farmland:
Mix of 18th and 19th century field enclosures, with areas of larger 20th/21st century fields defined by hedgerows.
Settlement density is low comprising scattered farmsteads (many listed) and larger settlements on the edges of the area.
Remnant parkland landscape and features e.g. Breakspear Park and Harefield Place.</td><td>character of open green spaces within the green belt.
Temporary change in land use to accommodate construction activity.
The setting of historic landscapes including Huntsmoor Park, Harefield Place and Round Coppice Farm may be adversely affected by the presence of construction machinery and activity.
Disruption to pre 18th century historic field patterns due to the excavation of a broad corridor of land.
Loss of vegetation including woodland, pasture, scrub and hedgerows.</td><td>Permanent alteration to pre 18th century historic field patterns.
Permanent loss of vegetation including woodland, pasture, scrub and hedgerows loss of vegetation reducing landcover value.</td></tr>
</table>

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
• Sparse network of rural lanes. South Buckinghamshire LCA • Colne Valley: – Predominantly geometric field patterns, enclosed by low hedgerows. – Settlement density is low. – Mix of pre 18th century irregular and 20th century regular enclosures. London Natural Signatures LCA • Colne River Valley • Ruislip Plateau		
Vegetation and water		
NCA 115: Thames Valley • Numerous hydrological features provide unity to an area which otherwise lacks homogeny. • Woodlands characterise the north-western area. • Pockets of woodland, open grassland, parkland, wetlands and intimate meadows. Colne Valley LCA • A412 to Iver: – Numerous waterways have developed in the valley - Colne Brook flows along western side of valley floor while the River Colne flows along eastern edge - other waterways (Grand Union	• Large-scale excavation has the potential to result in the loss of woodland, parkland, wetland and meadow vegetation within the pipeline corridor. • Removal of riparian vegetation resulting in a change to the character of the watercourses, including Grand Union Canal, River Colne, Colne Brook, Alder Bourne, Fray's River. • Removal of screening vegetation along existing road corridors e.g.	• The pipeline corridor would be evident where vegetation has been removed. • Potential permanent loss of trees and woodland within the pipeline easement. • Potential presence of a culvert where crossings are proposed over watercourses. • Removal of screening vegetation along existing road corridors e.g. the M25, may open up views of

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
Canal, Fray's River and Duke of Northumberland's River) flow through the Uxbridge built up area. – Veteran infield trees reflect remnant historic parkland e.g. Huntsmoor Park. – Mixed and broadleaved woodland occurs on valley sides while the valley floor is more open particularly in the east. – Denham Valley Floor: Tree cover is limited to field boundaries and small ancient woodland. • Misbourne and Alder Bourne Tributaries: – Mosaic of woodland and farmland and some patches of acidic vegetation on the terrace between the valleys. – Important areas of wet meadow and small water bodies on the floodplain. – Notable areas of deciduous broadleaved woodland. – Extensive network of hedgerows and hedgerow trees delineate field boundaries. • Rickmansworth to Uxbridge Wooded Farmland: – Fields defined by hedgerows and scattered trees (oak in south). – Substantial ancient woodland including Ruislip NNR. South Buckinghamshire LCA • Colne Valley: – Tree cover is sparse, and largely confined to field boundaries. Small ancient woodlands are occasionally found in the north, close to settlement.	the M25 may open up views of vehicle movements for visual receptors.	vehicle movements for visual receptors.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
– Former gravel pits restored into a string of water bodies. A network of meandering rivers and streams, occupy the floodplain, and the River Colne runs largely along the east boundary. London Natural Signatures • Colne River Valley: – Water meadows and wet woodlands. – Meandering waterways. • Ruislip Plateau: – Remnant ancient woodlands. – Hornbeam coppice, glades and bluebell. – Wildflower meadows enclosed by species-rich hedgerows.		
Perceptual and experiential qualities		
NCA 115: Thames Valley • Although densely populated and developed, pockets of woodland, open grassland, parkland, wetlands and intimate meadows provide escape and tranquillity. Colne Valley • A412 to Iver LCA: – Strong visual and physical connection between western valley sides and valley floor. – M25 audible but visually well concealed due to vegetation • A412 to Iver: Long views eastwards and northwards across the Colne Valley floor.	• Construction activity has the potential to temporarily reduce tranquillity in the vicinity of the construction work. • Construction activity has the potential to be visible in views across the valley and from Hillingdon.	• Removal of vegetation may open up further views across the valley and of existing infrastructure.

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation

• Denham Valley Floor: urban fringe character.
• Misbourne and Alder Bourne Tributaries:
  – Rural lanes, field enclosures, woodland areas and remnant parkland give rise to a strong time depth in this landscape, despite modern infrastructure.
  – Occasional long views from the valley sides and higher land between the valleys.
  – Valleys are accessed primarily via PRoWs but are difficult to perceive due to development and road/rail infrastructure which disrupts the unity of the landscape.
• Rickmansworth to Uxbridge Wooded Farmland: Open views across farmland to wooded skylines.
South Buckinghamshire LCA
• Colne Valley:
  – Intermittent long views are afforded across open fields and across the Colne Valley; however views are often interrupted by roads. Extensive views towards this landscape from the adjacent Hillingdon District.
  – Roads and pylons fragment an otherwise simple landscape and generate a discordant and busy character. Away from these areas, pockets of tranquillity remain associated with water and woodland.
London Natural Signatures
• Colne River Valley:		

Key landscape sensitivities	Potential effects on landscape character during construction	Potential effects on landscape character during operation
– Seasonal transition – between wet and dry areas, as water ebbs and flows. – Views across the river floodplain – water, meadow and woodland.		
Landscape assets/designations		
• Green Belt • PRoWs, including – London Loop – Colne Valley Trail – Beeches Way – Grand Union Canal Walk – Colne Valley Regional Park	• Potential loss of open space during construction. • Potential temporary diversion or closure of footpaths and cycleways that intersect with the pipeline corridor. • Potential loss of vegetation alongside footpaths and cycleways. • Experience of the Colne Valley Regional Park is likely to be disrupted during construction due to potential temporary diversion of footpaths, temporary loss of open space and reduction in tranquillity due to the presence of construction activity.	• Permanent loss of vegetation along footpaths within the pipeline easement.

9.4.5 Harefield Service Reservoir Connection

9.36. The Lower Thames Reservoir Option would not require any changes to the existing service reservoir in the vicinity of Harefield therefore there are no anticipated landscape effects.

9.37. Based on the information available, no arboricultural constraints in relation to protected trees have been identified for the Harefield Service Reservoir Connection.

9.5 Recommended mitigation and enhancement opportunities

9.5.1 Landscape mitigation

9.38. Table 9.9 presents recommended mitigation for potential landscape effects.

Table 9.9: Recommended mitigation for potential landscape effects

Component	Recommended mitigation for potential effects
Wraysbury Tunnel Connection	• Careful siting of permanent structures to avoid tree/vegetation loss. • Replace existing vegetation lost during construction.
Raw Water Transfer Main Route Corridor	Landform: • Work with the existing topography and use soil storage bunds for temporary visual screening of construction where appropriate. • Return the land to the existing levels following construction. Land cover / use: • Allow for changes to the width of the working corridor to minimise the vegetation loss. • Revisit the siting of construction compounds to avoid vegetation removal. • Strengthen blue-green networks through the planting of new areas of vegetation including woodland and hedgerows. • Replace existing vegetation lost during construction. Vegetation and water: • Avoid routing the pipeline outside the existing WTW boundary and car park to the north of the WTW. • Careful siting of the pipeline to avoid permanent tree/vegetation loss, within the existing WTW.

Component	Recommended mitigation for potential effects
	• Narrow the working corridor to avoid removal of trees on the WTW boundary and within the Colne Brook and River Colne corridor. • Replace all trees removed during construction. Perceptual and experiential qualities: • Locate construction compounds adjacent to existing infrastructure e.g. the existing railway and M25 corridor and away from recreational areas. Landscape assets/designations: • Provision of managed access or a diversion during construction. • Avoid prolonged closure of footpaths. • Avoid removal of vegetation along PRoWs in particular along long distance footpaths.
Indicative WTW Site	• Limit the footprint of the construction compound to avoid the wooded areas to the west and north of Thorney Lane to minimise vegetation loss. • Retain existing vegetation where possible as it would assist in the mitigation of landscape and visual effects beyond the proposed temporary and permanent compound areas. • Avoid removal of trees within the Colne River corridor and Grand Union Canal corridor particularly in proximity to the PRoW along the Slough Arm of the Grand Union Canal Walk. • Replace all woodland removed during construction. • Look for opportunities to reduce the proportion of hard surfacing to soft landscape to increase landcover value within the proposed temporary and permanent sites. • Allow for re-wilding of the temporary site following the completion of the construction phase to enhance landcover and biodiversity value.
Drinking Water Transfer Main Route Corridor	Landform: • Return the land to the existing levels following construction. • Work with the existing topography and use soil storage bunds for temporary visual screening of construction where appropriate. Land cover / use: • Allow for changes to the width of the working corridor to maintain existing land use and in particular vegetation cover and field boundary vegetation. • Avoid excavation and construction within historic parkland landscapes. • Locate construction compounds in areas of low landcover value. • Improve landcover value by planting new areas of vegetation including woodland and hedgerows. • Restore land to its former use following construction.

Component	Recommended mitigation for potential effects
	• Reinstate field boundaries where removed. Vegetation and water: • Adjust the pipeline route to avoid removal of vegetation and avoid root protection zones where possible. • Adjust the pipeline route to cross watercourses where there is little or no vegetation. • Avoid running parallel to watercourses for long stretches. • Replace vegetation removed during construction. • Narrow the working corridor where crossing vegetated areas in order to reduce vegetation loss. • Sympathetic design of pipeline intersection points with existing watercourses to minimise visual impact. • Link mitigation woodland and other screen planting to existing nearby woodland belts and vegetation to aid landscape integration. Perceptual and experiential qualities: • Locate construction compounds adjacent to existing infrastructure elements and away from recreational routes and residential receptors. • Locate pipelines away from PRoWs, to avoid reduced perceptual and experiential value for footpath users, albeit this would be temporary. • The removal of vegetation along PRoWs may permanently lower perceptual and experiential value for footpath users. • The removal of screening vegetation along existing infrastructure and detracting elements should be avoided and, if not possible to avoid, reinstated following construction. • Minimise lighting during construction to avoid introducing additional lighting in the vicinity of residential receptors. Landscape assets/designations: • Keep working width to a minimum and restore landscape to its former use following construction (to reduce effects within the Green Belt and Colne Valley Regional Park). • Provision of managed access or a diversion of PRoWs during construction. • Avoid prolonged closure of footpaths. • Avoid removal of vegetation along PRoWs.

9.5.2 Mitigation for protected trees

9.39. Ancient woodland is irreplaceable and so the loss or deterioration resulting from the development is not currently considered an option. Therefore, compensation measures are not considered as part of the assessment at this stage.

9.40. Guidance[73] states that for ancient woodlands, ancient trees, and veteran trees, developments should have a buffer zone of at least 15 metres from the boundary of the woodland to prevent significantly damaging the root system (known as the root protection area, RPA). For ancient or veteran trees (including those on the woodland boundary), the buffer zone should be at least 15 times larger than the diameter of the tree. The buffer zone should be a minimum of 5 metres from the edge of a tree canopy if that area is larger than 15 times the diameter of the closest tree stem. Where assessment shows other impacts are likely to extend beyond this distance, a larger buffer zone is likely to be needed.

9.41. Buffer zones should be created around the areas of ancient woodland where they are in close proximity to the footprint of construction works. The buffer zones should be 5 metres from the edge of the tree's canopy if that area is larger than 15 times the tree's diameter. Where a buffer zone cannot be created then a walked inspection should be undertaken to determine the level of impact and consultation undertaken with the Local Planning Authority.

9.42. Where possible, the Drinking Water Transfer Main Route Corridor should be re-routed to avoid trees within conservation areas. Where this is not practicable, consultation with the Local Planning Authority would be required. Where works may enter the RPA of trees in conservation areas, these areas should be physically inspected via a walkover assessment by a qualified arboriculturist to determine the level of impact.

9.43. For works in conflict or close to TPOs, the Drinking Water Transfer Main Route Corridor should be rerouted to avoid works close to TPOs. Where this is not possible, RPAs of the trees are to firstly be avoided, if this is not practicable and TPOs are within 15m of the works footprint, any RPAs are to be protected by barriers. All protective barriers should be installed prior to works commencing and maintained for the duration of the construction works in accordance with BS 5837:2012.

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[73] Natural England and Forestry Commission (2022) Ancient woodland, ancient trees and veteran trees: advice for making planning decisions. Available at: https://www.gov.uk/guidance/ancient-woodland-ancient-trees-and-veteran-trees-advice-for-making-planning-decisions [Accessed April 2022]

9.5.3 Enhancement opportunities

9.44. Table 9.10 presents potential landscape enhancement opportunities that should be explored as the design develops at a subsequent project stage.

Table 9.10: Potential landscape enhancement opportunities

Component	Enhancement opportunities
Wraysbury Tunnel Connection	None
Raw and Drinking Water Transfer Main Route Corridors	• Opportunities to enhance nearby riparian vegetation and strengthen connections within the blue-green network. • Opportunities to enhance nearby sections of the long distance footpaths in terms of planting, resurfacing, information boards, way markers and social enhancements.
Indicative WTW Site	• Opportunities to strengthen the green corridor through additional planting to link vegetation along the River Colne, Grand Union Canal Slough Arm and M25 corridors. • Opportunities to enhance landscape character and the character of views from PRoWs through additional planting along the M25, Slough Arm and at the boundary of the Indicative WTW Site.
Harefield Service Reservoir Connection	None

9.6 Summary of main findings and recommendations for future technical work

9.45. Construction of both the Raw Water Transfer Main and Drinking Water Transfer Main has the potential to result in the loss of vegetation both in the working corridor and where compounds are located. This is of particular concern along watercourses, field boundaries and where vegetation has a screening effect, for example in screening existing roads (such as the M25) and infrastructure. Perceptual and experiential value may be adversely affected in the vicinity of PRoWs and residential properties as a result of the presence of construction activity which may result in a reduction in tranquillity of the landscape.

9.46. Construction of the Drinking Water Transfer Main would result in a temporary change to land use and to the generally flat low-lying recreational landscape of the River Colne valley, due to large scale excavation and stockpiling of materials within the working corridor, most of which lies within the London Green Belt. The temporary diversion or closure of footpaths, including the Colne Valley Trail, Grand Union Canal Walk and London Loop, would temporarily reduce recreational connectivity across a proportion of the Colne Valley.

9.47. There is potential for permanent loss of waterside vegetation along the River Colne, Colne Brook, Grand Union Canal, Alder Bourne and Fray's River and the introduction of man-made culverts at the intersection of the pipeline and these watercourses, which unless designed sympathetically, would locally detract from the character of the river corridors. Removal of roadside vegetation, most notably along the M25 corridor and vegetation around existing areas of industrial development/ infrastructure has the potential to open up views of detracting elements for residential and recreational receptors.

9.48. Although the pipeline would be buried below the surface of the ground, the pipeline corridor may be evident where vegetation is lost during construction along watercourses and PRoWs, in particular where vegetation cannot be replaced because it falls within the pipeline easement. This may result in a permanent change to the character along stretches of watercourses and PRoWs, which may in turn affect their perceptual and experiential value for users of the PRoW and waterside footpaths.

9.49. The Indicative WTW Site is a site of existing industrial use and provides an opportunity to reduce the extent of hardstanding in comparison to the existing land use.

9.50. The indicative location of the temporary construction compound for the WTW would require clearance of existing woodland and scrub woodland and as a result there could be localised, adverse landscape effects.

9.51. The study area lies on the western edge of greater London and, as such, visual receptors are typical of the urban/rural interface and include (but are not limited to) residential receptors; recreational receptors, including users of public rights of way, cyclists, visitors to country parks, recreational users of the waterways and people engaging in outdoor recreation at formal sports facilities; transport receptors, including users of the road and rail networks; and employment and education receptors. These types of visual receptors would be considered and potentially taken through to assessment at a subsequent project stages, once more detailed design information is available.

9.52. Construction of the Drinking Water Transfer Main has the potential to impact protected trees including those within conservation areas and with TPOs.

9.53. There are wider opportunities within the Lower Thames Reservoir Option to enhance landcover value and strengthen the blue-green network, for example through use of re-wilding techniques in the restoration of temporary compound areas and use of mitigation planting to link existing green infrastructure elements across the wider Colne Valley landscape.

9.54. Recommended future technical work at a subsequent project stage includes the following:

- Refining the pipeline construction corridor and location of above ground structures to reduce the likely loss of vegetation and impact to sensitive landscape features.
- Once the location of above ground structures has been refined, a ZTV should be produced to aid identification of possible visual receptors.
- Site visits should be to be carried out along the refined pipeline route corridor to confirm the findings of this DBA and the ZTV.
- Design landscape mitigation to integrate the above ground structures into the landscape and replace any vegetation removed during construction within the working corridor.
- To support to the detailed design phase of the Lower Thames Reservoir Option it is recommended that a full BS5837:2012 survey is conducted at a subsequent project stage, and an arboricultural impact assessment and tree protection plan produced. Where sensitive sites cannot be avoided, extra mitigation is likely to be required to minimise impacts during the construction phase.

10 Historic environment

10.1 Introduction

10.1. This chapter presents the results of a desk-based assessment undertaken to identify potential impacts on heritage assets from the transfer route corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to set out the characteristics of the historic environment and the key heritage assets associated with the Lower Thames Reservoir Option, identify constraints and opportunities, and identify the issues and heritage assets that may require further investigation at a subsequent project stage.

10.2. The need to consider the historic environment is driven by legislation (Ancient Monuments and Archaeological Areas Act 1979 and Planning (Listed Buildings and Conservation Areas) Act 1990) and planning policy, including the draft NPS for Water Resource Infrastructure[20] (Section 4.7, Historic Environment) and NPPF[21] (Section 16 (conserving and enhancing the historic environment), paragraphs 189-208).

10.2 Methodology

10.2.1 Study area and sources of information

10.3. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within 500m for designated heritage assets, and 200m for non-designated heritage assets. This search radius was considered sufficient to produce a comprehensive baseline and allowed for an understanding of the archaeological potential and historic significance to be established, and subsequently for appropriate mitigation to be recommended. Where heritage assets with the study areas are identified as being subject to potential impacts, consideration of those impacts also included the impacts on setting, which may extend beyond the extent of the study areas described above.

10.4. Table 10.1 outlines the baseline data sources which were collated and considered in the desk-based assessment.

Table 10.1: Sources of information (historic environment)

Data collected	Source
Historic environment – designated assets	
World Heritage Sites	National Heritage List for England (NHLE) data download[74]
Listed Buildings	
Scheduled Monuments	
Registered Parks and Gardens	
Registered Historic Battlefields	
Conservation Areas	
Historic environment – non-designated assets	
Locally Listed Buildings	Local Planning Authorities
Non-designated heritage assets	Datasets held by the Greater London Historic Environment Record (GLHER) and Buckinghamshire and Hertfordshire Historic Environment Record (HER) National Mapping Programme data Historic maps LiDAR data from the Environment Agency database The British Geological Society (BGS)

10.2.2 Approach to impact appraisal

10.5. The desk-based assessment used a qualitative approach to appraise the Lower Thames Reservoir Option and identify where there is potential for historic environment impacts, recognising the difference between impacts occurring at the construction phase and those occurring at the operational phase.

10.6. An understanding of the value of heritage assets was required to assess the potential impact of the Lower Thames Reservoir Option on the historic environment. Where the value of heritage assets was discussed, the following criteria was used:

[74] Historic England, Open Data from Historic England. Available at: https://historicengland.org.uk/listing/the-list/data-downloads/ [Accessed April 2022]

- High Value – a designated heritage asset of potentially national importance, including scheduled monuments, grade I and grade II* registered parks and gardens and grade I and II* listed buildings and structures.
- Moderate Value – a heritage asset of regional importance, including non-designated assets, conservation areas and listed buildings and registered parks and gardens with a grade II designation.
- Low value – non designated assets of local importance or no notable significance.

10.2.3 Assumptions and limitations

10.7. Information provided by the HER can be limited because it depends on previous opportunities for research, fieldwork and discovery. Where nothing of historic interest was shown in a particular area, this could have been down to lack of targeted research or investigation rather than the genuine absence of sub-surface archaeological deposits.

10.8. Documentary sources are rare before the medieval period, and many historic documents are inherently biased. Older primary sources often fail to accurately locate sites and interpretation can be subjective.

10.9. Historic maps provide a glimpse of land-use at a specific moment. It is therefore possible that short-term structures or areas of land-use are not shown and therefore not recorded within this assessment.

10.3 Understanding of the baseline

10.3.1 Designated heritage assets

10.10. There are no World Heritage Sites or Registered Parks and Gardens within the 500m study area.

10.11. There are two Scheduled Monuments within the 500m study area (Two Concentric Ditches Showing as Crop Marks at Thorney, which is within 500m of the Wraysbury Tunnel Connection, Raw Water Transfer Main and the Indicative WTW Site, and Brackenbury Farm moated site 3/4 mile (1210m) NW of Ickenham church, which is within 500m of the Drinking Water Transfer Main Route Corridor), as shown on Figure 10.1: Designated heritage assets. All Scheduled Monuments are considered of high heritage value because of their archaeological importance on a national scale.

10.12. There are 67 Listed Buildings located within the 500m study area, with the majority of these within 500m of the Drinking Water Transfer Main Route Corridor, as shown on Figure 10.1: Designated heritage assets. Grade I and Grade II* Listed Buildings are considered of high heritage value because of their heritage importance on a national scale. Grade II Listed Buildings are considered of moderate heritage value because of their heritage importance on a regional scale.

10.13. There are seven conservation areas within the 500m study area, as shown on Figure 10.1: Designated heritage assets. These are Iver, Cowley Lock, Uxbridge Moor, Uxbridge Lock, Ickenham Village, Denham Lock and Harefield Village. All conservation areas are considered of moderate heritage value because of their heritage importance on a regional scale.

10.3.2 Non-designated heritage assets

10.14. There are 98 non-designated assets within the 200m study area, as mapped by the GLHER, Buckinghamshire HER and Hertfordshire HER.

10.3.2.1 Colne Valley Archaeological Priority Area (Greater London)

10.15. The Drinking Water Transfer Main Route Corridor is partially within the Colne Valley Archaeological Priority Area (APA), HER ref. DLO36183, crossing it in some places and running parallel to it in others. This APA is particularly significant for remains dating from the prehistoric periods, particularly the early prehistoric. It could also provide information on the use and exploitation of riverine environments into the post-medieval period.

10.16. The area has been flagged as having a high potential for early prehistoric archaeology, particularly around the area of Three Ways Wharf which produced significant evidence of in situ Palaeolithic and Mesolithic occupation. Further evidence of human activity of this date was recorded at the Sanderson site and Denham. A Mesolithic occupation site and lithic working area have also been recorded at Dewes Pit with other scattered records in the northern half of the area.

10.17. There is more limited evidence for activity dating to the later prehistoric period, with a possible Bronze Age ring ditch and burial urns at Dewes Pit. There is very little recorded evidence for the Iron Age and Roman periods, with a few stray finds and a possible Roman causeway in the centre of Uxbridge. This is in line with limited evidence for these periods in the Colne Valley in general, though there is a slight increase in Roman activity.

10.3.2.2 Brackenbury Farm Archaeological Priority Area (Greater London)

10.18. The Drinking Water Transfer Main Route Corridor is adjacent to the western half of Brackenbury Farm APA (HER ref. DLO36185). Earthworks relating to the original house dating to 1312 are believed to survive in good condition in this area, particularly to the south-west.

10.3.2.3 Archaeological Notification Area (Buckinghamshire)

10.19. There are nine Archaeological Notification Areas, as designated by Buckinghamshire Council, that fall within the Drinking Water Transfer Main Route Corridor:

- Cropmarks of undated rectangular enclosure and possible field system (HER ref. DBC9314)
- Mesolithic flint working site found in gravel quarry (HER ref. DBC9324)
- Earthworks of Medieval moat at Southlands Manor (HER ref. DBC9306)
- Late Medieval timber-framed building at Southlands Manor, Denham (HER ref. DBC9817)
- Early Mesolithic hunting site found by test-pitting (HER ref. DBC9997)
- Early Mesolithic flint-working site excavated in advance of quarrying (HER ref. DBC9998)
- Late Palaeolithic and early Mesolithic flint scatters found by test pitting and trial trenching (HER ref. DBC9996)
- Late Palaeolithic and early Mesolithic camp site partly excavated in advance of re-development (HER ref. DBC9822)
- The southern extent of Late Palaeolithic and Mesolithic deposits (HER ref. DBC9833)

10.3.3 Archaeological potential

10.20. There is a high potential for remains of early prehistoric date, particularly in areas that fall within the Colne Valley Archaeological Priority Area. Archaeological investigations throughout the Colne Valley have uncovered extensive evidence of human activity dating to the Palaeolithic and Mesolithic periods, including in the vicinity of the existing Iver WTW, at Denham, at Boyers Pit and Dewes Farm. Evidence for late prehistoric activity is less prevalent than that of an earlier date along the Drinking Water Transfer Main Route Corridor, although monument records within the HER suggest a moderate potential for remains of Neolithic, Bronze Age and Iron Age date.

10.21. There is a moderate potential for archaeological remains dating to the Roman period within the Drinking Water Transfer Main Route Corridor, through which the HER has mapped the possible alignment of a Roman road between London and south Oxfordshire. Roman features and artefacts were recorded during excavations at Denham, which could be representative of roadside settlement. Evidence for Roman settlement activity is more prevalent in the northern half of the Drinking Water Transfer Main Route Corridor, suggesting a moderate potential for remains of a Roman date. Data within the HER and archaeological investigations suggest a lower potential for Roman remains towards the southern end of the Drinking Water Transfer Main Route Corridor.

10.22. There is a low potential for archaeological remains dating to the early medieval period. Evidence suggests that the Church of St Peter has early medieval origins, which may be Indicative of a small settlement at Iver during this period. Otherwise, there is little evidence in the HER data for Saxon activity across the length of the Drinking Water Transfer Main Route Corridor.

10.23. There is a high potential for remains of medieval date in localised areas of the Drinking Water Transfer Main Route Corridor. There is evidence for medieval activity at Southlands Manor and at Brackenbury Farm. There is also evidence of a medieval deer park at Breakspear Road North. Otherwise, medieval features and finds have been recorded as part of multi-period sites at various points throughout the Drinking Water Transfer Main Route Corridor, and so the potential for medieval remains is considered moderate for the rest of the Drinking Water Transfer Main Route Corridor.

10.24. There is a moderate potential for archaeological remains of a post-medieval date, particularly in the more urbanised areas of the Drinking Water Transfer Main Route Corridor. Along the undeveloped areas of the Drinking Water Transfer Main Route Corridor, there is the potential for evidence of post-medieval agricultural practices, as well as the exploitation of the riverine landscape throughout this period.

10.4 Appraisal outcomes

10.4.1 Wraysbury Tunnel Connection

10.4.1.1 Construction

10.25. The construction phase of the Wraysbury Tunnel Connection has the potential to permanently impact archaeological remains, if present, by severely truncating them or removing them entirely. This might include evidence for the early prehistoric exploitation of the Colne Valley.

10.4.1.2 Operation

10.26. There are no anticipated impacts to heritage assets whilst the Wraysbury Tunnel Connection is in operation.

10.4.2 Raw Water Transfer Main Route Corridor

10.4.2.1 Construction

10.27. No designated heritage assets are anticipated to be directly impacted by the construction of the Raw Water Transfer Main. However, construction activities have the potential to temporarily alter the settings of listed buildings through noise, visual and light intrusion, particularly those that are intervisible with the Raw Water Transfer Main Route Corridor.

10.28. The depth of the open cut trench is anticipated to be excavated to a depth of 0.9 to 1.2m, depending on the current land use. This would remove all potential archaeological remains within its footprint, particularly in undeveloped areas where archaeology is likely to survive relatively close to the surface.

10.29. Any top soil strip involved with the installation of compound and welfare sites along the pipeline route also has the potential to remove archaeological remains that survive close to the surface.

10.4.2.2 Operation

10.30. Any above ground structures associated with the pipeline have the potential to permanently and adversely alter the setting of listed buildings that are intervisible with them, through visual intrusion. Otherwise, there are no anticipated impacts to heritage assets whilst the Raw Water Transfer Main is in operation.

10.4.3 Indicative Water Treatment Works Site

10.4.3.1 Construction

10.31. The construction of the WTW at the Indicative WTW Site could alter the setting of Iver Court Farmhouse, a Grade II Listed Building, through noise, visual and light intrusion. Depending on the layout for the Indicative WTW Site, the construction phase has the potential to directly impact the asset through loss of fabric.

10.32. The construction of the WTW at the Indicative WTW Site would also permanently impact archaeological remains, if present, by severely truncating them or removing them entirely. This may include Palaeolithic findspots of a similar nature to those already recorded within the Indicative WTW Site. However, archaeological deposits may have already been removed by known gravel extraction that took place in the 20th century, as mapped by the HER, the extent of which is unknown.

10.33. Works within the indicative temporary compound site, located west of the M25 and north of Iver Station, have the potential to impact archaeological remains, if present, by severely truncating them or removing them entirely. However, archaeological deposits may have already been removed by known gravel extraction that took place in the 20th century to the south of the Ridgeway Trading Estate; a former gravel pit is shown on historic mapping, but the exact extent of the extraction is unknown. The 'Two Concentric Ditches Showing as Crop Marks at Thorney' Scheduled Monument is considered to be sufficiently screened for its setting to not be altered by the construction phase of the scheme.

10.4.3.2 Operation

10.34. The presence of the WTW at the Indicative WTW Site is unlikely to considerably alter the setting of Iver Court Farmhouse Grade II listed building from the surrounding industrial estate that the building is already located in. There would be no further impact to archaeological remains during the operation of the WTW.

10.4.4 Drinking Water Transfer Main Route Corridor

10.4.4.1 Construction

10.35. No designated heritage assets are anticipated to be directly impacted by the construction of the Drinking Water Transfer Main Route Corridor. However, construction activities have the potential to temporarily alter the settings of the 'Brackenbury Farm moated site 3/4 mile (1210m) NW of Ickenham church' Scheduled Monument, listed buildings and conservation areas through noise, visual and light intrusion, particularly those that are intervisible with the Drinking Water Transfer Main Route Corridor.

10.36. The depth of the open cut trench is anticipated to be excavated to a depth of 0.9 to 1.2m, depending on the current land use. This would remove all potential archaeological remains within its footprint, particularly in undeveloped areas where archaeology is likely to survive relatively close to the surface, and particularly in areas that have been recognised by the local authority as having a high archaeological potential.

10.37. Any top soil strip involved with the installation of compound and welfare sites along the Drinking Water Transfer Main Route Corridor also has the potential to remove archaeological remains that survive close to the surface.

10.4.4.2 Operation

10.38. Any above ground structures associated with the Drinking Water Transfer Main Route Corridor have the potential to permanently and adversely alter the setting of listed buildings, conservation areas and the 'Brackenbury Farm moated site 3/4 mile (1210m) NW of Ickenham church' Scheduled Monument, if these are intervisible with them, through visual intrusion. Otherwise, there are no anticipated impacts to heritage assets whilst the Drinking Water Transfer Main is in operation.

10.4.5 Harefield Service Reservoir Connection

10.4.5.1 Construction

10.39. The Lower Thames Reservoir Option would not require any changes to the existing service reservoir in the vicinity of Harefield. Minor construction works to facilitate the Harefield Service Reservoir Connection have the potential to permanently impact archaeological remains, if present, by severely truncating them or removing them entirely.

10.4.5.2 Operation

10.40. There are no anticipated impacts to heritage assets whilst the Harefield Service Reservoir Connection is in operation.

10.5 Recommended mitigation and enhancement opportunities

10.5.1 Mitigation

10.41. The following are potential avoidance, mitigation, and compensation measures that could be implemented to address the potential impacts.

10.42. Design considerations should aim to minimise change within the setting of designated heritage assets, with particular consideration to Grade II listed buildings which fall within or immediately adjacent to the Lower Thames Reservoir Option.

10.43. Strategic planting and other landscaping between the Indicative WTW Site and the Grade II Iver Court Farmhouse may soften the visual impact, especially in conjunction with design measures for the buildings. However, excessive planting may have an adverse effect on its character. The visual impact should be softened as much as possible; however, the mitigation factor which would have the greatest effect on reducing the potential for impact is the design, height and massing of the buildings and structures within the new WTW site.

10.44. Buildings or structures over 10m within the new WTW site should be designed to be the minimal feasible height, to further reduce impact on the setting of heritage assets. The exterior of tall elements should be designed to retreat into the landscape, for example by using gradated painting.

10.45. Excavation near to 'Brackenbury Farm moated site 3/4 mile (1210m) NW of Ickenham church' Scheduled Monument should be avoided.

10.46. Archaeological investigation would be required at a subsequent project stage. The extent of this investigation would be dependent on the results of further assessment and site survey, as well as consultation with the relevant stakeholders. This is likely to include geophysical survey and archaeological trial trenching as a minimum. Archaeological investigation, importantly, does not amount to mitigation as the remains would still be removed during construction; the potential for impact to the buried archaeological remains is therefore the same. However, this does not undermine the importance of undertaking archaeological investigation.

10.47. Geophysical survey, trial trenching and/or other survey may identify areas of greater archaeological potential or specific remains of moderate value within the site area. This may allow for the targeting of building and service locations to reduce impact on buried archaeology. However, as the landscape contains a high density of remains and the historic environment is not the only factor of consideration in the scheme design, this is unlikely to materially reduce the potential for impact.

10.5.2 Enhancement opportunities

10.48. There may be the opportunity to enhance the setting of the Grade II Listed Iver Court Farmhouse, should the Indicative WTW Site be taken forward. This heritage asset is currently located within an industrial park, less than 50m to the east of the M25 motorway and is therefore removed from its original agricultural setting. The redevelopment of this site presents the opportunity to restore value to the asset that has been lost through the surrounding unsympathetic development. This could be achieved by providing better screening of the heritage asset and ensuring that designs for the new WTW site are less visually intrusive than the existing industrial park. This opportunity should be investigated at a subsequent project stage.

10.6 Summary of main findings and recommendations for future technical work

10.49. There are 67 Listed Buildings, two Scheduled Monuments and seven conservation areas within 500m of the Lower Thames Reservoir Option. There are no World Heritage Sites or Registered Parks or Gardens within this area. There are 98 non-designated heritage assets within 500m of the Lower Thames Reservoir Option, as mapped by the GLHER, Buckinghamshire HER and Hertfordshire HER. Data within these HERs, along with several archaeological investigations, has identified a generally high potential for archaeological remains, particularly dating to the prehistoric period.

10.50. The excavation required for the Raw Water Transfer Main and Drinking Water Transfer Main would severely truncate, or remove entirely, potential archaeological remains. There is no anticipated impact to the two Scheduled Monuments in the study area and no Scheduled Monument Consent is anticipated to be required.

10.51. The construction of the WTW at the Indicative WTW Site could adversely affect the setting of the Grade II Iver Court Farmhouse however there is an opportunity to enhance the setting of this listed building, which should be investigated at a subsequent project stage. A Listed Building Consent may be required for the WTW if the Indicative WTW Site is taken forward and the proposals involve a direct impact to Iver Court Farmhouse.

10.52. Further assessment, at a subsequent project stage would refine the need for archaeological investigation, in consultation with local archaeological advisors. A programme of geophysical survey in undeveloped areas, and test pitting in developed areas, would help identify the presence of archaeological remains. Should remains of potential high significance be identified, a diversion of the pipeline route should be considered, to facilitate preservation in situ. The results of the survey or test pitting would enable a programme of targeted archaeological investigation to be developed, such as targeted trial trench evaluation, to ensure no significant archaeological remains are removed without adequate record.

11 Noise

11.1 Introduction

11.1. This section presents the results of a desk-based assessment undertaken to identify potential noise and vibration impacts on sensitive receptors from the transfer route corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to establish an outline of the baseline noise environment associated with the Lower Thames Reservoir Option, to the extent possible based on available data, identify the noise and vibration sensitive receptors, identify constraints and opportunities, and identify the issues that require further investigation.

11.2. The need to consider noise and vibration is driven by legislation (Environmental Protection Act 1990) and national planning policy (draft NPS for Water Resource Infrastructure[20] (Section 4.11, Noise and Vibration), NPPF[21] (Section 8, Promoting Healthy and Safe Communities) and the Noise Policy Statement for England[75] (NPSE).

11.2 Methodology

11.2.1 Study area and sources of information

11.3. The desk-based assessment focused on the transfer route corridors, location of associated infrastructure and the surrounding area within 300m where only daytime impacts are expected and 600m where night-time impacts may occur.

11.4. Potential vibration impacts were considered to a distance of 50m.

11.5. Table 11.1 outlines the baseline data sources which were collated and considered in the desk based assessment.

[75] Defra (2010) Noise Policy Statement for England (NPSE). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69533/pb13750-noise-policy.pdf [Accessed April 2022]

Table 11.1: Sources of information (noise and vibration)

Data collected	Source
Baseline Noise Data	Extrium Defra Noise Mapping Website Extrium > England Noise and Air Quality Viewer
Publicly available baseline noise data	Previous publicly available planning applications for proposed sites near the Lower Thames Reservoir Option.
Receptor locations within 300m of the pipeline and above ground infrastructure	OS mapping, publicly available satellite imagery This was undertaken alongside population and human health and air quality desk based assessments, to ensure a consistent set of receptors were used across the assessments.
Noise Action Planning Important Areas Round 3 England (2022)	Defra Noise Action Planning Important Areas Round 3 England[76]
Construction Plant Noise Levels	British Standard 5228-1:2009+A1:2014 entitled 'Code of practice for noise and vibration control on construction and open sites – Part 1: Noise
Construction Plant Vibration Levels	British Standard 5228-1:2009+A1:2014 entitled 'Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration
Construction Methodology	Concept Design Team and experience from previous similar projects

11.2.2 Approach to impact appraisal

11.6. The desk based assessment for noise and vibration used a qualitative approach to appraise the Lower Thames Reservoir Option and identify where there was potential for impacts and the likely mitigation that would be required.

[76] Defra Noise Action Planning Important Areas Round 3 England. Available at: https://www.data.gov.uk/dataset/948d6c4c-772e-4f55-9f39-97508e1cc701/noise-action-planning-important-areas-round-3-england [Accessed August 2022]

11.2.2.1 Operational noise

11.7. Once operational, the majority of the Lower Thames Reservoir Option components would generate no noise. Any noise created would be generated by the above ground facilities. The nature of these facilities is fairly common place and well understood, and controlling noise from them is relatively routine and achieved by enclosure within buildings, acoustic enclosures, acoustic louvers and duct silencers for ventilation systems, vibration isolation and acoustic barriers etc. During the design process, noise limits would be set based on measured background noise levels and the above ground facilities would be designed to comply with those limits.

11.8. Therefore, for the purposes of the desk based assessment noise predictions from the above ground facilities have not been made. It has been assumed that they would be designed to meet the relevant planning criteria which are outlined below.

11.9. The aims of the NPSE[75] are:

'Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

- avoid significant adverse impacts on health and quality of life;
- mitigate and minimise adverse impacts on health and quality of life; and
- where possible, contribute to the improvement of health and quality of life.'

11.10. Within the aims of the NPSE the key phrases 'significant adverse' and 'adverse' are introduced. NPSE refers to established concepts from toxicology to introduce the following terms:

- No Observed Effect Level (NOEL), the level below which no effect can be detected
- Lowest Observable Adverse Effect Level (LOAEL), the level above which adverse effects on health and quality of life can be detected
- Significant Observed Adverse Effect Level (SOAEL), the level above which significant adverse effects on health and quality of life occur

11.11. No single objective noise measure defines a value of SOAEL that is applicable to all sources in all situations and no prescribed value is given for SOAEL in NPSE[75]. Instead NPSE acknowledges that it is 'likely to be different for different noise sources, for different receptors and at different times.' Local planning authorities are expected to produce their own guidance and values for LOAEL and SOAEL based on the principles of the NPSE.

11.12. In setting LOAEL and SOAEL many planning authorities make reference to or expect a parallel assessment in terms of BS4142:2014. Using BS4142, the level of sound from proposed new plant, the 'rating level', would be predicted in terms of the A-weighted equivalent continuous sound level dBLAeq, and compared to the existing background sound level, in terms of LA90. The LA90 is to be representative of the period being assessed. If the new sound source is impulsive, intermittent, or tonal in nature, then a penalty is added to the 'rating level' to account for the character of the noise.

11.13. The outcome of the assessment is defined in BS4142:2014 with the following points that relate to the difference between the background noise level and the 'rating noise level':

- Typically, the greater this difference, the greater the magnitude of the impact.
- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.
- The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source would have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context, which was informed using BS8233.

11.14. This type of assessment would be used in deriving noise limits for the above ground facilities which would be used as design constraints and would therefore ensure that no noise impacts would occur due to the operation of these facilities.

11.2.2.2 Construction noise

11.15. The most geographically extensive impacts resulting from the Lower Thames Reservoir Option are likely to result from construction rather than operation. Potential construction impacts were appraised qualitatively with reference to B25228 Code of Practice for Noise and Vibration Control on Construction and Open Sites, Part 1 (noise) and Part 2 (vibration).

11.16. Appraisal of the potential impact of construction noise was done based on the ABC method from BS5228 Part 1 – where professional judgement may be used to identify the ambient noise level category based upon desktop review of the environment around the receptor using aerial photography, available noise mapping. The ABC method states the following:

'Table E.1 shows an example of the threshold of potential significant effect at dwellings when the site noise level (the noise level generated by the construction site), rounded to the nearest decibel, exceeds the listed value. The table can be used as follows: for the appropriate period (night, evening/weekends or day), the ambient noise level is determined and rounded to the nearest 5 dB.'

The receptor is then assigned a Category. The appropriate category is determined using the following three conditions:

- Category A: threshold values (Table 4.1 column 2) to use when ambient noise levels (when rounded to the nearest 5 dB) are less than 65 during Day, 55 during Evening and 45 at Night.
- Category B: threshold values (Table 4.1 column 3) to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as 65 during Day, 55 during Evening and 45 at Night.
- Category C: threshold values (Table 4.1 column 4) to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than 65 during Day, 55 during Evening and 45 at Night.

11.17. The category value is then compared with the predicted level of construction noise generated by the site. If the site noise level exceeds the appropriate category value, then a potential significant effect is indicated. The assessor then needs to consider other project-specific factors, such as the number of receptors affected and the duration and character of the impact, to determine if there is a significant effect.

11.2.3 Assumptions and limitations

11.18. At this stage, the actual construction methodology is not known, and noise level outline predictions were therefore based on construction methodologies from similar projects. The actual construction methodology used to construct the Lower Thames Reservoir Option may be different.

11.19. At this stage, noise predictions cannot take account of all the factors which affect sound propagation such as; terrain screening, screening due to buildings, detailed ground absorption, etc. Predictions used in the appraisal assumed flat ground.

11.20. Baseline noise data was taken from Defra noise mapping which is based on computer noise modelling of road and rail traffic. The traffic data used will now be dated and terrain and building data used in the modelling was necessarily of low resolution. This modelling can only be viewed, therefore, as indicative.

11.21. Defra noise modelling only covers areas near motorways trunk roads and rail lines. Coverage of the Lower Thames Reservoir Option is therefore incomplete.

11.22. Vibration impacts are extremely difficult to predict accurately even with a detailed construction methodology. With only an outline construction methodology, vibration predictions are indicative.

11.23. It is assumed that all works would take place during daytime. It is expected that ambient noise levels in most areas where construction would take place would be below the Category A values which is 65dBA for daytime. Therefore, the threshold of noise impact would be 65dBA at most locations.

11.24. Exceptions to this may occur where the receptor is near the M25, A412, A40 or other trunk roads which generate a high ambient noise level, in which case the noise category may be B or C and therefore the threshold for significant noise Impact may be 70dBA or 75dBA.

11.25. Vibration impacts are extremely difficult to predict accurately even with a detailed construction methodology. With only an outline construction methodology vibration predictions are indicative at this stage.

11.26. The Raw and Drinking Water Transfer Mains have been considered on the basis that the route corridor is fixed within certain limits but that the pipeline alignment may be varied within these limits. Based on plant used for similar projects the distance at which the threshold of significant noise impact has been calculated based on flat ground. As a guiding principle therefore, the pipeline alignment should be placed at least 85m away from any receptor where normal open trench methods are used. Where trenchless techniques are used the launch pit should be at least 130m from the nearest receptor. Where this cannot be achieved within the route corridors this is highlighted below in Section 11.4.

11.3 Understanding of the baseline

11.27. The majority of noise sensitive receptors affected by the Lower Thames Reservoir Option would be residential premises. Other noise sensitive receptors include schools, nurseries, churches, hospitals, ecological receptors, and public open spaces, including PRoWs. Commercial receptors are considered less sensitive and have not been considered at this stage unless they are also likely to include residences such as farms and small family businesses. Potentially affected noise sensitive receptors are presented in Table 11.2. Please refer to Chapter 4: Biodiversity, flora and fauna for impacts on ecological receptors.

Table 11.2: Potentially affected noise sensitive receptors and baseline noise description for components of the Lower Thames Reservoir Option

Component	Receptors within 300m buffer	Baseline noise description
Wraysbury Tunnel Connection	No residential receptors One non-statutory nature conservation site Golf course PRoWs	Light industrial area, M25 traffic noise

Component	Receptors within 300m buffer	Baseline noise description
Raw Water Transfer Main Route Corridor	No residential receptors Two non-statutory designated nature conservation sites Golf course PRoWs	Light industrial area, M25 traffic noise
Indicative WTW Site (including indicative site for the temporary construction compound)	Over 100 residential properties Two non-statutory designated nature conservation sites Allotments, public parks/gardens, play spaces and golf courses PRoWs	Light industrial area, M25 traffic noise
Drinking Water Transfer Main Route Corridor	Over 700 residential receptors Four SSSIs One LNR One NNR 17 non-statutory designated nature conservation sites Allotments, public parks/gardens, play spaces, playing fields and golf courses PRoWs	Residential area, M25 traffic noise Rural area, A412 traffic noise Residential area, traffic noise from A40 Rural area Residential/Rural area
Harefield Service Reservoir Connection	Less than 100 residential receptors Five non-statutory designated nature conservation sites Public park/garden PRoWs	Residential/rural area

11.28. There are a number of Noise Important Areas (NIAs) within 300m of the Lower Thames Reservoir Option. These are summarised in Table 11.3. NIAs are locations where the highest 1% of noise levels at residential locations can be found.

Table 11.3: Noise Important Areas within 300m of the Lower Thames Reservoir Option

Component	NIAs within 300m buffer	Reason for NIA designation
Wraysbury Tunnel Connection	None	N/A
Raw Water Transfer Main Route Corridor	Within 300m of NIA: 6291	Road noise (M25)
Indicative WTW Site (including indicative site for the temporary construction compound)	Intersects NIA: 6291 Within 300m of 1428 (indicative site for the temporary construction compound)	Road noise (M25) Rail noise
Drinking Water Transfer Main Route Corridor	Intersects NIA: 6291 Within 300m of NIA: 5807 Within 300m of NIA: 6242 Intersects NIA: 900 Within 300m of NIA: 6249 Intersects NIA: 14751 Within 300m of NIA: 902	Road noise (M25) Road noise (M25) Road noise (M25) Road noise (A4007) Road noise (M25) Road noise (A4020) Road noise (A4020)
Harefield Service Reservoir Connection	None	N/A

11.4 Appraisal outcomes

11.4.1 Wraysbury Tunnel Connection

11.4.1.1 Construction

11.29. The Wraysbury Tunnel Connection is located within the existing Iver WTW. Noise and vibration impacts from construction of the tunnel connection are expected to be low due to its location with respect to nearby noise sensitive receptors and the relatively high levels of ambient noise resulting from the M25.

11.30. Construction traffic routes are however not fully developed. There is potential for temporary adverse impacts at noise sensitive receptors. Several construction phases would result in larger increases in construction traffic (e.g. during concrete pours) however the duration of these activities is unlikely to result in significant adverse effects due to construction traffic. Impacts are subject however to development of the design of construction routes.

11.4.1.2 Operation

11.31. Noise impacts during the operational phase at the nearest receptors are expected to be low due to its location with respect to nearby noise sensitive receptors. Noise sources associated with operation of the pumping station have the potential to result in adverse effects if located near to noise sensitive receptors.

11.4.2 Raw Water Transfer Main Route Corridor

11.4.2.1 Construction

11.32. The Raw Water Transfer Main Route Corridor is located away from noise sensitive receptors and therefore the potential construction noise and vibration impacts are likely to be minimal. As stated in paragraph 11.30, construction traffic impacts are subject to development of the design of construction routes.

11.4.2.2 Operation

11.33. The buried pipeline along the Raw Water Transfer Main Route Corridor would make no noise when installed and operational.

11.34. Noise sources associated with operation of pipelines, or ancillary pumping stations along the pipeline, have the potential to result in adverse effects if located near to noise sensitive receptors. At this stage it is not known where these additional fixed plant items would be located, or noise levels generated by these elements. However, since the Raw Water Transfer Main Route Corridor is located away from noise sensitive receptors, it is unlikely that there would be any noise impacts.

11.4.3 Indicative Water Treatment Works Site

11.4.3.1 Construction

11.35. The Indicative WTW Site is to the north of the existing Iver WTW. There are no noise sensitive receptors close enough to be impacted by temporary construction works on this site.

11.36. The indicative temporary construction compound for the WTW is located west of the M25 and north of Iver Station. The nearest noise sensitive receptors are residential receptors south of the railway line. These receptors are unlikely to be close enough to be impacted by temporary construction works on this site. As stated in Paragraph 11.30, construction traffic impacts are subject to development of the design of construction routes.

11.4.3.2 Operation

11.37. The new WTW would be carefully designed with noise emissions in mind such that no adverse noise impact occurs. This would require these facilities to be designed such that the Rating Noise level emitted would be at or below, depending on local authority requirements, the local background LA_{90} at the receptor when assessed using BS 4142:2014+A1:2019 Methods for rating and assessing industrial and commercial sound. This would require a baseline noise survey to be conducted during the detailed design stages at potentially affected noise sensitive receptors to determine the background noise levels.

11.38. Methods which would be employed to mitigate noise emitted by above ground facilities include:

- Acoustic enclosure of plant
- Acoustic louvres, ducts silencers and plena for ventilation paths to enclosures and buildings
- Vibration isolation of plant
- Acoustic barriers

11.39. All of these means of noise mitigation have been used extensively and are well understood and therefore any potential adverse noise impacts can be designed out.

11.40. Operational HDV movements are not likely to result in significant additional daily vehicle movements therefore changes in road traffic using the existing road network due to additional vehicle movements are unlikely to result in adverse noise effects.

11.4.4 Drinking Water Transfer Main Route Corridor

11.4.4.1 Construction

11.41. Where the pipeline corridor is located away from noise sensitive receptors, the potential construction noise and vibration impacts are minimised. However, temporary adverse impacts could occur where construction activities, including construction of the pipeline, is unavoidable close to noise sensitive receptors.

11.42. It has been assumed that where the route corridor is wide enough the pipeline alignment can be located more than 85m from a noise sensitive receptor. At this stage, it is considered that this would be possible for the majority of the Drinking Water Transfer Main Route Corridor and adverse noise effects can be largely avoided.

11.4.4.2 Operation

11.43. The buried pipeline along the Drinking Water Transfer Main Route Corridor would make no noise when installed and operational.

11.44. Noise sources associated with the operation of pipelines, or ancillary pumping stations along the pipeline, have the potential to result in adverse effects if located near to noise sensitive receptors. At this stage it is not known where these additional fixed plant items would be located, or noise levels generated by these elements.

11.4.5 Harefield Service Reservoir Connection

11.4.5.1 Construction

11.45. The required construction works at the existing service reservoir in the vicinity of Harefield are subject to detailed design and may comprise modifications to the existing pipework within the existing site boundary. It is anticipated that any temporary land required would be accommodated within the construction working width for the Drinking Water Transfer Main. There are residential receptors within proximity and, depending on the extent and nature of the construction works, there may be some temporary construction noise impacts in this location.

11.4.5.2 Operation

11.46. It is not anticipated that any modifications to the existing service reservoir in the vicinity of Harefield would make any additional noise to the existing site.

11.5 Recommended mitigation

11.5.1 Construction noise mitigation

11.47. Where significant adverse noise and/or vibration impacts are identified for works within the construction phase cannot be avoided, appropriate mitigation measures should be applied including the use of Best Practicable Means (BPM) in accordance with BS5228-1&2:2009+A1:2014 guidance. Mitigation may comprise a number of measures including management of construction hours, selection of low noise and vibration construction plant, use of screening (enclosures, barriers, or bunds), noise and vibration monitoring.

11.48. Mitigation of construction traffic would include implementation of a Construction Management Plan.

11.49. Recommended mitigation measures are discussed below.

- Select a pipeline alignment to be at least 85m from dwellings and 130m from where trenchless techniques occur.
- Use any excess excavated material to construct temporary or permanent noise bunds where noise impacts are predicted.
- The effects of construction noise and vibration can be mitigated by good public relations and community liaison. Residents who are kept aware of the reasons for construction works, the expected duration of elevated noise or vibration and the date at which it would stop are more accepting of it than if the noise commences without warning or explanation and appears to be continuing for an indefinite period.
- BPM in terms of considerate working should be employed at all times. A letter box drop, and dedicated site contact for the public with a complaints handling procedure would also be put in place. The impact on noise sensitive receptors within the vicinity of the Lower Thames Reservoir Option can be controlled when undertaken in accordance with good practice as set out in BS5228 parts 1 and 2.
- Typical means by which noise and vibration may be minimised include the following:
  - Selecting quiet equipment.
  - Ensure equipment is maintained, in good working order, and is used in accordance with the manufacturer’s instructions.
  - Members of the construction team should be trained and advised on quiet working methods.
  - Equipment should not be left running unnecessarily.
  - Equipment should be fitted with silencers or mufflers.

- Use plant enclosures whenever feasible.
- Careful orientation of plant with directional features.
- Materials should be lowered instead of dropped from height.
- Inform nearby noise sensitive receptors in advance of construction activities and keep them up to date with progress and changes.
- Give nearby noise sensitive receptors a site contact telephone number; the contact should liaise with residents and maintain good rapport.
- Temporary noise barriers should be used where practicable.
- Effective construction programme management with the aim of minimising the duration of construction near any particular receptor.

11.5.2 Mitigation for above ground infrastructure

11.50. Mitigation of operational noise would be applied through design to minimise potential adverse noise impacts at the nearest noise sensitive receptors. Measures may include selection of plant and equipment, location and orientation of fixed plant items and use of screening (e.g., acoustic enclosures, barriers or bunds).

11.51. At this stage, it is not considered that noise mitigation would be required for the Indicative WTW Site.

11.52. Other above ground facilities may be acoustically screened form residential receptors by earth bunds where feasible. These bunds may be placed early in the construction process such that they screen construction noise as well as later operational noise. Although narrow bands of tree planting has negligible effect on noise propagation, it does have a psychological benefit in that if the noise source is not visible it is perceived to be quieter to some extent.

11.53. Acoustic design input should be obtained during the design stages of the pumping station. The noisiest equipment should be located centrally within the site and very noisy equipment should be contained within substantial buildings/enclosures (not GRP kiosks) with ventilation paths treated with acoustic louvres, duct silencers.

11.6 Summary of main findings and recommendations for future technical work

11.6.1 Construction

11.54. By careful design, the noise impact of the Lower Thames Reservoir Option could be minimised. Noise impacts from the construction of Wraysbury Tunnel Connection and Raw Water Transfer Main are likely to be minimal due the distance from noise sensitive receptors.

11.55. The alignment of the Drinking Water Transfer Main should be chosen to be at least 85m from noise sensitive receptors (130m where trenchless techniques occur) in order to minimise significant adverse noise impacts. It is considered that this can be achieved along the vast majority of the Drinking Water Transfer Main Route Corridor.

11.56. Once the final alignment of the Drinking Water Transfer Main has been agreed, the areas where residual construction noise impacts may occur should be identified and the noise mitigation options to be included in a Construction Noise Management Plan considered.

11.57. At this stage, it is considered unlikely that baseline noise surveys and construction noise assessments would be required for the Indicative WTW Site, since it is anticipated that significant adverse noise impacts could be avoided through design, although this should be kept under review as the design is developed at subsequent project stages, in particular the construction access routes.

11.6.2 Operational noise

11.58. All operational noise impacts for above ground infrastructure should be designed out through a number of methods including acoustic enclosure of plant, Acoustic louvres, ducts silencers and plena for ventilation paths to enclosures and buildings, vibration isolation of plant and acoustic barriers, where required. All of these means of noise mitigation have been used extensively and are well understood and therefore any potential adverse noise impacts can be designed out.

11.59. At this stage, it is considered likely that baseline noise surveys and operational noise assessments would be required at a subsequent project stage to determine the background noise levels and inform detailed design. If required, baseline noise monitoring should be undertaken in order to set noise limits in accordance with BS4142: 2014 for operational noise in the area of all of the above ground facilities. Once the noise baseline has been established use the derived criteria as design constraints for these facilities.

12 Population and human health

12.1 Introduction

12.1. This chapter presents the results of a desk-based assessment undertaken to identify potential impacts on sensitive receptors from the transfer route corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to identify the key receptors and resources features associated with the Lower Thames Reservoir Option, identify constraints and opportunities, and identify the issues that require further investigation.

12.2. The need to consider population and human health is driven by planning policy, including the draft NPS for Water Resource Infrastructure[20] (Section 4.10, Land use including open space, green infrastructure and Green Belt and 4.13, Socio-economic impacts) and NPPF[21] (Section 8 (promoting healthy and safe communities), Section 12 (achieving well-designed places), Section 15 (conserving and enhancing the natural environment), paragraph 185)).

12.2 Methodology

12.2.1 Study area and sources of information

12.3. The desk based assessment focused on the transfer route corridors, and the location of associated infrastructure. The study area for this topic is the transfer route and associated infrastructure, and a 500m buffer around them.

12.4. Where sensitive receptors (specifically education and healthcare facilities) or regional tourist attractions, lie outside of this study area, but are accessed by communities using routes within the study area (that may be disturbed as part of construction works within the transfer route corridors), these facilities were identified.

12.5. Table 12.1 outlines the baseline data sources which were collated and considered in the desk based assessment.

Table 12.1: Sources of information (population and human health)

Data collected	Source
Housing and private property	Google Maps and OS AddressBase
Businesses	OS OpenMap and Google Maps
Community facilities, focusing on schools and education facilities; hospitals and medical facilities; are homes and places of worship	OS OpenMap
Open space and recreation, focusing on national and regional trails; recreational facilities; allotments and regional tourist attractions	OS OpenMap
Population and health statistics	English Indices of Multiple Deprivation (IMD) 2019[77] – for the measurement and comparison of relative levels of deprivation (poverty – total IMD and individual domains for Health, Employment and Living Environment Public Health England data sets Office for National Statistics (ONS) data sets on demography

12.2.2 Approach to impact appraisal

12.6. The desk based assessment used a qualitative approach to appraise the Lower Thames Reservoir Option and identify where there was potential for community and health impacts and the likely mitigation that was required.

12.7. The appraisal identified the likely impacts on community and health resources / receptors including:

- Land requirement – a temporary or permanent (or both) requirement for land affecting resources.
- Change in access – a temporary or permanent (or both) restriction in access, either directly affecting a resource (such as a trail) or affecting the ability of a resource to function (e.g. customers being able to access a business, or

[77] Ministry of Housing, Communities & Local Government (2019) English indices of deprivation 2019. Available at: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019 [Accessed May 2022]

children/staff being able to access a school). This could also include positive changes where new or enhanced facilities are provided.

- Change in amenity – a temporary or permanent (or both) change in the environmental conditions (e.g. noise, air quality, visual impacts, presence of HGV traffic) which may affect the enjoyment of residential property, neighbourhoods, community and recreational facilities.

12.8. The appraisal considered the greatest impacts to be where:

- A residential property is demolished, or a business cannot continue to function
- A community facility or recreational facility cannot function, or a new / enhanced facility is provided
- Impacts occur over a long period (e.g. over a year) and/or affect an activity that is undertaken frequently (e.g. daily trip to school)
- Limited accessible alternatives are available
- A large number of people are affected or those with vulnerabilities are affected

12.2.3 Assumptions and limitations

12.9. The assessment was limited to desk-based activities only and no site visits to ground-truth data. No surveys (e.g. telephone surveys or email questionnaires) were undertaken.

12.3 Understanding of the baseline

12.10. The Wraysbury Tunnel Connection and Raw Water Transfer Main Route Corridor are within 500m of housing and private property located to the south of the railway line; they are not located within 500m of community facilities and do not bisect any open spaces, recreational areas or PRoWs. The closest businesses are located to the north of the existing Iver WTW within an industrial estate. There is a PRoW to the east and Thorney Park Golf Club is located within 500m of the Wraysbury Tunnel Connection to the south.

12.11. The Indicative WTW Site is within 500m of residential properties however these are located to the west of the M25; it is not located within 500m of private property or community facilities. The Indicative WTW Site is located on an industrial estate, north of the existing Iver WTW, and within 500m of PRoWs running along the Grand Union Canal and Colne Brook.

12.12. The indicative site for the temporary construction compound for the new WTW is within 500m of residential properties and a sports facility and is within 500m of PRoWs running along the Grand Union Canal. The site is open land, but it is not clear from the information available if it is publicly accessible.

12.13. The Drinking Water Transfer Main Route Corridor passes through agricultural land, with settlements located within 500m containing housing and private property, businesses and community facilities (including schools, a care home and a church). The closest communities the potential construction activities are located in the Iver, Cowley, Uxbridge, New Denham and Denham, Ickenham, South Harefield and Harefield areas.

12.14. The Drinking Water Transfer Main Route Corridor crosses a golf course and bisects several PRoWs and is within 500m of several open spaces and recreational facilities including Bayhurst Wood Country Park, Bishops Wood Country Park, a golf course, playing fields, sports facilities and allotments.

12.15. The Harefield Service Reservoir Connection is within 500m of housing, private property, businesses and community facilities. As it is an existing facility, it does not bisect any open spaces, recreational areas or PRoWs. The Harefield Service Reservoir Connection is within 500m of Bishops Wood Country Park and PRoWs.

12.16. Health indicators for the population within the local authority areas in which the Lower Thames Reservoir Option and a 500m buffer is located were analysed (Three Rivers District Council, London Borough of Hillingdon and Buckinghamshire Council[78]). Based upon the available data, all the local authorities perform relatively well on key public health indicators. Life expectancy (for both genders) is slightly higher across all areas, compared to the England average. The under-75 mortality rates (from all causes, cardiovascular diseases and cancer) for all the local authorities are also less than the national rates. The percentage of people in employment and that are physically active is higher for all the local authorities when compared to the England proportion. The indicators which performs worse than the national rate is the number of people reported killed and seriously injured on the road of all ages, and percentage of physically active adults.

12.17. The English IMD 2019[77] are commonly used for the measurement and comparison of relative levels of deprivation (poverty). For each local authority, a large proportion of residents live in the least or second least deprived deciles in the country.

12.18. Deprivation data for total IMD and health deprivation and disability, employment deprivation, and living environment deprivation indicate that none of the Lower-layer Super Output Areas (LSOAs) within the local authorities are within the most deprived 10% nationally for total IMD or health deprivation and disability although a

[78] South Buckinghamshire District Council is now part of Buckinghamshire Council (a unitary authority), however there is very limited recent data available on key public health indicators for Buckinghamshire Council or the former South Bucks District Council. Data for South Bucks District Council from 2014-2017 has been used.

small percentage of LSOAs in Three Rivers District Council and London Borough of Hillingdon fall within the most deprived 10% nationally for employment and living environment.

12.4 Appraisal outcomes

12.19. The potential impacts on housing and private property, businesses, community facilities and open space and recreation were considered. For each component of the Lower Thames Reservoir Option, a summary of the main findings is provided.

12.4.1 Wraysbury Tunnel Connection

12.20. The Wraysbury Tunnel Connection is within the existing Iver WTW. As this land is part of the existing Iver WTW, temporary and permanent land requirements are not anticipated to directly affect housing, private property, businesses, community facilities or areas of open space and recreation during construction. Temporary amenity impacts on residential receptors as a result of changes in environmental conditions are not anticipated due to the distance of these receptors from construction works. Given the proximity of recreational routes and facilities to construction activities, there may be temporary impacts from a change in amenity which should be assessed at the next stage of assessment.

12.21. No impacts on housing, private property, businesses, community facilities or areas of open space and recreation are anticipated during operation.

12.4.2 Raw Water Transfer Main Route Corridor

12.22. The Raw Water Transfer Main Route Corridor is largely within the existing Iver WTW therefore temporary and permanent land requirements are not anticipated to directly affect housing, private property, businesses, community facilities or areas of open space and recreation during construction. Temporary amenity impacts on residential receptors as a result of changes in environmental conditions are not anticipated due to the distance of these receptors from construction works. Given the proximity of recreational routes and facilities to construction activities, there may be temporary impacts from a change in amenity.

12.23. No impacts on housing, private property, businesses, community facilities or areas of open space and recreation are anticipated during operation as the pipeline would be underground and land temporarily required to construct the pipeline would be reinstated.

12.4.3 Indicative WTW Site

12.24. The Indicative WTW Site would have a direct impact on businesses within an industrial estate to the north of the existing Iver WTW.

12.25. Temporary and permanent land requirements are not anticipated to directly affect housing, private property or community facilities for the Indicative WTW Site although there would be a temporary land requirement at the indicative site for the temporary construction compound. Potential amenity impacts on residential and community receptors as a result of changes in environmental conditions are anticipated during construction, particularly for the indicative site for the construction compound although due to the distance of these receptors, impacts are not anticipated during operation of the new WTW.

12.26. Temporary and permanent land requirements are not anticipated to directly affect areas of open space and recreation. The Indicative WTW Site is within 500m of PRoW running along the Grand Union Canal and Colne Brook. Given the proximity of these recreational routes and facilities to the proposed construction activities, there may be temporary impacts on these locations from a change in amenity.

12.27. Depending on the design of the new WTW, there may be a change in environmental conditions during operation for open spaces and recreation in the surrounding area as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.4.4 Drinking Water Transfer Main Route Corridor

12.28. Temporary and permanent land requirements are not likely to directly affect housing, private property or community facilities within the Drinking Water Transfer Main Route Corridor. Impacts on access to housing, private property and community facilities are also not anticipated.

12.29. Depending on the construction methodology, there may be a change in environmental conditions within communities within 500m of the Drinking Water Transfer Main Route Corridor as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.30. Agricultural land may be temporarily acquired to construct the raw water pipeline. No others impacts on businesses are anticipated as a result of temporary land requirements or potential changes to access. However, depending on the construction methodology, there may be a change in environmental conditions for businesses in these locations as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.31. In relation to recreation facilities, the Drinking Water Transfer Main Route Corridor runs through a golf course, which may require temporary land acquisition and closure of parts of the golf course during construction. The Drinking Water Transfer Main Route Corridor bisects several PRoWs. Construction may cause temporary closure and/or diversion of these PRoWs. Depending on the construction methodology, there may be a change in environmental conditions for areas of open space and recreation as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.32. No impacts on housing, private property, businesses, community facilities or areas of open space and recreation are anticipated during operation as the pipeline would be underground and land temporarily required to construct the pipeline would be reinstated.

12.4.5 Harefield Service Reservoir Connection

12.33. As the service reservoir in the vicinity of Harefield is an existing facility, temporary and permanent land requirements are not anticipated to directly affect housing, private property, businesses, community facilities or areas of open space and recreation. Depending on the construction works required for the Harefield Service Reservoir Connection, there may be amenity impacts on receptors within 500m as a result of changes in environmental conditions. There may be increased construction traffic activity in and around the area although this is not anticipated to impact the access to, or function of businesses in this area.

12.34. No impacts on housing, private property, businesses, community facilities or areas of open space and recreation are anticipated during operation as the extent of the changes to the existing service reservoir in the vicinity of Harefield are limited.

12.5 Recommended mitigation and enhancement opportunities

12.5.1 Mitigation

12.35. To avoid or mitigate potential disruption and disturbance to communities during construction and operation of the Lower Thames Reservoir Option, best practice mitigation should be implemented. This includes:

- Setting out how engagement with local communities would be undertaken during construction, including with the golf course should temporary land acquisition and closure of parts of the golf course be required during construction.
- Implementation of specific measures in relation to air quality and noise to reduce impacts on neighbouring residential communities, particularly for sensitive community resources such as educational facilities, health facilities and care homes.
- Developing mitigation for local road closures and diversions when details are known regarding timing and duration of closure.
- The above ground assets should have landscaping, air quality and noise mitigation included in their design, in order to limit the potential indirect impacts from noise and air pollution on properties and businesses and open spaces.
- Sensitive layout and siting of potential construction compounds that take into consideration the potential impacts from noise, traffic, air quality and visual effects on communities.
- Maintenance or diversion of key routes used by the community such as footpaths and pedestrian and cycling routes (refer to Section 13.2).

12.5.2 Enhancement opportunities

12.36. Potential programmes and initiatives that could be implemented as part of the Lower Thames Reservoir Option to deliver public value. These include providing educational programmes on water at local educational facilities, placing particular emphasis on the benefits of water transfers and the necessity to implement sustainable water infrastructure solutions.

12.37. More widely, socio-economic benefits could accrue through:

- Job and training opportunities, particularly in the construction sector. This would occur primarily during the construction period through supply chain benefits generated by the Lower Thames Reservoir Option, together with the spend by construction workers and contractors in local communities.

- Cascading benefits through procurement, by requiring companies in the supply chain to demonstrate how they would provide social value to local communities in executing construction works or operation and maintenance contracts.

12.38. There are also opportunities to enhance areas of open space and recreational routes along the route which may be impacted as a result of construction of the Lower Thames Reservoir Option.

12.6 Summary of main findings and recommendations for future technical work

12.39. The Lower Thames Reservoir Option is located within 500m of housing and private property, businesses, community facilities and areas of open space and recreation. The Wraysbury Tunnel Connection and Raw Water Transfer Main Route Corridor are within the existing Iver WTW and the Indicative WTW Site is on existing industrial land. The Drinking Water Transfer Main Route Corridor crosses agricultural land and bisects areas of open space and recreation, including a golf course and several PRoWs, before terminating at an existing service reservoir in the vicinity of Harefield.

12.40. Health indicators for the population within the three local authority areas in which the Lower Thames Reservoir Option is located were also analysed. Life expectancy (for both genders) is slightly higher across all areas in which the Lower Thames Reservoir Option is located, compared to the England average. The under-75 mortality rates (from all causes, cardiovascular diseases and cancer) for all the local authorities are also less than the national rates. A large proportion of residents living within 500m of the Lower Thames Reservoir Option live in the least or second least deprived deciles in the country.

12.41. There are anticipated to be a range of community and human health impacts affecting housing and private property, businesses and open space and recreation as a result of the Lower Thames Reservoir Option during both construction and operation. These impacts include land requirements for the Indicative WTW Site affecting existing businesses and temporary land requirements affecting a golf course, PRoW closure and travel disruption. Depending on the construction methodologies, there may also be a change in environmental conditions as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles.

12.42. To avoid or mitigate potential disruption and disturbance to communities during construction and operation of the Lower Thames Reservoir Option, best practice mitigation should be implemented during construction.

12.43. Further assessment recommended at a subsequent project stage to understand the timing and extent of the population and human health impacts and whether the impacts are temporary or permanent.

13 Material Assets

13.1 Introduction

13.1. This chapter presents the results of a desk-based assessment undertaken to identify potential impacts on material assets from the transfer corridors and above ground infrastructure including the WTW. The objectives of the desk-based assessment were to identify the key material assets associated with the Lower Thames Reservoir Option, identify constraints and opportunities and identify the issues and features that may require further investigation at a subsequent project stage.

13.2. This chapter is split into two sections. Section 13.2 considers transport related material assets while Section 13.3 considers all other material assets.

13.2 Transport and access

13.3. This section presents the desk-based assessment undertaken to identify the transport and access constraints and opportunities for the Lower Thames Reservoir Option. The desk-based assessment identifies the transport infrastructure, road, rail, water, and PRoWs likely affects to users in the study area.

13.4. The need to consider transport and access is driven by legislation and national planning policy (draft NPS for Water Resource Infrastructure[20] (Section 4.14, Traffic and Transport) and NPPF[21] (Chapter 9, Promoting sustainable transport).

13.2.1 Methodology

13.2.1.1 Study area and sources of information

13.5. The desk-based assessment focused on the transfer route corridors and location of associated infrastructure for the Lower Thames Reservoir Option.

13.6. Table 13.1 outlines the baseline data sources which were collated and considered in the desk based assessment.

Table 13.1: Sources of information (transport and access)

Data collected	Source
Major Roads – A roads	OS Open data
Major Roads - Motorways	OS Open data
Railway lines	OS Open data
National Cycle Network	Sustrans[79]
National Trails	Natural England
PRoWs	GIS data from Local Planning Authorities (Buckinghamshire Council, Hertfordshire County Council and London Borough of Hillingdon)
Navigable Waterways	Ordnance Survey mapping

13.2.1.2 Approach to impact appraisal

13.7. The desk-based assessment used a qualitative approach to appraise the Lower Thames Reservoir Option and identify where there was potential for impacts on transport infrastructure (such as the strategic road network, PRoWs, etc) and the potential mitigation that would be required. It also identified opportunities for sustainable travel to those areas through identifying cycling, bus and rail proximities.

13.8. Impacts were scored using a high level assessment. The criteria assessed the challenges surrounding accessing the site from the local highway network and the National Highways Strategic Route Network (SRN)[80] and diversions of PRoWs/roads required due to proposed site compounds or water treatment facilities. Opportunity scoring criteria assessed the sites accessibility to connecting sustainable transport routes such as cycle routes, train stations and bus stops.

13.9. Based upon high level estimates of HGVs and staff vehicles that may be required during the construction and operational phases of the Lower Thames Reservoir Option (see Section 13.2.3.1), at this stage, it is not considered that the vehicles volumes generated would present additional constraints to the road network, and, as described in Section 13.2.3, the majority of roads are anticipated to provide practical options. Where access difficulties have been identified, these, together with further assessment of sensitive receptors would need to be investigated at

[79] Sustrans' Open Data Portal. Available at: https://data-sustrans-uk.opendata.arcgis.com/ [Accessed April 2022]
[80] National Highways: Roads we manage. Available at: https://highwaysengland.co.uk/about-us/our-roads/ [Accessed April 2022]

subsequent project stages, with reference to the Institute of Environmental Assessment 1993 (now the Institute of Environmental Management and Assessment) guidelines and Design Manual for Roads and Bridges (DMRB) Guidance Notes LA 101 (Introduction to Environmental Assessment) 2019, LA 103 (Scoping Projects for Environmental Assessments) 2020 and LA 104 (Environmental Assessment and Monitoring) 2020.

13.10. The scoring methodology that was applied in Sections 13.2.3.2 to 13.2.3.4 can be found in Table 13.2. A higher score represents fewer constraints and/or greater potential opportunity. At this stage of review, no weighting was given to any of the constraints or opportunities.

Table 13.2: Scoring methodology for transport and access

Scoring	Description
1	High risk, mitigation unlikely
2	Higher risk but could be partly mitigated
3	Medium risk but can be mitigated
4	Lower risk, likely that mitigation would overcome impacts.
5	No impact

13.2.1.3 Proximity to Strategic Road Network

13.11. The distance from the SRN, which consists of motorways and major A roads, was considered. This determines the most appropriate route to a site location for the import of material to the site. The scoring for each range band is based on professional judgement of acceptability in terms of distance from the SRN in this location. The method of scoring has been determined where 1 represents greater than 50km away from an SRN and 5 represents less than 1km, the full breakdown of the scoring can be found in Table 13.3 below.

Table 13.3: Scoring methodology for proximity to Strategic Road Network

Scoring	Description
1	>50km
2	40-50km
3	20-39km
4	1-19km

Scoring	Description
5	<1km

13.2.1.4 Proximity to public rights of way

13.12. The criteria for PRoWs shown in Table 13.4 was based around a distance which can be reached within five minutes using a comfortable walking pace of around 5kph for the average person. This is based on the guidance in LTN 1/20 that references a walking speed of 1.2 m/s, around 4.4 kph, which has been rounded up to 5kph for the purpose of this assessment.

13.13. A person walking at a speed of around 5kph would cover around 400m in 5 minutes. A 5-10 minute walk is a distance of around 400-800m, a 10-15 minute walk is around 800-1200m. A distance of greater than 1200m away or greater is deemed to be over a 15 minute walk. The measure is used to determine if site is well located for walking or if a diversion due to the development of infrastructure could cause a significant impact on walking in the area.

Table 13.4: Scoring methodology for proximity to public rights of way

Scoring	Distance / time
1	>1200m / Diversion required
2	800-1200m
3	400-800m
4	<400m

13.2.1.5 Local road suitability

13.14. This criterion focussed on the suitability of non-major roads/local roads once the vehicles have egressed from the SRN. This is important as it has the potential to highlight problematic infrastructure such as width, height and weight restrictions and also sensitive receptors so suitable diversion(s) can be made without negatively impacting the local network. This assessment does not consider characteristics such as the on-street parking situation; this would need to be identified by a site visit, to determine which days and times the streets/traffic are most affected by on-street parking. This also could involve a parking survey completed by an independent traffic survey company at a subsequent project stage.

13.15. The scoring criteria and application to individual bands was based on professional judgement and experience of highway and traffic management schemes. The criteria are presented in Table 13.5.

Table 13.5: Scoring methodology for local road suitability

Scoring	Description
1	Height and width restrictions
2	Narrow roads (one way traffic) / poor condition roads
3	Single carriageway, medium condition
4	Dual carriageway, wide, good condition

13.2.1.6 Proximity to public transport

13.16. In terms of railway station and bus stop distances, a standard has been published by Transport for London (TfL) for Public Transport Accessibility Level (PTAL) guidance[81]. This data has been used to inform the scoring criteria for railway station and bus stop proximity as shown in Table 13.6.

13.17. At an average walking speed of 5kph, railway criteria 4 states a 12 minute walk (1000m maximum) is the highest acceptable limit when walking to a station whereas the bus stop criteria 4 acceptable distance limit is considerably lower at around five minutes (less than 400m). This is due to the fact that bus stops occur far more frequently along a route compared to the railway stations and bus stops are typically used to travel shorter distances thus requiring them to be closer to be attractive to use.

Table 13.6: Scoring methodology for proximity to public transport

Scoring	Distance (railway station)	Distance (bus)
1	>8000m	>3000m
2	5000-8000m	1000-3000m
3	1000-5000m	400-1000m
4	<1000m	<400m

[81] Transport for London (2010) Measuring Public Transport Accessibility Levels. Available at: https://s3-eu-west-1.amazonaws.com/londondatastore-upload/PTAL-methodology.pdf [Accessed April 2022]

13.2.1.7 Proximity to cycle network

13.18. The criteria for proximity to the cycle network were based around a distance which can be reached within five minutes using the assumption that the average cycling speed is 25kph[82]. Therefore, a distance of 2km of less could be cycled in less than 5 minutes. Less than 6000m would be around 15 minutes and reasonably practicable to undergo a cycle ride using pavements and roadsides. 6000-9000m is around 22 minutes and unreasonable distance to cover to reach a designated cycle route. Anything over 9000m was deemed as impractical to the average cyclist and be attributed the lowest score. The criteria are presented in Table 13.7.

Table 13.7: Scoring methodology for proximity to cycle network

Scoring	Distance / time
1	>9000m
2	6000-9000m
3	2000-6000m
4	<2000m

13.2.1.8 Assumptions and limitations

13.19. No surveys or site visits were undertaken as part of this work.

13.20. Only publicly available data sets were used, alongside the available mapping and aerial imagery to determine high level transport impacts and receptors.

13.21. This assessment focused on the initial estimates for compounds and working widths, materials for pipe bedding, temporary road surfacing, and staff numbers. Assumptions with regard to construction material volumes and operational requirements were based upon information provided by the Concept Design team.

13.22. Consideration of impacts on future (i.e. yet to be built) transport infrastructure would be considered at subsequent stages of the project.

[82] This is based on LTN 1/20 guidance of an absolute minimum design speed of 20 kph and maximum of 30kph.

13.2.2 Understanding of the baseline

13.23. The Wraysbury Tunnel Connection and Raw Water Transfer Main Route Corridor are parallel to the M25 where both northbound and southbound accesses can be gained at junction 15, located less than 2km away. The A40 and M40 intersect the Drinking Water Transfer Main Route Corridor essentially splitting the route into a northern and southern section. The closest access point of the A40 and M40 to the corridor would be at junction 1. There is a PRoW to the east of the Wraysbury Tunnel Connection and the Raw Water Transfer Main Route Corridor.

13.24. The Indicative WTW Site is parallel to the M25 and is located on an industrial estate, north of the existing Iver WTW, and within 500m of PRoWs running along the Grand Union Canal and Colne Brook.

13.25. The indicative site for the temporary construction compound is located to the west of the M25 and is also within 500m of PRoWs running along the Grand Union Canal.

13.26. Iver Railway Station is situated approximately 500m and 900m south from the Indicative WTW Site and the indicative site for the temporary construction compound respectively. Iver Railway Station is served by both the national rail service on the Great Western Mainline and London Underground services on the Elizabeth line. Other than Iver Railway Station, there are no other railway stations located within 2km of the Drinking Water Transfer although there are several bus stops within 1-2km.

13.27. The nearest National Cycle Network (NCN) route to the Indicative WTW Site and the indicative site for the temporary construction compound is route 61 which interests and runs perpendicular to the M25. NCN route 61 runs from the east of Maidenhead to the west of Cowley along Iver Lane; this is located less than 2km north-east of both the Indicative WTW Site and the indicative site for the temporary construction compound. Furthermore, NCN route 6 starts its route by connecting to NCN route 61 along Iver Lane less than 2km away and follows the River Colne north running parallel to the Drinking Water Transfer Main Route Corridor.

13.2.3 Appraisal outcomes

13.2.3.1 Construction and operational vehicle movements

13.28. Current construction methodology indicates around 100 HGV and 220 LGV vehicle movements per day are anticipated for the temporary construction compounds and around 50 staff vehicle movements. Further refinement would be required at later stages of development to determine peak periods of activity and how HGV, LGV and workforce vehicle trips are managed or reduced to mitigate impacts on the road network.

13.29. During operation of the new WTW, between one and three additional HGVs are anticipated per day (i.e. between two and six HGV vehicle movements) and up to 30 staff vehicle movements per day. Additionally, these HGV/workforce assumptions are also applied to the other components of the Lower Thames Reservoir Option as HGV figures are expected to be low.

13.30. Based upon high level estimates of HGVs, LGVs and staff vehicles that may be required during the construction and operational phases of the Lower Thames Reservoir Option, at this stage, it is not considered that the vehicles volumes generated would present additional constraints to the road network.

13.2.3.2 Construction access for the Raw and Drinking Transfer Mains

Strategic Road Network (SRN)

13.31. All of the indicative locations for temporary construction compounds identified were considered to have a score of 4 (lower risk) in terms of their proximity to SRNs as they all were less than 20km away from an SRN junction; however, no sites were within 1km of an SRN. Both the northbound and southbound vehicles would use the M25 orbital, which is located to the west of the Lower Thames Reservoir Option. The vehicles would be expected to choose either J15 or J16 to access and egress the M25 Orbital as well as travelling on the M4, M40 and A40.

13.32. There is an opportunity for a closer access and egress from the M25, which could provide a more direct route to the Drinking Water Transfer Main Route Corridor during construction. It is estimated that if direct access could be gained by construction vehicles to the M25, it could save an approximately 34km round trip for construction vehicles and reduce the impact on the local community as vehicles would not need to navigate along B roads/local roads when accessing the temporary construction compound sites.

Public rights of way

13.33. All of the indicative locations for temporary construction compounds identified were considered to have a score of 4 (lower risk) in terms of their proximity to PRoWs as each one was less than 400m from a PRoW. Although this provides a potential opportunity in terms of adequate public accessibility to these sites, it also provides a constraint when undergoing development works where construction areas may impact on nearby PRoWs.

13.34. Around half of the PRoWs identified within 400m are within 50m or less of the indicative locations for temporary construction compounds. Consideration would need to be made to maintain walking routes around temporary construction compounds and ensure they are accessible and safe to use.

Local road suitability

13.35. This criterion focussed on the construction vehicle accessibility level to the indicative locations for temporary construction compounds once they have egressed from the SRN or from site. The majority of roads that were assessed provided practical options such as the dual carriageway of Denham Road and the single carriageways of Bangor Road South, Thorney Lane Street and Slough Road. The main notable issues identified related to height restrictions for example along Court Lane and Breakspear Road South, and narrow roads such as Palmers Moor Lane, which are anticipated to make construction traffic difficult to manage without appropriate mitigation in place.

13.36. The majority of roads scored a 4 (lower risk) or 5 (no impacts) whereas Palmers Moor Lane scored a 2 (higher risk).

13.37. The desk-based assessment has also highlighted potential access issues for some of the indicative locations for temporary construction compounds. For example, access difficulties from both Harvil Road and Skip Lane where the current landscape would require trees and hedges to be cut down. These access issues would need to be investigated at subsequent project stages.

Proximity to public transport

13.38. The majority of the indicative locations for temporary construction compounds are considered to score a 3 (medium risk) in terms of proximity to a railway station with only one area being in close proximity to Iver Station (and therefore scoring a 4 (lower risk), making it a potential destination for workers to choose the train as the mode of transport to get to work compared to opting for private transport.

13.39. Bus stop services are in closer proximity to indicative locations for temporary construction compounds for the southern areas of the Lower Thames Reservoir Option compared to the northern section with bus stops no further than 800m away, which equates to a 9-minute walk (and therefore scoring a 3 (medium risk). However, indicative locations for temporary construction compounds in both the middle and northern sections of the Drinking Water Transfer Main Route Corridor seem to be more isolated from bus routes, and therefore scoring mostly 2 (higher risk).

Proximity to cycle network

13.40. The desk-based assessment has highlighted that NCN routes 61 and 6 offer good connections with the indicative locations for temporary construction compounds being considered a score of 3 (medium risk) and 4 (lower risk) in terms of proximity to the cycle network. However, NCN route 61 is in close proximity to one of the indicative locations for temporary construction compounds and, while this would be beneficial in terms of connectivity, this road would likely be used for vehicle access to the pipeline construction works. Consequently, appropriate mitigation for NCN route 61 is likely to be required.

13.2.3.3 Intersections of the Raw and Drinking Transfer Mains with existing transport infrastructure

Railway lines

13.41. The Raw Water Transfer Main Route Corridor does not intersect any railway lines. The Drinking Water Transfer Main Route Corridor crosses the Chiltern Railway and the HS1 Phase 1 route between Denham and West Ruislip train stations.

Navigable waterways

13.42. The Drinking Water Transfer Main Route Corridor crosses the Grand Union Canal in two places, to the north of the Indicative WTW Site (Slough Arm) and to the south of the A40.

Public rights of way

13.43. The Raw Water Transfer Main Route Corridor does not intersect any PRoWs.

13.44. The Drinking Water Transfer Main Route Corridor intersects with PRoWs. In total, there are 14 PRoWs which may require temporary diversions. The vast majority of PRoWs run perpendicular to the Drinking Water Transfer Main Route Corridor, meaning only a small section of the PRoW would need to be temporarily diverted or controlled to maintain the pedestrian route during construction. However, there is a short section where the Drinking Water Transfer Main Route Corridor runs along a footpath, and at this location it would be beneficial to run the pipeline beside the PRoW to prevent the need for temporary diversions where possible.

Highways and local roads

13.45. The Raw Water Transfer Main Route Corridor does not intersect any highways or local roads.

13.46. The Drinking Water Transfer Main Route Corridor intersects with highways and local roads. The majority of these are single carriageways or narrow access tracks and there is one section where the Drinking Water Transfer Main Route Corridor crosses the A40 where there are six lanes to cross, although it is assumed that the pipeline would be laid using an open cut method under the road.

Cycle network

13.47. The Drinking Water Transfer Main Route Corridor intersects with NCN routes 6 and 61.

13.2.3.4 Indicative Water Treatment Works Site

Strategic Road Network

13.48. The Indicative WTW Site is considered to have a score of 4 (lower risk) in terms of proximity to the SRN as it is less than 20km away from an SRN Junction. Both the northbound and southbound vehicles would use the M25 orbital, which is positioned to the west of the Lower Thames Reservoir Option. The vehicles would likely access the site via the M4.

Public rights of way

13.49. The Indicative WTW Site is adjacent to a PRoW and the indicative temporary construction compound is within 50m of a PRoW, and therefore scored a 4 (lower risk). Although the proximity of PRoWs provides a potential opportunity in terms of accessibility to the sites, it also provides a reason for particular caution when undergoing development works to ensure that construction impacts are contained within the site boundary.

Local road suitability

13.50. This criterion focussed on the construction vehicle accessibility level to site once they have egressed from the SRN or from site. The desk-based assessment indicated that the local roads provide practical options such as the single carriageways of London Road, Sutton Lane, North Park, Richings Way and Thorney Lane Street. At this stage, it is considered that the local roads offer suitable conditions for construction vehicles for the Indicative WTW Site and the associated indicative temporary construction compound and therefore scored a 4 (lower risk).

Proximity to public transport

13.51. The Indicative WTW Site is considered to score a 3 (medium risk but can be mitigated) in relation to its proximity to Iver Station and score of 2 (higher risk but can be partly mitigated) in relation to its proximity to bus stops where the nearest bus stop ranges from a 1 to 1.4km walk away.

Proximity to cycle network

13.52. The Indicative WTW Site is considered to score a 4 (lower risk) in relation to its proximity to the cycle network as NCN route 61 offers good connections for cycling.

13.2.4 Recommended mitigation

13.53. To avoid or mitigate potential disruption to transport infrastructure during construction and operation of the Lower Thames Reservoir Option, mitigation should be implemented. This includes:

- Where possible, widen narrow, single track lanes and / or implement a traffic management plan during construction.
- Investigate the opportunity to gain direct access from the M25 to the Drinking Water Transfer Main Route Corridor during construction.
- Phased diversion for footpaths which intersect the Drinking Water Transfer Main Route Corridor, so PRoWs remain accessible at all times.
- Engagement with National Highways to confirm the engineering method where the pipeline intersects with highways (A40 – Western Avenue).
- Engagement with Network Rail to progress an Asset Protection Agreement or Basic Asset Protection Agreement where the pipeline intersects with the Chiltern Railway Line and HS2 Phase 1 route.
- Engagement with the Canal and River Trust to confirm the engineering method for crossing the Grand Union Canal.
- A temporary diversion for NCN route 61 may be required and/or a localised traffic management programme implemented to control the flows of vehicles around the NCN during construction.
- Pursuant to the consenting process, a Transport Assessment would be undertaken and supporting documents such as a Construction Traffic Management Plan, Travel Plan and Servicing and Delivery Plan would be produced detailing how transport impacts are mitigated and managed.

13.3 Other material assets

13.54. There is no specific legislation for the assessment of impacts on material assets. The need to consider material assets is driven by national planning policy (draft NPS for Water Resource Infrastructure[20] (Section 4.10, Land use including open space, green infrastructure and Green Belt) and NPPF[21] (Chapter 10, High quality communications, and Chapter 17, Facilitating the sustainable use of minerals)).

13.3.1 Methodology

13.55. The desk-based assessment was based upon a mapping exercise to identify key material assets present in the study area and an assessment as to the potential for the Lower Thames Reservoir Option to affect material assets.

13.56. For construction, the desk based assessment focused on the transfer route corridors, location of the associated infrastructure and surrounding area within 200m. There is no guidance on buffer areas but 200m was chosen based on previous projects and the nature of material asset features.

13.57. Table 13.8 outlines the baseline data sources which were collated and considered in the desk based assessment. There is no set definition of what is covered under material assets, therefore, the SEPA guidance on SEA[83] and materials assets has been used as a basis. The transport infrastructure considered in Section 13.2 has not been repeated in this section.

Table 13.8: Sources of information (other material assets)

Data collected	Source
Infrastructure relating to energy and heat generation and distribution	
Power lines	National Grid[84]
Power plants (coal, nuclear, EfW)	Open Power System Data[85]
Large-scale renewables – wind farms, solar farms, hydroelectric	Open Power System Data[86]
Existing water / wastewater infrastructure	
Treatment works/reuse plants Reservoirs (including service reservoirs)	Thames Water and Affinity Water

[83] Scottish Environment Protection Agency (SEPA) Strategic Environmental Assessment
SEPA Guidance Note 4: Guidance on consideration of material assets in Strategic Environmental Assessment. Available at: https://www.sepa.org.uk/media/219432/lups-sea-gu4-consideration-of-material-assets-in-sea.pdf [Accessed April 2022]
[84] National Grid Network route maps. Available at: https://www.nationalgrid.com/uk/electricity-transmission/network-and-infrastructure/network-route-maps [Accessed April 2022]
[85] Open Power System Data. 2020. Data Package Conventional power plants. Version 2020-10-01. https://doi.org/10.25832/conventional_power_plants/2020-10-01. (Primary data from various sources, for a complete list see URL) [Accessed April 2022]
[86] Open Power System Data. 2020. Data Package Renewable power plants. Version 2020-05-20. https://doi.org/10.25832/renewable_power_plants/2020-05-20. (Primary data from various sources, for a complete list see URL) [Accessed April 2022]

Data collected	Source
Transport	
Airports / Airfields	OS mapping
Waste management	
Landfill sites – authorised (type)	Environment Agency
Waste management facilities including recycling centres, energy from waste plants, incinerators	Local Authority data – Mineral and Waste Plans Aerial mapping
Minerals	
Quarries	Onshore Geoindex[38]
Mineral Safeguarding Areas / Mineral Allocation Sites	Local Authority data – Mineral and Waste Plans

13.58. The material assets considered were limited by the availability of data on certain assets. Where possible open-source datasets were used but there were some assets where information was not publicly available or was not available due to lack of records or confidentiality. In these cases, any baseline data gaps were identified.

13.59. Several assets that could be considered under material assets are instead covered under different topics for example, community assets are included under Chapter 1, Population and health. Natural material assets such as woodland and agricultural land are covered under Chapter 4, Biodiversity, flora and fauna, Chapter 9, Landscape and Chapter 5, Soils, respectively.

13.3.2 Understanding of the baseline

13.60. Powerlines, powerplants, cabling and large scale renewables assets were reviewed. The assets identified were within the Drinking Water Transfer Main Route Corridor and include two intersections with powerlines and three electricity cable intersections.

13.61. There is one relevant WTW within the study area: the existing Iver WTW, and one reservoir asset: the existing service reservoir in the vicinity of Harefield.

13.62. There is a waste water treatment works to the north of the Grand Union Canal.

13.63. The Lower Thames Reservoir Option would cross numerous water mains within the Thames Water and Affinity Water networks.

13.64. There are no airports or airfields within the study area. Heathrow Airport is approximately 3km to the south east of the study area.

13.65. There are two active or recent landfills (Summerleaze Limited and Cape plc) and a several licensed waste sites (including three sites operated by Summerleaze Ltd near Denham Quarry) within the study area.

13.66. The Wraysbury Tunnel Connection, Raw Water Transfer Main Route Corridor and Indicative WTW Site and the southern section of the Drinking Water Transfer Main Route Corridor lies within a minerals safeguarding area for Alluvium (clay, silt sand and gravel) superficial deposits.

13.67. There is a Minerals Commitment Area to the south of the M40. The area is split into three areas. The northern area is designated as an area subject to phasing for sand and gravel extraction. The southern area is allocated as a preferred area for mineral working under the Buckinghamshire Minerals and Waste Local Plan[87] for sand and gravels. Three extensions to the New Denham Quarry are designated as allocated mineral sites within this area.

13.68. There are no airports or airfields within the study area. RAF Northolt approximately 2km to the east and Heathrow Airport is approximately 3km to the south east of the study area.

13.3.3 Appraisal outcomes

13.69. Construction of the Drinking Water Transfer Main would require excavation and depending on the height of machinery required to excavate, there may be impacts on the power lines present within the study area. This may present potential safety hazards which may result in a power outage and damaged cables.

13.70. No impacts are anticipated on existing waste water treatment facilities. Temporary disturbance may occur to the existing service reservoir in the vicinity of Harefield during construction when the Drinking Water Transfer Main is connected, but disruption is likely to be minor and short-lived.

13.71. There would be no direct impacts on the operation of authorised landfills or waste management facilities as the Drinking Water Transfer Main can be routed to avoid

[87] Buckinghamshire County Council (2019) Buckinghamshire Minerals and Waste Local Plan 2016-2036. Available at: https://buckinghamshire-gov-uk.s3.amazonaws.com/documents/buckinghamshire-minerals-and-waste-local-plan-2016-2036_yiYUGSb.pdf [Accessed April 2022]

them. This would need to be confirmed at the next stage.

13.72. The Drinking Water Transfer Main Route Corridor is within a mineral safeguarding area and there are allocated mineral sites within the route corridor. It is considered that these sites could be avoided through route alignment therefore no adverse impacts are anticipated.

13.73. Aviation safeguarding zones for Heathrow Airport should be investigated at the next stage although it is not considered that this would present a significant risk for the Lower Thames Reservoir Option.

13.74. No impacts on material assets are anticipated during operation.

13.3.4 Recommended mitigation

13.75. In order to mitigate potential issues arising from the Lower Thames Reservoir Option on material assets, mitigation measures should be implemented such as selection of appropriate machinery for the pipeline excavation in proximity to any power lines and use of covers such as netting below power lines to reduce potential power outages.

13.76. The alignment of the Drinking Water Transfer Main should ensure avoidance of allocated minerals sites and existing operational assets such as landfills and waste facilities. Engagement should be undertaken with the Minerals and Waste Authority on sections of the Drinking Water Transfer Main Route Corridor that traverse strategic areas of minerals.

13.4 Summary of main findings and recommendations for future technical work

13.77. The Lower Thames Reservoir Option has the potential to affect other material assets during construction and operation including transport, energy, water and wastewater, waste and minerals infrastructure.

13.78. Based upon high level estimates of HGVs and staff vehicles that may be required during the construction and operational phases of the Lower Thames Reservoir Option, at this stage, it is not considered that the vehicles volumes generated would present additional constraints to the road network, and the majority of roads are anticipated to provide practical options such as the dual carriageway of Denham Road and the single carriageways of Bangor Road South, Thorney Lane Street and Slough Road. Potential issues have been identified in some areas, for example, access difficulties from both Harvil Road and Skip Lane where the current landscape may require trees and hedges to be removed. These access issues would need to be investigated at subsequent project stages.

13.79. The Drinking Water Transfer Main Route Corridor intersects with PRoWs and there are PRoWs in proximity to the indicative locations for temporary construction compounds and the Indicative WTW Site. Although this provides a potential opportunity in terms of adequate public accessibility to these sites, it also provides a constraint when undergoing development works where construction areas may impact on nearby PRoWs. Consideration would need to be given to maintain walking routes around temporary construction compounds and ensuring they are accessible and safe to use.

13.80. The Drinking Water Transfer Main Route Corridor intersects with NCN routes 6 and 61. NCN route 61 is in close proximity to one of the indicative locations for temporary construction compounds and, while this would be beneficial in terms of connectivity, this road would likely be used for vehicle access to the pipeline construction works. Consequently, appropriate mitigation for NCN route 61 is likely to be required, potentially including a temporary diversion. NCN route 61 offers good connections for cycling to the Indicative WTW Site.

13.81. The Drinking Water Transfer Main Route Corridor crosses the Chiltern Railway, HS2 Phase 1 route, Grand Union Canal and highways and local roads. Engagement would be required with the relevant stakeholders including National Highways, Network Rail and Canal and River Trust at a subsequent project stage.

13.82. The Lower Thames Reservoir Option has the potential to affect other material assets during construction including potential safety hazards from overhead powerlines, existing operational assets including licensed waste sites and strategic areas of minerals. During operation, there is potential for temporary disruption during maintenance work.

13.83. Recommended areas for future technical work at a subsequent project stage are summarised below:

- Review any changes to the conceptual design following Gate 2 in terms of access routes to the indicative locations for temporary construction compounds, pipeline crossings and HGV/workforce access for the new WTW.
- Review construction HGV and workforce numbers and programme once known to determine construction flows to assess future potential impact on roads.
- Review construction vehicle types once known to enable access roads and site access point suitability to be assessed.
- Collect baseline traffic data, depending on the expected volume of vehicles and the programme. Traffic surveys are only likely to be required at specific junctions. The scope of traffic surveys and need for modelling would be subject to engagement with the highway authorities.

- Update review of local authority local plans / transport schemes to understand potential cumulative effects from other projects to determine the modelling extents and junction analysis required.
- Engage with highway authorities where opportunities to create access routes access have been highlighted.
- Review alignment of the Drinking Water Transfer Main to ensure avoidance of existing and allocated minerals and waste sites and undertake engagement with relevant stakeholders including Minerals and Waste Authorities.
- Pursuant to the consenting process, a Transport Assessment would be undertaken and supporting documents such as a Construction Traffic Management Plan, Travel Plan and Servicing and Delivery Plan would be produced detailing how transport impacts are mitigated and managed.

14 Potential cumulative effects

14.1 Introduction

14.1. An initial cumulative effects assessment has been undertaken and is presented in Technical Supporting Document B4, Strategic Environmental Assessment Review. It is understood that if the Lower Thames Reservoir Option is selected as an option in the WRSE Regional Plan, as well as Thames Water WRMP24 and Affinity Water WRMP24, it will be subject to an in-combination effects assessment with the other selected options, neighbouring water companies plans and neighbouring regional plans. Until the WRSE Best Value Regional Plan has been developed and agreed, it is not known when the Lower Thames Reservoir Option would be implemented, and therefore, which other developments could act in-combination with it.

14.2 Plans, programmes and projects considered

14.2. The following plans, programmes and projects have been considered within the cumulative effects assessment:

- Other SROs
- Other water company schemes
- Local Development Frameworks
- Development Consent Orders for Nationally Significant Infrastructure Projects
- Relevant Transport and Works Act Orders
- Relevant planning applications

14.3 Strategic Resource Options

14.3. No other SROs are geographically near to the Lower Thames Reservoir Option and therefore effects during construction are unlikely to occur. Cumulative operational effects are unlikely.

14.4 Other water company schemes

14.4. Thames Water and Affinity Water have confirmed that there are no other relevant water company schemes that would need to be considered.

14.5 Local development frameworks

14.5.1 Three Rivers District Council, Batchworth Golf Course, New Local Plan – Sites for Potential Allocation

14.5. Batchworth Golf Course is a site for potential allocation 618 houses, required to provide a primary school, open space and play space. The site is located 1.3km from the Harefield Service Reservoir Connection. The phasing of the works of the Batchworth Golf Course allocation is 6-16 years. There is therefore potential for construction programmes to overlap with the Lower Thames Reservoir. If construction periods overlap then there is the potential for minor cumulative construction effects arising from visual intrusion, traffic disruption, noise, vibration and air quality. Potential receptors include Bishops Wood Country Park (LWS), Batchworth Heath (LWS), BMI Bishops Wood Hospital, Mount Vernon Hospital, Michael Sobell Hospice, Bishops Wood, Woodcock Hill, Rickmansworth (open access area), DM7 Landscape Character area Landscape Region - South Herts Plateau. No cumulative impacts resulting from operation are anticipated.

14.5.2 Pre-Submission Spelthorne Local Plan 2022-2037 - Spelthorne Borough Council – Site Allocation - ST4/009 (Elmsleigh Centre and Adjoining Land, South Street)

14.6. This site allocation is for 850 residential units and retail/commercial town centre uses. The construction period of the development has planned overlap with the Lower Thames Reservoir Option. Cumulative effects were therefore considered, however, none were identified for the construction or operational phases. The development is within 3km of the South West London Waterbodies SPA and Ramsar. HRA Stage 2 Appropriate Assessment did not identify any transmission pathways by which a Likely Significant Effect could reasonably occur. Therefore, no adverse effects on the integrity of the Habitats Sites are considered likely either alone or in-combination. The distance between the developments and the Lower Thames Reservoir Option are also significant enough that no other common receptors were identified with potential for cumulative effects.

14.5.3 Buckinghamshire Minerals and Waste Local Plan (to 2036)

14.7. The following allocated sites within the Buckinghamshire Minerals and Waste Local Plan were also considered:

- M3: New Denham Quarry Extension, Allocated Site for Sand and Gravel Provision
- M4: New Denham Quarry North West Extension, Allocated Site for Sand and Gravel Provision

14.8. These are allocated sites for mineral extraction and are adjacent to the Drinking Water Transfer Main Route Corridor. The plan period is up to 2036 so there could potentially be an overlap with the construction phase of the Lower Thames Reservoir Option. If construction periods overlap then there is the potential for minor cumulative construction effects arising from visual intrusion, noise, vibration and air quality on the local community and other sensitive receptors. Fray's Farm Meadows SSSI and Fray's Valley LNR, and Kingcup Meadows and Oldhouse Wood SSSI are all within 2000m of both the Drinking Water Transfer Main Route Corridor and the New Denham Quarry allocation therefore there is potential for cumulative indirect effects if construction periods were to overlap.

14.6 Planning applications

14.6.1 2019/0215 - Surrey County Council

14.9. This is an application for extraction of sand and gravel that would operate over a period of 14 years and would therefore overlap with the construction period for the Lower Thames Reservoir Option. Cumulative effects were therefore considered, however, none were identified for the construction or operational phases. The development is within 3km of the South West London Waterbodies SPA and Ramsar. HRA Stage 2 Appropriate Assessment did not identify any transmission pathways by which a Likely Significant Effect could reasonably occur. Therefore, no adverse effects on the integrity of the Habitats Sites are considered likely either alone or in-combination. The distance between the developments and the Lower Thames Reservoir Option are also significant enough that no other common receptors were identified with potential for cumulative effects.

14.6.2 Buckinghamshire Council, Buckinghamshire Council (CM/0049/21)

14.10. This is an application for a phased extraction of an allocated sand and gravel deposit, including for the construction and use of a new bell mouth access off North Park. The application is awaiting a decision. The development has an estimated period of operation of seven to eight years and is therefore likely to be fully built out before construction of the Lower Thames Reservoir Option commences in 2035, however, would need to be considered as part of a future cumulative effects assessment in terms of temporal effects, for example on local communities, and the potential deterioration of the environment as a result of successive developments.

14.7 Nationally significant infrastructure projects

14.11. The following developments were considered as part of the cumulative effect assessment:

- UK Government Hybrid Bill HS2 Phase One – this is likely to be completed between 2029 and 2033, and therefore would be fully built out and operational by the anticipated start of construction for the Lower Thames Reservoir in 2035.
- Planning Inspectorate, Western Rail Link to Heathrow – the timing of this development is uncertain as 2018 consultation material suggests a Summer 2019 DCO application, with works due to be completed by 2027 and a new rail service operational by 2028; the Planning Inspectorate website[88] currently states DCO application expected to be submitted in Winter 2021/2022 and the Network Rail website[89] suggests a Winter 2022 submission. Even with a delayed submission, it is anticipated that the scheme would be fully built out and operational by 2035.

14.12. These developments are located within 1km of the Lower Thames Reservoir Option. Both of these developments are likely to be fully built out before construction of the Lower Thames Reservoirs Option commences, however, they would need to be considered as part of a future cumulative effects assessment in terms of temporal effects, for example on local communities, and the potential deterioration of the environment as a result of successive developments. These developments would also need to form part of the future baseline for the Environmental Impact Assessment (EIA). In particular, the future baseline in relation to area north and south of the crossing of the HS2 Phase One would need to be considered.

[88] https://infrastructure.planninginspectorate.gov.uk/projects/south-east/western-rail-link-to-heathrow/?ipcsection=overview [Accessed April 2022]
[89] https://www.networkrail.co.uk/running-the-railway/our-routes/western/western-rail-link-to-heathrow/ [Accessed April 2022]

15 Invasive non-native species risk assessment

15.1 Introduction

15.1.1 Key legislation

15.1. The translocation of INNS is subject to regulation under the following national legislation:

- Under the Wildlife and Countryside Act 1981 (as amended), it may be an offence to release or allow to escape into the wild any animal which ‘is of a kind which is not ordinarily resident in and is not a regular visitor to Great Britain in a wild state’; or is included in Part I of Schedule 9.
- Under the Wildlife and Countryside Act 1981 (as amended), it may be an offence to plant or otherwise cause ‘to grow in the wild any plant which is included in Part II of Schedule 9’.
- The INNS (Amendment etc.) (EU Exit) Regulations 2019 ensures the continued operability of EU legislation which provides for a set of measures to combat the spread of INNS on the list of EU concern, through prevention, early detection and eradication, and management.
- Under the Invasive Alien Species (Enforcement & Permitting) Order 2019, it may be an offence to release, cause to escape, plant, or grow species of animal or plant ‘not ordinarily resident in’ and ‘not a regular visitor to Great Britain in a wild state’, or otherwise listed in Schedule 2.
- Waterbodies initially classified as ‘High Status’ (representing near-natural conditions) under the Water Environment (WFD) (England and Wales) Directive 2017, will be reclassified to the lesser ‘Good Status’ if populations of High Impact INNS are introduced. High Impact INNS are identified on the current aquatic alien species list produced by the Water Framework Directive UK Technical Advisory Group (WFD-UKTAG, 2015)[90].

[90] WFD-UKTAG (2015). UK Technical Advisory Group on the Water Framework Directive. Revised classification of aquatic alien species according to their level of impact. Public working draft.

15.1.2 Assessment objectives

15.2. The overall aim of this assessment is to determine the potential increase in INNS risk arising from the Lower Thames Reservoir Option. This overall aim was underpinned by the following objectives:

- To establish if the scheme would introduce a hydrological connection between previously isolated catchments.
- To identify INNS within an appropriate study area to understand the current INNS distribution.
- To outline the legislative context of INNS risk assessment.
- To use the SRO Aquatic INNS Risk Assessment Tool (SAI-RAT) developed by APEM Ltd on behalf of the Environment Agency[91] to quantify the INNS risk associated with the scheme based on the conceptual design information currently available.
- To review potential biosecurity options for implementation by the client and other relevant stakeholders to mitigate the INNS risk associated with the scheme.

15.2 Methodology

15.2.1 Study area

15.3. As outlined in Section 2.1, the Lower Thames Reservoir Option involves the transfer of water from Wraysbury Reservoir and Queen Mother Reservoir, located near Slough to an existing service reservoir in the vicinity of Harefield. For the purpose of the INNS Risk Assessment, the Lower Thames Reservoir Option has been divided into three sections, which have been assessed separately in the risk assessment tool:

- Section 1: Transfer of raw water originating from Wraysbury and Queen Mother Reservoirs through an existing tunnel from Shaft 6 located near Moor Lane, Staines to a new pumping station located within the site of the existing Iver WTW.
- Section 2: Transfer of raw water from the new pumping station via a new pipeline across the boundary of the existing Iver WTW to a new WTW at the Indicative WTW Site.
- Section 3: Pipeline transfer of drinking water from the new WTW to an existing service reservoir in the vicinity of Harefield.

[91] APEM Ltd (2021). SRO Aquatic INNS Risk Assessment Tool (SAI-RAT) – User Guide. Produced on behalf of the Environment Agency.

15.4. The Environment Agency guidance for SRO INNS risk assessments[91] specifies that the study area should be a 1km buffer zone either side of the proposed water transfer route.

15.2.2 High-level screening related to Environment Agency guidance

15.5. The Environment Agency position statement *Managing the Risk of Spread of Invasive Non-Native Species Through Raw Water Transfers*[92] outlines the organisation's position on how it will manage INNS risks associated with raw water transfers. The key points of relevance to this assessment are as follows:

- The focus of the Environment Agency's approach is on the pathways that the transfers create, not on current INNS distribution.
- New schemes that create a hydrological connection between isolated catchments must have mitigation measures in place to ensure INNS cannot be spread by the new transfer.
- Where water transfer into another watercourse remains the preferred solution, mitigation will need to be fail safe, resilient, and completely effective for all life stages and forms (e.g., plant propagules, animals, microscopic organisms and larval stages).
- Where catchments are already connected, a risk assessment will be required, which the Environment Agency will use to decide whether subsequent mitigation is required, to ensure the risk of INNS transfer is not significantly increased.

15.6. The Lower Thames Reservoir Option was screened to determine if it would create a link between isolated catchments, mapped in the Environment Agency document Invasive Non-Native Species Isolated Catchment Mapping[93].

15.2.3 Invasive non-native species records

15.7. Open-source macroinvertebrate, macrophyte and fish data for the period 1965 to 2022 were obtained for the study area from the Environment Agency Ecology and Fish Data Explorer app[94] and the NBN Atlas online records[23]. The data were screened against Schedule 9 of the Wildlife and Countryside Act 1981 (as amended) and WFD-

[92] Environment Agency (2017). Managing the Risk of Spread of Invasive Non-Native Species Through Raw Water Transfers. Position 1321_16.
[93] Environment Agency (2018). Invasive Non-Native Species Isolated Catchment Mapping. Prepared by Wallingford HydroSolutions Ltd.
[94] Environment Agency Ecology and Fish Data Explorer app. Available at: https://environment.data.gov.uk/ecology/explorer/ [Accessed April 2022]

UKTAG guidance[95] to identify INNS present within the study area.

15.2.4 Ricardo PLC field surveys

15.8. In support of the T2AT SRO, aquatic ecological monitoring was undertaken by Ricardo PLC in 2021, with additional surveys planned in 2022. Field surveys and environmental deoxyribonucleic acid (eDNA) samples for INNS were undertaken at six locations along the River Thames.

15.9. Further detail of the field surveys, including methods and locations is included in Appendix C.1. The field surveys results are discussed in Section 15.3.

15.2.5 Risk assessment

15.10. The SAI-RAT used for this investigation was developed by APEM Ltd on behalf of the Environment Agency[91]. The tool builds upon other assessment tools such as the Northumbrian Water Group (NWG) raw water transfer assessment tool and the Wessex Water asset assessment tool, to provide a standardised approach to quantifying the INNS risk associated with SROs.

15.11. Risk assessments are processes by which the level of risk presented by certain hazards can be assessed, where hazards are anything that can cause harm. The level of risk is typically the combination of the chance and extent of the harm which could be caused. In the case of this tool, the hazard is the potential movement of INNS along key pathways, and the risk is the chance of that movement occurring combined with the extent of the harm this could cause.

15.12. The tool takes a pragmatic pathway and source-pathway-receptor model approach to the assessment of INNS risk relating to assets and raw water transfers. An extended functional group mechanism has been included in the tool to account for future risks rather than only examining species known to be currently present within the vicinity of transfer routes and assets. These functional groups are listed in Table 15.1.

[95] WFD-UKTAG (2015). UK Technical Advisory Group on the Water Framework Directive. Revised classification of aquatic alien species according to their level of impact. Public working draft.

Table 15.1: INNS function groups

Animals	Plants
Mobile, juveniles < 1mm, eggs	Seed, aquatic, annual
Sessile, juveniles < 1mm, eggs	Vegetative, aquatic, annual
Mobile, juveniles > 1mm, eggs	Seed + vegetative, aquatic, annual
Sessile, juveniles > 1mm, eggs	Seed, riparian, annual
Mobile, juveniles < 1mm, no eggs	Vegetative, riparian, annual
Sessile, juveniles < 1mm, no eggs	Seed + vegetative, riparian, annual
Mobile, juveniles > 1mm, no eggs	Seed, aquatic, perennial
Sessile, juveniles > 1mm, no eggs	Vegetative, aquatic, perennial
	Seed + vegetative, aquatic, perennial
	Seed, riparian, perennial
	Vegetative, riparian, perennial
	Seed + vegetative, riparian, perennial
	Seed, aquatic + riparian, annual
	Vegetative, aquatic + riparian, annual
	Seed + vegetative, aquatic + riparian, annual
	Seed, aquatic + riparian, perennial
	Vegetative, aquatic + riparian, perennial
	Seed + vegetative, aquatic + riparian, perennial

15.13. The risk assessment matrix tool takes the form of a Microsoft Excel spreadsheet, into which data and information about SRO water transfers and asset options are entered by the assessor to automatically generate a risk score. Risk scores are presented as a percentage of the highest potential score, with a higher score signifying an increased risk of introducing and transferring INNS. Risk scores are categorised as Low, Medium or High, as shown in Table 15.2.

Table 15.2: Risk score categories

Percentage (%)	Category
0-33	Low
34-66	Medium
67-100	High

15.14. Detailed instructions for use of the tool are provided in the SRO Aquatic INNS Risk Assessment Tool (SAI-RAT) – User Guide (APEM Ltd, 2021). Tool input data is provided in Appendix D.

15.2.6 Biosecurity assessment

15.15. The SAI-RAT includes a high-level, qualitative assessment of biosecurity measures. Following input of proposed water transfer and new asset details to the tool, various biosecurity measures are presented based on the identified pathways of INNS spread. Each of the presented biosecurity measures in the tool are assigned a confidence rating of either High, Medium or Low based on their overall robustness at reducing risk in relation to the corresponding pathway and recreational activities occurring.

15.2.7 Constraints and limitations

15.16. The SAI-RAT used in this assessment quantifies the risk associated with the operational phase of a water transfer option, rather than the construction phase. The Lower Thames Reservoir Option would involve the construction of new assets and pipelines, which poses the risk of INNS being spread through the movement of personnel, vehicles and equipment to and from construction sites, as well as the excavation and disposal of materials (e.g., sediment and vegetation). As the design is further developed, construction-phase risks relating to INNS should also be considered, and any identified mitigation measures included in a CEMP to be prepared at a subsequent project stage, as set out in Section 2.3.

15.17. The data and information entered into the INNS risk assessment tool were based on the latest available conceptual design. As the conceptual design is still in development, these details may be subject to change. The INNS risk assessment should be revised throughout the design process. For example, at the time of assessment the number of washout/maintenance points along the tunnel and pipeline sections of the transfer route could not be confirmed. These should be factored into the risk assessment when they are incorporated into the design.

15.3 Results

15.3.1 High-level screening related to Environment Agency guidance

15.18. The transfer source, Wraysbury and Queen Mother Reservoirs, falls within area 73 of the Environment Agency's *Invasive Non-Native Species Isolated Catchment Mapping v3* (Environment Agency, 2018)[93]. This area is classified as 'Canal – CRT', meaning that it is connected to navigable canals controlled by the Canal and River Trust. As the transfer receptor is also located within the same area as the transfer source, it is concluded that the Lower Thames Reservoir Option would not create a link between 'isolated' catchments.

15.19. The Environment Agency guidance for raw water transfers states: 'where catchments are already connected, a risk assessment will be required, which the Environment Agency will use to decide whether subsequent mitigation is required, to ensure the risk of INNS transfer is not significantly increased.' The INNS risk assessment presented in this report fulfils this requirement at Gate 2. The output suggests that the Lower Thames Reservoir Option would not significantly increase the risk of INNS transfer. However, this conclusion is subject to the constraints and limitations detailed in Section 15.2.7 and should be taken under advisement from the Environment Agency.

15.3.2 Invasive non-native species records

15.20. A total of thirty-six invasive aquatic species were identified in the Environment Agency and NBN Atlas records for the study area. Four invasive fish species were identified, including the High Impact common carp (*Cyprinus carpio*). Eleven invasive macroinvertebrates taxa have been recorded in the study area, of which four are

High Impact species. Sixteen invasive aquatic and riparian plant species have been recorded, including seven High Impact species.

15.21. Most species records within the study area have occurred within the last 10 years, with the exception of Dreissenidae sp. which have been recorded within the last 15 years. Canadian pondweed (*Elodea canadensis*) has not been recorded since 2004 and is considered unlikely to be present. Overall, these records indicate that the prevalence of non-native plants have been increasing since 1965, with a surge in occurrences in the 2010s. The prevalence of non-native fish and macroinvertebrate species is relatively unchanged.

15.22. Further detail of the INNS records within 1km of the transfer routes is included in Appendix C.1.

15.3.3 Ricardo PLC field results

15.23. Several non-native macroinvertebrates and macrophytes were recorded during physical searches of all six sites on the River Thames, including High Impact macroinvertebrate species demon shrimp, quagga mussel and zebra mussel; and the High Impact macrophyte species Canadian waterweed, Nuttall's waterweed and Himalayan balsam. The greatest number of INNS was recorded at sites T2AT-002 and T2AT-006, with eight species recorded at each sites. Sites T2AT-003 to T2AT-005 are located within close proximity (<1.6km) to the source water, the Queen Mother Reservoir and Wraysbury Reservoir.

15.24. Further detail of the field survey results is included in Appendix C.2.

15.3.4 Species distribution

15.25. A summary of the distribution of INNS found during Environment Agency record searches and during field surveys by Ricardo PLC is presented below in Table 15.3. Note the INNS records identified using NBN Atlas were not included in this summary as individual grid references were not available.

15.26. It is noted that some species, such as New Zealand mud snail are considered 'naturalised' throughout the UK. These species are also considered in the Section 4.3 (Aquatic ecology).

Table 15.3: Summary of species distribution within study area

Species	Legislative status	Taxon group	Location of records	Distribution
Common carp (including koi carp, mirror carp and common and common carp varieties) *Cyprinus carpio*	UKTAG-High[96]	Bony fish	River Thames Colne Brook Duke of Northumberland's River	Widespread records of carp in the River Thames and Colne Brook.
Bladder snail *Physella acuta*	UKTAG-Unknown	Mollusc	River Colne River Misbourne Fray's River	Widespread throughout local river system
Caspian mud-shrimp *Chelicorophium curvispinum*	UKTAG-Unknown	Crustacean	River Colne River Thames	Found in one location on the River Colne, but widespread along the River Thames
Demon shrimp *Dikerogammarus haemobaphes*	UKTAG-High	Crustacean	River Colne River Thames	Widespread throughout local river system
Florida crangonyctid *Crangonyx floridanus*	UKTAG-Unknown	Crustacean	Colne Brook	Two records of Florida crangonyctid were found on the River Colne in close proximity. However, as this species is difficult to identify from northern river crangonyctid in the field, it is often recorded as Florida/northern river crangonyctid and is therefore likely to be widespread throughout the river system.

[96] WFD-UKTAG listed INNS, categorised as High / Medium / Low / Unknown Impact

Species	Legislative status	Taxon group	Location of records	Distribution
Freshwater bivalve *Dreissenidae sp.*	UKTAG-Unknown	Mollusc	Grand Union Canal Fray's River Grand Union Canal Slough Arm	Three individual records were found in rivers. Zebra mussel (*Dreissena polymorpha*) has been recorded in all of these rivers and is widespread. Quagga mussel (*Dreissena bugensis*) has also been recorded in Wraysbury River and is at risk of further spread.
Gastropod *Physella sp.*	UKTAG-Unknown	Mollusc	River Misbourne River Colne River Thames	Recorded at four sites. Records could also include Bladder snail *Physella acuta* which is widespread throughout local river system
New Zealand mud snail *Potamopyrgus antipodarum*	UKTAG-Moderate	Mollusc	River Colne River Misbourne Fray's River River Pinn Colne Brook Wraysbury River River Thames	Widespread throughout local river system
Northern river crangonyctid *Crangonyx pseudogracilis*	UKTAG-Low	Crustacean	Colne Brook River Misbourne River Colne	Widespread throughout local river system

Species	Legislative status	Taxon group	Location of records	Distribution
Northern river/Florida crangonyctid *Crangonyx pseudogracilis/floridanus*	UKTAG-Unknown	Mollusc	River Colne River Misbourne Alder Bourne Colne Brook Grand Union Canal Slough Arm Wraysbury River River Thames	Widespread throughout local river system
Quagga mussel *Dreissena bugenis*	UKTAG-High	Mollusc	Wraysbury River River Thames	The presence of quagga mussel was recorded by two different sources but were found in close proximity of each other potentially indicating a localised population at risk of further spread. Quagga mussels are a high impact species and are a known prolific invader
Side swimmer *Gammarus tigrinus*	UKTAG-Unknown	Crustacean	River Colne Colne Brook	Unlikely to be widely established throughout river system

Species	Legislative status	Taxon group	Location of records	Distribution
Signal crayfish *Pacifastacus leniusculus*	UKTAG-High WACA 1981 Sch. 9[97] EU species of special concern[98] IAS Order 2019 Sch. 2[99]	Crustacean	Alder Bourne River Misbourne	Signal crayfish recorded at two separate locations in close proximity. Populations likely to be relatively localised but are at risk of further spread. Signal crayfish are a high impact species and are a known prolific invader
Zebra mussel *Dreissena polymorpha*	UKTAG-High	Mollusc	Fray's River River Colne Colne Brook Wraysbury River River Thames	Zebra mussel recorded in several rivers close to the scheme. Zebra mussel is likely to be relatively widespread.
Tubificid worm *Branchiura sowerbyi*	UKTAG-Unknown	Oligochaete worm	River Thames	Located at one site on River Thames
Asian clam *Corbicula fluminea*	UKTAG-High	Mollusc	River Thames	Located at two sites on the River Thames approximately 15km apart.
Polychaete worm *Hypania invalia*	UKTAG-Unknown	Annelid worm	River Thames	Located on one site on River Thames
Canadian waterweed *Elodea canadensis*	UKTAG-Moderate WACA 1981 Sch. 9	Flowering plant	River Colne	Located at two sites on the River Colne approximately 13km apart.

97 Listed on Schedule 9 of the Wildlife & Countryside Act 1981
98 Invasive Non-Native Species (Amendment etc.) (EU Exit) Regulations 2019 – listed as an 'invasive alien species of union concern'
99 Listed on Schedule 2 of the Invasive Alien Species (Enforcement and Permitting) Order 2019

Species	Legislative status	Taxon group	Location of records	Distribution
Nuttall's waterweed *Elodea nuttallii*	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	Flowering plant	River Pinn Colne Brook River Colne Wraysbury River River Thames	Records for Nuttall's waterweed found in several adjacent rivers. Widespread in the River Thames
Floating pennywort *Hydrocotyle ranunculoides*	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch.	Flowering plant	River Colne Colne Brook Wraysbury River	Floating pennywort recorded within close proximity in several rivers adjacent to scheme
Himalayan Balsam *Impatiens glandulifera*	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	Flowering plant	River Pinn Colne Brook Wraysbury River River Colne River Thames	Himalayan Balsam recorded within close proximity in several rivers adjacent to scheme
Broadleaf arrowhead *Sagittaria latifolia*	UKTAG-Unknown	Flowering plant	River Thames	Located at one site on the River Thames

Species	Legislative status	Taxon group	Location of records	Distribution
Giant hogweed *Heracleum mantegazzianum*	UKTAG – High WACA 1981 Sch. 9	Flowering plant	River Pinn	Located at one site on River Pinn
Least duckweed *Lemna minuta*	UKTAG-Unknown	Flowering plant	River Colne River Misbourne Alder Bourne River Pinn Colne Brook River Colne Wraysbury River River Thames	Widespread throughout local river system
Monkey flower *Mimulus sp.*	UKTAG-Moderate	Flowering plant	River Misbourne	Recorded at two sites on the River Misbourne. This species potentially has a limited distribution with the local river network
Orange balsam *Impatiens capensis*	UKTAG-Low	Flowering plant	River Misbourne Alder Bourne Colne Brook Wraysbury River River Colne River Thames	Orange balsam recorded in several rivers adjacent to the scheme
Sweet flag *Acorus calamus*	UKTAG-Low	Flowering plant	River Thames	Located at one site on the River Thames

15.3.5 Risk assessment

15.3.5.1 Water transfer risk

15.27. The INNS risk assessment results for the Lower Thames Reservoir Option water transfer sections as derived from the Environment Agency SAI-RAT are summarised in Table 15.4 below. It should be noted that these scores do not take into account any engineering interventions that may be required as mitigation to prevent the spread of INNS.

Table 15.4: INNS risk assessment scores for water transfer

Transfer section name	Transfer section description	Risk score (%)	Risk score category
Section 1	Shaft 6 (Queen Mother/Wraysbury Reservoirs) to new raw water pumping station within the site of the existing Iver WTW via existing tunnel	44.25	Medium
Section 2	New raw water pumping station to new WTW via new pipeline	34.10	Medium
Section 3	New WTW to an existing service reservoir in the vicinity of Harefield via new pipeline	32.73	Low

15.28. Of the three water transfer sections, Section 1 was found to have the highest associated INNS risk, with a score of 44.25%, which falls into the Medium risk category. Section 2 also falls into the Medium risk category with a risk score of 34.10%. Section 3 generated the lowest risk score at 32.73%, which places it marginally within the Low risk category.

15.29. Section 3 generated the lowest risk score on account of the source being a WTW. Whereas the first two sections of the transfer contain raw water, Section 3 contains drinking water (this is acknowledged in the risk assessment tool through the selection of source type as 'water treatment site'). As such, there is considered to be no risk of introducing new INNS to either the pathway or receptor. The risk score generated for Section 3 is associated with the higher operation frequency and greater transfer distance than for Sections 1 and 2, though in reality this section of transfer poses a negligible INNS risk.

15.30. Although raw water is not discharged to an open waterbody at any point along the transfer route, the sections that contain raw water garner a higher score to account for the risk of INNS introduction to the environment via leaks or washout of raw water from the pipeline/tunnel, or movement of INNS due to operational procedures (e.g., contamination of personnel clothing, equipment or vehicles that come into contact with raw water). Additionally, water transfer via a tunnel, as in Section 1, poses a greater risk of INNS spread than water transfer via a pipeline, hence the higher score for Section 1 than for Section 2. The fact that Section 2 terminates at a WTW also contributes to the lower score.

15.3.5.2 Asset risk

15.31. The INNS risk assessment scores for the proposed new assets as derived from the Environment Agency tool are summarised in Table 15.5 below.

Table 15.5: INNS risk assessment scores for assets

Asset name	Risk score (%)	Risk score category
Raw water pumping station	14.72	Low
New WTW	19.59	Low

15.32. It is considered that the most likely pathway of INNS spread associated with the new assets would be the movement of personnel and vehicles from the sites following contact with raw water. Both of the proposed assets generated a Low risk score for introducing and spreading INNS. The new WTW scored slightly higher due to the higher frequency of maintenance and removal of waste sludge onto land. Suggested biosecurity measures are discussed in Section 15.3.6.

15.3.5.3 Overall risk

15.33. The overall risk associated with the Lower Thames Reservoir Option was found to be Low at 27.09%. The water transfer component of the Lower Thames Reservoir Option was deemed to be Medium risk overall whereas the asset component was deemed Low risk. A full breakdown is provided in Table 15.6.

Table 15.6: Overall risk scores associated with the Lower Thames Reservoir Option

Component	Average risk score (%)	Risk score category
Water transfers	37.03	Medium
New assets	17.16	Low
Overall	27.09	Low

15.3.6 Biosecurity assessment

15.34. The risk assessment tool identified a range of biosecurity measures to mitigate the risk associated with key pathways of INNS spread that may be introduced by the proposed water transfers and assets. Potential biosecurity measures specific to transfer pathway type are presented in Table 15.7. Only Section 1 and Section 2 of the transfer would benefit from biosecurity or mitigation measures as the only section which involves the transfer of raw water. Such measures would likely have minimal benefit as the risk would be related to rare accidental leaks of raw water from the closed system. As Section 3 transfers drinking water through a closed system, biosecurity and mitigation are not necessary as the risk posed by INNS is negligible.

Table 15.7: Potential biosecurity measures for pathway types

Biosecurity measure	Description	Applicable to pathway type(s)	Confidence
Biosecurity strategy	Biosecurity measures incorporated into water company standard operating procedure.	Pipeline and tunnel	Medium
Chlorination	Chlorination of transferred water using hypochlorite, chlorine gas or chlorine dioxide. Suggested pipeline concentration of 1mg Cl/L over 10 days of continuous dosing.	Pipeline and tunnel	High

Biosecurity measure	Description	Applicable to pathway type(s)	Confidence
Chemical treatment	Could include coagulation and flocculation, OZONE treatment, pH or salinity alteration, or application of an herbicide.	Pipeline and tunnel	High
Anti-fouling paints	Paint applied to surfaces of pipeline to create toxic/unfavourable substrate for bio-fouling INNS.	Pipeline	Medium
UV treatment	UV is transmitted through water as it flows through a specialised chamber. The radiation damages cells and DNA and causes mortality in the exposed organisms.	Pipeline and tunnel	Medium
Active filtration	Active filtration using screen filters, bed filters or other pumped filtration methods.	Pipeline and tunnel	Medium
Passive filtration	Installation of fish screens, rundown screens or conveyor screens to prevent the passage of suspended matter and organisms.	Pipeline and tunnel	Low
Raw water transfer (RWT) flows	Periodically stopping the flow of water and allowing the RWT to fully dry out would kill any aquatic INNS that have entered the RWT. A period of 2 weeks drying time would be sufficient to kill most aquatic INNS. Only feasible for small RWT and pipelines.	Pipeline and tunnel	Medium
Integrated/combination treatment	Combinations of filter-active treatment methods and chemical treatment.	Pipeline and tunnel	High

15.35. The overall INNS risk associated with the operation of assets is considered to be low as staff and equipment entering raw water is not planned as part of routine operation. The greatest risks identified within the risk assessment are associated with the introduction of INNS being introduced from outside sources such as on personnel and vehicles entering the site and INNS being transferred away from the asset via the same pathways. The new WTW also poses an additional risk of INNS transfer through removal of waste sludge from the site onto land. As the assets involved in the transfer are intended to be sealed, the likelihood of INNS transmission through the pathways identified within the risk assessment is negligible and implementation of biosecurity measures would likely have little to no risk reduction benefit. Medium and High confidence measures should be considered if the evolving design involves a point in the system being temporarily or permanently unsealed; however based on current design this is not considered to be the case.

15.36. Table 15.8 shows potential biosecurity measures which could be incorporated during scenarios where there may be a risk of INNS transmission and introduction.

Table 15.8: Potential biosecurity measures for implementation at assets

Biosecurity measure	Description	Confidence
Check, clean, dry (CCD)	Promotion of CCD protocol amongst WTW personnel.	Medium
Biosecurity strategy	Biosecurity strategy developed by water company.	Medium
Site-specific operational equipment	Provision of site-specific operational equipment (e.g., pontoons, buoys, vehicles) to reduce the inter-site movement of INNS.	High
Equipment and personal protective equipment (PPE) cleaning (dry)	Installation of waterless cleaning stations. May involve the use of brushes to decontaminate dirty equipment.	Low
Static water wash equipment and PPE (cold)	Water < 35°C to aid manual removal of INNS (ambient temperature water will not cause mortality of INNS). May involve use of dip tank.	Low

Biosecurity measure	Description	Confidence
Static water wash equipment and PPE (hot)	A temperature of > 35°C for 15 minutes, or > 45°C for 1 second has been proven effective against many invasive invertebrate species. May involve use of dip tank.	Medium
Running water (cold)	Running water can be effective against invertebrate INNS. However, efficacy (mortality endpoint) is reduced in comparison to pressurised water. Efficacy is dependent on the method and effort of cleaning.	Low
Running water (hot)	Running water can be effective against invertebrate INNS; however, efficacy (mortality endpoint) is reduced in comparison to pressurised water. Efficacy is dependent on the method and effort of cleaning.	Medium
PPE cleaning (dry)	Boot brushing/cleaning stations are a simple approach to decontamination of footwear.	Low
PPE cleaning (dip tank or sink, cold)	A dip tank or sink to allow total immersion of PPE. Brushes and cleaning tools would be a requirement. Ambient temperature water will not cause direct mortality in INNS (unless of much different salinity), so cleaning relies on manual action (scrubbing and drying). Wastewater would be contaminated, so appropriate disposal needed.	Low
PPE cleaning (dip tank or sink, hot)	A dip tank or sink to allow total immersion of PPE. A temperature of >35°C for 15 minutes, or >45°C for 1 second has been proven effective against many INNS. The efficacy of hot water against INN	Medium

Biosecurity measure	Description	Confidence
	plant species (mortality endpoint) is not as high as for invertebrates, so it is important that equipment is treated for sufficient time; immersion of equipment at 50°C for 5 minutes is recommended to achieve high INNS plant mortality.	
Pressure wash (cold)	High-pressure cold water can be effective against invertebrate INNS. However, efficacy (mortality endpoint) is reduced in comparison to pressurised hot water. Efficacy is dependent on the method of application of the spray, regarding duration and distance from surface.	Low
Pressure wash (hot)	High-pressure, hot water can be very effective against invertebrate INNS. However, the efficacy is dependent on the method of application of the spray, regarding duration and distance from surface.	Medium
Drying	Allowing equipment to completely dry ensures that hitchhiker INNS are rendered non-viable. Providing a drying room or other designated area on site for this purpose would allow PPE to be stored and dried at the same location.	High

15.37. While recreational activities would not occur at the source of this transfer (Shaft 6), angling is likely to be present at Wraysbury Reservoir and therefore contributes to the risk of INNS being transferred through the pipeline and pumping station. Table 15.9 demonstrates potential biosecurity measures for angling. It is possible that the Canal and River Trust, the Environment Agency and angling clubs, would be best placed to advise on mitigation options which are likely to be adopted. It is recommended that Thames Water and Affinity Water engage with third party organisations to select biosecurity measures and consider implementation of company-wide INNS strategies.

Table 15.9 Potential biosecurity measures for angling

Biosecurity measure	Description	Confidence
Check, clean, dry (CCD)	Promotion of CCD protocol amongst recreational user of the canal network.	Medium
Biosecurity strategy	Biosecurity strategy developed by canal recreational user groups.	Medium
Event management	A reduction in the number of events or scale of events. Increased biosecurity during events.	Medium
Site-specific recreational equipment	Equipment not to be transported between waterbodies. Use restricted to one site to prevent spread of INNS.	High
Live bait restrictions	Either prohibiting the use of live bait entirely, or managing live bait use, ensuring source from site only.	High
Equipment and personal protective equipment (PPE) cleaning (dry)	Installation of waterless cleaning stations. May involve the use of brushes to decontaminate dirty equipment.	Low
Static water wash equipment and PPE (cold)	Water < 35°C to aid manual removal of INNS (ambient temperature water will not cause mortality of INNS). May involve use of dip tank.	Low
Static water wash equipment and PPE (hot)	A temperature of > 35°C for 15 minutes, or > 45°C for 1 second has been proven effective against many invasive invertebrate species. May involve use of dip tank.	Medium
Drying	Allowing equipment to completely dry ensures that hitchhiker INNS are rendered non-viable. Providing a drying room or other designated area on site for this purpose would allow PPE to be stored and dried at the same location.	High

15.4 Summary of main findings and recommendations for future technical work

15.4.1 Summary of main findings

15.38. The following conclusions have been drawn from the results of the INNS risk assessment:

- The Lower Thames Reservoir Option would not introduce a new hydrological connection between previously isolated catchments as assessed by Environment Agency's Invasive Non-Native Species Isolated Catchment Mapping v3.
- Although a number of aquatic INNS have been identified within the study area, including several High Impact species, there is a very low risk that the Lower Thames Reservoir Option would facilitate their spread as water transfer is through a closed system.
- The risk assessment for the Lower Thames Reservoir Option was broken down into three sections based on the source, pathway and receptor: Section 1, a tunnel transfer of raw water from an existing shaft to a new pumping station within the boundary of the existing Iver WTW; Section 2, a short raw water pipeline transfer from the new pumping station at Iver WTW to a new WTW to the north of Iver WTW; and Section 3, a drinking water transfer pipeline from the new WTW to an existing service reservoir in the vicinity of Harefield.
- The INNS risk for Section 1 and Section 2 is marginally higher than Section 3, largely on account of Section 3 transferring drinking rather than raw water. Both Section 1 and 2 were assessed as Medium risk and Section 3 was assessed as Low risk.
- The main risk associated with the water transfer component of the Lower Thames Reservoir Option was identified as raw water movement between the source (Shaft 6) and the new WTW (Sections 1 and 2). This may pose a risk of new INNS introductions if raw water escapes through damaged structures. Angling at Wraysbury Reservoir, the origin of the raw water which passes through Shaft 6, may contribute additional INNS risk.
- Section 1 and Section 2 would have minimal benefit from the implementation of biosecurity measures in reducing the risk relating to the rare event of water leakage. The most effective and appropriate biosecurity measures suggested to reduce the risk of INNS transference and introduction through pathways include the use of chemical treatment and chlorination, UV treatment application of antifouling paint (pipeline only) and various types of filtration, all of which have High and Medium confidence. However, implementation of these measures may be considered disproportionate in relation to the risk.
- As Section 3 of the transfer would involve drinking water, there would be negligible risk of INNS transfer and further biosecurity/mitigation measures would have no tangible benefit.

- The INNS risk associated with the proposed new assets (raw water pumping station at the Wraysbury Tunnel Connection and the new WTW) was assessed as being Low. The assets are designed to move water within a sealed system, therefore it is considered unlikely that additional biosecurity measures would reduce risk further.
- This risk assessment considers operational risk only. Consideration of biosecurity measures during construction is also recommended at a subsequent project stage. Engagement with third parties may identify measures which are most appropriate.

15.4.2 Further investigative actions

15.39. The data and information input to the INNS risk assessment tool were based on the latest available conceptual design. It is recommended that the INNS risk assessment is reviewed at a subsequent project stage to account for any changes that may introduce INNS risk. As the design is further developed, construction-phase risks relating to INNS should also be considered, and any identified mitigation measures included in a CEMP to be prepared at a subsequent project stage, as set out in Section 2.3.

15.4.3 Biosecurity and mitigation

15.40. Measures to mitigate the INNS risk associated with water transfers and assets have not yet been incorporated into the design. Biosecurity measures would have minimal benefit for Section 1 and Section 2 of the transfer (due to the transfer of raw water). It is recommended that the design team review whether it would be feasible and proportionate to apply Medium and High confidence biosecurity measures to further reduce risk at a subsequent project stage.

15.41. Consideration of biosecurity measures during construction is also recommended at a subsequent project stage. Engagement with third parties may identify measures which are most appropriate during the construction and operational phases. The implementation of company-wide INNS strategies is also recommended.

16 Natural capital and biodiversity net gain

16.1 Introduction

16.1. This chapter presents the findings from the NCA and BNG calculations undertaken for the Lower Thames Reservoir Option.

16.2. Natural capital refers to the elements of the natural world that provide benefits to society and includes aspects such as woodland, grassland, freshwater, marine, urban greenspace and wetland habitats.

16.3. The benefits that are provided to humans by the natural environment vary from regulating services such as natural flood management to cultural services such as recreational value.

16.4. BNG refers specifically to the combination of habitats present within a site and their ability to support biodiversity. Each habitat is given a distinct score that relates to its area, condition, distinctiveness and connectivity. The change in habitat due to the construction and operation of the regional plan options informs the overall BNG score and whether they are likely to contribute to a net gain in biodiversity.

16.5. At Gate 1, a BNG, NCA and ecosystems services assessment was carried out. This assessment used the most-up-to-date guidance available at the time to undertake the assessment, the Biodiversity 2.0 Metric. In July 2021, Defra and Natural England launched the Biodiversity 3.0 Metric[100]. The Biodiversity 3.0 Metric presents significant improvements for measuring and accounting for nature losses and gains. The Biodiversity 3.0 Metric has been used for this Gate 2 assessment, and therefore replaces the assessment carried out at Gate 1. Defra and Natural England have since published the Biodiversity 3.1 Metric[101], in July 2022.

16.6. The T2AT SRO is committed to achieving a minimum 10% biodiversity net gain, which would be reviewed when the precise regulatory and legislative requirements are known (e.g. under the Environment Act 2021[102]. Opportunities were identified to achieve this for the Lower Thames Reservoir Option, however specific habitat mitigation and enhancement proposals would be set out at a subsequent project stage.

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[100] Natural England, 2021. ARCHIVE SITE for the Biodiversity Metric 2.0 and the Biodiversity Metric 3.0. Available at: http://nepubprod.appspot.com/publication/5850908674228224?_sm_au_=iVVPNqtWD1q4R02FB4M2vK7TFvCft [Accessed May 2022]

[101] Natural England, 2022. The Biodiversity Metric 3.1 (JP039). Available at: http://nepubprod.appspot.com/publication/6049804846366720 [Accessed August 2022]

[102] Environment Act 2021, c.30. Available at: https://www.legislation.gov.uk/ukpga/2021/30/contents/enacted [Accessed April 2022]

16.2 Structure of this chapter

16.7. This chapter presents the NCA, BNG, and opportunities relating to the Lower Thames Reservoir Option. There are five parts to this chapter.

- Methodology – Definition of how the NCA and BNG has been assessed.
- Assumptions and limitations – A list of assumptions and limitations that are applicable to the results.
- The Gate 2 NC and BNG assessment findings – Outputs of the NCA and BNG and description of optimised routes. Assessments have been undertaken in line with the methodology found in the WRSE Regional Plan Environmental Assessment Methodology Guidance[18].
- Results and opportunities – Summaries of the assessment and the potential opportunities to achieve a minimum 10% net gain in BNG as well as improve the overall provision of ecosystem services provided by natural capital.
- Recommendations for future technical work – Developed design, finalised feasibility, pre-planning investigations and planning investigations.

16.3 Methodology

16.3.1 Defining the natural capital baseline

16.3.1.1 Zone of Influence

16.8. The Zone of Influence (ZoI) was defined as the area of receiving (i.e. a watercourse receiving a discharge) or providing (i.e. an aquifer where abstraction would occur) environment with the potential to be altered or changed as a result of the Lower Thames Reservoir Option.

16.9. The transfer pipelines would be installed primarily using open cut excavation. To provide sufficient working space to construct the pipeline, a temporary working area would be required, which would include the temporary removal of natural capital stocks within that area. For areas where the pipeline would be constructed in open field, or areas not otherwise limited by physical constraints such as nearby buildings, it has been assumed that the temporary works area would extend a maximum of 25m on both sides of the pipeline, resulting in a total working width of 50m. The assumed temporary works area has been reduced in built-up areas for the NCA to ensure that impacts on natural capital stocks are not overstated (e.g. to avoid natural capital stocks that are separated from the working area by above ground permanent structures such as buildings). It has therefore been assumed that for built-up areas, the temporary works area would extend a maximum of 10m on both sides of the pipeline, resulting in a total width of 20m. The natural capital stocks that are both temporarily and permanently impacted by the construction of permanent above-ground infrastructure and the temporary working area required to construct the pipeline are included within the ZoI. In later stages of design, the ZoI would need to be further refined with the availability of greater design detail and site survey data.

16.3.1.2 Developing a natural capital baseline

16.10. A natural capital baseline was developed for the Lower Thames Reservoir Option. This baseline was developed using open-source data as described in the NECR285 National Natural Capital Atlas[103] to generate a natural capital account of the stocks within the ZoI. The list of stocks considered within the accounts and the methodology for mapping them are provided in Appendix E. The methodology used to map natural capital utilises the same breakdown of stocks as the NECR285 National Natural Capital Atlas where possible. However, the list has been supplemented with additional abiotic stocks and key habitats that are vital such as chalk streams and rivers.

16.11. The natural capital baseline reports the total quantity of each stock within the study area, and where suitable, an indication of natural capital condition.

16.3.2 Overview assessment methodology: natural capital assessment

16.12. An NCA has been undertaken in accordance with the Environment Agency's Water resources planning guideline supplementary guidance – Environment and society in decision-making[104] (WRPG supplementary guidance) and Enabling a Natural Capital Approach (ENCA)[105] requirements. ENCA is recommended for use by HM Treasury's Green Book: appraisal and evaluation in central government (2020)[106] and represents supplementary guidance to the Green Book[107]. In August 2021, ENCA

[103] Natural England (2020). National Natural Capital Atlas: Mapping Indicators (NECR285). Available at: http://publications.naturalengland.org.uk/publication/4578000601612288 [Accessed April 2022]
[104] Environment Agency (2020) Water resources planning guideline supplementary guidance – Environment and society in decision-making.
[105] Defra (2021) Enabling a Natural Capital Approach guidance. Available online at: https://www.gov.uk/government/publications/enabling-a-natural-capital-approach-enca-guidance/enabling-a-natural-capital-approach-guidance [Accessed April 2022].
[106] HM Treasury (2020) The Green Book Central Government Guidance On Appraisal And Evaluation. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/938046/The_Green_Book_2020.pdf [Accessed April 2022].
[107] HM Treasury (2020) Green Book supplementary guidance: climate change and environmental valuation. Available at: https://www.gov.uk/government/publications/green-book-supplementary-guidance-environment [Accessed April 2022].

updated its guidance. The approach for Gate 2 is to update the NCA in line with this.

16.13. The August 2021 ENCA guidance includes updated values within the Asset Databook and Service Databook. Within the Service Databook, the carbon reduction tab now includes Department for Business, Energy and Industrial Strategy (BEIS) (2021) carbon values – a set of values produced by the Government to be used in policy appraisal and evaluation, reflecting the latest evidence. The climate regulation section of the assessment has been updated in line with this.

16.14. The impact of the Lower Thames Reservoir Option on the natural capital stocks and indicators of condition was reported for each element quantitatively. This impact was reported for during construction and post construction to give an estimation of the impact of the whole lifecycle of the Lower Thames Reservoir Option. The results of the stock assessment were reported in total losses and gains within the ZoI.

16.15. The results of the change in natural capital stocks informed the assessment against the six natural capital metrics (also known as ecosystem services) listed below using the Natural England logic chains, shown in Figure 16.1: Ecosystem services valuation logic chain. The cost / benefit assessment was informed by the option type, option description and any embedded mitigation. The outputs of the NCA were compared to the pre-construction provision of impacted services to assess the impact of the Lower Thames Reservoir Option. Four ecosystem services were monetised, and the results of the assessment reported as a discreet monetary figure (subject to the ecosystem service scoping exercise set out below), water purification was assessed qualitatively, and biodiversity has been assessed via the Biodiversity 3.0 Metric. Water regulation has not been included for assessment to avoid the potential double accounting of benefits with capacity-based and financial assessment, and to align with the WRPG supplementary guidance[104] that recommends not including monetisation of water regulation benefits in decision making.

Figure 16.1: Ecosystem services valuation logic chain

16.16. The metrics used to assess the impact on natural capital include:

- Carbon sequestration (climate regulation)
- Natural hazard management
- Water purification (qualitative assessment only)
- Biodiversity and habitats (assessed as part of the BNG assessment)
- Air pollutant removal
- Recreation and amenity
- Food production

16.17. Both natural capital assessment strategies, as outlined in the WRPG supplementary guidance[104] and the Defra ENCA[105], discuss taking a proportionate approach to the assessment. It is therefore important to accommodate this when integrating a natural capital approach within the SRO gated process. A natural capital approach has the potential to inform concept design and aid decision making, by quantifying the relative cost benefits and disbenefits of SROs to aid the initial assessment of the identified strategic solutions.

16.18. During the initial phase of the NCA, all of the six ecosystem services were reviewed and scoped in or out due to the geographical or socio-economic context of the Lower Thames Reservoir Option and its ZoI. The approach taken to screening for individual metrics is provided below.

16.3.2.1 Carbon sequestration (climate regulation)

16.19. The climate regulation metric focuses on carbon sequestration, which can be defined as the capture and secure storage of carbon that would otherwise be emitted to, or remain, in the atmosphere. The carbon sequestration NCA is in addition to construction and operational carbon calculations (see Section 8.3.2) and provides a holistic assessment of carbon emissions for the Lower Thames Reservoir Option.

16.20. The assessment was determined by land management within the ZoI of the Lower Thames Reservoir Option, which influenced the carbon store for prolonged periods of time and results in a change in net emissions. The estimate of the carbon stocks for the footprint of the Lower Thames Reservoir Option was based on the area of broad land use types according to literature and research. The estimated carbon stocks for broad habitat types are listed below and the sequestration rates are shown in Table 16.1.

Table 16.1: Carbon sequestration rates for broad habitat types (JBA Consulting) [108,104]

Land use type	C Seq rate (tCO2e/ha/yr)
Woodland – deciduous	4.97
Woodland – coniferous	12.66
Arable land	0.107
Pastoral land	0.397
Peatland – undamaged	4.11
Peatland – Overgrazed	-0.1
Peatland – Rotationally burnt	-3.66
Peatland – Extracted	-4.87
Grassland	0.397
Heathland	0.7
Shrub	0.7
Saltmarsh	5.188
Urban	0
Green Urban	0.397

16.21. The carbon sequestration rates were converted to monetary values using standard methods and the BEIS Interim Non-Traded Carbon Values from 2022, shown in Table 16.2. The NCA is based on a 2022 price year; however, it is assumed that adjustments for inflation have been accounted within the annual projections provided by BEIS and therefore the 2022 value presented below has not been adjusted. High series values were used to reflect a conservative estimate for the price of carbon.

[108] Alonso, I., Weston, K., Gregg, R. and Morecroft, M. 2012. Carbon storage by habitat - Review of the evidence of the impacts of management decisions and condition on carbon stores and sources. Natural England Research Reports, Number NERR043.

Table 16.2: BEIS interim non-traded carbon values for policy appraisal, £/tCO2e (£2020)

Year	Low series	Central series	High series
2020	120	241	361
2021	122	245	367
2022	124	248	373
2023	126	252	378
2024	128	256	384
2025	130	260	390
2026	132	264	396
2027	134	268	402
2028	136	272	408
2029	138	276	414
2030	140	280	420
2031	142	285	427
2032	144	289	433
2033	147	293	440
2034	149	298	447
2035	151	302	453
2036	155	307	460
2037	156	312	467
2038	158	316	474
2039	161	321	482
2040	163	326	489
2041	165	331	496
2042	168	336	504
2043	170	341	511
2044	173	346	519
2045	176	351	527

Year	Low series	Central series	High series
2046	178	356	535
2047	181	362	543
2048	184	367	551
2049	186	373	559
2050	189	378	568

16.3.2.2 Natural hazard management

16.22. Different habitat types have intrinsic flood risk management values by intercepting, storing and slowing water flows. This is known as natural flood management (NFM) and is listed as a policy within the Government's 25 Year Environment Plan[109]. The capacity of habitats to achieve this can be quantified, and then a monetary value can be assigned based on the damage-costs avoided from flooding or replacement costs due to their capacity to regulate flood waters. The capacity for a given natural capital asset to provide a flood regulation service will depend on two factors:

- Its capacity to slow overland flows
- Whether the asset is located in an area of flood risk

16.23. This ecosystem service also applies in urban areas, where vegetation can reduce surface water flooding from heavy rainfall, with benefits to sewerage capacity. Coastal flood risk, which has been predicted to increase with future climate change, is reduced by coastal margin habitats such as saltmarsh.

16.24. The Lower Thames Reservoir Option was assessed on the ability to positively or negatively impact flood risk through the comparison of pre- and post-construction natural capital stocks and the catchment in which it is located. The assessment is restricted to catchment areas which drain to downstream communities impacted by flooding. These communities were identified using the Environment Agency's Indicative Flood Map[47], which overlays areas at risk of fluvial flooding and the National Receptor Database. The ecosystem service was scoped in for assessment as it was identified that the Lower Thames Reservoir Option would have a temporary or permanent impact upon the relevant natural capital stocks, such as areas of woodland, located within the floodplain.

[109] 25 Year Environment Plan – Policy Paper. GOV.UK. Available online at: https://www.gov.uk/government/publications/25-year-environment-plan [Accessed April 2022]

16.25. Reduced flood damage to downstream or coastal settlements as a result of reduced magnitude / frequency of flood / storm events; and / or lower sewer capacity or water storage costs was valued in line with Broadmeadow et al, 2018[110]. This assessment was developed to provide indicative national estimates of water regulation services of woodland to inform natural capital accounts, this is based on modelling to estimate the potential volume of flood water avoided by woodland ecosystems in flood risk catchment. The methodology adopts a replacement-cost (rather than damage cost) approach to valuing the flood regulation service of woodland by applying annualise average capital and operating costs of flood reservoir storage that would be required in the absence of the ecosystem service.

16.26. Central estimate of the average annual costs of reservoir floodwater storage is £0.42/m^3. The range is from £0.10 to £1.19/m^3 per year. The central estimate was used to derive an annual average estimate for the flood regulation service of woodland in Great Britain, which was then uplifted to a 2022 price year. These 'replacement costs' can be considered a lower bound of the benefit if it can be assumed that such expenditure would be deemed value for money by the flooding authorities within flood risk catchments in terms of avoided flood damage costs (ENCA[105]).

16.3.2.3 Water purification

16.27. Based on their ecological functioning, different habitat types have varying capacities for absorbing pollutants from a given water source. This service is dependent on the location of the natural capital asset and the nature of the surrounding area. If a natural capital asset has a high capacity to remove pollutants but is not close to a water source, the service will not be provided. Due to this, valuation of the static water purification services of different natural capital assets as part of the NCA was not considered appropriate. A common value for different habitat types could not be applied due to extensive variation in local factors which determine the provisioning of this service.

16.28. To account for the provision of this service within the NCA, the impact of the Lower Thames Reservoir Option associated with the provision or removal of woodland and semi-natural grassland was considered qualitatively and with consideration of the NEVO[111] tool. The tool defines the resulting changes for the following water quality variables:

- Dissolved oxygen concentration
- Nitrogen concentration (including organic nitrogen, nitrate, nitrogen dioxide, ammonium)

[110] Broadmeadow, S., Thomas, H., Nisbet, T. and Valatin, G., 2018. Valuing flood regulation services of existing forest cover to inform natural capital accounts. Forest Research.
[111] Luizzo, L., (2019) Natural Environment Valuation Online Tool - Chapter 6a: Water Quantity & Quality Model

- Phosphorous concentration (including organic and mineral phosphorous)
- Pesticide concentration (for eighteen different pesticide types

16.29. This approach followed the methodology that if an area of woodland were to be lost, the resultant impacts on water quality can be qualitatively assessed within the ZoI. Any negative changes to the natural capital in theory, reflects the loss of this service within the ZoI.

16.3.2.4 Air pollutant removal

16.30. Air pollution presents a major risk to human health, resulting in premature deaths and reduced quality of life. By removing air pollution, habitats help to lessen these impacts on health and wellbeing. The provisioning of the service is positively related to several key aspects:

- The surrounding area of the natural capital assets with regards to background pollution, especially particulate pollutant
- The quantity and type of natural capital asset, woodland is the major service provider
- The density of population potentially benefiting from reduced exposure; because pollutants are transported, beneficiaries may be downwind of the ecosystem (ENCA[105]).

16.31. The Lower Thames Reservoir Option was screened against the provision of air pollutant removal according to its location. Air pollutant removal was only considered within built up areas or when the ZoI includes AQMAs. The impact of the Lower Thames Reservoir Option was assessed according to changes in natural capital stocks within these areas.

16.32. The value provided by natural capital assets was taken from the UK Government's air quality economic assessment methodology[112]. The assessment embeds these values (based on the damage cost approach, i.e. damage to health avoided from reductions in air pollution) and estimates the present value automatically based on the quantitative estimates provided. Indicative average values for air pollution removal in 2015 for different habitats were calculated from aggregate UK values published in February 2019, as shown in Table 16.3.

16.33. The value of each habitat was combined with the changes expected in natural capital stocks to provide a value for the change in service provision. The final impact was reported as a single value that is incorporated within the NCA metric.

[112] Jones L., Vieno M., Morton Dan et al. (2017) Developing Estimates For The Valuation Of Air Pollution Removal In Ecosystem Accounts. Final Report For Office Of National Statistics - NERC Open Research Archive

Table 16.3: Air pollutant value by habitat type (£2022)

Habitat group	Value (£ per hectare per year)
Urban woodland	942
Rural woodland	299
Urban grassland	182
Enclosed farmland	17
Coastal margins	31

16.3.2.5 Recreation and amenity

16.34. The recreational value of green spaces can be significant. This value reflects both the natural setting and the facilities on offer at the site and often has a strong non-market element. It varies with the type and quality of habitat, location, local population density and the availability of substitute recreational opportunities. Recreational values can be beneficially affected by enhancements in green spaces, or adversely affected by new developments or infrastructure. The wider tourism and outdoor leisure sector is also dependent upon nature to varying degrees (ENCA[105]). This metric depends on the extent to which the natural capital stocks the Lower Thames Reservoir Option provides would enhance the opportunity for recreation.

16.35. The key parameter needed to estimate in this category is the number of additional or enhanced recreational visits created because of the option. This was estimated using the Outdoor Recreation Valuation Tool (ORVal). ORVal[113] is referenced in HM Treasury Green Book. Random utility / travel cost model of recreational demand for all sites in England and Wales and generates probabilistic predictions of visitor numbers for any publicly accessible outdoor recreation park, path, or beach. It takes account of scarcity of sites and substitution possibilities, as well as travel distances to sites and their attributes. This is useful for baseline initial assessment, accounting, and multiple sites. This should be seen as an estimation in the absence of site-specific data on visitor numbers.

16.36. Following the development of the natural capital baseline, it was determined that the construction of the Lower Thames Reservoir Option would not result in the permanent loss of greenspace. Therefore, the change in recreation and amenity services has been scoped out of this assessment.

[113] ORVal, Land, Environment Economics and Policy Institute. University of Exeter. Available at: https://www.exeter.ac.uk/research/leep/research/orval/ [Accessed April 2022]

16.3.2.6 Food production

16.37. Food is produced by a range of ecosystems and in some cases, the food for human consumption is effectively the same as the ecosystem service (e.g., wild fruit, fishing). More often, the provisioning service is a raw material (e.g., crops) that is harvested and processed by humans and produced capital into added value processed food (e.g., bread). The boundary between what is provided by natural capital and the contribution of other forms of capital is often a grey area, e.g., crops require agricultural management; livestock need grassland ecosystems (ENCA[105]).

16.38. Food production has been calculated using the NEVO agricultural model; this is a structural model of agricultural land use and production for Great Britain estimated using Farm Business Survey (2005 – 2011) and June Agricultural Census data. The agricultural land use component in NEVO builds upon the approach developed by Fezzi and Bateman[114]. NEVO was used to assess the impact of the creation or removal of agricultural land for the Lower Thames Reservoir Option. The change in value of food provision for the footprint of the Lower Thames Reservoir Option was calculated using this online tool and reported within the NCA.

16.3.3 Overview assessment methodology: biodiversity net gain

16.39. The BNG requirement, as outlined in the WRPG supplementary guidance[104], stipulates that each SRO should look to maximise BNG. In July 2021, Defra and Natural England launched the Biodiversity 3.0 Metric. The Biodiversity 3.0 Metric presents significant improvements for measuring and accounting for nature losses and gains. It encourages users to create and enhance habitats where they are most needed to help establish or improve ecological networks through rural and urban landscapes. By linking to current and future habitat plans and strategies, including the future Local Nature Recovery Strategies, the Biodiversity 3.0 Metric incentivises habitat creation and enhancement where most needed. It also ‘rewards’ landowners who undertake work early, creating or enhancing habitats in advance, allowing them to generate more biodiversity units from their land. Condition assessment approaches have also been significantly updated and simplified for the Biodiversity 3.0 Metric and some key changes made. The metric can support and complement a natural capital approach by providing a consistent method for quantifying impacts on biodiversity, which underpins many other ecosystem services.

16.40. The Government anticipates the Biodiversity 3.0 Metric (and subsequent revisions) to become the industry standard for biodiversity assessments for on-land and intertidal development types in England. As set out in the Environment Act 2021[102], BNG must be measured using a recognised biodiversity metric. The biodiversity metric essentially underpins the Environment Act’s provisions for mandatory BNG in England, subject to any necessary adjustments for application to major infrastructure

[114] Fezzi, C., Bateman, I., Hadley, D. & Harwood, A. 2019. Natural Environment Valuation Online Tool - Chapter 1: Agriculture Model

projects. The Environment Act 2021[102] further specifies the requirement of biodiversity reports to include specified quantitative data relating to biodiversity, and as such any tool which evaluation is predominantly qualitative is not recommended.

16.41. The Gate 2 approach has been to use the Biodiversity 3.0 Metric. Any new scheme elements brought into the gated process at this stage have been assessed by the Biodiversity 3.0 Metric, aligning the T2AT SRO with those assessments undertaken to inform the regional planning process and the associated WRMP24s. It should be noted that in April 2022, Defra and Natural England released the Biodiversity Metric 3.1, providing an update to the Biodiversity 3.0 Metric. The BNG calculation should be revisited and updated using the latest version of the metric at a subsequent project stage.

16.42. A biodiversity baseline has been developed from spatial data sets of habitats inventories to calculate BNG change through land use. The Priority Habitat Inventory and sites with SSSI, SAC, SPA and Ramsar designations were used to identify areas with high biodiversity importance (see Chapter 4: Biodiversity, flora and fauna for data sources). Units have been assigned to the pre-construction land use according to the habitats present in the ZoI. Post construction land use, including any mitigation described in the scheme description, has been used to calculate the post construction score. As this assessment was carried out using only open-source data a precautionary approach has been applied, presuming that where not specifically known, habitats are assigned the moderate habitat score so as not to overstate or understate the likely effects.

16.3.4 Natural capital optimised routes

16.43. As described in Section 2.1, the Lower Thames Reservoir Option is comprised of a number of key components. The NCA has considered the potential impact of the Raw and Drinking Water Transfer Mains, the Indicative WTW Site, the temporary working width required to facilitate construction, and the indicative locations of temporary construction compounds.

16.44. The Lower Thames Reservoir Option has been developed based on series of criteria that consider engineering, environmental, social, and planning constraints. Indicative route corridors for the Raw and Drinking Water Transfer Mains have been identified, which are designed to avoid key environmental constraints such as statutory designated nature conservation sites. For the purpose of this assessment, an indicative working width within the wider corridor has been identified taking into account engineering, environmental, social, and planning constraints, for example, avoiding intersecting deciduous woodland priority habitat wherever possible. This route is referred to as the 'Indicative Route' and was assessed as the baseline case.

16.45. As part of the NCA, the Indicative Route was optimised by adjusting it in discrete locations to ensure that the temporary works area, alternating between 10m and 25m along the route, similarly avoids temporary impacts on natural capital assets, wherever possible, while remaining within the wider route corridor. For example, if the route avoided intersecting deciduous woodland priority habitat, but the temporary works area passes within 25m of the habitat, then the route was realigned further away from that habitat. This resulting route is referred to as the 'NC Optimised Route'. The NC Optimised Route was assessed using the same NC and BNG methodology set out above and the findings are presented in Section 16.5 for comparison against the Indicative Route. It should be noted that for both the Indicative Route and the NC Optimised Route, the assumed temporary works area is considered to be constrained by the route corridors, and therefore, the temporary works area is narrower in discrete locations so that the working area, and any associated works, do not extend outside the route corridors.

16.4 Assumptions and limitations

16.46. The following assumptions and limitations are applicable to the results.

Natural capital assessment

- The costs for constructing, operating and maintaining the scheme were not considered within the assessments.
- The provision of public water supply has been excluded from all assessments to avoid potential double accounting of benefits with capacity-based and financial assessment.
- Natural capital stocks identified within the areas allocated for above ground infrastructure have been assumed to be completely lost as a result of the Lower Thames Reservoir Option.
- Natural capital stocks presumed temporarily lost are expected to be reinstated/compensated.
- It has been assumed that for each pipeline, the temporary working width required to facilitate construction would extend a maximum of 10m on both sides of the pipe in built-up areas, resulting in a total width of 20m, and would extend a maximum of 25m in open areas not limited by physical constraints, resulting in a total working width of 50m.
- The area provided for the temporary works area is assumed to be constrained by the route corridors. Permanent and temporary works are assumed to not extend outside the route corridors.

Biodiversity net gain

- No enhancement of biodiversity post-construction was considered. BNG habitat units were assigned to the pre-construction land use according to the habitats present within the boundary of the Lower Thames Reservoir Option. The post construction land use, including agreed mitigation, was used to calculate the post construction biodiversity score. Where temporary impacts are expected, it is assumed that habitats will be replaced on a like-for-like, and irreplaceable habitats are assumed to be permanently lost.
- The desk-based assessment was carried out using open-source data. As such, a precautionary approach was applied, presuming that where not specifically known, habitats were assigned the maximum habitat score. Habitat identification would need to be refined with habitat survey data at a subsequent project stage to refine the accuracy of the BNG calculations.
- It has been assumed that for the pipelines, the temporary works areas required to facilitate construction would extend a maximum of 10m on both sides of the pipeline in built-up areas, resulting in a total width of 20m, and would extend a maximum of 25m in open areas not limited by physical constraints, resulting in a total working width of 50m.
- The area provided for the temporary works area is assumed to be constrained by the route corridors. Permanent and temporary works are assumed to not extend outside the route corridors.
- The duration of disturbance and timeline for habitat creation has not been included in the assessment. Durations of disturbance, including proposals for creating habitats in advance of disturbance, would need to be refined with greater design detail at subsequent project stages to refine the accuracy of the BNG calculations.

16.5 Natural capital assessment and biodiversity net gain findings

16.47. The NCA and BNG findings are summarised in Table 16.4 to 16.7, with commentary presented in Section 16.6. A summary of what is included within each table is outlined below.

- Table 16.4 shows the predicted impacts on natural capital during and post construction.
- Note: Only those stocks with predicted impacts are listed.
- Table 16.5 summarises the predicted impacts to the provision of ecosystem services screened in for detailed assessment.
- Table 16.6 summarises the predicted impacts to the provision of water purification for the Lower Thames Reservoir Option, where screened in for qualitative assessment.

- Table 16.7 shows the BNG outputs, including the total net change for habitat and river units where impacted. These outputs have been informed using the predicted impacts on natural capital in Table 16.4.
- Note: At this stage the BNG only takes account of reinstatement and standard mitigation or design assumptions (such as micro-tunnelling for main rivers), not reprovision or additional habitat creation unless outlined in the scheme description.

16.48. Mitigation has only been considered when outlined in the scheme description, or where standard mitigation must be applied. It is recommended that the BNG assessment is revisited as the scheme design develops and habitat survey information is available at a subsequent project stage, and mitigation or enhancement opportunities developed further to achieve a minimum 10% BNG.

16.49. Additionally, where possible, the Lower Thames Reservoir Option should aim to not only reinstate lost habitat, but also provide a greater or more diverse habitat than is lost, to achieve overall BNG in line with regulatory requirements for BNG at the time of the project consenting. The latter could be achieved by identifying local sites of ecological interest and proposing measures which enhance these features. Further to the above, the calculations would be updated to the BNG 3.1 metric when considering the opportunities for habitat mitigation and enhancement.

Table 16.4: Predicted impacts on natural capital stocks

Natural capital stock	Area of stocks within ZoI pre-construction (Ha)	Stocks present within ZoI during construction (Ha)	Stocks present within ZoI post construction (Ha)	Change (Ha)
Indicative Route				
Arable	2.11	0.00	2.11	0.00
Pastures	47.21	0.00	41.89	-5.32
Other semi-natural grassland	0.11	0.00	0.11	0.00
Broadleaved, mixed and yew woodland	0.44	0.00	0.44	0.00
Woodland priority habitat	2.43	0.00	2.38	-0.05
Coniferous woodland	1.03	0.00	1.03	0.00

Natural capital stock	Area of stocks within ZoI pre-construction (Ha)	Stocks present within ZoI during construction (Ha)	Stocks present within ZoI post construction (Ha)	Change (Ha)
Greenspace	2.02	0.00	2.02	0.00
Urban woodland	0.13	0.00	0.13	0.00
Active floodplain	6.88	6.78	6.78	-0.09
Lakes and standing waters	0.02	0.02	0.02	0.00
Rivers	0.55	0.55	0.55	0.00
Ponds (non-linear)	0.00	0.00	0.00	0.00
NC Optimised Route				
Arable	2.11	0.00	2.11	0.00
Pastures	42.48	0.00	41.50	-0.98
Other semi-natural grassland	0.11	0.00	0.11	0.00
Broadleaved, mixed and yew woodland	0.43	0.00	0.43	0.00
Woodland priority habitat	2.25	0.00	2.20	-0.05
Coniferous woodland	1.03	0.00	1.03	0.00
Greenspace	1.84	0.00	1.84	0.00
Urban woodland	0.13	0.00	0.13	0.00
Active floodplain	6.64	6.64	6.64	0.00

Natural capital stock	Area of stocks within ZoI pre-construction (Ha)	Stocks present within ZoI during construction (Ha)	Stocks present within ZoI post construction (Ha)	Change (Ha)
Lakes and standing waters	0.02	0.02	0.02	0.00
Rivers	0.57	0.57	0.57	0.00
Ponds (non-linear)	0.00	0.00	0.00	0.00

Table 16.5: Quantitative detailed assessment of the unmitigated predicted impacts on the provision of ecosystem services (£2022[115])

Ecosystem services	Baseline value (£/year)	Estimated value post construction (£/year)	Temporary impact from construction (£/year)	Total future value (£/year)	Overall change in value (£/year)
Indicative Route					
Carbon storage	£17,526.54	£0.00	-£17,526.54	£14,061.13	-£3,465.41
Natural hazard management	£395.33	£0.00	-£395.33	£292.86	-£92.66
Air pollutant removal	£1,330.43	£0.00	-£1,330.43	£995.75	-£273.92
Recreation and amenity value[116]	Scoped out	Scoped out	Scoped out	Scoped out	Scoped out
Food production	£193,300.00	£191,300.00	-£2,000.00	-£191,300.00	-£2,000.00
Total	£212,552.29	£191,300.00	-£21,252.29	£206,649.73	-£5,902.56

[115] Ecosystem service values have been calculated as the present value for a consistent price year (£2022), where possible. The price of carbon has relied on BEIS annual projections for 2022, as set out in the methodology above.
[116] Scoped out when the option does not cause the permanent loss of greenspace.

Ecosystem services	Baseline value (£/year)	Estimated value post construction (£/year)	Temporary impact from construction (£/year)	Total future value (£/year)	Overall change in value (£/year)
NC Optimised Route					
Carbon storage	£16,473.25	£0.00	-£16,473.25	£13,744.48	-£2,728.77
Natural hazard management	£376.65	£0.00	-£376.65	£279.14	-£97.51
Air pollutant removal	£1,273.32	£0.00	-£1,273.32	£953.81	-£319.52
Recreation and amenity value	Scoped out	Scoped out	Scoped out	Scoped out	Scoped out
Food production	£193,300.00	£191,300.00	-£2,000.00	£191,300.00	-£2,000.00
Total	£211,423.23	£191,300.00	-£20,123.23	£206,277.43	-£5,145.80

Table 16.6: Qualitative assessment of the unmitigated predicted impacts on the provision of water purification

Likely baseline provision	Construction impacts	Likely future provision	Overall change in provision
Indicative Route			
The stocks both temporarily and permanently lost likely provide a high provision of the ecosystem service due to the natural capital assets high capacity to store and absorb pollutants and the proximity of the asset to a water source. These stocks include, for example, different types of woodland area.	The provision of services would be lost during construction.	The future provision of the ecosystem service provided by the stock would likely be reduced.	The provision of water purification provided by the associated stocks would likely be reduced due to the option.

Likely baseline provision	Construction impacts	Likely future provision	Overall change in provision
NC Optimised Route			
The stocks both temporarily and permanently lost likely provide a high provision of the ecosystem service due to the natural capital assets high capacity to store and absorb pollutants and the proximity of the asset to a water source. These stocks include, for example, different types of woodland area.	The provision of services would be lost during construction.	The future provision of the ecosystem service provided by the stock would likely be reduced.	The provision of water purification provided by the associated stocks would likely be reduced due to the option.

Table 16.7: Summary of the unmitigated BNG metric outputs

Route	On-site baseline (biodiversity units)	On-site post intervention (biodiversity units)	Total net unit change (biodiversity units)	Total percentage change
Indicative Route	240.54	164.04	-76.51	-31.81%
NC Optimised Route	218.66	161.78	-56.88	-26.01%

16.6 Results and opportunities

16.6.1 Summary of NCA and BNG assessments

16.6.1.1 Natural capital assessment

16.50. The Lower Thames Reservoir Option would likely cause the temporary and permanent loss of stocks during construction. Stocks that are likely to be permanently lost include pasture, woodland priority habitat, and active floodplain. However, best practice mitigation (such as the use of trenchless techniques) and reinstatement/compensation of habitat means that most natural capital stocks post construction would have no to little change.

16.51. The transfer routes and associated above ground infrastructure are concept designs at this stage and, through further investigative work at subsequent project stages, the route could be aligned to further minimise the impact upon priority habitat such as deciduous woodland.

16.52. The NC Optimised Route has reduced the total amount of pasture permanently lost, as well as the temporary impact on woodland priority habitat and broadleaved, mixed and yew woodland, when compared to the Indicative Route and avoided the permanent loss of active floodplain, with a subsequent reduction in the loss of ecosystem services.

16.6.1.2 Ecosystem services assessment

16.53. The Lower Thames Reservoir Option is likely to generate the loss of natural capital stocks during construction. However, habitat that is expected to be reinstated/compensated to pre-construction conditions following best practice techniques would likely have no permanent impact to the provision of ecosystem services. Broadleaved, mixed and yew, priority, coniferous and urban woodland have a significant maturity time with a delay of 30 years. Therefore, this delay is considered within potential future provision of this stock through the ecosystem services assessment. This can be accounted to the tree mortality rate presumed after woodland areas are replanted.

16.54. Construction impacts include the release of CO_2 due to habitat clearance, a reduction in air pollutant removal, a reduction in food production services, a reduction in natural hazard management, and a reduction in water purification services. For those stocks that are temporarily lost, it is expected that the future value is not affected as stocks are assumed to be reinstated.

16.55. As discussed in Section 16.6.1.1, the NC Optimised Route has reduced the loss of natural capital stocks, with a subsequent reduction in the loss of those ecosystem services that have been monetised.

16.56. The Lower Thames Reservoir Option presents an opportunity to improve the existing habitats through post construction remediation and replacement of low value habitats with higher value habitats. The Indicative Route crosses several priority habitats, Network Enhancement Zones, Fragmentation Action Zones, and Network Expansion Zones and is therefore suitable for the planting of new high value habitats.

16.6.1.3 Biodiversity net gain assessment

16.57. Applying the Biodiversity 3.0 Metric, the Indicative Route would result in the loss of approximately 77 BNG habitat units due to the temporary and permanent removal of habitats during construction.

16.58. When compared to the Indicative Route, the NC Optimised Route results in a lower loss of BNG habitat units, with the loss of approximately 57 BNG habitat units due to the temporary and permanent removal of habitats during construction.

16.6.2 Mitigation and enhancement opportunities

16.6.2.1 Mitigation and enhancement opportunities

16.59. Following the BNG and NCA, opportunities should be considered to ensure the natural environment is left in better condition than pre-construction conditions. When considering these opportunities, it is important to note that the construction and operation of the Lower Thames Reservoir Option may not be required for a considerable period of time. Opportunities for mitigation and enhancement would need to consider the timing of delivery, noting that there may be changes to land use by existing landowners over this period. Therefore, to allow for greater flexibility, the identification of opportunities should be considered within the wider route corridor. This should be achieved by one or both of the following:

- Mitigation: Opportunities to offset the net loss of biodiversity asset(s) and/or Natural Capital stock(s) (ecosystem service).
- Enhancements: Opportunities that, once introduced and established, would result in a net gain to a biodiversity asset and/or Natural Capital stock(s) (ecosystem service).

16.60. As a core principle, where possible, the Lower Thames Reservoir Option should aim to not only reinstate lost habitat, but also provide a greater or more diverse habitat than is lost, to achieve overall BNG. The latter could be achieved by identifying local sites of ecological interest and proposing measures. It could also be achieved by identifying sites with limited biodiversity value and improving these, such as enhancing arable or improved grassland habitats to provide habitats with a higher biodiversity value. Any habitats that are created or enhanced to achieve BNG are required to be secured for 30 years, through management, maintenance, and monitoring.

16.61. A summary of the potential NCA, BNG mitigation and enhancement measures for each sub-component type is outlined in Table 16.8. Further explanation of the potential enhancement measures is provided within the sections below.

Table 16.8: Summary of potential net gain mitigation and enhancement opportunities

Component	Mitigation opportunity	Enhancement opportunity
Raw Water and Drinking Water Transfer Main Route Corridors	Scheme layouts, including the aboveground infrastructure and pipeline alignment, to be amended to avoid the permanent loss of natural capital assets, wherever possible.	Creation of higher value habitat within grassland, arable and pasture natural capital assets onsite to achieve an increase in Biodiversity Units (BU) and work towards a minimum 10% uplift in BNG.
	Schemes to identify area for the creation and/or reinstatement of high value natural capital assets, including: • Coastal and floodplain grazing marsh • Lowland fens • Lowland raised bog • Reedbeds • Blanket bog • Hay meadows • Dwarf shrub heath • Broadleaved, mixed and yew woodland • Coniferous woodland • Bluespace • Greenspace	Habitat creation work within the adjacent priority habitats. Scheme falls within and is in proximity to habitat network zones[117]: • Habitat restoration-creation • Restorable habitat • Fragmentation action zone • Network enhancement zones 1 and 2 • Expansion zone These areas identify specific locations for a range of actions to help improve the ecological resilience for each of the habitats/habitat networks. The scheme should look to identify habitat network zones and priority habitats within the near vicinity and look to improve/create/restore habitats which would help to work towards increasing BU and work towards a minimum 10% uplift in BNG.
	Construction practices to be considered to reduce the amount of clearance required for, especially in areas that include high value natural capital assets (see above for list).	Increase the quality/quantity of freshwater assets, including lakes, ponds located in designated SSSIs, pending detailed assessment of local conditions and available space.

[117] Edwards J, Knight M, Taylor S & Crosher I. E (May 2020) 'Habitat Networks Maps, User Guidance v.2', Natural England.

Component	Mitigation opportunity	Enhancement opportunity
	Trenchless techniques to be used where possible to avoid loss of high value natural capital assets (see above for list).	Scheme to identify suitable areas offsite for the creation, enhancement and/or restoration in order to develop off-site net gains, working towards achieving a minimum 10% uplift in BNG.
		Identify areas of local peatland restoration.
Indicative WTW Site and other scheme elements that contain above ground infrastructure	N/A	Seeding of grassland within footprints of the above ground infrastructure, where possible.

16.6.2.2 Nature Recovery Networks and opportunities

16.62. The Government's 25 Year Environment Plan[109] includes provision for an NRN and states that it will deliver on the recommendations of the Lawton Report and that recovering wildlife will require more habitat; in better condition; in bigger patches that are more closely connected. As well as helping wildlife thrive, the NRN could be designed to bring a wide range of additional benefits: greater public enjoyment; pollination; carbon capture; water quality improvements and flood management.

16.63. Natural England has produced a series of habitat network maps to help address the challenges outlined in the Lawton report and believe they should provide a useful baseline for the development of a NRN as required within the 25 Year Environment Plan[109] and Local Nature Recovery Strategies as proposed within the Environment Act[102]. The maps have been created to provide a national overview of the distribution of habitat networks with suggestions for future action to enhance biodiversity, to help stimulate local engagement with partners and to agree local priorities and identify where action might help build more ecologically resilient ecosystems across landscapes.

- Habitat creation/restoration: Areas where work is underway to either create or restore the primary habitat.
- Restorable habitat: Areas of land, predominantly composed of existing semi-natural habitat where the primary habitat is present in a degraded or fragmented form, and which are likely to be suitable for restoration.

- Network Enhancement Zone 1: Land connecting existing patches of primary and associated habitats which is likely to be suitable for creation of the primary habitat. Factors affecting suitability include proximity to primary habitat, land use (urban/rural), soil type, slope and proximity to coast. Action in this zone to expand and join up existing habitat patches and improve the connections between them can be targeted here.
- Network Enhancement Zone 2: Land connecting existing patches of primary and associated habitats which is less likely to be suitable for creation of the primary habitat. Action in this zone that improves the biodiversity value through land management changes and/or green infrastructure provision can be targeted here.
- Fragmentation Action Zone: Land within Enhancement Zone 1 that connects existing patches of primary and associated habitats which are currently highly fragmented and where fragmentation could be reduced by habitat creation. Action in this zone to address the most fragmented areas of habitat can be targeted here.
- Network Expansion Zone: Land beyond the Network Enhancement Zones with potential for expanding, linking/joining networks across the landscape i.e., conditions such as soils are potentially suitable for habitat creation for the specific habitat in addition to Enhancement Zone 1. Action in this zone to improve connections between existing habitat networks can be targeted here.

16.64. The NCA and BNG assessments consider the impacts of the Lower Thames Reservoir Option on priority habitat, however there are opportunities for the scheme to support the NRN. For example, where the pipeline is to be constructed within one of the identified habitat zones, reinstatement of land following construction could be linked to the priorities of that area such as habitat creation, restoration, or improvement. To provide an indication of the potential opportunity associated with the Lower Thames Reservoir Option, the total area of Network Enhancement Zone 1, Network Enhancement Zone 2, Fragmentation Action Zone, and Network Expansion Zone located within the route corridor and in proximity to each corridor (i.e. within 500m of the route corridor) has been summarised in Table 16.9 below. Both the Indicative Route and the NC Optimised Route are located within the wider route corridor, as set out above. Therefore, the NRN areas have been summarised for the wider route corridor (and surrounding 500m area).

Table 16.9: Area of Nature Recovery Network in proximity to the Lower Thames Reservoir Option

NRN classification	Total NRN area located within, and in proximity to (500m), the Lower Thames Reservoir Option (ha)
Network Enhancement Zone 1	284.20
Network Enhancement Zone 2	346.45

NRN classification	Total NRN area located within, and in proximity to (500m), the Lower Thames Reservoir Option (ha)
Fragmentation Action Zone	3.79
Network Expansion Zone	340.20

16.65. The measures identified by the NCA and BNG assessment can be used to target mitigation and enhancement to support the NRN areas set out above, as well as other local sites of ecological interest. For example, Biodiversity Opportunity Areas (BOAs) similarly identify areas where improved habitat management and restoration activities can be targeted to support priority habitats and increase connectivity. The transfer route corridors extend through Buckinghamshire Council and the London Borough of Hillingdon. Buckinghamshire Council has identified BOAs[118] that are located within, or in proximity to, the transfer route corridors. The BOAs include a description of the local environment and target measures such as woodland management, restoration of lowland calcareous grassland, river restoration, and parkland management.

16.66. For example, the Drinking Water Transfer Main Route Corridor passes through the Colne Valley BOA[119], which has been identified as a BOA by the Buckinghamshire and Milton Keynes Local Nature Partnership (LNP). The BOA profile for Colne Valley provides a summary of a number of environmental characteristics, such as the geology and topography, as well summaries on habitat characteristics, for example identifying that there are areas of fen habitat at Kingcup Meadows & Oldhouse Wood SSSI. In addition to the environmental and habitat characteristics, the following measures have also been identified as targets for the BOA:

- Rivers and streams – management, restoration
- Eutrophic standing water – management, restoration
- Reedbed – management, restoration, creation
- Woodland – management, restoration, creation
- Lowland meadows – management, restoration, creation
- Purple moor grass and rush pastures – management, restoration, creation
- Fens – management, restoration, creation
- Ponds – management, restoration, creation

[118] Buckinghamshire & Milton Keynes Local Nature Partnership, Biodiversity Opportunity Areas. Available at: https://bucksmknep.co.uk/biodiversity-opportunity-areas/ [Accessed May 2022]
[119] Buckinghamshire & Milton Keynes Local Nature Partnership, Colne Valley Biodiversity Opportunity Area. Available at: https://bucksmknep.co.uk/boa/colne-valley/ [Accessed May 2022]

- Wood pasture and parkland – management, restoration
- Traditional orchards – management, restoration
- Hedgerows – management, restoration, creation

16.67. The BOAs provide a useful resource to supplement the areas identified at the national scale by the NRN, providing further local context as to which mitigation and enhancement opportunities would yield the most environmental benefit. It is anticipated that the forthcoming Local Nature Recovery Strategies, as set out by the Environment Act 2021[102], will bring together information on existing priority habitats, as well as the opportunities identified by these regional and national networks, to set out the biodiversity priorities for a given strategy area. These strategies could then be supplemented with further review of national, regional and local strategies, such as priorities set out by the Chalk Stream River Strategy[120].

16.68. It is recommended that these opportunities are further explored at subsequent project stages. Wider partnership working with landowners, conservation groups and other organisations should be explored to help deliver opportunities for biodiversity enhancement.

16.6.2.3 BNG unit purchase

16.69. BNG can be achieved via a new statutory biodiversity credits scheme. Credits can be bought by developers as a last resort when onsite and local offsite provision of habitat cannot deliver the BNG required. It is important to emphasise that the purchase of BNG units should only be considered as a last resort when alternative methods for habitat provision are not possible for achieving a minimum 10% net gain in biodiversity. The price of biodiversity credits will be set higher than prices for equivalent biodiversity gain on the market and are expected to be purchased through a national register for net gain delivery sites. Natural England is in the process of running pilot schemes to provide a practical insight into the implications of the scheme, which is expected to go live spring 2023. The number of credits required to be purchased to achieve a minimum 10% increase in BNG for each route option has been calculated and presented in Table 16.10 (i.e. how many BNG units are required to offset the loss plus achieve a minimum 10% net gain).

16.70. Habitat creation possibilities, other than unit purchase, to achieve a minimum 10% BNG gain include:

- On-site: Improve the existing habitats on-site through post construction remediation and replacement of low BNG value habitats with higher BNG value habitats

[120] Catchment Based Approach (CaBA). Chalk Stream Restoration Strategy 2021 Main Report. https://catchmentbasedapproach.org/learn/chalk-stream-strategy/ [Accessed September 2022]

- Off-site: Purchase suitable areas of off-site land within the local area and/or at a regional scale to offset BNG decrease by improving the existing habitats within the off-site land and/or by replacing existing habitats with higher BNG value habitats.
- On-site and off-site: Improve existing habitats and/or replacement of low BNG value habitats with higher BNG value habitats as part of the catchment management options.

Table 16.10: BNG habitat units required to be purchased to achieve a minimum 10% net gain

Route option	BNG habitat unit purchase
Indicative Route	100.66
NC Optimised Route	78.75

16.7 Summary of main findings and recommendations for future technical work

16.71. The NCA, BNG and ecosystem services outputs identified the following:

- NC: The Lower Thames Reservoir Option would cause the temporary and permanent loss of natural capital stocks.
- BNG: The Lower Thames Reservoir Option is likely to result in a loss of BNG habitat units due to the temporary and permanent loss of natural capital assets during construction. Mitigation and enhancement opportunities for the scheme have been suggested in this section, which can work in tandem to reducing the loss of BNG and introducing net gain. It is recommended that these are developed further at subsequent project stages.
- Ecosystem services: The Lower Thames Reservoir Option presents opportunities to improve the existing habitats along the route through post construction remediation and replacement of low value habitats with higher value habitats.

16.72. The NC Optimised Route resulted in a reduction in temporary impacts on woodland priority habitat and broadleaved, mixed and yew woodland. The NC Optimised Route reduced the total amount of pasture permanently lost and avoided the permanent loss of active floodplain. The NC Optimised Route resulted in greater value retained for those ecosystem services scoped in for quantitative assessment. The NC Optimised Route also resulted in a smaller total quantity of BNG habitats units lost. The feasibility of the NC Optimised Route should be further investigated at subsequent project stages against engineering, environmental, social, and planning constraints, as well as against potential opportunity areas and proposals for environmental net gain.

16.73. The opportunities identified in the BNG/NC assessment have the potential to contribute to government ambitions for environmental net gain. This could take the form of habitat compensation, creation and/or species relocation schemes. Any schemes would need to be taken forward based on a comprehensive understanding on the interaction between natural systems and between natural systems and social uses of land.

16.74. It is recommended that the underlying data sources are confirmed and refined with on-site surveys at a subsequent project stage to provide a more-detailed understanding of habitat condition. Opportunities should also be considered to create and improve habitat on-site and off-site through local schemes, NRNs and wildlife corridors in order to achieve a minimum 10% net gain in BNG units and increase the provision of ecosystem services, therefore aiding in developing more resilient options for the future provision of water for the T2AT SRO.

17 Wider benefits

17.1 Introduction

17.1. This chapter summarises the wider benefits that are predicted to arise from implementing the Lower Thames Reservoir Option. Wider benefits are those areas of environmental and social value that are associated with constructing and operating the scheme. Areas of disbenefit are also considered.

17.2. The consideration of wider benefits draws on the findings of other assessment work to inform the Gate 2 submission, as well as introducing additional information where material in the context of the Lower Thames Reservoir Option.

17.3. The overall Best Value and solution benefits are presented in the Gate 2 Report.

17.2 Methodology

17.4. This section sets out the methodology for identifying and assessing wider benefits.

17.2.1 Six Capitals framework

17.5. There is no specific methodology guiding wider benefits assessments for SROs. Approaches set out in WRMP Guidance[121] (on identifying benefits (both monetary and non-monetary) for customers, environment and society) and Ofwat's Public Value Principles[122] have influenced the methodology. The starting point for the assessment of wider benefits is the Six Capitals framework[123] (see Table 17.1), which is used by organisations, including UK water companies, as a framework for considering social, governance and environmental issues.

[121] Environment Agency, Natural Resources Wales and Ofwat (2022) Water Resources Planning Guideline. Available at: https://www.gov.uk/government/publications/water-resources-planning-guideline/water-resources-planning-guideline [Accessed May 2022]
[122] Ofwat, Ofwat's Public Value Principles. Available at: https://www.ofwat.gov.uk/about-us/our-strategy/ofwats-public-value-principles/ [Accessed May 2022]
[123] Integrated Reporting Framework. Available at: https://www.integratedreporting.org/resource/international-ir-framework/ [Accessed May 2022]

Table 17.1: Six Capitals framework

Capital	Description
Financial	The pool of funds available for use in the production of goods or provision of services, obtained through financing or generated through operations or investments.
Human	People's competencies, capabilities and experiences, and their motivation to innovate.
Manufactured	Manufactured physical objects available to an organisation for use in the production of goods and services.
Intellectual	Organisational, knowledge-based intangible aspects such as intellectual property, systems and procedures.
Social	The institutions and relationships within and between communities, groups of stakeholders and other networks and the ability to share information to improve individual and collective wellbeing
Natural	The physical stocks of renewable and non-renewable resources that provides goods and services of value to society.

17.2.2 Scoping of potential benefits

17.6. The ZoI was defined as the area of receiving (i.e. experiencing a benefit or disbenefit) or providing (i.e. providing workforce) environment with the potential to be altered or changed as a result of the Lower Thames Reservoir Option.

17.7. A review of the potential wider benefits that are relevant to the Lower Thames Reservoir Option was undertaken. Table 17.2 sets out the findings of the review.

Table 17.2: Wider benefits scoping

Capital	Description	Applicability to Lower Thames Reservoir Option	Scoped into wider benefits
Financial	Economic benefits – Job creation	The Lower Thames Reservoir Option is expected to generate temporary and permanent employment opportunities. This will bring benefits through the supply chain.	Yes
Financial	Economic benefits – through capital expenditure		

Capital	Description	Applicability to Lower Thames Reservoir Option	Scoped into wider benefits
Financial	Economic benefits – through supply chain		
Financial	Economic benefits – increase in tourism related to new recreation assets	The Lower Thames Reservoir Option would not build or enhance assets that could be used for tourism or recreation. The existing service reservoir in the vicinity of Harefield is not accessible to the public.	No
Financial	Financial asset value – some properties or premises may experience a change in value due to proximity to the Lower Thames Reservoir Option	The Lower Thames Reservoir Option is not likely to increase or decrease the value of property. The implications for businesses / landowners directly affected by the requirement for land are considered separately in the Cost analysis for Gate 2.	No
Social	Health and wellbeing – from access to recreation and / or open space	The Lower Thames Reservoir Option provides the opportunity to enhance recreation features such as PRoWs.	Yes
Social	Education – opportunities to provide educational resource	The Lower Thames Reservoir Option would not provide additional educational resources.	No
Social	Social value – quality of life benefits associated with other economic benefits	The Lower Thames Reservoir Option could provide an opportunity to continue the deployment of apprenticeships.	Yes
Social	Partnerships – working collaboratively with other organisations	The Lower Thames Reservoir Option provides the opportunity to link with local organisations to deliver benefits, for example, implementing BNG initiatives.	Yes
Natural	Natural capital – any additional benefits in addition to the scope of the NCA (see Chapter 16)	The ability of the Lower Thames Reservoir Option to contribute to other aspects of natural capital has been reviewed and no additional	No

Capital	Description	Applicability to Lower Thames Reservoir Option	Scoped into wider benefits
		issues to the NCA have been identified.	
Natural	Flood risk – any additional benefits derived from decreasing flood risk (see Chapter 6)	The Lower Thames Reservoir Option is not likely to affect wider flood risk management measures.	No

17.8. The scoping exercise identified that items applicable to financial, social and natural capital were relevant to the assessment, and that items relating to human, manufactured and intellectual capital were not specifically relevant. The items relating to natural capital are already covered and assessed (see Chapters 6: Water and 16: Natural capital and biodiversity net gain) and are therefore not duplicated here.

17.9. In summary, the key issues for the Lower Thames Reservoir Option are:

- Economic impacts deriving from employment and the benefits through the supply chain
- Health and well-being benefits occurring from opportunities to enhance local footpaths / PRoWs
- Ongoing contribution to enabling apprenticeships
- Partnership strategy to work with local organisations

17.10. The detailed methodology for assessing the wider benefits varies for each of these issues and the following section presents these details alongside the results.

17.3 Results

17.11. This section set out the findings from the assessment of wider benefits for employment impacts, health and well-being benefits and apprenticeships. A partnership strategy is set out in Section 17.4.

17.3.1 Employment impacts

17.12. Employment impacts are expected to result in positive outcomes. The beneficiaries are those who are directly employed, as well as indirect and induced impacts on the local economy (goods and services). The number of potential employees is identified for both the construction and operation phases.

17.13. Employment impacts were calculated by applying standard data from the ONS on Gross Value Added (GVA) per worker at the UK level in the production sector, as this includes employment in the utilities and water industries the number of jobs estimated by the client. This gross figure was adjusted for additionality by applying deadweight and displacement. Leakage was considered to be zero as the study area for this analysis is too large for leakage to be likely. This data was adjusted to 2022 prices using Gross Domestic Product (GDP) deflators from HM Treasury. The GVA impact was then modelled over a 30-year appraisal period and the present value of this benefit was calculated using the standard HMT discount rate of 3.5% per annum. Indirect and induced employment impacts were calculated using a standard multiplier of 1.1 from the HCA (now Homes England) Additionality Guide[124]. GVA per worker data was then applied to the multiplier jobs and discounted.

17.14. For the construction of the Raw Water and Drinking Water Transfer Mains, it is anticipated that approximately 220 full time equivalent staff could be employed. For construction of the Indicative WTW Site, approximately 220 full time equivalent staff could be employed. The construction period is assumed to be 2034-2038.

17.15. The construction jobs could generate positive economic impacts (direct, indirect and induced) of approximately £76 million. However, the assumption here is that construction jobs are likely to be fully displaced from elsewhere. The assumption is based on how construction jobs are supported, in that many construction firms, big and small, would move around between jobs and if they were not working on this, would likely be working on another project elsewhere. The water companies and any contractors would likely be working on other projects or maintenance if it were not for this project being delivered. This would mean that the jobs supported by the delivery of this project would otherwise be supported by another project. As this assessment looks at national level impacts, a conservative assumption that the jobs would not otherwise exist means this financial benefit is not likely to be able to be attributed to the Lower Thames Reservoir Option.

17.16. For the operational phase, it is anticipated that 15 full time equivalent staff could be employed.

[124] Homes and Communities Agency 'Additionality Guide'. Fourth Edition 2014. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/378177/additionality_guide_2014_full.pdf [Accessed May 2022]

17.17. The operational jobs could generate positive economic impacts (direct, indirect and induced) of approximately £13 million. These jobs could be attributable to the Lower Thames Reservoir Option and therefore represent a benefit associated with the T2AT SRO.

17.3.2 Health and well-being

17.18. Health and well-being benefits, such as physical and mental health benefits, could accrue through enhancing opportunities for recreation by enhancing local footpaths / PRoWs to enable access and exposure to greenspace. A Public Health England review[125] concluded that people who have greater exposure to greenspace have a range of more favourable physiological outcomes. Greener environments are also associated with better mental health and wellbeing outcomes including reduced levels of depression, anxiety, and fatigue, and enhanced quality of life for both children and adults.

17.19. Opportunities to enhance access to greenspace are most likely to occur in areas where construction activity is affecting existing PRoWs. This is likely to benefit local people, although linkages to any national trails could have a wider benefit. No specific proposals have been incorporated into the scheme design at this stage, therefore benefits are qualitative. The benefits would accrue following construction activity. Examples of opportunities include:

- Opportunities to enhance nearby riparian vegetation and strengthen connections within the blue-green network (Raw and Drinking Water Transfer Main Route Corridors).
- Opportunities to enhance nearby sections of the long distance footpaths in terms of planting, resurfacing, information boards, way markers and social enhancements (Raw and Drinking Water Transfer Main Route Corridors).
- Opportunities to strengthen the green corridor through additional planting to link vegetation along the River Colne, Grand Union Canal Slough Arm and M25 corridors (Indicative WTW Site).
- Opportunities to enhance landscape character and the character of views from PRoWs through additional planting along the M25, Slough Arm (of the Grand Union Canal) and at the boundary of the Indicative WTW Site.

17.20. The partnership strategy identifies those organisations that could be engaged to help develop and realise these benefits.

[125] Public Health England (March 2020): Improving access to greenspace- a new review for 2020 [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904439/Improving_access_to_greenspace_2020_review.pdf [Accessed August 2022]

17.3.3 Apprenticeships

17.21. Both Thames Water and Affinity Water have existing apprenticeship schemes to assist in introducing people to the workplace and develop skills through a variety of advanced, higher and degree level apprenticeships across a range of roles. As well as benefits to the individual employee, a skilled workforce contribute to increased Human capital of the organisation. The educational / training facility also benefits through running successful apprenticeship programmes (developing knowledge, skills of trainers) and the local employment and economic market also benefit. Although the apprenticeships are timebound for an individual, organisations such as water companies can provide long term career options as a wide range of roles at all levels are available. Water companies also partner with other organisations, such as contractors, and it is therefore likely that apprentices contribute to construction activities.

17.22. As the water companies run the apprenticeship schemes at a corporate level, rather than recruit for specific projects, it is not possible to assign particular numbers of apprentices to the Lower Thames Reservoir Option.

17.4 Partnership strategy

17.4.1 Introduction

17.23. This section and sets out an approach for identifying partners that may benefit from the delivery of the Lower Thames Reservoir Option.

17.24. As presented in Chapter 16, Natural Capital and Biodiversity Net Gain, to align with WRPG[104] and RAPID Gate 2 guidance[8], and to ensure the project creates value beyond public water supply, a NCA has been undertaken to understand the benefits that are currently delivered by the Lower Thames Reservoir Option, as well as the likely impact on those benefits resulting from construction of the scheme. The potential beneficiaries associated with the findings of the NCA represent a group of stakeholders that could have existing aspirations and priorities that align with the Lower Thames Reservoir Option, and therefore represent an opportunity to collaboratively deliver environmental enhancement through partnership working.

17.4.2 Approach

17.25. The NCA has estimated the impact of the Lower Thames Reservoir Option natural capital stocks, which has then informed the assessment against six natural capital metrics (also known as ecosystem services). The approach undertaken for the NCA aligns with Defra's ENCA[105]. ENCA is recommended for use by HM Treasury's Green Book: appraisal and evaluation in central government (2020)[106] and represents supplementary guidance to the Green Book[107]. An assessment on biodiversity and habitats has also been undertaken in order to calculate the biodiversity net gain associated with the route options, following Defra and Natural England's Biodiversity 3.0 Metric[100].

17.26. For each natural capital metric, or ecosystem service, ENCA[105] defines the final welfare benefit and the likely beneficiaries of that service. To inform the various types of partners that may benefit from the Lower Thames Reservoir Option, likely beneficiaries of the service, and a discussion of other types of organisations that are working within the environmental topic area has been provided for each of the ecosystem services assessed as part of the NCA (see Section 17.4.3).

17.27. Consideration of public water supply and the resulting benefits that customers could receive as a result of the Lower Thames Reservoir Option has been excluded from the consideration of potential partners. It is assumed that these benefits, including any associated changes to deployable output, are captured separate to the partnership strategy and managed by the associated water companies.

17.28. As part of the RAPID gated process, Thames Water and Affinity Water will engage with a number of statutory consultees and regulators, including but not limited to, the Environment Agency, the Drinking Water Inspectorate, Natural England and Ofwat. For the purposes of identifying potential partnerships, these organisations have been excluded, as engagement is expected to be collaborative and iterative throughout the planning process.

17.29. There are a number of constraints to consider when identifying opportunities for environmental and social benefits, such as the budget for delivering the scheme, the amount of benefit technically possible for each type of proposal given existing land uses, land availability, and the trade-off between prioritising certain types of benefits over others. Further to these constraints, the construction and operation of the Lower Thames Reservoir Option may not be required for a considerable period of time, at which point constraints such as land use or land availability may have changed. As the scheme continues to progress through the gated process, the relevance of these constraints would be considered when identifying and engaging potential partners.

17.4.3 Natural capital benefits and potential partners

17.4.3.1 Carbon sequestration (climate regulation)

17.30. The NCA identified that both the indicative route and the NC Optimised Route would result in the release of CO_2 due to habitat clearance. The reduced capacity for the route to deliver carbon sequestration as an ecosystem service would result from the temporary and permanent loss of associated stocks, followed by replacement of those same stocks through inset re-planting.

17.31. There is an opportunity to reduce the loss in carbon sequestration by replacing low value habitats with higher value habitats, specifically habitats that can act as carbon sinks. For example, cultivars of carbon sequestering grassland and meadows with enhanced root growth, combined with a good soil profile, have the potential to sequester greater amounts of carbon. natural capital proposals to enhance carbon sequestration benefits, proper consideration should be given to the habitats being lost in favour of higher value habitats, and whether the retention of less carbon-rich but well-established habitats may sometimes be a better option for local biodiversity. Habitat created to compensate for the loss of natural or semi-natural habitat should be of the same broad habitat type unless there is good ecological reasoning to do otherwise, as espoused by Defra and Natural England's Biodiversity Metric 3.0[100].

17.32. ENCA[105] identifies the final welfare benefit of carbon sequestration as the contribution to meeting national greenhouse gas (GHG) targets to avert damaging climate change, while noting that the resulting benefits of mitigating climate change (such as reducing the severity of extreme weather events) are far broader and uncertain. In the context of meeting GHG targets, the government is the direct beneficiary of reduced emissions, but other beneficiaries include businesses and individuals who demand carbon offsets. Local legislation and policy set out by the Local Planning Authorities impacted by the Lower Thames Reservoir Option identifies the need to address climate change risks through mitigation and adaptation. Iterative engagement with both the Local Planning Authorities and regulators throughout the planning process would help to identify potential stakeholders with an interest in reducing carbon emissions through increased sequestration. Local business networks, such as the Buckinghamshire Local Enterprise Partnership can provide a valuable resource for identifying both local business partners and local initiatives interested in promoting carbon sequestration.

17.33. When considering potential partnerships, it would be useful to also consider potential funding opportunities available to either the scheme or the potential partner. For example, if woodland planting is identified as a potential carbon sequestration opportunity that could be collaboratively delivered with a local partner, then Forestry Commission funding could be available to create a woodland creation plan through the Woodland Creation Planning Grant[126].

17.4.3.2 Natural hazard management

17.34. The NCA identified that both the indicative route and the NC Optimised Route would result in a reduction of natural hazard management due to the temporary and permanent loss of associated stocks with the floodplain. Where stocks are temporarily lost, it is expected that the future value would not be affected as stocks are expected to be reinstated. Any permanent changes to surface water flood risk, for example by the construction of the new WTW as permanent aboveground infrastructure, would be appropriately assessed and mitigated as set out in Section 6.4.4.4.

17.35. There is an opportunity to further reduce the loss in natural hazard management through enhancements, specifically by replacing low value habitats with higher value habitats, that is habitats that can intercept, store and slow water flows. These types of enhancements can provide a flood risk management value. ENCA[105] identifies the final welfare benefit of natural hazard management as reduced flood damage to downstream settlements, noting that downstream households and businesses, as well as water companies and insurance companies are likely to be the key beneficiaries. Given the linear nature of the Lower Thames Reservoir Option, with potential enhancements to natural capital stocks being delivered predominately within the transfer main route corridors, the beneficiaries, and potential partners, are likely to be limited to local landowners and businesses located in close proximity downstream.

17.4.3.3 Biodiversity and habitats

17.36. The BNG calculation presented in Table 16.7 shows that both the indicative route and the NC Optimised Route would result in a net loss of biodiversity.

17.37. This BNG calculation has considered agreed mitigation and best practice measures for habitat reinstatement and compensation but has not considered any habitat creation or enhancement proposals. As set out in Section 16.6, the SRO could aim to not only reinstate lost habitat, but also provide a greater or more diverse habitat than is lost, to achieve an overall net gain in biodiversity in line with regulatory requirements for BNG. A summary of potential mitigation and enhancement opportunities has been provided in the Section 16.6.2.

17.38. The potential mitigation and enhancement opportunities include, for example, habitat creation that increases connectivity between Natural England's Nature

[126] Forestry Commission 2018. Woodland Creation Planning Grant. Available at: https://www.gov.uk/guidance/woodland-creation-planning-grant [Accessed May 2022]

Recovery Networks, where the networks overlap with, and are located in proximity to, the route options. It is anticipated that the forthcoming Local Nature Recovery Strategies, as set out by the Environment Act 2021[102], will bring together information on existing priority habitats, as well as the opportunities identified by regional and national networks, to set out the biodiversity priorities for a given strategy area. The local plans for the Local Planning Authorities impacted by the Lower Thames Reservoir Option emphasise the importance of conserving biodiversity, recognising priority areas with environmental designations, such as LWSs and SINCs, and through local services, such as the Buckinghamshire & Milton Keynes Biodiversity Partnership. The Local Planning Authorities, as well the as regulators with local knowledge of ongoing biodiversity initiatives, would be an important partnership for targeting enhancements in biodiversity.

17.39. ENCA[105] identifies a range of final welfare benefits from enhancements to biodiversity, as biodiversity underpins, to varying degrees, all ecosystem services. For example, biodiversity underpins the provisioning (food production), regulating (carbon sequestration, natural hazard management, air pollutant removal, and water purification), and cultural services (recreation and amenity) set out within this section. The numerous benefits received from conserving and enhancing biodiversity are widely recognised, and in addition to the local authorities and regulators, there are many organisations that work collaboratively on biodiversity conservation activities. For example, a number of organisations are focused on developing multidisciplinary projects to conserve biodiversity, such as the Buckinghamshire and Milton Keynes Natural Environment Partnership (NEP), the Berkshire and Buckinghamshire and Oxfordshire Wildlife Trust. These organisations are complemented by other organisations that have a greater focus on a particular aspect of conservation, such as the Bucks Amphibian and Reptile Group, Buckinghamshire Bird Club, and the Bucks Geology Group. National organisations can help to connect these local initiatives across the region through, for example, the Forestry Commission, the Woodland Trust, and the RSPB.

17.40. Exploring local partnership opportunities would allow Thames Water and Affinity Water to further identify and engage with landowners and businesses that are similarly interested in conserving biodiversity, as well as potentially provide access to greater amount of local data. For example, the Buckinghamshire and Milton Keynes NEP has identified the Colne Valley as a BOA[119], and have provided a description of the local environmental characteristics and biodiversity features, such as known areas of lowland meadows, fens and wet woodland, as well as targets for conserving biodiversity, such as managing and restoring eutrophic standing water.

17.4.3.4 Food production

17.41. The NCA identified that both the indicative route and the NC Optimised Route would result in a reduction of food production services due to the permanent loss of associated stocks, replaced by permanent aboveground infrastructure. Where stocks are temporarily lost, it is expected that the future value is not affected as stocks are expected to be reinstated. Arable land and pasture may be temporarily acquired to construct the Drinking Water Transfer Main.

17.42. ENCA[105] identifies the final welfare benefit of food provisioning services as food for human consumption, with the provisioning service providing a direct input into the agricultural sector and food processing. Although the majority of the effects on agricultural stocks are expected to be temporary, there is an opportunity to partner with farmers, local landowners and agricultural businesses to delivery environmental enhancements as the land is reinstated along the pipeline route.

17.43. The UK Agricultural Act 2020[127] sets out the legislative framework for replacing direct payments to farmers in England with a new system of 'public money for public goods.' The aim of the new Environmental Land Management Scheme (ELMS) will be to deliver benefits such as improved air, water and soil quality, increased biodiversity, climate change mitigation, cultural benefits and to protect the historic environment. There is an opportunity to link any ongoing agri-environment schemes along the Drinking Water Transfer Main Route Corridor with the proposed components of the ELMS and identify where environmental enhancements, such as carbon sequestration or habitat creation, may contribute to these schemes. Given the localised nature of the effects on agricultural stocks, the beneficiaries, and potential partners, are likely to be limited to local landowners and businesses located in close proximity to Drinking Water Transfer Main Route Corridor. National organisations, such as the National Farmers Union, Farming and Wildlife Advisory Group or the Country Land and Business Association, may be able to provide support in identifying opportunities for local partnerships or sources of potential funding, such as the Countryside Stewardship scheme.

17.4.3.5 Air pollutant removal

17.44. The NCA identified that both the indicative route and the NC Optimised Route would result in a reduction of air pollutant removal services due to the temporary and permanent loss of associated stocks within built-up areas. Where stocks are temporarily lost, it is expected that the future value is not affected as stocks are expected to be reinstated.

17.45. There is an opportunity to further reduce the loss in air pollutant removal through enhancements, specifically by replacing low value habitats with higher value habitats. In this context, higher value habitats are those that remove harmful air pollutants from the atmosphere, mainly through direct deposition on leaves and bark and through internal absorption of pollutants through stomatal uptake. ENCA[105] identifies the final welfare benefit of air pollutant removal as reduced health costs from lower levels of exposure to pollution, with both individuals and government

[127] Agriculture Act 2020. Available at: https://www.legislation.gov.uk/ukpga/2020/21/contents/enacted [Accessed May 2022]

identified as the key beneficiaries of reduced health costs.

17.46. Given the localised nature of the effects, with potential enhancements to natural capital stocks being delivered predominately within the narrow transfer main route corridor, the beneficiaries, and potential partners, are likely to be focused on Local Planning Authorities, local landowners and businesses located in close proximity to the Lower Thames Reservoir Option. The local authorities, for example, may have an aspiration to reinstate affected areas with a greater number of street trees. It should be noted that delivering new or enhanced natural capital stocks, such as street trees, in a built-up area may be challenging given the high concentration of local landowners and businesses, and the complications of land ownership that accompanies densely populated areas.

17.4.3.6 Recreation and amenity value

17.47. The NCA scoped out the consideration of recreation and amenity value as the Lower Thames Reservoir Option is not likely to result in the permanent loss of designated green space, as set out in Section 12.4. However, the Lower Thames Reservoir Option is likely to result in temporary effects to recreational and landscape features, such as temporary diversion or closure of PRoWs, as well as permanent effects, such as the loss of small areas of vegetation along some footpaths and waterways. Appropriate mitigation is recommended for these effects, and landscape enhancement opportunities are proposed in Section 9.5.3 to strengthen the existing blue-green networks and enhance local footpaths.

17.48. ENCA[105] identifies the final welfare benefits for enabling recreational services as the use values to individuals visiting recreational sites, such as physical and mental health benefits, noting that the individuals visiting the sites, as well as recreation and tourism related businesses, are likely to be the key beneficiaries. Similar benefits and beneficiaries are identified by ENCA for enabling local environmental amenity, adding that local property prices can often reflect the added amenity value.

17.49. There are a number of local organisations working to maintain and enhance recreational and landscape features within the areas affected by the Lower Thames Reservoir Option, which may provide an opportunity for developing local partnerships. For example, the Colne Valley Regional Park organises community groups, social enterprises, government agencies, businesses, and landowners to undertake landscape and biodiversity conservation activities. The network is managed by the Friends of the Colne Valley Park, as part of the Colne Valley Park Trust and Colne Valley Community Interest Company. The network may have priority activities or aspirations for areas that may be affected by the Lower Thames Reservoir Option. In addition to identifying and prioritising areas for enhancement, these partnerships may allow the SRO to support ongoing volunteering opportunities, as well as connect with local volunteering networks, such as Community Impact Bucks.

17.4.3.7 Water purification

17.50. The NCA identified that both the indicative route and the NC Optimised Route would result in a reduction of water purification services due to the temporary and permanent loss of associated stocks. Where stocks are temporarily lost, it is expected that the future value is not affected as stocks are expected to be reinstated.

17.51. There is an opportunity to further reduce the loss in water purification services through enhancements, specifically by replacing low value habitats with higher value habitats, that is habitats that can absorb pollutants from a given water source. ENCA[105] identifies the final welfare benefit of water quality as recreational benefits for anglers, rowers, and other users of riparian habitat, as well as more general local amenity benefits and lower costs for water treatment.

17.52. In addition to the groups identified for biodiversity and food production, potential partners include The Rivers Trust, and more specifically the Thames River Trust which coordinates partnerships in the area. These wider networks could assist in identifying more local community groups to prioritise for engagement and volunteering opportunities.

17.5 Summary of main findings and recommendations for future technical work

17.53. The main findings from a review of the wider benefits associated with the Lower Thames Reservoir Option are as follows.

17.54. Beneficial economic impacts associated with new operational phase jobs are expected to generate approximately £13 million (over the 30 year appraisal period).

17.55. Proposals to enhance green infrastructure links and local footpaths could lead to health and well-being benefits. Further work to develop these opportunities and incorporate into the scheme design could be undertaken at subsequent project stages.

17.56. A draft partnership strategy has been developed as a basis for future engagement with stakeholders in order to help deliver some of the benefits and enhancements from changes to land use and provision of BNG.

18 Summary of main findings and recommendations for future technical work

18.1 Summary of main findings

18.1. This EAR presents the findings of desk-based studies undertaken following the selection of the Lower Thames Reservoir Option as one of the preferred options for the Thames to Affinity Transfer SRO. A number of constraints and issues for further investigation and work have been identified however, the assessments did not identify any environmental risks where mitigation could not be provided, and the viability of the Lower Thames Reservoir Option would be affected.

18.2. Table 18.1 presents the environmental appraisal summary for the Lower Thames Reservoir Option.

Table 18.1: Environmental appraisal summary

Assessment / topic	Environmental appraisal summary
Informal Habitats Regulations Assessment	Stage 1 Screening: Potential for Likely Significant Effects on South West London Waterbodies SPA/Ramsar. Stage 2 AA: No adverse effects on the integrity of South West London Waterbodies SPA/Ramsar are expected. In-combination effects assessment not required as no residual effects are expected.
Water Framework Directive Compliance Assessment	Level 1 Screening: One surface water river (the Thames (Cookham to Egham)) and two lakes (Queen Mother Reservoir and Wraysbury Reservoir) had an impact score greater than 1 due to new or increased abstraction. No groundwater bodies were taken forward to a Level 2 assessment. Level 2 Screening: It was determined that the new or increased surface water abstraction activity does not have the potential to deteriorate the WFD elements of the water body or prevent them from attaining Good status. The Lower Thames Reservoir Option is therefore considered to be compliant with the WFD.

Assessment / topic	Environmental appraisal summary
Strategic Environmental Assessment Review	Major positive effects identified on delivering reliable and resilient water supplies. Moderate negative effects (pre-mitigation) and minor negative effects (post-mitigation) were identified for biodiversity, flora and fauna, soil, flood risk, air quality, and population and human health for the construction of the Lower Thames Reservoir Option. Moderate negative effects on carbon emissions during the operational phase. Minor negative or neutral effects were identified for the remaining SEA objectives.
Biodiversity, flora and fauna	No direct impacts on statutory designated sites. Potential for indirect effects on statutory designated sites including Kingcup Meadows and Oldhouse Wood, Fray's Farm Meadows, Denham Lock Wood, Ruislip Wood SSSIs, Frays Valley and Denham Quarry Park LNRs during construction. Direct and indirect negative effects on non-statutory designated sites, including Southlands Manor LWS, Mid Colne SINC, Shepherd's Hill Woods and Fields SINC and Newyears Green SINC, including potential loss of habitat as a result of construction. No loss of ancient woodland. Potential loss of deciduous woodland priority habitat and potential impacts on protected and priority species. Based on currently available information, the majority of identified effects on the aquatic environment are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity during operation. Identified adverse effects with risks to the overall ecological integrity of affected reaches include potential primary productivity/food-chain effects within the River Thames, upstream of the abstraction point for the Lower Thames Reservoir Option. Flow changes within the River Thames as a result of SESRO have the potential to be both beneficial and adverse (at different times and for different species) for the existing baseline ecology and may affect the overall ecological integrity of the affected reaches.

Assessment / topic	Environmental appraisal summary
Soils	No direct or indirect impacts on designated geological sites. No permanent loss of best and most versatile agricultural land as above ground infrastructure is on non-agricultural land. Potential for temporary loss of Grade 2 and 3 (including 3a) agricultural land due to pipeline construction within the Drinking Water Transfer Main Route Corridor. Potential for contamination due to construction works within historic landfills and other contaminated land.
Water	The majority of identified effects on the aquatic environment are considered likely to be either negligible or result in minor adverse or minor beneficial effects that are unlikely to affect the overall ecological integrity of affected reaches. Sections of pipeline pass through SPZs, with potential risk of pollution during construction. No further requirements for assessment of groundwater flow under the WFD at this stage, as neither of the groundwater bodies considered in the Level 1 – basic screening assessment were carried through to the Level 2 – detailed screening assessment. Permanent infrastructure is in flood zone 1; low surface water flood risk for Indicative WTW Site, closed loop sustainable drainage system required for raw water pumping station at Wraysbury Tunnel Connection and new WTW to capture potential contaminants from the treatment process. Fluvial flood risk along the Drinking Water Transfer Main Route Corridor near watercourse crossings would need to be managed during construction.
Air	Majority of option is within AQMAs. Annual mean NO_2 objective may be exceeded during construction in areas that are located close to the roadside within Buckinghamshire Council's 'South Bucks District Council AQMA No. 2' AQMA. Exceedances of the PM_{10} and $PM_{2.5}$ objectives are not expected to occur. Operational effects associated with traffic and standby generators for the new WTW are unlikely to exceed air quality objectives.

Assessment / topic	Environmental appraisal summary
Climatic factors	Climatic risks include exacerbation of flood risk, higher temperatures and drought leading to change in ground conditions, and exceedance of operational temperature limits leading to shutdowns. Construction carbon emissions associated with the transfer pipelines and WTW. Operational carbon emissions primarily associated with power consumption for pumping.
Landscape	Potential for permanent change in landscape character along the pipeline route where vegetation, such as trees and woodland, is lost during construction and cannot be replaced because it falls within the pipeline easement. Indicative WTW Site is proposed on a site of existing industrial use and provides an opportunity to reduce the extent of hardstanding in comparison to the existing land use. Potential visual receptors identified include residential, recreational (including users of PRoW and cyclists), users of transport networks and employment and education receptors. Potential impacts on protected trees within proximity to the Drinking Water Transfer Main Route Corridor including within Harefield Village Conservation Area and TPOs in the Ickenham area. Opportunities to enhance landcover value and strengthen the blue-green network, for example through use of re-wilding techniques in the restoration of temporary compound areas and use of mitigation planting to link existing green infrastructure elements across the wider Colne Valley landscape.
Historic environment	No permanent impacts on designated heritage assets with exception of Iver Court Farmhouse, a Grade II Listed Building, which, depending on the layout for the Indicative WTW Site, could be directly impacted. Construction of the new WTW could also adversely affect the setting of the Grade II listed Iver Court Farmhouse however there is an opportunity to enhance the setting of this listed building. A Listed Building Consent may be required if the Indicative WTW Site is taken forward. High potential for archaeological remains, particularly dating to the prehistoric period. Excavation during construction would severely truncate, or remove entirely, potential archaeological remains.

Assessment / topic	Environmental appraisal summary
Noise	Construction and operational noise impacts from the Wraysbury Tunnel Connection, Indicative WTW Site and Raw Water Transfer Main Route Corridor are likely to be minimal due the distance from noise sensitive receptors. Pipeline alignment should be chosen to be at least 85m from noise sensitive receptors (130m where trenchless techniques occur) in order to minimise significant adverse noise impacts. This could be achieved along the vast majority of the Drinking Water Transfer Main Route Corridor and should be factored into refinement of the pipeline route alignment.
Population and human health	Community and human health impacts affecting housing and private property, businesses and open space and recreation during both construction and operation, including permanent and temporary land requirements, PRoW closure, travel disruption and a change in environmental conditions as a result of a combination of noise, air quality, visual impacts or presence of HGV vehicles. No permanent loss of housing and private property, community facilities or recreational assets.
Material assets	It is not considered that the vehicles volumes generated during construction and operation would present additional constraints to the road network. The majority of roads are anticipated to provide practical options for construction access. There are some localised construction access issues to be investigated in further detail at a subsequent project stage. Major infrastructure crossings including A40, Chiltern Line, HS2 Phase 1 route and Grand Union Canal would require further investigation and agreement with stakeholders at a subsequent project stage. Opportunity for a closer access and egress from the M25, which could provide a more direct route to construction sites. Potential impacts on existing utilities and minerals and waste sites.

Assessment / topic	Environmental appraisal summary
INNS Risk Assessment	Lower Thames Reservoir Option would not introduce a new hydrological connection between previously isolated catchments. Very low risk that the Lower Thames Reservoir Option would facilitate their spread of INNS as water transfer is through a closed system. Main risk identified is raw water movement between the source / intake and the new WTW. Minimal benefit from implementation of biosecurity measures and implementation of these measures may be considered disproportionate in relation to the risk. Negligible risk of INNS transfer of drinking water and further biosecurity/mitigation measures would have no tangible benefit. Low risk associated with the new assets as they are designed to move water within a sealed system; unlikely that additional biosecurity measures would reduce risk further.
Natural Capital Assessment and Biodiversity Net Gain	Potential for temporary loss of natural capital and ecosystem services as a result of the pipeline and permanent loss as a result of above ground components. Transfer routes could be optimised within the current transfer route corridors to reduce the loss of natural capital stocks. Approximately 77 BNG habitat units could be lost due to the temporary removal of habitats during construction. This could be reduced to 57 BNG habitat units through optimisation of the transfer routes.

18.3. Taking into account the key legislation and national planning policy outlined in this EAR, and with the information available at this stage, it is not considered that there any insurmountable environmental issues that should prevent the Lower Thames Reservoir Option from progressing. A summary of key risks is outlined below.

- Potential indirect effects on statutory designated sites and direct and indirect effects on non-statutory designated sites, priority habitat and protected species would require further consideration in terms of draft NPS Section 4.3[20] and NPPF[21] Section 15 (paragraph 180), which states that *'as a general principle, and subject to the specific policies below, development should avoid significant harm to biodiversity and geological conservation interests and contribute overall to net biodiversity gain. Where significant harm cannot be avoided or mitigated, as a last resort, appropriate compensation measures should be sought to provide net gains for biodiversity.'* Further technical work, including surveys, is recommended to investigate potential impacts, proposed mitigation and proposals for biodiversity net gain.

- Potential direct effects on the Grade II listed Iver Court Farmhouse would require further consideration in terms of draft NPS Section 4.7[20] (paragraphs 4.7.11 to 4.7.25 and NPPF[21] Section 16 (paragraphs 199-202), which states that *'substantial harm to or loss of a Grade II Listed Building…should be exceptional,'* and *'any harmful impact on the significance of a designated heritage asset should be weighed against the public benefit of development, recognising that the greater the harm to the significance of the heritage asset, the greater the justification that will be needed for any loss.'* It is considered that in the case of the Grade II Listed Iver Court Farmhouse, the Lower Thames Reservoir Option could provide an opportunity to enhance its setting and restore value to the asset that has been lost through the surrounding unsympathetic development. Further technical work is recommended at a subsequent project stage to investigate if the public benefit would outweigh the potential harm, or if the tests in Paragraph 4.7.19 of the NPS[128] would apply.

18.2 Recommendations for future technical work

18.4. Recommendations for future technical work are presented in this section. It is recommended that the following activities are prioritised ahead of commencing formal environmental assessment pursuant to the consenting process:

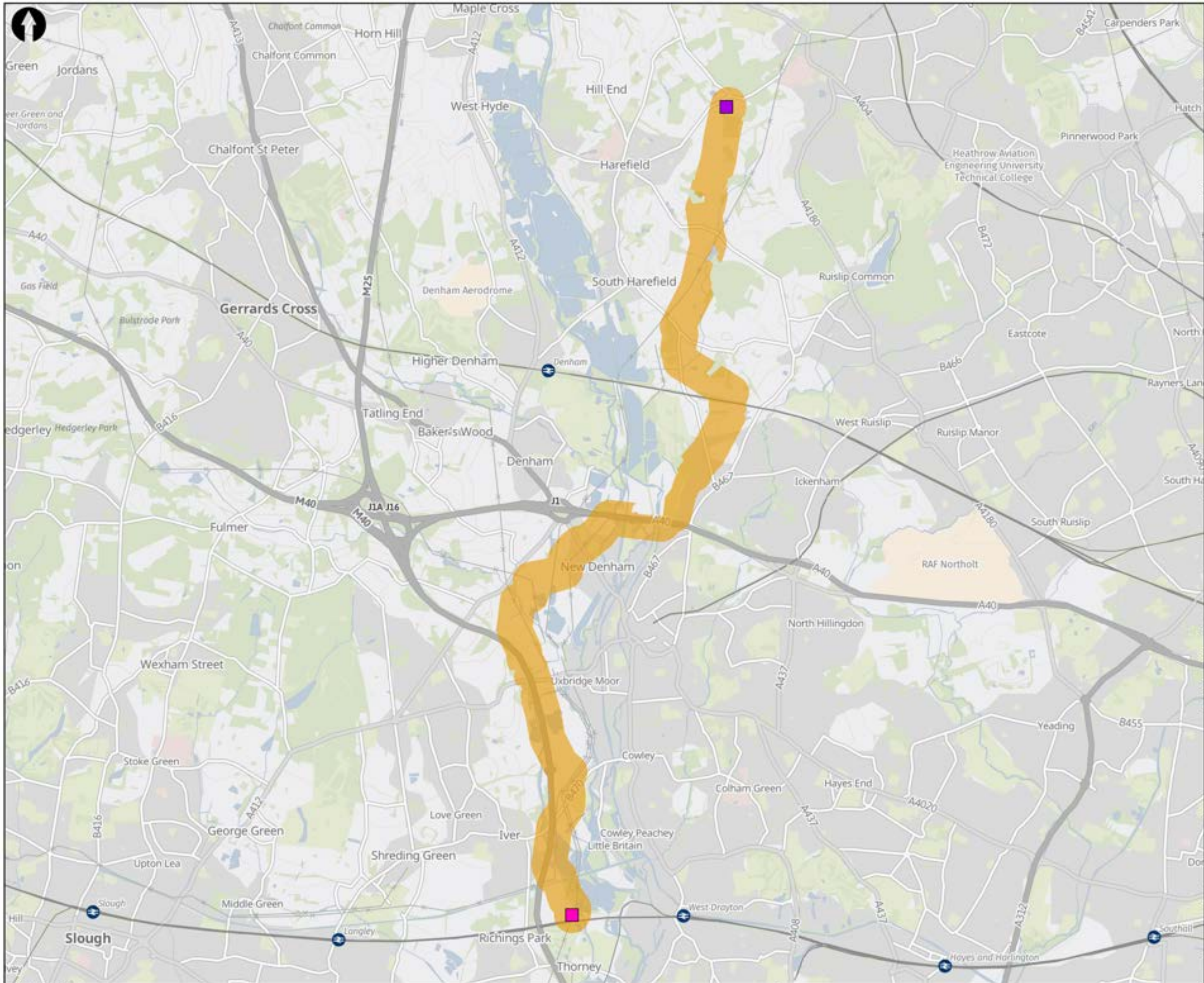
- Stakeholder engagement on the transfer routes and sites, including with statutory environmental stakeholders (Natural England, Environment Agency and Historic England), Local Planning Authorities, including County Archaeologists, and non-statutory environmental stakeholders including Wildlife Trusts.
- Further work on pipeline routing and siting of above ground infrastructure to avoid constraints such as non-statutory designated sites and priority habitats; this includes investigating the engineering feasibility of the NC Optimised Route and determining future environmental baseline, particularly in relation to the HS2 Phase 1 crossing.
- Informing the design to review biosecurity measures and improve resilience to physical climate change risks.

---

[128] *'Where the proposed development will lead to substantial harm to or the total loss of significance of a designated heritage asset, the Secretary of State will refuse consent unless it can be demonstrated that the substantial harm or total loss of significance is necessary in order to deliver substantial public benefits that outweigh that loss or harm, or alternatively that all of the following apply: the nature of the heritage asset prevents all reasonable uses of the site; no viable use of the heritage asset itself can be found in the medium term through appropriate marketing that will enable its conservation; conservation by grant funding or some form of not for profit charitable or public ownership is demonstrably not possible; and the harm or loss is outweighed by the benefit of bringing the site back into use.'*

- Further work to understand contamination risks including a geotechnical and geo-environmental ground investigation and a hydrogeological risk assessment to identify risks to SPZs and likely mitigation.
- Further work to investigate risks and impacts to the setting of affected features could be undertaken. In particular, a feasibility study for the Grade II listed building within the Indicative WTW Site could be undertaken should this site be taken forward following stakeholder engagement and public consultation.
- Targeted surveys of macroinvertebrate, fish and macrophyte/phytobenthos is required for several of the tributaries of the River Colne and Aldbourne as there is currently no data available to inform the sensitivity of these water bodies.
- Investigate the opportunity to gain direct access from the M25 to the Drinking Water Transfer Main Route Corridor.
- Scope and undertake surveys and investigations in order to inform design development and EIA scoping, including:
  - Preliminary Ecological Appraisal to identify the targeted ecology surveys required.
  - Continued aquatic ecology and water quality monitoring.
  - Targeted walkovers of the watercourse crossings the inform the need for and scope for additional mitigation measures.
  - Preparation of a ZTV to identify visual receptors followed by site visits to confirm the ZTV and identify viewpoints and locations for visually verified views.
  - Initial arboricultural survey to inform ahead of a full BS5837:2012 survey.
  - Historic environment walkovers and engagement with local archaeological advisors to determine the programme of geophysical and intrusive survey required.
  - Transport Assessment Scoping to identify the traffic surveys and assessment required.
- Undertake optioneering on delivering BNG, including identifying specific locations for opportunities and investigating the merits of the timing of interventions, and developing partnerships to help deliver some of the benefits and enhancements from changes to land use and provision of BNG.

Appendix A Maps



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Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
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P01	S2	FOR INFORMATION	KL	CLB	CLB	27/05/22

Thames Water | Affinity Water

Location Code: N/A
OS Reference:
Security Reference: STD
Project Group: N/A
Sub Process: N/A
Location/Town: N/A
Site Name: Lower Thames Reservoir
Project Name: T2AT SRO Gate 2 Environmental Assessments
Drawing Title:

Figure 2.1:
Lower Thames Reservoir Option – key components

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Revision: P03

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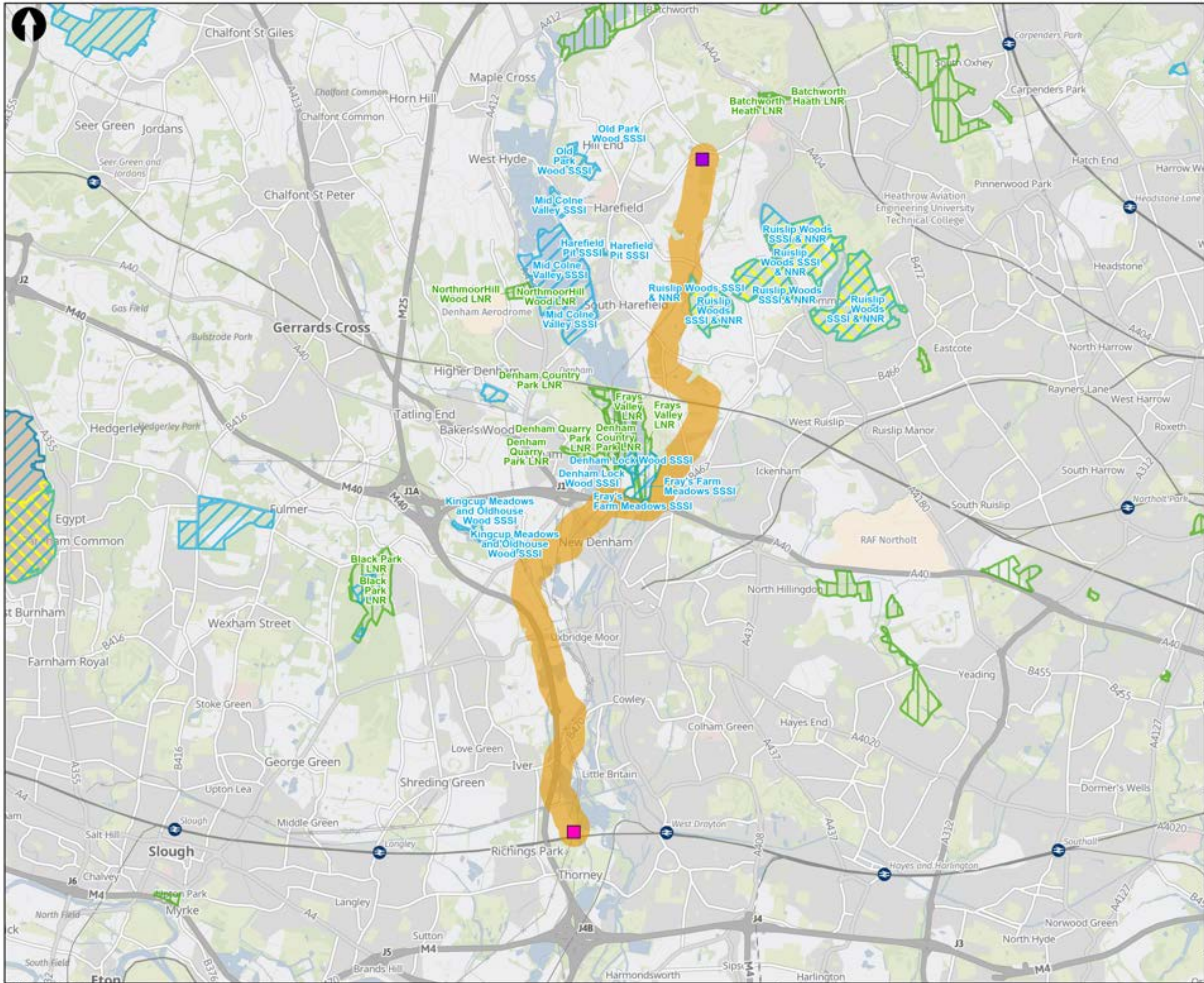

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Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network
- Special Area of Conservation (SAC)
- Special Protection Area (SPA)
- Site of Special Scientific Interest (SSSI)
- Ramsar
- National Nature Reserve (NNR)
- Local Nature Reserve (LNR)

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
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P01	S2	FOR INFORMATION	KL	JR	CLB	27/05/22

Thames Water · Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	

Location/Town: N/A

Site Name: Lower Thames Reservoir

Project Name: T2AT SRO Gate 2 Environmental Assessments

Drawing Title:
Figure 4.1: Statutory designated nature conservation sites

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Drawing Number:	Revision:
100383187-023-MMD-00-XX-GIS-Y-0034	P03

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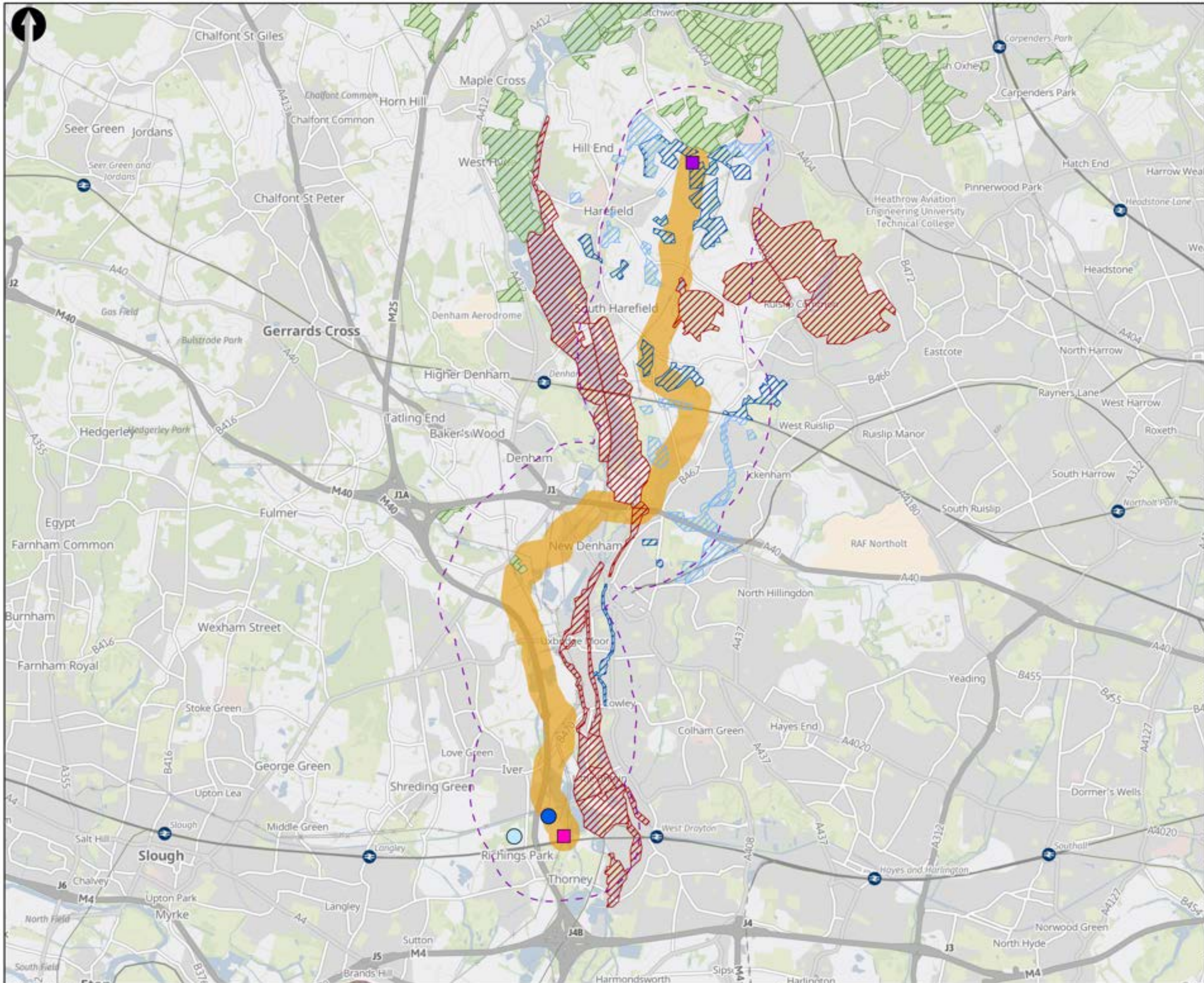

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Local wildlife site: Buckinghamshire CC, Hertfordshire CC, Three Rivers DC.
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Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Transfer Main Route Corridor (1km buffer)
- Indicative Water Treatment Works (WTW) Site
- Indicative Site for Temporary Construction Compound for WTW
- Connection into Affinity Water distribution network
- Connection into raw water network
- Local Wildlife Site

Sites of Importance for Nature Conservation (SINC)
- Metropolitan Importance
- Borough Importance Grade 1
- Borough Importance Grade 2
- Important Bird Area

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
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Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	

Location/Town: N/A

Site Name: Lower Thames Reservoir

Project Name: T2AT SRO Gate 2 Environmental Assessments

Drawing Title:

Figure 4.2: Non-statutory designated nature conservation sites

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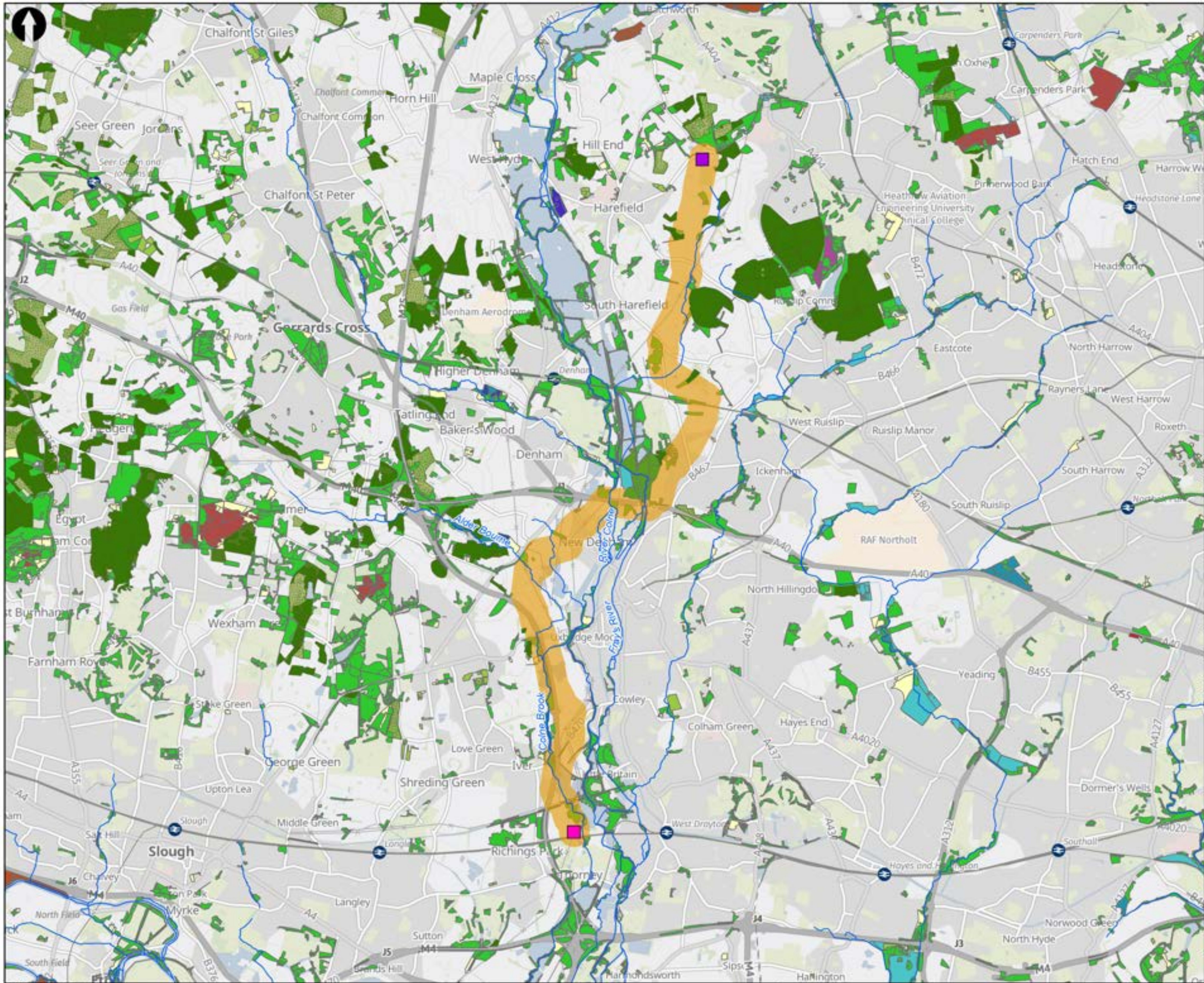

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Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network
- Main River

Ancient woodland
- Ancient & Semi-Natural Woodland
- Ancient Replanted Woodland

Priority Habitat Inventory
- Coastal and floodplain grazing marsh
- Deciduous woodland
- Good quality semi-improved grassland
- Lowland calcareous grassland
- Lowland dry acid grassland
- Lowland fens
- Lowland heathland
- Lowland meadows
- No main habitat but additional habitats present
- Purple moor grass and rush pastures
- Reedbeds
- Traditional orchard

Location Map

St Albans
London

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Project Group: N/A
Sub Process: N/A
Location/Town: N/A
Site Name: Lower Thames Reservoir
Project Name: T2AT SRO Gate 2 Environmental Assessments
Drawing Title:

Figure 4.3:
Ancient woodland and priority habitats

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Revision: P03

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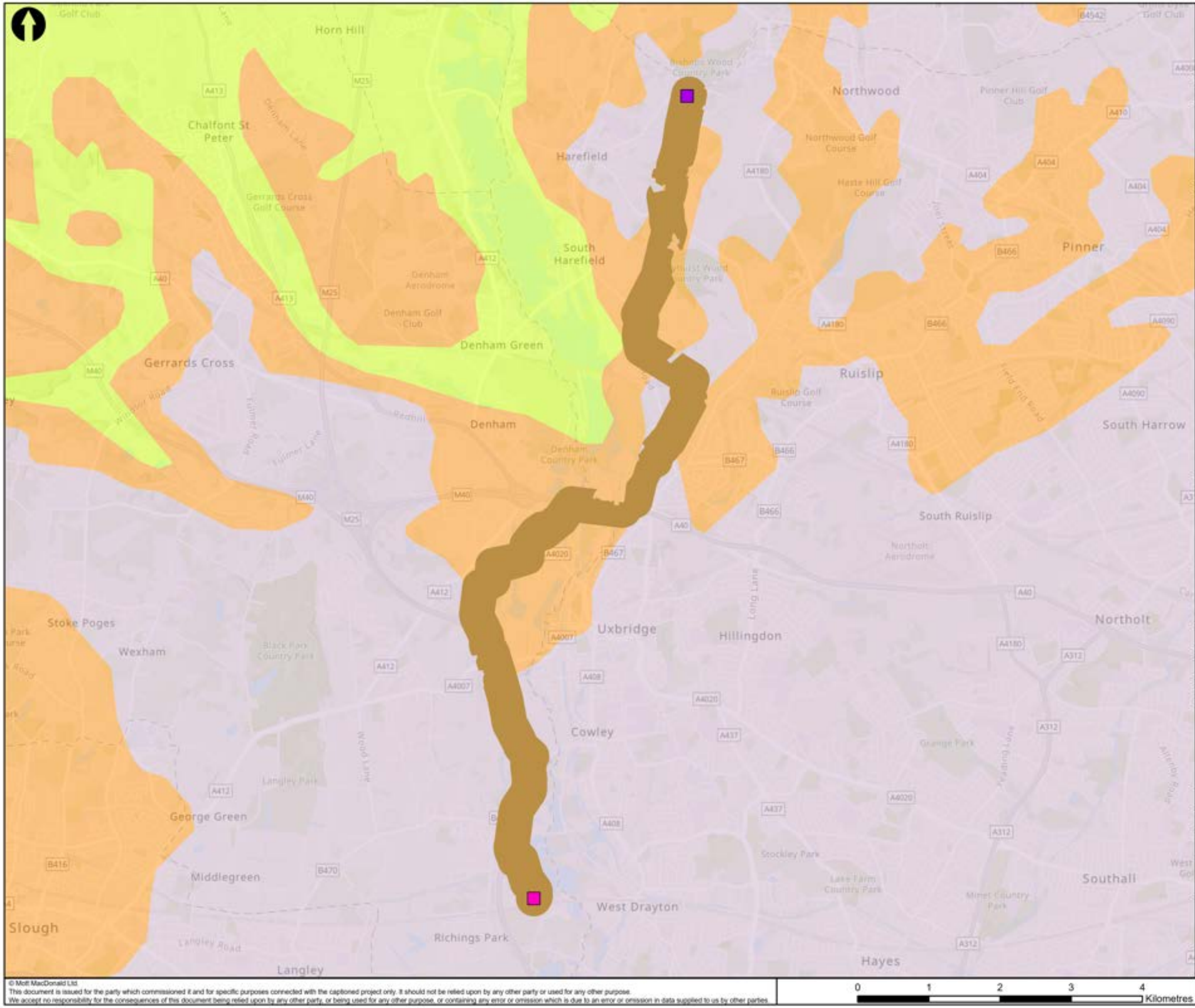

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Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network

Bedrock geology
- Lambeth group - clay, silt, sand and gravel
- Thames group - clay, silt, sand and gravel
- White chalk subgroup - chalk

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
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Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Lower Thames Reservoir		
Project Name: T2AT SRO Gate 2 Environmental Assessments		

Drawing Title:
Figure 5.1:
Bedrock geology

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Drawing Number:	Revision:
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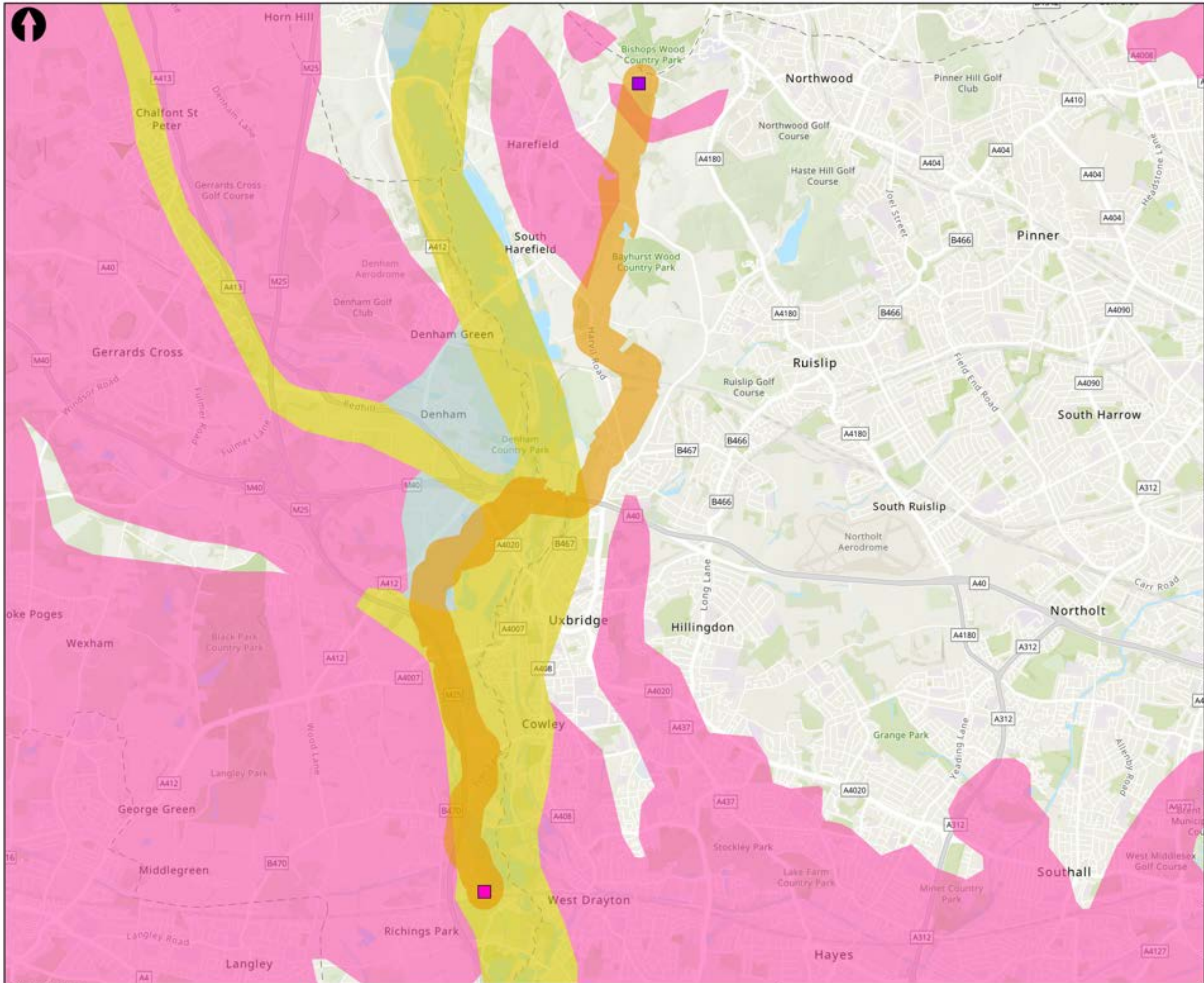

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Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network

Superficial Geology
- Clay, silt and sand
- Diamicton
- Sand and gravel

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
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P01	S2	FOR INFORMATION	CD	CLB	CLB	01/09/22

Thames Water Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	

Location/Town: N/A

Site Name: Lower Thames Reservoir

Project Name: T2AT SRO Gate 2 Environmental Assessments

Drawing Title:

Figure 5.2: Superficial geology

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Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0070

Revision: P03

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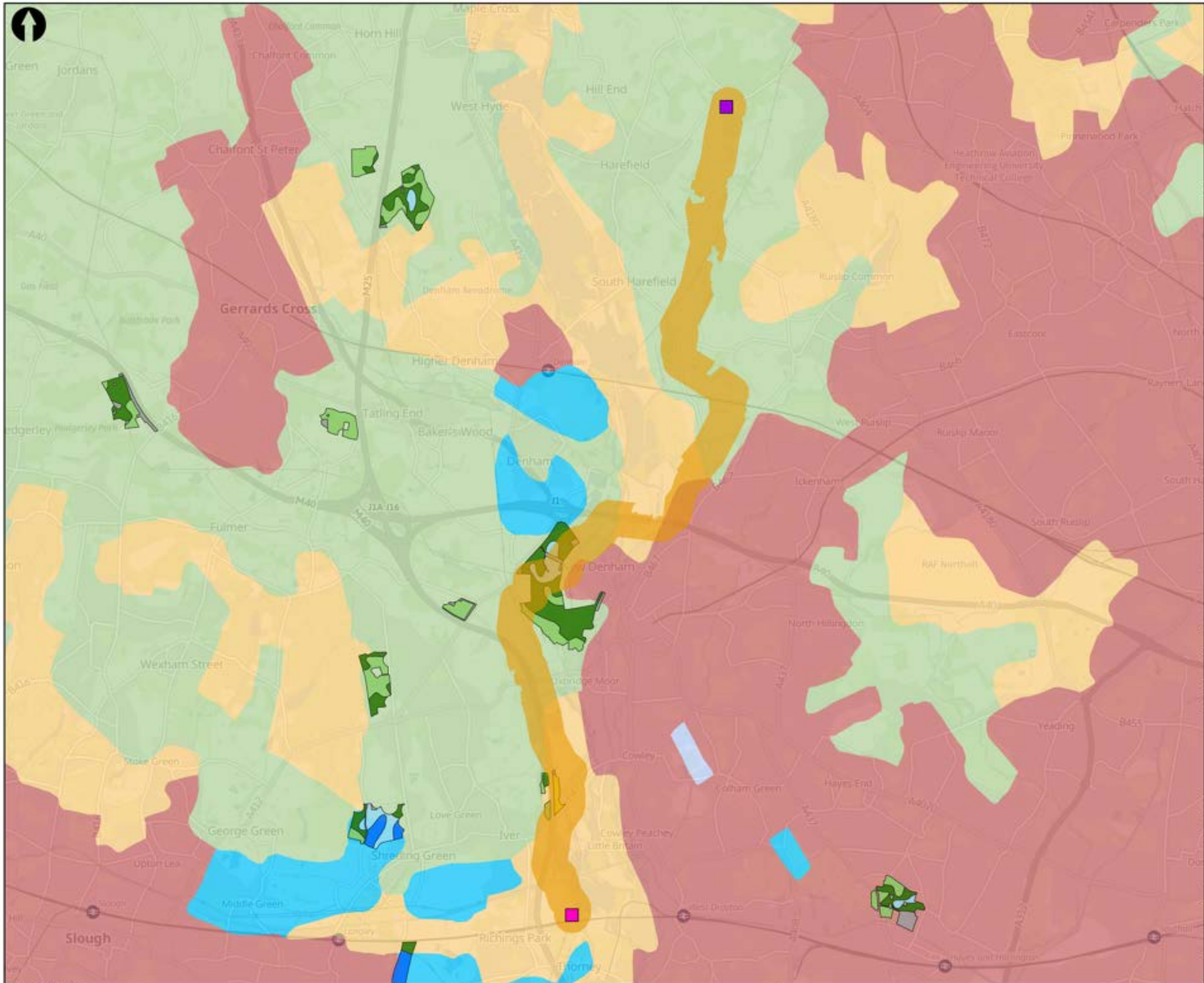

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Current Revision Information

Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network

Post 1988 Agricultural Land Classification
- Grade 1
- Grade 2
- Grade 3a
- Grade 3b
- Grade 4
- Other

Provisional Agricultural Land Classification
- Grade 1
- Grade 2
- Grade 3
- Non Agricultural
- Urban

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	JK	VS	CLB	19/05/22

Thames Water
Affinity Water

Location Code: N/A
OS Reference:
Security Reference: STD
Project Group: N/A
Sub Process: N/A
Location/Town: N/A
Site Name: Lower Thames Reservoir
Project Name: T2AT SRO Gate 2 Environmental Assessments
Drawing Title:

Figure 5.3:
Agricultural land classification

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Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0038
Revision: P03

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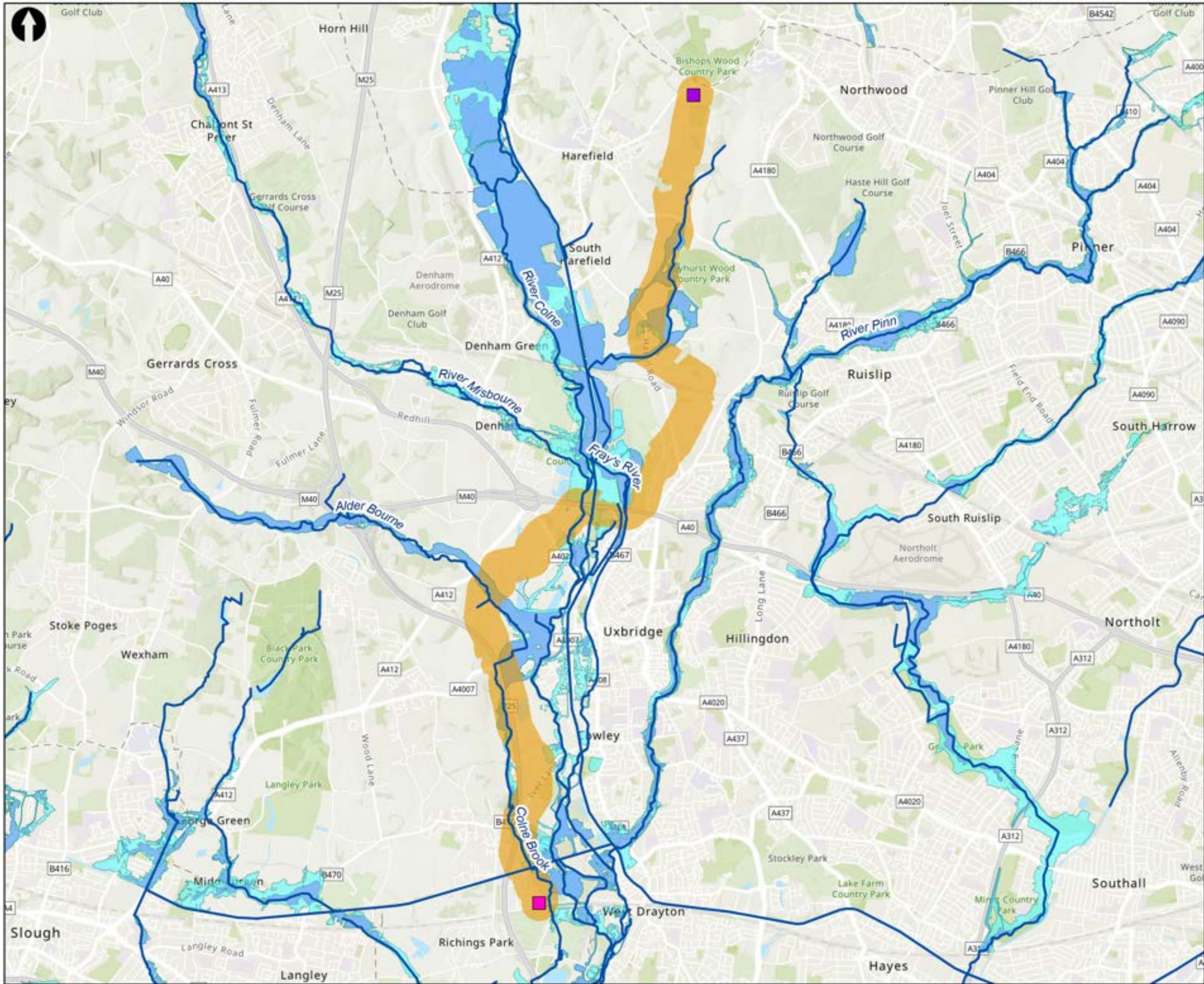

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Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- River
- Connection into Affinity Water distribution network
- Connection into raw water network
- Flood Zone 2
- Flood Zone 3

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
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P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	CD	CLB	CLB	01/09/22

Thames Water | Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	

Location/Town: N/A

Site Name: Lower Thames Reservoir

Project Name: T2AT SRO Gate 2 Environmental Assessments

Drawing Title:
Figure 6.1: Flood risk zones and main river network interactions

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Drawing Number:	Revision:
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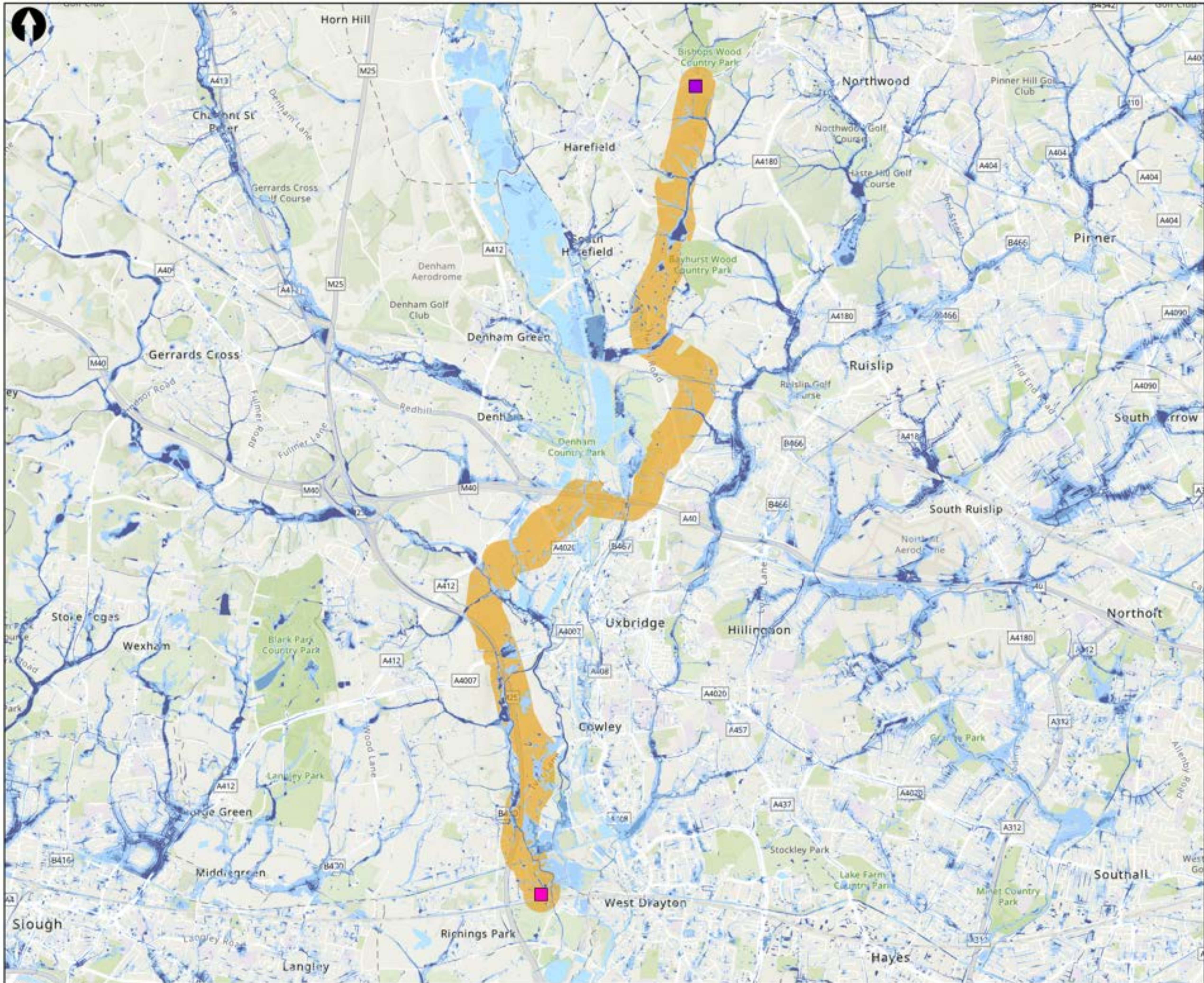

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Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network
- Risk of flooding 3.3% annual chance
- Risk of flooding 1% annual chance
- Risk of flooding 0.1% annual chance

Location Map

St Albans
London

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
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P01	S2	FOR INFORMATION	CD	CLB	CLB	01/09/22

Thames Water | Affinity Water

Location Code: N/A
OS Reference:
Security Reference: STD
Project Group: N/A
Sub Process: N/A
Location/Town: N/A
Site Name: Lower Thames Reservoir
Project Name: T2AT SRO Gate 2 Environmental Assessments

Drawing Title:
Figure 6.2:
Surface water flood extents

Scale: 1:50,000
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Status: S2
Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0074
Revision: P03

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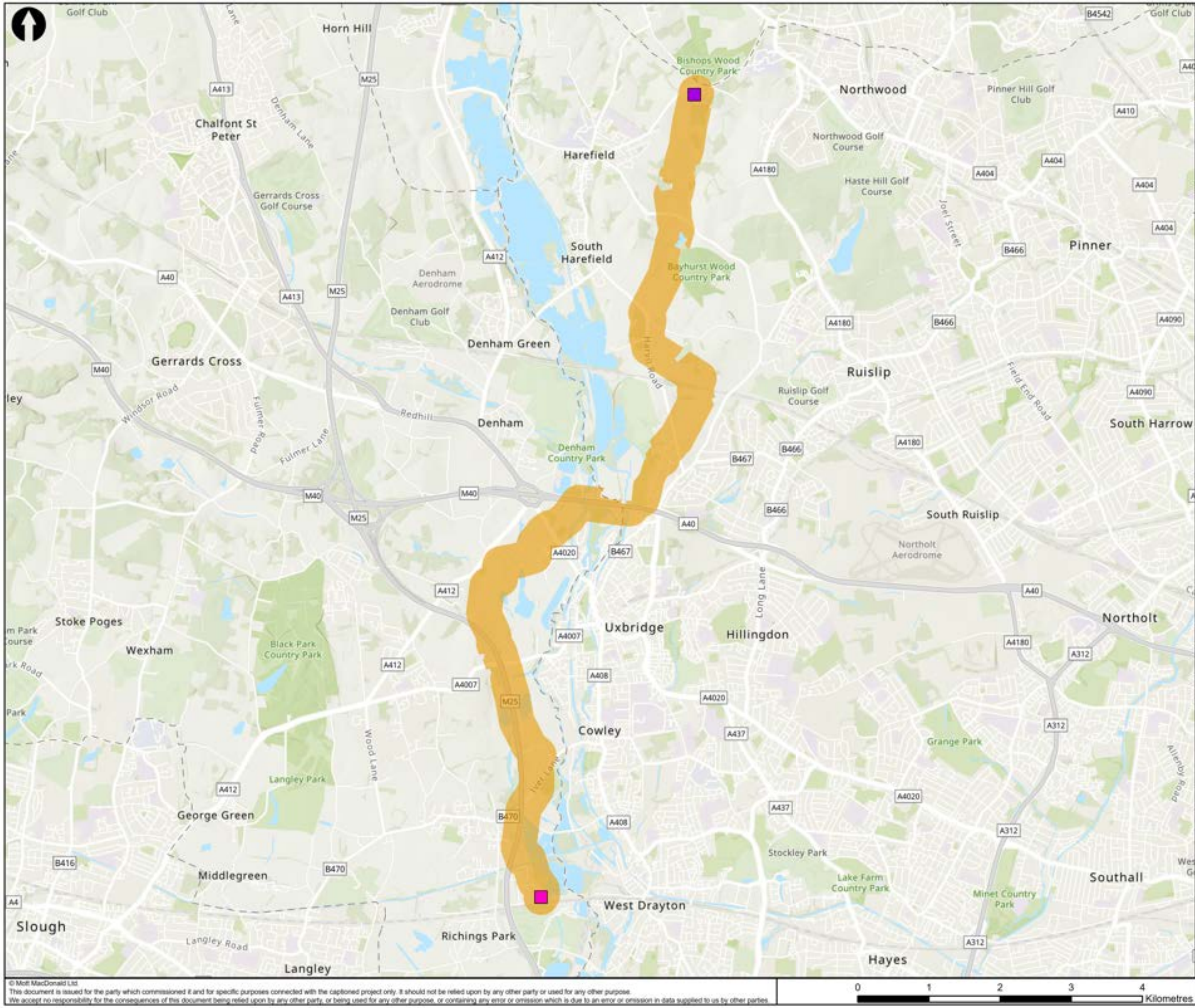

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Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network
- Reservoir flood extent

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	CD	CLB	CLB	01/09/22

Thames Water | Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Lower Thames Reservoir		
Project Name: T2AT SRO Gate 2 Environmental Assessments		

Drawing Title:

Figure 6.3:
Risk of flooding from reservoirs

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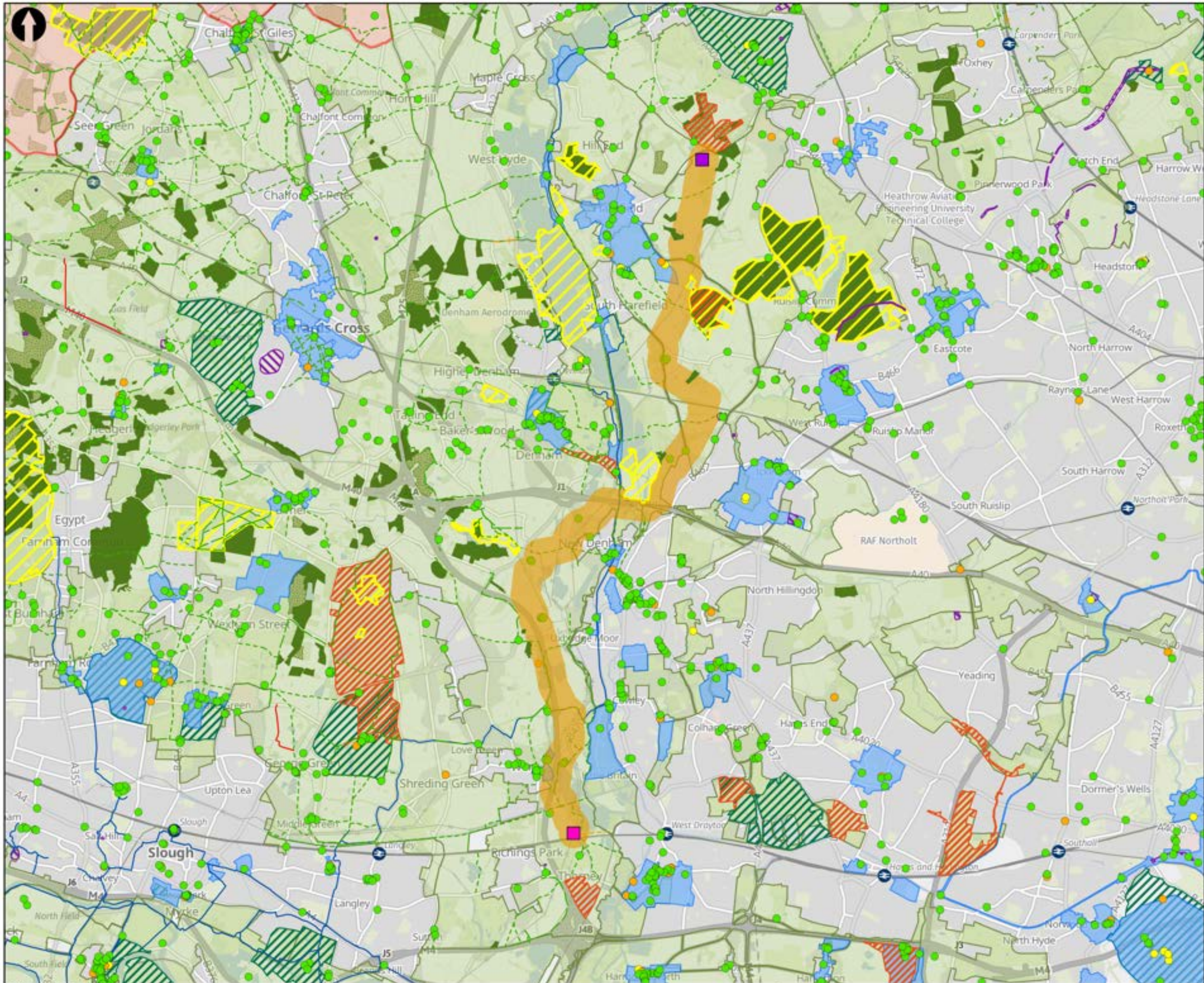

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Ancient woodland, AONB, country parks, SSSI: © Natural England copyright.
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Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network

- Byway Open to All Traffic
- Bridleway
- Footpath
- Permissive Route
- Restricted Byway
- Temporary Diversion
- National Cycle Network
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Site of Special Scientific Interest (SSSI)
- Scheduled monument
- Registered park or garden
- Country park
- Conservation area
- Area of Outstanding Natural Beauty
- Ancient & Semi-Natural Woodland
- Ancient Replanted Woodland
- Green belt

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
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P01	S2	FOR INFORMATION	KL	GL	CLB	25/05/22

Thames Water

Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Lower Thames Reservoir		
Project Name: T2AT SRO Gate 2 Environmental Assessments		

Drawing Title:

Figure 9.1:
Landscape assets and designations

Scale:	Sheet Size:	Status:
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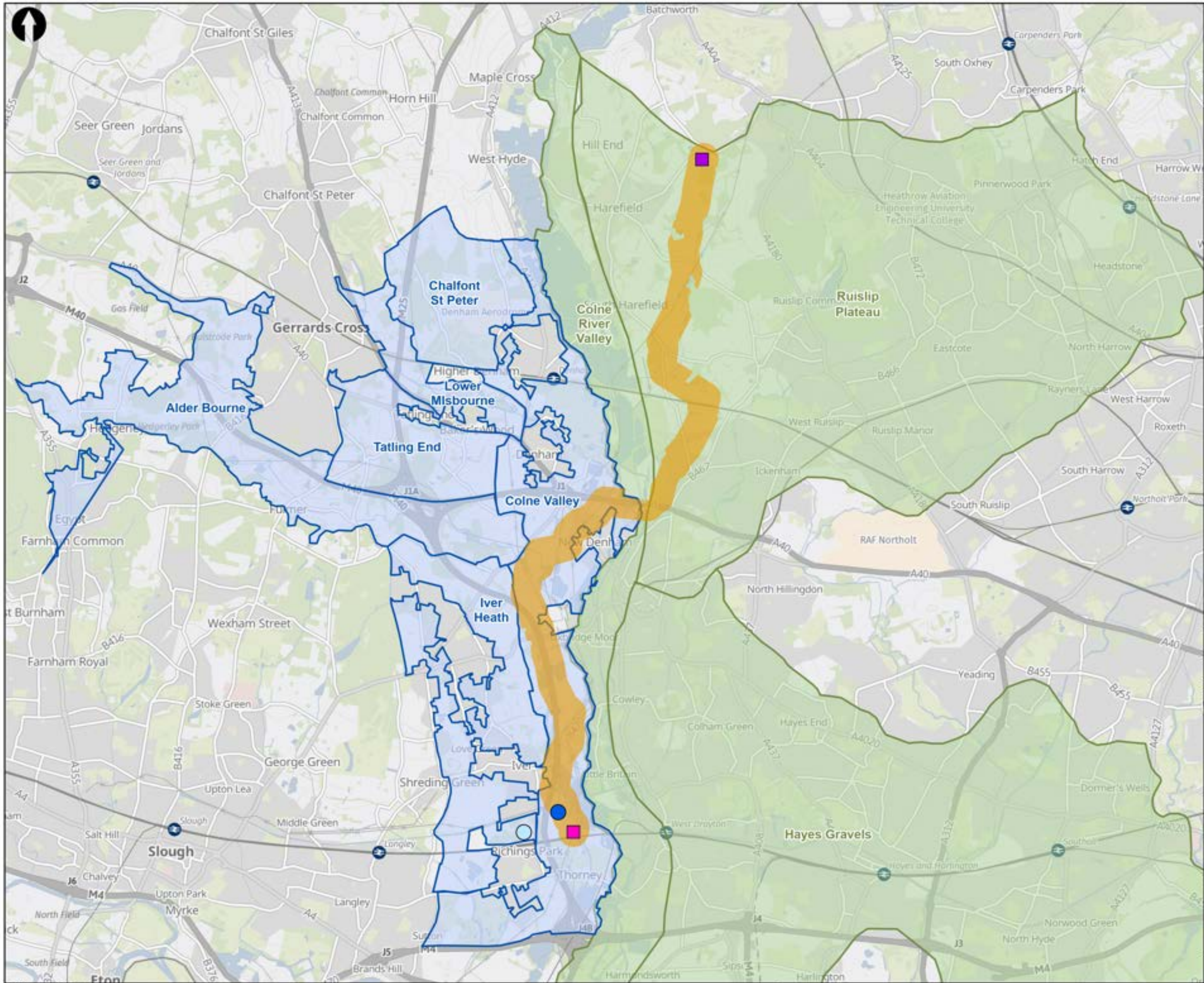
0 1 2 3 4 Kilometres



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Legend

Lower Thames Reservoir Option components
- Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network
- London Landscape Natural Signatures Landscape Character Assessment
- South Buckinghamshire Landscape Character Assessment

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	KL	GL	CLB	25/05/22

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	

Location/Town: N/A

Site Name: Lower Thames Reservoir

Project Name: T2AT SRO Gate 2 Environmental Assessments

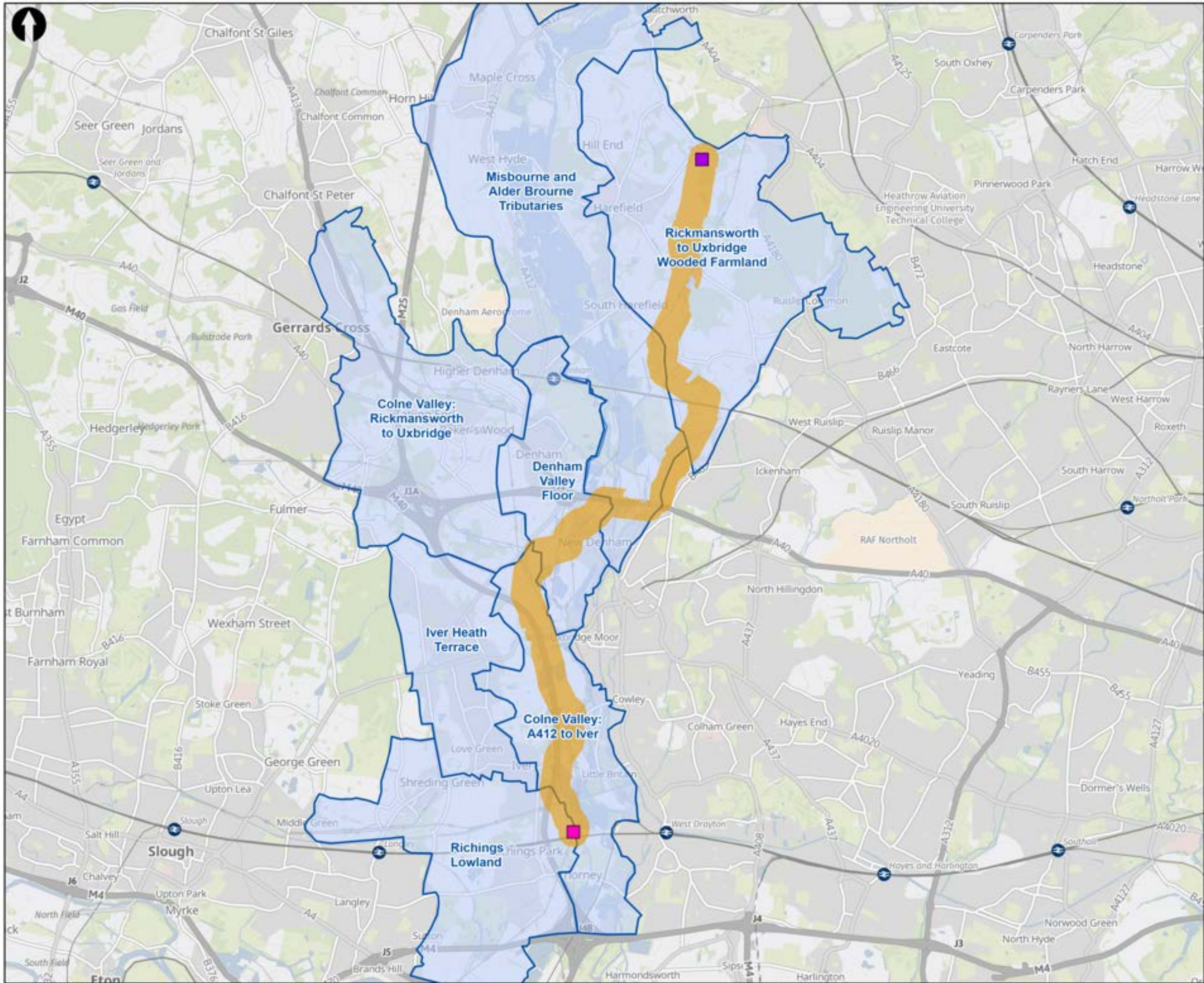
Drawing Title:
Figure 9.2: South Buckinghamshire and London Natural Signatures Landscape Character Areas

Scale:	Sheet Size:	Status:
1:60,000	A3	S2

0 1 2 3 4 Kilometres

Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0047

Revision: P03



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Legend

Lower Thames Reservoir Option components
- Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network
- Colne Valley Landscape Character Assessment

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	KL	GL	CLB	25/05/22

Thames Water
Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	

Location/Town: N/A

Site Name: Lower Thames Reservoir

Project Name: T2AT SRO Gate 2 Environmental Assessments

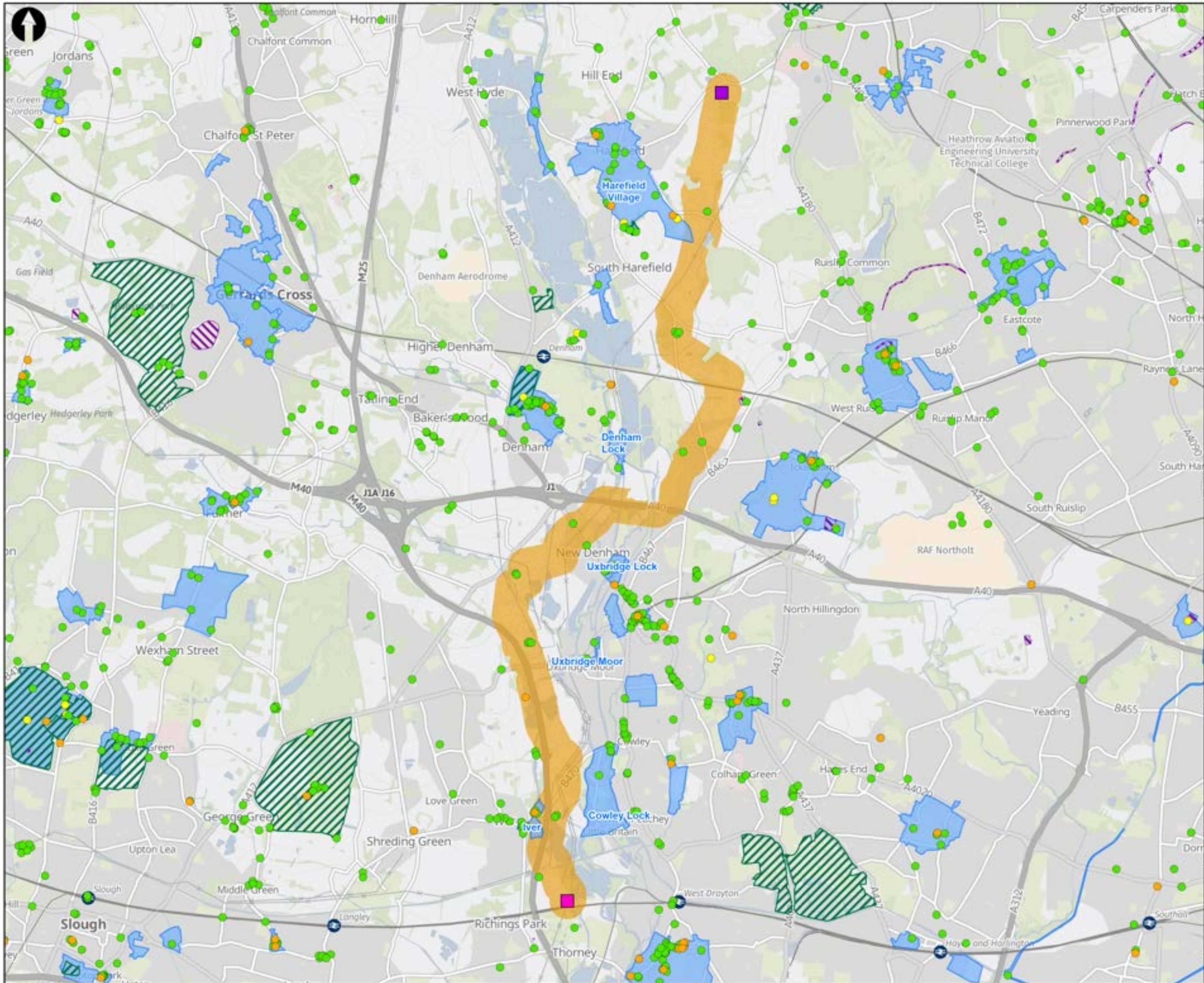
Drawing Title:
Figure 9.3: Colne Valley Landscape Character Assessment

Scale:	Sheet Size:	Status:
1:60,000	A3	S2

Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0049

Revision: P03

0 1 2 3 4 Kilometres



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Current Revision Information

Legend

Lower Thames Reservoir Option components
- Indicative Transfer Main Route Corridor
- Connection into Affinity Water distribution network
- Connection into raw water network
- Grade I Listed Building
- Grade II Listed Building
- Grade II* Listed Building
- Scheduled monument
- Registered park or garden
- Conservation area

Location Map

St Albans
London

P03	S2	FOR INFORMATION	CD	CLB	CLB	18/10/22
P02	S2	FOR INFORMATION	CD	CLB	CLB	21/09/22
P01	S2	FOR INFORMATION	KL	ED	CLB	25/05/22
Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date

Thames Water
Affinity Water

Location Code: N/A	OS Reference:	Security Reference: STD
Project Group: N/A	Sub Process: N/A	
Location/Town: N/A		
Site Name: Lower Thames Reservoir		
Project Name: T2AT SRO Gate 2 Environmental Assessments		

Drawing Title:
Figure 10.1:
Designated heritage assets

Scale: 1:50,000	Sheet Size: A3	Status: S2
Drawing Number: 100383187-023-MMD-00-XX-GIS-Y-0061		Revision: P03

0 1 2 3 4 Kilometres

Appendix B Climate change risk assessment

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
Higher summer temperatures	Underground pipelines / pipe connection	Higher temperatures can lead to expansion and damage to pipes. However, the pipes are buried with suitable cover and are unlikely to be impacted by increase in temperatures.	1	2	2	Low	Structural elements would be designed to include thermal expansion and greater thermal variation specification to account for climate change.	1	1	1	Low
Higher summer temperatures	Overground pipelines/ overground cabling	Pipe and cabling material would be exposed to increased solar radiation (UV) and may deteriorate at a faster rate. Higher temperatures may also cause increased expansion and damage to overground pipes.	2	3	6	Moderate to low	Pipe design and choice of materials to consider higher summer temperatures and greater annual temperature variation. Exposed elements such as air valves and electrical equipment would sit in protective chambers	1	2	2	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
							which may provide some protection from solar gain and higher temperatures.				
Higher summer temperatures	Pipejack/ micro tunnels crossing for railway, roads and rivers	Cracking, strength loss and more rapid deterioration of concrete due to high temperatures.	2	4	8	Moderate to high	Materials selection and specification to consider future temperatures. Monitor and adjust the curing process of the concrete accordingly in order to minimise the risk of high temperatures on the deterioration rate of the structure.	1	3	3	Low
Higher summer temperatures	New WTW New raw water pumping station	Chemical and mechanical processes/equipment (chlorine disinfection, pumps, valves) exceed their operational temperature limit (chlorine works less	2	3	6	Moderate to low	Include greater thermal variation in design and specification of equipment to account for the extremes in temperature.	1	3	3	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
		effectively at high temperatures, generator engine~35°C) and do not operate as efficiently/shut down.					Consider nature-based solutions to provide shade and reduce temperature.				
Extreme low temperature events	Underground pipelines/connection pipes	There is a decreased frequency of extreme ground frost, however cold events would still occur and could lead to cracking and fracturing of pipes. The pipes are buried with suitable cover so there is little impact expected.	1	2	2	Low	None required.	1	2	2	Low
Extreme low temperature events	Overground pipelines/overground cabling	There is a decreased frequency of extreme ground frost, however cold events would still occur. Pipe	2	3	6	Moderate to low	Pipe design and choice of materials to consider greater annual temperature variation.	2	2	4	Moderate to low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
		and cabling material would be exposed to air frost and extreme cold temperatures / ice leading to deterioration of materials and cracking of pipes.					Exposed elements such as air valves and electrical equipment would sit in protective chambers which may provide some protection from colder temperatures.				
Higher annual and winter rainfall and more extreme rainfall events throughout the year	Underground Pipelines/connection pipes	The pipeline passes through areas of existing Flood Zone 2 and 3: in the west of Uxbridge Moor (M25), Alder Bourne crossing, North of New Denham (A40), Harvil Road, and west of Bayhurst Wood Country Park. Flood risk in these areas is likely to be exacerbated with higher winter rainfall and more extreme rainfall events throughout the year and may cause issues with access	3	4	12	High	Locate pipeline maintenance access points in areas where there is low risk of flooding to ensure that they are accessible at all times. Ensure pipe design and cover is enough to withstand seepage from flooding into the pipes.	2	3	6	Moderate to low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
		to the pipes and may cause flood water to seep into pipe and contaminate supply, however low risk as it is a buried pipe..									
Higher annual and winter rainfall and more extreme rainfall events throughout the year	Underground pipelines/connection pipes	High rainfall levels can cause swelling of the ground surrounding the pipe and lead to instability. Groundwater levels may increase following wet winters and extreme events.	2	3	6	Moderate to low	Ensure that ground movements are monitored, and repairs made when necessary to avoid further damage. Consider the changes in soil moisture in the pipe bedding material specification.	2	2	4	Moderate to low
Higher annual and winter rainfall and more extreme rainfall events	Overground pipelines/overground cabling	Risk of corrosion of pipe and cable materials.	2	3	6	Moderate to low	Additional protective measures (such as insulating the cables with cathodic protective material) would be implemented to ensure	1	2	2	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
throughout the year							that the pipes and cabling are sufficiently protected to reduce the corrosion rates. Selection of materials to consider future rainfall regime.				
Higher annual and winter rainfall and more extreme rainfall events throughout the year	Pipejack/ micro tunnels crossing for railway and roads	Insufficient drainage on the railway and road leading to flooding around base of structure which could cause instability. Extra loading on the structure due to rainfall and winds which can cause collapse.	2	4	8	Moderate to high	Ensure that drainage capacity is designed to limit the flooding at the structure and account for future increased rainfall. Ensure that the foundations are not susceptible to seepage due to poor drainage.	2	2	4	Mode rate to low
Higher annual and winter rainfall and more extreme	Pipejack/ micro tunnels	Flooding events raising the river levels and damaging the pipe jack/micro tunnel if	3	4	12	High	Ensure that designs take into consideration the raised river levels during floods over the lifetime of	2	3	6	Mode rate to low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
rainfall events throughout the year	crossing for rivers	there is not enough clearance.					the pipe (i.e. including climate change).				
Higher annual and winter rainfall and more extreme rainfall events throughout the year	New WTW New raw water pumping station	The assets are not located in a flood zone so there is low risk that there would be flooding in the future. However, the level of flood risk should be kept under review over the lifetime of the assets and as climate changes.					None required				
Drier summers	Underground pipelines/connection pipes Overground pipelines/overground cabling	The soil type that the pipeline route would be built on is primarily clay, silt & sand, and sands & gravels, so drought would have an impact on the stability of this. There is a risk of ground cracking/shrinkage due to	3	3	9	Moderate to high	Ensure that ground movements are monitored, and repairs made when necessary to avoid further damage. Consider future ground conditions when choosing	2	3	6	Moderate to low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
		drought which can cause instability issues and weakness.					and specifying pipe materials.				
Drier summers	Pipejack/micro tunnels crossing for railway, roads and rivers	Shrinkage and desiccation of ground leading to cracks, strength loss and instability. Foundations may be affected.	2	3	6	Moderate to low	Consider future ground conditions, temperature, and rainfall regime when designing foundations and specifying foundation depth. Ensure that ground movements are monitored, and repairs made when necessary to avoid further damage.	1	3	3	Low
Drier summers	New WTW	The WTW would use potable water for processes and site operations may be disrupted if there is a drought. The site would not be affected by Temporary Use Bans (TUBs)	1	3	3	Low	None required.	1	3	3	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
		or Non-Essential Use Bans (NEUBs), so therefore the likelihood of this is low.									
Drier summers	New WTW	The Indicative WTW Site is on clay, silt & sand, and sand & gravel soils, so therefore susceptible to shrinkage which would lead to cracks and weakness. Foundations may be affected.	2	3	6	Moderate to low	Consider future ground conditions, temperature and rainfall regimes when designing foundations. Ensure that ground movements are monitored, and repairs made when necessary to avoid further damage.	2	2	4	Mode rate to low
Drier summers	New raw water pumping station	Site uses potable water on site for processes and site operations may be disrupted if there is a drought. The site would not be affected by Temporary Use Bans (TUBs) or Non-Essential Use Bans	1	3	3	Low	None required.	1	3	3	Low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
		(NEUBs), so therefore the likelihood of this is low.									
Drier summers	New raw water pumping station	Parts of the site are located on clay, silt & sand, and sand & gravel soils, so therefore susceptible to shrinkage which would lead to cracks and weakness. Foundations may be affected.	2	3	6	Moderate to low	Consider future ground conditions, temperature and rainfall regimes when designing foundations. Ensure that ground movements are monitored and repaired when necessary to avoid further damage.	2	2	4	Moderate to low
Increase in storm intensity	New raw water pumping station New WTW	Structural damage resulting from storminess and high winds, including a series of storms occurring in quick succession.	2	3	6	Moderate to low	Ensure that associated buildings are designed as a minimum to withstand wind loadings calculated in accordance with building codes that account for the change in	2	2	4	Moderate to low

Potential changing climate variable	Asset	A - Impact	B - Likelihood	C - Severity	D - Risk (BxC)	Risk category	E - Mitigation	F - Likelihood (after mitigation)	G - Severity (after mitigation)	H - Residual risk (FxG)	Risk Category
							climate and increases in wind gusts. Locate critical infrastructure and staff welfare facilities in areas of the site least likely to suffer storm damage, or provide additional resilience / strengthening measures for situations where a series of storms affects the site				
Increase in storm intensity	New raw water pumping station New WTW	Disruption to utilities, i.e. electricity supply and communications due to increase in lightning strikes, local power outages and storm disruption	2	3	6	Moderate to low	Install back-up generators for any safety critical systems, and ability of the stations to work offline for several days while power supplies are restored.	2	2	4	Mode rate to low

Appendix C Invasive non-native species records and surveys

C.1 Environment Agency and NBN Atlas records

The Environment Agency and National Biodiversity Network (NBN) Atlas INNS records for the study area are summarised in Table C.1 (fish), Table C.2 (macroinvertebrates) and Table C.3 (plants).

Table C.1: Non-native fish species identified in Environment Agency and NBN Atlas records within 1km of the Lower Thames Reservoir Option transfer routes

Common name	Scientific name	Functional group	Legislative status	Environment Agency records	NBN Atlas records
Common carp	*Cyprinus carpio*	Mobile, juvenile >1mm, eggs	UKTAG-High[129]	✓	✓
Grass carp	*Ctenopharyngodon idella*	Mobile, juvenile >1mm, eggs	UKTAG-Low		✓
Rainbow trout	*Oncorhynchus mykiss*	Mobile, juvenile >1mm, eggs	UKTAG-Low		✓
Wels catfish	*Silurus glanis*	Mobile, juvenile >1mm, eggs	UKTAG-Low		✓

Table C.2: Non-native invertebrate species identified in Environment Agency and NBN Atlas records within 1km of the Lower Thames Reservoir Option transfer routes

Common name	Scientific name	Functional group	Legislative status	Environment Agency records	NBN Atlas records
Bladder snail	*Physella acuta*	Mobile, juvenile <1mm, no eggs	UKTAG-Unknown	✓	✓
Caspian mud-shrimp	*Chelicorophium curvispinum*	Mobile, juvenile >1mm, no eggs	UKTAG-Unknown	✓	

[129] WFD-UKTAG listed INNS, categorised as High / Medium / Low / Unknown Impact

Common name	Scientific name	Functional group	Legislative status	Environment Agency records	NBN Atlas records
Demon shrimp	*Dikerogammarus haemobaphes*	Mobile, juvenile >1mm, no eggs	UKTAG-High	✓	✓
Florida crangonyctid	*Crangonyx floridanus*	Mobile, juvenile >1mm, no eggs	UKTAG-Unknown	✓	
Freshwater bivalve	*Dreissenidae sp.*	Sessile, juvenile <1mm, eggs	UKTAG-Unknown	✓	
Gastropod sp.	*Physella sp.*	Mobile, juvenile >1mm, no eggs	UKTAG-Unknown	✓	
New Zealand mud snail	*Potamopyrgus antipodarum*	Mobile, juvenile <1mm, no eggs	UKTAG-Moderate	✓	✓
Northern river crangonyctid	*Crangonyx pseudogracilis*	Mobile, juvenile >1mm, no eggs	UKTAG-Unknown	✓	
Northern river/Florida crangonyctid	*Crangonyx pseudogracilis/ floridanus*	Mobile, juvenile >1mm, no eggs	UKTAG-Unknown	✓	
Quagga mussel	*Driessena bugenis*	Sessile, juvenile <1mm, eggs	UKTAG-High	✓	✓
Side swimmer	*Gammarus tigrinus*	Mobile, juvenile >1mm, no eggs	UKTAG-Unknown	✓	

Common name	Scientific name	Functional group	Legislative status	Environment Agency records	NBN Atlas records
Signal crayfish	*Pacifastacus leniusculus*	Mobile, juvenile >1mm, no eggs	UKTAG-High WACA 1981 Sch. 9[130] EU species of special concern[131] IAS Order 2019 Sch. 2[132]	✓	✓
Turkish crayfish	*Astacus leptodactylus*	Mobile, juvenile >1mm, no eggs	UKTAG-Low		✓
Wautier's limpet	*Ferrissia (Petancylus)*	Sessile, juvenile <1mm, eggs	UKTAG-Unknown		✓
Zebra mussel	*Dreissena polymorpha*	Sessile, juvenile <1mm, eggs	UKTAG-High	✓	✓

Table C.3: Non-native macrophyte species identified in Environment Agency and NBN Atlas records within 1km of the Lower Thames Reservoir Option transfer routes

Common name	Scientific name	Functional group	Legislative status	Environment Agency records	NBN Atlas records
Broadleaf arrowhead	*Sagittaria latifolia*	Vegetative, aquatic, perennial	UKTAG-Unknown	✓	

[130] Listed on Schedule 9 of the Wildlife & Countryside Act 1981
[131] Invasive Non-Native Species (Amendment etc.) (EU Exit) Regulations 2019 – listed as an 'invasive alien species of union concern'
[132] Listed on Schedule 2 of the Invasive Alien Species (Enforcement and Permitting) Order 2019

Common name	Scientific name	Functional group	Legislative status	Environment Agency records	NBN Atlas records
Canadian waterweed	*Elodea canadensis*	Vegetative, aquatic, perennial	UKTAG-High WACA 1981 Sch. 9	✓	✓
Floating pennywort	*Hydrocotyle ranunculoides*	Seed + vegetative, aquatic, perennial	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	✓	✓
Giant hogweed	*Heracleum mantegazzianum*	Seed, riparian, perennial	UKTAG-High WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	✓	✓
Himalayan balsam	*Impatiens glandulifera*	Seed, riparian, annual	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	✓	✓
Japanese knotweed	*Fallopia japonica*	Vegetative, riparian, perennial	UKTAG-High WACA 1981 Sch. 9		✓
Least duckweed	*Lemna minuta*	Vegetative, aquatic, perennial	UKTAG-Unknown	✓	✓

Common name	Scientific name	Functional group	Legislative status	Environment Agency records	NBN Atlas records
Monkey flower	*Mimulus sp.*	Vegetative, riparian, perennial	UKTAG-Moderate	✓	
Montibretia	*Crocosmia pottsii x aurea = C. x crocosmiiflora*	Vegetative, riparian, perennial	UKTAG-Low		✓
Nuttall's waterweed	*Elodea nuttallii*	Vegetative, aquatic, perennial	UKTAG-High EU species of special concern WACA 1981 Sch. 9 IAS Order 2019 Sch. 2	✓	✓
Orange balsam	*Impatiens capensis*	Seed, riparian, annual	UKTAG-Low	✓	✓
Parrot's-feather	*Myriophyllum aquaticum*	Vegetative, aquatic, perennial	UKTAG-High		✓
Rhododendron	*Rhododendron ponticum*	Seed, riparian, annual	UKTAG-High		✓
Snowberry	*Symphoricarpos albus*	Vegetative, riparian, perennial	UKTAG-Unknown		✓
Sweet flag	*Acorus calamus*	Seed, riparian, annual	UKTAG-Low	✓	
Water fern	*Azolla filiculoides*	Seed, vegetative, aquatic, perennial	UKTAG-High		✓

C.2 Ricardo PLC field surveys

C.2.1 Macroinvertebrate surveys

Samples were taken at approximately three sub sample locations per site during which a visual search, grapnel throws, and INNS sampling were undertaken. Macroinvertebrate samples were taken using a three-minute kick/sweep and 1 minute manual search across representative habitats. In areas where marginal habitat was poor, a dredge and net sweep was undertaken to collect a mass of material equivalent to that collected by a standard kick sample. In areas where the river channel was wide and deep, an airlift sampler was deployed from a boat to collect samples along a cross section of the river.

C.2.2 Environmental DNA

In addition to the collection of macroinvertebrate samples, eDNA samples were collected at suitable locations to identify the presence of non-native macroinvertebrates and fish. In summary, several sub-samples of water were collected from the identified sample site, combined within a sterile sample bag and then shaken to ensure thorough mixing. Using a syringe, up to 2,000mL of sampled water was filtered through an encapsulated disk filter immediately upon collection until the filter became blocked with sediment and the sampled water was no longer able to pass through. A preservative solution was immediately added to the filter units, and they were then sent for laboratory analysis.

C.2.3 Field survey locations

Field survey locations are presented in Table C.4.

Table C.4: Field survey details

Site ID	Grid reference	Waterbody	Location	Survey date
T2AT-001	SU 78263 85124	River Thames	Medmenham	10/07/2021

Site ID	Grid reference	Waterbody	Location	Survey date
T2AT-002	SU 90407 85496	River Thames	Odney Weir	10/07/2021
T2AT-003	SU 99228 75492	River Thames	Sunnymeads	10/07/2021
T2AT-004	SU 99440 75691	River Thames	Ham Island	10/07/2021
T2AT-005	TQ 01245 72292	River Thames	Bell Weir	10/04/2021
T2AT-006	TQ 07945 66341	River Thames	Desborough Loop, nr. Walton	10/04/2021

C.2.4 INNS field survey results

Results are presented below in Table C.5. All eDNA tests for non-native fish, unionid mussels and signal crayfish were negative for all sites.

Table C.5: INNS field survey results

Species	T2AT-001	T2AT-002	T2AT-003	T2AT-004	T2AT-005	T2AT-006
Oligochaete worm *Branchiura sowerbyi*			✓			
Caspian mud shrimp *Chelicorophium curvispinum*	✓	✓	✓	✓	✓	✓
Asian clam *Corbicula fluminea*			✓			✓
Northern river/Florida crangonyctid *Crangonyx pseudogracilis/ floridanus*			✓			✓
Demon shrimp *Dikerogammarus haemobaphes*	✓	✓	✓	✓		✓

Species	T2AT-001	T2AT-002	T2AT-003	T2AT-004	T2AT-005	T2AT-006
Zebra mussel *Dreissena polymorpha*	✓				✓	
Quagga mussel *Dreissena bugensis*					✓	
Canadian pondweed *Elodea canadensis*				✓		
Nuttall's pondweed *Elodea nuttallii*	✓	✓	✓			✓
Floating pennywort *Hydrocotyle ranunculoides*						✓
Polychaete worm *Hypania invalida*	✓					
Himalayan Balsam *Impatiens glandulifera*						✓
Bladder snail/tadpole physa *Physella acuta/gyrina agg.*	✓	✓	✓	✓		
New Zealand mud snail *Potamopyrgus antipodarum*	✓	✓	✓	✓	✓	✓

Appendix D - Invasive non-native species tool input data

D.1 Tool input data

The information and data entered into the water transfer INNS risk assessment tool for each section of the Lower Thames Reservoir Option transfer routes are detailed in Table D.1.

Table D.1: INNS risk assessment tool water transfer input data

Input variable	Section 1	Section 2	Section 3
Source	Shaft 6 (Queen Mother / Wraysbury Reservoirs)	New raw water pumping station within the site of the existing Iver WTW	New WTW
Source management catchment	Colne / Maidenhead and Sunbury	Colne	Colne
Source operational catchment	Colne / Thames Lower	Colne	Colne
Source type	Offline waterbody	Offline waterbody (pumping station receiving water from tunnel)	WTW
Number of raw water transfers into source	2	None	None
Pathway type	Tunnel	Pipeline	Pipeline
Receptor name	New raw water pumping station within the site of the existing Iver WTW	New WTW	Harefield SR
Receptor management catchment	Colne	Colne	Colne
Receptor orientational catchment	Colne	Colne	Colne

Input variable	Section 1	Section 2	Section 3
Receptor type*	Offline waterbody (pumping station receiving water from tunnel)	WTW	Sealed water tank
Isolated receptor catchment	No	No	No
Volumetric rate of transfer (Ml/d)**	101-150 Ml/d	101-150 Ml/d	101-150 Ml/d
Frequency of transfer	Year round – continuous, variable flow	Year round – continuous, variable flow	Year round – continuous, variable flow
Distance of transfer (km)	5.1-10	<1	10.1-15
Washout/maintenance points along route***	Unknown	Unknown	Unknown
Source navigable	0 (Never)	0 (Never)	0 (Never)
Pathway navigable	0 (Never)	0 (Never)	0 (Never)
Angling at source	0 (Never)	0 (Never)	0 (Never)
Angling on pathway	0 (Never)	0 (Never)	0 (Never)
Water sports at source	0 (Never)	0 (Never)	0 (Never)
Water sports along pathway	0 (Never)	0 (Never)	0 (Never)
High impact INNS at source	Known to be present	Known to be present	Known to be present
High impact INNS within 1km of pathway	Known to be present	Known to be present	Known to be present
Highest order site designation within 1km of receptor	National	Local	National
Presence of priority habitats within 1km of pathway	Known to be present	Known to be present	Known to be present

Input variable	Section 1	Section 2	Section 3
Presence of priority habitats within 1km of receptor	Known to be present	Known to be present	Known to be present
Other existing connections present between source and receptor	None	None	None

* Pumping station is not included in the tool as a source/receptor option for water transfers. Of the options available, offline waterbody was considered the best descriptor for a pumping station that receives raw water from offline reservoirs via a tunnel.

** Additional volume of water transferred.

*** Number of washout/maintenance points could not be confirmed at this stage of design. To be accounted for at a later stage.

D.2 Tool input data for new assets

The tool separates the INNS risk associated with water transfers from the INNS risk associated with assets. The information and data entered into the asset INNS risk assessment tool for the proposed raw water pumping station and new shaft for the Wraysbury Tunnel Connection, and the new WTW are detailed in Table D.2.

Table D.2: Risk assessment tool new asset input data

Input variable	Raw water pumping station and new shaft	New WTW
Asset type	Pumping station	WTW
Asset location	Existing Iver WTW	North of existing Iver WTW
Asset size (m^2)	TBC	53000
Existing high impact INNS records on site/area of proposed site	Known to be present	Known to be present
Existing priority habitats on site	Known to be present	Known to be present
Frequency of personnel site visits	2 (Daily)	2 (Daily)
Frequency of personnel entering or in contact with raw water*	0 (Never)	0 (Never)
Frequency of road vehicles on site	2 (Daily)	2 (Daily)
Frequency of maintenance operations not requiring personnel to enter water	0.5 (Monthly)	2 (Daily)
Frequency of maintenance operations requiring personnel to enter water	0 (Never)	0 (Never)
Transfer of waste sludge to land frequency	0 (Never)	2 (Daily)

Appendix E Natural capital stocks and mapping methodology

Broad natural group	Subgroup	Mapping methodology
Freshwater	Active flood plain	Areas at high or medium risks within the Environment Agency's Risk of Flooding from Rivers and Sea dataset.
	Blanket bog	Area of blanket bog mapped using Natural England's Priority Habitat Inventory.
	Chalk rivers*	Mapped using the Environment Agency chalk rivers dataset and mapping intersections with OS watercourse polygons.
	Coastal and floodplain grazing marsh	Area of coastal floodplain and grazing marsh mapped using Natural England's Priority Habitat Inventory.
	Lakes and standing waters	Area of lakes and reservoirs mapped using the Centre for Ecology and Hydrology (CEH)'s UK Lakes Portal dataset.
	Lowland fens	Area of lowland fens mapped using Natural England's Priority Habitat Inventory.
	Lowland raised bog	Area of lowland raised bog mapped using Natural England's Priority Habitat Inventory
	Modified waters e.g. reservoirs	Area of reservoirs mapped by selecting Ordnance Survey (OS) surface water polygons (VectorMap District) that coincide with CEH's Inventory of UK reservoirs (points).
	Other semi-natural habitats	Area of other semi-natural habitat mapped using Natural England's Priority Habitat Inventory (including upland and lowland grasslands, heathland and saltmarsh).
	Ponds and ditches	Mapped by selecting surface waterbodies (from OS VectorMap District) that do not intersect rivers, are smaller than 2ha in size.
	Reedbeds	Area of reedbed habitat mapped using Natural England's Priority Habitat Inventory
	Rivers	Length of rivers mapped using the Environment Agency's Water Framework Directive (WFD) river

Broad natural group	Subgroup	Mapping methodology
		waterbodies dataset (cycle 1, to include coastal streams).
Mountain, moor and heath	Blanket bog	Area of blanket bog mapped using Natural England's Priority Habitat Inventory.
	Dwarf shrub heath	Mapped using Natural England's Priority Habitat Inventory ('fragmented heath', 'lowland heathland' and 'upland heathland').
	Inland rock, scree and pavement (AML*)	Area of inland rock and limestone pavement above the moorland line, mapped using CEH's LCM2015 ('inland rock'), Natural England's Priority Habitats Inventory ('limestone pavement') and the Rural Payment Agency (RPA)'s Moorland Line dataset.
	Lakes and reservoirs	Area of lakes and reservoirs above the moorland line, mapped using CEH's UK Lakes dataset, CEH's Inventory of UK reservoirs dataset and RPA's Moorland Line dataset.
	Mountain heath and willow scrub	Area of mountain heath and willow scrub mapped using Natural England's Priority Habitat Inventory.
	Rivers (AML)	Length of rivers mapped using the Environment Agency's WFD river waterbodies dataset and RPA's Moorland Line dataset.
	Semi-natural grassland (AML*)	Area of semi-natural grassland above the moorland line, mapped using Natural England's Priority Habitat Inventory and RPA's moorland line dataset.
	Upland flushes fens and swamps	Area of upland flushes, fens and swamps, mapped using Natural England's Priority Habitat Inventory.
	Wood pasture (AML*)	Area of wood pasture above the moorland line, mapped using Natural England's provisional Wood-Pasture and Parkland BAP Priority Habitat Inventory and RPA's Moorland line dataset.
	Woodland (AML*)	Area of woodland above the moorland line, mapped using Forestry Commission's National Forest Inventory and RPA's moorland line dataset.
Urban	Blue space	Mapped by intersecting OS VectorMap District Surface Water with the Office for National Statistic (ONS)'s Built-Up areas dataset.

Broad natural group	Subgroup	Mapping methodology
	Green space – not semi-natural	Area of urban green space (not semi-natural), mapped using the OS Open Greenspace Layer.
	Open mosaic habitats	Area of open mosaic habitats on previously developed land, mapped using Natural England's draft Open Mosaic Habitat dataset.
	Woodland, scrub and hedge	While urban scrub and hedge are difficult to map at a national scale, the area of urban woodland is mapped here by intersecting the Forestry Commission's National Forest Inventory with ONS Built-Up Areas.
	Semi-natural habitats	Mapped by intersecting Natural England's Priority Habitat Inventory habitats (excluding woodland, good quality semi-improved grassland and traditional orchards) with ONS Built-Up Areas.
Farmland	Arable and rotational leys	Area of arable and rotational leys, and horticulture individually, this map shows the area of arable and horticulture combined. Mapped using UK Land Cover 2018 Sub Classes.
	Horticulture	Area of arable and rotational leys, and horticulture individually, this map shows the area of arable and horticulture combined. Mapped using CEH's Land Cover Map 2015 (LCM2015).
	Improved grassland	Area of improved grassland mapped using CEH's LCM2015.
	Orchards and top fruit	Area of orchards and top fruit mapped using Natural England's Priority Habitat Inventory ('traditional orchards').
Woodland	Ancient woodland	Mapped using Natural England's ancient woodland dataset.
	Broadleaved, mixed and yew woodland	Mapped using Forestry Commission's National Forest Inventory.
	Coniferous woodland	Area of coniferous woodland mapped using Forestry Commission's National Forest Inventory.

Broad natural group	Subgroup	Mapping methodology
	Woodland priority habitats	Mapped using Natural England's Priority Habitat Inventory ('deciduous woodland').
Grasslands	Hay meadows	Area of hay meadow mapped using Natural England's Priority Habitat Inventory ('upland meadow' and 'lowland meadow').
	Other semi-natural grasslands	Area of other semi-natural grassland, mapped using Natural England's Priority Habitat Inventory ('upland calcareous', 'lowland calcareous', 'lowland dry acid', 'good quality semi-improved', 'grass moorland' and 'purple moor grass and rush pasture').
Coastal	Beach	Area of beach mapped using OS VectorMap District ('foreshore'). Note that this dataset includes areas of intertidal sediment as well as beaches.
	Coastal lagoons	Area of coastal lagoons mapped using Natural England's Priority Habitat Inventory ('saline lagoons').
	Mudflats	Area of intertidal mudflats mapped using the EMODnet (Natural England) Intertidal Mudflats dataset.
	Salt marsh	Area of saltmarsh mapped using the Environment Agency's Saltmarsh Extent dataset.
	Sand dunes	Area of sand dunes mapped using Natural England's Priority Habitat Inventory ('coastal dunes').
	Sea cliff	Area of sea cliff habitat mapped using Natural England's Priority Habitat Inventory ('maritime cliff and slopes').
	Shingle	Area of shingle mapped using Natural England's Priority Habitat Inventory ('coastal vegetated shingle').
Marine	Intertidal rock	Area of intertidal rock mapped using Natural England's Open Marine Evidence Base (EUNIS code A1).
	Maerl beds	Area of maerl beds mapped using Natural England's Open Marine Evidence Base (EUNIS code A5.51).
	Reefs	Area of potential reefs mapped using JNCC's Potential Annex 1 Reefs.

Broad natural group	Subgroup	Mapping methodology
	Sea grass beds	Area of seagrass beds mapped using Natural England's Open Marine Evidence Base (EUNIS code A2.61).
	Shallow subtidal sediment	Area of shallow subtidal sediment mapped using JNCC's UKSea Map 2018 (biozone = shallow ircalittoral or infralittoral and substrate = sediment, sand or mud).
	Shelf subtidal sediment	Area of shelf subtidal sediment mapped using JNCC's UKSea Map 2018 (biozone = deep circalittoral and substrate = sediment, sand or mud).
	Subtidal rock	Area of subtidal rock mapped using JNCC's UKSea Map 2018 (substrate = rock).
Soils	Nutrient status of soil	Mean estimates of total nitrogen concentration in topsoil (0-15cm depth) - % dry weight of soil, mapped using data produced from Natural England and CEH's 'Mapping Natural Capital' project (2016).
	Soil carbon/Organic matter	Mean estimates of carbon density in topsoil (0-15cm depth) – tonnes per hectare, mapped using data produced from Natural England and CEH's 'Mapping Natural Capital' project (2016)
	Soil biota	Mean estimates of total abundance of invertebrates in topsoil (0-8 cm depth), mapped using data produced from Natural England and CEH's 'Mapping Natural Capital' project (2016).
Indicators of condition	Natural aquifer function	Area of groundwater catchment with 'good' quantitative status for WFD 2016, mapped using the Environment Agency's WFD data and groundwater catchment boundaries (C2).
	Naturalness of flow regime	The WFD hydrological regime classification describe the naturalness of river flows. This map shows the length of river with 'high' WFD hydrological status in 2016, mapped using the Environment Agency's WFD data and river water bodies (C2).
	Lack of physical modifications of water bodies	Lack of physical modification of rivers, mapped using EA's Reasons for Not Achieving Good Status data (SWMI = 'physical modification'), 2013-2016.
	Presence and frequency of	Mean estimates of number of nectar plant species for bees per 2x2m plot, mapped using data produced

Broad natural group	Subgroup	Mapping methodology
	pollinator food plants	from Natural England and CEH's 'Mapping Natural Capital' project (2016).
	Chemical status of water bodies	River chemical status for WFD 2016, mapped using the Environment Agency's WFD data and river water bodies (C2).

Affinity Water

Thames Water