ANNEX A2

Pipeline Route Appraisal Report

This document has been written in line with the requirements of the RAPID gate two guidance and to comply with the regulatory process pursuant to Severn Trent 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, Severn Trent 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.

STSources SRO

Severn Trent Water

Severn Trent Water

SEVERN TRENT SOURCES STRATEGIC RESOURCE OPTIONS

Netheridge Pipeline Route Appraisal Report

70088464-WSP-NETHSRO-RP-CY-4000
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Severn Trent Water

SEVERN TRENT SOURCES STRATEGIC RESOURCE OPTIONS

Netheridge Pipeline Route Appraisal Report

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1 INTRODUCTION

1.1 CONTEXT

This Pipeline Route Appraisal Report details the pipeline route selection, appraisal, and design for the Severn Trent Sources Strategic Resource Option (STS SRO) Netheridge Concept Design.

It should be read in conjunction with the Severn Trent Sources Strategic Resource Option Netheridge Concept Design Report and is part of a suite of reports completed in support of the STSources RAPID Gate 2 Submission.

Other reports completed as part of the Gate 2 concept design development include:

- Severn Trent Source SRO - Netheridge Concept Design Report (Annex A1)
- Severn Trent Source SRO - Netheridge Process Basis of Design (Annex A3)
- Severn Trent Source SRO - Netheridge Carbon Report (Annex A4)
- Severn Trent Source SRO - Netheridge Cost Report (Annex A5)

1.2 SEVERN TO THAMES TRANSFER SRO

The STS SRO is linked to the Severn to Thames Transfer SRO (STT SRO) as flows diverted from Netheridge WwTW will be used to augment flow transfers south to the Thames Water region.

The intent of STT SRO scheme is to transfer up to 500Ml/day from the River Severn to the Thames region. At Gate 1 there were two options being considered:

1. Abstraction from the River Severn with treatment at Deerhurst before transfer via pipeline to Culham for onward distribution; and
2. Abstraction via the Gloucester docks, transfer along the Cotswolds canals, treatment and then pumped from Lechlade to Culham for onward distribution.

The option ultimately chosen for the STT SRO will dictate the discharge location for the Netheridge flows with flows being transferred to Deerhurst for option 1 or to the canal for option 2.

The Netheridge SRO scheme requirements are primarily determined by the STT SRO operational requirements. The scheme will only transfer flows when called for by the STT SRO scheme. The key operational parameters of the STT SRO scheme are as follows:

- The STT SRO scheme will provide at least 17 days' advance notice of the intent to begin transfer of flow to the River Thames;
- The STT SRO will operate for a minimum of 20 days once fully operational;
- The STS SRO will provide 35Ml/day when the STT SRO scheme is operational; and
- The STS SRO will provide 20Ml/day when the STT SRO is not operational but when levels in the River Severn are below 'hands off flow'(HOF) and therefore cannot abstract 'sweetening' flows from the River Severn without augmentation from other sources.

1.3 SCHEME OVERVIEW AND LOCATION

The intent of the Netheridge part of the STS SRO scheme is to divert up to 35Ml/day of treated effluent from the Netheridge WwTW to augment the STT SRO at the point of abstraction. This report details the development of transfer options in support of STW's Gate 2 STS SRO submission.

Netheridge WwTW is located just south of Gloucester and is bounded by the River Severn to the west and the Gloucester and Sharpness Canal (G&S Canal) to the east. The WwTW can treat up to 42.8Ml of wastewater (DWF) a day with flows coming from Gloucester and the surrounding catchments. The existing treatment process comprises screening, preliminary settlement, biological treatment via Activated Sludge Process (ASP) lanes and final settlement. The WwTW currently discharges treated effluent to the tidal zone of the River Severn.

The Netheridge SRO scheme will comprise two main elements:

- Additional treatment of the diverted flows to meet the higher water quality standards at the discharge location;
- Transfer of flows to the discharge point via a pumped pipeline; and
- The treatment options are addressed in the Netheridge Basis of Design Report and are not discussed further in this report.

The transfer options and pipeline routes have been developed based on the STT SRO potential abstraction points:

- **Deerhurst**. The STT SRO is proposing to construct a new water treatment works at Deerhurst that will abstract water from the River Severn. If this abstraction point is used, then options to discharge Netheridge effluent at Deerhurst or 3km downstream at Haw Bridge are proposed; and
- **G&S Canal**. The STT SRO is proposing to abstract water from the G&S Canal south of Gloucester. If this abstraction point is used, then options to discharge Netheridge effluent directly to the G&S Canal at Netheridge and to the East Channel for the River Severn at Gloucester Docks are proposed.

Figure 1-1 shows the location of Netheridge WwTW and the transfer pipeline route options to the STT SRO abstractions points at Deerhurst and the G&S Canal.

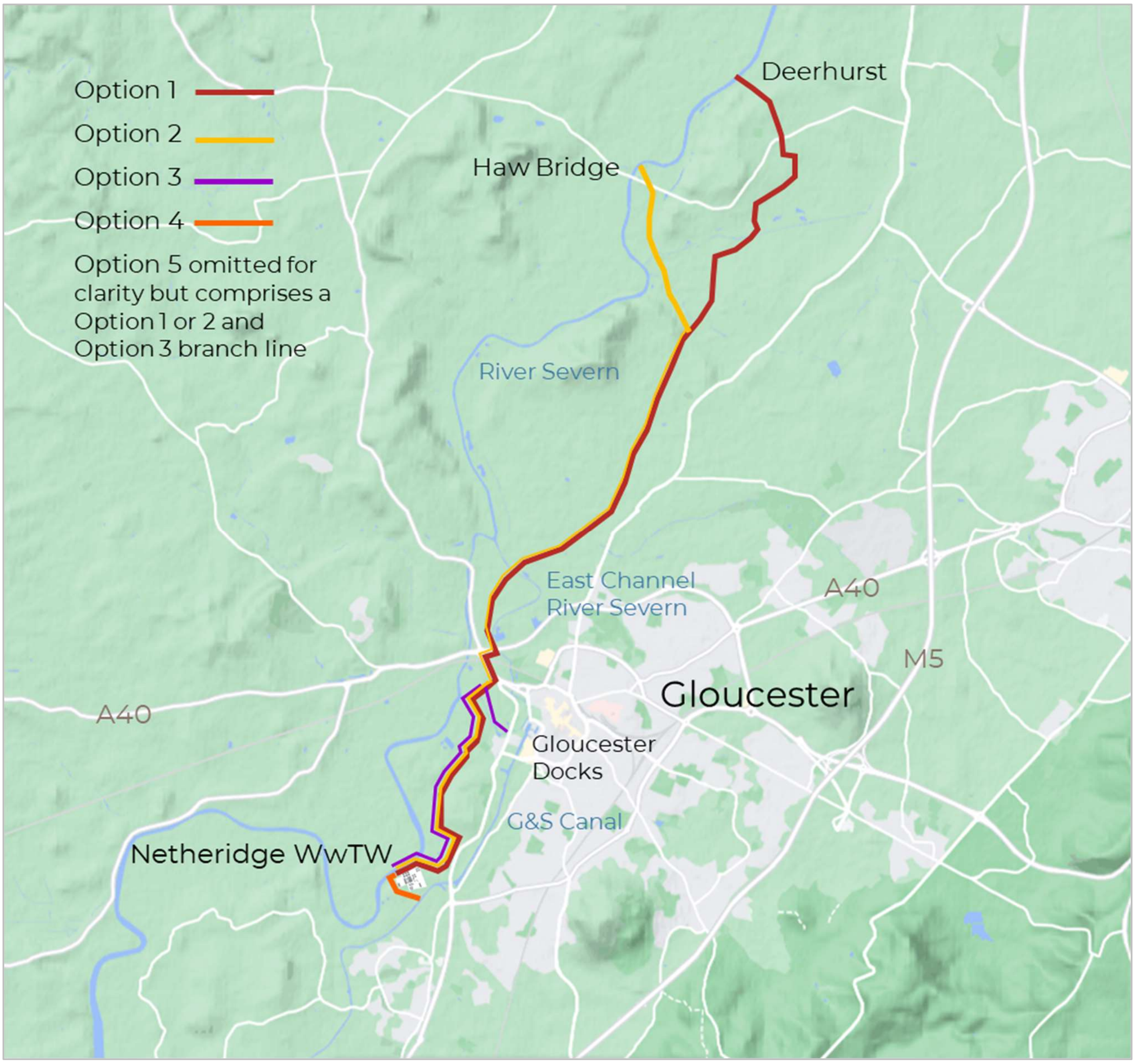

Figure 1-1 – STS SRO Netheridge Scheme Overview

1.4 GATE 2 OPTIONS

A summary of the Gate 2 transfer options is provided below:

OPTION 1 – RIVER SEVERN - DEERHURST

A pipeline from Netheridge WwTW to the River Severn just downstream of the new STT SRO Deerhurst Water Treatment Works. Pipeline approximately 18km in length.

OPTION 2 – RIVER SEVERN - HAW GAUGING STATION

A pipeline from Netheridge WwTW to the River Severn just upstream of the EA Gauging Station at Haw. Pipeline approximately 15.5km in length.

OPTION 3 – RIVER SEVERN EAST CHANNEL

A pipeline from Netheridge WwTW to the East Channel of the River Severn downstream of the existing Canal and River Trust (CRT) pumping station to Gloucester Docks. Pipeline approximately 5km in length.

OPTION 4 – GLOUCESTER AND SHARPNESS CANAL

A pipeline from Netheridge WwTW to the Gloucester and Sharpness Canal. Pipeline approximately 400m in length.

OPTION 5 – SOUTHWEST REGION BRANCH PIPELINE

Additional pipeline for diversion of flows from the Netheridge to Deerhurst (or Haw Bridge) pipeline for discharge to the East Channel of the River Severn downstream of the intake for Gloucester Docks. This branch will follow the same route as Option 3.

1.4.1 PREFERRED OPTION

During the development of the Gate 2 report, discussions have taken place with the Environment Agency (EA) in relation to the issues and benefits associated with Option 2 to discharge upstream of the Haw gauging station when compared to Option 1 (to discharge 3km further north), downstream of the Deerhurst abstraction point. Environmental modelling and WFD assessments have shown Option 2 to be acceptable, however it is anticipated that further work will be necessary in Gate 3 to enable agreement to be reached with the EA.

Option 2 (Haw Bridge) is the preferred option and will be progressed to the next stage alongside ongoing discussion with the EA.

1.5 REPORT REQUIREMENTS AND SCOPE

The scope of work for the Netheridge Pipeline Route Appraisal Report includes:

- Review of Gate 1 pipeline route options;
- Detailed development of the pipeline route options; and
- Requirements for investigations and studies in the next phase of the project.

Pipeline hydraulic analysis and geology assessment are detailed in Appendix A and B.

It should be noted that the environmental consultant was appointed fairly late in the process and therefore no formal environmental screening of the route(s) was completed. During the route development and selection process potential environmental constraints, such as SSSI's nature reserves, schedules ancient monuments, large areas of woodland, locations of ponds and lakes etc were considered and as far as reasonably practicable, the pipeline options were routed to avoid these. It was not considered reasonably practicable to avoid the Alney Island local nature reserve entirely, however potential impact on the area was considered when routing the pipeline through this area, hence the pipeline following the route of the former railway line and away from other likely more sensitive areas of woodland and flooded meadows etc.

1.6 APPROACH AND METHODOLOGY

The approach at Gate 2 has been to continue and enhance work carried out in the development of the scheme at Gate 1.

There are a number of potential pipeline route options for each of the potential discharge locations. However, preliminary assessment has determined that variations to the identified routes will likely be small and determined by local constraints such as obstacle crossings, land ownership boundaries and hydraulics. As such there are only likely to be small variations in terms of cost, risk, and level of disruption. Any cost variations are anticipated to be within the overall margin of error and therefore there was little value in presenting each variation at this stage of the design.

The transfer pipeline routes were developed around the following principles:

- Only one pipe route to each discharge location was developed as the opportunity for alternative pipe routes are limited and within the margin of error of the cost estimates.
- Pipe size was selected based on hydraulic performance with optimisation to be carried out in subsequent stages of the design.

Cost and carbon estimates have been carried out in accordance with ACWG guidance and utilised the STW Cost Tool Lite. Cost and carbon information is presented and discussed in the cost and carbon reports, Annex A5 and Annex A4 respectively.

2 REVIEW OF GATE 1 OPTIONS

2.1 GATE 1 DISCHARGE LOCATION REVIEW

Following the receipt of additional guidance and information at the start of the Gate 2 process, including the findings of the environmental modelling of the dispersion and dilution of effluent discharge into the River Severn at Deerhurst, a number of the Gate 1 options were discounted. The following table contains details of the options considered at Gate 1 with a summary of why they were discounted or carried forwards to Gate 2.

Table 2-1 – Review of Gate 1 Discharge Location Options

Gate 1 Option	Details of Progression to Gate 2
Option 1A: River Severn at Deerhurst **downstream** of abstraction.	Yes – discharge downstream of abstraction is acceptable following completion of environmental modelling study. This option has been progressed into Gate 2 and has split into two options: Option 1 Deerhurst, and Option 2 Haw.
Option 1B: River Severn at Deerhurst **upstream** of abstraction.	No – discounted due to need to extend pipeline to minimum 300m upstream of proposed abstraction to ensure suitable dilution resulting in unnecessary added cost and complexity. Not recommended by environmental modelling.
Option 2A: New Deerhurst WTW – **Inlet**	No – discharge to the WTW is no longer considered suitable. This would be classed as direct effluent reuse and would require additional treatment including disinfection at Netheridge. Added complexity in dependency and control between the STS SRO and the STT SRO.
Option 2B: New Deerhurst WTW – **Outlet**	No – discharge to the WTW is no longer considered suitable. This would be classed as direct effluent reuse and would require additional treatment including disinfection at Netheridge. Added complexity in dependency and control between the STS SRO and the STT SRO.
Option 3A.1: Direct discharge to Gloucester and Sharpness Canal	Yes - progressed to Gate 2, Option 4.
Option 3A.2: Final effluent to the River Severn East Channel, **upstream** of the Gloucester Docks abstraction.	No – discharge to the East Channel upstream of Gloucester Docks would be classed as direct effluent reuse due to inadequate dilution. This would require additional treatment, including disinfection, at Netheridge which would not be required for a downstream discharge proposed in option 3B.
Option 3B: Final effluent to the River Severn East Channel, **downstream** of the Gloucester Docks abstraction.	Yes – progressed as Gate 2, Option 3.

2.2 GATE 1 PIPELINE ROUTES REVIEW

At Gate 1, a common pipeline route was proposed between Netheridge and Twigworth and two separate pipeline routes to the north between Twigworth and Deerhurst, the eastern route known as the Coombe Hill route and the western route known as the Apperley Route. These are shown in Figure 2-1 below.

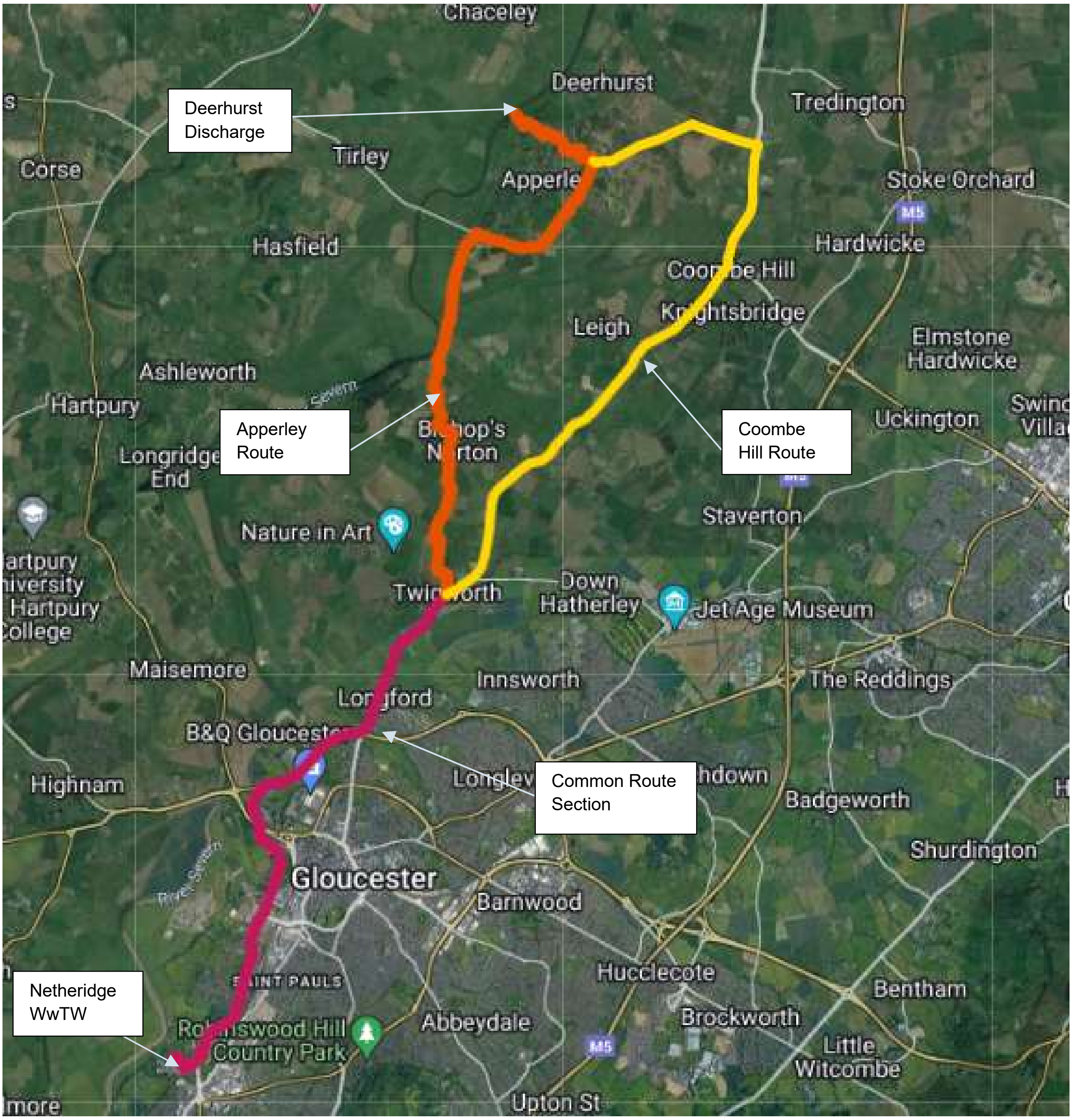

Figure 2-1 – Gate 1 Pipeline Routes

A full engineering review of the Gate 1 route options was completed at the start of the Gate 2 process. A summary of the findings is given below:

- When compared against the Gate 1 selection criteria, both routes have achieved the aim of staying close to the existing road network. However, this has been achieved at the expense of other selection criteria and as a result both routes are unnecessarily long and contain avoidable elevation gain resulting in additional high and low points;
- The decision to follow the road network results in the need for construction within the carriageway for a significant portion of both routes. Construction in the carriageway will cause significant disruption due to the need for rolling full road and single lane closures;
- Similarly, following the road network results in routing the pipeline though areas of population, this will in turn lead to greater public interaction and therefore a greater risk of complaints and criticism of the scheme; and
- Construction in the carriageway is more costly per metre length in all respects (time, cost, and carbon).

  Whilst it is acknowledged that construction of pipelines in private land has some drawbacks, including possible future access and development issues, these can be mitigated with easement and wayleave agreements. As a result of following the road network it is felt that the selected routes failed to achieve the stated aims of:

- Identifying the shortest possible routes between Netheridge and Deerhurst – more direct routes between Netheridge and this discharge location are achievable; and
- Reduced interaction with major roads and utilities - both routes have sections within road carriageway and will require at least partial closures of these roads.

Following review of the Gate 1 pipeline route proposals it was determined that a more direct pipeline route, with significantly less interaction with the existing road network and in particular areas of population, could be achieved.

3 FACTORS AFFECTING ROUTE SELECTION

3.1 GATE 2 DISCHARGE LOCATIONS

3.1.1 OPTION 1: DISCHARGE AT DEERHURST

The findings of the environmental modelling study into the effects of the proposed discharge of Netheridge effluent at Deerhurst, found that the most appropriate location for the discharge was a short distance downstream of the proposed abstraction point. Whilst a discharge point upstream was also acceptable, this would need to be a minimum of 350m upstream of the proposed abstraction to ensure mixing of flows, which was deemed un-economical and unnecessary when a downstream discharge location was acceptable. At Gate 2 a new more direct cross-country route to Deerhurst was developed.

3.1.2 OPTION 2: DISCHARGE AT HAW BRIDGE

The first Environment Agency (EA) river gauging station downstream of the proposed Deerhurst abstraction point is at Haw Bridge. Discussions with the EA and STW have indicated that it would be acceptable to discharge flows from Netheridge into the River Seven upstream of the Haw Bridge Gauging station, however no formal agreement has yet been reached. This may satisfy EA augmentation requirements as flow would be recorded as being maintained between gauging stations. If this is acceptable to the EA, Option 2 to discharge at Haw Bridge reduces the length of the proposed pipeline by circa 3km, removes the need to cross the high ground in the vicinity of Apperley and therefore reduces the static head on the pumping main by approximately 5m providing a long-term energy and carbon benefit. As noted in Section 1.4.1 this option is to be taken forward to Gate 3 as the preferred option on the basis that further discussions with the EA are required.

3.1.3 OPTION 3: DISCHARGE TO THE RIVER SEVERN EAST CHANNEL

This option considers the discharge of Netheridge treated effluent to the River Severn East Channel. This option has been developed from Gate 1 with the location of the proposed discharge point being moved to ensure that the proposed discharge is located downstream of the existing Canal and River Trust (CRT) screw pumping station at Gloucester Docks. The CRT pumping station lifts flows from the East Channel to discharge into Gloucester Docks to mitigate the loss of water from the Gloucester and Sharpness Canal. It is understood that no formal flow modelling of the River Severn East Channel has been completed as part of the STT SRO option appraisal, therefore details of the flows and dilution effect of the river flow on the effluent discharge is not fully understood. Based on advice from the environmental modelling consultants the discharge location has been moved to the furthest downstream point practicable, prior to the East Channel becoming tidal. The aim of this is to minimise the risk of any undiluted effluent being drawn into the CRT pumping station if the pumps cause backflow in the channel when operating.

3.1.4 OPTION 4: DISCHARGE TO GLOUCESTER AND SHARPNESS CANAL

This option considers direct discharge into the Gloucester and Sharpness Canal and remains unchanged from Gate 1.

3.1.5 OPTION 5: DISCHARGE TO RIVER SEVERN (DEERHURST OR HAW BRIDGE) AND RIVER SEVERN EAST CHANNEL

Option 5 aims to investigate the possible opportunity to supply the existing Bristol Water Treatment Works (WTW) at Purton with additional raw water by providing compensation flows from Netheridge. Purton WTW draws its raw water supply from the Gloucester and Sharpness Canal, which in turn is supplied with water from the River Severn East Channel via the existing CRT screw pumping station at Gloucester Docks. This option considers the possibility of combining the STT SRO discharge route to either Deerhurst (Option 1) or Haw (Option 2) with a discharge to the River Severn East Channel downstream of the CRT screw pumping station (Option 3). In this option during times when STT SRO was not demanding water, STW could use treated flows from Netheridge to provide a supplementary supply to the River Severn East Channel and G&S Canal for Bristol Water use.

3.2 OVERALL APPROACH TO ROUTE SELECTION

The transfer pipeline routes were developed based on the following principles:

- Achieve the shortest and most direct viable route between the Netheridge WwTW and the proposed discharge point;
- Minimise construction within the existing road networks to minimise disruption to the local area, maximise construction productivity and reduce construction financial and carbon costs;
- Avoid areas of population (towns and villages, farms, and private gardens), where possible;
- Avoid areas of woodland, ponds, and other environmentally sensitive areas where possible;
- Minimise the maximum elevation of the pipeline to reduce static pumping head requirements;
- Minimise the total amount of rise and fall on the pipeline; and
- Consider the crossing points for major infrastructure and ensure that there is sufficient space available for the construction of the crossing.

Based on the above selection criteria an initial route corridor was developed using widely available mapping and aerial photography sources. Once the route corridor had been developed the route of the pipeline was refined within the corridor by considering the impacts and influences outlined in the following sections.

3.3 TOPOGRAPHY (LIDAR DATA)

Following the determination of the preferred corridor for the pipelines, up to date LiDAR data at 1m grid spacing was obtained from the EA data sources[1].

The LiDAR data was processed and used to create a digital terrain model and triangulated irregular network (TIN) surface in an Autodesk Civil 3D model. This surface information was used to refine the pipe route and produce longitudinal sections for the proposed pipeline routes.

[1] Reference: Data obtained & Jan 2022 from https://environment.data.gov.uk/DefraDataDownload/?Mode=survey.

3.4 STAKEHOLDERS AND LAND OWNERSHIP

3.4.1 STATUTORY UNDERTAKERS (UTILITIES)

Existing statutory undertakers' services information has been obtained, digitised and added to the pipeline route model. This information has been used to inform and update the pipeline route alignments to avoid construction in close proximity (within circa 10m), or within already established easements, of existing utilities.

Existing utilities information has been obtained from the following organisations:

- Linesearch before you dig (Multi utilities overview);
- Wales and West Utilities (Gas);
- Western Power Distribution (Electricity);
- Exolum Pipeline (Aviation Fuel pipeline);
- National Grid (Electricity and Gas);
- Severn Trent Water (Water and Sewerage);
- BT Openreach (Telecoms);
- Gigaclear (High Speed broadband);
- DIO (Abandoned Ministry of Defence Pipeline);
- Fulcrum Pipelines;
- Last Mile (Gas); and
- ESP Utilities.

3.4.2 LAND OWNERSHIP AND STAKEHOLDERS

No contact has been made with landowners or critical assets owner/operators during the development of the concept design. This process is being undertaken by an independent consultant appointed by STW separately and is largely the focus of Gate 3 and 4 activities.

A number of key stakeholders have been identified and should be consulted early in subsequent phases of the project. These stakeholders include:

- Environment Agency (river and water course crossings);
- Gloucestershire County Council, Highways and Local drainage departments;
- Alney Island Nature Reserve;
- Owners / Operators of Hempsted landfill site;
- Network Rail;
- National Highways (formally Highways England);
- Representatives of the Coombe Hill Canal SSSI; and
- Enovert Owner / Operator of Gloucester Green Energy and Eco Park.

3.4.3 PLANNING REQUIREMENTS

It is understood that the treatment upgrades at Netheridge WwTW and the associated pipeline are to be considered Associated Development to the STT SRO DCO application. STS SRO qualifies as Associated Development on the basis that it is directly related to the STT SRO and will help support its operation, therefore satisfying the definition of Association Development in the Planning Act 2008.

It is therefore, expected that all planning permissions, for both enabling works and the main construction process with be granted as part of the DCO process.

Should at a later date, (however unlikely), Netheridge SRO be no long considered associated development and therefore outside the STS DCO process, then it is expected that because the pipeline and associated infrastructure will be predominantly constructed below ground, it is likely that this would be considered water industry permitted development and is unlikely to require specific planning permission, over and above standard water industry permitted development rights.

However, specific planning permission is likely to be required for any new permanent site compounds and above ground features to be created to facilitate the draining of the pipeline when not in use. Additionally, planning permission is expected to be required for the creation of any temporary entrances on to major roads and any temporary site compound establishments which are remote from the main construction easements.

Full assessment of planning permission and permitted development rights is outside the scope of the concept design report.

3.4.4 RIGHTS OF ACCESS

Construction Phase

It is understood that the treatment upgrades at Netheridge WwTW and the associated pipeline are to be considered Associated Development to the STT SRO DCO application. STS SRO qualifies as Associated Development on the basis that it is directly related to the STT SRO and will help support its operation, therefore satisfying the definition of Association Development in the Planning Act 2008. It is therefore, expected that all planning permissions and associated land access permissions, for both enabling works and the main construction process with be granted as part of the DCO process.

If later in the consultation process it is decided that Netheridge SRO does not fall within the wider DCO process, STW have powers under the Water Industry Act 1991 to enter land to construct water assets. Where possible this access should be achieved through negotiation, however where a suitable agreement cannot be reached, then STW can access using statutory powers. As such there are unlikely to be significant issues with accessing land for construction.

Permanent Easements, Wayleaves and Protected Strips

In addition to access requirements to allow the construction of the pipeline, there will be a requirement to establish guaranteed access along the length of the pipeline. Depending on the location and land use it is expected that a combination of permanent easements, wayleaves or protected strips will be needed to allow access for operation, inspection, and maintenance. As well as, to offer protection to the main from the encroachment of developments and to prevent changes of land use which would be detrimental to the life span of the pipeline, such as woodland planting within a set distance of the pipeline. STW guidance documents indicated that the proposed 700NB pipeline will require minimum easement or strip width of 3.5m from the centre line of the pipeline in each direction. Its is expected that these permanent easements, wayleaves and protected strips, will be formalised as part of the DCO process or Water industry act powers if the DCO process is not applicable.

3.5 HYDRAULIC DESIGN

A preliminary level of hydraulic design has been undertaken to inform the feasibility and engineering scope associated with each option. The primary consideration for concept design is the steady-state hydraulics. The basis for this assessment aligns with the treatment design basis of 200 – 550 l/s. The results of these calculations are presented in Technical Note Netheridge SRO Hydraulic Analysis (Appendix A).

The key conclusions of the hydraulic assessment as relevant to the pipeline route selection are:

- [redacted]mm diameter pipelines are proposed for Options 1, 2 and 3;
- A [redacted]mm pipeline is proposed for Option 4; and
- Hydraulic break chambers are required at final high points on Options 1 and 2 to allow the transition between pumped and gravity flow regimes and prevent siphoning of flows.

3.6 GEOLOGY AND GROUNDWATER

3.6.1 GEOLOGY

A desk top geotechnical assessment was completed for the Gate 1 pipeline route options. This study has been reviewed and updated to reflect the proposed changes in pipe routes for the Gate 2 pipeline routes. A summary of this review is presented in Appendix B.

The following possible geotechnical risks have been identified along the pipeline routes which will require further investigation in subsequent phases of the project. None of the risks identified present a significant risk that cannot effectively managed during construction.

- Low strength soils (alluvium);
- Thin drift deposits and shallow rock head;
- Water bearing deposits and shallow groundwater;
- Variable Made Ground deposits associated with former landfill sites; and
- Contamination associated with former land uses.

It is expected that for the most part the pipeline will be constructed through low strength variable alluvial deposits. These materials are likely to provide relatively easy digging for pipeline installation by open cut. The pipeline has been routed through open areas so there are unlikely to be significant space restrictions allowing battered excavations to be used. However, vertical excavations supported using trench boxes and trench sheets and frames are likely to be required at service and road crossings to minimise the risk of ground loss adjacent to the excavation.

The possibility of thin drift deposits and shallow rock head has been identified. Geological mapping indicates that the underlying rocks generally comprise sedimentary deposits of a mixture of lithologies including mudstones, limestones, and sandstones. It is possible that rock will be encountered in the trenching works for the pipeline, particularly in the northern sections in the vicinity of and north of Bishops Norton. It is anticipated that the large excavators (20-30 tonne) required to excavate lift and install the pipework will be capable of excavating the upper (likely weathered) layers of rock. Some excavation in rock using pneumatic / hydraulic brakers may be required.

It is likely the excavations for tunnel shafts and tunnels for the River Chelt and Coombe Hill Canal crossings will encounter shallow rock. This may be beneficial giving a constant horizon through which to tunnel. When ground conditions are confirmed by ground investigations, appropriate tunnelling equipment can be selected to overcome particular ground conditions. The most problematic conditions for tunnelling are where there is an interface between low strength material and underlying rock. In these situations, it is more beneficial to reduce the level of the tunnel and tunnel through the competent material to ensure accuracy in line and level.

3.6.2 GROUNDWATER

Water bearing alluvial deposits may be problematic in some areas of the pipeline route. Historic borehole records indicate water strikes at 3-4m below ground level in the vicinity of the northern East Channel crossing. The presence of a significant number of land drainage ditches and surface water features also indicate the likelihood of shallow groundwater.

3.6.3 CONTAMINATED LAND

Previous land use at Alney Island Nature Reserve (former railway sidings) and the Hempsted landfill site increases the likelihood of contaminated land being encountered along the route of the pipeline in specific areas.

The proposed pipeline is to be routed to the south of the Hempsted land fill site and is expected to be outside the area of filling, therefore the risk of encountering contaminated land is considered to be low.

The pipeline will be routed through Alney Island Nature Reserve, this area was formally an area of yards and siding, and as such a wider range of contaminants including but not limited to hydrocarbons, coolants, solvents, asbestos-containing materials, polychlorinated biphenyls (PCBs) and contamination from ash/fill materials could be expected.

Outside of these areas the majority of the proposed pipeline routes will be through undeveloped greenfield environments and as such it is unlikely that contamination will be encountered in these areas. Pockets of isolated contamination such as areas of Fly tipped materials and other waste, such as agricultural waste pits may also be encountered.

It is not anticipated that the likely contamination will have a significant effect on the selection of or longevity of the pipe material, but it may impact on construction methods. Excavation material not retained on site may need specialist disposal. Contaminated land may present a risk to the health and safety of construction workers.

3.7 ECOLOGY AND ENVIRONMENT

Environmental consultants for the Netheridge SRO scheme were not appointed until late in the pipeline route assessment process therefore limited formal input or environmental modelling results have been received to inform pipeline route selection. Gate1 environmental assessment information has been utilised where applicable along with public and open-source data relating to environmental classification of land areas within the pipe route corridor[2]. Refer to Figure 3-1.

2 DEFRA magic mapping site includes details of the recorded presence of protected species, SSSI and other sensitive areas. https://magic.defra.gov.uk.

Areas of dense and mature woodland have been avoided as far as reasonably practicable. The pipeline routing process has taken into consideration the locations of surface water bodies such as ponds which could provide habitat for protected species. Similarly, the pipeline route aims to cross existing water course perpendicularly to minimise the length and hence impact on the water courses.

All pipeline routes, apart from Option 4, will require construction within the boundary of the Alney Island Local Nature Reserve. The nature reserve has been created in a post-industrial landscape comprising former electricity substations, railway sidings and goods yards. The route of the pipeline through the Nature Reserve has been selected to follow one of the main rail spurs running generally north – south through this area. This rail spur route appears to have been retained as an access path through the nature reserve area and so its use will minimise disruption and present an opportunity for enhanced reinstatement on completion.

The construction of the pipeline is a temporary activity and if properly planned and managed, particularly with respect to the reinstatement, has the potential to benefit the area through enhanced reinstatement and the deployment of biodiversity and offsetting scheme funds.

Enhanced reinstatement is where the construction of the pipeline provides an opportunity to improve the local environment beyond that which existed prior to construction, the addition of rare plant species or protecting existing plants from invasive species. A pipeline is a linear feature and there is an opportunity to create wildlife corridors with additional planting of flora that will provide cover for wildlife and allow the natural migration of flora and fauna species, connecting areas of woodland or other habitats.

3.7.1 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

STS Netheridge SRO is considered associated development to the STT SRO DCO, therefore it is expected that the scheme will fall under the overall EIA requirement of the DCO process. Therefore, it is assumed that an EIA will be required for the whole of the Netheridge SRO scheme, (Treatment works upgrade and pipeline install). As such, it is recommended that the EIA screening process for the preferred option commences early in Gate 3”

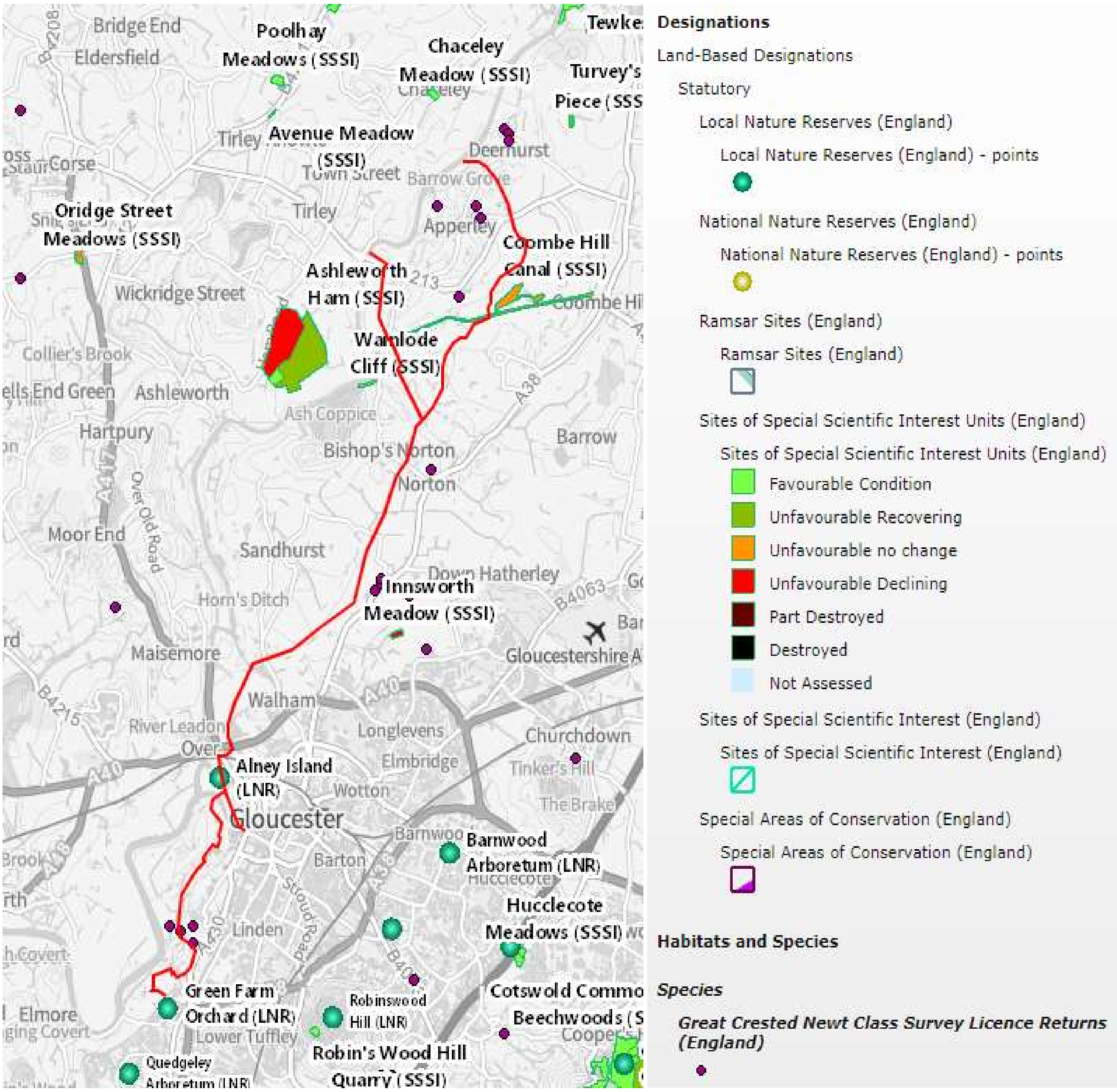

Figure 3-1 – DEFRA MAGIC Map Extract for Netheridge Pipe Routes (as of July 2022)

4 SELECTED PIPELINE ROUTE OPTIONS 1 TO 5

Large sections of the proposed pipeline routes for Options 1, 2 and to a lesser extent option 3 are common. Therefore, to avoid repetition these common elements have been assessed separately, followed by assessments of the option specific sections of the proposed route. Figure 4-1 below shows the location of the common and option specific sections of the pipeline that have been assessed in this report.

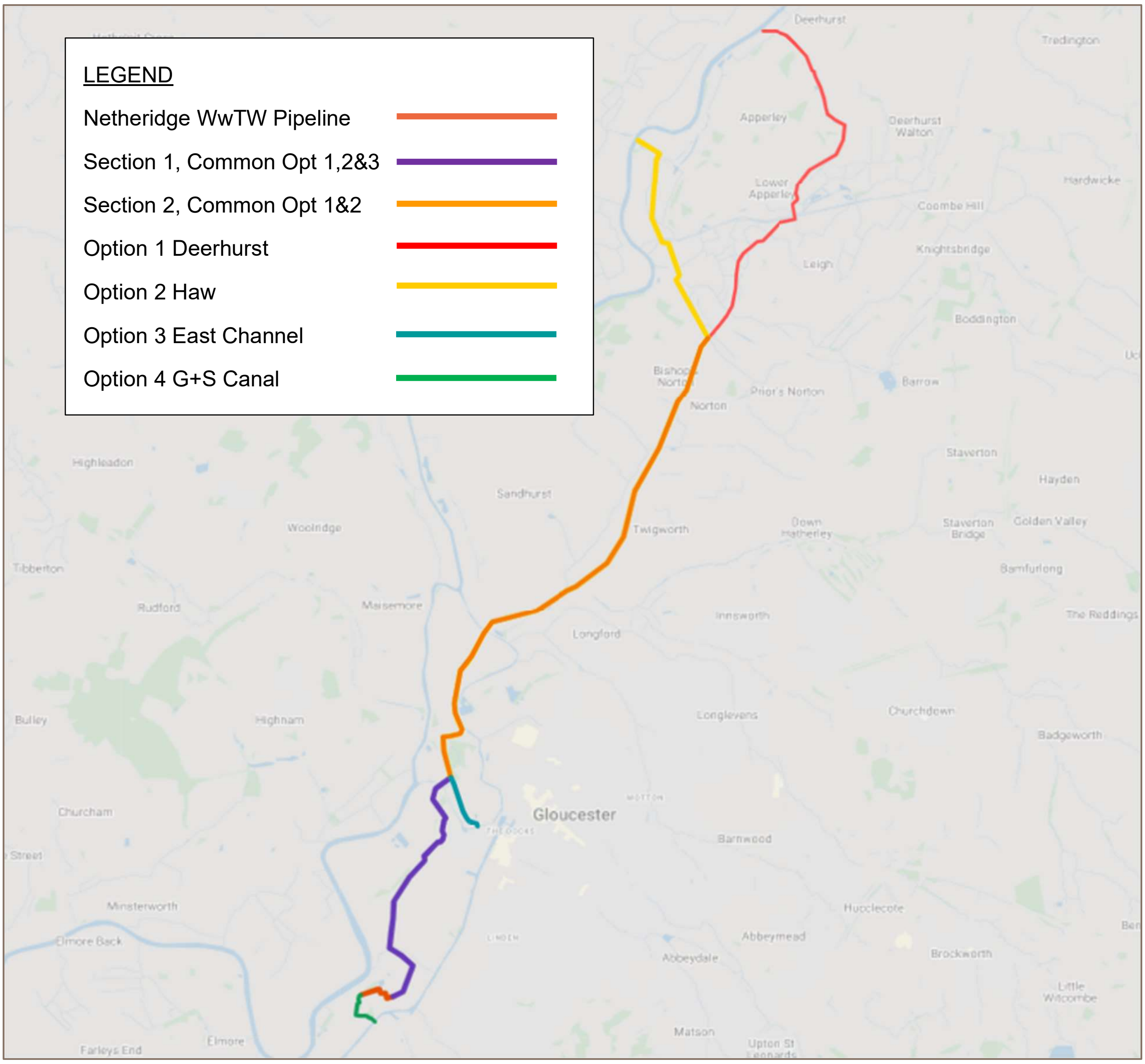

Figure 4-1 – Netheridge Pipeline Route Sections Overview[3]

[3] Note that all pipeline maps and aerial photos are courtesy of Google Maps.

4.1 NETHERIDGE WWTW PIPELINE

The proposed transfer pumping station is to be located to the northwest of the existing works.

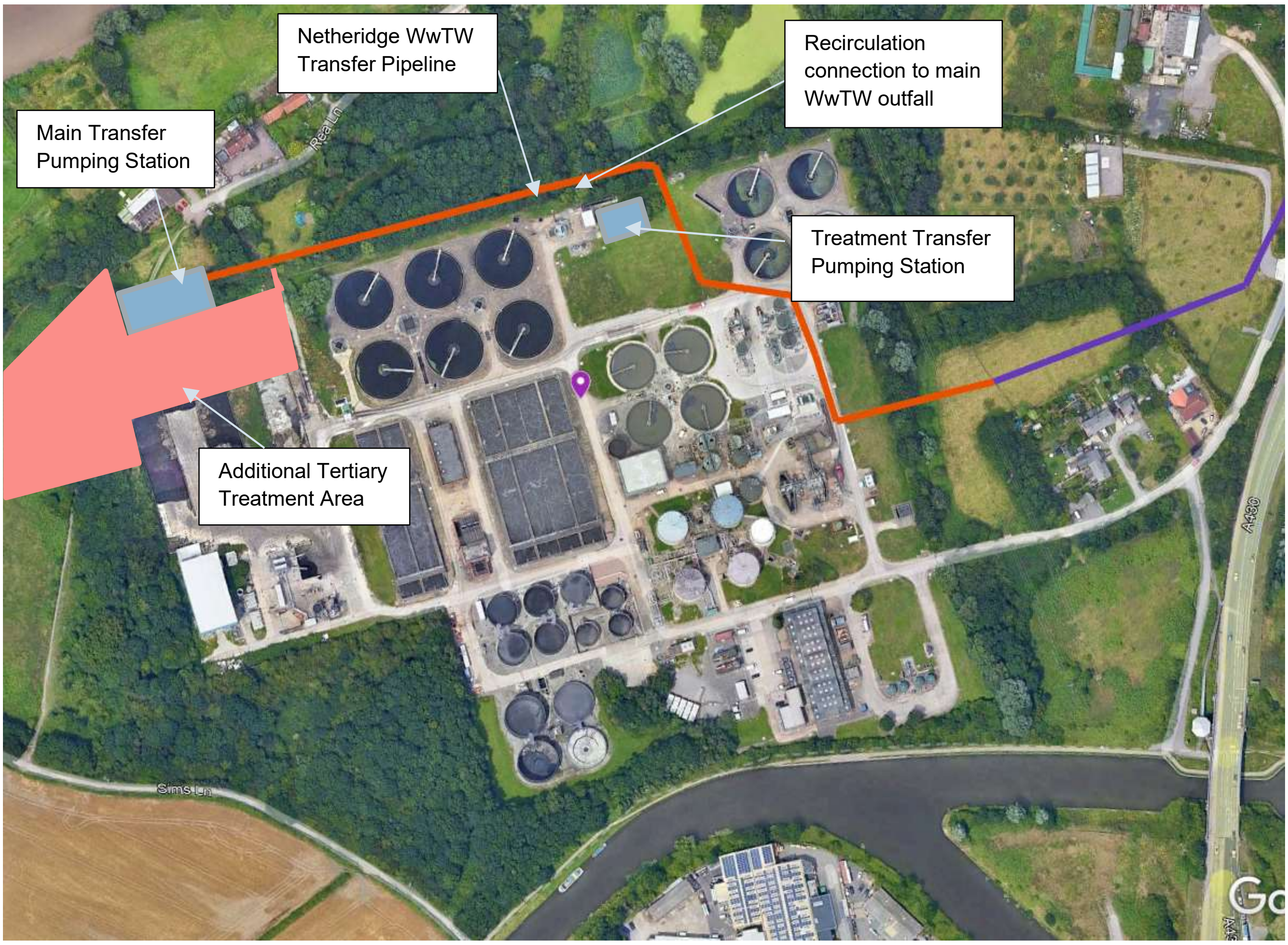

Figure 4-2 – Netheridge WwTW Pipeline Section Generalised Route

4.1.1 CHAINAGE 0 TO 560[4]

The proposed transfer pumping station is to be located in the northwest of the existing WwTW site along with the additional tertiary treatment facilities, as shown in Figure 4-2. The route of the transfer pipeline to all discharge points, with the exception of Option 4, is to the northeast of the WwTW therefore it is necessary to route the pipeline back through the WwTW site. It is proposed to route the first section of the pipeline along the northern boundary of the WwTW parallel with the fence line to the point where the main WwTW outfall pipe crosses the boundary. The first section of the transfer main is intended to double up as the conduit for recirculation flows back to the main outfall during periods when the STT SRO is not demanding flows. It is intended that there will be a flow splitting tee with electrically actuated valves at this location which will allow flows to switch between recirculation and transfer as required.

4 Note that the pipeline within the WwTW boundary is not included in the total pipeline chainages quoted in the following sections as it is anticipated that this will form part of the treatment plant construction contract.

From this point the pipeline route will turn south and east within the confines of the WwTW boundary. The exact alignment of the route in this section is yet to be finalised and is reliant on the alignments and positions of the existing utilities and process pipework within the WwTW.

4.2 SECTION 1 (OPTIONS 1,2 AND 3)

Figure 4-3 – Section 1 Common to Options 1,2,3 and 5 Generalised Route

The first section of the transfer pipeline for Options 1,2 and 3 shown in purple in Figure 4-3 runs in a north easterly direction for approximately 3.9km between Netheridge WwTW and Alney Island Nature Reserve. This section comprises generally open agricultural fields, interspersed with areas of woodland. This section also incorporates the first crossing of the River Severn East Channel.

There are a number of critical existing services in this area including high pressure gas mains, buried and overhead high voltage electricity cables. The pipeline route has been selected to minimise as far as possible any interaction with these existing services, however, some crossings cannot be avoided. There are also a number of minor water course crossings within this section.

4.2.1 CHAINAGE 0 TO 1838

There is a natural low point in the ground profile at chainage CH 1838m. To avoid an excessively deep pipeline excavation elsewhere, there is a need for a low point in the pipeline at this location. Hence this location will become a drain point, DP1 for the pipeline when its operational cycle has been completed. There is a small water course in this location, and it is proposed to discharge the effluent from the pipeline into this water course which flows directly into the River Severn. Further details of the water course and its flow characteristics need to be obtained in the next stage to assess its suitability as a receiving water course, and if suitable what the maximum drain down flow rate can be without causing detriment to the water course environment.

4.2.2 CHAINAGE 2400 TO 2750

Of particular note is chainage 2400m to 2750m at this point the route of the pipeline has been routed to the north of two sets of existing overhead HV electricity cables. These cables are located on the south-eastern edge of the now closed Hempsted landfill site. At this point the LiDAR indicates that the proposed route is encroaching on the spoil mound at the boundary of the landfill. As such the pipeline is shown to be circa 3m deep. At present it is not possible to move the alignment outside the landfill bund area due to the presence of the HV OH cables and the safe working clearances they require. Similarly, it is not possible to route the pipeline to the south of the cables due to the presence of existing buildings. As such it is recommended that early in the next stage discussions are held with Western Power Distribution regarding arranging for this section of cables to be converted to underground and aligned such that the pipeline can be safely constructed through this section.

Dropping and realigning the cables is preferable to construction in the edge of the landfill bund area, where the quality and consistency of the bund construction is likely to be variable and hence could lead to problematic differential ground movements during and post construction, which may compromise the health and safety of the pipe laying crews and the structural integrity of the pipeline. The costs associated with dropping and realigning the cables, if carefully planned are also likely to be less than the costs and risks associated with construction in deep excavations.

Consideration was given to routing the pipeline to the north of the landfill site. However, this route was ruled out due to the presence of a number of existing buried HP Gas Mains and Electric cables in the narrow corridor between the edge of the former landfill site and the flood prevention embankment.

The former landfill site is to be developed into Gloucester Eco- Park, with a significant area of new woodland, comprising 100,000 new trees being planted in the fields to the north and west of the existing landfill site. Tree planting in this area is understood to have commenced in March 2021. The eastern area of the landfill is to be developed into a solar farm. The proposed pipeline route is to the east of this solar farm development.

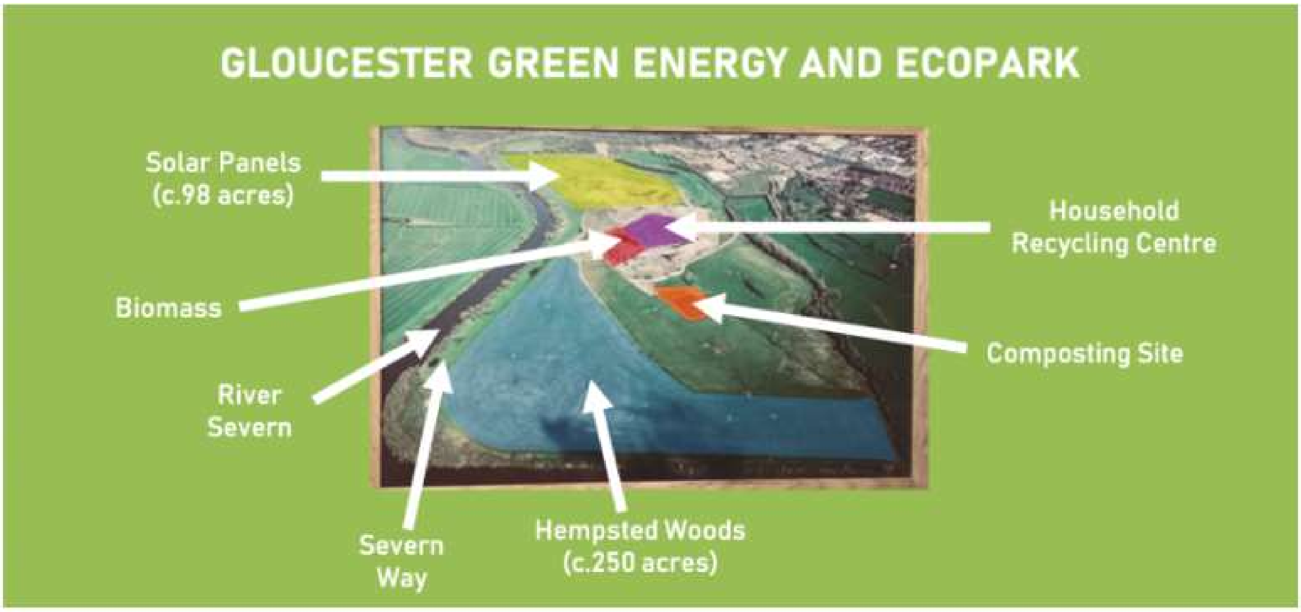

Figure 4-4 – Gloucester Green Energy and Ecopark Plan

(Image from Enovert Owner operator)

4.2.3 CHAINAGE 2750 TO 3600

Between chainages 2750m and 3600m, the pipeline is routed through an area of woodland. This is unavoidable due to the presence of an existing HP gas main in the access track to the west. During the next stage it is necessary to confirm the exact easement and separation requirement with the asset owner. The location of the main should also be confirmed on site. This will allow the exact alignment of the proposed pipeline to be confirmed along with the impact on the woodland.

4.2.4 CHAINAGE 3600 TO 3814

Between chainages 3600m and 3814m, the pipeline will cross the River Severn East Channel in a tunnelled crossing as discussed in Section 5.4.

Due to the lack of information about the channel, it is assumed that the depth of the channel below the adjacent bank is approximately 5m and that the crown of the tunnel will be a minimum of 3m below the bed level of the channel. However, it should be noted that the depth of the tunnel may be deeper if unsuitable strata for tunnelling is encountered at shallow depths.

Further intrusive and non-intrusive surveys are required to fully define ground levels in the vicinity of the launch and reception shafts and the riverbed profile along with works to determine the ground and groundwater conditions for the design of the tunnel crossing.

It is proposed that the southern tunnel shaft will form a drain point, DP2 for the tunnel and adjacent pipeline sections. Effluent drained from the pipeline at this location will be discharged via a short rising main and new permanent outfall on the southern bank of the River Severn East Channel. This section of the channel is downstream of the weir and is tidal. Refer to Section 7 and Table 7-1 for further details.

The northern tunnel shaft will be located within the boundary of Alney Island Nature Reserve. From the shaft, the pipeline trends northeast towards the alignment of the former railway line into Gloucester Docks. At this point the route of the proposed pipeline can turn north for Options 1 and 2, or South for Option 3. If Option 5 were to be progressed a valved tee would be installed at this location to allow flows to be switched between discharges to Deerhurst / Haw or the East Channel.

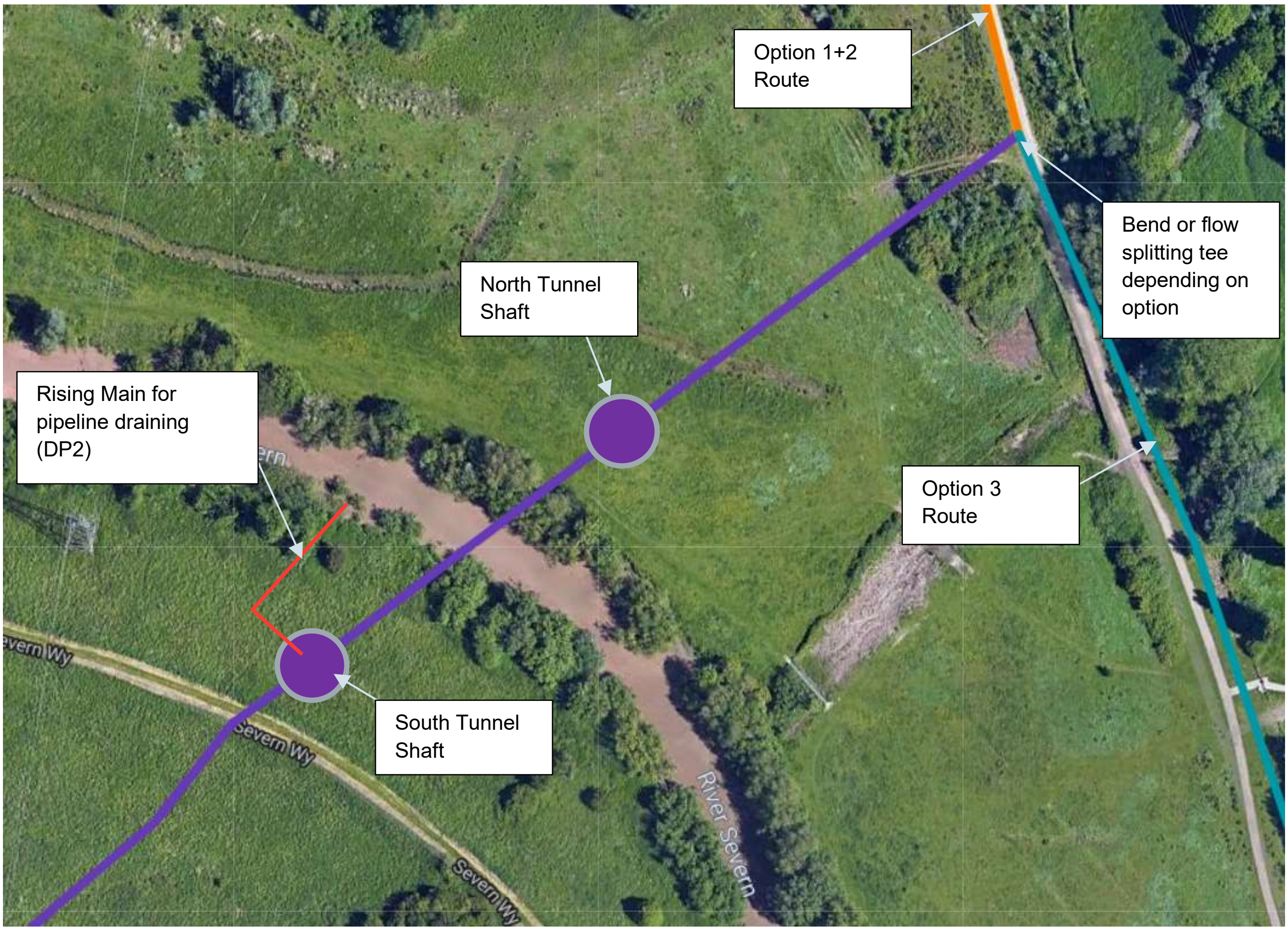

Figure 4-5 – River Severn East Channel Crossing (South)

(Image from Google Earth Pro)

The tunnel shaft locations are within an area at risk of flooding. Therefore, it is recommended that the tops of the shafts are raised above existing ground level and normal flood levels. It is also recommended that the shafts are fitted with water excluding access covers.

4.3 SECTION 2, OPTIONS 1 AND 2

Figure 4-6 – Section 2 Common to Options 1 and 2 Generalised Route

(Image from Google Earth Pro)

Section 2 of the proposed pipeline route comprises approximately 7.85km along the route between Alney Island in the south and Bishops Norton in the north. In the south the pipeline trends in a northerly direction and is routed through the Alney Island Nature Reserve. To the north of the A40 viaduct the pipeline route trends northeast and is routed through mixed use agricultural fields comprising pastures and arable interspersed with areas of woodland, hedgerows, and small water courses. The local topography is gently undulating for the majority of the route. Ground levels start to rise to the south of Bishops Norton with the highest ground level on this section of the route, and the highest point for Option 2 being at this point.

4.3.1 CHAINAGE 3814 TO 4377

Between chainages 3814m and 4377m the pipeline is routed through the Alney Island Local Nature Reserve. The local nature reserve is managed by Gloucester County Council and has been created from a mix of post-industrial uses including railway sidings and goods yards as well as former electricity substations.

The route of the pipeline has been selected with a view to minimising the impact on the local nature reserve, as discussed in Section 3.7. It is proposed that the pipeline will be laid in a vegetated area to the immediate west of the existing access track, allowing the track to be retained as access in the permanent case.

Due to the industrial nature of the former land uses in this area it is likely that some contaminants could have leached into the ground; PCBs for example, were widely used in electrical equipment making up a sub-station, similarly heavy metal and hydrocarbon contamination can be associated with former railway infrastructure sites. As such it is recommended that a full ground investigation including full contamination sampling is completed throughout this section. This is required to inform the design of the pipe, confirm the details of the pipeline coating, and provide information to ensure the health and safety of construction workers handling the soils. The results of contamination testing should also be used to inform the likely waste handling and disposal requirements for materials excavated from this area.

4.3.2 CHAINAGE 4377 TO CHAINAGE 4775

Between chainages 4377m and 4411m the pipeline is required to pass below the Gloucester to Lydney railway line. This section of the pipeline will be tunnelled below the embankment as discussed in Section 5.5. The northern tunnel shaft will be used as the drain point, DP3 for the tunnelled section. It is proposed that the rising main will discharge back into the main pipeline to allow it to drain to the River Severn East Channel under gravity at DP4.

At chainage 4411m the route of the pipeline turns east and cross the alignment of the Over Causeway. At the proposed crossing point, the Over Causeway is built on a viaduct which carries it over the railway line. There is sufficient height clearance to the underside of the viaduct to allow open trench installation to take place below the viaduct. Further investigation and consultation are required to confirm this in the next stage.

It is proposed that drain point, DP4 will be installed at chainage 4740m. This drain point will discharge to the River Severn East Channel.

At Chainage 4525m the route turns northeast across an area of open meadow land which is associated with the Alney Island Nature Reserve. At chainage 4750m the route crosses under the

A40 viaduct. As with the Over Causeway crossing, there is sufficient clearance below the viaduct to allow open cut construction.

4.3.3 CHAINAGE 4775 TO 6200

From chainage 4775m to 6200m the pipeline route trends northeast towards the second crossing of the River Severn East Channel. The ground levels in this area are gently undulating and the land use is typically open arable filed. There are a number of underground and overhead utility crossings in this section.

4.3.4 CHAINAGE 6200 TO 6300

This section of the route comprises the second crossing of the River Severn East Channel and as with the other major water course crossings this crossing is to be a tunnel. The shaft on the northern bank is located on the landward side of the existing flood embankment and the shaft on the southern bank is located on higher ground so these shafts are at lower risk of flooding.

It is proposed that the northern shaft will be the drain point, DP5 with the rising main discharging into the River Severn East Channel.

4.3.5 CHAINAGE 6300 TO 10,000

In this section the route trends generally northeast towards Bishops Norton. The ground levels are gently undulating and rising gently to the northeast. In this section there are numerous small water course crossings as well as two crossings of Sandhurst Lane at chainage 6525m and 9687m.

Drain point, DP6 is located at chainage 7600m within this section, and the rising main for this drain point will discharge into the adjacent Cox's Brook which in turn drains to the River Severn East Channel.

4.3.6 CHAINAGE 10,000 TO 11,593

To the north of chainage 10,000m the ground levels rise gradually from circa 11mAOD to the high point at chainage 11,593m of 21.21mAOD. Within this section the pipeline route crosses Wainlodge Lane at chainage 11,000m and associated services.

4.3.7 CHAINAGE 11,593 TO 11,812

The ground level and hence the pipeline falls steeply between chainage 11,593m and 11,730m before levelling off once again to chainage 11,812m and the point where the routes to Options 1 (Deerhurst) and Option 2 (Haw) diverge.

4.4 OPTION 1 - DEERHURST

The pipeline route for Option 1 Deerhurst comprises a 5.75km section of pipe between the Option1 / 2 divergence point at chainage 11,812m and the proposed discharge point immediately downstream of the STT SRO proposed Deerhurst abstraction as shown in Figure 4-7.

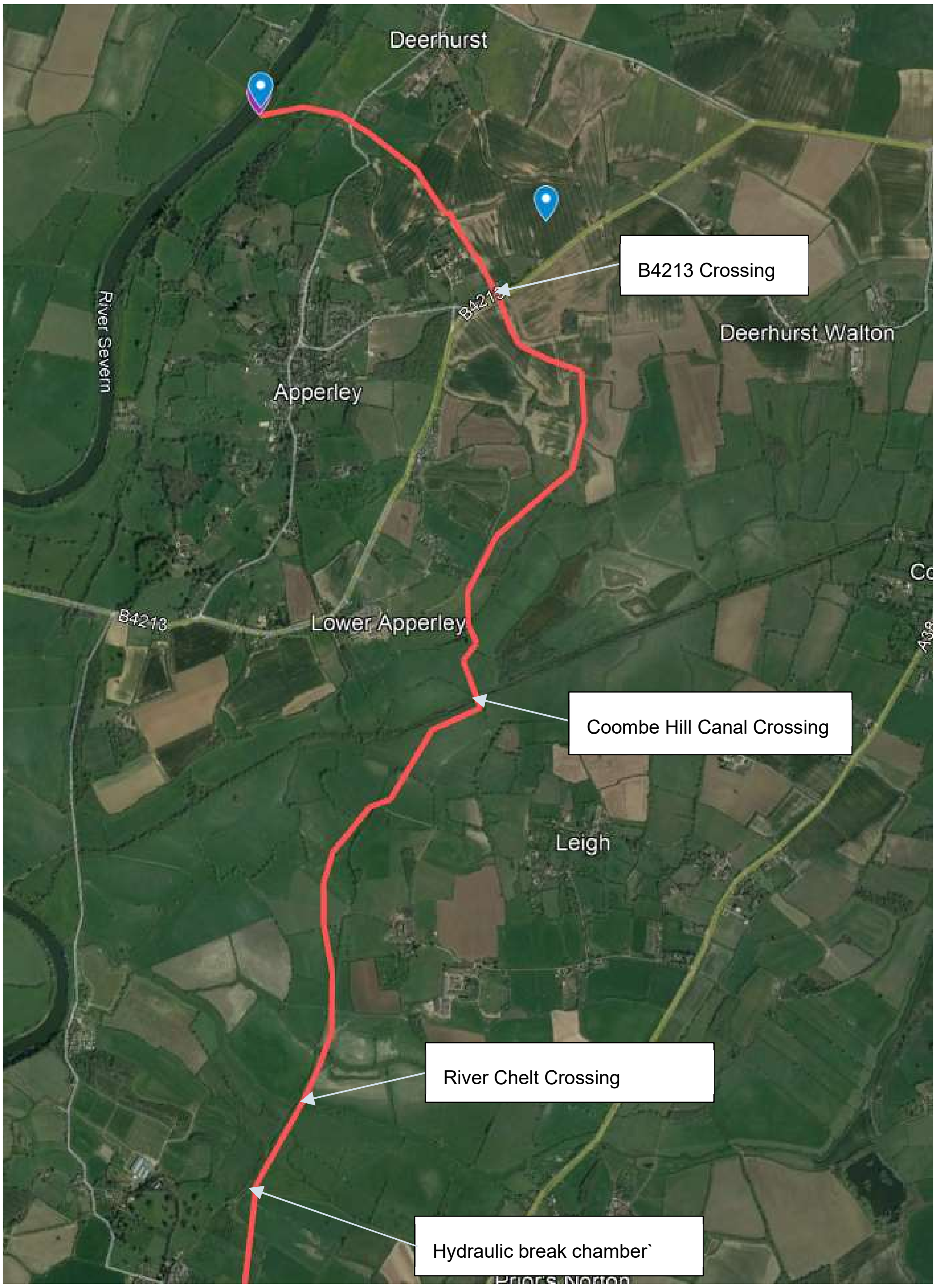

Figure 4-7 – Option 1 Generalised Route to Deerhurst

4.4.1 CHAINAGE 11,812 TO 14,460

This section of the route traverses gently undulating mixed use agricultural land interspersed with numerous mature hedges, small water courses and drainage ditches. The pipeline route skirts to the west of an area of high ground in the vicinity of The Leigh. There are two major water course crossings in this section which will require tunnelled crossings as discussed in Section 5.4.

These major crossings are the River Chelt, located at chainage 12,020m to 12,075m and the Coombe Hill Canal SSSI located at chainage 14,025m to 14,120m. In both cases it is proposed that the southern shaft of these tunnel sections will be the drain points DPD7 and DPD8. Refer to Section 7 and **Table 7-1** for further details. The rising mains from the drain points will discharge into the water course adjacent to the River Chelt and a drainage ditch, respectively.

4.4.2 CHAINAGE 14,460 TO 16,695

In this section the pipeline is routed through gently undulating agricultural land which rises in elevation from circa 9.75mAOD to 29.25mAOD throughout the section. The pipeline crosses the B4213 at chainage 16,013m to 16,023m. This crossing is to be constructed as open cut as discussed in Section 5.6.

Due to the undulations in the ground and the lack of surface water features in this section the pipeline has been designed to continuously fall to the south throughout to ensure that it can be drained. As a result, some sections of the pipeline will require excavations in excess of 3.5m in depth.

4.4.3 CHAINAGE 16,695 TO 17,172

Chainage 16,695m is the highest point of the main. Downstream of this point the main falls towards the river discharge under gravity. As a result, a hydraulic break chamber, as discussed in Section 7.2 is required to facilitate the transition between pumped and gravity flows.

From the high point at chainage 16,695m the pipeline continues northwest wards towards the discharge point on the River Severn. The ground levels in the first section of main, to chainage 17,025m fall from around 29.25mAOD to 11.25mAOD. From this point the ground levels out towards the river and the discharge point. The pipeline crosses Deerhurst lane between chainages 17,009m and 17,009m. This crossing is to be constructed as open cut as discussed in Section 5.6.

4.5 OPTION 2 - HAW BRIDGE

Discharge route Option 2 diverges from the route of Option 1 at chainage 11,812m and trends northwest wards to a discharge point immediately upstream of the river gauging station at Haw Bridge. The generalised route of Option 2 is showing in Figure 4-8 below.

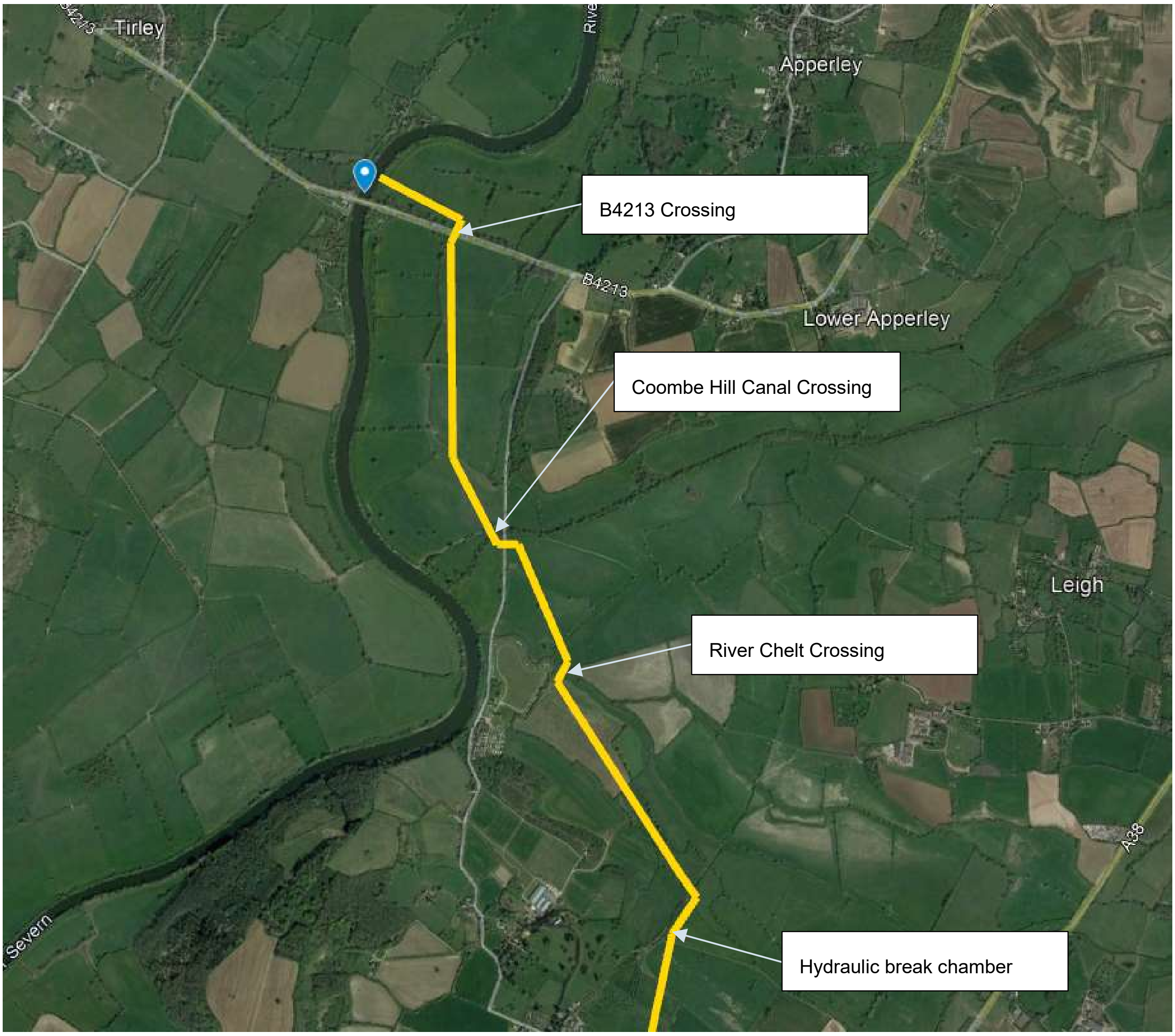

Figure 4-8 – Option 2 – Generalised route to Haw Bridge

4.5.1 CHAINAGE 11,593 TO 12,870

Chainage 11,593m is the highest point of the rising main from Netheridge to Haw Bridge. Downstream of this point the natural topography and hence the pipeline falls towards the river discharge point. As a result, a hydraulic break chamber, as discussed in Section **7.2** is required to facilitate the transition between pumped and gravity flows. The remainder of the pipeline from this point flows under gravity to the discharge point.

From chainage 11,593m the pipeline route trends northwest wards downhill though open fields towards the crossing point at the River Chelt. As with the other major water course crossings this crossing is to be constructed as a tunnel.

A drain point, DPH7 will be created as part of the southern tunnel shaft construction, with a discharge rising main to the River Chelt.

4.5.2 CHAINAGE 12,870 TO 13,487

The pipeline route continues to trend northwest wards, crossing gently undulating farmland associated with the River Chelt valley towards the crossing point of the Coombe Hill Canal.

Between chainages 13,357m and 13,362m the pipeline route will cross Wainlodge Lane as an open cut crossing as discussed in Section 5.6.

Immediately west of Wainlodge Lane at chainage 13,381m the route turns north to cross the Coombe Hill Canal and associated water courses. A review of publicly available information indicated that the Wainlodge Lane road bridge over the Canal forms the southwestern extent of the Coombe Hill Canal SSSI, and therefore the risk of interaction with the SSSI is reduced by taking the crossing downstream of this point.

Nonetheless it is proposed that the crossing of the canal and associated water courses will be completed as tunnelled crossings. The northern shaft will become a drain point for the main (DPH8). The pipeline to the north of the tunnel continues to gravitate towards the outfall point. Therefore, it is proposed to discharge drained effluent back into the continuing section of the pipeline rather than to the small water courses or the Canal itself which may pose a risk to the SSSI.

4.5.3 CHAINAGE 13,487 TO 15,051

From chainage 13,487m the route trends generally north across gently undulating open agricultural land towards the B4213. The pipeline crosses the B4213 between chainages 14,649m and 14,658m however the road is built up on an embankment and has ponds and water courses at the toe of the embankment on either side. Therefore, to mitigate any risks associates with disturbing the construction of the road embankment as well as to safely achieve the crossing of the ponds and water courses it is proposed that this crossing will be tunnelled between chainages 14,615m and 14,688m. The northern tunnel shaft at 14,688m will be used as the drain point, as with DPH8 it is proposed that this drain point (DPH9) will lift effluent back into the main pipeline for discharge to the river via the main outfall.

At chainage 14,688m the pipeline turns northwest towards the outfall point on the east bank of the River Severn approximately 50m upstream of the Haw Bridge River gauging station.

4.6 OPTION 3 - RIVER SEVERN EAST CHANNEL

Discharge route Option 3 diverges from Section 1 at chainage 3814m where it rises gently to chainage 4257m, where a new air valve will be required. The main then falls gently to the discharge point at chainage 4597m on the north bank of the River Severn East Channel between Llanthony Bridge and Castle Meads Way Bridge, as shown Figure 4-9 below

The entirety of this section is located within the boundary of the Alney Island Nature Reserve. However, to minimise the impact on the nature reserve the pipeline has been routed as much as possible to follow the alignment of the former railway line to Gloucester Docks.

However, the final section from chainage 4400m to the discharge point deviates from the route of the former railway through an area of mature trees to reach the riverbank. It is unavoidable that some significant vegetation clearance will be required in this area.

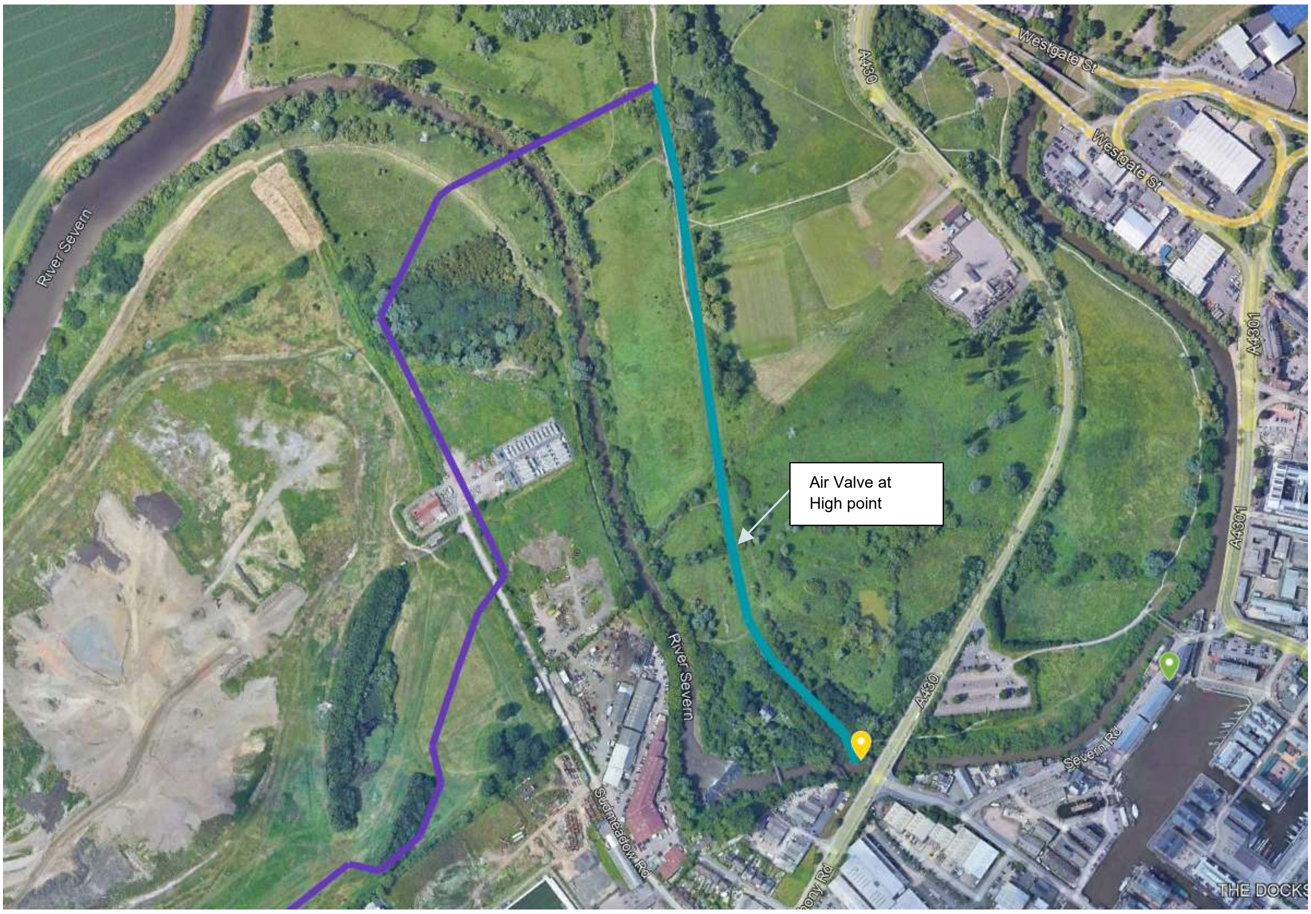

Figure 4-9 – Option 3 Discharge Route

4.6.1 DRAIN POINTS

There are no additional drain points downstream of DP2 at the southern shaft of the east channel crossing. The gradients of the pipe are such that the majority of the effluent will drain out of the pipeline at the outfall under gravity. The small amount of effluent “trapped” on the upstream side of the high point will drain back to DP2 and be pumped into the east channel tidal section.

4.7 OPTION 4 - DIRECT DISCHARGE TO G&S CANAL

Option 4 considers a discharge route direct to the Gloucester and Sharpness Canal.

Hydraulic analysis of this route has shown that due to the relatively short length of this main and low head differential a 600NB pipeline is applicable.

4.7.1 CHAINAGE 0 TO 248

The first section of the proposed main rises at a steady rate to the high point at chainage 248m. This section is located within land owned by STW. However, this section will be routed through an area of established woodland. Some of the woodland will need to be cleared permanently to provide an easement for the new pipeline at 7m wide, with an additional area of clearance required for the construction phase.

The pipeline route in this section also follows the alignment of an established public footpath. This will need to be diverted in the permanent case around the proposed treatment works extension. A temporary diversion of the footpath will also need to be put in place to allow the construction of the pipeline.

4.7.2 CHAINAGE 248 TO 559

From the high point at chainage 248m the pipeline falls steadily towards the outfall on at the Gloucester and Sharpness Canal at chainage 559m. The pipeline crosses Sims Lane between chainages 269m and 273m. Sims Lane is a narrow single-track road which provides access to a single property and farm. It is expected that this road crossing can be completed using open cut techniques. With a temporary access being created around the working area if required.

From chainage 300m the pipeline is routed through arable fields on the southern side of Sims Lane to the discharge point on the bank of the canal. The pipeline crosses below two of STW's pumped sewer mains which run parallel with the bank of the canal with a 350NB PVC at chainage 522mm and a 400 DI at chainage 529m.

4.7.3 RECIRCULATION PIPELINE

In addition to the transfer pipeline there is a need to construct a recirculation pipeline, show in orange in Figure 4-10, along the northern boundary of the WwTW back to the main WwTW main outfall to the River Severn. The recirculation pipeline to the main outfall is required during periods when the STT SRO is not demanding flows, to allow the additional treatment processes which cannot be shut down to be maintained.

Figure 4-10 – Option 4 Discharge Route and Recirculation Pipeline

4.7.4 DRAIN POINTS

There are no intermediate drain points required on the Option 4 pipeline. On suspension of transfer of flows to the canal the pipeline downstream of the high point will drain under gravity to the canal. While the first section of main will be drained back to the pumping station wet well via drain point on the pump manifold. This will then be transferred back to the main WwTW outfall when the transfer pumping is switched back to the recirculation pipe configuration.

4.8 OPTION 5 - SOUTHWEST REGION BRACH

Option 5 combines the routes of either Option 1 Deerhurst or Option 2 Haw with Option 3 River Severn East Channel. The aim of this option is to allow STW the option to be able to supply the STT (assuming the northern route from Deerhurst is adopted), and to support the abstraction of additional flows from the River Severn East Channel into the Gloucester Docks via the existing CRT screw pumping station to allow levels in the canal to be maintained if Bristol Water require additional raw water for the Purton Works at the southern end of the Canal.

To allow this these options to be combined and allow flow switching between the two discharge routes it is proposed to install a flow splitting arrangement comprising a tee with a gate valve on each branch.

Figure 4-11 – Flow Splitting Location to Enable Option 5

Due to the remote location of the tee (within the Alney Island Local Nature Reserve and the relative infrequency that flows will need to be switched it is proposed that the valves will be manually controlled. The flow splitting arrangement is to be located close to the existing access track and the valves will be buried. Therefore, it is unlikely that any additional access provision will be required for this location.

5 PIPELINE CONSTRUCTION

5.1 GENERAL

It is assumed that the transfer pipeline throughout its length will be constructed using open cut trenching techniques, except at specific strategic crossing points where trenchless, jacked micro-tunnelling techniques will be employed. It is anticipated that the working area will comprise a 20m to 25m working strip along the length of the proposed pipeline route. Topsoil will be removed for this working strip and carefully stockpiled for reinstatement. Pipe lengths will be strung out along the working area in advance of the excavation. The excavation would generally be offset to one side of the working strip allowing space for the temporary stock piling of excavated material, as well as the establishment of a haul road for plant and materials and a safe pedestrian access route in the vicinity of the working zone. Typically, the working strip would be fenced with post and wire fencing and the topsoil stripped and stockpiled for the duration of the works within that section.

It is assumed that the pipeline installation will be completed in vertically sided (supported with trench boxes or drag boxes) or battered excavations depending on depth, ground and groundwater conditions.

Where possible the depth of the pipeline typically ranges between 0.90m and 2.3m below ground level (bgl), however there are some local areas where excavations are unavoidably deeper due to undulations in topography and the need to manage the number of high and low points to allow the pipeline to be drained.

5.2 MATERIAL SELECTION

The hydraulic analysis shows that the maximum steady state working pressure of the pipeline will be a maximum of 5.4 bar. This occurs at the transfer pumping station for Option 1 Deerhurst and comprises a combination of static and friction heads. Option 1 is the longest pipeline and has the highest elevation to overcome. All other route options result in a lower steady state working pressure.

Leading on from Gate 1, Gate 2 has progressed with the assumption that the pipeline will be constructed using ductile iron pipe. Standard ductile iron pipe has a maximum working pressure rating of 16 bar and is therefore well suited to this application.

Ductile iron pipework has a number of advantages when compared to other materials such HDPE and steel, including:

- Speed of laying, ductile iron pipes can be readily pushed together without the need for complex and time-consuming welding. Typically, in open ground laying rates of >50m per day can be achieved.
- Ductile iron pipes are classed as semi-rigid (BS9295) as such the structural performance is not as heavily reliant on the quality of pipeline bed and surround and the need for this to act as a composite with the pipeline as with flexible pipe materials such as HDPE and steel. As a result, this allows the pipes to be installed and backfilled with selected excavated materials rather than imported granular materials which has many benefits including:
  - Less waste generated for disposal;
  - Less imported material required;

- Fewer vehicle movements for imports and exports; and
- Lower embedded carbon value.
- End-load resistant push fit joints can be used to create an anchorage system to provide restraint to thrust at changes of direction and testing points allowing it to mimic the performance advantages of welded jointing systems associated with HDPE and steel joints.

Where the pipeline is required to cross the existing road network, it is anticipated that the pipeline will be installed with a full granular bed and surround BS9295 Class S1. With the trench fill comprising compacted Type 1 granular sub-base or foam mix concrete between the top of the granular material and the underside of the road construction.

For the Netheridge SRO scheme there are no overriding factors that dictate pipe material selection. The contractor preference in construction methods and the price of materials at the time of construction will inform a cost benefit analysis.

5.3 GROUNDWATER CONTROL

It is anticipated that, for the majority of the transfer pipeline route, groundwater ingress into excavations will be readily controlled using traditional sump pumping techniques. It is noted that a high groundwater table has been observed in the vicinity of Alney Island and more advanced groundwater control may be required in this area.

Care will be required to ensure that the formation level of the excavations is not disturbed by groundwater ingress through the base of the excavation ("boiling" of the base in granular deposits and/or heave and blow in cohesive deposits).

Disturbance of the formation level can lead to undue amounts of settlement upon backfilling of the trenches, which can lead to deviations in line and level of the pipeline or excessive pulling of flexible joints leading to risk of failure of the pipeline. Should a detailed ground investigation indicate that groundwater will pose a significant risk to excavation stability, specialist techniques such as groundwater exclusion with overdriven interlocking sheet piles or groundwater draw down with well point systems may be required to ensure a dry and stable excavation.

Groundwater is likely to be encountered during shaft sinking and tunnelling operations. As such it is expected that shafts will be sunk using balanced head or caisson techniques to ensure the stability of formation level prior to construction of the base of the shaft. It is expected that tunnelling will require the use of a jacket micro-tunnel boring machine equipped with a pressurised face to ensure that any groundwater (and in the case of river crossing, river water) is excluded from the tunnel.

5.4 RIVER AND MAJOR WATER COURSE CROSSINGS

Major infrastructure crossings below a main river are exempt from the requirements of a Flood Risk Activities Permit (FRAP) providing that they are constructed at a depth greater than 1.5m below the riverbed along its entire length. A 700NB pipe is generally considered too large for installation by directional drilling techniques. It is likely that the pipeline will be installed within an oversized tunnel sleeve, typically of 1000-1200mm NB of steel or concrete construction, installed by micro-tunnelling / pipe jacking techniques. A typical arrangement for a tunnel construction is shown in Figure 5-1.

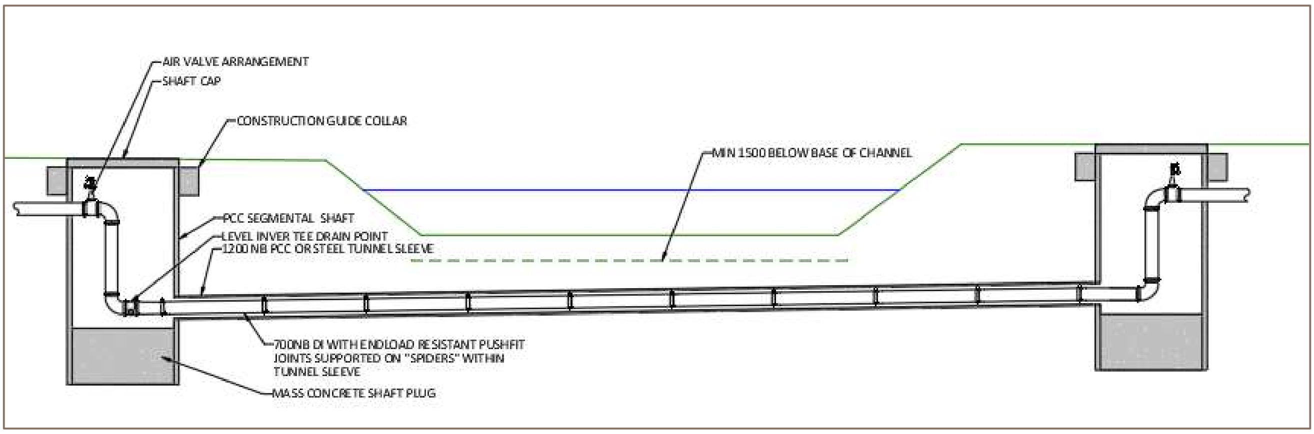

Figure 5-1 – Typical Tunnel Arrangement Below Major Water Course

It is likely that the depth of the tunnel below the riverbed could be significantly greater than the minimum required 1.5m. Many factors influence depth of the tunnel including identification of a suitable and consistent tunnel horizon material and risk of “breakthrough” at the tunnel face of water from the overlying water body.

5.5 RAIL CROSSINGS

The transfer pipeline route to Deerhurst and Haw Bridge (Options 1 and 2) requires the crossing of the Gloucester to Lydney railway line. At the proposed crossing point the railway line is elevated above the surrounding ground on an embankment to allow it to cross both the River Severn and the River Severn East Channel. See Figure 5-2 below.

Figure 5-2 – Rail and Road (A40) Crossing Points

At Gate 1 it was proposed to cross the railway line using one of the existing arches in the viaduct over the River Severn East Channel. However, subsequent investigations and the findings of the utilities searches show that all viable routes under these arches are occupied with existing high voltage electricity cables.

At this stage Network Rail have not been engaged to discuss the pipe crossing. It is likely that the crown of the proposed crossing will need to be a minimum depth of 5m below the level of the running rail and constructed in a stratum and at a depth where predicted settlement at the rail head is less than 5mm. Similarly, it is a requirement that pressure pipelines are constructed within an oversized sleeve to ensure they contain water and minimise the risk of disruption of railway in the event of the rising main bursting. Figure 5-3 shows a typical crossing point arrangement.

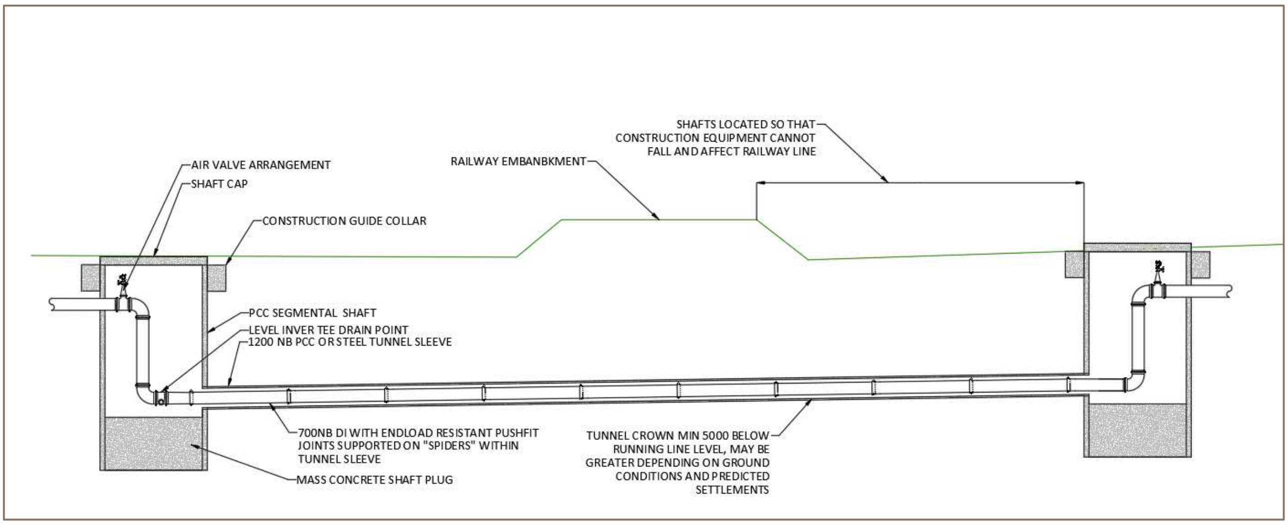

Figure 5-3 – Rail Crossing Tunnel Typical Arrangement

5.6 ROAD CROSSINGS

The transfer pipeline routes have been selected to minimise the likely impact on the existing road network. However, where road crossings are required, the pipeline has been routed such that it will cross perpendicular to the road alignment to minimise the impact on the road.

It is assumed that pipeline construction across minor roads including B class roads will be possible using traditional open cut trenching techniques under full road closures or where this is not possible the crossing will be constructed in two halves under single lane road closures.

The pipeline routes to Deerhurst and Haw Bridge (Options 1 and 2) are required to cross both the A40 and the A417 on the approach to the Over Causeway roundabout. In both cases these roads are on elevated viaducts. A preliminary site inspection indicates that there is sufficient headroom below the viaducts to allow construction using traditional open cut trenching techniques, providing height restricted equipment is used to prevent bridge strikes. See Figure 5-2 for location of the A40 crossing points and Figure 5-4.

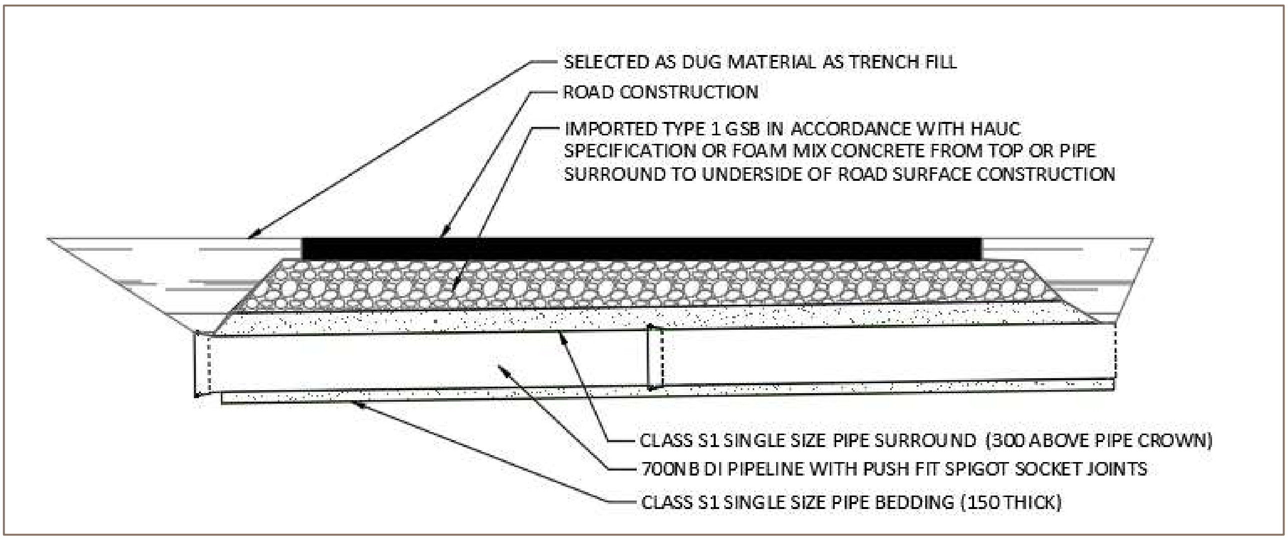

Figure 5-4 – Open Cut Road Crossing Typical Arrangement

5.7 SMALL WATER COURSE CROSSING

It is anticipated that for small water courses it will be possible for the pipeline to cross using open cut trenching techniques. It is assumed that these crossings will be in accordance with STW SDD 6061 with the crown of the pipeline a minimum 1m below the bed of the water course. It is also assumed in constructing these crossings it will be possible to cut off flows using a pair of overdriven interlocking sheet pile walls. If flow conditions require, over pumping will be used to locally transfer water while the crossing is being constructed.

No contact with the EA or local council drainage board has been made during the Gate 2 design process to determine the water course classification of any of these small water courses. It is recommended that the water course classification is determined in advance of the detailed design. The water course classification and hence regulatory body will likely have an impact on the nature of crossing design that is permissible at each location.

5.8 TESTING AND THRUST RESTRAINT

It is recommended that provision for pressure testing the transfer pipeline is to be made at circa 1000m intervals in the form of a bolted flange connection, tied flange adaptor with a removeable 2m long spool pipe to give the flexibility for testing.

Thrust blocks or pipes with end load resistant “anchored” joints should be used to provide thrust restraint at all changes of direction and testing points where thrust forces will be generated. Given the likely presence of soft alluvial ground conditions expected along the Netheridge pipe route, traditional mass concrete thrust blocks would be large and slow to construct. This, combined with the relatively low operating pressures in the pipeline (circa 5 bar) means the targeted utilisation of anchored jointing systems would simplify construction, reduce the carbon footprint, and increase productivity.

5.9 CONSTRUCTION DELIVERY AND PROGRAMME

The construction programme will be subject to the winning tendering contractor and any restrictions imposed on them. However, an initial construction programme estimate has been prepared as a guide. An indictive programme for the earliest delivery of the Netheridge SRO is shown in Figure 5-5.

5.9.1 OPTIONS 1, 2, 3 AND 5

The construction of the pipeline is dependent on the number of pipe laying crews involved in the works. Based on a production rate of 40m per day and a standard five-day working week, the construction of the pipeline to Deerhurst would take approximately 83 weeks excluding works to test and commission the pipeline and construction easement reinstatement. Civils and tunnelling works could be undertaken concurrently. A likely construction programme for the Deerhurst pipeline (18km) would be approximately 24 months.

5.9.2 OPTION 4

The Option 4 pipeline is less than 600m in length and would likely be constructed concurrently with other civils works as part of the treatment works upgrade contract.

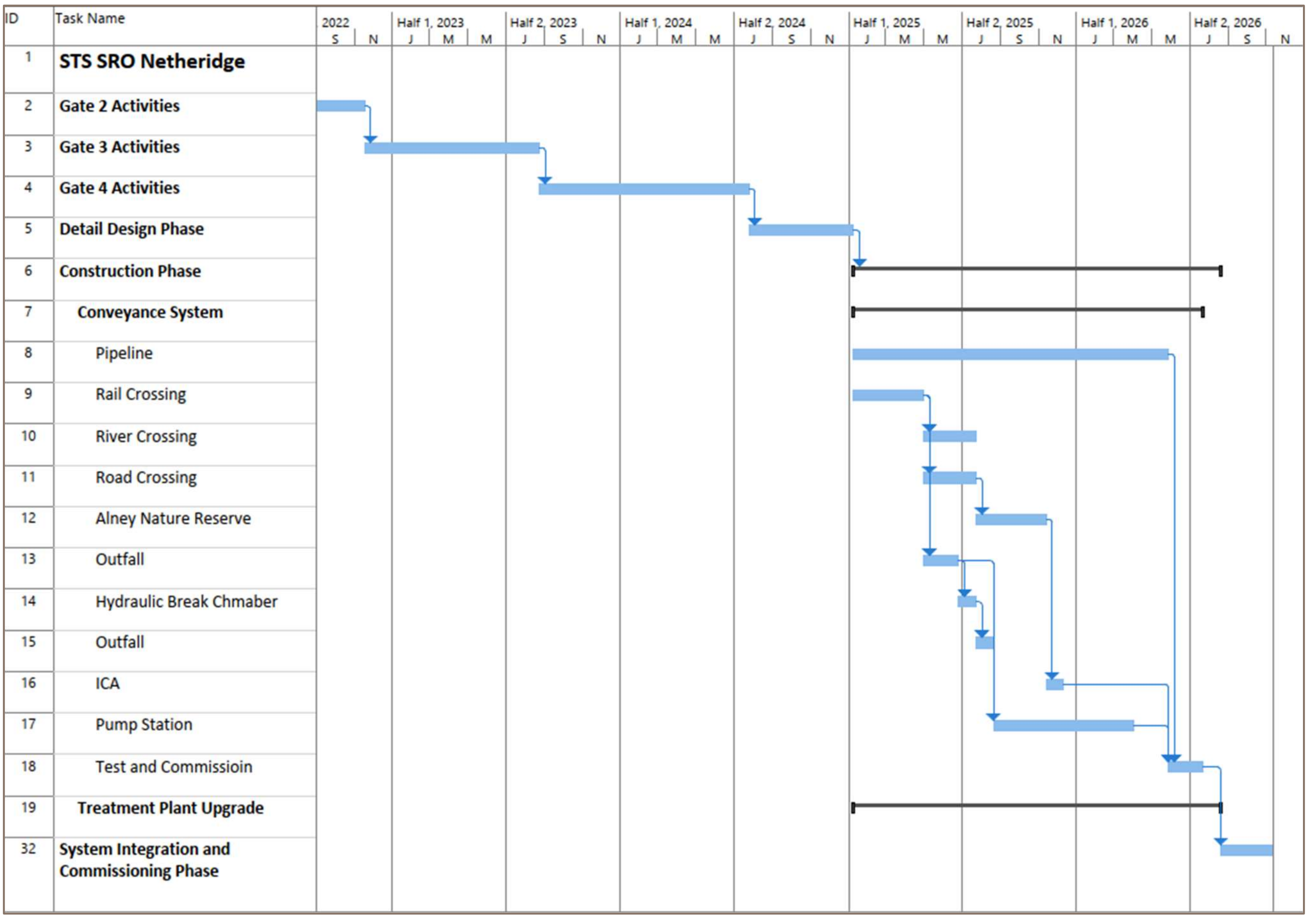

Figure 5-5 – Pipeline Indicative Programme

6 OPERATION AND CONTROL

6.1 OPERATIONAL PHILOSOPHY

The Netheridge SRO will operate in conjunction with the STT SRO, with the transfer of treated effluent occurring on an 'on demand' basis determined by the STT SRO.

When not in use the transfer pipeline will be drained and left empty to avoid risk of septicity. Some elements of the Netheridge SRO treatment process will operate on a continual basis to ensure viability of the biological processes. The remaining treatment processes will be decommissioned when not in use. When not transferred to the STT SRO, treated effluent will be discharged to the River Severn via the existing WwTW outfall.

The STT SRO will provide at least 17 days' notice of the requirements for 'sweetening' flows (20 Ml/day) or full operational flows (35Ml/day). This period will allow for the recommissioning and testing of the full treatment process, priming of the pipeline and testing of the pump system.

The Netheridge SRO will operate for at least 20 days at any one time. When treated effluent is no longer required by the STT SRO, flow diverted to the Netheridge SRO treatment processes will be reduced to a minimum to ensure viability or decommissioned and left ready for recommissioning when next required. The pipeline will be drained manually to local watercourses, as determined by the topography and pipe hydraulics. Draining of the pipeline will be carried out over a period that will allow adequate dilution in the water course but prevent the content of the pipeline becoming stagnant and septic prior to discharge.

6.2 PIPELINE FLOW MONITORING

Flow monitoring is required on the transfer pipeline, to accurately measure the flows delivered to the abstraction point of the STT SRO scheme, and to ensure a quick response to any break or leakage from the pipeline that could result in an effluent spill.

It is proposed to install a standard electromagnetic flow meter on the initial section of transfer pipeline within the boundary of Netheridge WwTW, immediately downstream of the transfer pumping station on the section that is both recirculation and main transfer main.

It is also necessary to monitor flows at the discharge end of the pipeline to ensure that all directed flows are reaching the discharge point. Due to the remote locations of the discharge points, there would be a need to install a power supply to power a traditional flow monitor. Additionally, the discharge sections of the main operate with gravity flows and may not run full and as such traditional electro-magnetic meters are unlikely to read correctly. Therefore, it is proposed to utilise remote flow monitoring systems to measure the head of water flowing over the weir of the discharge chamber. These systems are battery operated and fitted with a mobile sim card to allow them to dial into the regional control system and periodically upload flow monitoring results. These systems can be used to raise an alarm of pipeline failure if no or lower than expected flows are recorded compared to the main flow meter.

7 CIVIL STRUCTURES

7.1 PIPELINE DRAIN POINTS

Due to the intermittent nature of the operation of the transfer pipeline, it is necessary to be able to drain the main to prevent the effluent stagnating during periods when transfers are not required. If the effluent becomes stagnant it could be an issue for water quality as the main is returned to operation.

To combat this, it is proposed to drain the main at various locations along its length. Drain points generally consist of tunnel shaft locations and standalone drain points. Refer to Table 7-1 for details of the drain point location, type, and proposed discharge location.

7.1.1 TUNNEL SHAFTS

Drain points are to be located in one of the tunnel shafts at each of the tunnel crossings, for each option. In these locations it is proposed that the effluent will discharge into a small wet well, constructed within the tunnel shaft with a suction riser to the surface for the connection of mobile pumps.

Where tunnels are located near major water courses it is proposed to discharge the drained effluent into the adjacent water course. At other locations such as at the railway line crossing, it is proposed to lift effluent out of the tunnel shaft and discharge it back into the rising main to allow it to flow under gravity to a drain point with an appropriate water course discharge.

7.1.2 STANDALONE DRAIN POINTS

Due to factors such as topography and practical depths of excavations it has not always been possible to locate drain points at shafts. As such there is a need for intermediate drain points to be constructed away from tunnel shafts. In this case it is proposed to construct a small standalone pumping well similar to that of STW STD1018 Pumping Station, but without the pumps and associated M+E infrastructure. This will be connected to the main pipeline via a level invert tee with dual isolating valves.

Where possible these additional drain points have been located close to large water courses to allow the treated effluent to be discharged locally without the need for long rising mains.

7.1.3 OPERATION AND POWER

It is recognised that these drain down pumping stations will only be required for a short duration, typically once a year, at the end of the operational cycle for the pipeline. It would not be economical to install permanent pumping stations with multiple dedicated pumps, MCC and control kiosks as well as a new permanent power supplies. Instead, it is proposed that these drain points should be operated by mobile pumps which can be transported on or towed by the operations team normal transport vehicles.

It is proposed that the wet wells will be equipped with a suction riser with a Bauer coupling rather than fixed pumps, similarly, there will be a Bauer coupling on the drain point discharge rising main to allow the mobile pump to be connected. Adopting this approach removes the need for the purchase and maintenance of pumps, MCC kiosks and provision of a new power supply to each of the drain down locations.

7.1.4 COMPOUNDS AND ACCESS

A minimum of twice-yearly vehicle access will be required to each of the drain down points, to allow them to be maintained and checked prior to pipeline operation and allow the drain downs to be operated. New permanent access roads and compounds will be required at each of the proposed drain points to allow safe access, operation, and maintenance of the drain point. It is envisaged that the drain down compounds will be arranged in a similar arrangement that of a standard pumping station arrangement as shown in STW STD1016 Sewage Pumping Station Template Site Layout.

Planning permission will be required for each of the drain down point compounds and associated access tracks.

7.1.5 SUMMARY OF DRAIN DOWN POINTS

The following table shows the anticipated locations for the pipeline drain down points. These locations are based on the low points.

Table 7-1 – Summary of Pipeline Drain Points and Volumes

Drainage Location	Drain Point Ref	Start Ch (m)	End Ch (m)	Vol m3	Time to Drain @ 10l/s	Flow Rate (l/s) to Drain in 3 Days	Drain Point Type	Discharge Point + Notes
Section 1 Opt 1,2+3								
CH 1838	DP1	0	3100	1193	33.1	4.603	Standalone PS	Small un-named water course / drainage ditch. Includes WwTW section.
Section 2 Opt 1+2								
CH 3600	DP2	3100	4140	400	11.1	1.544	Shaft	River Severn East Channel (Tidal).
CH 4411	DP3	4140	4411	104	2.9	0.402	Shaft	Lift from rail tunnel back into rising main at tunnel shaft.
CH 4749	DP4	4411	6200	688	19.1	2.656	Standalone Grav	Discharges under gravity to River Severn East Channel
CH 6274	DP5	6200	7550	520	14.4	2.004	Shaft	Pumped to River Severn East Channel
CH 7600	DP6	7550	11593	1556	43.2	6.003	Standalone PS	Pumped to Cox's Brook
Option 1 Deerhurst								
CH 12200	DPD7	11593	13900	888	24.7	3.425	Shaft	River Chelt
CH 14025	DPD8	13900	16695	1076	29.9	4.150	Standalone PS	Small Water Course Adjacent to Coombe Hill Canal
Outfall		16695	17047	135	-	-	Outfall Structure	Drain out naturally at outfall
Option 2 Haw								
CH 12786	DPH7	11593	13380	688	19.1	2.653	Shaft	River Chelt

Drainage Location	Drain Point Ref	Start Ch (m)	End Ch (m)	Vol m3	Time to Drain @ 10l/s	Flow Rate (l/s) to Drain in 3 Days	Drain Point Type	Discharge Point + Notes
CH 13487	DPH8	13380	13487	41	1.1	0.159	Shaft	Lifts to main pipeline to be transferred to outfall
CH 14688	DPH9	13487	14688	462	12.8	1.783	Shaft	Lifts to main pipeline to be transferred to outfall
Outfall		14688	15051	140	-	-	Outfall	Drain out naturally at outfall
Options 3 East Channel								
CH 3600	DP2	3100	3813	274	7.6	1.059	Shaft	River Severn East Channel (Tidal)
Outfall		3813	4605	305	-	-	Outfall	Drain out naturally at outfall
Option 4 G+S Canal								
Pumping Station Manifold		0	248	95	2.7	0.368	Manifold Drain down	Drain Valve to Wet Well
Outfall		248	559	120	-	-	Outfall	Drain out naturally at outfall

7.2 HYDRAULIC BREAK CHAMBER

For a pumped rising main, the idealised pipeline profile is continuously rising to its discharge. For the Options 1 (Deerhurst) and 2 (Haw Bridge), the pipeline profiles include a high point in the route somewhat upstream of the outfall location, with a downhill profile from this high point. Without a hydraulic break, these high points would lead to siphoning of flows with a corresponding negative pressure in the main. This condition is non-preferred as it could exacerbate transient negative pressures and complicates the filling and draining of the pipeline. By providing a hydraulic break in the form of a chamber at the crest of the profile, the rising section is separated from the final falling section, simplifying hydraulic design and pump operation.

The hydraulic break chamber will allow air into the pipeline at the head of the gravity system and prevent negative pressures being developed. Given the capacity of the main it is unlikely that sufficient air can be let into the system using air valves, therefore a hydraulic break chamber will be required at these high points.

A 5m high vent stack should be incorporated into the design to allow air to be drawn into the chamber safely and without causing suction currents at the surface. The design of any access chambers should be carefully considered, particularly if they are designed to be opened when the main is in operation due to the risk of suction currents when covers are first opened.

A typical design for a hydraulic break chamber is given in Figure 7-1.

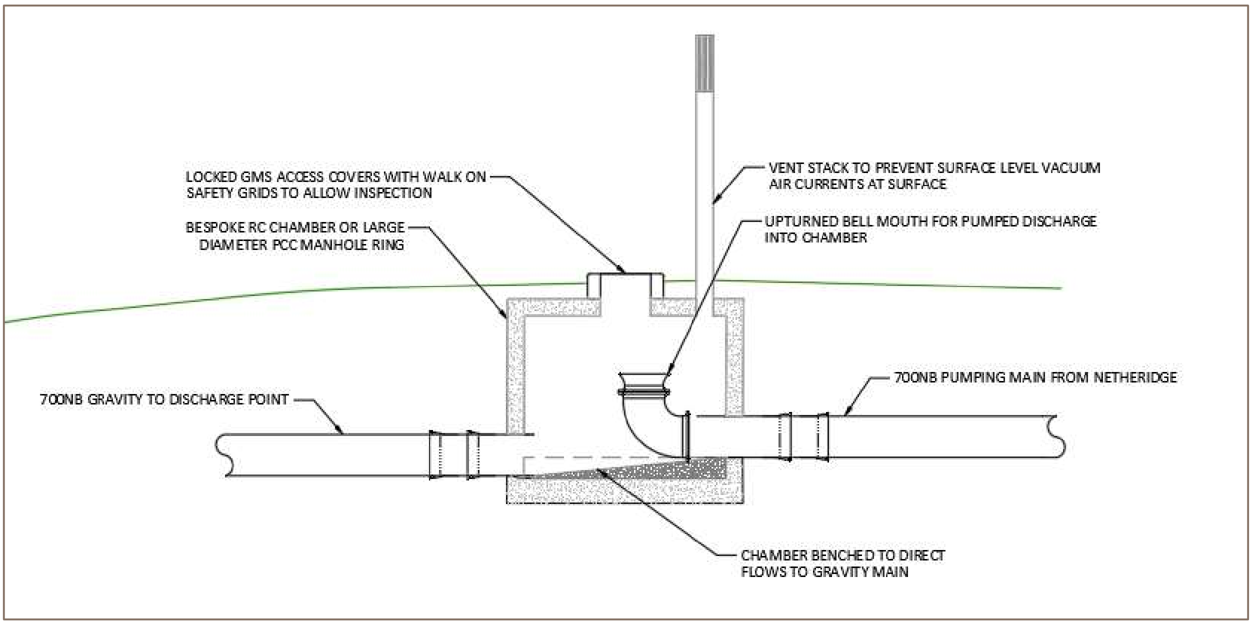

Figure 7-1 – Typical Hydraulic Break Chamber Design

7.2.1 ACCESS

It is anticipated that a minimum of once yearly vehicle access will be required at the hydraulic break chamber, to allow it to be inspected and maintained prior to pipeline operation.

A new permanent access road and compound will be required to allow safe access, operation, and maintenance of the break chamber. It is envisaged that the break chamber compound will be arranged in a similar arrangement that of a standard pumping station arrangement as shown in STW STD1016 Sewage Pumping Station Template Site Layout. Planning permission will be required for the compound and associated access track.

7.3 OUTFALL STRUCTURE

A new outfall structure will be required at each of the proposed discharge locations. It is proposed that the outfall structure for each of the options shall be a submerged type outfall as opposed to a bank side outfall cascade. It is preferable and considered good practice to use submerged outfall structures where high volume and or high velocity discharges such as WwTW, industrial or Hydroelectric waters are to be discharged to the natural environments.

A bank side cascade style outfall was considered however a submerged type outfall has several advantages over a traditional bank side cascade outfall including.

- Better flow mixing, by discharging the flows directly into the river channel close to the centre of the flow where there is a greater degree of instantaneous dilution and mixing compared to a bank side outfall where a “plume” of un or poorly diluted effluent can track the bankside for a distance downstream of the outfall.
- Reduced risk scour and erosion. With a submerged outfall the weir chamber (and hence the main hard engineering structure, is set back from the riverbank edge with only the buried pipeline entering the river channel. The soft superficial deposits are prone to erosion by water flow particularly if hard structures are added to the bank. Where these structures interface with the water flow, disturbances in flow patter and eddies result in increased erosion around the structure. At times of high flow this can lead to significant and rapid bank erosion and cause instability of the structure if adequate protection is not installed. In comparison with a submerged outfall, the “soft” natural riverbank material and vegetation can be rapidly excavated, re-established and the surface provided with temporary reinforcement to reduce the risk of loss of the soft material.
- Reduced visual impact on the riverbank, given that a bank side outfall for a 700NB pipeline discharging flows in excess of 500l/s will be substantial. In comparison a submerged outfall would be relatively concealed from public view.
- Reduced maintenance requirement. An outfall cascade is open to the elements as a result will be more likely to suffer natural degradation as well as being at increased risk of vandalism. As a result, regular and more onerous maintenance such as vegetation removal, point and concrete repairs are likely to be required. In comparison, the submerged outfall is all underground / below the water line with only the access covers exposed and as a result will be less susceptible to damage / degradation.
- Reduced bank side or riparian habitat loss, either through the direct removal of vegetation by the construction, or indirectly by exacerbating bank side erosion and bank collapse.

- Improved health and safety:
  - Large diameter outfall structures pose a confined space entry risk. There is often high temptation for persons, particularly children, to enter outfall structures out of curiosity especially in situations where bar screens or flap valves become damaged and can be bypassed;
  - Falls from height, construction of a large diameter outfall and associated headwall structure could result in serious injury; and
  - Risk of sudden water discharge following pump switch on, leading to a risk of persons, animal or objects being swept away, injured, or killed. This risk is significantly reduced with a submerged outfall. However, strong underwater currents can be generated, and appropriate warnings will be required.

There are many advantages to the employment of a submerged discharge arrangement however a traditional bank side cascade could still be used in this application. Further consultation should be held with the EA and other interested parties prior to a final design being developed.

7.3.1 EEL PROTECTION

The River Severn is known to be a habitat for European eels and their young (elvers / glass eels). Eels are critically endangered and considered a red list species and as such there is a requirement to project eels from damage or death as a result of entering an intake or outfall.

Current EA guidance[5] recognises that it is not generally viable to install fine eel screens on outfalls to exclude elvers due to the very high associated hydraulic losses. Electric based barriers could be considered; however these need to be assessed on a case-by-case basis and may not be safe or practicable to install.

Further EA guidance for eel and elver protection is to set an outfall above normal river level so that it is not possible for elvers to ascend and enter the pipework. However, this guidance opposes the principles and benefits of a submerged outfall discussed above.

7.3.2 OUTFALL DESIGN

In order to satisfy both situations consideration should be given to the construction of a submerged outfall combined with a hydraulic break weir chamber. The hydraulic break chamber will likely include a weir wall and stilling basin arrangement. The inside of the chamber and weir should be vertical and finished such that elvers cannot climb over the weir and access the pipeline. The chamber should be self-draining by installing drain points at the base of the weir wall; however, these drains will require eel screens to be installed to prevent passage.

A conceptual arrangement for the outfall arrangement is shown in Figure 7-2 below.

[5] The Eel Manual - GEH00411BTQD-E-E, Screening at Intakes and Outfalls: Measures to protect eel.

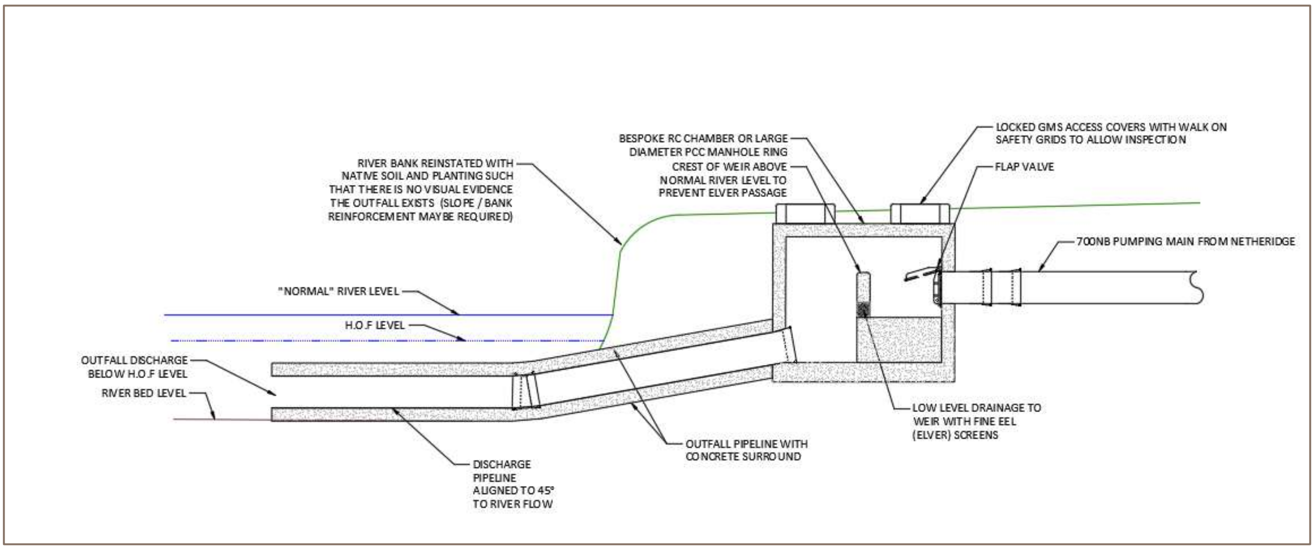

Figure 7-2 – Typical Outfall Design

Further works to develop the outfall design and ensure eel protection compliance are required at the next stage. Including consultation with the EA and Natural England.

7.3.3 ACCESS

It is anticipated that a minimum of once yearly vehicle access will be required at the outfall structure, to allow it to be inspected and maintained prior to pipeline operation.

A new permanent access road and compound will be required to allow safe access, operation, and maintenance of the outfall. It is envisaged that the outfall compound will be arranged in a similar arrangement to that of a standard pumping station arrangement as shown in STW STD1016 Sewage Pumping Station Template Site Layout.

Planning permission will be required for the outfall compound and associated access tracks.

8 HYDRAULIC DESIGN

A preliminary level of hydraulic design has been undertaken to inform the feasibility and engineering scope associated with each option. The primary consideration for concept design is the steady-state hydraulics. The basis for this assessment aligns with the treatment design basis of 200 – 550 l/s. The results of these calculations are presented in Technical Note Netheridge SRO Steady State Hydraulics (Appendix A).

The key conclusions of the hydraulic assessment as relevant to the pipeline route selection are:

- [redacted]mm diameter pipelines are proposed for Options 1, 2 and 3;
- A [redacted]mm pipeline is proposed for Option 4; and
- Hydraulic break chambers are required at final high points on Options 1 and 2 to allow the transition between pumped and gravity flow regimes and prevent siphoning of flows.

9 RISKS AND UNCERTAINTIES

As part of the Gate 2 design process the following risks and uncertainties have been identified which need further investigation to enable mitigation and control in the next stages:

- **Route of pipeline with Netheridge WwTW** – further survey works are required to clearly define the route through the WwTW and avoid the existing services and process pipelines;
- **Ground and groundwater conditions** – a full geotechnical and contamination ground investigation is required when the preferred option is defined;
- **Errors and uncertainty in the LiDAR Data** – the available LiDAR data is affected by thick vegetation resulting in inaccuracies. Further detail surveys are required along the route of the preferred option during Gate 3;
- **Utilities crossings** – further details for key utilities crossings are required;
- **Major infrastructure crossings** – rail consultation is required with Network Rail;
- **Drain points discharge consents** – consultation is required with the Environment Agency and local drainage board;
- **River and water course bed levels** – river and watercourse bed level information are required to allow the crossings to be appropriately designed; and
- **Increased number of tunnelled sections** – risk that it is not possible to cross minor water courses with open cut trenches resulting in a need for additional tunnelled sections.
- **Environmental Risk** – Formal environmental screening has not been completed. It is expected that a full Environmental Impact Assessment (EIA) will be required as part of the overall STS and Associated Development DCO process.
- **Endangered and Protected Species** - mitigation for protected and endangered species is likely to be required resulting in increased cost and time.
- **Management of Contaminated Land** – If encountered contaminated land management and disposal is likely to be required resulting in increased cost and time.

10 NEXT STEPS

10.1 ENVIRONMENT AND ECOLOGY

10.1.1 ENVIRONMENTAL ASSESSMENTS

It is understood that the upgrades to the treatment process at Netheridge WwTW and associated pipeline is considered Associated Development to the STS SRO DOC. Therefore, it is expected that the scheme will fall under the overall EIA requirement of the DCO process. Therefore, it is assumed that an EIA will be required for the whole of the Netheridge SRO scheme, (Treatment works upgrade and pipeline install).

When the preferred discharge point and hence pipeline route has been confirmed, an environmental screening process should be commenced along with early consultation around the need for a formal Environmental Impact Assessment, (EIA) for all or key parts of the scheme.

10.1.2 DRAIN DOWN DISCHARGES

Preliminary discussions have been had with the environmental consultant around the discharges of drained effluent. Further discussion will be required and approval in principle for discharge consents will need to be obtained during the next phase to ensure that the "operate and drain" model is viable.

The capacity of the proposed receiving water courses, particularly the small watercourses at DP1, DP6 and DPD8 should be checked to ensure that they are suitable and capable of receiving the proposed discharge volumes in a short period of time.

10.1.3 WORKS IN ALNEY ISLAND LOCAL NATURE RESERVE

It is recommended that early discussions are had with Gloucestershire County Council and the charities and organisations that own and maintain the Alney Island Local Nature Reserve to discuss the transfer pipeline construction as well as any environmental off setting, improvements and mitigations that could be implemented as part of the construction reinstatement.

10.2 GEOTECHNICAL

The following geotechnical investigations are required in the next stage to inform the pipeline design:

- Review and update geotechnical desk study report, hazard map and geotechnical risk register. At this stage no significant geotechnical hazards are expected to be encountered along the proposed pipeline route;
- Further investigation into the extent of the land filling operations at the now closed Hempsted landfill is required, which will require consultation with the site operator and the analysis of site records; and
- Undertake geotechnical ground investigations along pipeline route to confirm ground and groundwater conditions when the preferred option is defined.
- Investigate the possible presence and confirm the type of residual ground contamination associated with the former railway yard and sidings on Alney Island.

10.3 CORROSION PREVENTION

10.3.1 SOIL RESISTIVITY SURVEYS

The current design considers a ductile iron main. The ground conditions are known to vary along the proposed pipeline route. As such it is recommended that consultation is undertaken with pipeline manufacturers and consideration be given to undertaking a soil resistivity survey in addition to a standard geotechnical ground investigation. The purpose of this is to determine if additional protective measures, over and above standard pipeline coatings, will be required in sections along the proposed pipeline route.

10.3.2 CATHODIC PROTECTION

The proposed transfer pipeline crosses and runs parallel with a significant number of high voltage cables. The presence of cables in close proximity to the main has the potential to cause increased corrosion rates on metallic mains. Therefore, consideration should be given to the need for cathodic protection on the main to mitigate this risk.

10.4 TERRAIN MAPPING

Current digital terrain models for the transfer pipeline route have been prepared using freely available LiDAR data obtained from the EA data source. This data has limited accuracy. Additional data with increased levels of accuracy should be obtained for the next design stages. It is recommended that the additional data gathering should include the surveys outlined in the following sections.

10.4.1 TERRESTRIAL TOPOGRAPHICAL SURVEYS

Traditional terrestrial topographical surveys should be completed in specific areas to ensure they capture key details and features in strategically important areas such as:

- River and other major water course crossings - a survey of both banks and areas with tunnel shaft construction works are to take place is required;
- Rail crossing - survey of the area where tunnel shafts are to be constructed is required, the survey should also access the railway property and survey details of the embankment, as well as position and level of the running rails. These levels are key in the design and suitability assessment for the tunnel crossing;
- Road crossings - survey of all major and minor road crossings is required. To confirm road levels, presence of kerb line, surface water gullies and other street furniture, survey areas at road crossings should extend to include adjacent hedges and drainage ditches to ensure that the ground profiles on the approaches to road crossings are accurate and sufficient pipeline cover is achieved; and
- Pipeline permanent access points - it also recommended that traditional topographical surveys are completed in areas where new permanent access points, track and compound areas are to be created.

10.4.2 LIDAR – IMPROVED ACCURACY

Improved accuracy LiDAR data should be obtained for the proposed pipeline route, typically using a UAV (drone). The survey should include a buffer of typically 30-50m either side of the proposed centre line of the pipeline to allow local variations in route to be made. The use of such data has been found to be fast and cost effective when compared with traditional terrestrial topographical surveys for long cross-country pipelines such as this.

10.4.3 BATHYMETRIC SURVEYS

At present no information has been obtained relating to the depths of river channels at the key crossing points on the River Severn East Channel, River Chelt and Coombe Hill Canal. It is recommended that a bathymetric survey of the channels of these water courses is completed over an area of approximately 30m upstream and downstream of the proposed crossing points to allow channel profiles and cross sections to be generated and included in the design considerations. This information should be used in conjunction with a marine based geotechnical investigation to allow the design of the tunnel crossings of these elements.

10.5 UTILITIES

It is recommended that early engagements are made with the previously identified Statutory Undertakers with discussions around the proposed transfer pipeline alignment and construction techniques taking place.

During the next stage, it will be important to determine the material of construction, depth, working pressures, voltages and minimum separation requirements between the existing utilities and the proposed pipeline. It will also be necessary to determine if there are and to what extent existing easement agreements are in place for the existing utilities.

All of these factors could have a bearing on the final alignment of the transfer pipeline route.

10.5.1 OVERHEAD ELECTRICITY DIVERSION, HEMPSTEAD LANDFILL

It has been identified that the proposed transfer pipeline route and depth of excavations required could be improved if a corridor currently occupied by twin OH HV cables could be used for the proposed pipeline. As such it is recommended that early engagement and discussions take place with Western Power to discuss diverting the existing overhead cable underground to create a corridor for the pipeline as well as to facilitate a safe working area for construction of the pipeline.

10.5.2 NETHERIDGE WWTW

Limited as built records have been received for this area and further investigation is required to locate and confirm a clear route for the pipeline.

It is recommended that a combination of non-intrusive (GPR) and intrusive surveys (trial pits and trenches) are completed during the next design phase to confirm the locations of all inground hazards and allow a suitable route through the works to be designed.

10.6 LAND OWNERSHIP

A number of key stakeholders likely to be affected by the pipeline development have been identified during Gate 2 process and should be consulted early in the next phase, these include:

- Environment Agency, (river and water course crossings);
- Gloucestershire County Council, Highways and Local drainage departments;
- Alney Island Nature Reserve;
- Owners / Operators of Hempsted landfill site;

- Network Rail;
- National Highways (formally Highways England);
- Representatives of the Coombe Hill Canal SSSI; and
- Enovert Owner and Operator of Gloucester Green Energy and Eco- Park.

In addition to these key stakeholders the proposed pipeline route will cross numerous areas of private land ownership. A comprehensive land referencing process should be undertaken early in the next stage to determine land ownership along the proposed route.

When this process is completed, it is likely that it will be possible to make minor changes to the proposed pipe route to minimise small areas of interaction. It is recommended that the landowner consultation process is undertaken early in the process to ensure a good relationship ahead of completing the various non-intrusive and intrusive surveys which will be required ahead of the construction phase.

10.6.1 PLANNING PERMISSION RIGHTS OF ACCESS

It is understood that the treatment upgrades at Netheridge WwTW and the associated pipeline are to be considered as Associated Development to the STT SRO DCO application. STS SRO qualifies as Associated Development on the basis that it is directly related to the STT SRO and will help support its operation, therefore satisfying the definition of Association Development in the Planning Act 2008. It is therefore expected that all planning permissions and associated land access permissions with be granted as part of the DCO process. However, this should be confirmed in the next stage.

10.6.2 MAJOR ROAD CROSSINGS

It is recommended that early consultations with the owner / operator of the A40 and Over Causeway viaducts are carried out to confirm as built details of bridge pier and abutment foundations.

The pipeline should be routed to ensure that the pipe trench does not interact with the zone of influence of the bridge foundations.

10.7 SURGE ANALYSIS

Hydraulic transients can result in pipeline damage, pump damage, ingress into the rising main and other operational issues. Hydraulic transient analysis identifies the extent of positive and negative pressure variations, whether engineering mitigations are required, and helps to size those mitigations. Whilst this is an important exercise for detailed design of a pipeline, it is a minor factor in the overall feasibility and benefits of the different route options under consideration in the Netheridge SRO.

Assessment of hydraulic transients or surge requires the following information:

- Rising main profile including the location of air valves;
- Details of the pump start and stop operation under normal (powered) conditions;
- Details of any valves implicated as being causes of surge events;
- Details of the discharge condition e.g., whether the discharge is submerged;
- Parameters from a steady-state hydraulic assessment; and
- Pump details including moment of inertia.

Not all of this information is defined at Gate 2, and that which is defined is likely to change in subsequent design stages. Accordingly, a hydraulic transient analysis has not been undertaken at Gate 2. As part of the costing exercise, an allowance has been made for surge mitigation measures for all options.

Appendix A

HYDRAULIC ANALYSIS

TECHNICAL NOTE 70088464-WSP-NETHSRO-CA-CY-4003

DATE:	18 July 2022	**CONFIDENTIALITY:**	Confidential
SUBJECT:	Netheridge SRO Pipeline Hydraulic Analysis		
PROJECT:	Severn Trent Sources Strategic Resource Options		

AMENDMENT RECORD

REVISION	DESCRIPTION	AUTHOR	CHECKED	APPROVED
P01	First Issue	DO	TJ	LJ

INTRODUCTION

Scheme Overview

This Technical Note describes the hydraulic assessment undertaken by WSP for the Netheridge Severn Trent Sources Strategic Resource Options (STS SRO) at concept design. This Technical Note supports the Route Appraisal Report and Process Basis of Design. The hierarchy of documentation is described within the Concept Design Report. The following summary of the main options considered under the Netheridge SRO is repeated from these documents.

A pipeline from the Netheridge SRO Treatment Plant will transfer treated final effluent to one of the following destinations:

- Option 1 – to the River Severn, downstream of the new STT SRO Deerhurst abstraction;
- Option 2 – to the River Severn at the EA gauging station located near Haw;
- Option 3 – to the River Severn East Channel, downstream of the existing Canal and River Trust pumping station to Gloucester Docks;
- Option 4 – to the Gloucester and Sharpness Canal at a location determined by the Route Appraisal Report;
- Option 5 – to combine Options 1 or 2 with Option 3 to allow discharge to either the River Severn or River Severn East Channel.

Objectives

The objectives of the assessment are outlined below:

- To identify hydraulic design constraints that influence the transfer pipeline design;
- To establish steady-state operating pressures to enable pump sizing;
- To undertake preliminary pump sizing to inform the design and costing of the transfer pumping station.

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STEADY-STATE HYDRAULIC ASSESSMENT

System Description

The Netheridge SRO is intended to transfer up to 35 Ml/d of treated final effluent to support a corresponding abstraction of raw water for the Severn to Thames Transfer.

To provide effluent for this transfer, the concept design basis for the process design at Netheridge is for the flow rate through the additional treatment to vary from 200 – 550 l/s. The flowrate will vary based on the available flow from the existing upstream processes at Netheridge WWTW. This is described within the Process Basis of Design Report. The design basis for the transfer pumping station is to follow the same flow rate basis as the Netheridge SRO treatment plant.

The description provided herein of the steady state hydraulics assessment is separated into the pipeline profile, rising main (pumped) calculations and gravity main calculations. In practice, these tasks were completed iteratively.

Assumptions

The following assumptions have a significant bearing on the calculations and should be reviewed once further detail is available:

- Pipe roughness is assumed to be based on the characteristics of the pipe material rather than internal sliming (as would be considered for a sewage rising main);
- A Bottom Water Level for the transfer pumping station has been assumed relative to the pipe invert of the transfer pipeline at the boundary of the Netheridge site.

The calculations and assessments entail other assumptions with lower sensitivity and less likelihood of change (e.g., fluid temperature).

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Pipeline Profiles

Pipeline profiles are shown in Figure 1. The profiles have the following notable features:

Table 1 Transfer Pipeline Option Features

Option 1	Approximately 18km long transfer pipeline. Large flat sections with two significant high points, the greater of which is relatively close to the final discharge location
Option 2	16km transfer pipeline. Large flat sections with one significant high point at around chainage 12km.
Option 3	5.1km transfer pipeline. Shallow fall along much of the pipeline route, steeper fall in the first 500m.
Option 4	560m transfer pipeline, with a single high point at approximately chainage 250m.

For Options 1, 2 and 4, an initial review of simplified pipeline profiles, assuming a fully pumped transfer pipeline, indicated the potential for negative pressures at profile high points (approx. -5m over several hundred meters for Option 1). To avoid the operational issues associated with sustaining negative pressures, hydraulic breaks were added to the transfer pipelines for Options 1, 2 and 4.

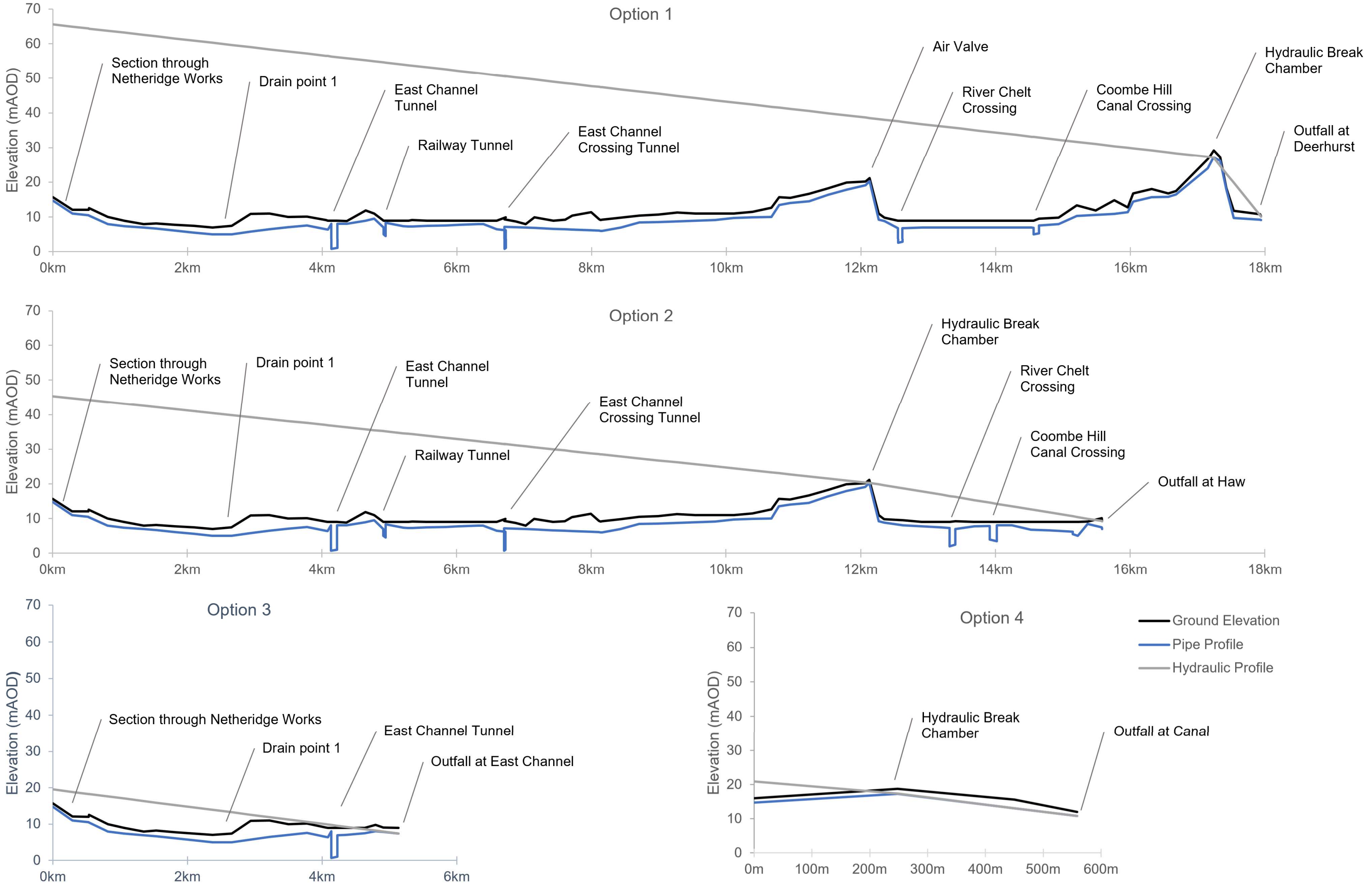

Figure 1 Hydraulic Profiles for Options 1 - 4

Rising Main Calculations

TRANSFER PIPELINE DIAMETER

The transfer pipeline diameter was selected on review of the velocities and pressure losses. The following table shows figures for Option 1:

Table 2 Transfer Pipeline Diameter Comparison – Option 1

For Option 1 - Discharge at Deerhurst

	Nominal Diameter (mm)		
	600	700	800
Velocity at 200 l/s (m/s)	0.71	0.52	0.4
Velocity at 550 l/s (m/s)	1.95	1.44	1.09
Pipe friction loss at 200 l/s (m)	10.8	5.2	2.6
Pipe friction loss at 550 l/s (m)	73.2	34.3	17.4

As neither a sewage rising main or potable distribution/trunk main, STW standards for pipeline velocity do not apply. For pipeline sizes above 800mm, there is a diminishing benefit in terms of friction loss reduction for the increased material costs. For pipeline sizes below 600mm, maximum velocity and friction losses climb, increasing operational costs.

For Options 1, 2 and 3 a diameter of 700mm is chosen, expecting that this offers a balance between capital and operational costs. This judgement is based on typical pipeline velocities present in the water industry.

For Option 4 which has a substantially shorter pipeline, the friction losses for a given pipeline diameter are significantly reduced. A pipeline size of 600mm has been selected to realise material savings and to offer some friction loss, without which the design of the pipeline and pump control may become sensitive (flat system curve).

In subsequent design stages, review of the whole-life costs for the transfer pipeline should be undertaken to confirm the pipeline diameter. This will require more definition of the expected frequency and duration of the STT demand for flow. If for instance the transfer pipeline is rarely used, capital costs will contribute a larger portion of the whole-life costs which may in turn favour a smaller pipeline diameter.

PRESSURE LOSS CALCULATIONS

Rising main pressure loss calculations were undertaken using a Colebrook-White formula basis. Each Option was modelled as a single ‘lumped’ rising main section with length corresponding to the chainage to the hydraulic break chamber (or the full pipeline length for Option 3). Pipe roughness has been taken as 0.06 mm based on a ductile iron transfer pipeline. Fittings losses were modelled as the greater of 2m or 1K per km – for Option 4 a number of fittings were assumed for this short route. Details for each option are shown in Table 3.

Table 3 Rising Main Hydraulic Details

Option	1	2	3	4
Design Flowrate Basis (l/s)	550	550	550	550
Total Transfer Pipeline Length (m)	17943	15587	5133	559
Rising Main Length (m)	17236	12129	5133	248
Rising Main Diameter (mm)	700	700	700	600
Velocity at Design Flowrate (m/s)	1.44	1.44	1.44	1.95
Pipe Roughness (mm)	0.06	0.06	0.06	0.06
Pipe Friction Losses (m)	35.0	24.6	10.4	1.1
Fittings Losses (m)	2	2	2	2.5
Suction Level (m)	12	12	12	12
Discharge Level (m)	28.2	20.3	7.4	17.4
Geodetic Head (m)	16.2	8.3	-4.6	5.4
Total Pump Head (m)	53.2	34.9	7.8	9.0
Concept Design Sizing Basis THD (m)	55	36	8	9.5

Given the level of design development at the concept design stage, it was appropriate to apply some allowance to the calculated figures before pump sizing.

Gravity Main Calculations

The transfer pipelines for Options 1, 2 and 4 include a final section flowing under gravity. Assessment of the capacity of this section used a Colebrook-White calculation basis with a wetted perimeter correction to model partially full pipelines. The section was modelled with a continuous gradient. For the discharge elevation, local ground levels were used as opposed to pipe crown levels, as submerged river outfalls or bankside outfall chambers could be proposed within subsequent design stages.

Where the gradient is steeper, the flow capacity of the gravity main will be higher. To reduce construction costs, smaller diameters may be appropriate for the gravity section. For Option 1, a 500mm diameter is proposed. Details are shown in Table 4.

Table 4 Gravity Main Hydraulic Details

Option	1	2	3	4
Chainage of Hydraulic Break Chamber (m)	17236	12129		248
Chainage of Discharge (m)	17943	15587		559
Length of Gravity Main (m)	707	3458		311
Elevation at Hydraulic Break Chamber (m)	27.1	20.3		17.4
Elevation at Discharge (m)	10.2	9.27		12
Change in Elevation (m)	-17.0	-11.0		-5.4
Average Gradient	1 in 42	1 in 313		1 in 58
Diameter (NB)	500	700		600
Flow Capacity at Full Bore (l/s)	765	661		1046
Proportional Depth at 550 l/s	0.63	0.7		0.52

PUMP SIZING

Pump Sizing

A manufacturer's pump selection tool was used to provide motor sizes and energy consumption figures. The Process Basis of Design Report states that different pumping station designs may be applicable for the different options, potentially allowing for different pump types to be utilised. At concept design stage, this opportunity cannot be confirmed and therefore the following figures assume submersible centrifugal pumps are selected for all options. The power consumption shown is based on a daily flow of 35 Ml/d.

Table 5 Pump Sizing

Option	1	2	3	4
Pump Arrangement	D/A/S	D/A/S	D/A/S	D/A/S
Flow per Pump (l/s)	275	275	275	275
Indicative Motor Rating (kW)	215	170	45	45
Specific Energy (kWhr/m3)	0.204	0.145	0.032	0.035
Power Consumption (kWhr/day)	7140	5075	1120	1225

TRANSIENT PRESSURE CONSIDERATIONS

Transient Pressures / Surge

Before any option can be constructed an assessment of the hydraulic transients for the rising main part of the transfer pipeline will be necessary. Assessment of hydraulic transients or surge requires the following information:

- Rising main material;
- Rising main profile including the location of air valves and characteristics of the air valves;
- Details of the pump start and pump stop operation under normal (powered) conditions;
- Details of any valves implicated as being causes of surge events;
- Details of the discharge condition e.g., whether discharge is submerged;
- Parameters from a steady-state hydraulic assessment; and
- Pump details including moment of inertia.

At the concept design stage not all this information is defined or available, and that which is defined is likely to change in subsequent design stages. Accordingly, a hydraulic transient analysis has not been undertaken at concept design. Surge is a minor factor in the overall feasibility and benefits of the different route options under consideration in the Netheridge SRO.

Some factors relevant for subsequent design stages are:

- The length of the rising mains for Options 1 and 2 make surge issues more likely and could result in larger surge mitigation measures than may be required for Options 3 and 4;
- Option 3 has a downhill profile which increases the likelihood of negative pressures occurring;
- Power reliability of the site will need to be known to inform the likelihood of power failure-initiated surge events.

Appendix B

GEOTECHNICAL REVIEW SUMMARY TABLE

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Pipeline Ref.	Chainage	Geology *Source of Information: BGS Geoindex Online Mapping*	Potential Contaminated Land Constraints	Potential Geotechnical Constraints	Suggested Further Work *To be re-Assessed once Details of Temporary and Permanent Works have been Determined*
Section 1 Netheridge to River Severn East Chanel	0 - 3km	Superficial geology: Alluvium and Tidal Flat Deposits. Made Ground associated with historical landfill site. Solid geology: Blue Lias Formation and Charmouth Mudstone Formation (undifferentiated) - Mudstone.	Potential for contamination associated with Historical Landfill Sites and former land uses.	Potential for variable near surface ground conditions relating to the historical landfill site. Potential for low strength soils (Alluvium / Tidal Flat Deposits). River Severn (east channel) crossing. A40 and A417 crossing.	Targeted ground investigation required to further assess the risks once a detailed desk study has been undertaken.
Section 2 Alney Island	3 – 4.5km	Superficial geology: Alluvium and Tidal Flat Deposits. Solid geology: Blue Lias Formation and Charmouth Mudstone Formation (undifferentiated) - Mudstone.			
Section 2 Alney Island	4.5 - 6km	Superficial geology: Alluvium. Solid geology: Blue Lias Formation and Charmouth Mudstone Formation (undifferentiated) - Mudstone. Charmouth Mudstone Formation - Mudstone. Rugby Limestone Member - Mudstone and Limestone, interbedded.	No significant contaminated land constraints identified from records reviewed.	Potential for low strength soils (Alluvium)	Risks to be further assessed as part of the projects desk study and ground investigation.
Section 2 River Severn to Bishops Norton	6 - 9km	Superficial geology: Alluvium and Cheltenham Sand and Gravel Deposits. Solid geology: Charmouth Mudstone Formation - Mudstone. Rugby	No significant contaminated land constraints identified from records reviewed.	Potential for low strength soils (Alluvium). Potential shallow groundwater. Historical borehole data record	Risks to be further assessed as part of the projects desk study and ground investigation

Pipeline Ref.	Chainage	**Geology** ***Source of Information: BGS Geoindex Online Mapping***	**Potential Contaminated Land Constraints**	**Potential Geotechnical Constraints**	**Suggested Further Work** ***To be re-Assessed once Details of Temporary and Permanent Works have been Determined***
		Limestone Member - Mudstone and Limestone, interbedded.		ground water strikes at 3.00 - 4.00 m bgl. River Severn (east channel) crossing.	
Section 2 River Severn to Bishops Norton	9 - 12km	Superficial geology: Predominantly no superficial cover. Alluvium and Head Deposits. Solid geology: Rugby Limestone Member - Mudstone and Limestone, interbedded. Saltford Shale Member - Mudstone. Wilmcote Limestone Member - mudstone and limestone, interbedded. Penarth Group - mudstone. Blue Anchor Formation - mudstone. Branscombe Mudstone Formation - mudstone.	No significant contaminated land constraints identified from records reviewed.	Potential for low strength soils (Alluvium). Potential for rock at or near the ground surface leading to increased difficulty for open trench excavations.	Risks to be further assessed as part of the projects desk study and ground investigation
Option 1 Deerhurst	12 - 15km	Superficial geology: Alluvium, areas of no superficial cover. Solid geology: Charmouth Mudstone Formation - Mudstone. Rugby Limestone Member - Mudstone and Limestone, interbedded.	No significant contaminated land constraints identified from records reviewed.	Potential for low strength soils (Alluvium). Potential for rock at or near the ground surface leading to increased difficulty for open trench excavations. River Chelt crossing.	Risks to be further assessed as part of the projects desk study and ground investigation

Pipeline Ref.	Chainage	Geology *Source of Information: BGS Geoindex Online Mapping*	Potential Contaminated Land Constraints	Potential Geotechnical Constraints	Suggested Further Work *To be re-Assessed once Details of Temporary and Permanent Works have been Determined*
	15 - 17.7km	Superficial geology: Predominantly no superficial cover. Alluvium. Solid geology: Charmouth Mudstone Formation - Mudstone. Rugby Limestone Member - Mudstone and Limestone, interbedded.	No significant contaminated land constraints identified from records reviewed.	Potential for low strength soils (Alluvium). Potential for rock at or near the ground surface leading to increased difficulty for open trench excavations. Coombe Hill Canal crossing.	Risks to be further assessed as part of the projects desk study and ground investigation
Option 2 to Haw Bridge	12 – 15.5km	Superficial geology: Alluvial Deposits. Solid geology: Branscombe Mudstone Formation - Mudstone.	No significant contaminated land constraints identified from records reviewed.	Potential for low strength soils (Alluvium). Crossing the River Chelt and the Coombe Hill Canal.	Risks to be further assessed as part of the projects desk study and ground investigation
Option 3 River Severn East Channel	3 - 4km	Superficial geology: Tidal Flat Deposits. Made Ground associated with historical landfill site. Solid geology: Blue Lias Formation and Charmouth Mudstone Formation (undifferentiated) - mudstone.	Potential for contamination associated with historical landfill site.	Potential for variable near surface ground conditions relating to the historical landfill site. Potential for low strength soils (Alluvium / Tidal Flat Deposits).	Risks to be further assessed as part of the projects desk study and ground investigation
Option 4 Direct Discharge G+S Canal	0 - 1km	Superficial geology: Alluvial Deposits.Solid geology: Blue Lias Formation and Charmouth Mudstone Formation (undifferentiated) - mudstone.	No significant contaminated land constraints identified from records reviewed.	Potential for low strength soils (Alluvium)	Risks to be further assessed as part of the projects desk study and ground investigation

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