Grand Union Canal Transfer

Grand Union Canal Strategic Resource Option: Detailed Feasibility and Concept Design.

Annex A1 - Engineering.

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Author names redacted

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Prepared by	Checked by	Verified by	Approved by
[redacted]	[redacted]	[redacted]	[redacted]

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Distribution List

# Hard Copies	PDF Required	Association / Company Name

Prepared for: Affinity Water Ltd

Prepared by:

WSP UK Ltd

WSP House

70 Chancery Lane

London WC2A 1 AF

T: 0 44 20 7314 4411

Website: https://www.wsp.com

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EXECUTIVE SUMMARY

This is the Engineering Annex to the Gate 3 report on the Grand Union Canal Strategic Resource Option (Grand Union Canal Strategic Resource Option: Detailed Feasibility and Concept Design Annex A - Engineering.)

It summarises the current level of design development of the Grand Union Canal (GUC) Strategic Resource Option (SRO) and sets out the next steps to be completed to advance the design through Gate 4.

Scope of Scheme

The GUC SRO is being developed by Affinity Water (AfW), Severn Trent (ST) and the Canal & River Trust (the Trust), in parallel with the separate Minworth SRO which will provide up to 115Ml/d source water for the transfer by further treating recycled water in the new Minworth Wastewater Recycling Centre (WwRC) and discharging it to the Coventry Canal near Atherstone in Warwickshire, which then feeds into the GUC.

The GUC SRO is now intended to be consented under the Development Consent Order (DCO) process so there is an extensive consultation and stakeholder engagement process required to underpin the selection of the preferred scheme. There are three sites that have been identified as having greater potential for the development of the proposed water storage and treatment works, with associated transfer routes to an underground reservoir near Luton. The non-statutory consultation occurred over September and October 2024 with the outputs allowing the scheme to be developed further, before statutory public consultation in 2025, further scheme refinement and then the subsequent DCO application submitted.

The GUC SRO will transfer water southwards from the discharge near Atherstone along the GUC to an abstraction point proposed to be south of Milton Keynes. The abstracted water will be passed to a bankside storage reservoir which will act as a buffer to protect against pollution events and to allow settlement of some sediment before treatment. The treatment process is designed to suit the current assessment of likely water quality and to meet the requirements of the drinking water quality risk assessment developed in consultation with the Drinking Water Inspectorate (DWI).

To affect the southwards transfer of the water, a series of pumped bypasses to take water around uphill lock flights and gravity bypasses to take water around downhill lock flights will be needed. These have been located and designed in co-ordination with the Trust and taking account of the output in respect of water levels and flow velocities from the latest hydraulic model. Flow velocities have been restricted even at the highest transfer flow rates to limits agreed with the Trust and the Environment Agency. Detailed design of the bypass works, including finalising the locations of the intake and outlet works and interconnecting pipelines, will take account of feedback from the wider consultation process.

The transfer of water along the canal will require an increased driving head which will raise the hydraulic grade line in each canal pound. The current hydraulic model has indicated those lengths of the canal that will need to be modified to allow safe transfer of the water. Outline designs for the canal bank and towpath have been developed primarily based on adopting the same canal bank or towpath type as exists currently. The costs and programme have been developed assuming a conservative (higher) water level and it is expected that, subject to agreement with the Trust and the riparian landowners, the costs and construction duration may be reduced.

For the three sites with greater development potential, there are 4 different arrangements of abstraction point, storage reservoir, potable treatment works and pumped pipeline to an existing underground potable water storage. Feasible sites and pipeline routes have been developed and are to be consulted on before landowner negotiation, and detailed topographic and geotechnical studies will be undertaken.

Costs, construction programmes and carbon budgets have been prepared for each of the currently available options to a level suitable for comparison. Opportunities for cost, programme and carbon reduction exist and will be explored for the selected option.

1. INTRODUCTION

1.1 INTRODUCTION AND PURPOSE OF REPORT

This is the technical report for the Grand Union Canal (GUC) Strategic Resource Option (SRO) submitted as part of the Regulators' Alliance for Progressing Infrastructure Development (RAPID) assessment at Gate 3.

The GUC SRO is currently in development and is intended to enable the transfer of up to 115Ml/d of treated recycled water provided by the Minworth SRO to support up to 100Ml/d of demands in Affinity Water's (AfW) supply zone to the north of London.

The GUC and its associated facilities necessary to allow operation is in the ownership of the Canal & River Trust (the Trust). The Trust will be a party to the transfer scheme along with AfW and Severn Trent (ST) who own and operate the current Minworth wastewater recycling centre (WwRC) which will be the source of the treated recycled water for the transfer.

The purpose of this report is to summarise the scheme as it was expressed at Gate 2 of RAPID's process and then to describe the development of the scheme during Gate 3 studies as further and better information has been secured.

1.2 SCOPE OF THE REPORT

The work reported covers the following scope of works:

- A new flow discharge structure into the GUC in the vicinity of Atherstone, to safely convey the treated recycled water supplied by the Minworth SRO scheme into the canal.

- The works to facilitate the transfer of the flow along the canal, which consist of:
    - some bank raising works to retain the additional water,
    - pumped bypass systems at "uphill" locks,
    - gravity bypass systems at "downhill" locks,
    - any necessary adjustments to bridges, tunnels and other flow constrictions to ensure that velocities and levels do not exceed allowable limits,
    - modifications to some of the waste weirs and flow inlet structures and
    - new screened abstraction pumping station south of Milton Keynes to remove the additional flow from the canal.

- A new potable water treatment works at the southern end of the GUC SRO, consisting of:
    - a raw water transfer main from the abstraction pumping station to a new large raw water storage reservoir complete with associated inlet/outlet/emergency drawdown and spillway systems,
    - a new treatment works,
    - clear water storage reservoir and
    - high lift pumping station to an existing AfW underground water service reservoir near Luton where the water can be introduced to the supply system.

Initially work at Gate 2 focussed on the development of an example design for an abstraction and treatment works on a site near Leighton Buzzard. The Leighton Buzzard site is now considered to be less suitable for development, so the design has not been progressed there. During Gate 3 the scope expanded to consider other site options, and the Leighton Buzzard site was dropped as described below.

- In addition, to provide sufficient raw water storage in the system to allow for transfer of water in the event of a short-term requirement to reduce take from the Minworth SRO, a new abstraction, pumping station, transfer pipe and inlet system will take water from the canal and deliver it to the Trust's Daventry and Drayton reservoirs where it will be held until needed. Works will be required to allow the stored raw water to be released safely in a controlled manner back into the canal through energy dissipating discharge structures.

The designs must be aligned to the Operational Philosophy (please see GUC SRO Gate 3 Annex E5) which is in development by multiple parties and must consider any requirements relating to the procurement option for delivery and operation of the GUC SRO when commissioned.

1.3 OTHER PARTIES INVOLVED

The development of the design and arrangement of proposed assets has been done in close co-ordination with other parties, consultants and advisers. These and an outline of their scopes of work and interfaces are given below:

- **Hydraulics Consultant**: The Hydraulics Consultant is responsible for undertaking the necessary computer modelling of the canal transfer to determine as far as possible:
  - The hydraulic grade lines along the canal for the various potential flow rates resulting from the additional water added to the canal, to allow assessment of the engineering work needed to manage and contain the additional water.
  - Velocities in the canal due to discharge into the canal, transfer of water along the canal and around the locks and abstraction of water from the canal, to allow assessment of any scour and any impacts on users of the canal and wildlife.
  - Operational considerations such as start-up/run up of the flow, rapid shut down, effects on water elevation of lock operations, inlet and outlet weir conditions to allow assessment of any engineering modifications necessary to mitigate impacts.
  - Confirmation of the water resource benefit from the transfer, and outline assessment of any impact on the losses from the canal as a result of the increased water elevations expected.
  - Impacts on the current water quality in the canal from the effects of mixing the new, highly treated flows from Minworth, to inform the design of the potable water treatment process at the new works site.
  - Development of a "digital twin" for the transfer system.

- **DCO/Planning Consultant**: the DCO/Planning Consultant is responsible for developing and implementing the strategy for obtaining the relevant consents for the construction of the GUC SRO and co-ordinating with and directing the studies of the other consultants. This includes ensuring that the required options and environmental/social impact studies and various levels of stakeholder engagement are undertaken at an appropriate time and with suitable information to allow smooth progress to consent. This consultant is also responsible for developing and managing the land and property strategy to ensure the access for studies and assessments is available at an appropriate time.

- **Environmental Consultant**: the Environmental Consultant is responsible for ensuring environmental screening and baseline studies and impact assessments are undertaken at the appropriate time and at the appropriate level of detail to support a successful consent application.

- **Water Quality Consultant**: the Water Quality Consultant is responsible for ensuring that sufficient water quality sampling is undertaken at suitable locations and that appropriate and timely laboratory assessments are made to provide sufficient information to support the design of the scheme in resolving any regulator's concerns regarding water quality impacts.

- **Minworth SRO Engineering Consultant**: the Minworth Engineering Consultant is responsible for:
    - Assessment of the recycled water treatment process to meet the needs of the environmental and drinking water regulators in respect of the transfer of water via a different water body (the GUC) from one catchment to another and its subsequent use for drinking water after appropriate treatment.
    - Outline design and layout of the Minworth AWTP and consideration of any operational constraints resulting from the process design and its output requirements as agreed with the relevant regulators.
    - Route options assessment and outline design for the new pumped/gravity transmission main (route, diameter, operational modes) to take the treated recycled water from Minworth to the discharge location on the GUC in the vicinity of Atherstone.
    - Confirmation of the preferred location for discharge of treated recycled water into the GUC to allow the engineering consultant to design the structure and the planning and environmental consultants to assess potential impacts and mitigations.

- **Commercial Consultant**: the Commercial Consultant is responsible for examining procurement and delivery options and the associated costs and risks.

There are also other advisers such as the legal and communications strategy advisers, who work directly with the DCO consultants but with whom liaison is also maintained as necessary by the engineering team.

All interfaces are managed by the Project Management Board (PMB) with delegated responsibility for co-ordination to the PMO and AfW's Project Manager.

1.4 AREAS OF CONSTRAINT TO PROGRESS

One of the main aims of the Gate 3 studies was the development of the Gate 2 work to improve the level of certainty regarding design of the largest cost and programme risk items, namely the raw water storage reservoir, the treatment works and the route assessment for the potable water main from the new treatment works to the existing underground service reservoir near Luton.

To conform to the procedural requirements of the Development Consent Order (DCO) process, which is the preferred route for consenting confirmed by Defra (subject to acceptance of the Section 35 application) certain aspects of the work reported as viable solutions at Gate 2 have had to be re-assessed. Subject to wider engagement and consultation the scheme will be developed further in accordance with the outcomes of further modelling, testing, studies, investigation and formal consultation. At the time of writing, several sites have been identified as having the potential for development and were shared for consideration at the non-statutory consultation in September/October 2024.

The preferred locations of the new treatment works, the reservoir and the route for the potable water line to the existing underground service reservoir near Luton are not yet selected. Geotechnical and topographical studies of these locations have also not been undertaken so uncertainties associated with these items cannot yet be resolved.

Similar concerns regarding uncertainty of the location of the discharge structure near Atherstone and of the final routes for the lock bypasses along the GUC mean that geotechnical studies for these proposed assets have also not been undertaken. The impact on time and cost of the GUC SRO of not having such information for these latter assets is markedly less than the impact of not having this information for the larger risk items such as the treatment works, the reservoir and the transfer pipelines.

In addition, other areas of uncertainty remain:

- the current state of development of the hydraulic modelling means that the water levels which will result from the additional transfer flow are still relatively uncertain. This affects the amount of canal bank raising needed and thus the potential for impact on riparian owners, bridge/tunnel soffits and locks. The project partners are committed to reducing the amount of bank raising to a minimum, including significantly below the worst case scenario presented in this report. This will continue to be developed further in Gate 4
- the water quality modelling will remain indicative only, so the treatment process train at the new potable treatment works at the southern end of the transfer will remain conservative in design.
- land ownership issues and access management are still being worked through as the need for access and acquisition depends on the outcome of the DCO process of review of options and stakeholder engagement.
- the environmental baseline studies and subsequent impact assessment will depend on the outcome of the DCO review of options and stakeholder engagement, so the need for and scale of any mitigations has not been significantly advanced further than at Gate 2.

Nonetheless, significant progress has been made in many areas of the scheme to refine the design and operational modes, as reported on in the chapters below.

2. SCOPE OF PROJECT AT GATE 2

2.1 AREAS OF UNCERTAINTY REMAINING AT GATE 2

At the end of Gate 2 there were areas of uncertainty noted in the Conceptual Design Report which needed attention during Gate 3. RAPID also, in their final decision at Gate 2, listed a series of questions and areas for attention.

As referenced above the principal uncertainties from scheme design, scheme cost and programme perspectives related to finalisation of the location of the discharge structure from Minworth, and the location of the raw water storage and treatment works which in turn affects the location of the abstraction for potable treatment and the route of the treated water pipeline to the existing underground service reservoir near Luton.

These unknowns and the associated lack of access for topographical, geotechnical and environmental assessments meant that costs, carbon and programme were subject to substantial risk allowances.

A check list at the end of this current report identifies where responses have been made to the Gate 2 uncertainties and the RAPID questions and areas for attention.

GATE 2 CONCEPT DESIGN REPORT UNCERTAINTIES

Our Gate 2 Concept Design Report expanded on these uncertainties and other less critical issues:

Land Referencing, Access and Surveys

- Site notices to be made on unregistered land requesting those with an interest in the land to make contact.
- Collation of information required to inform the development of the proposals and the Book of Reference.
- Contacting land interests to secure agreement where access is required for engineering and ecological surveys.
- Engaging with persons with an interest in land in accordance with s 42(1)(d) of the Planning Act 2008

Planning, Operation and Control

- A more detailed concept to be developed giving the configuration of the operating and control system to allow all elements to be able to operate at a range of flows to suit demands from AfW to be further investigated.
- Phasing options have not been studied in depth as there remains significant uncertainty around demand patterns. Additional work with AfW to review the impact of strategic operating decisions will be required.
- Further assessment at Gate 3, preferably including input from an Early Contractor Involvement (ECI), will allow the preparation of a costed Monte Carlo appreciation of residual risks to replace the Optimism Bias allowance.
- The choice of whether the works should be consented through Development Consent Order (DCO), or the more conventional Town and County Planning Act (TCPA) approach was still under review.

- Confirm integration of Minworth Pumping Station with Minworth WwRC extension.
- Working with the ECI contractor to establish the least risk programme of works.

Pipeline Routes

- Further refinement of the routes will be undertaken for Gate 3 based on a range of variables such as length, energy requirement, material type, pressure rating, carbon budget, capital cost etc.
- At Gate 3 early engagement with HS2 and the utilities companies will be required to accurately plot a route from Minworth to Atherstone.
- More detailed, field-based survey will be used during Gate 3 studies to make the next stage of assessment to allow the route, necessary mitigations and costs to be confirmed. This will require consultation with the relevant stakeholders (e.g. Natural England etc.) before final quantities can be agreed.
- Engagement with HS2 design teams to agree crossing point and constraint details.

Discharge Point

- The final position will be fixed based on Gate 3 detailed studies of ground conditions, local bathymetry and any velocity constraints.
- Include further evaluation of energy recovery options (e.g. potentially more efficient turbine types and arrangements) can be developed.

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- A more detailed model is being developed by Hydraulics Consultant (using Aquator and Flood Modeller) for use in the design of the preferred option at Gate 3.
- Sites have been selected by inspection of local mapping and are not supported by any detailed studies which will be carried out in the Gate 3 study period.
- Canal bypass pumping stations: the arrangement of pumps to achieve the required range of flows efficiently will be investigated further at Gate 3, to include:
  - Confirm strategy of fixed, dual or VSD pumps.
  - Confirm layout and design. At Gate 3 various alternative layouts can be evaluated once land availability is confirmed.
  - Modelling of flow patterns such as pump on and off levels.
- Gravity bypass design studies will be needed to revisit assumptions in line with the findings from the Hydraulics Consultant’s model which is being undertaken at Gate 2.
- Consultation with the Local Planning Authority will be required at Gate 3 for agreement on constraints around listed structures.
- Surveys to confirm construction type and potential for habitat creation.
- Engagement with landowners for access and discussion regarding habitat creation.
- Potential additional access options have been identified (e.g. potential connections to adjacent footpaths etc.) that could be investigated at Gate 3.

- Confirm towpath design with the Trust and agree management (e.g. planting shelves and dredging) along different lengths. Stakeholder engagement at Gate 3 to confirm proposed construction methods and locations.
- Investigation of material supply volumes required and specifically availability of sufficient suitable timber.

Bankside Storage and Treatment

- To balance the potential volume required for storage with the abstraction and treatment capacity, it has been assumed the provision of 5 days storage would suffice in a single element (i.e. not split into multiple storage elements), requiring a useable volume for the reservoir of 575 Ml (575,000 m^3.). The wider need for storage will need confirming with AfW.
- Treatment Works Process optimisation following Gate 3 water quality modelling.
- At Gate 3, using updated water quality parameters, the type of chemicals used, and dosing volumes will be investigated further.
- At Gate 3, alternative processes, media and chemicals will be evaluated.

General and Project Wide Actions

- At Gate 3, engagement with specialist concrete suppliers to maximise the carbon saving of using low carbon concrete.
- Investigate if excavated sewage sludge material at Minworth may be suitable for cement or lime stabilisation and used as a general backfill.
- Site Specific FRA.
- Consultation for construction work access and pipeline routes with landowners.
- Stakeholder engagement with landowners.
- At Gate 3 the potential for using the scheme for local flood alleviation could be investigated.
- At Gate 3, through consultation with the Trust (canal safety), the Environment Agency (work around the River Ouzel) and specialist contractors (construction staff safety) alternative construction methods with lower WLC impacts can be investigated.
- At Gate 3 the following technologies and their potential application on site will be evaluated further:
    - water source heat pumps,
    - algae harvesting,
    - photo voltaic floating cells.
- Carbon. At Gate 3 more detailed layouts and evaluation of alternative materials (e.g. Glulam structural frame versus steel) and the potential for sequestering will be investigated.

Following the issue of the Gate 2 report further water resource modelling suggested that there were risks associated with continuous supply from Minworth during extended droughts. There is a “hands off flow” (HoF) requirement in the Trent to which the Minworth recycled water is a significant contribution via the River Tame. Whilst there is reportedly no duty to discharge the Minworth recycled water into the Tame the project team decided to mitigate the additional impact on operation of the HoF of diverting the flow from the Tame, by providing additional storage on the GUC.

Modelling of the Trent and GUC system by a third party (see GUC SRO Gate 2 Annex B1.4 Water Quality Modelling) indicated that storage of around 11 days full flow rate would be needed somewhere between Minworth and the AfW treatment works to allow AfW to continue to benefit from the scheme. Options to store around 6 days full flow rate storage to supplement the 5 days storage proposed at the downstream abstraction point were considered by others.

RAPID's COMMENTS

RAPID's report "Strategic regional water resource solutions: standard gate two final decision for the Grand Union Canal Transfer, June 2023" presented actions and recommendations for Gate 3 in tabular form. This is provided in Table 2-1 below as an excerpt from the above report.

Regulator Actions – to be addressed in standard gate three submission (except where an earlier date is given below).

Nr	Section	Detail
1	Solution Design	Confirm to RAPID that the solution aligns with Severn Trent's and Affinity Water's Water Resource Management Plans (WRMP) and relevant Regional Plans at the next available regular checkpoint meeting after the publication of the WRMPs and Regional Plans.
2	Solution Design	The scheme must provide updates on solution design to the Environment Agency through the development of design and operation of storage options which are to be incorporated within the scheme.
3	Evaluation of Costs & Benefits	Update the Natural Capital Assessment so that valuation of ecosystem services is comparable and demonstrates benefit to the environment and society. The rationale for scoping out recreation requires additional explanation and amenity enhancement should be assessed quantitatively.
4	Programme and Planning	Risk remains to the solution from the potential impact on water quality and compliance with the Water Framework Directive and environmental standards. Mitigation to reduce this risk is planned in the form of further modelling, monitoring and trial treatment programmes. Delivery of this mitigation should be completed by December 2023. For the treatment programme, this means the bench trial package should be completed by this date, to allow time for unresolved risks to be managed by the end of gate three
5	Programme and Planning	Further engage with Ofwat on the proposed commercial arrangements – specifically the approach to delivering the required work to the Canal & River Trust's assets. We expect that for gate three you will also be carrying out market engagement on this approach and would like you to engage with RAPID on feedback from the market prior to gate three. Review technical discreteness assessment following Ofwat's forthcoming consultation on updated guidance and provide an updated assessment.
6	Environment	Protected species (notably including water voles) surveys to be included within further assessment work. Consultation with the Environment Agency and Natural England on scope of surveys is necessary. Potential impacts on habitats and features of Local Wildlife Sites which the scheme has potential to impact should be investigated in gate three

Nr	Section	Detail
7	Environment	Further assessment into sediment mobilisation is necessary. Investigate the correlation between sediment mobility with release of contaminant into the water through operation of the transfer scheme causing sediment disturbance. Refine hydrological modelling of the Grand Union Canal, as per Final Modelling Report recommendations and through engagement with the Environment Agency, to better understand potential impacts. Refine Water Quality modelling, as per recommendations in the Point of Discharge WQ Assessment and through engagement with the Environment Agency, to better understand potential impacts
8	Environment	Investigate pollution risk and potential impacts from various scenarios causing pollution events in gate three.
9	Environment	Continue to investigate areas of INNS risk. Engage with the Environment Agency on scope for this work. Provide evidence to confirm treatment process will eliminate INNS from discharge into canal.
10	Environment	Recommendations made by the Environment Agency and Natural England through gate two engagement should be used to inform gate three environmental work.
11	Environment	Improve the carbon assessment through clearer presentation on cost estimation and evidence thereof, and costs being mitigated by focussing on carbon. Uncertainty range, and mitigation, is expected to be presented in future assessments

Regulator Recommendations – to be addressed in standard gate three submission (except where an earlier date is given below)

Nr	Section	Recommendations
1	Solution Design	More detailed utilisation profiles should be provided at gate three. Uncertainty and assumptions with utilisation profiles should be made clear.
2	Solution Design	Acknowledgement of Level of Service is recommended for future submissions. The Level of Service against which the water resource benefit is calculated should be explained.
3	Solution Design	We would like to see evidence of proactive engagement with the Forestry Commission on solution design and site location.
4	Evaluation of Costs & Benefits	Include descriptions and tables to show how cost estimates, including total planning period indicative option cost (net present value), for the preferred option have changed between each gate. Provide more detail on how uncertainty has been taken into account when calculating deployable output.
5	Environment	Refine pipeline route in gate three to minimise potential impact on sites such as priority habitats and ancient woodland. Explore dredging as an alternative to bank raising.

Nr	Section	Recommendations
		Provide more detail on how uncertainty has been taken into account when calculating carbon values
6	Solution design	We recommend that the solution owner continues to engage with Historic England on the work required to consider the historic environment. We recommend that the programme of planned investigations and assessments is reviewed regularly with Historic England.

Table 2-1 RAPID's Gate 2 Comments

Where these actions and recommendations relate to the engineering scope of works, they are responded to in this report.

3. SCOPE OF PROJECT AT GATE 3

3.1 SCOPE OF THE PROJECT

Scope of the overall project remains unchanged as does the purpose.

All design work is undertaken in alignment with the All Companies Working Group (ACWG) Design Principles. Appendix A includes a tabulation of how these design principles are taken account of. In summary, the GUC SRO is to be designed to offer social and environmental value and biodiversity net gain, to fit in appropriately with the landscape and the heritage vernacular of the canal and its assets and their setting, to ensure minimum disruption to residents, businesses, canal users and the environment during construction and operation, to provide increased resilience in respect of climate change effects and population growth to the customers and owners of the assets, to minimise cost and carbon (embedded and operational) in pursuit of the best value outcome for customers and those affected by the GUC SRO.

3.2 PROJECT DESCRIPTION AT GATE 3

The works studied and reported on in this Concept Design Report (CDR) at Gate 3 were essentially the same as for Gate 2 with the following exceptions:

- Pumping station and associated works at Minworth WwRC to transfer treated recycled water from the AWTP to the discharge point on the GUC have been re-allocated to the Minworth SRO Scheme, and the development work from Gate 2 has been undertaken by others. Work has included pilot plant testing, and review and revision of the plant layout resulting from the requirement from ST as the site owner to re-locate the new plant elsewhere on the site. The GUC SRO Engineering Consultant has been in liaison with the consultant responsible for the Minworth SRO to ensure compatibility of designs.
- The new pumped and gravity transmission main between Minworth and the proposed discharge point on the GUC has also been re-allocated to the Minworth SRO Scheme, and the development work beyond Gate 2 has been undertaken by others. Work has included further study of the route and break tank options with site walkovers, more assessment of utilities, road and watercourse crossings and development of an operating philosophy proposal to support the operational needs of the associated new advanced water treatment plant (AWTP) at Minworth.

In addition, additional water resources modelling was done (by others) to assess the likely impact of low flows in the River Trent on the availability for transfer by the Grand Union Canal Transfer (GUCT) scheme of the treated recycled water from Minworth AWTP. This modelling confirmed that in drought conditions the contribution of the Minworth recycled water via the River Tame to sustain the Hands-Off Flow (HoF) in the Trent may be significant and mitigation of the impact of the transfer on the operation of the HoF would be needed in the form of additional storage on the GUC.

Taking account of future impacts of climate change (Minworth SRO Gate 3 Annex B1.6) the modelling indicated that, as suggested from the earlier modelling, the HoF constraint at North Muskham could restrict diversion from Minworth to the canal for up to 11 days.

However, this would not affect the whole flow, with constraints dropping from no impact full to full restriction over the course of those 11 days.

Water resources modelling using the Aquator model has therefore been used to evaluate the need for storage. This demonstrated that 5-6 days of storage at full flow is sufficient to manage both the HoF constraints and manage the risk of outage at Minworth, when considered in combination with existing Affinity Water WRZ3 resources. Additional storage is then required to manage water quality risks at the abstraction point. AfW have therefore instructed that a '6+5' approach to storage is needed, with 11 days storage at full flow required, separated between the northern and southern ends of the scheme.

The layout of the scheme and principal options at Gate 3 are shown in Figure 3-1.

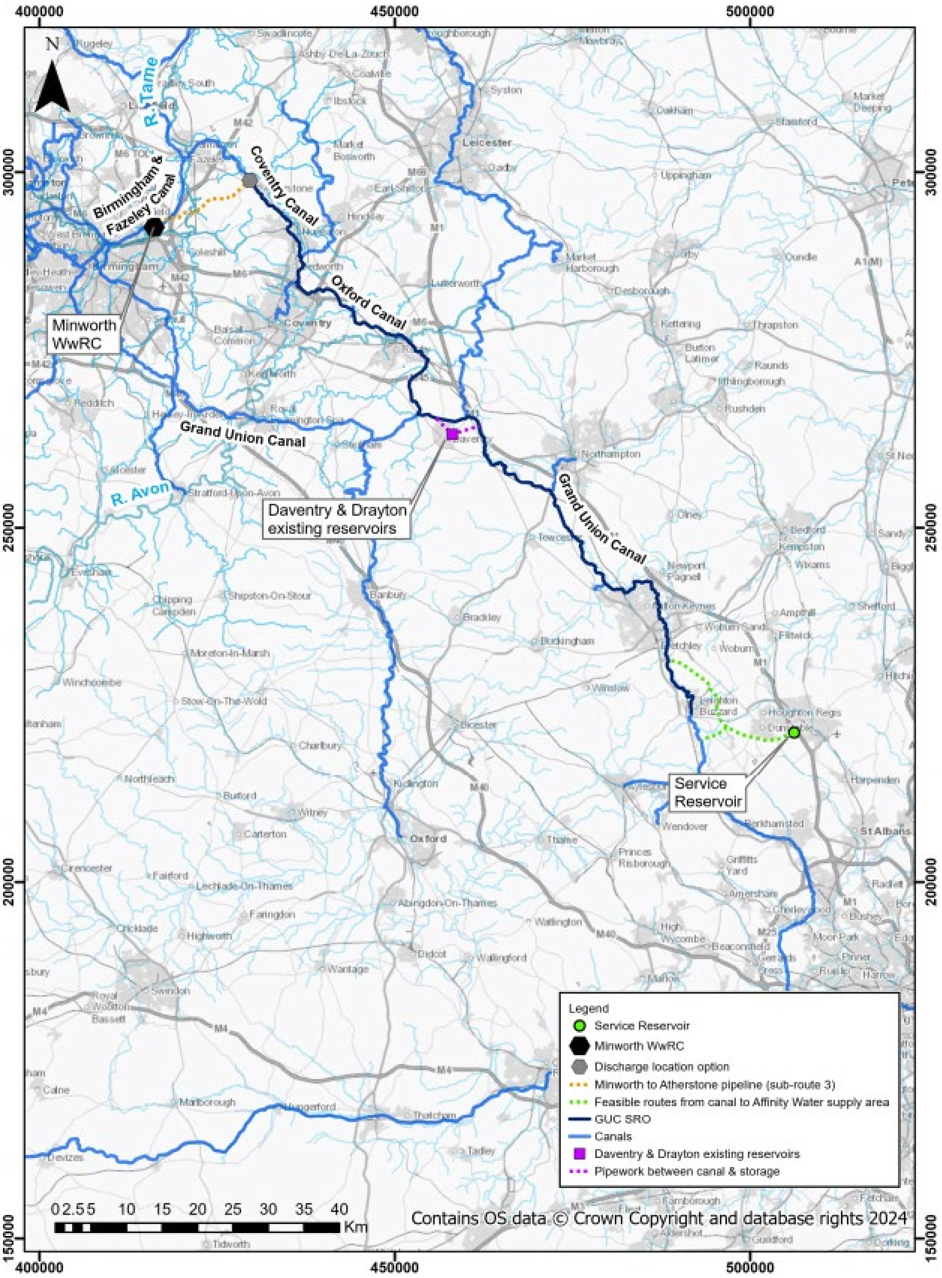

Figure 3-1 Overall Extent of Gate 3 Scheme

4. REMAINING AREAS OF CONSTRAINT TO PROGRESS

4.1 CONSULTATION AND SCHEME DEFINITION

During Gate 1 and Gate 2 studies, limited work was done in respect of consultation; the development process governed by RAPID's stage gated procedure did not allow for extensive public consultation while candidate SROs were still being compared for economic, impact and programme viability. The scheme and its many variants were therefore discussed in strategic terms only with parties such as the Environment Agency NAU, the Canal Users Group and the DWI.

As reported in Section 1.4 above, to allow scheme development to be fully compliant with the proposed consenting process under Development Consent Order (DCO) as described in the Planning Act 2008, a formal and structured consultation was required to be undertaken.

A DCO/Planning Consultant and a separate Environmental Consultant were commissioned, along with an Engagement Consultant, to take forward the DCO application and its associated consultation and environmental assessment.

Potential sites for GUC SRO asset construction were evaluated at Gate 2. As part of the DCO process and preparation for external consultation, a further site screening process was undertaken. Two potential sites where water can be abstracted, stored in the raw water reservoir and treated have been confirmed as suitable for the consultation. These are known as Site H and Site B.

The sites that were identified from this process as having greater potential are considered suitable for the engineering and operational purposes of locating the abstraction pumping station. The sites are sufficiently large, are on agricultural land avoiding designated sites (ecological, environmental, heritage), contamination, flood risk and utility clashes, are on soils/ground which will allow the construction of the new assets without special and costly ground treatment and which are suitably close to the canal to allow reasonably unconstrained operations. Further details of the assessment are included in Sections 7 and 8 below.

Two additional sites, Site P and Site Q, have also been identified and may play a role in the transfer as they are suitable for locating a treatment works remote from the storage and/or a booster station for passing potable water from the treatment works to the existing underground service reservoir near Luton. These sites are not sufficiently large to accommodate the bankside storage reservoir although they are sufficiently large to allow construction and operation of the treatment works and the new high lift pumping/booster station. The sites are on agricultural land avoiding designated sites (ecological, environmental, heritage), contamination, flood risk and utility clashes, are on soils/ground which will allow the construction of the new assets without special and costly ground treatment and which are suitably close to drainage and sewerage networks to allow relatively unconstrained operation of the treatment works and pumping station. Further details of the assessment are included in Sections 7 and 8 below.

These candidate sites and the discarded Site F are all located approximately as shown in Figure 4-1 below.

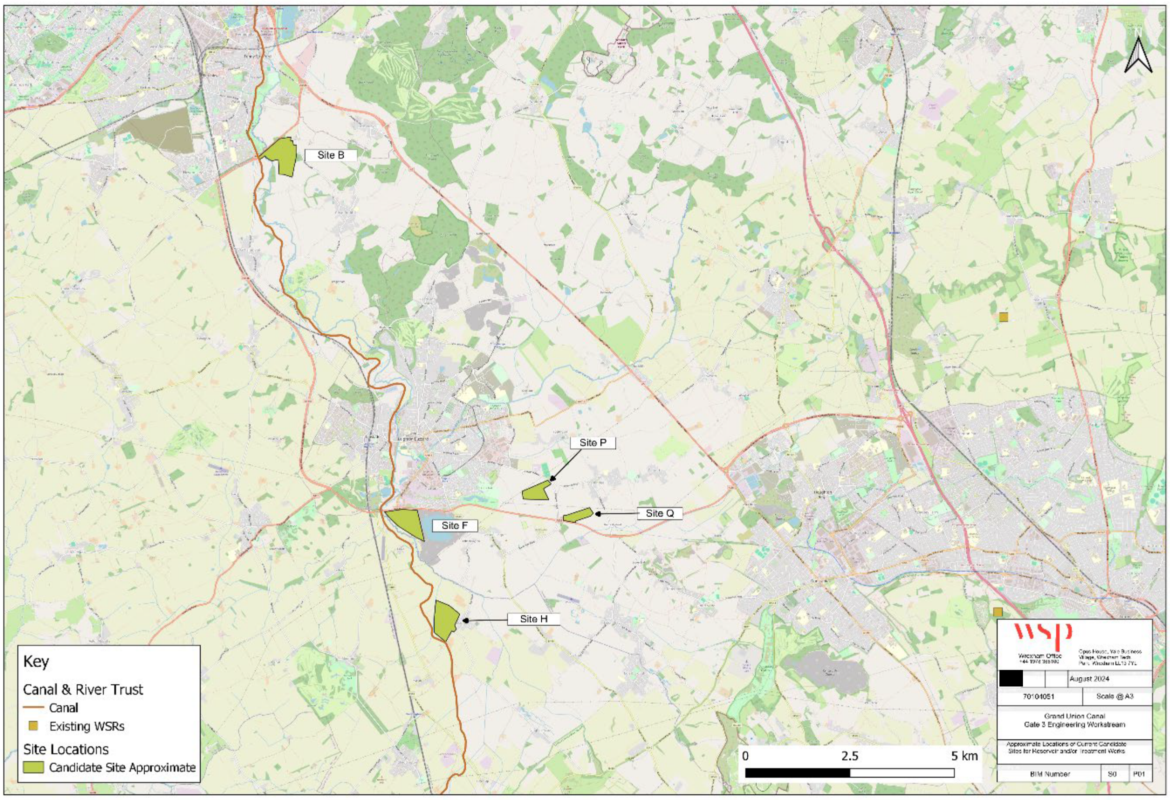

Figure 4-1 Approximate Locations of Current Candidate Sites for Reservoir and/or Treatment Works

The ultimate destination of the treated water has been specified by AfW as an existing underground service reservoir near Luton, where it can be used to replace water which will be unavailable when planned reduction in abstraction from the ecologically valuable chalk streams occurs in accordance with AfW's Environmental Destination plans.

Pipeline route corridors for the raw water pipelines from the canal to the bankside storage and for the transmission pipelines for treated water from the new treatment works at potential Sites H, B, P and Q to the service reservoir have been outlined, but these are still subject to consultation and further assessment. These are discussed and reported on in Section 11.

Further implications of the consultation process include the need to consider alternative locations for the structure to discharge treated recycled water from Minworth into the GUC near Atherstone, as part of the Minworth SRO scheme. There are currently two potential locations for the discharge structure and two pipeline routes from the break tank down to the discharge point; these sites and pipeline routes are to be consulted on.

The discharge structure will remain in the same canal pound as selected for the Gate 2 scheme, so there is no change to any requirement for canal bank raising because the hydraulics will not be affected; the water level in this pound will rise to an almost identical level to provide the necessary hydraulic gradient wherever in the upper reaches of the pound the discharge is located.

4.2 ACCESS

Since the scheme definition is still to be finalised following consultation, it has not been possible to arrange access to the proposed work locations except where the land is owned by the Trust and in some limited additional areas (separate land parcels at Whitton Lock, Fenny Stratford and Leighton Lock) where landowners were contacted by the GUC SRO Team, and permission was granted.

This lack of access means that geotechnical and topographical surveys have not been undertaken for a large proportion of the potential work sites. The development of designs is thus based on desk-based study of publicly available information. Not having site specific information could notably affect the layout, costs and risks for the raw water storage reservoir, the treatment works, canal bank raising and the potable water pipeline, which together represent, at the current level of assessment, c90% of the overall capital cost. For the other proposed scheme works the impact on costs and risks of not having the geotechnical and topographical information is much less.

4.3 HYDRAULIC MODEL

The hydraulic model of flows in the canal during transfer has a number of purposes:

- Assessment of increases in water level along the canal for different flow rates, to consider need for bank raising and bridge modifications.
- Assessment of velocities for various flow rates at constrictions, intake and discharge structures to test potential impacts on fish, sediment and water users.
- Consideration of operational conditions such as lock operation during high transfer flows, flood flows and/or pump station failure.
- Study of potential changes to water quality when transfer is operating.
- Support for development of a digital twin of the transfer system.

This is a very complex model and it remains under development. The output from the model therefore has been treated with some caution.

4.4 WATER QUALITY FOR TREATMENT WORKS

The current water quality in the canal is being monitored for a wide range of determinants. Samples have been taken for use in jar tests to support the outline design of the proposed treatment works, but it is acknowledged in the development of the process design to date that the water during the operation of the transfer may be different to that currently tested. The canal receives water inputs from several sources especially when it rains so there may be some volatility in water quality as a result. The raw water storage provided will offer a buffer to most poor water quality spikes and if there is a serious pollution incident can be used to supply the treatment works while abstraction from the canal is stopped.

Water quality modelling on a mass-balance basis is being undertaken to account for the impact of the water to be discharged into the canal from Minworth, based on the current design of the Minworth AWTP. A pilot test plant of the treatment process using current treated recycled water from Minworth WwRC is being developed to confirm the quality of the recycled water post treatment. The pilot test is due to commence in October 2024 and will run for a year.

The current process design for the new potable water treatment works at the southern end of the transfer is based on the jar testing undertaken to date, on a drinking water quality risk assessment and an understanding of the existing treated water chemistry of the potable water in AfW's distribution system at and downstream of the existing service reservoir near Luton. It is intended to design and operate a pilot plant during 2025 assuming that the GUCT is approved for Gate 4 and that a preferred abstraction and treatment works site has been agreed. The pilot plant will allow more investigation of flows, dosing rates, energy inputs to refine the design and provide additional confidence in the process reliability.

4.5 TRANSFER USAGE PATTERNS

Eventually the volume and timing of water transfers will be governed by actual needs as they develop over time in response to demands and weather.

Nonetheless, the operating principle for the GUC SRO is that it will run at a "tickover" flow for the bulk of the year, with a ramp up to a summer period demand and ramp down to the tickover flow after the peak period.

From the WRSE regional modelling AfW have stated that the GUC SRO will vary from year to year with the following likely peak flowrates:

- Wet year - peak flow 60 Ml/d
- Dry year (1:10 – 1:50 year event) - peak flow 80 Ml/d
- Drought year (1:200 year event) - peak flow 100-115 Ml/d

Operating at tickover flow will help to ensure that the system is functioning at all times, particularly important for biological water treatment processes, filtration processes, and water quality management in long water transmission pipelines.

The tickover flow will be as low as possible to keep the energy and treatment costs down; operating the system at 50Ml/d for 9 months of the year will be significantly more costly, with a higher carbon burden, than operating at 23 Ml/d.

The size of the tickover flow depends on the element of the overall system which is most sensitive to the flow rate, whether the AWTP at Minworth, the new potable treatment works at the southern end of the GUC SRO or either of the raw water transmission pipeline from Minworth to Atherstone or the potable water transmission pipeline from the new treatment works to the existing AfW underground service reservoir near Luton.

The various design decisions related to these elements are summarised in Table 4-1:

Element	Minimum Throughput	Design Consideration
Minworth AWTP	23Ml/d	"the minimum flows are driven by the need to maintain 20% flow through the AWTP" (ref Operational Philosophy, GUC Gate 3 Annex E5)
Minworth-Atherstone	1.96Ml/d	"flow required so that the turnover of water in the pipeline does not exceed a water age of 7 days" (ref Operational Philosophy, GUC Gate 3 Annex E5)
Southern Site Water Treatment Works (WTW)	10Ml/d	"deployable output of up to 100 Ml/d …in the following flow steps: 10%."
WTW to existing Service Reservoir	c6Ml/d	Pipeline is between [redacted] and [redacted]km long, [redacted]mm dia. Allowing for 4 days residence time.

Table 4-1 Design decisions affecting minimum (tickover) flow rate

This means that the constraining condition will be the minimum flowrate at Minworth AWTP at 20% of peak flow or for 23Ml/d.

The transfer pattern used assumes:

- Tickover flow rate for October to April
- Ramp up to (normal summer flow 60Mld) over May c1Ml/d increase per day
- Ramp up to (high summer flow 80Mld) at max 10 Ml/d per day (2 days)
- Ramp up to 100Ml/d (worst case summer flow 100Ml/d) at max 10Ml/d increase per day
- Flow at target rate from June - September
- Ramp down to tickover flow at between 1 and 2.5Ml/d max decrease per day.

The rates of increase/decrease are provisional at this stage and will be updated following Digital Twin modelling. In setting the initial values it has been assumed that during normal operation (i.e. ramp up to normal summer flows) flow increases are planned to meet known/predicted demand and therefore can progress gradually. In high/worst case scenarios flows will have to change more rapidly as drought/emergency demands are triggered.

Special cases of operation will occur for example when the system fails and requires management of the system storage at Daventry, Drayton and at the southern potable treatment works site, during flood events and if the Hands-off Flow at North Muskham is reached, requiring the supply from Minworth to be interrupted.

These operational modes will be developed in detail alongside the digital twin, but the overall principles are outlined in Table 4-2:

Mode	Actions Upstream of Daventry and Drayton	Actions At Daventry and Drayton	Actions at Southern Treatment Works Site
Unplanned operational failure downstream of Daventry and Drayton	Sustain full storage at Daventry and Drayton, increasing flows if necessary.	N/A	Draw from WTW storage, drawing from Grafham system by preference to sustain storage at WTW site as long as possible.
Unplanned operational failure upstream of Daventry and Drayton	N/A	Release flow from Daventry and Drayton up to peak rate of c63Ml/d. (Current peak rate can be increased if required by further investment in transfers from reservoirs to GUC.)	Sustain storage at WTW site as long as possible, drawing from Daventry and Drayton and Grafham system by preference
HoF breach under tickover flow	Sustain system storage prior to interruption.	Release required flow from Daventry and Drayton.	Avoid using storage at WTW by preference.
HoF breach under summer demand	Maximise flows to storage prior to interruption.	Release flow from Daventry and Drayton up to peak rate of c63Ml/d. (Current peak rate can be increased if required by further investment in transfers from reservoirs to GUC.)	Sustain storage at WTW site as long as possible, drawing from Daventry and Drayton and Grafham system by preference.
Flood event	Stop flows to GUC.	Stop releases from Daventry and Drayton.	Maximise abstraction to southern WTW storage. Activate any waste weirs in accordance with the Trust's current mode of flood operation.

Table 4-2 Draft Operational Modes for GUC SRO

Author names redacted

Asset size redacted

5. DISCHARGE FROM MINWORTH

5.1 INTRODUCTION

The treated recycled water from Minworth will be discharged into the Coventry Canal section of the GUC near Atherstone in Warwickshire. The selection of the final discharge location is still under review and an initial non-statutory consultation was undertaken during September and October 2024, but the discharge will be within the top pound of the GUC in this area.

Cost estimates for the discharge structure have been prepared based on the outline design work during Gate 3 (see Section 13).

5.2 LOCATION AND BASIS OF DESIGN

The two potential locations which formed part of the public consultation during September and October 2024 are shown in Figure 5-1 :

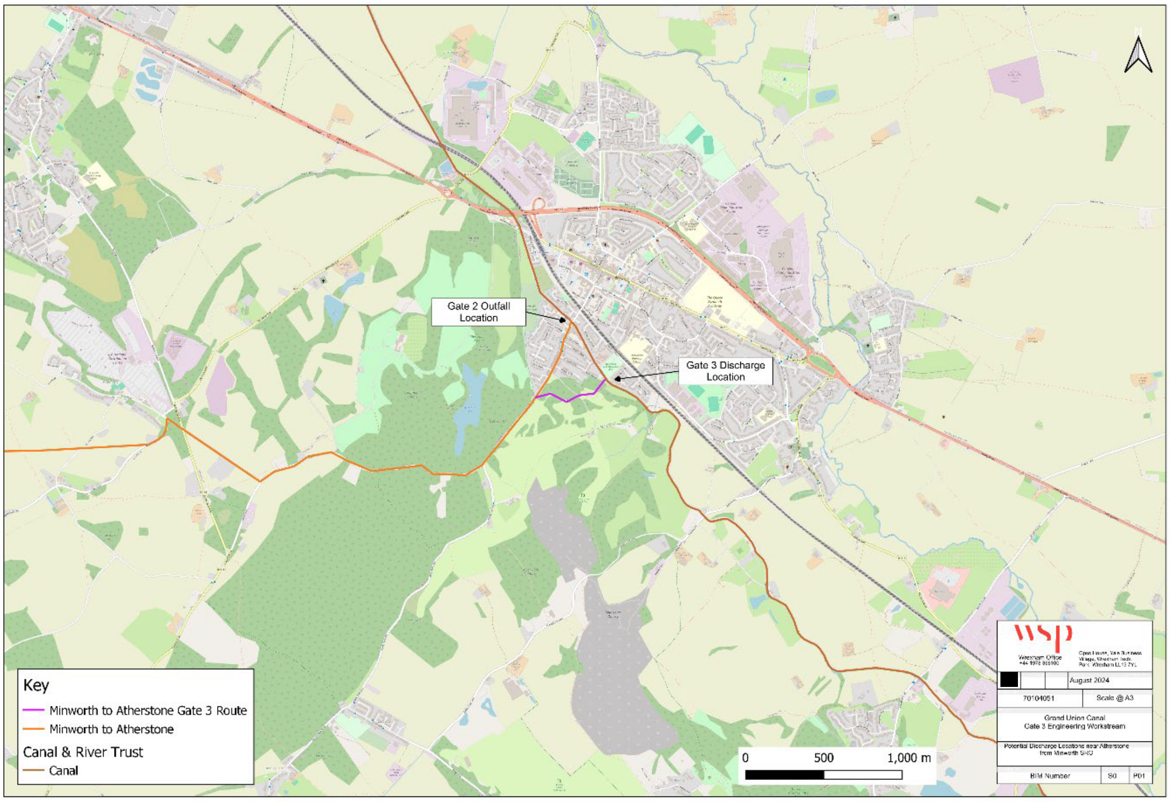

Figure 5-1 Potential Discharge Locations near Atherstone from Minworth SRO

From the Minworth SRO Consultant's report (Minworth SRO Gate 3 Annex A1) the treated recycled water from Minworth will be delivered at up to 115Ml/d (1.33m^3/sec) via a pumped and gravity main o[redacted]mm internal diameter. The pipeline material will ultimately be selected by the design and build contractor but is assumed for the purposes of this report to be steel.

Ordnance Survey mapping shows the Top Water Level (TWL) at the break pressure tank (Gate 3) is circa 165m AOD, and elevation at either of the proposed outfall structures (Gate 2 and Gate 3) is circa 92m AOD. Therefore, a static “shut in” head of 72m of 7.2 bar will be present in the pipeline at the discharge point.

The Minworth SRO Consultant’s document confirms that flows, once selected based on system demand, will be transferred at a constant rate with any ramp up and ramp down of flows being a gradual process. i.e. there will not be a shock increase or decrease in flows.

The discharge structure must be capable of discharging the full range of allowable flow into the GUC without causing nuisance to canal users, significant impacts on fish and other wildlife or any erosive effects on the canal itself.

At Gate 2 an option was proposed to include energy recovery at the discharge structure to take advantage of the flow and residual head in the system. At this stage a review of the opportunity has noted the following:

- The flow through the discharge structure will vary from low tickover flow (23Ml/d) up to 115Ml/d but, given the transfer pattern noted in 4.5 above the bulk of the time flows will be at the low end of the range.
- Turbines which can operate over this wide range of flow rates tend to be inefficient.

Therefore, for Gate 3 the design is for 2 turbines in a duty/standby rotation for the tickover flow. This will offer higher efficiency and more consistent energy recovery and should improve the benefit/cost ratio.

Energy could be either exported to the local energy grid or be used by the Trust in providing electrical hook up and charging points. A battery storage bank to be owned and operated by the Trust, may be located at the outfall structure to help manage the peaks and troughs of energy demand associated with charging electrically operated barges. An assessment of the benefits of export to the grid will be undertaken when the final location of the discharge structure is fixed and the distances to grid connection are known.

5.3 CONTROL

Flow control will be required at the outfall structure to ensure that the upstream gravity pipeline and break tank remain primed and ready for use if pumping from Minworth is interrupted. This will allow the system flows to be returned to normal as soon as possible without the need for a prolonged re-priming exercise. As such actuated valves will be required.

Minworth SRO Consultant’s operating philosophy advises that flow control valves will be required at the discharge structure to control flow changes, keep the pipeline charged in the event of flow interruption from Minworth AWTP, to mitigate surge/transients and to facilitate pump changeover. The operating philosophy will also need to be cognisant of the event whereby the Trust has to interrupt flow in the event of an emergency, as a design case (for example a breach of the canal onto towpath).

The current proposed design combines the flow control system with the outfall structure, a simpler arrangement with less mechanical equipment which reduces capex and opex costs.

5.4 DISCHARGE STRUCTURE LAYOUT AND DESIGN

There will be a single outfall structure, combining flow control, energy recovery turbines and peak flow bypass arrangements. This will comprise:

- A new concrete structure with a long weir to discharge into the GUC at controlled velocity. Maximum head over the weir will be c300mm at peak flow.
- The crest of the weir is to be ≥ 500mm above the TWL of the canal to ensure that the water forms a full nappe and does not drown out. There will be two separate weirs; the first weir for the base flows and the second for bypass flows only.
- The outfall structure will include concrete baffle walls and water filled cells for energy dissipation to avoid the need for higher maintenance requirement flow control and energy dissipation needle valves.
- All base, tickover flows will pass through one of two energy recovery turbines. Single turbine will operate at any given time on a duty/standby rotation.
- Flows to the turbines will be through a dedicated manifold with independent actuated valves to allow the duty of the turbines to be switched automatically. A flow meter with manual isolation will be included on the branch to the turbines.
- The turbines will sit above a “collecting well” with water falling into a dedicated water filled tank with a submerged orifice leading to a second stilling chamber.
- Two 500mm NB bypass pipes will be provided for the higher flow discharges. Higher flows will discharge via upturned bell mouths into individual chambers in the outfall structure to provide hydraulic isolation. From this chamber flows will weir over into the second chamber and combine before discharging into the GUC.
- The bypass pipes will have flow meters and actuated valves and manual isolation valves. The flow meters and actuated valves will control the flow through the bypass pipes so that sufficient flow is maintained to the energy recovery turbines.

A sketch of the potential layout in plan is shown in Figure 52. When the preferred location is confirmed further refinement of the design to take account of the actual site conditions will be undertaken. These refinements will include the geotechnical conditions, groundwater and access, and architectural style etc.

Additional modelling will also be required at Gate 4 to confirm water quality parameters at the discharge point. The design, depending on modelling of water quality in the pipeline from Minworth, may need to include re-aeration of the flow from the pipeline to maintain suitable oxygen levels at the discharge point.

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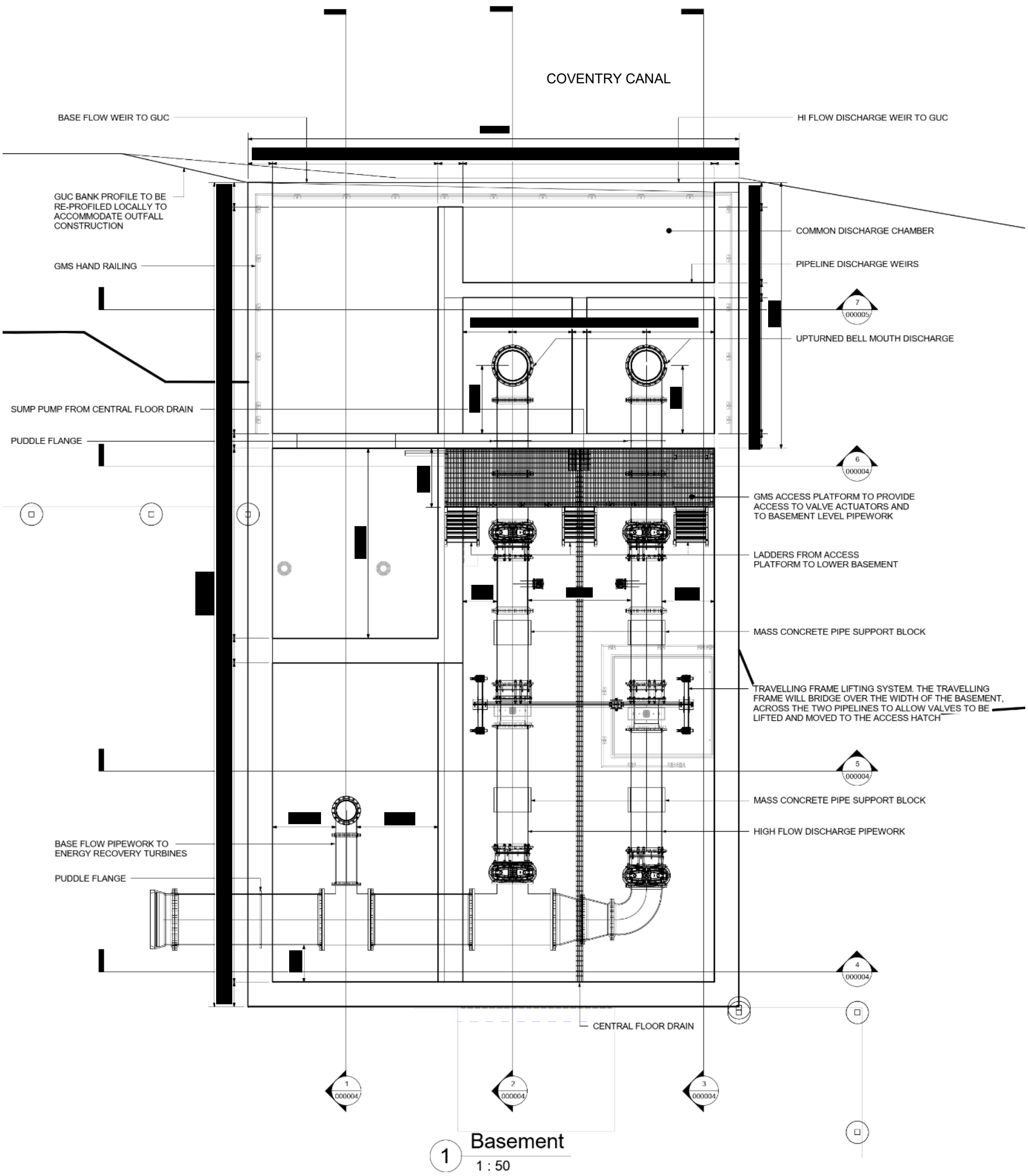

Figure 5-2 Excerpt of General Arrangement of Atherstone Discharge

5.5 CONSTRUCTION AND OPERATIONAL ACCESS

Access for construction will be resolved by others as part of the Minworth SRO scope of works. Access for on-going operations is intended to be aligned to the temporary works given the constraints for access in the area.

5.6 BIODIVERSITY NET GAIN (BNG)

In accordance with Government policy there will be a requirement for biodiversity net gain associated with the GUC SRO works. During Gate 2 some examples of work that could be undertaken to secure at least 10% BNG for the project were developed for illustrative purposes.

The Environmental Consultant will be responsible for developing the natural capital and BNG accounts against which the necessary gain to be included in the project scope will be estimated. The Engineering Consultant will then work with the Environmental Consultant, the Planning Consultant, the Engagement Lead and the Trust to specify, plan, design and cost out the best options at locations to be determined. Where any net gain works can contribute to the effective operation of the scheme and for social gain these would be of interest.

6. CANAL WORKS

6.1 INTRODUCTION AND SCOPE

Use of the canal system as a bulk transfer of water will change the Trust's current operating envelope and requires works along the canal to facilitate this change of operation.

The canal works consist of:

- some bank raising works to retain the additional water,
- pumped bypass systems at "uphill" locks,
- gravity bypass systems at "downhill" locks,
- any necessary adjustments to bridges, tunnels and other flow constrictions to ensure that velocities and levels do not exceed allowable limits,
- modifications to some of the waste weirs and flow inlet structures and
- new screened abstraction pumping station south of Milton Keynes to remove the additional flow from the canal.

Cost estimates have been prepared further developing the outline design work during Gate 2 as modified following the updated hydraulic design by the Hydraulic Consultant during Gate 3.

6.2 BANK RAISING

6.2.1 Need for Raising

Indicative bank raising details are provided in Appendix C. The current designs are summarised below.

In current normal operation without bulk transfer of water, each canal section or "pound" between locks effectively has a flat, or nearly flat, water profile as water transfers along the canal are limited to very low lockage flows; a "lockage" flow is that volume of water that is released when the lock is operated. By way of illustration if a typical lock operation releases around $80m^3$ and there are 30 operations a day in summer, this is equivalent to a local flowrate of c5Ml/d during daylight hours.

When the canal receives a large quantity of rainfall or a bulk water inflow the water elevation rises at the point of inflow to establish sufficient hydraulic gradient to force the water along the canal against the friction provided by the canal walls and base. Excess water is spilled over waste weirs along the canal into local drainage channels and rivers.

The Trust has a current operating level regime which has on average a Normal Operating Zone (NOZ) of Normal Water Level +/- 50mm with a freeboard provided to allow for natural variation in the water level due to rainfall, day to day operations, use by boaters and river inputs.

The proposed flows of up to 115Ml/d will cause the canal water levels to rise at the upstream end of each pound with longer pounds having higher rises to overcome the larger friction from the longer length of canal walls and base. There is a risk that these increased water levels may cause the water to flow out of bank or over the waste weirs, where the current freeboard is insufficient to allow the rise.

In the sketch shown in Figure 6-1 the solid green line represents the top of the canal bank, and the thin green line is c 250mm below this representing the freeboard. The dashed blue line is the normal water level, and the solid blue line represents the water level when the canal transfer is running at peak flow.

Where the solid blue line lies below the freeboard line then sufficient freeboard remains available even for this worst case of flow; where the solid blue line lies above or on the freeboard line then bank raising work is indicated as necessary. The Hydraulics Consultant's computer flow model develops the blue line (hydraulic gradient) and compares this with the freeboard level, reporting where bank raising is needed.

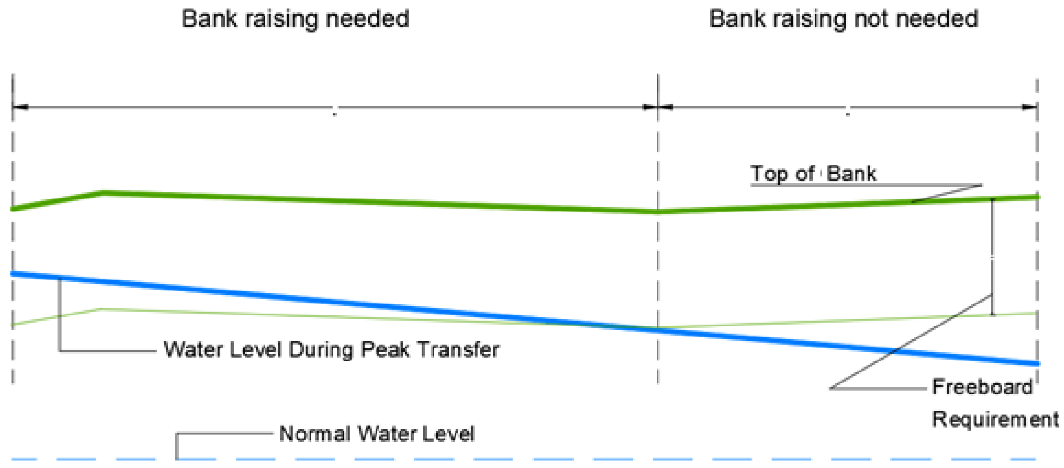

Figure 6-1 Sketch showing how the need for bank raising is estimated.

Bank raising and restoration work plus modifications to the waste weir levels may be required to allow the additional water during transfer to be retained safely in the canals. Typically canals have a towpath on one side only (examples of exceptions are at some locks and junctions); this allows identification of the "towpath side" and the "offside" where there is no towpath or a towpath side bank comprising stone revetments slabs over puddle clay.

6.2.2 Water Level Assessment

The Hydraulic Consultant's workstream has assessed raised water elevations for a range of flow rates and initial water levels against topographic information collected either as LIDAR data or actual site won levels.

There is unlikely to be a need for transfer of high flows when the environmental conditions are already wet and canal water levels already elevated. The range of flows and initial water levels assessed by the Hydraulics Consultant are shown in Table 6-1:

Flow Rate	Demand Condition	Initial Environmental Condition	Initial Canal Water Level Condition
115Mld	Peak flow in exceptional drought (1:200 year drought for AfW customers)	Dry, with mean/low canal water levels	Mean Normal Operating Level
80 Mld	Peak flow in 1:20-1:50 drought	Dry, but high canal water levels	Normal Operating Level +50mm
60 Mld	Peak flow in normal year	Dry, but high canal water levels	Normal Operating Level +50mm

Table 6-1 Hydraulic Modelling Scenarios

For lengths of the canal bank or towpath identified by the Hydraulic Consultant as being below the raised water level or where any remaining freeboard is judged unacceptable, the existing banks (towpath and/or offside lengths) will need raising to prevent overtopping and increased seepage (i.e. water level below the towpath/bank level but above the watertight lining level).

The latest hydraulic modelling shows in the following table the approximate lengths of canal (towpath and offside) that will need raising or restoring to prevent over-topping or restore freeboard to 250mm at peak flow.

The initial condition referred to in Table 62 is either for:

- "NWL" which is taken to mean that the water level is the Mean Normal Operating Level. This is the level experienced in the canal during much of a normal year, when there is no significant drought or wet periods. Running the GUCT at the maximum flow of 115Ml/d in such "normal" weather is unlikely but it is feasible; for example if there has been an outage at Minworth requiring the available storage at Daventry and Drayton and/or at the southern water treatment works site to be draw down it would be important to try to refill the storage as soon as reasonably practicable, so a high transfer flow would be desirable.
- "NWL u/s and NWL-0.05m d/s" which is when the water level in the canal is lower than normal due to an extended drought period. In these circumstances the maximum flow might well be needed. The initial condition would be where the downstream water level is drawn down 50mm below NWL and the water level at Atherstone would be at NWL. The high flow would require the establishment of a hydraulic gradient to drive the flow against the friction presented by the canal's wetted perimeter. The initial condition would have the effect of lowering the resulting operating water level along the length of the GUC by between 0mm and 50mm. This would reduce the length of canal which would require raising to maintain freeboard. The Trust notes that not all canals are run within these bounds all the time so the assessment for Gate 4 will need to be done pound by pound. For further information, please refer to GUC SRO G3 Annex A4.2 Hydraulic Modelling Report.

Flow	Initial Canal WL Condition	Worst-Case Scenario for Length of Canal Bank Raising (Combined Offside and Towpath Side) (km)
115Ml/d	NWL	104km
115Ml/d	NWL u/s and NWL-0.05m d/s	58km

Table 6-2 Estimated Worst-Case Scenario for Length of Canal Bank Raising

The hydraulic model is still in development with a conservative approach taken to friction/roughness along the canal; during Gate 4 a series of sensitivity tests will be run to establish the risk of reduced or zero freeboard when the roughness is varied, to represent different levels of activity by the Trust to maintain clearer channel sections.

The model will also be used to evaluate the use of stop locks to split the longer canal pounds. The shorter pounds will have the same hydraulic gradient as the original longer pounds but the stop lock will cause a step down in the total head and therefore has the potential, if suitably located, to reduce the water level increase.

It is worth noting that the operation of the transfer as shown in Section 4.5 Transfer Usage Patterns will mainly be for low "tickover" flows which will not require any significant works to maintain 250mm freeboard. Operation of the transfer at higher flows is likely to occur infrequently and during summer or extended drought periods when the canal water level is most likely lower than average.

The estimates of how much bank raising will be required are therefore likely to be conservative.

Further consideration may be given by the project partners during Gate 4 studies of options to reduce the quantity of bank raising while still being able to operate within acceptable risk parameters during the rare occasions when the transfer will need to operate at or near its design capacity.

6.2.3 Bank Raising Options

For the purposes of assessing cost and programme a conservative approach has been taken to defining the lengths of canal bank that will need raising, and also the height of raising or restoration that will be needed as described above. We have assumed 104km of bank raising (approx. 53km towpath side and 51km offside), which is based on the assumptions in the Hydraulic Consultant's model relating to hydraulic roughness and acceptable freeboard. The project partners are committed to reducing the amount of bank raising to a minimum, including significantly below the worst-case scenario presented in this report. This will continue to be developed further in Gate 4.

The length of canal to be raised needs to be agreed and then decisions may be made, based on practical considerations from the Trust's operational requirements, landowner requirements and on optimal environmental and ecological outcomes, as to what bank/towpath treatment would be preferred in which location, but since these have not yet been agreed with The Trust and the Environmental Consultant, nor have landowner requirements been sought, they may be subject to change.

Suitable bank raising techniques were identified at Gate 2 to cover a range of different types of soft earth banks, vegetated banks, sheet-piled and/or masonry/brickwork banks. These, and the Trust’s standard details listed in Figure 63, will be used in coordination with the Environmental and Hydraulic Consultants to finalise the Gate 4 bank raising design.

For costing and programme estimation purposes, for each section of the canal affected by the transfer an assessment has been made of the probable raising technique. A preference is to make the raising using a technique which leaves the bank and/or towpath looking essentially the same as it is now. Where a sheet pile wall is currently used it is proposed to be raised using a sheet pile wall, where it is a softer edge then a similar soft technique is proposed. The soft technique may not always be possible, particularly where space is restricted by physical or landowner constraints for example, as larger bank raising heights using earth embankments occupy a large footprint.

Canal raising options have been developed as below.

Construction Type*	Description
0.0 & 0.1	These sections do not require raising. Either the predicted water level increase is below the freeboard or the section is already suitable to cope with the new water level (e.g. tunnels)
1.0 & 1.1	Earth embankments – these tend to be in rural areas where the towpath is grass.
2.0 & 2.1	Timber piling – sawn treated wood with walings and capping. Suitable for moorings and aesthetically suitable in areas of character.
3.0 & 3.1	Stakes and rock roll construction – suitable in heavily used areas that may require more bank protection/reinforcing (e.g. junctions etc.)
4.0 & 4.1	Stakes and coir roll construction – suitable where widths allow, can be planted.
5.0 & 5.1	Similar to type 2 but using simple poles, locally sourced where suitable. More rustic and not suitable for moorings (e.g. risk of snagging on uneven surface).
6.0 & 6.1	PCC sections to retain fill – suitable in urban areas with limited space and higher traffic loads and modern marinas. Surfacing and finish to suit location.
7.0	Treatment to buildings/structures that form the bank edge (e.g. old wharf building, boundary wall etc.). Treatment is to provide water proofing/damp proofing similar to standard Property Level Protection (PLP) used in urban flood prevention schemes by the Environment Agency/Local Authorities.
8.0 & 8.1	Heritage brickwork
9.0	Similar to type 4 but more extensive and only used on the non-towpath side where restoration of the bank is likely.

*Suffix x.0 indicates along the non-towpath side and suffix x.1 is the towpath side of the canal

Table 6-3 Bank Raising Options

An example of the drawings produced to estimate the type of raising required is provided in Figure 6-2 with more detail provided in Appendix D.

Figure 62 shows the first section of the canal after the discharge from Minworth AWTP near Atherstone, the construction type is shown for both towpath and off-side. The dashed line

Author names redacted

Commercially sensitive information redacted

and numbers at nodes between the connecting lines show the locations the computer model reaches for which level output is available.

Figure 6-2 Bank Raising Construction Type for Indicative Section of Canal

Until the final hydraulic model has been accepted, and site appraisal work and geotechnical assessment has been undertaken it is not currently possible to further refine the design options at each stretch.

However, taking a conservative high cost/metre of repairs and raising from the Trust's records (c£[redacted]-£1[redacted]/m) an outline cost can be developed based on the current range of lengths to be raised/repaired.

The costs are variable depending on the technique, associated materials and access constraints as well as any requirements to manage wildlife impacts in accordance with licences; for example works may have to be mobilized, demobilized and re-mobilized to avoid interfering with nesting seasons etc.

Author names redacted

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Making life better by water

Document Ref	Rev	Ver	Author
DD-G-0002	P01 27.05.22	01 27.05.22	[redacted]

Guidance

Design & Development

List of Standard Details

Drawing Number	Solution Type	Drawing Title	Revision
STD-CRT-ZZ-ZZ-01-DR-C-01	Towpath	Towpath Detail Unbound Stone no timber edge boards	0.1
STD-CRT-ZZ-ZZ-01-DR-C-02	Towpath	Towpath Detail Unbound Stone with timber edge boards	0.1
STD-CRT-ZZ-ZZ-01-DR-C-03	Towpath	Towpath Detail Unbound Stone with timber edge boards and rasied surface level	0.1
STD-CRT-ZZ-ZZ-01-DR-C-04	Towpath	Towpath Detail KBI Flexipave	0.1
STD-CRT-ZZ-ZZ-01-DR-C-05	Towpath	Towpath Detail Repairs to Existing Tarmac with spray and chip finish	0.1
STD-CRT-ZZ-ZZ-01-DR-C-06	Towpath	Towpath Detail Tarmac with spray and chip finish	0.1
STD-CRT-ZZ-ZZ-01-DR-C-07	Towpath	Surfacing Pothole Repair	0.1
STD-CRT-ZZ-ZZ-01-DR-C-08	Towpath	Brick Paving	0.1
STD-CRT-ZZ-ZZ-01-DR-C-09	Towpath	Brick Paving Ramp Detail	0.1
STD-CRT-ZZ-ZZ-01-DR-C-10	Towpath	Typical Towpath drain detail	0.1
STD-CRT-ZZ-ZZ-01-DR-C-11	Towpath	Towpath Drainage Concrete Dish Channels	0.1
STD-CRT-ZZ-ZZ-02-DR-C-01	Bank Protection	Concrete bag wall	0.1
STD-CRT-ZZ-ZZ-02-DR-C-02	Bank Protection	Coir topped concrete bag	0.1
STD-CRT-ZZ-ZZ-02-DR-C-03	Bank Protection	Coir rolls laid on existing bed	0.1
STD-CRT-ZZ-ZZ-02-DR-C-04	Bank Protection	Coir rolls with single rock roll or hazel faggot base	0.1
STD-CRT-ZZ-ZZ-02-DR-C-05	Bank Protection	Coir rolls with double rock roll or hazel faggot base	0.1
STD-CRT-ZZ-ZZ-02-DR-C-06	Bank Protection	Coir rolls with triple rock roll or hazel faggot base	0.1
STD-CRT-ZZ-ZZ-02-DR-C-07	Bank Protection	L8 Trench Sheet Piles	0.1
STD-CRT-ZZ-ZZ-02-DR-C-08	Bank Protection	Timber posts and boards	0.1
STD-CRT-ZZ-ZZ-02-DR-C-09	Bank Protection	Timber posts and boards topped with Coir Rolls	0.1
STD-CRT-ZZ-ZZ-02-DR-C-10	Bank Protection	Brick Coping Bonding Detail	0.1
STD-CRT-ZZ-ZZ-02-DR-C-11	Bank Protection	Puddle Clay leak Stopping Works behind Masonry Wall	0.1
STD-CRT-ZZ-ZZ-02-DR-C-12	Bank Protection	Clay Fillet Capped with cellular geotextile - Dewatered Canal	0.1
STD-CRT-ZZ-ZZ-02-DR-C-13	Bank Protection	Clay Fillet - Dewatered Canal	0.1
STD-CRT-ZZ-ZZ-02-DR-C-14	Bank Protection	Fenders attached to masonry bank wall	0.1

Figure 6-3 The Trust's Standard Detail List

Copies of these details are available in Appendix D.

A typical raising detail, in this example for raising an earthen bank, is shown in Figure 6-4. This is for illustration only as individual sites may have different requirements for finishes and layout or towpath user requirements[1], but the access arrangement as shown from a canal boat is relatively frequently used.

[1] Towpaths for Everyone – "Canal & River Trust" January 2024

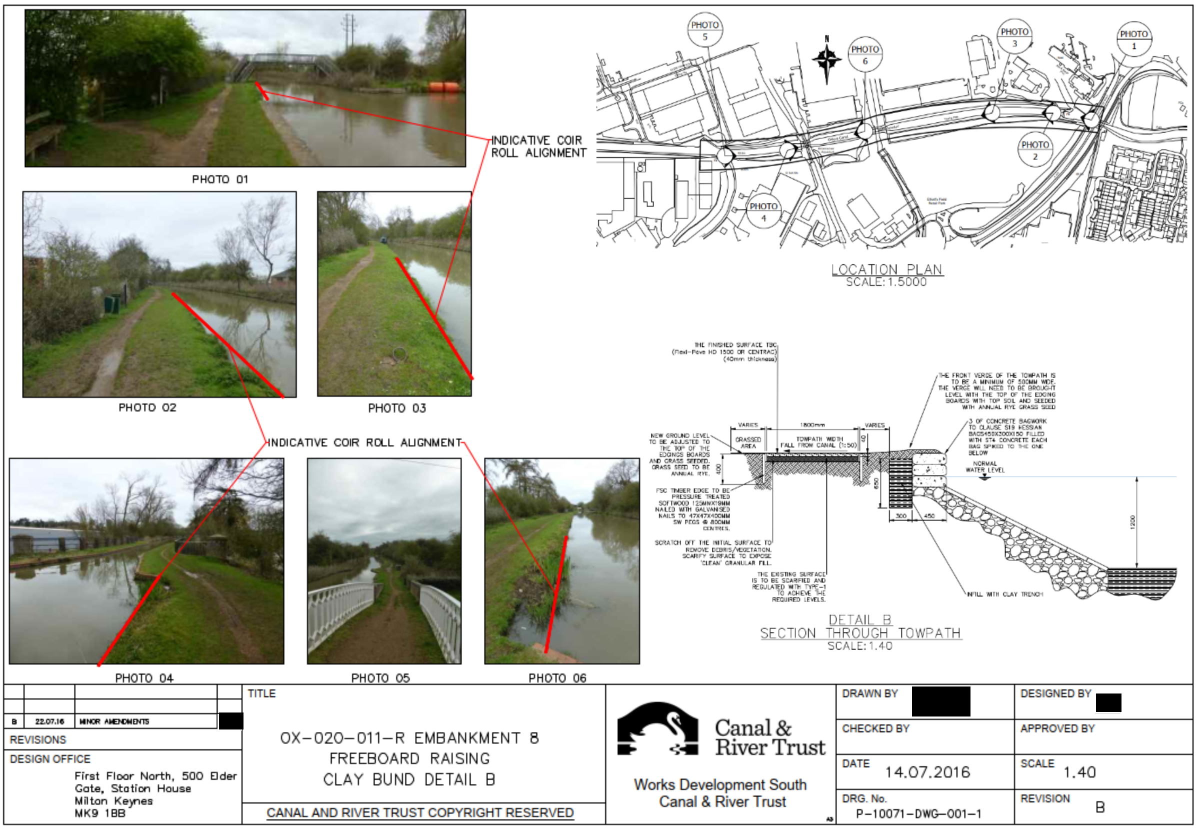


Figure 6-4 Typical Detail for Raising an Earthen Canal Bank

(Reproduced with kind permission of the Canal & River Trust)

Figure 6-5 Photograph of an Example of Raising Works Showing Access

(Reproduced with kind permission of the Canal & River Trust)

Assessments of the possible options for bank raising have been undertaken considering different freeboard allowance options to provide cost and carbon estimates and to feed into the estimated construction programme. For each reach in each pound an initial view of the likely raising technique has been made based on a like-for-like modification, but since these have not yet been agreed with the project team, nor have landowner requirements been sought, they may be subject to change.

If the project partners are able to accept a minimum freeboard lower than the 250mm currently assumed in the concept design then significant savings of cost, carbon and time could be made, which would need to be balanced against increased risk of overtopping. This will be developed further in Gate 4.

As an example of the reductions in bank raising possible, Table 63 shows the estimated ranges of length affected for different freeboard allowance options for the peak flow assuming NWL initial condition.

Peak Flow	115Mld	115Mld	115Mld
Max Freeboard Reduction	50mm	100mm	150mm
Raising Type	Total Length (m)	Total Length (m)	Total Length (m)
0.0	15,311	5,521	8
0.1	14,572	5,101	-
1.0	7,154	6,323	5,990
1.1	9,224	8,238	7,903
2.0	8,053	7,376	6,307
2.1	8,958	5,574	5,210
3.0	4,527	3,610	466
3.1	20,426	16,177	7,186
4.0	12,391	7,920	2,822
4.1	8,614	7,287	4,381
5.0	7,923	7,755	6,016
5.1	3,410	3,410	2,869
6.0	1,820	1,650	1,122
6.1	1,138	1,038	978
7.0	1,032	662	567
8.0	2,554	2,237	2,098
8.1	1,321	1,010	878
9.0	5,512	4,412	3,317
9.1	-	-	-
	133,939	95,301	58,116

*Type 0.0 & 0.1 do not require raising – towpath is higher than canal edge.

Table 6-3 Estimated Length of Different Options for Canal Bank Raising depending on Freeboard Requirement

6.3 BYPASSES

The current operation of the canal in the absence of the bulk water transfer is for water released from locks during operation to flow downhill from summit pounds towards low points where waste weirs discharge the water back to the environment.

As water is lost from the system at waste weirs sources of water at summit pounds and from connections to rivers and streams are required to make up such losses. The Trust has a number of reservoir sources and connections to local rivers and streams that have historically provided the water and generally continue to do so. The availability of water to the Trust is under some pressure due to environmental concerns and increased summer use of the canal; higher boat traffic increases the amount of lockage water which eventually flows downhill and over the waste weirs. Legislative changes in the Acts which govern water abstraction also influence the availability of water to the Trust.

To improve the efficiency of use of the water sources the Trust economises on water losses by back-pumping at many locks so that lockage water is largely retained in the system, thereby optimising the value of make-up water sources.

The water transferred by the GUC SRO will be continually from North to South, rather than “downhill” in both directions from high point sources to waste weirs, and the volume to be transferred at peak flow will be considerably larger than is currently moved at downhill locks or at back-pumping stations. New assets will be required to allow the uni-directional flow to be sustained, by means of bypasses.

Figure 66 provides a long section of the canal system shows both “downhill” and “uphill” bypasses required at locks or lock flights.

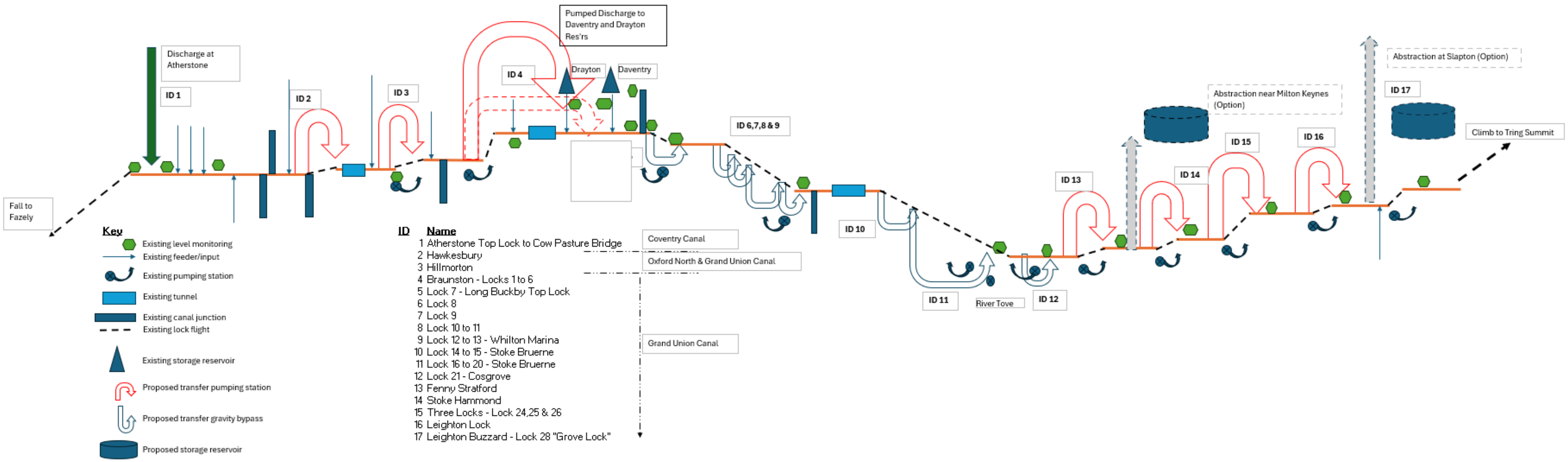


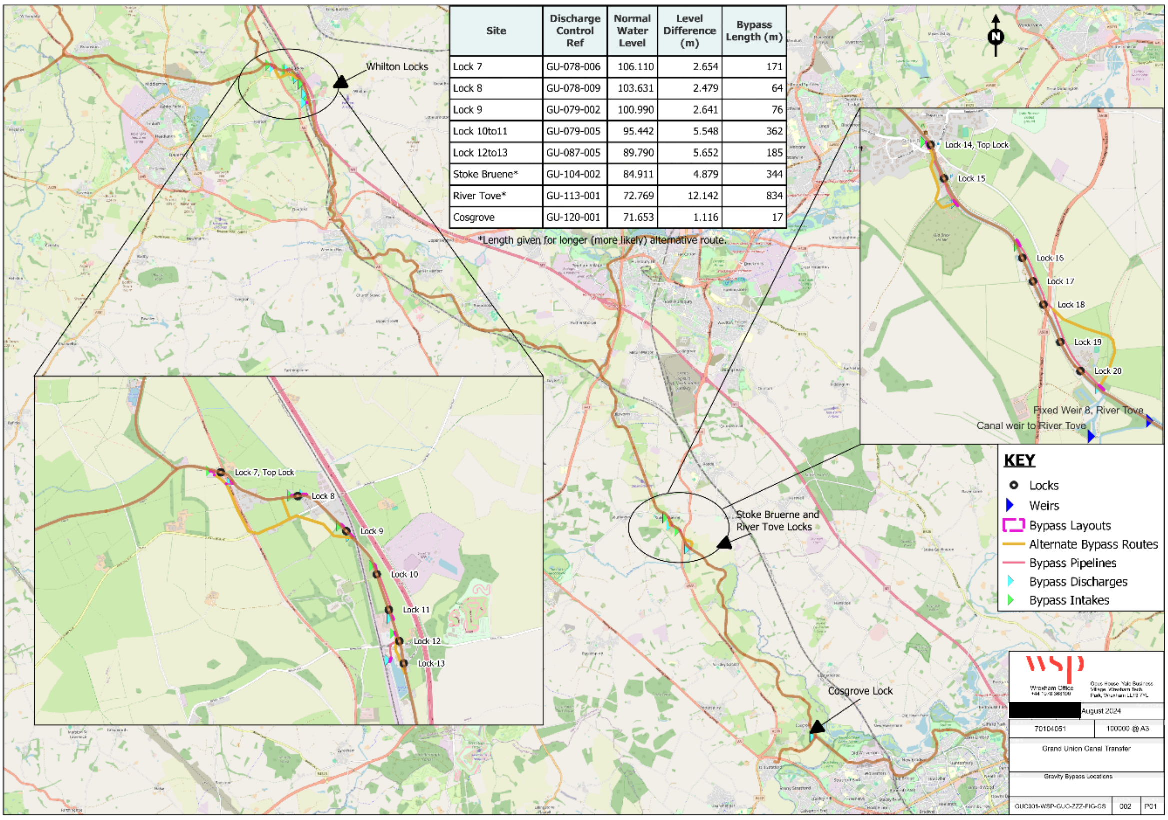
Figure 6-6 Schematic of Canal Transfer Assets (Gate 3 Scope)

Existing gravity and pumped bypasses at the locks are used by the Trust for normal, "non-transfer" operation of the GUC; the new bypasses will be completely separate so as to allow the GUC to be operated effectively with or without the transfer operating.

6.3.1 Gravity Bypasses

The "downhill" bypasses are gravity bypasses and are needed at up to 8 locations as shown in Figure 6-7 : Details of the various bypass lengths and associated drops are provided in Table 6-4.

- Buckby Flight – Lock 7.
- Buckby Flight – Lock 8.
- Buckby Flight – Lock 9.
- Buckby Flight – Lock 10-11.
- Buckby Flight – Lock 12-13.
- Stoke Bruerne – Locks 14-15.
- Stoke Bruerne – Locks 16-20, and
- Cosgrove Lock.



Site	Discharge Control Ref	Normal Water Level	Level Difference (m)	Bypass Length (m)
Lock 7	GU-078-006	106.110	2.654	171
Lock 8	GU-078-009	103.631	2.479	64
Lock 9	GU-079-002	100.990	2.641	76
Lock 10to11	GU-079-005	95.442	5.548	362
Lock 12to13	GU-087-005	89.790	5.652	185
Stoke Bruene*	GU-104-002	84.911	4.879	344
River Tove*	GU-113-001	72.769	12.142	834
Cosgrove	GU-120-001	71.653	1.116	17

Figure 6-7 Location on GUC of Gravity Bypasses

Lock	Drop (m)	Approximate Bypass Length (m)
Buckby Flight – Lock 7	c19.2m	c150m
Buckby Flight – Lock 8		c100m
Buckby Flight – Lock 9		c80m
Buckby Flight – Lock 10-11		c350m
Buckby Flight – Lock 12-13		c200m
Stoke Bruerne – Locks 14-15	c4.87m	c250m
Stoke Bruerne – Locks 16-20	c12.19m	c700m
Cosgrove Lock	c1.01m	c50m

Table 6-4 Currently Proposed Gravity Lock Bypass Characteristics

Each gravity bypass consists of:

- An inlet weir which is screened for public safety and to prevent debris entering, with automated moveable weirs to allow the transfer inlets to be adjusted and/or closed. The weir length is sized to ensure that water velocities due to the transfer flow will not affect canal users and local flora and fauna. Velocity constraints were agreed with the Trust and the Environment Agency as no greater than 0.3m/sec in the main canal channels and no greater than 0.05m/sec at the screens.
- A wet well into which the transfer water will flow after the screened weirs.
- A connecting gravity pipeline to the outlet weir wet well. The gravity bypass pipeline will be sized for each bypass so as to not create a hydraulic constraint at the peak flow. There will be intermediate access chambers at any change of direction. These will have locked hatches and safe access for maintenance.
- A wet well at the outlet structure in which the water will be stilled and then rise to flow over the screened outlet weir.
- An outlet structure with automated, moveable weirs which will be screened for public safety and to prevent debris entering if the weirs were to fail in the wrong position. The weir length is sized to ensure that water velocities due to the transfer flow will not affect canal users, towpath users and local flora and fauna.
- Both inlet and outlet structures will be set into the canal bank. Safe access with locked access hatches will be provided to the automated weirs and the wet wells for maintenance.

At Locks 16-20 of the Stoke Bruerne Flight it may be feasible to install an energy recovery system if a suitable energy demand is identified.

These arrangements remain subject to change following formal stakeholder engagement.

6.3.2 Pumped Bypasses

The “uphill” bypasses are pumped bypasses and are needed at up to 7 locations, which are shown in Figure 6-8. Details of the various bypass lengths and associated raises are provided in Table 6-5:

- Hawkesbury - Lock OX001-002.
- Hillmorton – Lock OX025-008
- Braunston – Lock 6. This is a special case of a pumping station to deliver flow to the Daventry and Drayton reservoirs and to a bypass around Braunston tunnel.
- Fenny Stratford - Lock 22.
- Stoke Hammond - Lock 23.
- Three Locks - Locks 24-26, and
- Leighton - Lock 27.

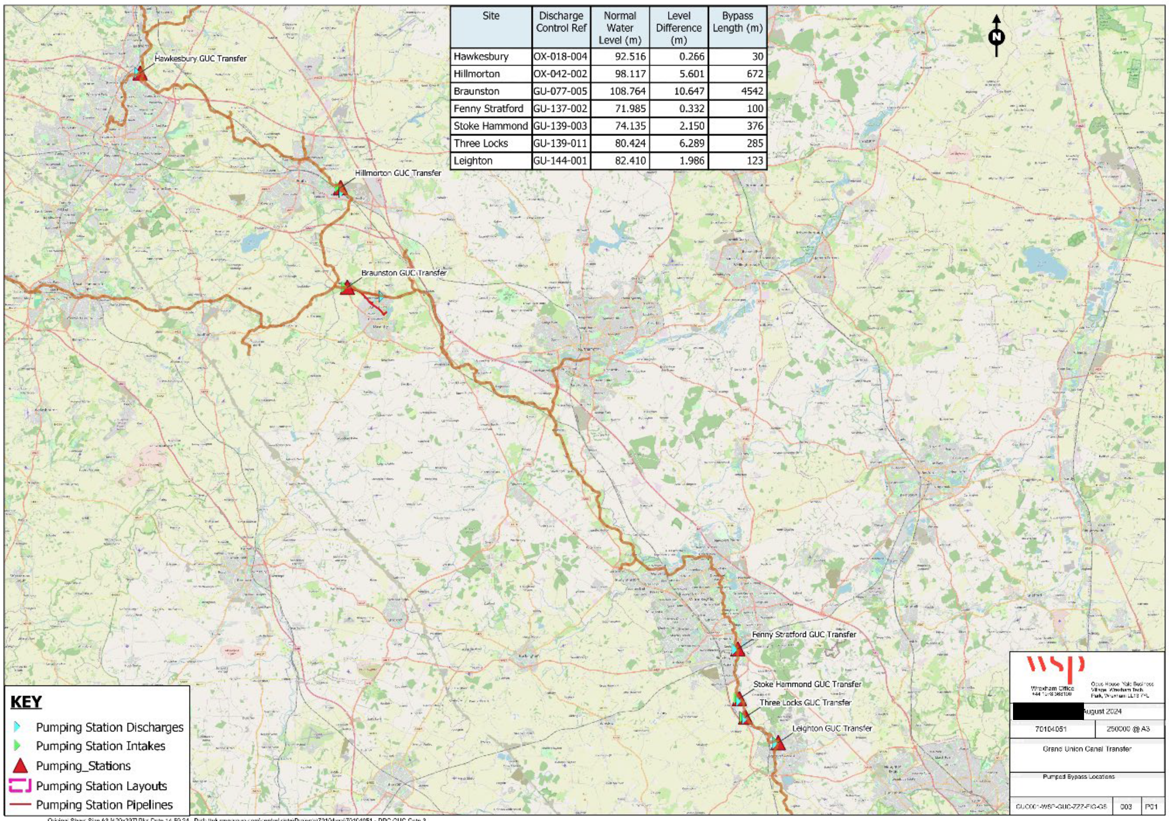


Figure 6-8 Location on GUC of Pumped Bypasses

Lock	Rise (m)	Approximate Bypass Length (m)
Hawkesbury – Lock OX001-002	c0.26m	c50m
Hillmorton – Lock OX025-008	c6m	c700m
Braunston – Lock 6 Bypass	c30m	c3500m
Braunston – Lock 6 Daventry Link	c25m	c3500m
Fenny Stratford- Lock 22	c0.33m	c50m
Stoke Hammond- Lock 23	c2.3m	c350m
Three Locks – Locks 24-26	c6.3m	c250m
Leighton - Lock 27	c2m	c150m

Table 6-5 Currently Proposed Pumped Lock Bypass Characteristics

When the location of the abstraction from the GUC to supply the new potable water treatment works is agreed following consultation, the final number of pumped bypasses will be determined. For example, if Site H were to be chosen then all 7 of the above pumped bypasses would be needed, with a possible further 2 pump stations (depending on whether abstraction were located near the storage facility, or whether a higher lift pump and short pipeline is used). If Site B were to be chosen then only 4 bypasses would be needed in total. with Stoke Hammond, Three Locks and Leighton being omitted. Other treatment works sites might require different numbers of bypasses.

Each pumped bypass consists of:

- An inlet weir which is screened for public safety and to prevent debris entering, with automated moveable weirs to allow the transfer inlets to be adjusted and/or closed. The weir length is sized to ensure that water velocities due to the transfer flow will not affect canal users and local flora and fauna. Velocity constraints were agreed with the Trust and the Environment Agency as no greater than 0.3m/sec in the main canal channels and no greater than 0.05m/sec at the screens.
- A new pumping station, which will be designed to reflect an appropriate architectural style for each site. The pumping station will have a wet well into which the transfer water will flow after the screened weirs. The pumping station will have 3 - 5nr pumps sized to cover the range of transfer flows, with VSD/VFD drives to optimise energy efficiency.
- Power supply from the local grid delivered to a new on-site transformer and switchgear, with a UPS to allow control of the system in the event of a power outage.
- The pumps will deliver via control valves, protection valve and flow meter into a connecting pressurised pipeline to the outlet weir wet well. The bypass pipeline will be sized for each bypass to ensure a hydraulic constraint is not created at the peak flow.
- A wet well at the outlet structure in which the water will be stilled and then rise to flow over the screened outlet weir.
- An outlet structure with automated, moveable weirs which will be screened for public safety and to prevent debris entering if the weirs were to fail in the wrong position. The weir length is sized to ensure that water velocities due to the transfer flow will not affect canal users and local flora and fauna.
- Both inlet and outlet structures will be set into the canal bank. Safe access with locked access hatches will be provided to the automated weirs and the wet wells for maintenance.

A typical layout of a pumped bypass is shown in Figure 6-9, with the approximate location of the inlet and outlet weirs and pumping station indicated along with a provisional route of the connecting pressurised bypass pipe.

A summary of the equipment requirements at each potential bypass pumping station is provided in Table 6-6.

Bypass Stations				
Name	**Duty No.**	**Standby No.**	**Head max. (m)**	**kW/pump**
Leighton Lock	3	1	4.64	28
Three Locks	3	1	11.27	67
Stoke Hammond	3	1	7.44	44
Fenny Stratford	4	1	4.9	20
Braunston Bypass	3	0	70.04	509
Braunston Feed to Reservoirs	3	0	57.2	507
Hillmorton	3	1	14.5	69
Hawkesbury	4	1	4.85	19.9

Table 6-6 Current Proposal for Pumped Bypass Equipment

Figure 6-9, Figure 6-10 and Figure 6-11 were extracted from the 3D drawing model and show typical structures, pumping plant layout and chambers. These arrangements remain subject to change following formal stakeholder engagement.

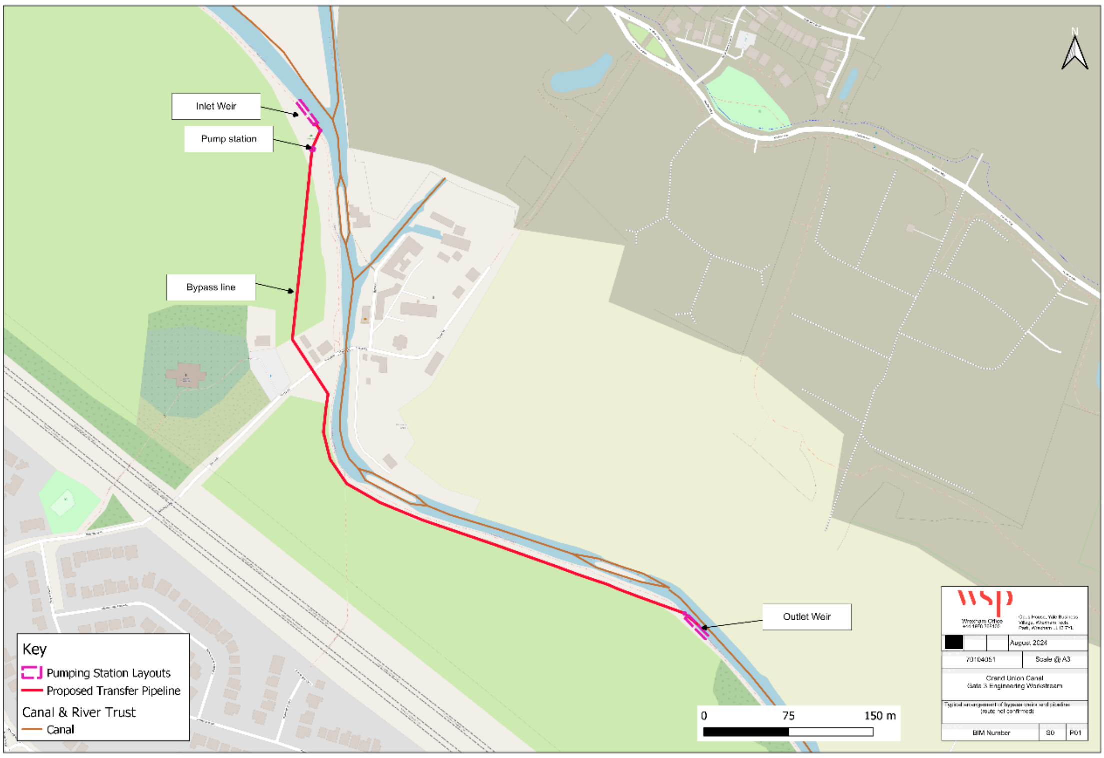


Figure 6-9 Typical arrangement of bypass weirs and pipeline (route not confirmed)

Asset size redacted

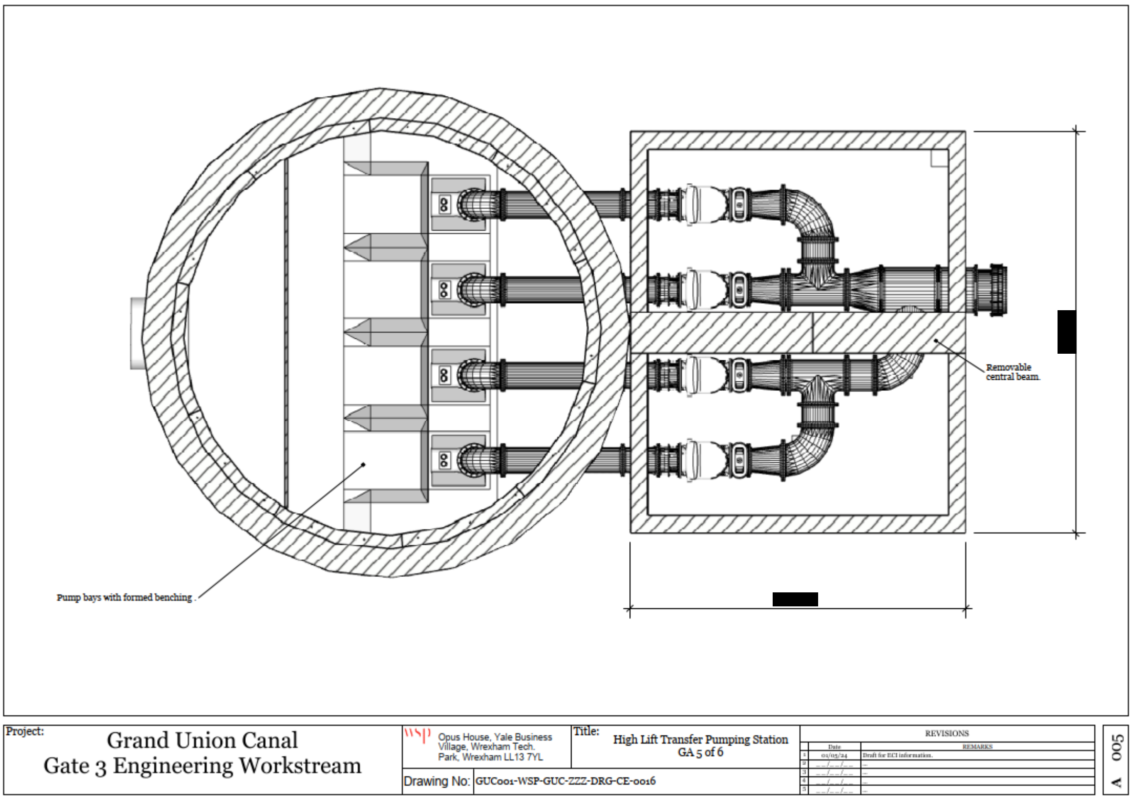


Figure 6-10 High Lift Transfer Pumping Station Plan View

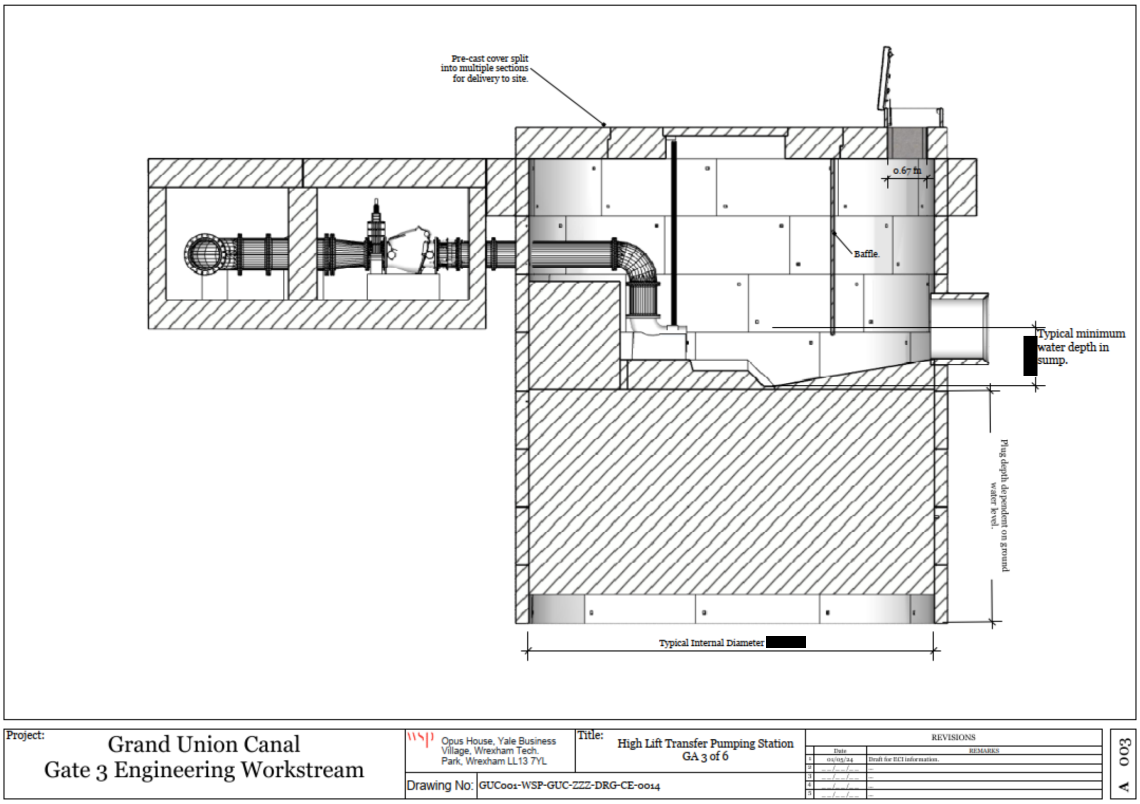


Figure 6-11 Transfer Pumping Station General Arrangement Section View

6.4 BRIDGES, TUNNELS AND OTHER CONSTRICTIONS

At Gate 2 several potential constrictions to flow were noted, based on an initial spreadsheet based hydraulic model. These constrictions, at bridges, tunnels and other locations, could cause flow velocities above those recommended by the Trust for navigation and for other canal users, could raise velocities to a level that could affect flora and fauna and/or could result in reduced headroom at tunnels and bridges affecting canal navigation.

These potential effects were studied in more detail during Gate 3 studies by the Hydraulics Consultant, using their more sophisticated hydraulic model of the system.

From the latest modelling report (see GUC SRO Gate 3 Annex A4.2 Hydraulic Modelling Report) the bridges and tunnels in Table 6-7 are shown to have air draught/headroom less than the current normal operating minimum when the transfer is in operation:

Identifier	Name	Pound	Soffit Level (m AOD)	Min. Head room (m)	Headroom with Max WL (m)			Headroom with Average WL (m)		
					Wet 115Mld	Wet 29Mld	Dry 115Mld	Wet 115Mld	Wet 29Mld	Dry 115Mld
GU-083-001	Bridge 22 (Watling St)	GUC 13-14	92.73	2.67	2.49	2.6	2.57	2.57	2.86	2.59
GU-088-001	Bridge 29 (High House)	GUC 13-14	92.36	2.67	2.27	2.33	2.31	2.31	2.53	2.32
GU-092-001	Bridge 36 (Wharf Bridge)	GUC 13-14	92.57	2.67	2.58	2.61	2.6	2.6	2.76	2.61
GU-117-002	Bridge 70A (Stevenson's)	GUC 21-22	74.611	2.67	2.631	2.611	2.621	2.641	2.721	2.621

Table 6-7 Significant Headroom Reductions at Peak Flow (current hydraulic model)

Legend: >200mm | 100-200mm | 50-100mm | <50mm

Establishing the necessary headroom is a question of policy for the Trust as there are no fixed headroom requirements. Figure 6-12 shows how headroom can be measured depending on the shape of the bridge.

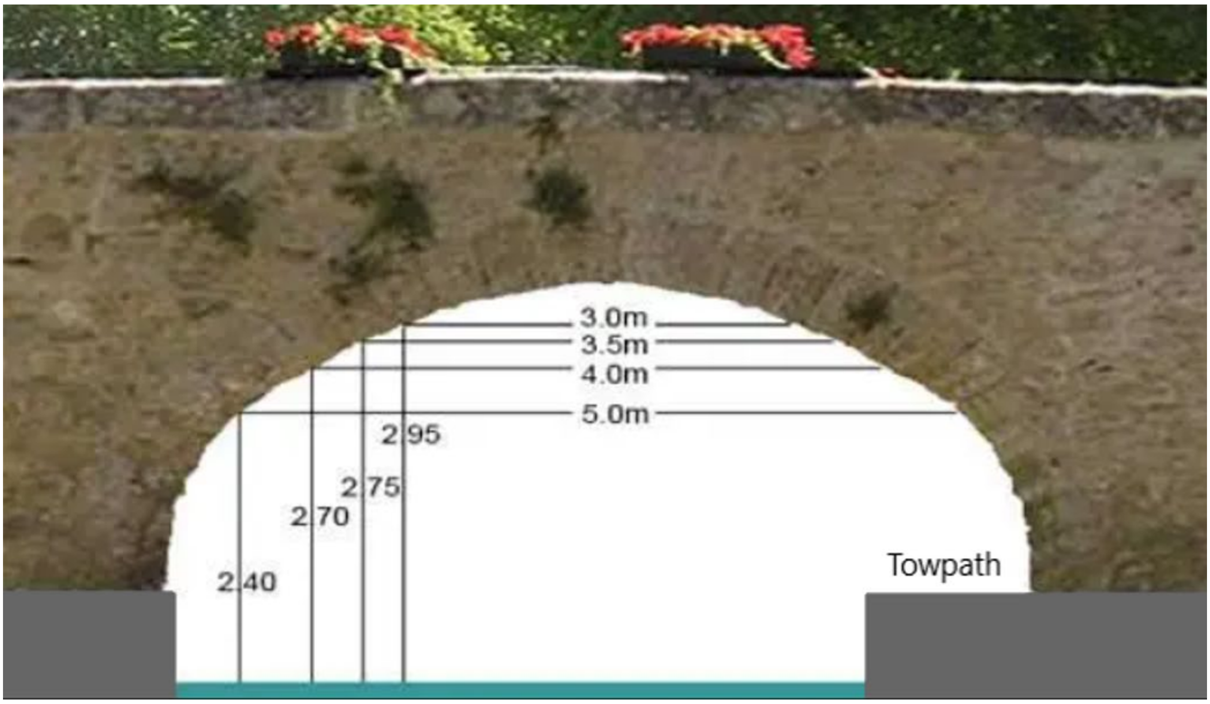


Figure 6-12 Headroom measurement
(Please note this is a generic figure and width of towpath may affect headroom)

From a practical perspective, assuming a narrow boat maximum beam of 7ft (2.13m) as per Trust guidance, headroom at the 3.5m arch width would seem to be reasonable using a narrow canal such as the Coventry or Oxford Canals as an example. At the time of writing guidance from the project partners is still pending.

The table below shows the current headroom on different sections of the canal are different meaning there is no common, specified headroom. For the sections modelled Table 6-8 shows the different sections and headroom:

Canal Section Name	Pound Names	Minimum Headroom (m)
Ashby Canal	Full length	1.98
Coventry Canal	1-1	2.08
Grand Union	13-14 to 21-22	2.67
Grand Union	6-7 (Braunston Tunnel)	1.98
Grand Union	7-8	2.67
Oxford Canal	2-1 to 7-8	2.07

Table 6-8 Minimum Accepted Current Headroom on Canal Sections

When measured against this range of minima it can be seen that the reduced headroom for the GUC as modelled is never less than the allowed headroom for Ashby, Coventry, Braunston Tunnel or the Oxford Canal.

This opportunity has been proposed to the project partners for consideration and further investigation (see GUC SRO Gate 3 Annex A4.2 Hydraulic Modelling Report).

6.5 ADJUSTMENTS TO THE TRUST'S EXISTING WEIRS

The Trust has existing waste weirs and inlet weirs which control the amount of water in the canal as well as bypass weirs at locks.

When the GUCT is in operation the canal water levels will rise compared to the "without scheme" levels and adjustments may be needed for existing weirs to avoid the additional water from being wasted or otherwise mis-managed.

Using the Trust's asset information (GIS location, asset name and level information) in conjunction with the latest version of the hydraulic modelling output preliminary designs for the adjustments have been completed.

Each of the Trust's existing weirs affected by the GUCT is proposed to be fitted with new fixed weir plates to allow flow control when the canal water level is raised.

There is a similar number of weirs per pound with most of the weirs needing only minor adjustment. Full surveys have not been undertaken of every affected weir as access was occasionally difficult but from site visits and topographical surveys of many of the weirs and inspection of sites using GoogleEarth™, it is noted that there is a fairly standard design for such weirs. It is therefore assumed that the majority of weirs can be adjusted using minor works to add a weir plate. Most weirs are concrete broad crested weirs dropping into a 1-2m deep channel and exiting via 1200mm culvert. A typical example of this is shown in the photo provided in Figure 613.

There are 17 weirs in the longer pounds that, according to the hydraulics model, will require >100mm increase in weir level. It is assumed for programme, cost and carbon purposes that these will need additional sheet piling and new concrete weir raising.

A typical low raise weir is shown in Figure 6-13.

Figure 6-13 Photo of Typical Existing Waste Weir Owned/Operated by the Trust

The weir shown in Figure 613 would require a 20mm high weir plate to be added to the existing weir level. This would be a minor work which could be achieved relatively simply for example with the addition of a thin course of brick or similar, keyed into and blended with the existing weir.

The 17 weirs which may require more substantial works as noted above are located as shown in Figure 6-15, with an example of a weir which may have heritage value; if a structure has heritage impacts, it will be assessed and will require additional treatment, following a heritage assessment under the EIA process, which will aim to assess in more detail any impacts on environment, heritage, etc, and will be the process through which the project seeks to minimise and mitigate the impacts.

Figure 6-14 Photo of Existing Waste Weir with Heritage Value Owned/Operated by the Trust

To amend such a weir with heritage value it would be undesirable to simply add a plate or adjustment to the weir level. It may be more appropriate to amend the outlet pipe, which lies beyond the wooden fence near the surveyor, and which conveys the water away to the local stream. This would not require any amendment to the weir structure but would raise the water level in the weir structure. This would mean that the appearance of the weir would not change in any way apart from slightly increasing the submergence of the weir passage.

The final design will be informed by the EIA process and consultation with heritage experts in the project partners.

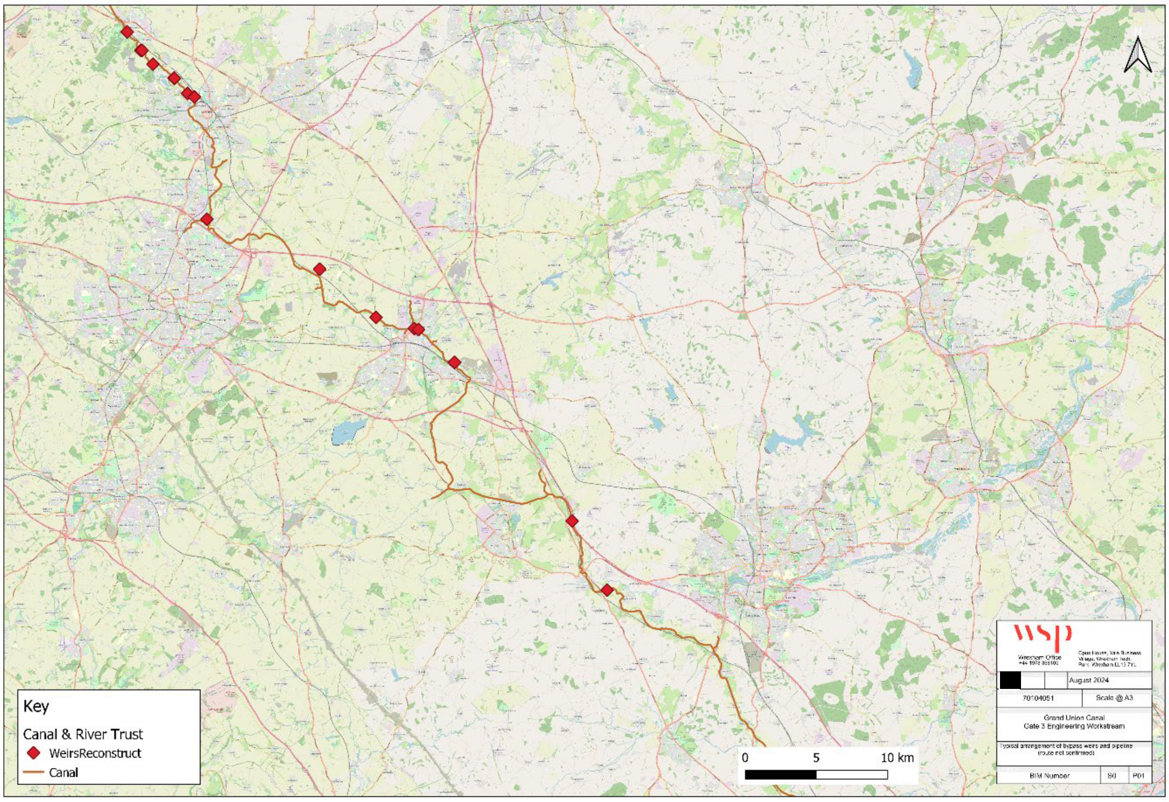


Figure 6-15 Existing Waste Weirs Requiring More Substantial Remedial Work

For the weirs identified in Figure 615 additional cost and programme has been added to account for the more substantial work needed, with appropriate contingency and Optimism Bias.

6.6 CONSTRUCTION ACCESS

Initial concepts for construction access were developed as part of the Gate 2 studies. The output from these studies has been provided to an ECI contractor to review and revise these access proposals. The ECI contractor is currently operating as a framework contractor working on Canal & River Trust projects and is familiar with the type of work, access constraints and the type of construction equipment that can be used.

The ECI contractor has yet to report on any modifications to access they feel will be required for the type and scale of work proposed.

6.7 BNG AND SOCIAL VALUE OPPORTUNITIES

In accordance with Government policy there will be a requirement for biodiversity net gain associated with the GUC SRO works. During Gate 2 some examples of work that could be undertaken to secure at least 10% BNG for the project were developed for illustrative purposes.

An initial tabulation of some of the main opportunities for BNG and social benefit associated with the bypasses has been prepared for consideration in future by the wider group of keyholders and is included in Appendix J.

The Environmental Consultant will be responsible for developing the natural capital and BNG accounts against which the necessary gain to be included in the project scope will be estimated. The Engineering Consultant will then work with the Environmental Consultant, the Planning Consultant, the Engagement Lead and the Trust to specify, plan, design and cost out the best options at locations to be determined. Where any net gain works can contribute to the effective operation of the scheme and for social gain these would be of interest.

7. BANKSIDE WATER STORAGE WORKS

7.1 INTRODUCTION

The existing canal system is long and has a relatively slow response time when a change of flow rate is required. Currently the most significant changes of flow rate and velocity are when rainfall within contributing catchments causes large inflows. The canal responds to these inflows by water levels rising locally and flows in the canal being established to allow excess water to flow from the canal to the natural drainage systems via the nearest waste weirs and other outlets.

When available the GUCT is intended to operate with low rates of change of state to avoid any discomfort to users of the canal, whether human or flora/fauna. These low rates of change of state will be similar to or slower than the current natural changes of state caused by rainfall.

Bankside raw water storage is proposed to be provided on the GUC SRO to facilitate the safe and controlled operation of the canal at low rates of change, to provide buffer storage to cope with any pollution events, to provide buffer storage for when flow from Minworth is interrupted during high demand periods and to provide storage to encourage settling out of any sediment in the transfer flows to reduce load on the new potable water treatment works.

Subject to a final decision on the location of the new potable water treatment works at the southern end of the GUC SRO, 5 days storage at peak design flow rates must be provided. If the "Hands Off Flow" at North Muskham on the Trent is breached the Environment Agency may request the diversion to the GUC of recycled water from Minworth AWTP to be interrupted to support flows in the Trent.

System modelling carried out by others shows that to sustain the resources benefit of the GUCT to AfW in these unusual circumstances will require around 11 days storage on the GUCT system between Minworth and the new potable water treatment works.

Investigations by others (STT Strategic Resource Option, Support Options Optioneering, Options Appraisal Report, Atkins, February 2023) into the most suitable location for the additional 6 days storage at full design peak flow rate (115Ml/d) has proposed that optimising storage at the existing Daventry and Drayton reservoirs will be the most beneficial.

7.2 BANKSIDE WATER STORAGE AT THE SOUTHERN WATER TREATMENT WORKS SITE

7.2.1 Storage Location

During Gate 2, an example storage location was used at Site F which lies on a backfilled sand quarry to the south of Leighton Buzzard. The site location is shown in in Figure 7-1.

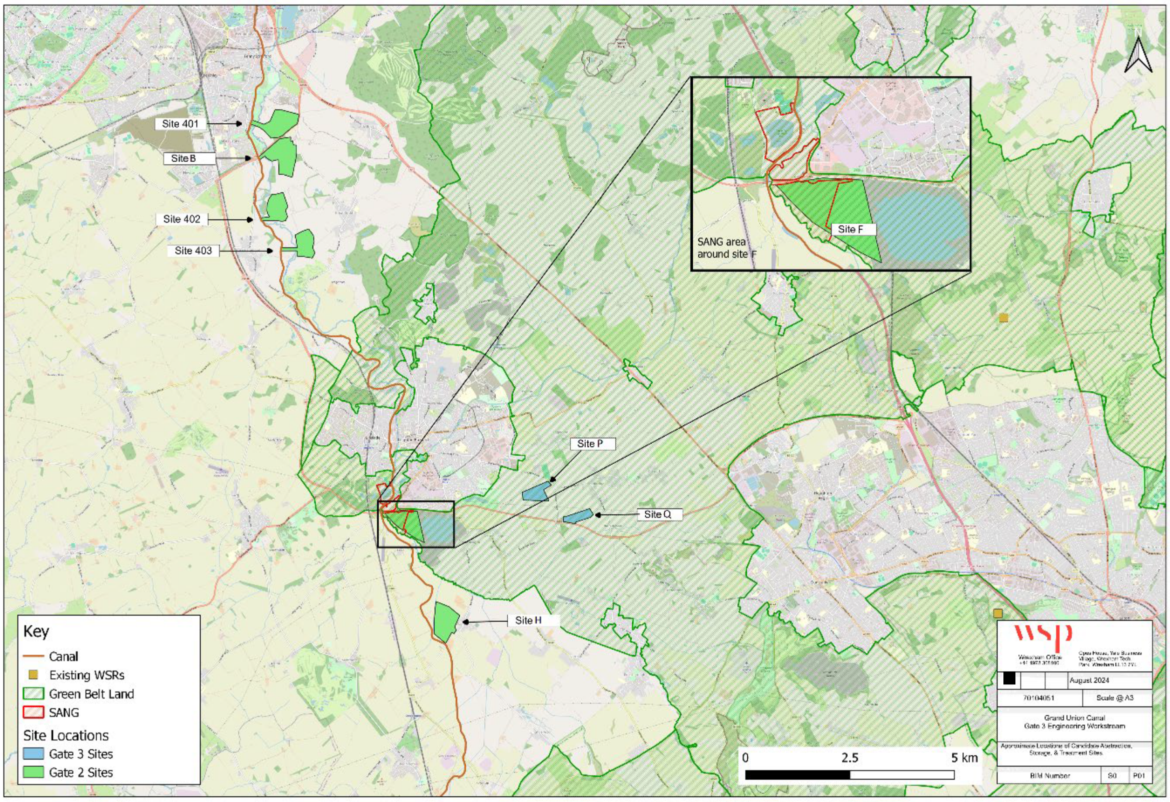


Figure 7-1 Approximate Locations of Candidate Abstraction/Storage/Treatment Sites

Neither geotechnical investigation nor detailed topographic information is available for this site, in common with other sites, but a scheme layout showing the abstraction works, the reservoir and associated structures and the connection to the treatment works was established. This was necessarily based on some assumptions, particularly in respect of the depth to which the reservoir could be excavated and the presence or absence of contaminated land, so a conservative design was prepared with appropriate allocation of risk and optimism bias costs.

When the DCO/Planning Consultant commenced Gate 3 evaluations, the Local Planning Authority (LPA) revealed that Site F had recently been designated as a Suitable Alternative Natural Green space (SANG), as a necessary condition for planned housing to proceed in the area. The LPA were therefore opposed to the site, and it was not taken forward for further evaluation. The work originally done for this site was used to inform assessments at other sites, with modifications as appropriate. A final site selection will not be made until after wide stakeholder consultation has been completed. The consultation was undertaken in September and October 2024. Several candidate sites have been screened from a much wider group and it is currently assumed that these sites could be used in suitable combinations to provide 5 days raw water storage.

Figure 71 shows the location of the potential reservoir sites. All the sites are located south of Milton Keynes and north of the existing flight of locks which takes the GUC up to the Tring summit.

During Gate 2 the preferred site was Site F, but this proved to be non-viable due to its designation as a SANG. Sites which remained viable from Gate 2 were:

- Site H
- Site B
- Site H with storage only, with treatment works at Site P
- Site H with storage only, with treatment works at Site Q.

Cost estimates for the bankside storage and abstraction works have been prepared based primarily on the outline design work during Gate 2, as there has been insufficient additional information on which to confidently revise the earlier designs. A reduction has been made to the risk costs for developing a reservoir on the predominantly undisturbed agricultural land at Sites B and H, compared to the risk of developing the same reservoir on a backfilled quarry where the condition, strength and presence of contamination are highly uncertain.

The Gate 3 screening studies, which were led by the DCO/Planning consultant, supported by the Environmental Assessment consultant, the Engineering consultant and the land and legal consultants, confirmed that the Gate 2 sites as listed above remained the most suitable and developable. Reporting from this assessment is included in the GUC Gate 3 Annex C1.3 Planning and Consents Strategy.

Detailed geotechnical and topographical investigation has not been possible to date as a preferred site has not been selected. A desk-based review of the geotechnical context, the land form and utilities has been undertaken to inform an assessment of whether there are any site-specific risks that would affect cost effectiveness or the risks at each site. The study concluded that the storage sites at Site B and Site H are both potentially suitable being within an area of mudstone and clays and on undisturbed agricultural land.

Both sites have some utilities crossing them, which will need to be diverted or avoided. Access to Site B appears preferable and the extent of the land available at Site B offers more flexibility. Site H could be used for both storage and treatment works, although the site is fairly constrained, or could be used for storage only in combination with a treatment works at either Site P or Site Q.

Site B requires fewer canal bank raising and bypass works than Site H which lies south of Site B but the potable water transmission pipeline from Site B to the existing service reservoir near Luton is notably longer than the potable water transmission pipeline from Site H or Sites P and Q to the service reservoir.

None of the sites lie within the Flood Risk Zone 3. Construction and operational access to the works on Site B is the most readily available.

7.2.2 Supply to the Reservoir

Supply will be from an intake at the canal side in the vicinity of the storage site. The intake will be essentially the same as the intakes for the lock bypasses but modified to suit the actual situation at the site (to be selected). The flow will be coarsely screened and passed to a low lift pumping station fitted with fine travelling band screens before transfer to the bankside storage. The low lift pumping station, having the same maximum capacity and similar delivery head will be the same layout as the bypass pumping stations shown in Section 6.3.2 above modified to suit the required depth. Further details are included in Section 8.3.

7.2.3 Storage Layout and Design

The current layout and design is based on public domain information, supplemented by a full utilities search.

A geotechnical appreciation of the site has been produced based on the following sources:

- BGS information and data sets, including historical borehole logs, accessed via online BGS GeoIndex.
- Coal Authority Mining information and data sets.
- Environment Agency information on Groundwater Source Protection Zone and Aquifer Designations accessed through Natural England's MAGIC mapping.
- Natural England information on Environmental Designations accessed through Natural England's MAGIC mapping.
- UXO information accessed through Zetica UXO.
- Aerial photography accessed through Google Earth Pro.

The full study report is available in Appendix E but a summary of the findings for the reservoir/treatment works Sites H and B is outlined in Table 7-1 and Table 7-2:

SITE H	Geotechnical Study Findings
Historical Aerial Photography	1945 onwards: farmland
Published Geological Information	No Made Ground mapped at this location by BGS. Superficials: No superficial geology indicated, however Oadby Member-Diamicton (Secondary Aquifer) is recorded 150m south of the site and Alluvium (Secondary A Aquifer) recorded at the GUC west of the site. Bedrock: Gault Formation (Mudstone). Selborne Group is the parent unit.
Historical Borehole Records	SP92SW6: c110m west of proposed site. 0.0m-0.3m Topsoil 0.3m-1.5m Stiff, brown/grey, mottled silty CLAY with coarse sand and fine gravel composed of chalk and flint (Boulder Clay). 1.5m-5.5m Stiff, greenish grey, silty CLAY (Gault Clay formation)
SPZ	This site is not within a Source Protection Zone.
UXO risk	LOW UXO risk.
Coal Mining	This site is outside the Coal Authority's Coal Mining Reporting Area.
Environmental Designations	No environmental designations found within 1000m of site.
Anticipated ground and groundwater conditions.	No Made Ground mapped at this location. Superficials: No superficial deposits mapped at this location, however as both Oadby Member and Alluvium are recorded on BGS mapping and logs, these may be present. Bedrock: BGS records this as Gault Clay Formation

Table 7-1 Summary of Geotechnical Appreciation - Site H

SITE B	Geotechnical Study Findings
Historical Aerial Photography	1945 onwards: farmland
Published Geological Information	No Made Ground mapped at this location by BGS. Superficials: Intersecting Alluvium (clay, silt, sand and gravel), Head deposit (clay, silt, sand and gravel) and River Terrace Deposit 2 (sand and gravel). Bedrock: West Walton Formation, Mudstone with a small proportion of the proposed site area with Oxford Clay Formation to the West.
Historical Borehole Records	SP83SE203: c180m north-west of proposed site. 0.0m-0.5m Topsoil and vegetation 0.5m-2.0m Alluvium – sandy CLAY with gravel/clayey SAND and gravel. 2.0m-5.0m West Walton Formation: firm becoming stiff laminated and fissured green, silty CLAY with fossils. SP83SE204: c70m north-west of proposed site. 0.0m-0.3m Topsoil and vegetation 0.3m-2.0m Alluvium – sandy CLAY with gravel/clayey SAND and gravel. 2.0m-5.0m West Walton Formation: firm becoming stiff laminated and fissured grey-green, silty CLAY with fossils.
SPZ	This site is not within a Source Protection Zone.
UXO risk	LOW UXO risk.
Coal Mining	This site is outside the Coal Authority's Coal Mining Reporting Area.
Environmental Designations	No environmental designations found within 1000m of site.
Anticipated ground and groundwater conditions.	No Made Ground mapped at this location. Superficials: Alluvium with adjacent River Terrace Deposit Bedrock: West Walton Formation/Oxford Clay Formation

Table 7-2 Summary of Geotechnical Appreciation - Site B

For the bankside storage at both sites the following design issues are highlighted:

- The bankside storage will be a single storage and will have c 575,000m^3 of active storage available for use.
- The bankside storage will be formed from earth embankments using balanced cut and fill as far as possible, using native soils. Both potential storage sites are gently sloping which is beneficial for achieving such a balance compared to very flat sites.
- The bankside storage is assumed to be lined to ensure low seepage losses. Until the geotechnical investigation is completed this is a reasonable and conservative assumption from cost estimation and construction schedule perspectives. As noted above there is no particular reason to differentiate between the two sites in this matter.
- Sloped storage bottom to support drain down for inspection and maintenance.
- Relatively shallow borrow excavations are assumed within the bowl of the proposed storage. It may be possible to have a deeper excavation and thus reduce the footprint of the storage. A final assessment of the suitability of material, any need for groundwater management and of the balance between cut and fill will depend on the geotechnical investigation.

- Multi-gate hydraulic structures will be required to control inlet, outlet, and overflows. There will be a bypass to allow water to be directly abstracted from the GUC and sent to the inlet of the water treatment works if for any reason use of the storage is compromised. As a reservoir covered under the Reservoirs Act 1975 a spillway/overflow is required to protect the embankment from damage due to overtopping. The overflow system may be combined with the overflow system of the treatment works if required.
- Protection may be required against erosion for portions of the downstream embankments potentially subject to stream flows (i.e. River Ouzel in flood flow). A review of the up to date Flood Zone maps on Gov.UK indicates that this is a low risk unless the storage footprint has to be modified to suit ground conditions, utilities avoidance and/or planning and landowner constraints.
- Protection will be required to the inner slopes of the storage to protect against any wind driven wave attack. Freeboard will be provided to ensure that waves do not run up and overtop the embankment taking account of latest advice and forecasts on wind force and direction.
- Instrumentation will be included in the embankment and under the liner and the main structures to monitor the health and performance of the system as whole. The storage will be provided with a spillway and bottom outlet for emergency management, and long-term monitoring will help to assess any risks to the embankment from seepage paths leading to weakening of slopes.
- Provisions will be made, in association with the Environmental, Planning and landscape consultants, to ensure that suitable biodiversity and environmental enhancements are included and that any visual impact of the embankment is minimised by earth bunds, softened more natural slopes and planting which reflects local conditions.

Current indicative layouts of storages and their relationship to the treatment works, the canal and other landscape elements are shown Section 8.

Indicative cross sections of the proposed embankment and its principal structures are also shown in Figure 7-2.

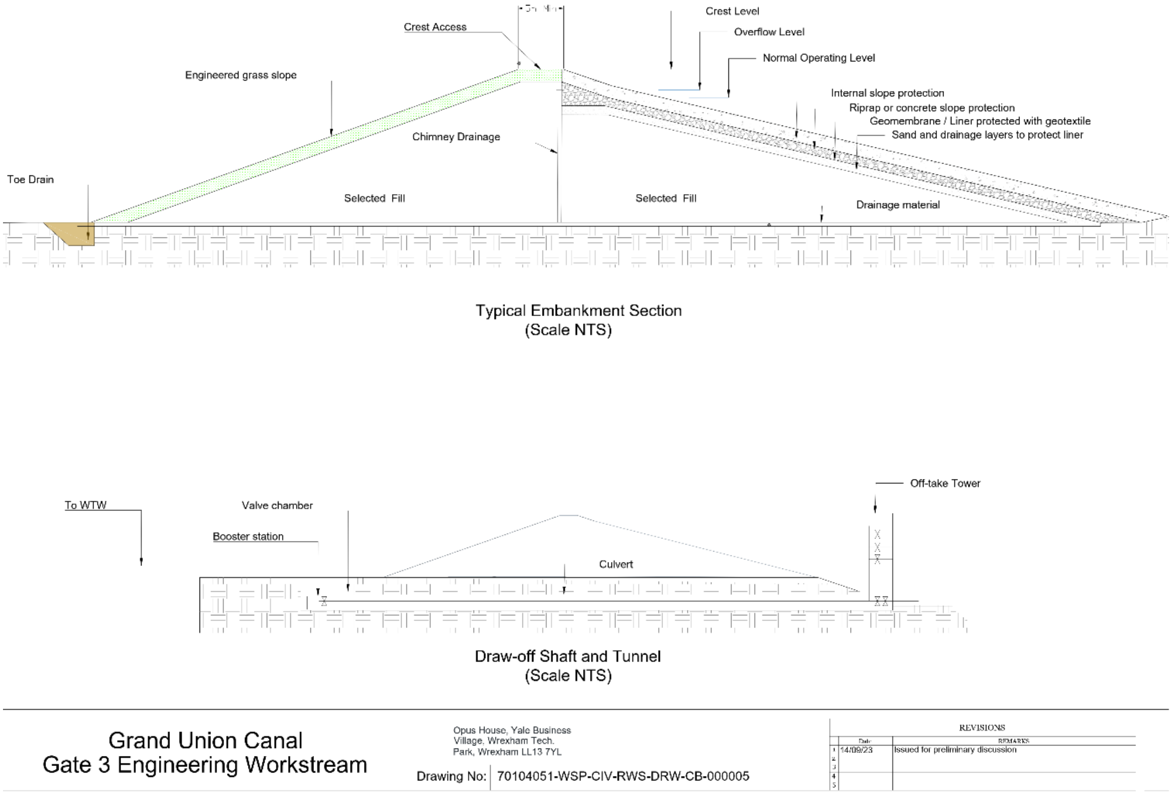


Figure 7-2 Schematic Cross Section of Typical Bankside Storage Reservoir

7.2.4 Operation of the Storage

The current overall draft operational philosophy of the GUC SRO requires that the storage at the treatment works site remains at TWL for as long as possible.

During the low flow tickover periods, at c23Ml/d, this means that turnover in the reservoir will have a c25 day duration. This will facilitate settlement of any fine materials which would otherwise need to be removed in treatment but could lead to other water quality issues such as the growth of algae.

For the purposes of Gate 3 it is assumed that the inlet and outlet will be positioned to maximise the opportunity to avoid still water areas and aeration devices may be included to reduce such quality risks.

During higher flow periods turnover will be more rapid which may lead to more fine particles being able to pass through the reservoir. Coarse and fine screening is included before the inlet to the treatment works to manage this risk.

The multi-level outlet to the treatment works will be screened and with the lowest offtake located at the lowest elevation possible whilst avoiding entrainment of fine sediments.

The storage will be subject to the Reservoirs Act 1975 and will be provided with a bottom outlet or “scour” system to allow routine or emergency drawdown; current guidance is that the reservoir shall be capable of being drawn down by at least 1m in 24 hours. The peak flow to achieve this will be a minimum of c1m^3/sec. Currently this is shown as an open channel, but it may be appropriate to use a buried gravity pipeline, subject to agreement of the construction engineer responsible under the Reservoirs Act.

During Gate 4, when the depth of the reservoir is known, modelling will be undertaken to define the most appropriate peak flow rate, taking account of costs to construct and any impacts on local watercourses, acceptable to the Environment Agency, or risks of flooding to third-parties or designated sites. A design flow rate will be agreed with the construction engineer responsible under the Reservoirs Act. Current guidance also requires that the bottom outlet function be tested from time to time to ensure it is available. Disposal of the water which arises from the test will be managed with controlled discharge into the local watercourse.

The reservoir will also be provided with an ungated spillway to ensure that the stability of the reservoir embankment is not compromised by overtopping. Consideration may be given to ensuring that the spillway can be retrofitted with a gate to allow for future management options. Opportunities to raise the top water level would require study to ensure freeboard can be maintained or increased to suit. The capacity of the spillway weir and channel will allow peak pumped inflow plus the effects of intense rainfall on the surface of the reservoir to pass without the water level rising to cause any risk to the embankment. Since the surface area of the bankside storage is relatively low it is likely that the required flow capacity of the spillway will be dominated by the pumped inflow.

System interlocks will be installed so that the abstraction pumping station will shut down when water reaches TWL, so there is a very low risk of the combination of inlet flow and intense rain. The peak spillway flow rate and resulting freeboard required will be agreed with the construction engineer responsible under the Reservoirs Act during Gate 4.

An onsite flood management plan will be required to be developed at Gate 4.

7.3 BANKSIDE RAW WATER STORAGE AT THE DAVENTRY AND DRAYTON RESERVOIRS

7.3.1 Storage Location

The design philosophy and outline drawings are contained in the Basis of Design for Daventry and Drayton which is included in Appendix F and summarised below.

The two existing reservoirs at Daventry and Drayton have been selected as the preferred sites for managing the required additional 6 days' worth of storage at peak flow rate, which amounts to c690,000m^3.

The reservoirs are owned by the Trust and are located at a summit point c40 km south of the Minworth discharge point near Atherstone meaning that should the stored water be required it can be released from the reservoirs and be available to the GUC SRO.

The reservoirs' location is shown in Figure 7-3:

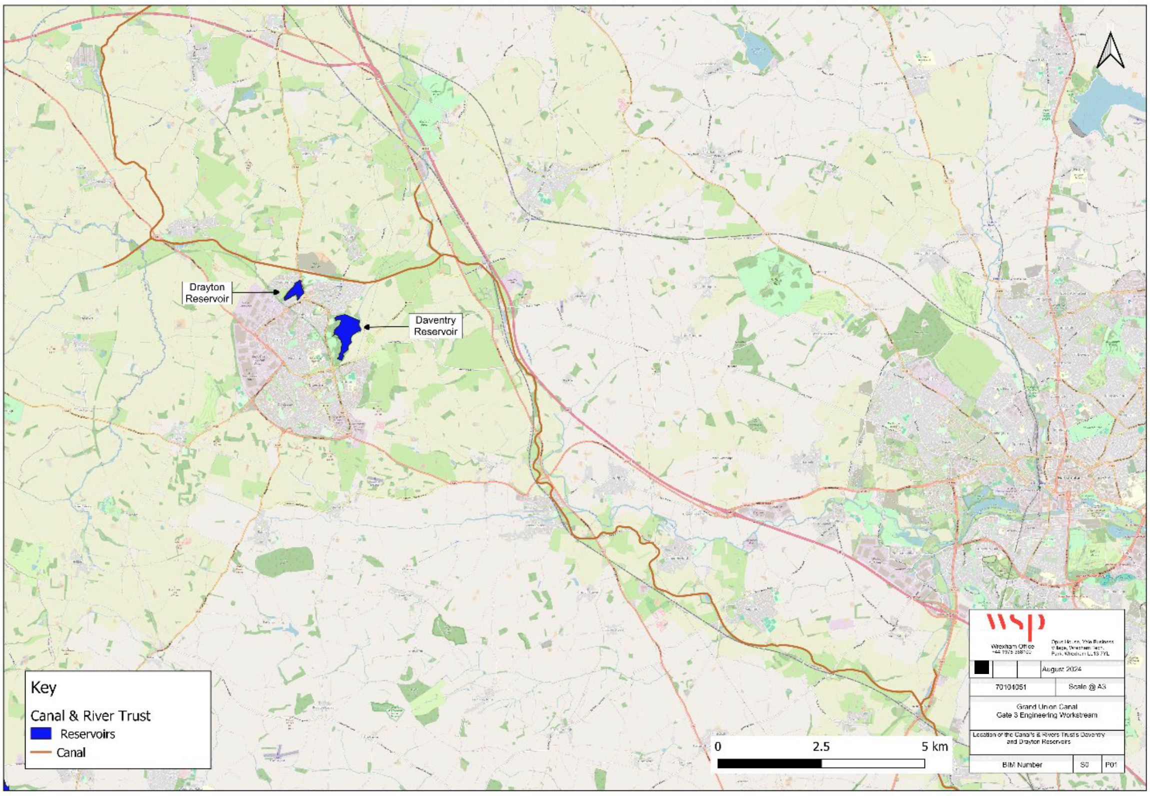


Figure 7-3 Approximate Locations of the Trust's Daventry and Drayton Reservoirs

Drayton reservoir was completed in 1804 to supply water to the Grand Union Canal to make up losses from waste weirs during operation.

The small catchment, which is generally low-lying and characterised by gentle slopes, has an area of 2.06 km^2. The main feeder rises in Royal Oak industrial estate and is mostly culverted as it passes through the built-up area.

Daventry reservoir was constructed between 1796 and 1804 to similarly supply make-up water to the Grand Union Canal. The catchment, which is generally low-lying and characterised by very gentle slopes, has an area of 8.43km^2.

Data from the most recent available Section 10 reports and the Prescribed Form of Record are presented in Table 7-3:

Reservoir	Area (ha)	Capacity at TWL (m^3)	TWL (m AOD)	Embankment Crest Level (m AOD)	Embankment Height (m)	Embankment Length (m)
Daventry	32	933,000	122.09	124.75	11	550
Drayton	11	324,000	133.21	134.53	8	310

Table 7-3 Daventry and Drayton Reservoir Characteristics from Section 10 Reports

Daventry and Drayton Reservoirs are used as principal supplies for navigation of the Braunston Summit. The current operational mode of the reservoirs is to capture and store runoff from the River Tove and Ouse catchments and release stored water into the GUC during the drier periods of the year to sustain canal water levels during the boating season.

The water levels in the reservoirs, which are used for angling and some water sports, therefore vary over the year with rate of draw off restricted as the water level reduces to the minimum water level.

7.3.2 Supply to the Reservoirs

Currently the reservoirs are supplied solely with water from the local catchments. For the proposed new function of long-term storage for the GUC SRO additional water needs to be supplied to maintain water near TWL throughout the year.

Water will be pumped from the GUC, just upstream of the Braunston tunnel, to discharge structures to be sited at the upstream end of each reservoir. Figure 7-4 below shows the approximate location of the screened intake and pumping station near Lock 1 Braunston and the start of the delivery pipeline route. This is near the existing Trust pumping station on the southern side of the canal, on Trust land.

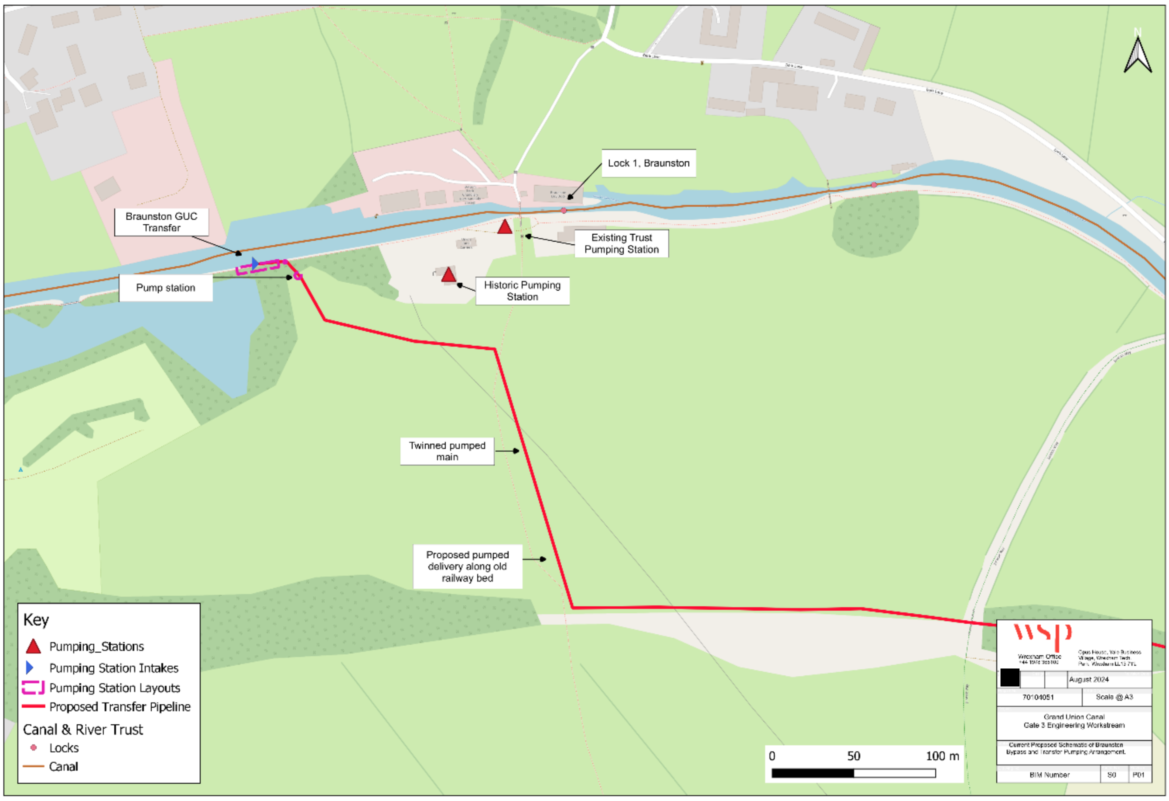


Figure 7-4 Current Proposed Schematic of Braunston Bypass and Transfer Pumping Arrangement

The delivery pipeline is currently proposed as twin 700mm diameter, with one branch leading to the reservoirs' discharge structures and one acting as a bypass to take flow directly to the GUC downstream of Braunston tunnel. The bypass may be needed when maintenance work is being undertaken on the reservoirs, the tunnel or the pipeline.

The Braunston transfer/bypass pumping station is a special case of a bypass pumping station as it has both a transfer function, to the Daventry and Drayton reservoir, and a bypass function around the tunnel and the rising locks leading to the tunnel.

The current peak outflow from the two reservoirs is c 63Ml/d; this could be increased with additional investment in the outlet systems leading from the reservoirs to the GUC but this has not been proposed at this stage.

The cost of modifying the outlet systems to be capable of carrying 115Ml/d is significant and such works will be disruptive. The current draft operating philosophy is to run the GUCT at the tickover flow for most of the time with occasional increase to 60Ml/d, more infrequent increase to 80Ml/d and very infrequent increase to the maximum 115Ml/d; it therefore seems unlikely that the cost and disruption could be justified.

A further evaluation of this work may be undertaken in Gate 4 after the Trust has considered their future investment plans at the sites and after the users of the reservoirs and the downstream areas which will be affected have been consulted.

For the purposes of Gate 3 costing and programme the transfer to Daventry and Drayton is limited to c63Ml/d with the nominal balance of up to 52Ml/d at peak flow rate to be bypassed.

Therefore, the maximum delivery head and flow for both the bypass pipeline and for the transfer to Daventry and Drayton are similar under the current proposal.

Options for combining these functions into one, smaller footprint, station or having two separate stations have been considered and further consideration may be needed at Gate 4 as the operational philosophy matures.

The current proposed arrangement assumes that the station will be combined as shown in Figure 7-5 and Figure 7-6. This arrangement is compact and simplifies the inlet structure which requires eel screens to avoid transfer of eels out of the current GUC boundary in this area. Further details are available in the Appendices. The eel screen will be similar in layout to the one shown in Figure 9-1 for the abstraction from GUC to the bankside reservoir storage at the new potable treatment works at the southern end of the GUC SRO.

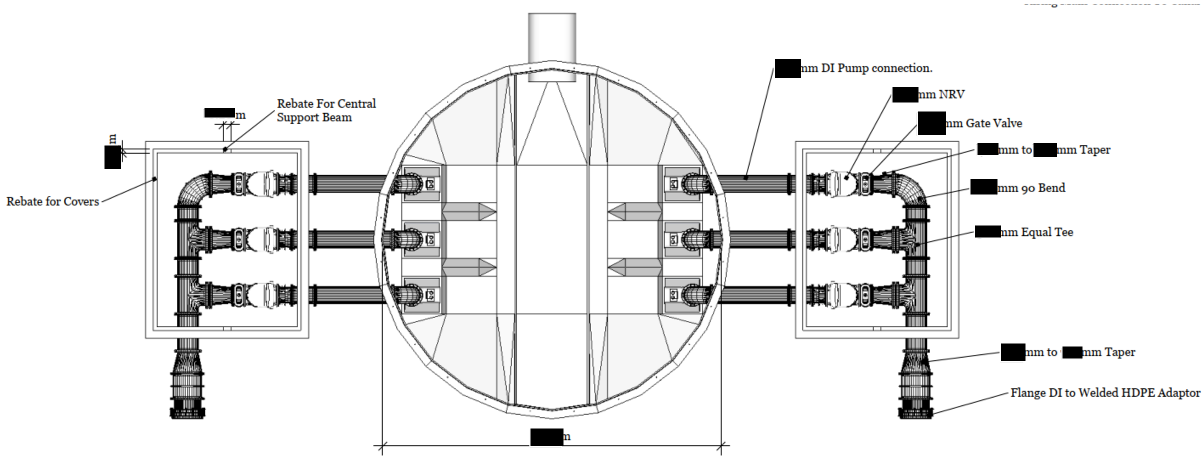


Figure 7-5 - Excerpt of Braunston Bypass/Transfer Pumping Station General Arrangement Plan View

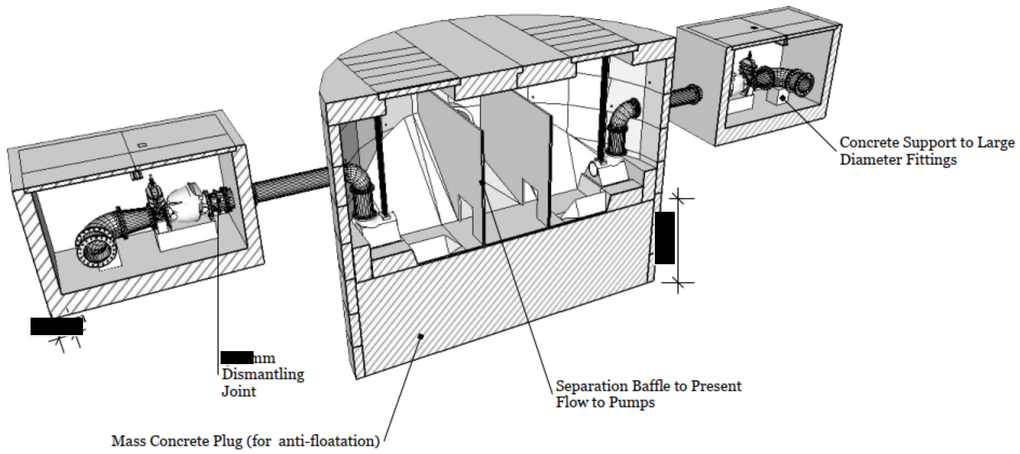


Figure 7-6 Excerpt of Braunston Bypass/Transfer Pumping Station General Arrangement Section View

The proposed route for the transfer pipeline to the reservoirs' new discharge structures is along an abandoned railway alignment (Weedon & Leamington line) as shown in Figure 7-7:

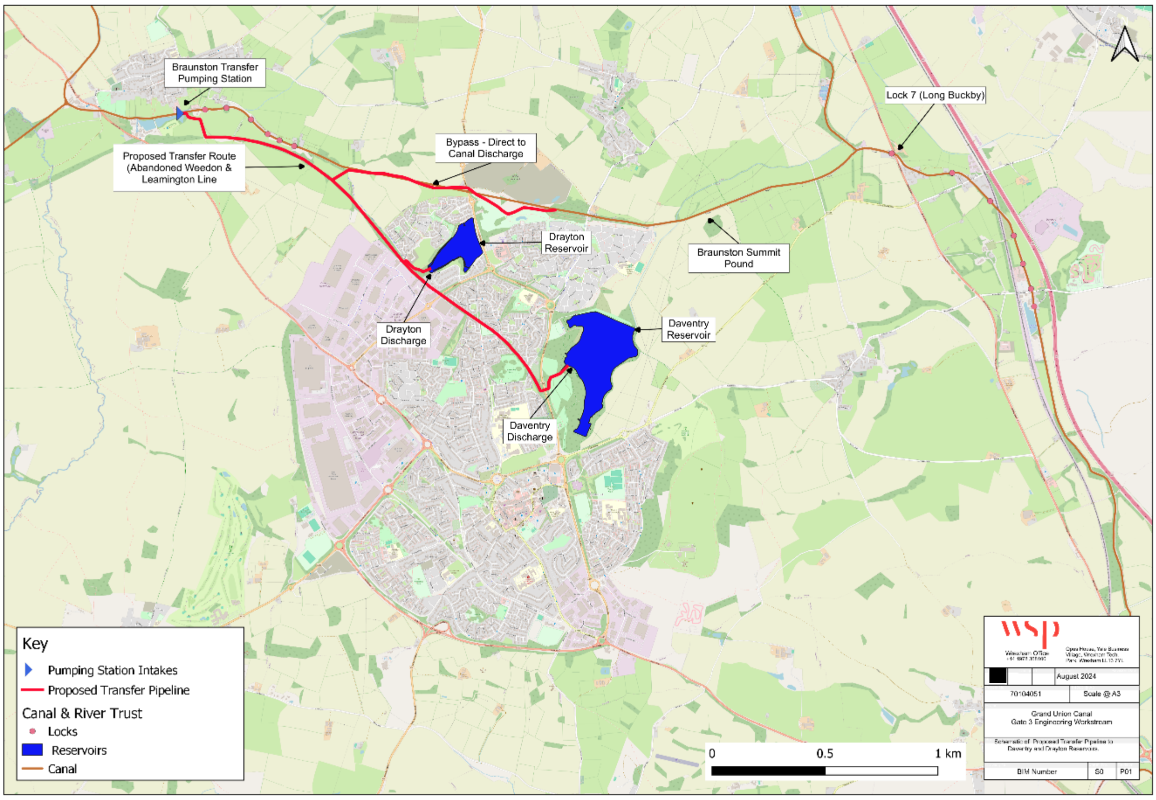


Figure 7-7 Schematic of Currently Proposed Transfer Pipeline to Daventry and Drayton Reservoirs

The [redacted]mm bypass pipeline extends beyond the Braunston tunnel with a controlled discharge into the GUC through the existing Drayton canal feeder outlet structure, which will require some minor modification to accept the new pipeline. The route of the bypass pipeline is shown to be generally following the line of the existing Braunston tunnel. The new pipeline will be relatively shallow but investigations at Gate 4 will be required to assess the impact of crossing the line of the tunnel. The bypass could be capable of passing 115Mld but would need increasing in size from 700mm. Gate 4 will consider the costs and benefits compared to the risk of this event happening.

The inlet to the Drayton reservoir will be via a [redacted]mm tee off the delivery pipeline, discharging through the existing headwall carrying the culvert for the catchment flow and into a shallow intermediate ponded area before entering the main reservoir pool.

The inlet to the Daventry reservoir will be at the same location as the existing highway drainage discharge structure. The highway discharge structure is a complex of culverts and weirs that overflow into a channel flowing into the reservoir.

The existing structure is in reasonable condition but is heavily silted with a significant amount of plastic waste (e.g. bags, bottles etc.) that has been flushed down during storms. The proposed new outlet structure would be constructed in the same location and, in consultation with the highway authorities, aim to improve the retention and collection of any waste flushed into the system. The proposal would also be to improve the downstream channel by introducing SuDS type arrangements (e.g. reed beds etc.) to improve water quality. These SuDS arrangements and the dilution that the GUC transfer flows would provide will improve water quality over time.

The new GUC transfer inlet can be incorporated into the same space currently occupied by the highway drainage structure. Although the current access will need to be cleared (i.e. currently very overgrown and impassible) the final structure will not be visible by the public.

7.3.3 Supply from Daventry and Drayton Reservoirs to the GUC

The reservoirs will accept flow from the Braunston transfer pumping station to ensure that they are kept at TWL, with all excess water flowing down the overflow channels back to the GUC.

A schematic of how the flows may typically be split between the two reservoirs during the low "tickover" flowrate of 23Ml/d is shown in Figure 7-8 below.

Work, currently underway, in the Gate 4 scope is looking at the water quality issues in the existing reservoirs and the likely impacts of diverting GUCT flow through them. This work includes baseline water quality and ecology surveys in addition to consultations regarding the operating philosophy options.

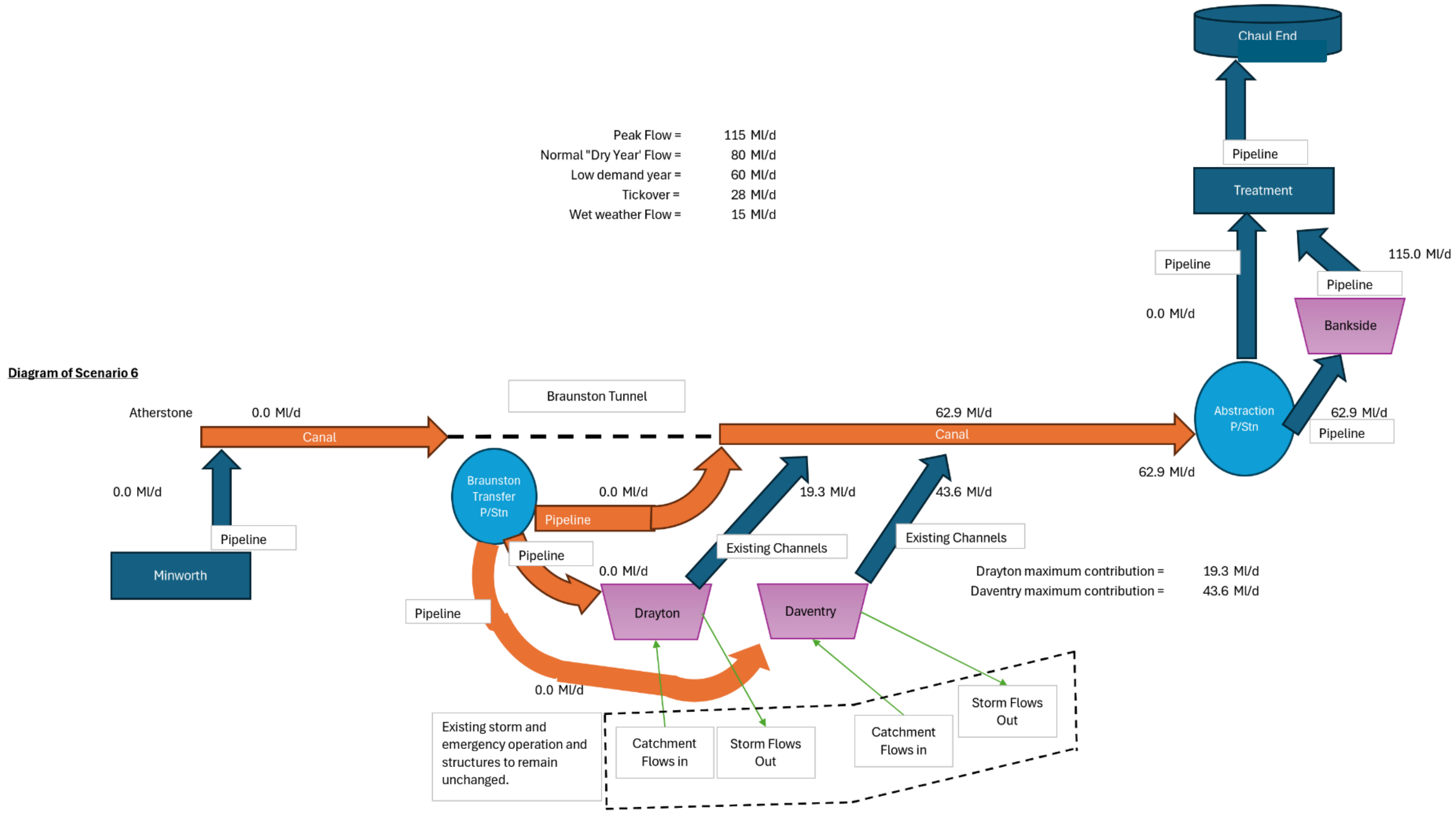


Figure 7-8 Schematic of Flow Scenario During Worst Case Drought Conditions

(Operational philosophy to be developed further during Gate 4, and agreed in consultation with the Trust and project team).

The schematic in Figure 7-8 shows how the water storage will be sustained at TWL and assumes that all the tickover flow will pass through the reservoirs. This approach would keep the water moving through the storage and should contribute to better overall water quality. However, during Gate 4 it is recommended that studies are undertaken to assess the balance between energy and security of the transfer if the transfer pipeline system and bypass system are optimised given the significant period of the year when tickover flows will be operating and the slightly lower energy cost for the bypass.

At the full peak flow of 115Ml/d the proposed operating mode would be that the flow through the reservoirs would be limited to the current maximum safe long-term outflow capacity of the canal feeder channels from the reservoir outlets to the GUC, with the balance passing via the bypass transfer. Whilst the outlet channels can take larger flows, and do during flood events, they can flow out of bank at high flows meaning that either long-term out of bank flows would need to be tolerated or some significant additional works would be needed to contain the higher flows.

Since the bypass transfer system will be in place and the frequency of higher flows passed will be relatively low it makes financial sense, in the absence of any other confounding factors, to not upgrade the channels. The maximum safe long-term capacity of each channel is conservatively assessed as:

- Daventry 43.6Ml/d
- Drayton 19.3Ml/d
- TOTAL 62.9Mld

The bypass system may therefore be required to transfer the balance of c52 Ml/d at full flow. However, to address situations when both reservoirs may be drawn down for repairs and maintenance, or when the reservoirs can be maintained at TWL with lower flows being passed along the delivery system, the bypass may need to be designed to transfer up to 115 Ml/d. The operating philosophy will be considered further at Gate 4.

7.3.4 Required Works at Daventry and Drayton Reservoirs

These works will need to be coordinated with any works that the Trust has planned at Daventry and Drayton Reservoirs which may take precedence over the GUCT works; for example works required due to Reservoirs Act requirements:

Delivery System

Pipeline (c [redacted] m) to be laid from the transfer pumping station at Braunston along the abandoned railway line bed.

Offtake ([redacted] mm) parallel to the existing feeder ditch to a headwall at the existing inlet structure to **Drayton**, modified to accept the [redacted] mm pipe.

Continuation of the [redacted] mm pipeline along the abandoned railway, crossing in an underpass to the A425 to join the existing highway drainage culvert that discharges into **Daventry** reservoir through a series of existing ponds. A new discharge structure will be built in this location for the delivery pipe.

Inlets to both of the reservoirs will be valved so that water can be transferred to one, or both or neither.

Author names redacted

Asset size redacted

Embankment

Since the TWL at both reservoirs will be retained there will be no works required to either embankment.

Reservoir Offtakes

At **Drayton** the existing overflow will be used to ensure the TWL does not alter. In normal operation the existing overflow has sufficient capacity. An additional siphon ([redacted]mm dia) will be laid over the embankment to increase the outlet flows when needed. The siphon will be laid approximately parallel to the to the [redacted]mm overflow pipe, running in the left mitre of the embankment. A new siphon discharge chamber will be installed to control the siphon flows into the existing overflow culvert which leads to an open channel and thence to the GUC.

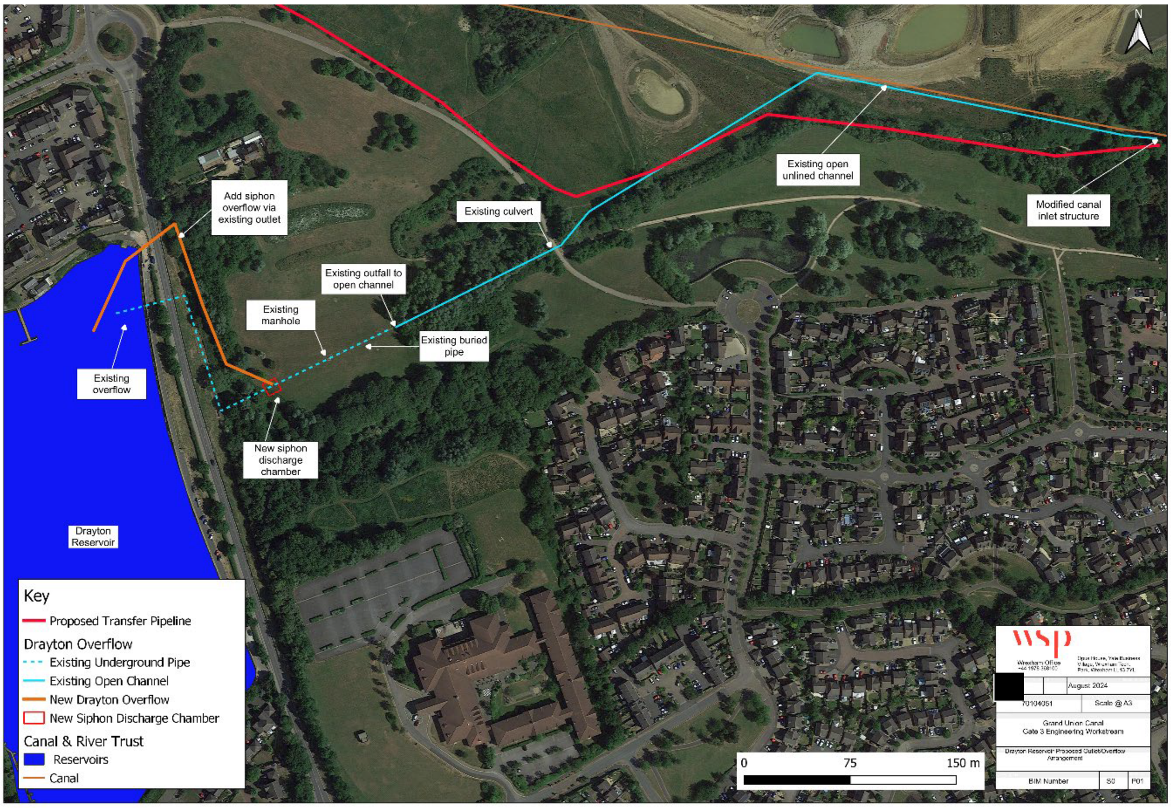


Figure 7-9 Proposed Outlet/Overflow Arrangement at Drayton Reservoir

At **Daventry** there are two existing overflow structures which will remain unaffected. A new outflow structure, matching the existing TWL, will be installed on the right bank of the reservoir upstream of the embankment and the existing overflow. This will normally be closed as the existing overflow is capable of passing the lower flows.

A rendering of the proposed change to the Daventry outflow structure extracted from the Basis of Design report is shown in Figure 7-10.

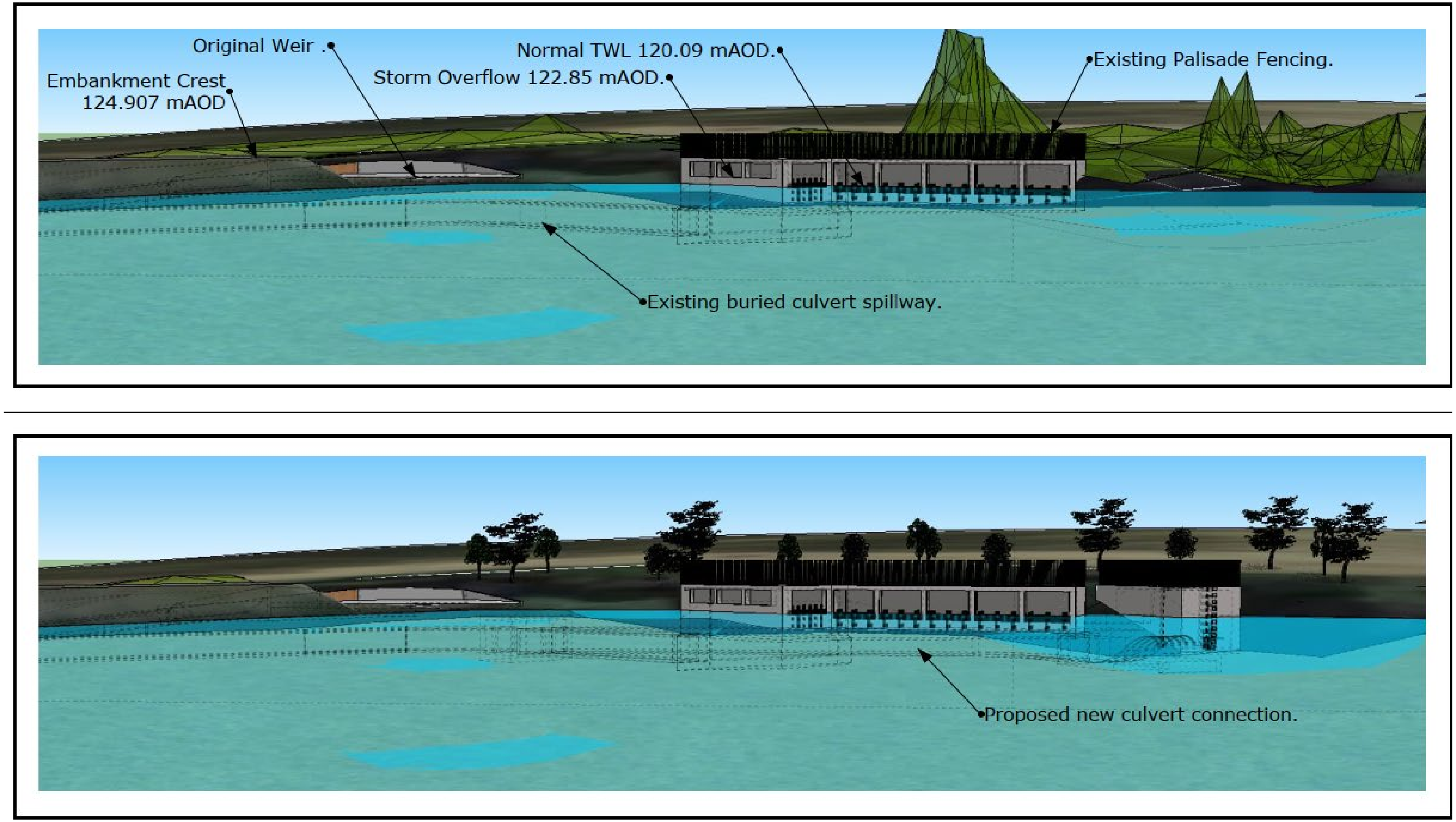


Figure 7-10 Proposed Change to Daventry Outfall Structure

When it is required the overflow gates will be remotely operated and flows will pass into the existing overflow culvert and thence into the open channel which leads to the outfall to the GUC.

Overflow Conveyance

At **Drayton** the existing pipework and channels from the reservoir to the canal outfall structure have sufficient capacity and therefore do not require replacing. There are however several sections of the existing channel that will need to be cleared as part of the normal reservoir management (e.g. vegetation management to prevent blockage etc.). This work is part of the Trust's normal operating procedures for the reservoir and covered by separate "business as usual" projects. The GUC Transfer Scheme will need to coordinate with the Trust regarding the timing of their works.

At **Daventry** the existing culvert and channel feeding the canal have sufficient capacity for the GUC transfer flows but will need some minor work in the following areas (see Figure 711):

- The existing weir and penstock arrangement for diverting flows into the canal will need raising and the channel banks upstream for 46m will need raising. The bank raising will be via grass covered earth embankments. The hydraulic model for this section of channel shows the GUC transfer flows being retained in-channel, but the freeboard is reduced to less than 100mm. The bank raising is therefore a precautionary measure.
- The existing [redacted] mm pipe discharge to the canal is to be replaced by a larger culvert to reduce discharge velocities to less than 0.3m/s.

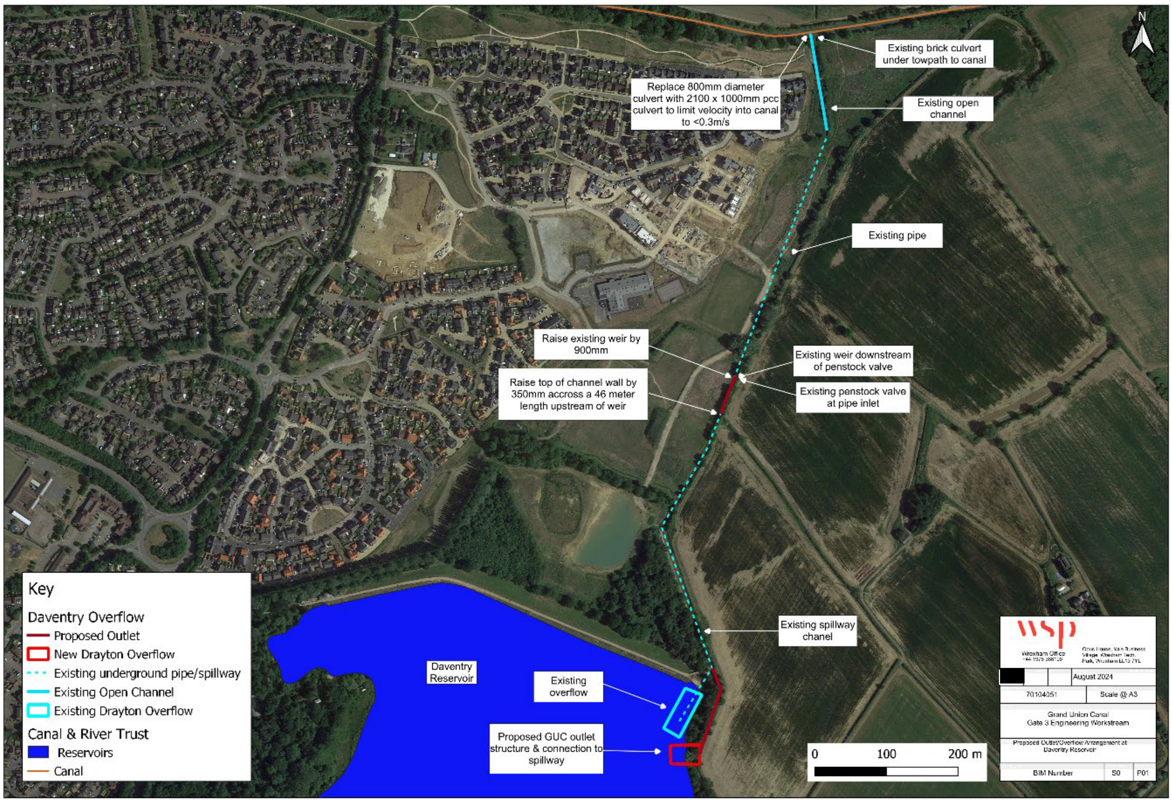


Figure 7-11 Proposed Outlet/Overflow Arrangement at Daventry Reservoir

Cost estimates have been prepared based on the outline design work during Gate 3 (see Section 13).

8. SITE OPTIONS FOR TREATMENT WORKS

8.1 INTRODUCTION

The new water treatment works site has not yet been finally selected. As reported in Section 4 and Section 7.2 above a number of sites will be subject to non-statutory consultation in September/October 2024, after which is expected that the design can proceed for the works required at the preferred site.

The treatment works site will generally consist of:

- An abstraction inlet on the GUC.
- A low lift pumping station to direct the water to the bankside storage and/or the works.
- A bankside storage reservoir as discussed in Section 7 above.
- A low lift pumping station to ensure water from the bankside storage can be delivered to the WTW inlet.
- A potable water treatment works, capable of successfully treating the water from the GUC to potable standards, taking account of the need to manage water chemistry in AfW’s existing water supply system and having sufficient flexibility to cover the range of flowrates expected and future tightening of potable water quality standards.
- A clear water storage tank.
- A high lift pumping station to deliver the water into a new potable water pipeline.

Options still exist to have the abstraction point and bankside storage in one location and the treatment works, clear water storage tank and high lift pumping station in another. The options still under review and for which outline designs have been prepared are:

- Site B – all treatment works site assets.
- Site H – all treatment works site assets.
- Site H/Site P – abstraction works, bankside storage and ancillaries, low lift raw water pumping station at Site H, treatment works, clear water storage tank and high lift pumping station at Site P.
- Site H/Site Q – abstraction works, bankside storage and ancillaries, low lift raw water pumping station at Site H, treatment works, clear water storage tank and high lift pumping station at Site Q.

The abstraction point layout, treatment works duty and layout, and clear water tank layout will be common to all options.

The abstraction point duty, low lift pumping station and high lift pumping station duties will depend on the site option.

Grid references and postcode redacted

8.2 SITE OPTION LAYOUTS

Without detailed topographical or geotechnical information for the sites, layouts remain conceptual. The final arrangement of the bankside raw water storage will define most of the site layout detail.

Initial outline concept layouts for each of the currently retained site options are shown in Figure 8-1, Figure 8-2, Figure 8-3 and Figure 8-4. These layouts are very high level and have been developed in the absence of detailed geotechnical and topographical information and without consultation with wider stakeholders. The layouts are to demonstrate that the assessed land area, as delineated by the red line bounding the site on the figures below, would be sufficient to allow the proposed assets to fit within the boundary, and are used for cost estimation purposes and for construction programme estimation.

8.2.1 Site Layout – Site B (Bletchley Option)

Site B lies on an area of agricultural land to the southeast of Milton Keynes. The site is centred at: Grid Reference (6 figure) [redacted], X (Easting), Y (Northing): ([redacted]) and Postcode: [redacted]. If this site is selected, as the more northerly of the sites, up to 5 fewer lock bypasses will be required and there will be less need for canal bank raising/repair work than if Site H is selected.

The site is bounded to the north by the A4146, from which construction site access will be provided. Operational access could also be provided off Galley Lane for the longer term. The WTW is shown at the west of the reservoir, but this may change depending on land acquisition and more detailed geotechnical information; the WTW may be located to the south of a reshaped bankside storage reservoir. Likewise, the reservoir could be moved and re-shaped to accommodate land form and stakeholder concerns.

A geotechnical appreciation, based on desk study, has been undertaken with the main characteristics of the site shown in Table 7-2 in Section 7.2.3 above and is included in Appendix E.

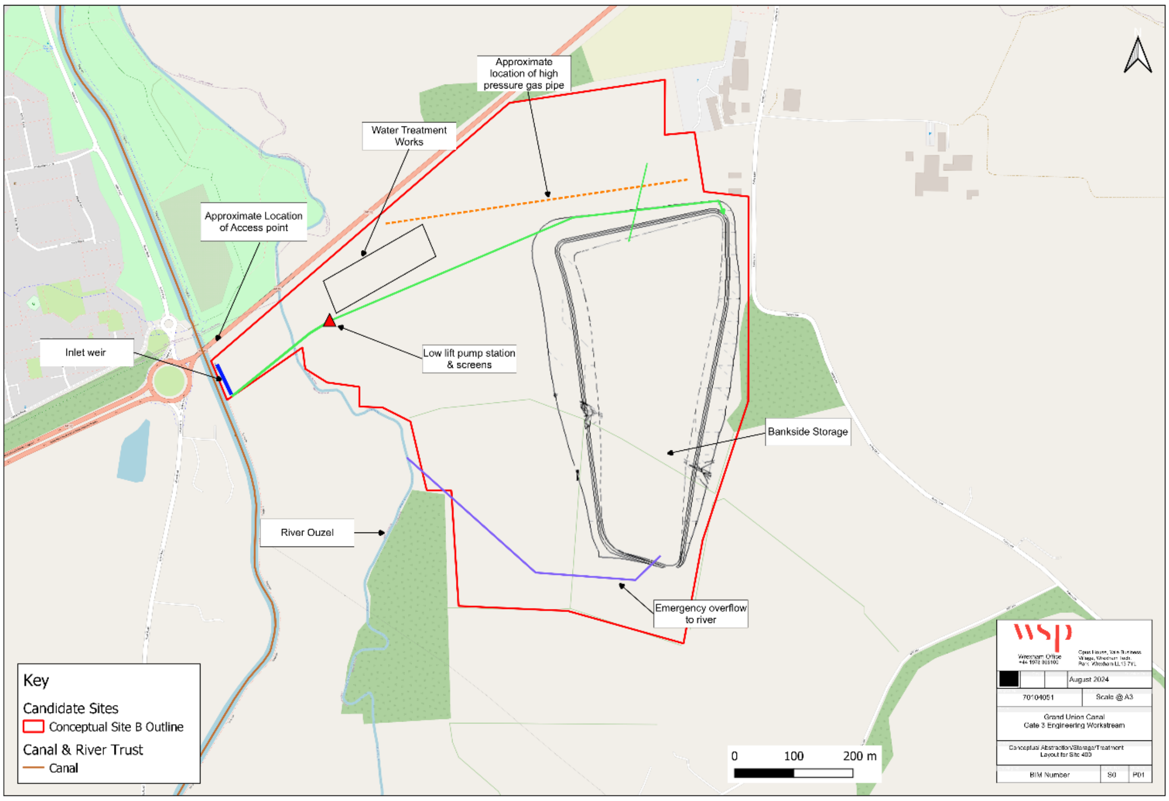


Figure 8-1 Conceptual Abstraction/Storage/Treatment Layout for Site B

A 600mm high pressure gas main crosses the site from west to east at approximately the location shown on the plan above.

An outline flood risk appraisal has been undertaken and a full report is available in Appendix G. Land drainage ditches cross the area and are reportedly a source of surface water flooding. When finally mapped it may be necessary to divert these depending on the final footprint of the reservoir and treatment works. Otherwise, site flooding risk is reportedly low.

The land slopes from east to west and an early assessment of the soil conditions indicates that the geology of the site is the following:

- Bedrock West Walton Formation - Mudstone. Sedimentary bedrock
- Superficial- River Terrace Deposits, 2 - Sand and gravel and Head - Clay, silt, sand and gravel.

BGS borehole records (Borehole BGS Reference: SP83SE204) located around 200m north, show a groundwater depth of 2m with clayey sand gravel.

A review of Defra's MAGIC Maps shows the site is not within any Groundwater Source Protection zone (SPZ), is located above an unproductive bedrock aquifer and a secondary superficial drift aquifer. It also shows the site has a Low/ Medium Groundwater vulnerability.

A review of Buckinghamshire Council's information showed they currently have no sites that have been formally determined as contaminated.

Grid references and postcode redacted

Asset size redacted

A screened inlet will lie on the east bank of the GUC, south of the A4146 road crossing. Pipelines will deliver the abstracted water under the River Ouzel into a travelling band screen building which will remove material down to 5mm. The screened water will flow into a wet well low lift pumping station for delivery to the bankside storage inlet works where the water will cascade into the reservoir. Screenings are likely to be low volume given the generally low throughput and slow velocities in the canal, which tends to ensure most material is settled in the canal. Screens will be flushed with partially treated water from the treatment works and the flow settled out in a small retention pond before overflowing to the River Ouzel

The bottom outlet and spillway will be located to allow flow to return to the River Ouzel.

The offtake to supply water to the treatment works inlet will be located to optimise flow across the reservoir to reduce risks of stagnating water.

We have assumed connection to a sewer for wastewater disposal would be available in the New Woburn Downs estate ([redacted]km off A4146) or in "The Lakes" estate ([redacted]m but requires crossing River and Canal). Milton Keynes Treatment Works is owned and operated by Anglian Water and currently serves a population equivalent of 2.57 million people and is likely to have sufficient capacity. Consultation with Anglian Water will be required if this is the preferred site to confirm availability. Wastewater flows will be very low as the WTW has been configured to have very high recovery rates.

8.2.2 Site Layout – Site H (Slapton Option)

Site H is located on an area of agricultural land to the south of Leighton Buzzard. The site is centred at: Grid Reference (6 figure) [redacted], X (Easting), Y (Northing): ([redacted]) and Postcode: [redacted]. If this site is selected, as the more southerly of the sites, up to 5 more lock bypasses will be required and there will be more canal bank raising/repair work than if Site B is selected.

The site is bounded to the south-east by Horton Road, from which access will be provided. Horton Road is a minor road off the B488. The road bridge, owned by Buckinghamshire County Council, over the GUC that will be used for access will need to be strengthened. The northern end of the site is bounded by further agricultural land, with the southern and south eastern border adjacent to the Grand Union Canal. The construction and operation of Site H will likely cause disruption to the Slapton community. The site is in Buckinghamshire's proposed Freight Strategy Zone. Before any site is taken forward a detailed access and traffic assessment will need to be undertaken.

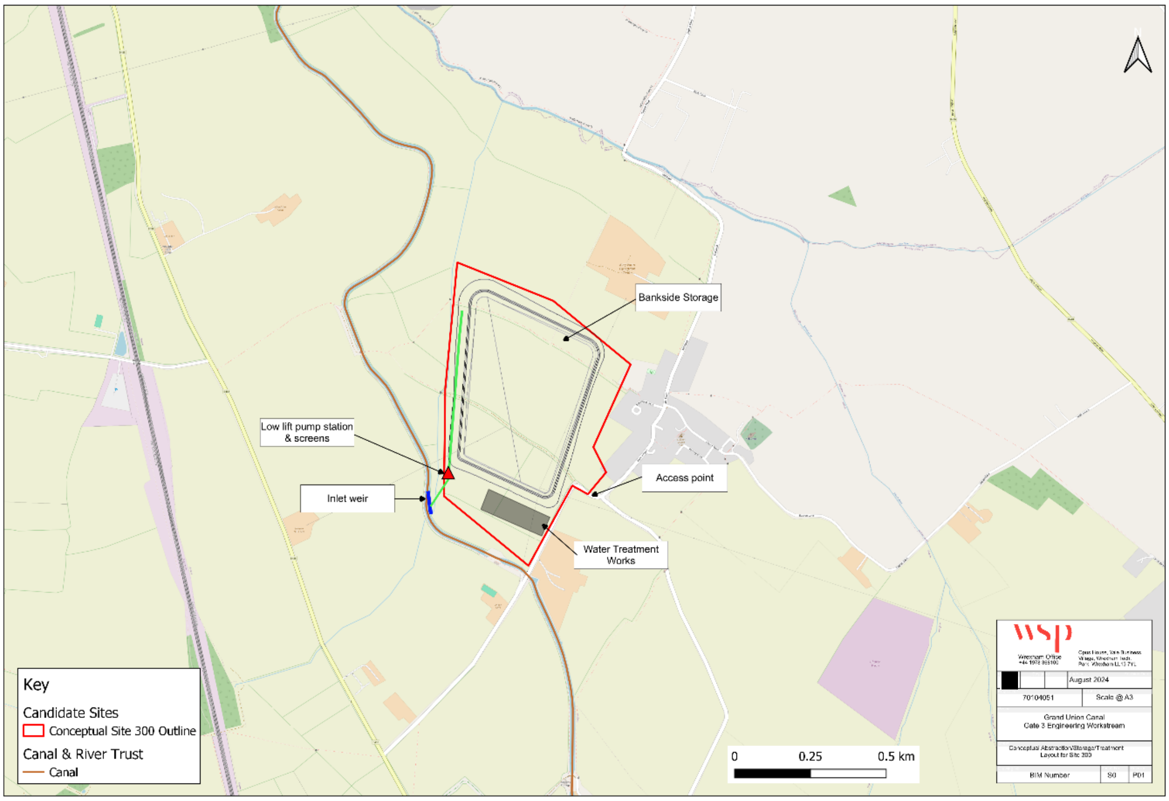


Figure 8-2 Conceptual Abstraction/Storage/Treatment Layout for Site H

The southern part of the site has been planted up as a new woodland plantation. The WTW is proposed conceptually to be located at the southern end of the site, to allow easier access for abstraction and to ensure it is further away from the village, with the proposed reservoir located across the northern area of the site.

Figure 82 shows a reservoir layout occupying a large proportion of the site but a different layout with a smaller footprint may also be possible, when fuller geotechnical and topographical information is available. If this option is selected the footprint of the reservoir will be determined following geotechnical and topographical studies and taking account of stakeholder feedback on possible layouts and landscaping.

A geotechnical appreciation, based on desk study, has been undertaken with the main characteristics of the site shown in Table 7-1 in Section 7.2.3 above and the fuller report included in Appendix E.

Two electrical power lines (HV) cross the site and will require diverting.

An outline flood risk appraisal has been undertaken and a full report is available in Appendix G. Land drainage ditches cross the area and are reportedly a source of surface water flooding particularly at the southern end of the site. When finally mapped it may be necessary to divert these depending on the final footprint of the reservoir and treatment works. Otherwise, site flooding risk is reportedly low.

The land slopes from east to west and an early assessment of the British Geology Survey Geology Viewer shows that the geology of the site is the following:

- Bedrock - Gault Formation - Mudstone
- Superficials – not recorded but it is expected that Alluvium - Clay, silt, sand and gravel, will be present.

A review of Defra's MAGIC Maps shows the site is not within any Groundwater Source Protection Zone (SPZ), is located above an unproductive bedrock aquifer and a Secondary A superficial drift aquifer. It also shows the site has a low/unproductive Groundwater vulnerability.

A review of Buckinghamshire Council's information showed that they currently have no sites that have been formally determined as contaminated.

A screened inlet will lie on the east bank of the GUC, south of the currently proposed bankside storage. Pipelines will deliver the abstracted water into a travelling band screen building which will remove material down to 5mm. The screened water will flow into a wet well low lift pumping station for delivery to the bankside storage inlet works where the water will cascade into the reservoir. Screenings are likely to be low volume given the generally low throughput and slow velocities in the canal, which tends to ensure most material is settled in the canal. Screens will be flushed with partially treated water from the treatment works and the flow settled out in a small retention pond before overflowing to the GUC.

The bottom outlet and spillway will be located to allow flow to return to the GUC.

The offtake to supply water to the treatment works inlet will be located to optimise flow across the reservoir to reduce risks of stagnating water.

There are no obvious disposal routes for wastewater from the WTW. The site may therefore require additional pumping towards Leighton Buzzard for disposal at Stanbridge Sewage Treatment Works which has a population equivalent of 15,000. This is a small-scale plant and its capacity would need to be confirmed with Anglian Water who own and operate the works, if this is the preferred site. Wastewater flows will be very low as the WTW has been configured to have very high recovery rates.

8.2.3 Site Layout - Site H/Site P (East of Leighton Buzzard Option)

This arrangement has the bankside storage reservoir at Site H where it is close to GUC for abstraction, overflow spillway and WTW returns. If this option is selected the footprint of the reservoir will be determined following geotechnical and topographical studies and taking account of stakeholder feedback on possible layouts and landscaping.

Access, geotechnical and utilities information and constraints will be the same as for the Site H discussion above as regards the bankside storage and associated structures, the canal side inlet weir, screen building and low lift pumping station to the reservoir inlet. Site H will also contain a second pumping station to transfer raw water from the bankside storage to the inlet to the treatment works at Site P.

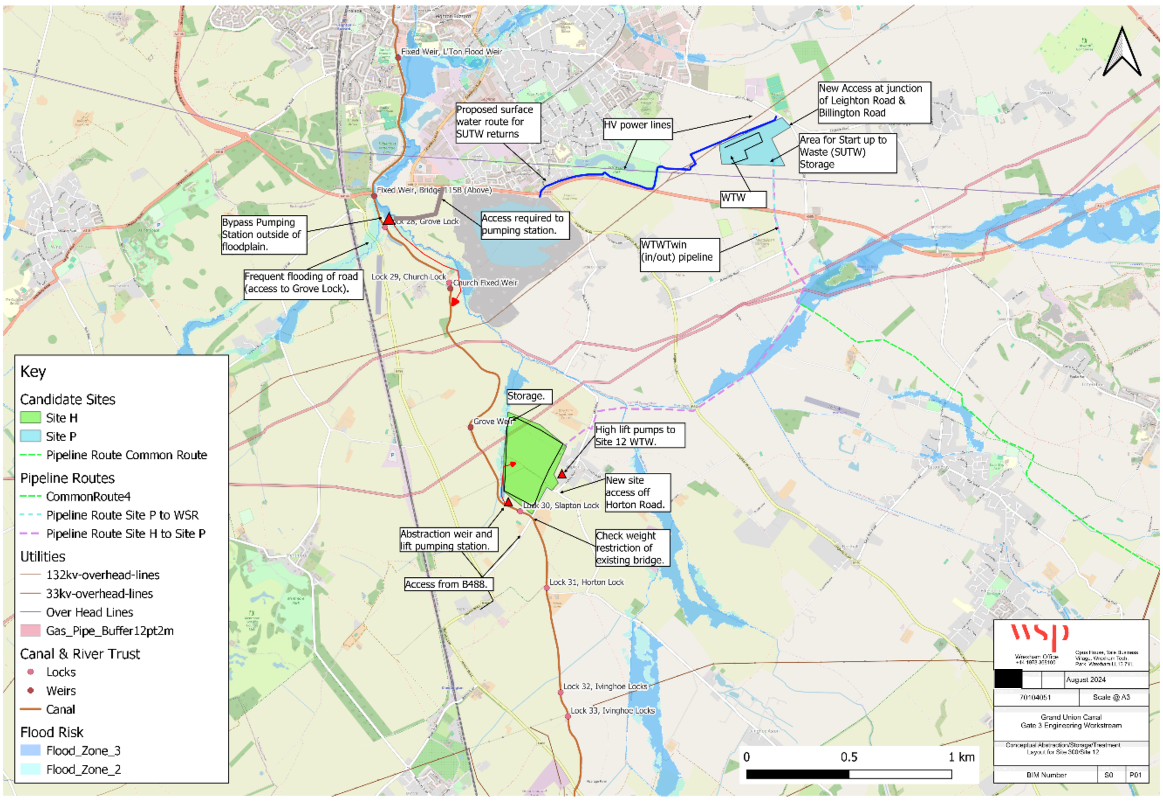


Figure 8-3 Conceptual Abstraction/Storage/Treatment Layout for Site H/Site P

The WTW will be located on a small site north of the A505 and close to the junction of Leighton Road and Billington Road. A geotechnical appreciation of Site P based on publicly available information has been undertaken and a summary is provided in Table 8-1 and a fuller report is included in Appendix E.

SITE P	Geotechnical Study Findings
Historical Aerial Photography	1945 onwards: farmland
Published Geological Information	No Made Ground is mapped by the BGS at this location. However, Made Ground is recorded in the historical borehole logs. Superficials: Head Deposit is present at the east of the site along Billington Rd. Bedrock: Gault Clay Formation (Mudstone). The Selborne Group is the parent unit.
Historical Borehole Records	SP92SE195: c90m north of proposed site, in a mapped area of absent superficial deposits 0.4m-40.7m Stiff grey CLAY 40.7m-42.5m Brown silty CLAY 42.5m-111.5m Green SAND – very hard in places, cemented 111.5m-115.5m Stiff grey CLAY SP92SW200: c360m south of proposed site, in a mapped area of absent superficial deposits 0.0m-0.2m Topsoil 0.2m-0.6m Made Ground. Brown fine to coarse sand with grey very silty clay and ash in the southwest corner 0.6m-2.0m Firm brownish grey and grey/brown, mottled slightly silty CLAY with rootlets and occasional chalk fragments 2.0m-4.5m Stiff grey and grey and grey/brown, mottled slightly silty CLAY. Fissured and with occasional medium gravel sized chalk fragments. Groundwater: Large inflow from Made Ground, particularly from south side at 0.5m.
SPZ	This site is not within a Source Protection Zone.
UXO risk	LOW UXO risk.
Coal Mining	This site is outside the Coal Authority's Coal Mining Reporting Area.
Environmental Designations	No environmental designations found within 1000m of site.
Anticipated ground and groundwater conditions.	No Made Ground mapped at this location. However one of the BGS boreholes in the vicinity of this location recorded Made Ground from 0.2m to 0.6m bgl. Superficials: Superficial deposits are recorded by BGS to be Head Deposit (clay, silt, sand and gravel) to the east of the proposed site. Bedrock: BGS records this as Gault Clay Formation. The reviewed BGS boreholes in the vicinity recorded rockhead depths of 0.0m to 0.6m with the upper layer being described as a firm clay.

Table 8-1 Summary of Geotechnical Appreciation - Site P

Figure 8-4 Conceptual Location Plan for Site P

Access to the site will be off the A505 and Billington Rd. The nearest significant residential area is c1km to the west and the completed works may be quite visually intrusive.

Site P is very flat falling very gently from northwest to southeast and has low to very low risk of surface water flooding and no reported risk of fluvial or groundwater flooding. Surface water flooding risk is largely confined to the drainage ditch to the right of the plot, sub-parallel to Billington Rd.

Since the site is relatively flat, even if the plant is set in a N-S direction there will probably need to be interstage pumping for the treatment works and some excavation to optimise the pumping. A flood risk appraisal has been undertaken and a full report is available in Appendix G. Surface water risk can be managed within the excavation works.

The raw water transfer pipeline from Site H bankside storage will enter the site from the south, crossing under the A505 and following the field edge as shown.

The treated water delivery main is proposed to follow the same route out of the site, crossing the A505.

Ground conditions are currently unknown but the land is relatively undisturbed agricultural land and loadings from the WTW are unlikely to be high enough to require special ground treatment.

Site P is c 2 km from the River Ouzel and c 2.3km from the GUC and a route will need to be confirmed to carry away “start up to waste” (SUTW) flows from the WTW plus any overflow or drawdown flow from the on-site works storage. Currently for this conceptual arrangement the SUTW flows and drawdown flows would be conveyed in a common conveyance from the attenuation pond adjacent to the site to the River Ouzel. The acceptability of this proposal is not yet confirmed and discussions will be required with the Environment Agency if this option is confirmed as preferred following non-statutory consultation.

A connection to a sewer will also be required to export wastewater from the WTW. Wastewater flows will be very low as the WTW has been configured to have very high recovery rates. Discussions with Anglian Water, the local water and sewerage undertaker which owns and operates the sewer will be required if this option is confirmed as preferred following non-statutory consultation.

8.2.4 Site Layout - Site H/Site Q

This arrangement has the bankside storage reservoir at Site H where it is close to GUC for abstraction, overflow spillway and WTW returns. If this option is selected, as for the Site H/Site P option, the footprint of the reservoir will be determined following geotechnical and topographical studies and taking account of stakeholder feedback on possible layouts and landscaping.

Access, geotechnical and utilities information and constraints will be the same as for the Site H discussion above as regards the bankside storage and associated structures, the canal side inlet weir, screen building and low lift pumping station to the reservoir inlet. Site H will also contain a second pumping station to transfer raw water from the bankside storage to the inlet to the treatment works at Site Q.

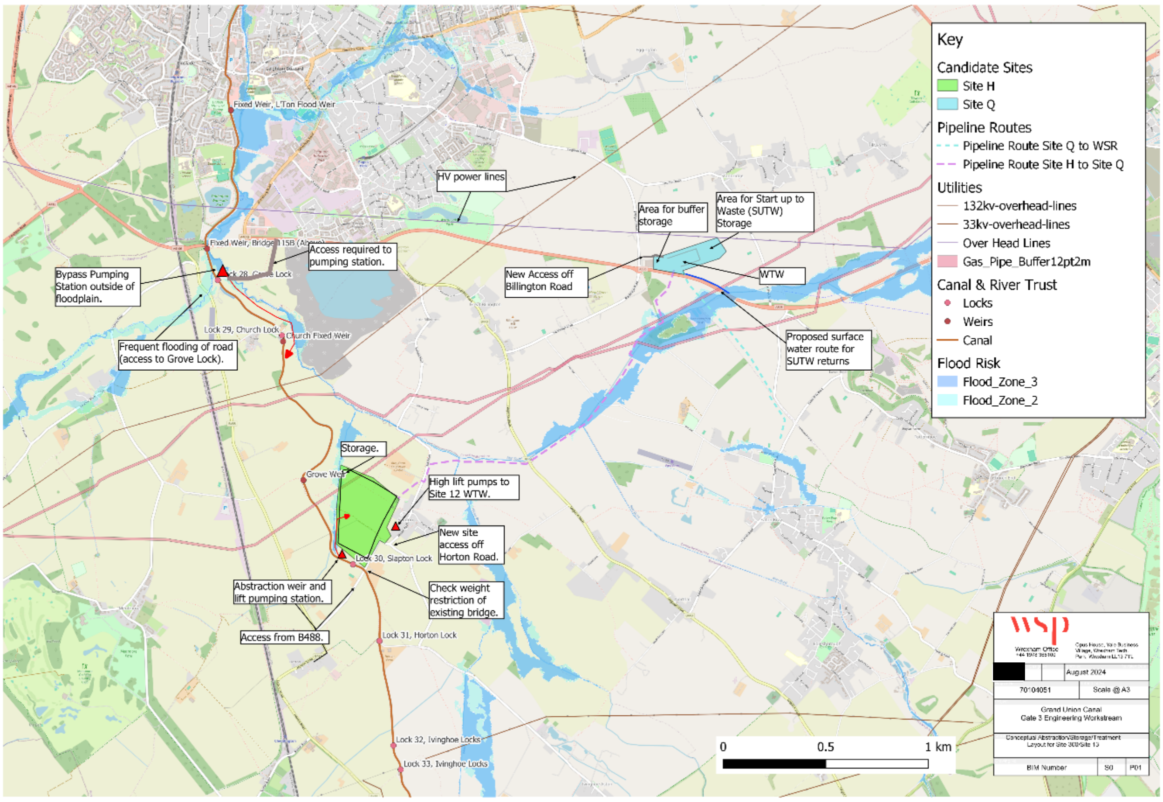


Figure 8-5 Conceptual Abstraction/Storage/Treatment Layout for Site H/Site Q

The WTW will be located on a site immediately north of the A505 and east of Site P. A geotechnical appreciation of Site Q based on publicly available information has been undertaken and a summary is provided in Table 8-2; a full report is included in Appendix E.

SITE Q	Geotechnical Study Findings
Historical Aerial Photography	1945 onwards: farmland
Published Geological Information	No Made Ground is mapped by the BGS at this location. Superficials: No superficial geology is recorded by the BGS. Bedrock: Gault Clay Formation (Mudstone)
Historical Borehole Records	SP92SE97: c150m south of proposed site. 0.0m-0.4m Topsoil 0.4m-3.3m Firm grey and brown, mottled slightly silty CLAY 3.3 -5.5m Stiff fissured grey, slightly silty CLAY Groundwater: no groundwater encountered during drilling. SP92SE98: c150m south of proposed site. 0.0m-0.3m Topsoil 0.3m-1.0m Soft to firm, grey/brown, mottled silty CLAY 1.0m-3.3m Firm grey with some brown, silty CLAY becoming stiff in places 3.3m-10.0m Stiff grey slightly silty CLAY becoming dark grey at 8.50m. Groundwater: no groundwater encountered during drilling. SP92SE2: c320m southeast of proposed site. 0.0m-0.4m Topsoil 0.4m-3.5m Stiff, light brown/grey, mottled silty, calcareous CLAY with some chalky sand. Grades down into no calcareous firm to stiff, dark grey/blue silty laminated CLAY with numerous decomposed shell fragments. 3.5m-5.5m Stiff, greenish grey, silty CLAY (Gault Clay formation). Groundwater: no groundwater encountered during drilling.
SPZ	This site is not within a Source Protection Zone.
UXO risk	LOW UXO risk.
Coal Mining	This site is outside the Coal Authority's Coal Mining Reporting Area.
Environmental Designations	No environmental designations found within 1000m of site.
Anticipated ground and groundwater conditions.	No Made Ground mapped at this location. Made Ground associated with the construction of the A505 is anticipated at the site. Superficials: No superficial deposits mapped at this location. Head Deposit may be present as it is recorded 130m to the west by BGS. Bedrock: BGS records this as Gault Clay Formation recorded from depths of 0.3m to 0.4m in boreholes.

Table 8-2 Summary of Geotechnical Appreciation - Site Q

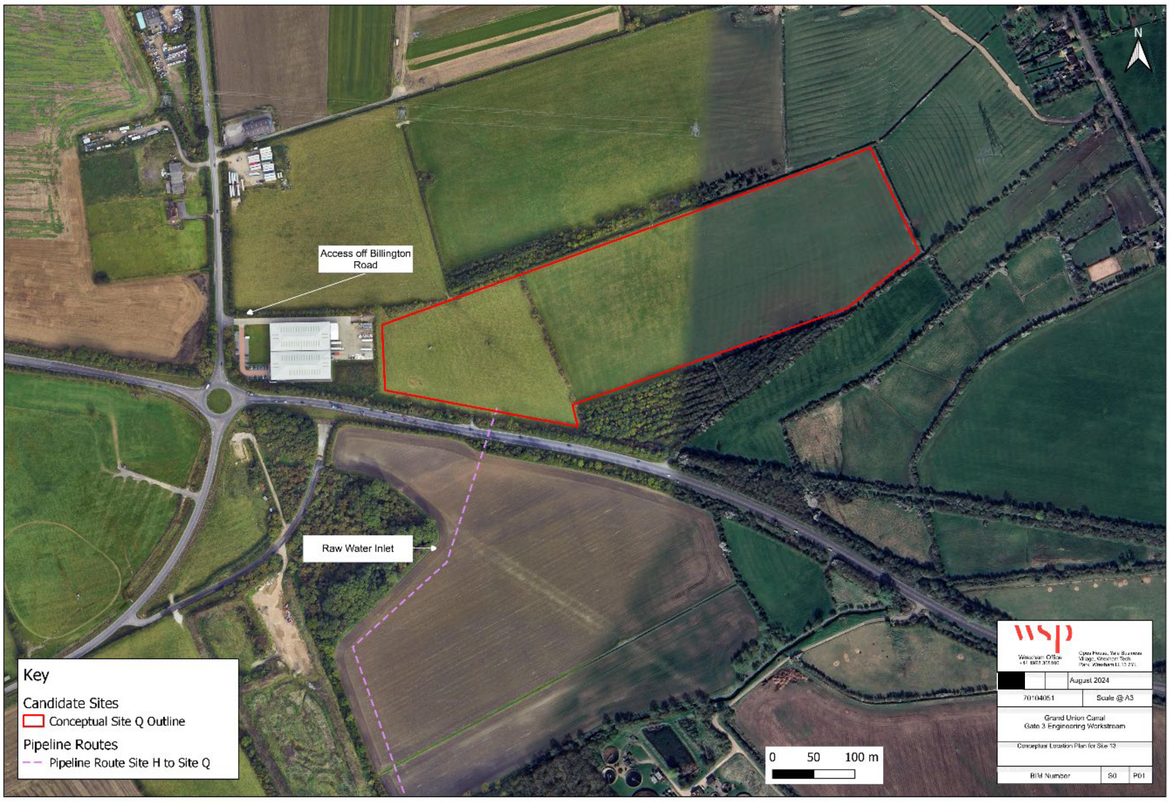


Figure 8-6 Conceptual Location Plan for Site Q

Access to the site is proposed off Billington Rd. The nearest significant residential area is immediately to the east at Stanbridge village and the completed works may be quite visually intrusive.

Site Q is very flat with a lower fall from west to east than Site P. An outline flood risk appraisal has been undertaken and a full report is available in Appendix G. The site has low to very low risk of surface water flooding and no reported risk of fluvial or groundwater flooding.

Since the site is relatively flat there will probably need to be interstage pumping for the treatment works and some excavation to optimise the pumping. Surface water risk can be managed within the excavation works.

The raw water transfer pipeline from Site H bankside storage will enter the site from the southwest, crossing under the A505 as shown.

The treated water delivery main is proposed to follow the same route out of the site, crossing the A505.

Ground conditions are currently unknown but the land is relatively undisturbed agricultural land and loadings from the WTW are unlikely to be high enough to require special ground treatment.

Site Q is c 2 km from the River Ouzel and c 2.3km from the GUC and a route will need to be confirmed to carry away “start up to waste” (SUTW) flows from the WTW plus any overflow or drawdown flow from the on-site works storage. A route has been shown to the upper reaches of the River Ouzel to the southeast of the site at a distance of c350m. The acceptability of this proposal is not yet confirmed and discussions will be required with the Environment Agency if this option is confirmed as preferred following non-statutory consultation.

A connection to a sewer will also be required to export wastewater from the WTW. A small sewage treatment works, which also discharges to the River Ouzel is located c 300m due south of Site Q. Wastewater flows will be very low as the WTW has been configured to have very high recovery rates. Consultation with Anglian Water, who own and operate this sewage works, will be needed to confirm it can accept the flow.

9. ABSTRACTION

The inlet layout and general arrangement will be as per the screened inlet for a lock bypass pumping station. Screens and approach velocity to the screens will be required to be sized to minimise the risk of entrainment of eels/elvers/fry into the system.

The flow into the intake will pass into a wet well from which pipelines will transfer the water to the low lift pumping station wet well. Thrust bored or auger bored pipelines will cross the River Ouzel at Site B.

The low lift pumping station will transfer the water to the bankside raw water storage at either Site H or Site B.

The low lift pumping station, having the same maximum capacity and similar delivery head will be the same layout as the bypass pumping stations shown in Section 6.3.2 above modified to suit the required depth. Refer to Table 7-1 and Table 7-2 for geotechnical appreciation of these sites.

Figure 9-1 and Figure 9-2 show outline information of the inlet screen chamber and an indicative layout of the abstraction point is provided in Figure 9-3 .

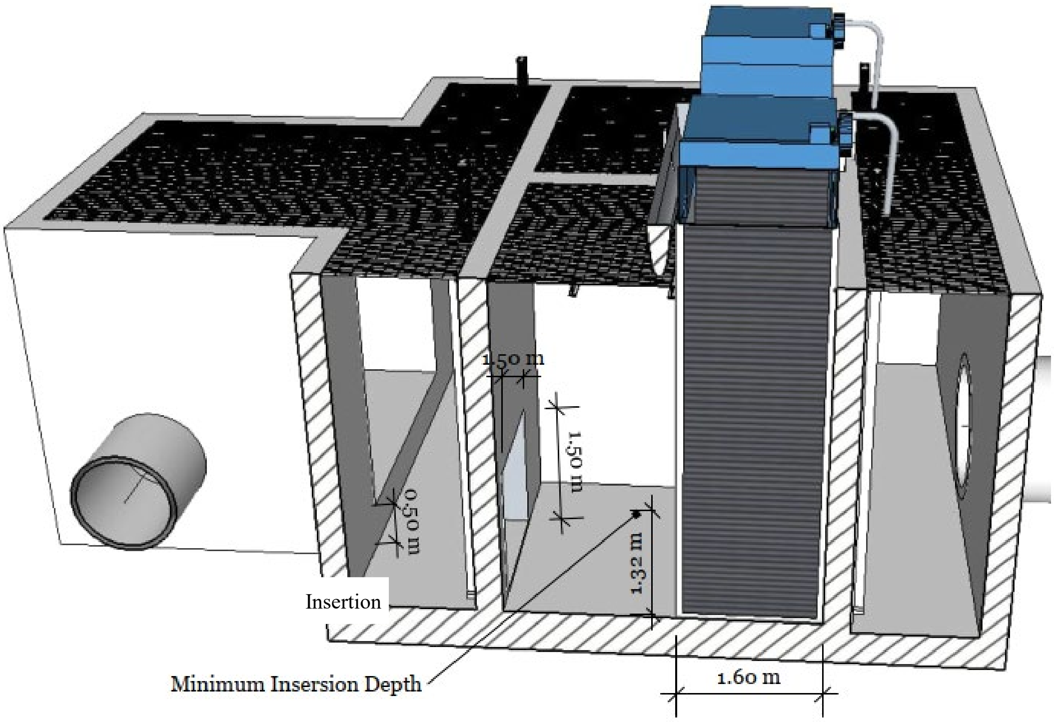


Figure 9-1 Abstraction Inlet Screen Chamber Section View

Asset size redacted

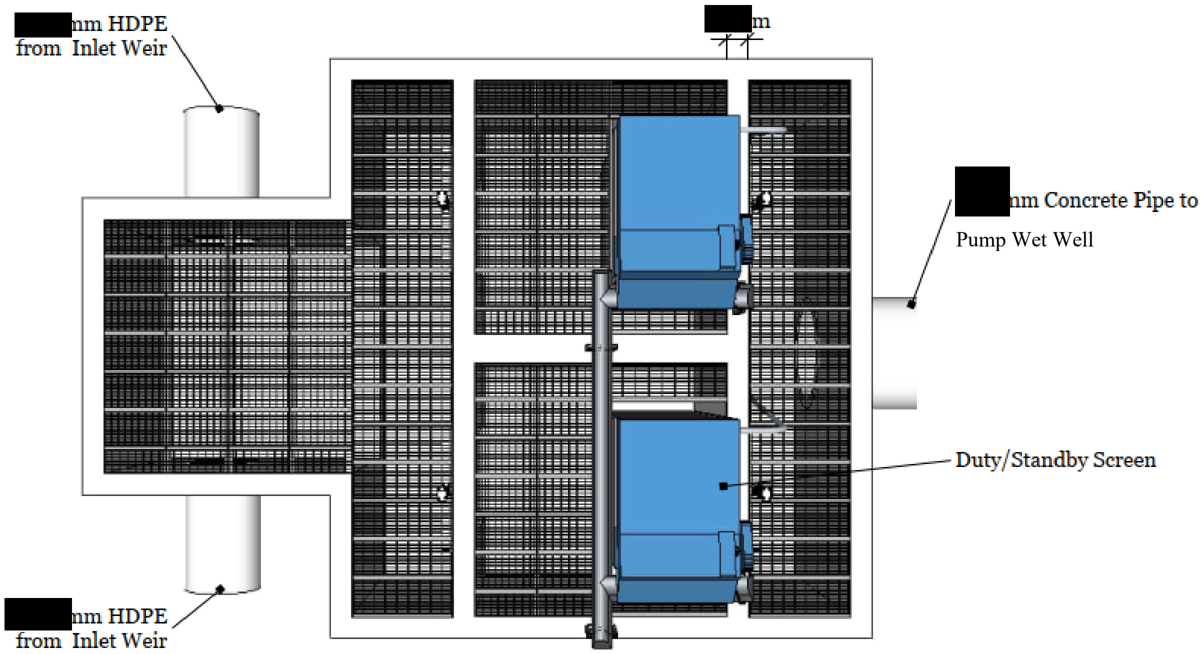


Figure 9-2 Abstraction Inlet Screen Chamber Plan View

Anything retained on the band screens will be washed off using screened or partially treated water from the WTW and the flow will be directed to a small retention pond prior to overflowing to a local drainage feature. Flows are expected be low because the system will be operating at tickover for much of the year and there will be low levels of material in the water abstracted from the canal.

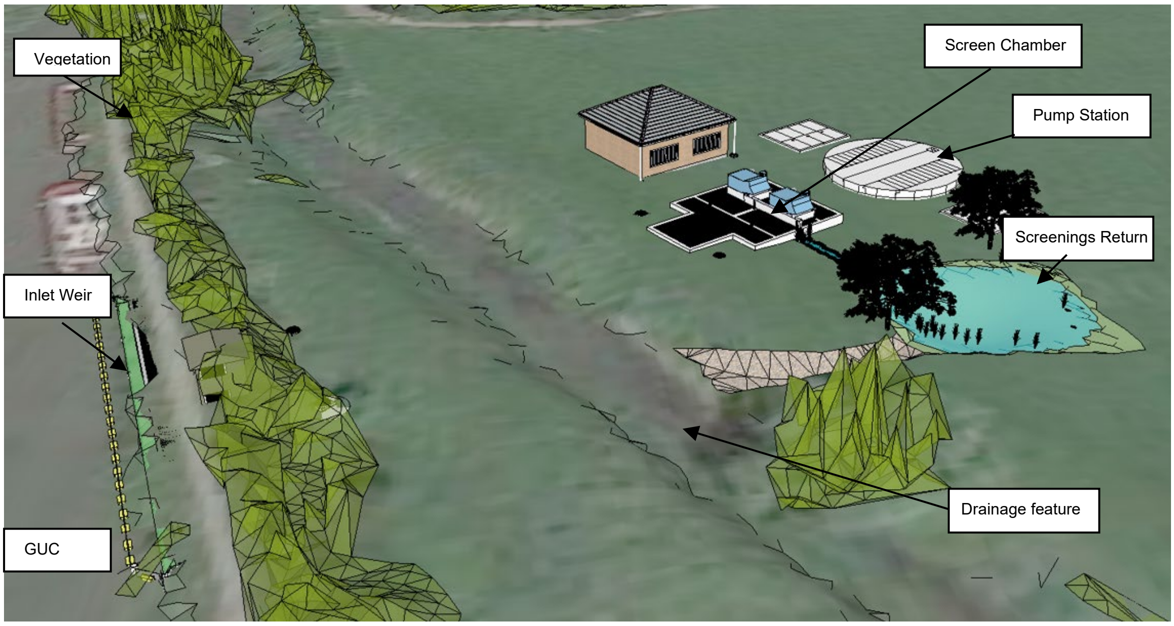


Figure 9-3 Conceptual Typical Layout for Abstraction Point

Flow from the low lift pumping station will be delivered in a [redacted]mm pressurised pipeline to the bankside storage inlet works. There are fibre optic cables buried beneath the towpath in the vicinity of the proposed abstraction structure. These are on the opposite side of the canal to the proposed works and works may be needed to protect them.

9.1 PUMPING STATION TO NEW POTABLE TREATMENT WORKS

9.1.1 Introduction

If the bankside storage is on the same site as the water treatment works, i.e. at Site H or Site B, there will be a low lift pumping station which will be needed when the water level in the bankside storage drops below a trigger level.

If the bankside storage is separate from the treatment works, i.e. at Site P or Site Q, a high lift pumping station will be needed to deliver the water to the higher elevation works inlet.

9.1.2 Low lift pumping station

The low lift pumping station will be required to lift the raw water from the bankside storage reservoir at Site H or Site B to the inlet of the treatment works when the head in the reservoir is insufficient.

Under the current operating philosophy, the reservoir is intended to be full most of the time so the head available should be sufficient to deliver water to the inlet of the treatment works. When the reservoir is drawn down, due to an operational incident such as pollution, bypass pumping station failure or Minworth AWTP failure/interruption due to flow constraint, the pumping station will need to operate.

Since the duty of the pumping station is similar to that of a bypass pumping station, the size and layout of this low lift pumping station will be the same.

9.1.3 High lift pumping station

The high lift station will be required to lift the raw water from the bankside storage reservoir at Site H to the inlet of the remote treatment works at either Site P or Site Q.

The elevation difference between the bankside storage reservoirs and Site P or Site Q is c15m, as established from publicly available mapping, and the headloss in the delivery main will range from 2m to 15m, depending on flow rate, making the maximum lift c 30m at peak flow of 115 Ml/d (1.33m^3/sec).

The duty of the high lift pumping station is similar to that of a bypass pumping station, although the pump drive will be larger. Thus, the size and layout of this low lift pumping station will be similar to a bypass pumping station with additional costs for the larger drive and switchgear.

9.1.4 Treatment works raw water delivery pipeline.

The design and route plans are presented in Section 11.

10. NEW POTABLE TREATMENT WORKS

10.1 INTRODUCTION

The new water treatment works will be located at a site still to be selected as preferred following the non-statutory consultation.

The layouts presented below are therefore not specifically adapted to the actual site location and may change in future, particularly in respect of the scope and scale of inter-stage pumping. The assumption is currently that the site will be flat so that inter-stage pumping will be required; if this is not needed then more rationalisation of the works footprint may be possible.

Geotechnical appreciations of Site H and Site B are summarised in Table 7-1 and Table 7-2. Geotechnical appreciations of Site P and Site Q are summarised in Table 8-1 and Table 8-2.

The drinking water quality risk assessment, process design and operational control philosophy to allow reliable treatment of the raw water has been developed in a Conceptual Design Report (included as Appendix H) which is reported in summary below, along with a review of the elements of the work that will require further assessment during Gate 4.

The report sets out the basis of the design requirement in Section 10.2 and outlines the treatment requirement to treat the abstracted water to within the required limits in Section 10.3 and the outline operational philosophy is reported in Section 8.5.4.

Expert judgement has been used to identify possible treatment routes and communication with suppliers has allowed for the recommended technologies to be assessed and verified. Jar tests to review and confirm the treatability of the water have been undertaken as reported on in Section 10.5

A review of some process options which may be preferred by the future process contractor is discussed in Section 10.6 and areas for future assessment are given in Section 10.7

10.2 DESIGN REQUIREMENTS AND BASE DATA

The design of the new WTW is defined by the performance it has to achieve (water quality and recovery rate), scheme operating philosophy, environmental and spatial location, regulation and practice accepted by AfW. A summary of the design constraints is provided below. This includes guidance from the Water Industry Mechanical and Electrical Specifications (WIMES), design textbook and our experience in designing such plants for the UK water industry. More details can be found in Appendix H.

10.2.1 Treated water quality requirements

<u>REGULATIONS</u>

The WTW design must mitigate public health risks associated with the delivery of the scheme, complying Drinking Water Inspectorate's (DWI's) guidance note on long-term planning for the quality of drinking water supplies (Guidance Note: Long-term planning for the quality of drinking water supplies, DWI, July 2022).

This includes compliance with:

- The Water Supply (Water Quality) Regulations 2016 (England) (with 2018 amendments consolidated) – These are national standards that ensure the safety and quality of drinking water. The treatment process will aim to meet or exceed these standards to ensure the water is wholesome and safe for consumption.
- The statutory obligations on water suppliers under section 68 of the Water Industry Act 1991 to supply wholesome water and ensure as far as reasonably practicable that there is “no deterioration in the quality of the water which is supplied from time to time from that source or combination of sources”. Water quality in Affinity Water’s service reservoir thus sets certain requirements for the incoming water to maintain the overall quality in the reservoir, minimising change in water chemistry that may affect network corrosivity and acceptability by customers.

WATER QUALITY RISKS IDENTIFICATION

A water quality sampling programme has been in operation from Gate 1 to 3 to support derivation of the canal’s and Minworth AWTP’s recycled water quality baseline. Details can be found in GUC Gate 2 Annex B1.4 Water Quality Monitoring (although some water quality parameters have been added for Gate 3).

Based on this data a water quality risk assessment was carried out at Gate 1 and Gate 2 following the ACWG methodology. The water quality risk assessment allows for the determination of the limiting hazards that the water treatment works need to mitigate risks to public health present in the catchment of the WTW and to comply with regulations.

This report has used outcomes from the water quality risk assessment reported in GUC Gate 3 Annex B1.12.

The water quality data were also reviewed to appraise the treatability of the water (process risks) and the potential to form by-products through the treatment.

The drinking water safety plan and Affinity Water’s service reservoir’s water quality data were reviewed to determine water quality targets to meet no deterioration conditions and ensure that any current risks associated with this asset are not exacerbated by the scheme.

TREATED WATER QUALITY TARGETS

Water quality targets are proposed for each of the parameters that may affect current customers’ supply in terms of increased health risks and acceptability. Water quality targets were attributed to risks that were identified as per above, i.e. either they could lead to a breach of DWI regulations, or they would lead to a material deterioration of the quality of water customers currently receive from Affinity Water’s service reservoirs. Table A-1 Appendix I lists these parameters, alongside the relevant DWI water quality standards, the average water quality for Affinity Water’s service reservoirs and the proposed targets.

For parameters not listed in Table A-1, we have assumed that the prescribed and specification concentrations and values provided respectively in Schedule 1 and Schedule 2 of The Water Supply (Water Quality) Regulations 2016 (England) will be used.

10.2.2 Raw water quality

Water quality modelling has been done by the Hydraulics Consultant to identify any impacts of the Minworth SRO's recycled water on the canal environmental status. As part of this study, the correlation of canal and discharge flows at the initially proposed abstraction location (GUC at Leighton Buzzard – Site 6) was modelled.

Using the water quality monitoring data for the current Minworth WwRC's recycled water (Site 1) and the GUC at Site 6 and the modelled flow ratio, the future water quality was estimated as shown in Table 101.

Parameter	Note	Unit	Blend concentration		
			Min	Mean	Max
Microbiological parameters					
Enterococci, confirmed	Max values recorded as >100 and >1,000	Number (no)/100ml	62.2	108.5	475.1
Escherichia coli	Max >2,420	no/100ml	553.4	1,792.9	2,420
Coliform bacteria	Max >2,420	Most Probable Number (MPN)/100ml	1,004.9	2,231.8	2,420
Cryptosporidium	Max >2,420	no/100ml	0.0	0.0	0.8
Chemical parameters					
Chloride		mg/l	38.7	80.9	551.6
Chromium		µg/l	0.8	3.0	16.4
Chromium IV		µg/l	0.0	2.1	4.3
Iron		µg/l	63.3	214.1	1,177.1
Manganese		µg/l	39.2	73.6	140.5
Sodium		mg/l	35.5	50.0	72.1
Sulphate		mgSO_4/L	0.1	85.7	434.0
Chemicals: Drinking Water					
Bromate		µg/l	0.4	1.2	6.4
Lead		µg/l	0.1	0.6	2.8
Nickel		µg/l	5.3	12.9	33.9
Trihalomethanes	All values below LOD <4	µg/l	2.0	2.0	2.0
Nitrate (NO_3)		mg/l NO_3	27.2	54.9	96.5
Pesticides (Total)		µg/l			
Mercury		µg/l	0.0	0.1	3.3
Benzo(a)pyrene		µg/l	0.0	0.0	0.1
Ammonium	Recording for NH_4 only taken at site 1. All values are below the LOD which varies for each sample.	mg/l as NH4	0.0	0.1	0.7
17ß-Oestradiol		µg/l	0.00015	0.00070	0.00265
Bisphenol A		µg/l	0.005	9.9	80.3
Nonylphenol		µg/l	0.0063	0.0132	0.020
Turbidity		Nephelometric Turbidity Units (NTU)	4.1	12.4	89.9

Parameter	Note	Unit	Blend concentration		
			Min	Mean	Max
Algae		No/ml	57.7	1,139.9	5,315.5
Metaldehyde	Many values below LOD <0.02	µg/l	0.010	0.013	0.037
Tributyltin Compounds (TBT)		µg/l	0.0000	0.0001	0.0002
Triclosan	Site 6 all values below LOD <0.01	µg/l	0.000	0.012	0.036
Fluoranthene		µg/l	0.001	0.007	0.050
PFAS	0.1	µg/l			
Boron		µg/l	82.5	146.2	268.8
Sum of Tri and Tetrachloroethane	All values below LOD <1	µg/l	0.5	0.5	0.5
Chlorophyll	All site 1 values below LOD <7 or 20	µg/l	4.2	15.2	53.6
Phaeophytin	All values below LOD <6 or 20	µg/l	3.6	5.2	7.1
Soluble Reactive Phosphorous		mg/l	0.02	0.3	1.8
Organic Nitrogen	Most values below LOD <5	µg/l	1.2	2.4	3.2
Geosmin		ng/l	0.8	6.5	14.8
Alkalinity		mg/L as $CaCO_3$	52.6	132.5	435.0
Alkalinity		mg/L as HCO_3	64.2	141.4	207.6
pH		pH Units	6.9	7.4	8.0

Table 10-1 Predicted Minworth Final Recycled Water and Site 6 blended concentrations of high-risk parameters

Assumptions about the quality of the water which will need to be treated at the new southern WTW include:

Coventry Canal: Coventry Canal currently has the highest levels of pollution measured from the monitoring campaign, likely due to the low input of new water sources and continued re-circulation of flow in this area. The high level of treatment proposed at Minworth AWTP means that the addition of Minworth SRO's recycled water will likely dilute current pollution of the Coventry Canal which would not reach the abstraction point.

Daventry/Drayton: The proposed use of the reservoirs will have limited impact on canal water quality, apart from the potential for higher algal content.

Bankside storage: Any possible improvement of water quality through the reservoir (e.g. solid sedimentation) was not accounted for, bearing in mind that it can be by-passed and abstracted water treated directly through the treatment plant. However, it is possible that algae growth and blooms will occur, posing a risk both in terms of water treatability and customers' taste and odour complaints.

10.2.3 Parameters of interest

Bromide and disinfection-by product concentrations were estimated based on average monthly values for January and July. Results show that there is potential for the bromate and THMs concentration to be over the drinking water limits making it important that the management of the formation of bromate and THMs is considered through the design of the works.

PFAS has not been detected in Affinity Water's service reservoirs to date but has been detected at various locations along the canals and in the Minworth WwRC recycled water. This means any PFAS compounds in the water abstracted from the GUC will need to be removed such that PFAS concentration is below the limit of detection, before being transferred. The current PFAS Tier level at the existing service reservoir is PFAS Tier 1. The PFAS Tier level at abstraction varies from PFAS Tier 1 to Tier 3 (see Drinking Water Safety Plan in Appendix H for more information).

Larson-Skold Index provides an indication of water corrosiveness. A change in corrosiveness may lead to water discoloration and could impact network infrastructure. The Larson-Skold Index could increase if the chemicals used in the advanced water treatment plant for the Minworth SRO and the southern WTW are not chosen carefully.

Taste – levels of Sulphate, Chloride and Sodium in the canal network have been identified as being higher than those at Affinity Water's service reservoirs. Sulphate concentration is lower in the Minworth WwRC's recycled water than at Site 6. The Minworth SRO's recycled water may have a positive impact by reducing the sulphate concentration in the canal network through dilution and it is not proposed that treatment mitigation is included to reduce chloride, sodium and sulphate concentrations.

Detergents and Personal Care Products were identified as an amber risk in the Gate 3 draft water quality risk assessment. It is highly likely that processes in the Minworth SRO's AWTP and the southern WTW will reduce the concentration of these compounds below the level specified by DWI.

Please note, as the effluent from Minworth WwRC is not currently being treated through the AWTP, it is assumed that the Minworth SRO effluent will meet environmental quality standards. This has been confirmed as part of the DWSP process through discussion with the Minworth SRO design team.

It has to be noted however that the Minworth SRO AWTP includes a nitrification step to reduce ammonia concentration, which is oxidised to nitrate. Discussions are progressing to address the cost benefit of either a denitrification step as part of the Minworth SRO AWTP or as part of the AfW GUC WTW, to reduce nitrate concentration and therefore reducing risks of non-compliance with nitrate consent in the treated water. Data from the pilot plants will be used as part of this Gate 4 cost benefit assessment.

10.2.4 Design constraints and parameters

The following aspects were identified as being necessary considerations in the design.

Recovery rate:	To achieve a minimum recovery rate of 87%; in practice the recovery rate is much better.
Wastewater:	Process wastewater quantities should be minimised due to a lack of easy disposal routes. Plant is designed to produce a limited volume of wastewater, with a 25% dry solids sludge and the softener regeneration and CIP waste to be neutralized and sent to nearest sewer. The proposed usage pattern means that the waste flows will be very low for most of the year.
Treated water:	The transfer to Affinity Water's service reservoir near Luton is through a long pipeline and flows for most of the year will be quite low. A disinfection residual will need to be provided.
Site:	Whilst the site location is not yet finalised it is clear that space for the site will be limited. The layout is therefore designed to be very compact and assumes that the site is essentially flat.
Design standards:	Design complies with AfW's asset design standards. This includes guidance from the Water Industry Mechanical and Electrical Specifications (WIMES) design textbook. When not available, best available technique approach was used based on engineering experience of designing such plants for the UK water industry.
Resilience:	Design is aligned with DWI guidance note on resilience of water supplies in Water Resource Planning for the long-term.
Redundancy:	Design minimises risks associated with the probability of unscheduled maintenance/downtime. The likelihood of an event has been assessed against the potential additional capital expenditure.
Regulation 31:	Design assumes using chemicals, equipment and construction materials that have approval under Regulation 31 of the Water Supply (Water Quality) Regulations 2016 (as amended in 2018).

10.3 TREATMENT PROCESS SELECTION

The treatment process is planned to consist of the following stages:

- Screens
- pH adjustment
- Coagulation and flocculation
- Dissolved Air Flotation (DAF)
- Ultrafiltration (UF)
- Granular Activated Carbon (GAC)
- Disinfection using ultraviolet (UV) light and sodium hypochlorite dosing
- pH adjustment and orthophosphoric acid dosing

10.3.1 Screens and filters

There will be 2 no. coarse screens at the point of abstraction to remove large items that may have entered the water in the storage reservoir. The works will also be protected against grit and debris by six no. 0.5 mm strainers to help mitigate mechanical issues downstream in the process. The design includes six cylindrical filter candle strainers.

10.3.2 pH adjustment

Jar test experiments were conducted indicating the requirement to reduce pH of the raw water to improve the coagulation and flocculation process. Three options were considered but carbon dioxide was selected as it is also likely to be used as part of any conditioning plant that may be required.

10.3.3 Blend tank

A blend tank is used to mix the backwash streams from the GAC and UF with the pH adjusted raw water. The need for a high recovery rate means that a blend tank is required to recycle water where possible and ensure relatively consistent amounts of total suspended solids (TSS) in the feed water to the DAF process.

10.3.4 Coagulant dosing

The Bench Scale Tests indicate that either PACl and Aluminium chlorohydrate (ACH) are appropriate coagulants, with the optimised tests indicating a dose of 10mg/l ACH to be the most effective and as it has lower potential for increasing the Larson-Skold Index. An economic evaluation may be needed to determine the optimum dosing regime.

10.3.5 Flocculation

Four flocculation tanks will be directly upstream of the DAF units to remove/reduce any pumping or piping requirements. A CFD model of the flocculation tank demonstrated there was sufficient kinematic energy in the proposed design and that mixing would be sufficient with a baffle arrangement.

10.3.6 Dissolved air flotation (DAF)

DAF will be used for clarification of the raw water. DAF systems are effective treatment for the removal of suspended solids and are suitable where there is a risk of algae growth in the raw water, as in the case here. Four DAF units are required each with a volume of 266 m^3.

10.3.7 Ultrafiltration membrane process

Membranes will remove particles, colloids, very large natural organic materials, algae and micro-organisms. Two membranes options were considered: polymeric membranes and ceramic membranes. The design currently includes polymeric membranes as the footprint is larger, making the layout conservative. The proposed treatment solution includes 15 pressurised ultrafiltration racks (12 duty / 3 standby), with each rack containing 96 membranes.

10.3.8 Granular activated carbon (GAC)

GAC is effective at removing a wide range of contaminants and with effective pretreatment, competition for active sites should be reduced and subsequent capacity increased for contaminant removal. Compounds removed by GAC include volatile organic compounds, disinfection byproducts, geosmin and 2-methylisoborneol (MIB), heavy metals, and microorganisms.

TOC, and PFAS removal using GAC has been considered during the bench scale tests, using rapid small scale column test. The results shows that TOC breakthrough is reached at 30,000 bed volumes, whilst PFAS removal concentration remains below the limit of detection.

12 GAC units are proposed with an empty bed contact time of 20 minutes, a media depth of 3.0 metres and a velocity of 9m/hr with all units in service.

UV

Ultraviolet (UV) is proposed for disinfection as it is highly effective at inactivating a wide range of microorganisms. UV is chemical free, meaning no harmful disinfection by-products are formed and provides rapid treatment, ~1 second.

The design proposes 2 No. duty / standby 1.4m latest generation low-pressure UV lamps, specifically designed for improved energy efficiency and operational stability. Each UV is protected by intensity and quartz sleeve integrity monitoring and incorporates an automatic wiping system. A UV dose of 40 mJ/cm^2 to is used to ensure Adenovirus inactivation, although system validation could reduce this requirement to 25 mJ/cm^2.

10.3.9 Disinfection

Sodium hypochlorite solution (12.5%) in series with UV is proposed providing high levels of disinfection in treatment and residual disinfection, maintaining protection against microbial growth within the piping and storage networks.

10.3.10 Conditioning

Conditioning is required to meet a Larson-Skold Index of 0.9. This will be achieved through dosing of carbon dioxide and sodium hydroxide.

10.3.11 Phosphoric acid dosing

Phosphoric acid dosing is required to reduce plumbosolvency in the network.

Two 1.8m^3 tanks will be provided for the phosphoric acid which is dosed at a rate of 6 l/hr. Because of the very low acid flow required, to aid dispersion in the mixer, it is first fed into 8m^3/hr of soft water before mixing with the main flow.

10.3.12 Wastewater treatment and management

DAF sludge:	Will be sent to 4+1nr sludge tanks for settling and then thickened in 2 nr volute thickeners.
Backwash water:	Will be sent from UF and GAC process units to a buffer tank before transfer to the blend tank, where settled water from the sludge will also discharge. Subject to TSS levels, the water from the blend tank

may be recycled via the DAF units to enhance overall recovery rates or sent to sewer.

Run-to-waste:	There are run-to-waste streams for the candle filters, water from the DAF and UF units, and from the GAC filters for removing water during startup or if there is an operational issue. There is provision for the dosing of sodium hydroxide, sulphuric acid, and sodium bisulphite prior to being discharged back into the GUC or bankside storage reservoir.
UF CIP/GAC Regen:	Effluent from the softener and CIP systems is classified as trade effluent. The effluent will be neutralised, as required, before being disposed of to the local sewer.
Sludge:	Subject to future testing it is assumed the sludge will be recycled through spreading on agricultural land. If this is not acceptable the sludge will need to be further dried and sent to landfill.

Author names redacted

Asset size redacted

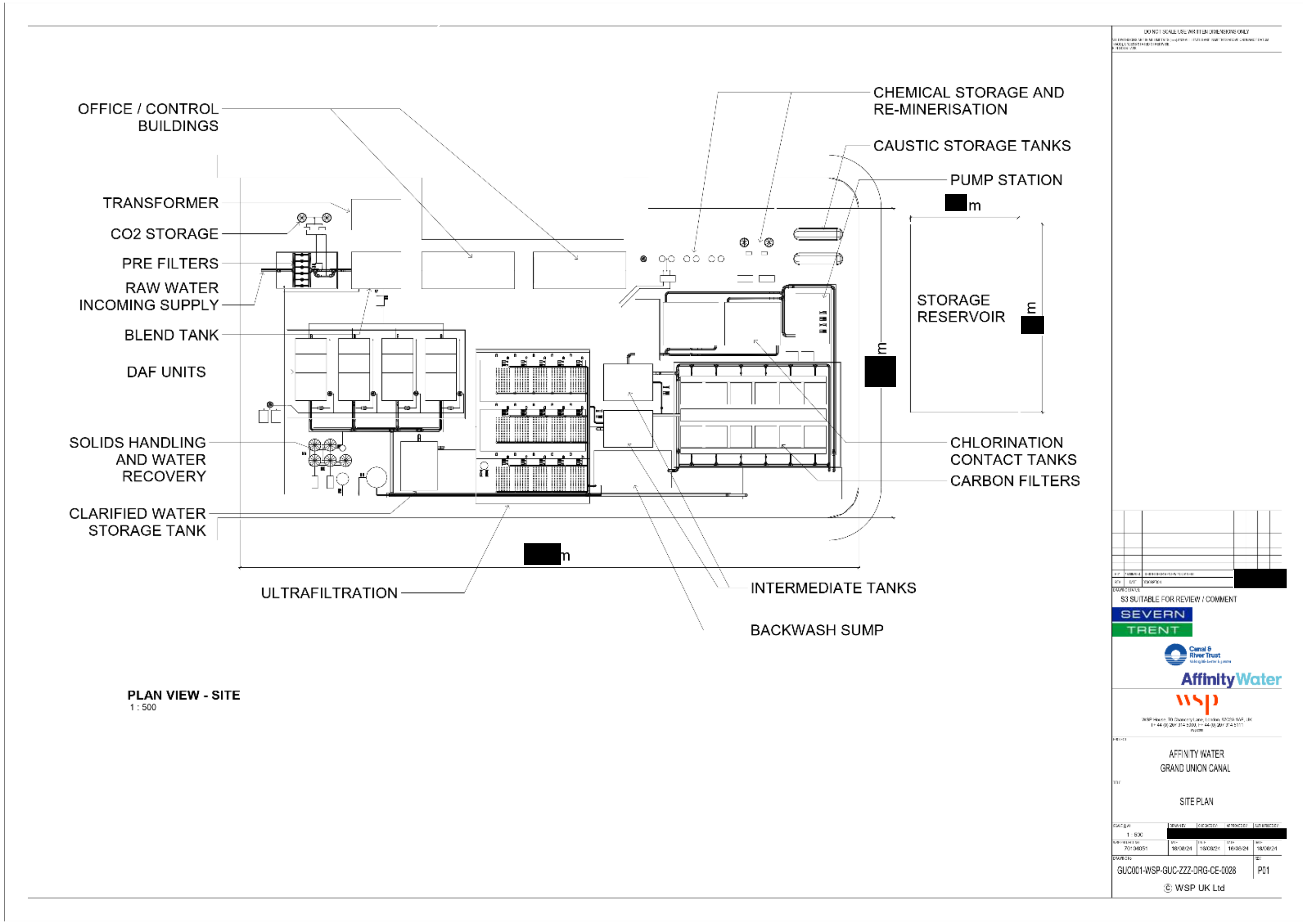


Figure 10-1 Conceptual Schematic Layout of Treatment Works at Southern End of the GUC SRO

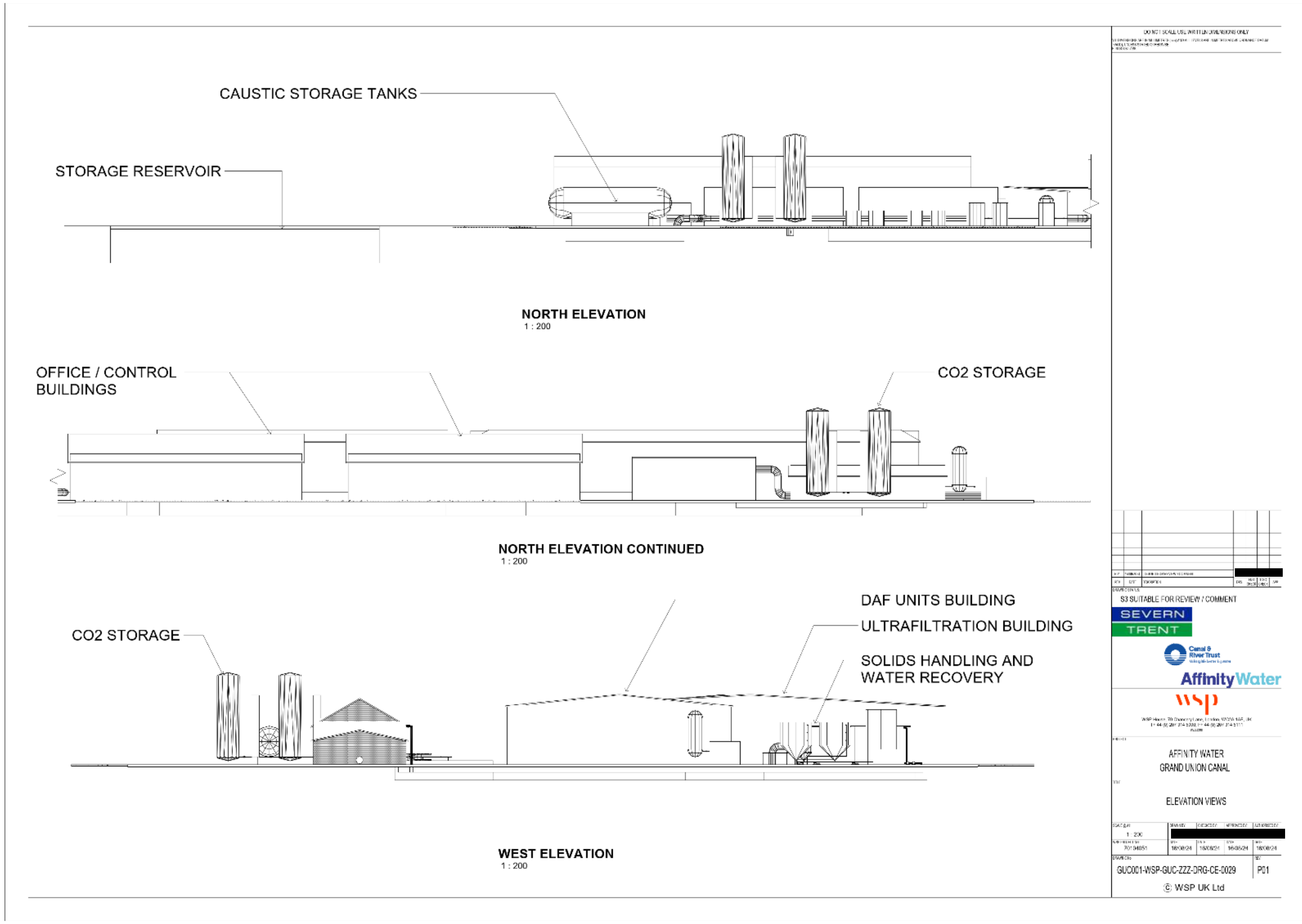


Figure 10-2 Conceptual Elevations of Treatment Works at Southern End of the GUC SRO

10.4 CONTROL PHILOSOPHY

At this stage, the control philosophy is at high-level and based only on requirements that must be met by the project.

The control philosophy assumes for local, main control system, with control interlocks for the process interfaces between the southern WTW, the GUC transfer and abstraction system and the existing underground reservoir near Luton.

Control is assumed by networked PLC/BUS system, with the protocol to be confirmed.

Operator interaction would be through local panel HMI or via a SCADA system which monitors all treatment process.

The control philosophy is based on all major process drives being centrally controlled with single intelligent motor control centre (MCC).

10.4.1 Process control

Raw water:	Will be monitored on a continuous basis for pH, turbidity, colour, conductivity and chlorophyll A to determine changes in quality and its suitability for treatment. The information is also used on feed forward control to adjust the coagulant dosing algorithm.
Strainers/filters:	These are fully automatic backflushing filters, with selection of filter to backwash on a carousel basis with high differential pressure override.
pH adjustment:	Carbon dioxide will be dosed into the feed water controlled on feedback from pH using 3 term (PID) control and a manually adjusted set point. The measured flow of raw water from the GUC is also used as a control term in the injection of gas.
DAF Coagulant:	Dosed into the flocculator feed water, controlled on the flow to the flocculator, measured at the DAF outlet, the raw water colour and turbidity and amount of recovered water returned to the blend tank.
Floc tanks:	The flow through the flocculators is by gravity and is controlled by the relative levels in the blend tank and the clarified water tank.
DAF:	Stable water quality is measured by turbidity, pH and Aluminium levels at the outlet of the DAF. Failures in DAF output water quality during service are managed via the run-to-waste, with the flow diverted until corrective action returns the water to specification.
UF:	Flow and therefore the number of racks in service is controlled by the level in the UF filtrate tank, with the maximum flow achieved with 12 racks in service. The UF racks are backwashed on carousel basis with a high differential pressure override.
GAC filters:	GAC filters are fed by gravity from the UF filtrate tank, and the numbers of filters in service is dependent on the treated water demand up to a maximum of 12 filters. The service filters are rotated so that no filter is in standby for an extended period. The filters are backwashed on a carousel basis with a high differential pressure

override. The flow through each of the filters is controlled by a flow regulating valve using feed forward control.

UV disinfection:	2 No. duty / standby UV systems provide disinfection of the GAC filtrate. The UVs are rotated so that no UV is in standby for an extended period. Light intensity and vessel pressure are continuously monitored, and lamp or sleeve failure will start the standby UV automatically.
Sodium Hypochlorite:	Dosing is controlled on feedback from flow and chlorine monitoring at both the inlet and outlet of the chlorine contact vessel. The dose is controlled using 3 term (PID) control to a manually adjusted set point.
Sodium Bisulphate:	Dosing is controlled on feedback from chlorine monitoring at the outlet of the chlorine contact vessel to trim the residual chlorine if required. The dose is controlled using 3 term (PID) control based on triple validation instrumentation for chlorine monitoring.
CO_2 and Caustic:	Caustic and CO_2 are dosed in combination after the UV and hypochlorite disinfection units to a control system derived set point. The control system target is to generally match the pH of Affinity Water's service reservoir's water and to maintain a Larson-Skold index of 0.9. The dosing of CO_2 and caustic is controlled on a feedback loop using 3 term (PID) control based on triple validation instrumentation for pH monitoring. Alkalinity adjustment to maintain Larson-Skold index of 0.9 will be by a manually adjusted setpoint.
Phosphoric acid:	Dosed after the hypochlorite contact tanks to a manually adjusted setpoint. Final treated water is monitored for pH, chlorine and turbidity by a triple validation instrumentation system. Water which is out of specification can be diverted to the run-to-waste system with the flow diverted until corrective action returns the water to specification.
DAF sludge:	Sludge settling tanks are filled 24 hours a day and the sludge is required to be stored in the tanks for at least 6 hours to allow for adequate settling. The tanks operate on a cycle with only one tank filling or emptying at one time.
Sludge thickener:	Sludge is thickened using two duty / standby volute thickeners which take settled sludge from the settled sludge tanks.

10.5 JAR TEST RESULTS

WSP, supported by Bath University, has carried out Jar Tests and Rapid Small Scale Column Tests.

Jar testing – to define best coagulant and pH adjustment requirements to maximise organic removal while keeping a low coagulant metals residual. The equipment set up is shown in Figure 10-3.

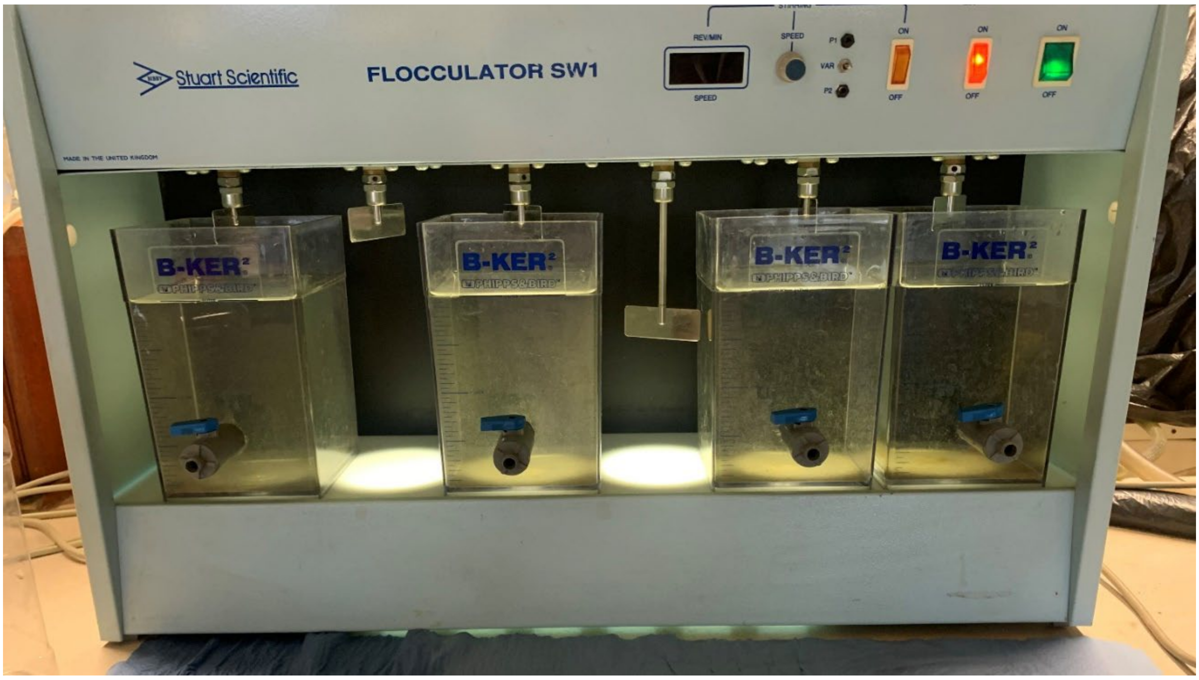


Figure 10-3 Photo of Jar Testing at Bath University

Raw water from Coventry Canal, near the proposed discharge location from Minworth, and from sampling Site 6, near to the originally proposed abstraction location for the southern WTW (near Leighton Buzzard) was tested using the coagulants shown in Table 10-2:

Coagulant	Active Component
Ferric Sulphate	44.8% $Fe_2(SO_4)_3$
High Basicity PACl	13% Al_2O_3
PACl	10.7% Al_2O_3
ACH	23.6% Al_2O_3

Table 10-2 Coagulant dosing rates

Turbidity results for the two raw waters, for different dose rates are shown in Figure 10-4 and Figure 10-5:

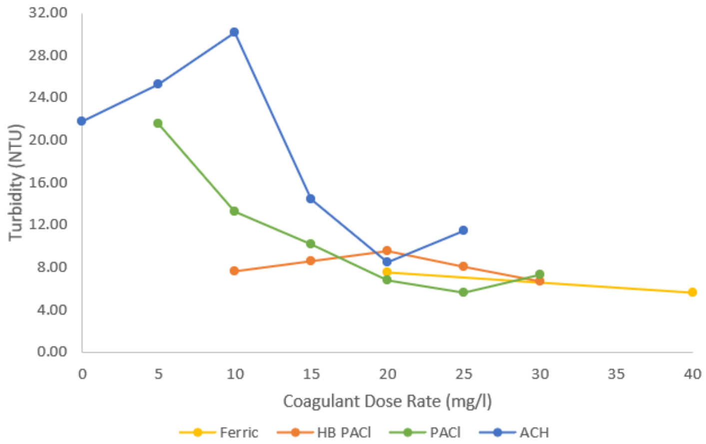


Figure 10-4 Final Turbidity using different coagulants on Coventry Canal samples

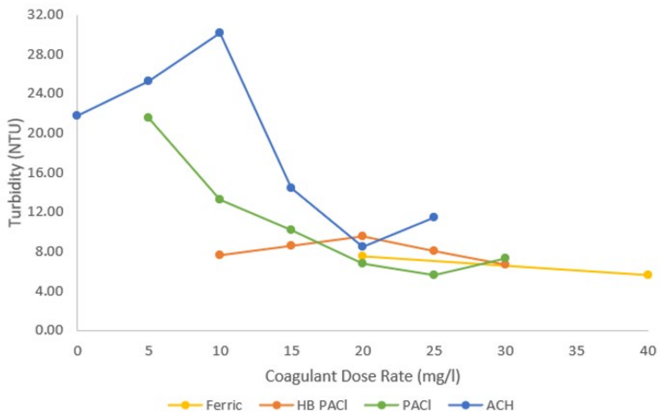


Figure 10-5 Final Turbidity using different coagulants on Site 6 samples

The series of tests concluded that ACH dosing would be the preferred process.

For detailed design of the clarification unit further analysis of the optimal coagulant, dose rate, and conditions is required. The selected dose rate for this set of experiments was on the lower end of the optimal range to ensure the process is likely to be economically feasible. Higher dose rates under different conditions may be economically viable and increase the efficacy of the treatment. The economic viability of this part of the process will also depend on the acid/caustic dosing requirements for the unit itself and downstream. It is likely that a dosing system will be required due to the pH variations in the feed, i.e., Site 6 raw water having a maximum measured raw water pH of 8.4, and Coventry Canal having a maximum measured raw water with a pH of 7.7.

The mixing, flocculation, and settling times, and mixing speed should also be optimised in the detailed design of the clarification unit. A longer flocculation time with a reduced mixing speed, i.e., 30 rpm instead of 60 rpm, may lead to more larger flocs forming and less likelihood of large flocs breaking up. In addition, increasing the settling time would be likely to improve the final turbidity and UVT results.

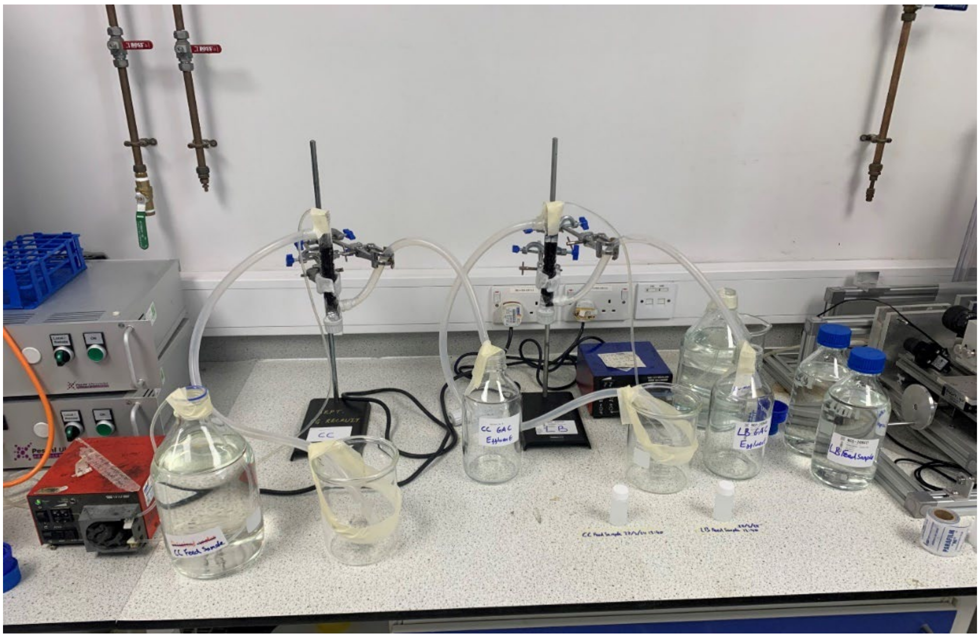


Figure 10-6 Photo of Rapid Small Scale Column Test at Bath University

Rapid Small Scale Column test (RSSCT) – to define number of bed volumes achievable before observing dissolved organic and PFAS breakthrough through an activated carbon bed. The equipment set up is shown in Figure 106:

The analytical protocol used a ten-compound standard to detect C4 to C10 PFCAs and C5 to C8 PFAS. These results showed that the post-GAC effluent water was below the detection limit, even after being spiked with PFOS and PFOA. As a result, plotting the saturation curves or breakthrough points was not possible.

Estimates were made of the number of Bed Volumes required at maximum flow before GAC would be exhausted and were found to be satisfactory.

10.6 PROCESS OPTIONS

Various process options were considered with the following processes potentially viable.

PWNT ILCA®/Ceramac®: This option uses in-line coagulation and adsorption (ILCA®) as an alternative to DAF units, followed by ceramic microfiltration membrane. Due to the inclusion of UV and sodium hypochlorite disinfection, microfiltration may be sufficient.

PWNT's ILCA® process, can amalgamate separate coagulation, flocculation, and clarification units, reducing plant footprint. It is implemented prior to PWNT ceramic ultrafiltration membranes where creating large and strong flocs is not as important as for other types of membranes. The ILCA® system can optimise the floc to enhance DOC removal and high-performance membrane filtration. This technology simplifies the pre-treatment of the raw feed upstream of the ceramic membranes by reducing the complexity of the overall process. The ILCA® system can use any commercially available coagulant, with short contact times and the appropriate level of mixing. Other advantages include minimal operating and maintenance costs, operated as gravity or pressure driven to fit the hydraulic profile, and a smaller footprint and operating cost compared to conventional clarifiers.

Nanostone: Nanostone ceramic membranes are modular and are similar in configuration to polymeric ultrafiltration systems. Nanostone ceramic membranes offers some as they have higher flux rates and therefore a reduced footprint. The membranes have a high inherent permeability while offering true ultrafiltration with 30nm nominal pore size.

Purifics: The Purifics system provide a small footprint zero liquid discharge solution by combining two of Purific products:

- DM54 Cuf® platform – combining the coagulation and ultrafiltration.
- D160 DeWRS® sludge treatment platform – providing sludge dewatering.

This option would consist of 14 No. DM54 Cuf ® Platforms which comprise a recirculating coagulation vessel which feeds a Silicon Carbide (SiC) UF system. The SiC membrane operates at a potential flux rate of 400lmh which helps reduces the overall footprint of the coagulation and UF plant to an area of approximately 30m x 50m. The UF system incorporates a hydraulic pulse cleaning system to maintain the high flux rate during normal service. The system is very efficient in the use of power and chemicals and operational plants in Canada operate at Can$0.02/m^3 (£0.012/m^3). This treatment option uses in-line coagulation and recirculation as an alternative to the DAF units.

As part of the sludge dewatering process, the system includes 14No D160 DeWRS® sludge treatment platforms. The D160 uses similar technology to the DM54 to produce a 25% DS cake and return any recovered water to the process so there is zero liquid discharge from the process. The D160 are compact and would also be located within the 50m x 30m area allocated to the DM54 Cuf ® Platforms.

10.7 AREAS FOR FUTURE ASSESSMENT

The proposed treatment routes should be validated prior to selection and implementation.

Factors to consider when selecting the optimal treatment process, include:

Land and space requirements. The selected site affects the space available for the treatment works, potentially meaning that a process route with fewer units would be required. Furthermore, the treatment works should not obstruct any views of existing residential homes or office spaces.

Economic viability. As the water quality information is revised and updated following further design development of Minworth AWTP and development of water quality modelling, the process design will be reviewed to validate or amend the process train, with an assessment of the financial and carbon costs for options to allow an economic viability assessment.

Pilot scale testing. This is particularly required to ensure the proposed treatment route can remove all contaminants to the required regulatory levels.

11. PIPELINES

11.1 INTRODUCTION

This section describes the various pipelines which are required for the options studied noting the design assumptions made. Design considerations have been reported on in technical notes which are included in Appendix I.

Access has not been made available for assessment of geotechnical or topographic detail so designs are based on publicly available information, and some site walkover assessments for part of the routes.

Gate 2 Pipeline Route Development

At the start of the Gate 3 studies Site F was selected as the preferred site for the treatment works and bankside storage reservoir. Four pipeline route options for delivering the treated water to Affinity Water's service reservoir near Luton were studied with routes 1 and 4 being deemed most viable and route 1 being preferred as being marginally shorter and with a lower peak elevation. The routes proposed at the time are shown in the Figure 111:

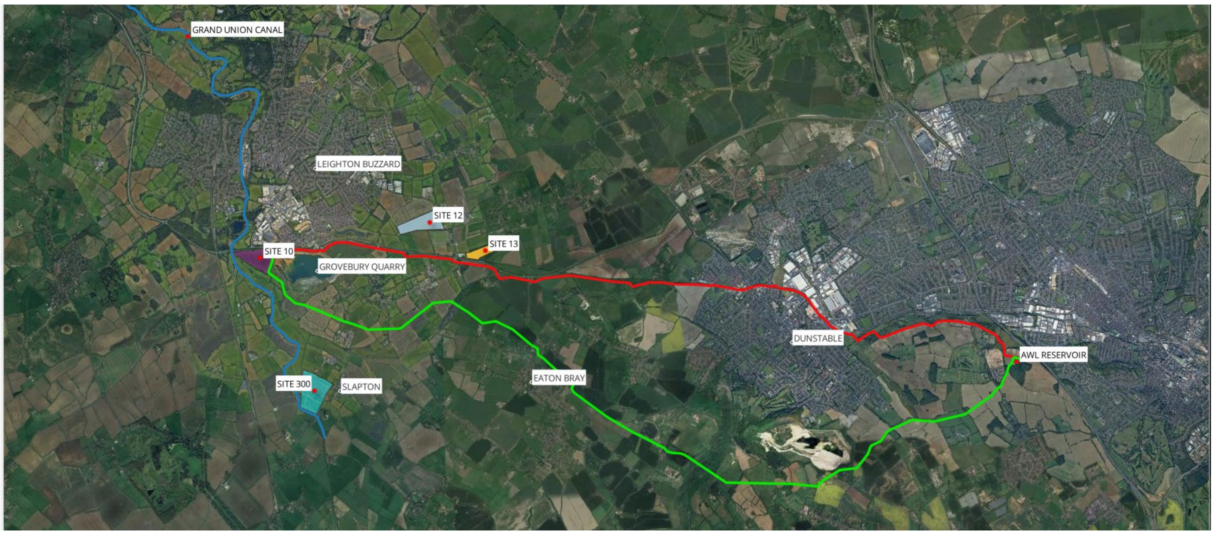


Figure 11-1. Candidate Routes from Site F to AfW Service Reservoir at Gate 2

During Gate 3 both route 1 and route 4 were reviewed and site walkovers made to assess the constructability of each route. It became clear that route 1, through the centre of Dunstable was likely to be very difficult to construct and to be very contentious. Much of the route would have to follow the Luton-Dunstable Guided Busway with severe disruption likely to operation of the system during construction. Access would also prove to be very hard in some locations with some pinch points and the need to use light construction equipment, which would add to the costs.

Route 4 was therefore also studied in more detail with a walkover and geotechnical appreciation using publicly available information. Much of the route would be in open countryside with the main obstacle being the escarpment of Dunstable Downs which rises to c 235m AOD. There are also some designated areas and a National Trust property which present some constraints to a consentable route. The proposed route makes the ascent of the Downs via a corridor which has no formal restrictions, and the design takes advantage of the ability to directionally drill the transfer pipelines up the escarpment without breaking ground except at the launch and reception pits. This technique avoids many issues of access and visual impact. Route 4 was therefore further developed, and line and long section drawings produced.

Gate 3 Pipeline Route Options

Following the decision to reject Site F near Leighton Buzzard for the treatment works additional route options have been reviewed and assessed. Part of route 4 remains the best option for approaching and ascending the Dunstable Downs and all of the new routes for transferring potable water from the various sites to Affinity Water's existing underground reservoir near Luton connect to this part of route 4 as shown in the discussions and Figures in the following sections of this report.

An initial assessment of the pipeline size has settled on twin [redacted] mm OD HDPE. This provides a reasonable compromise between the capital financial and carbon costs and operational energy and carbon costs. The operating philosophy is for the system to run at a low tickover flow for much of the year and it is essential to keep the retention time of the water down to a reasonable period. This indicates relatively small diameter pipelines. For the higher flow rates pipeline pressures, velocities and energy/carbon costs will be elevated for short periods and as the grid decarbonises the carbon penalty of the additional energy needed will reduce. When the final routes are selected a more detailed assessment will be made to test the optimal balance of capital financial and carbon costs and operational costs.

The route descriptions and outline design outputs are described in Table 11-1 for the various pipeline routes.

Pipeline Name	Start	End	Appx. Length	Pipe	P Stn Name
GUC-Site B Res	GUC – Pound 22-23	Site B Storage	850m	2 x 560OD	AbsSiteBLL
GUC-Site H Res	GUC – Pound 29-30	Site H Storage	750m	2 x 560OD	AbsSiteHLL
Site B Res-TW	Site B Storage	Site B TW Inlet	150m	2 x 560OD	SiteBRAFWL
Site H Res-TW	Site H Storage	Site H TW Inlet	150m	2 x 560OD	SiteHRAFWL
Site H Res-Site P	Site H Storage	Site P TW Inlet	4600m	2 x 560OD	SitePRawHL
Site H Res-Site Q	Site H Storage	Site Q TW Inlet	4200m	2 x 560OD	SiteQRawHL
Site B Potable	Site B WTW	AFW SR	29800m	2 x 560OD	Site B Potable/Site B Booster
Site H Potable	Site H WTW	AFW SR	16500m	2 x 560OD	Site H Potable
Site P Potable	Site P WTW	AFW SR	14750m	2 x 560OD	Site P Potable
Site Q Potable	Site Q WTW	AFW SR	13500m	2 x 560OD	Site Q Potable

Table 11-1 Characteristics of Treated Water Pipeline Route Options to AfW Service Reservoir

Desk based geotechnical appreciations of the possible pipeline routes have been made based on publicly available information. These are summarised in the Appendix E.

The ground conditions along the probable pipeline corridors generally consist of alluvium, Gault Clay, Woburn Sands, and Oxford Clay with some limited areas of harder sandstone. None of these materials appear to present any significant obstacles to pipeline trenching, directional drilling or other shallow tunnelled techniques. Similarly, there are no records of UXO and limited impact from any recorded groundwater.

Routes are therefore assumed to be in mainly competent, but not hard, ground but more detailed site-based and intrusive assessment of soils, groundwater, corrosivity, contamination or other factors which would make pipeline construction more onerous will be required in Gate 4. Currently the risks associated with such conditions are accounted for in the risk allowances from the risk register.

11.2 GUC- SITE B RES

This is the short pipeline route from the inlet weir on the GUC in pound nr 22-23 to the cascade inlet to the bankside storage at Site B (see Figure 11-2).

The pipeline is proposed as twin 560OD HDPE with thermal welded joints. Thrust blocks are unlikely to be needed due to welded joints and low pressures.

Author names redacted

Asset size redacted

Pipeline is c [redacted]m long starting at the wet well outlet from the inlet weir and terminating at the storage inlet structure which will have a free, uncontrolled overflow cascade into the reservoir. The pipelines will cross under the river Ouzel from the inlet weir wet well using directional drilling or similar, will enter the low-lift abstraction pumping station (AbsSiteBLL) wet well via the band screens.

The pumping station will be the same size and layout as the bypass pumping stations as the duty (flow rates and head) is similar.

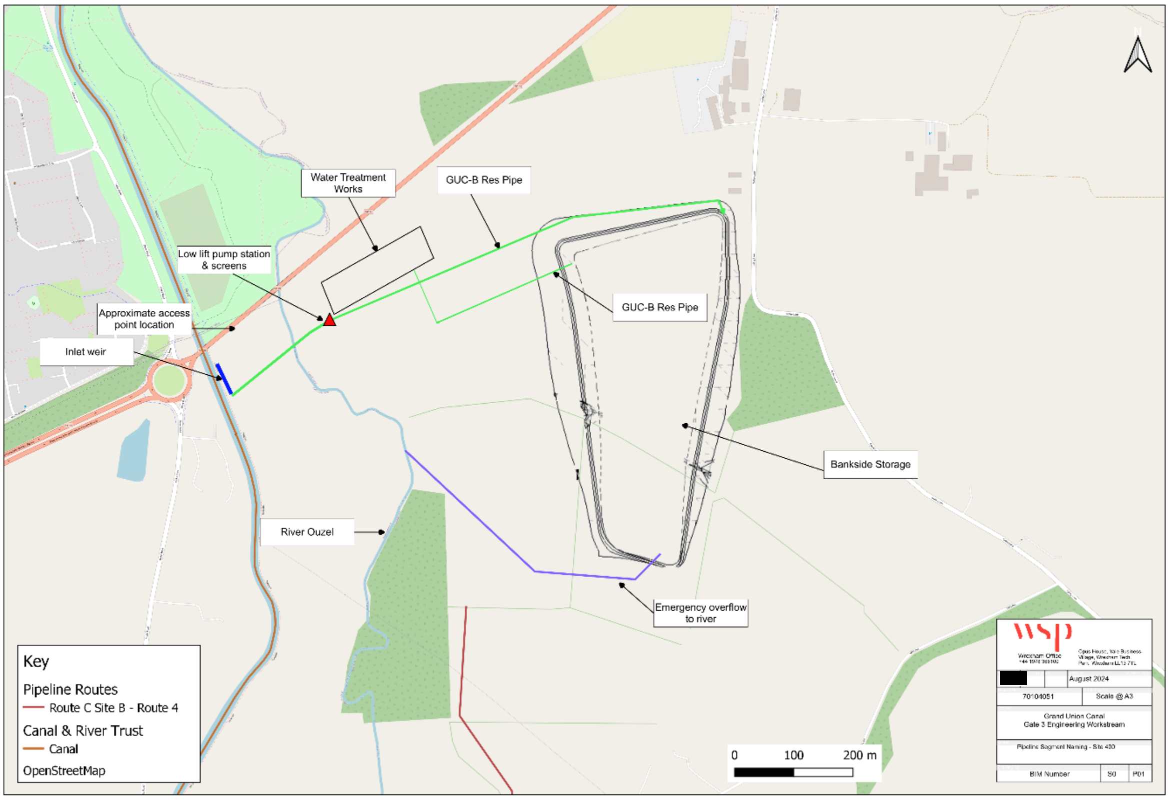


Figure 11-2 Pipeline Segment Naming - Site B

11.3 GUC-SITE H RES

This is the short pipeline route from the inlet weir on the GUC in pound nr 29-30 to the cascade inlet to the bankside storage at Site H (see Figure 11-3).

The pipeline is proposed as twin 560OD HDPE with thermal welded joints. Thrust blocks are unlikely to be needed due to welded joints and low pressures.

Pipeline is c 850m long starting at the wet well outlet from the inlet weir and terminating at the storage inlet structure which will have a free, uncontrolled overflow cascade into the reservoir. The pipelines will cross under the river Ouzel from the inlet weir wet well using directional drilling or similar, will enter the low-lift abstraction pumping station (AbsSiteBLL) wet well via the band screens.

The pumping station will be the same layout as the bypass pumping stations as the duty (flow rates and head) is similar.

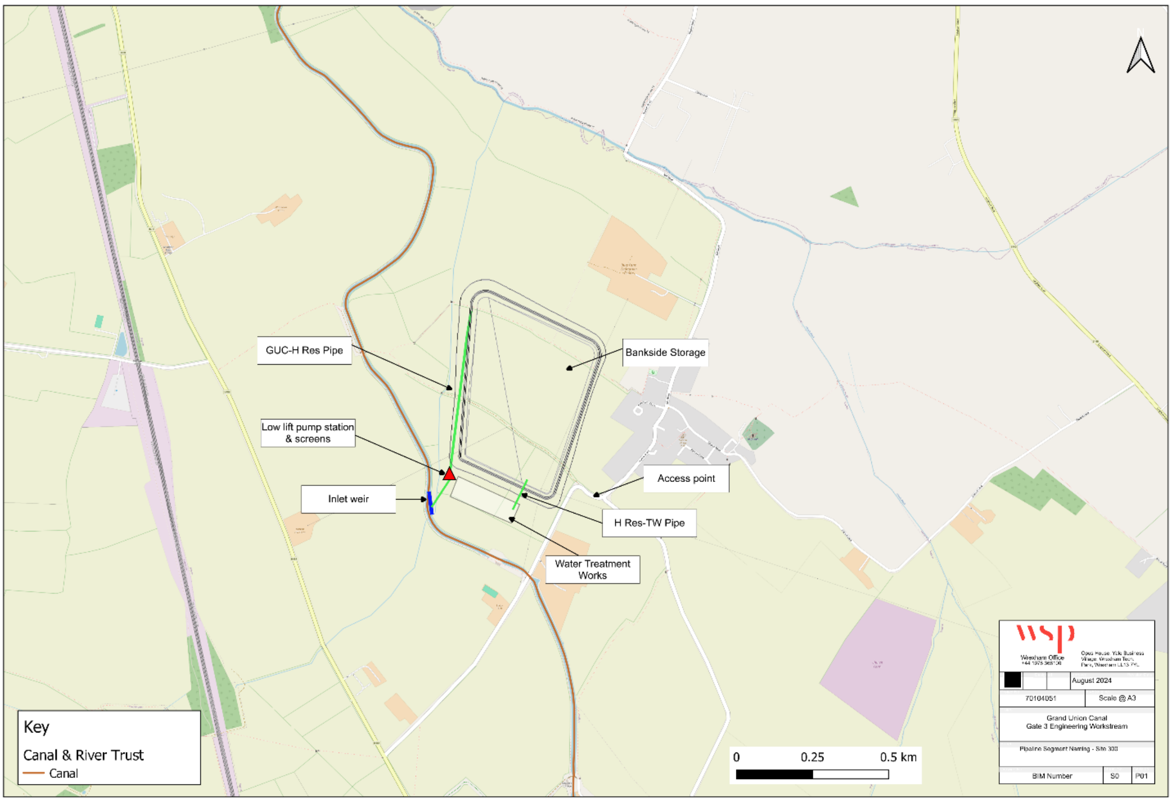


Figure 11-3 Pipeline Segment Naming - Site H

11.4 SITE B RES-TW

This is the short pipeline which transfers the water from the bankside storage, via the reservoir outlet structure to the inlet of the treatment works. See Figure 112 for the nominal location of the pipeline.

The pipeline is proposed as twin 560OD HDPE with thermal welded joints. Thrust blocks are unlikely to be needed due to welded joints and low pressures.

Generally, the flow will be by gravity unless the reservoir is substantially drawn down during a period when the canal transfer is interrupted, in which case a low lift pumping station (SiteBRAFWL) will boost the flow to the inlet.

Since the duty of the pumping station is similar to that of a bypass pumping station, the size and layout of this low lift pumping station will be the same.

11.5 SITE H RES-TW

This is the short pipeline which transfers the water from the bankside storage, from the reservoir outlet structure to the inlet of the treatment works. See Figure 11-3 for the nominal location of the pipeline.

The pipeline is proposed as twin 560OD HDPE with thermal welded joints. Thrust blocks are unlikely to be needed due to welded joints and low pressures.

Asset size redacted

Generally, the flow will be by gravity unless the reservoir is substantially drawn down during a period when the canal transfer is interrupted, in which case a low lift pumping station (Site HRAFWL) will boost the flow to the inlet.

Since the duty of the pumping station is similar to that of a bypass pumping station, the size and layout of this low lift pumping station will be the same.

11.6 SITE H RES-SITE P

This pipeline is c 5000m long and delivers raw water from Site H bankside storage reservoir to the inlet of the treatment works at Site P (see Figure 114).

The pipeline is proposed as twin 560OD HDPE with thermal welded joints. Thrust blocks are unlikely to be needed due to welded joints and low pressures.

A pumping station (SitePRawHL) will boost from the reservoir to the higher elevation site. The elevation difference is c 20m so the pumping station will have a relatively low lift (>40m at maximum flow), and the layout of the pumping station will be similar to the other raw water pumping stations.

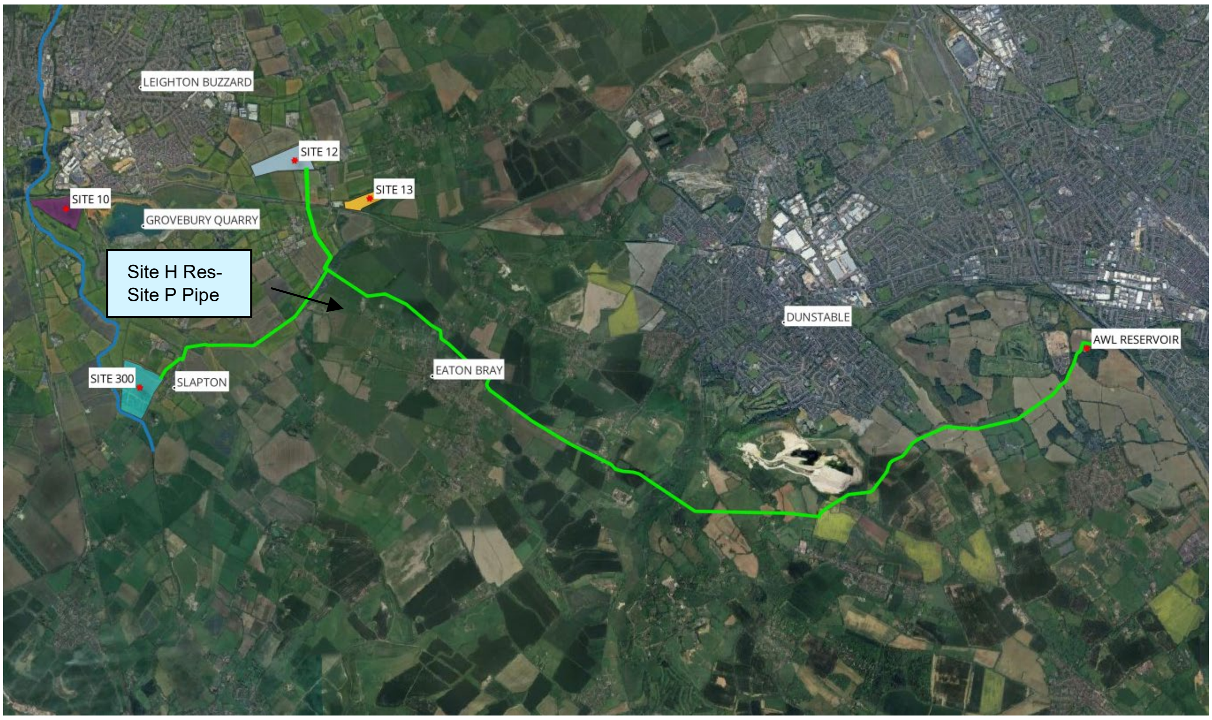


Figure 11-4 Pipeline Segment Naming - Site H/Site P

11.7 SITE H RES-SITE Q

This pipeline is c 5250m long and delivers raw water from Site H bankside storage reservoir to the inlet of the treatment works at Site Q (see Figure 11-5).

The pipeline is proposed as twin 560OD HDPE with thermal welded joints. Thrust blocks are unlikely to be needed due to welded joints and low pressures.

A pumping station (SiteQRawHL) will boost from the reservoir to the higher elevation site. The elevation difference is c [redacted]m so the pumping station will have a relatively low lift (>40m at maximum flow), and the layout of the pumping station will be similar to the other raw water pumping stations.

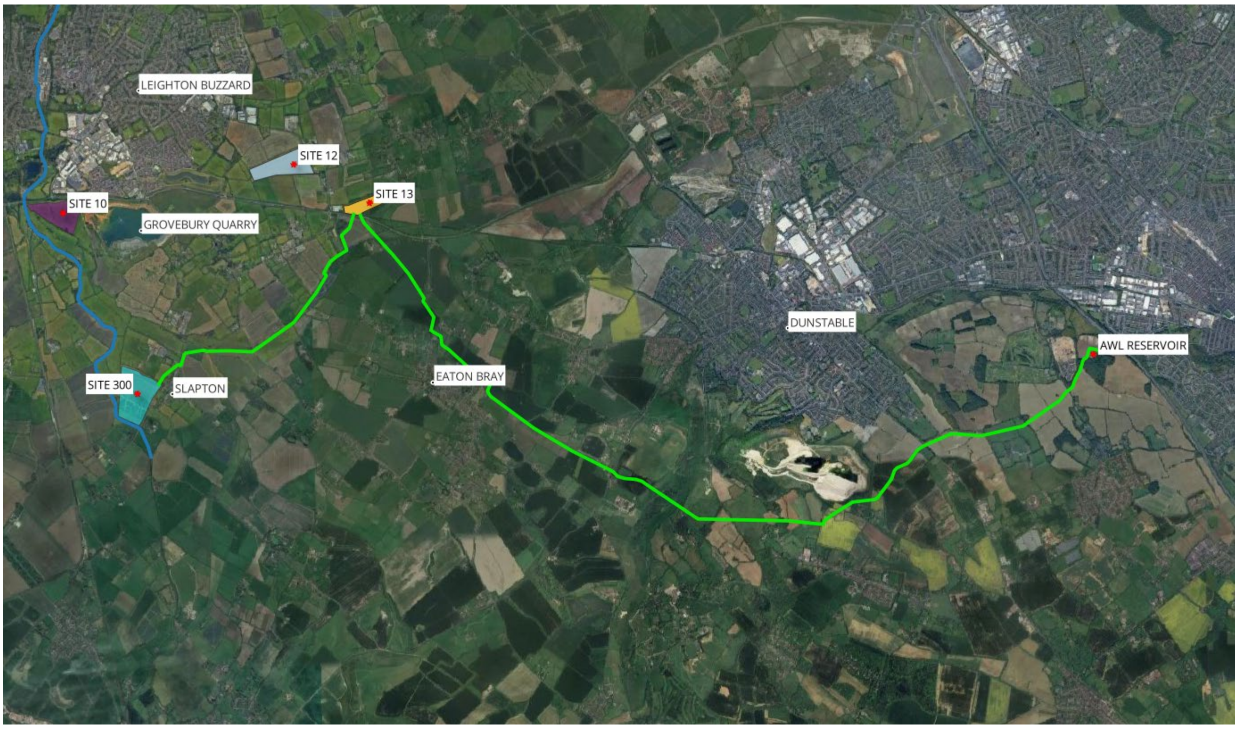


Figure 11-5 Pipeline Segment Naming - Site H/Site Q

11.8 SITE B POTABLE

This pipeline, shown on Figure 11-6 is the green line segment from Site B to the Affinity Water service reservoir.

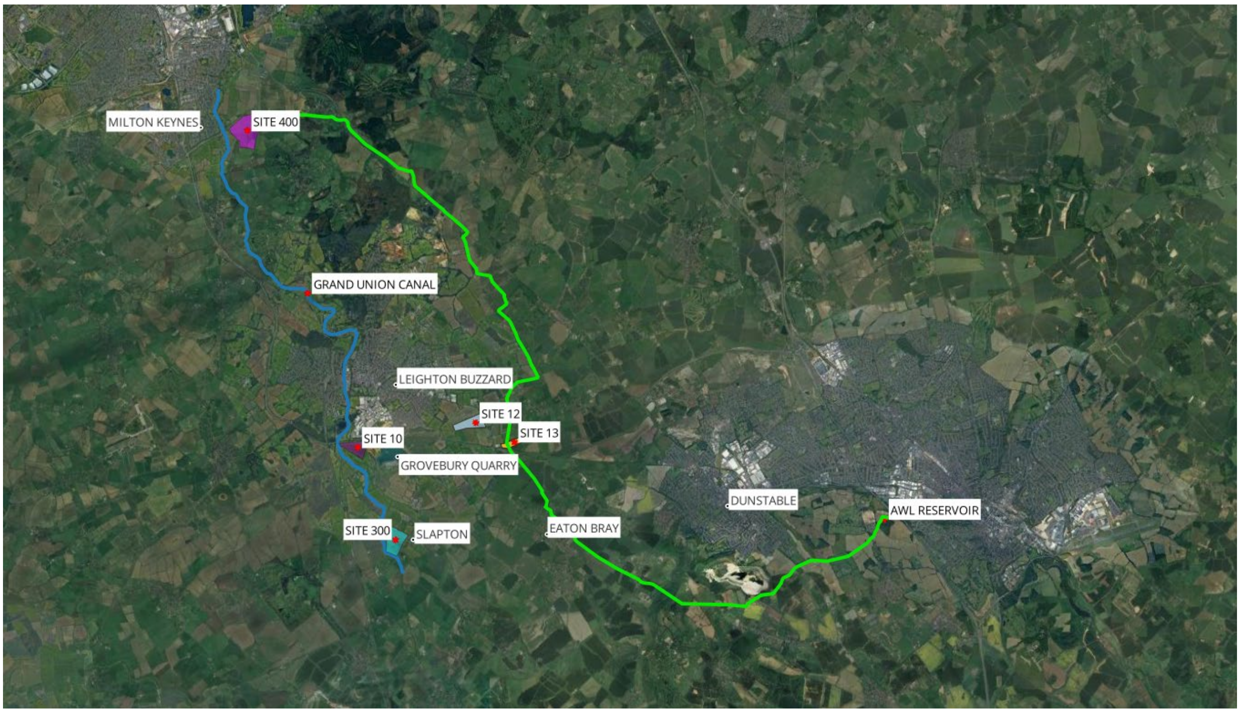


Figure 11-6 Pipeline Segment Naming - Site B to the Affinity Water Service Reservoir

Figure 11-7 shows the ground profile of the currently preferred route from Site B to the Affinity Water service reservoir.

Asset size redacted

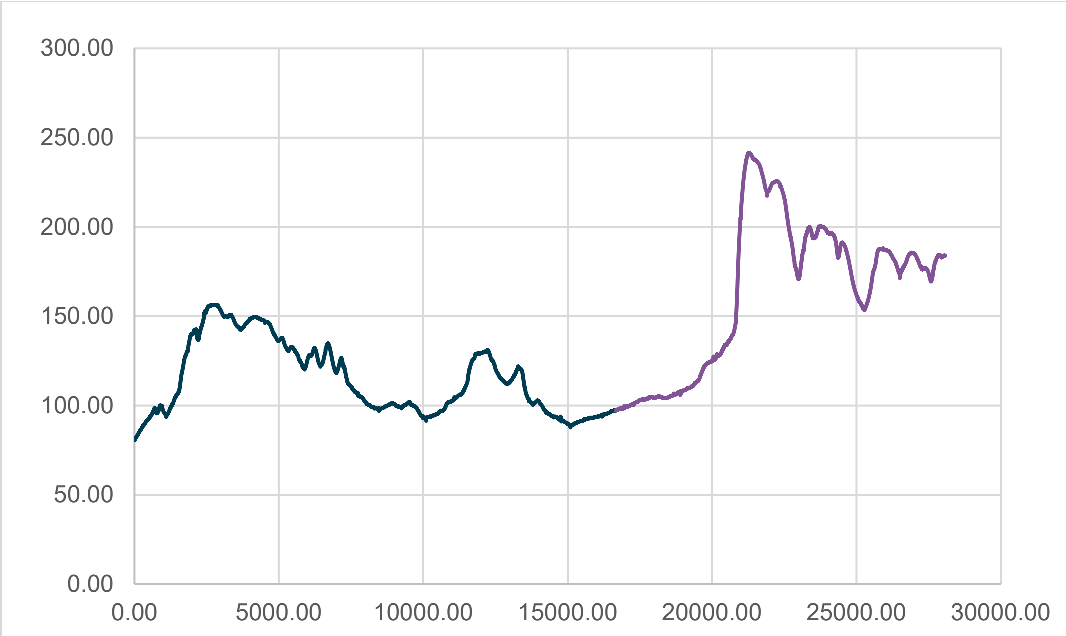


Figure 11-7 Typical Ground Profile for Route Option Site B Potable

The pipeline route is [redacted]m in total length and will be laid in twin 560OD HDPE or similar. The ground rises immediately from Site B until it reaches the A5 near Little Brickhall. The route then follows the A5, with the ground elevation dropping gently, and the route switches from the east to west side of the A5 to avoid designated sites and then heads approximately SSE towards Eggington to the east of Leighton Buzzard. In the vicinity of Site P, a booster pumping station will be required to ensure that the flow can be lifted over the Dunstable Downs which rise to c235m ASL. Site P has sufficient space for a small booster station and a break tank if necessary, is close to grid power and to a drainage system which can accept waste flows from the pumped system once dechlorinated. Beyond the crest of the downs the ground slopes back down to around 180m ASL. The pipes will be directionally drilled up the Dunstable Downs scarp to avoid affecting the designated sites and National Trust land holdings.

For the directional drill a launch site and a reception site will be needed. These have been provisionally located from the site walkover as below.

11.9 SITE H POTABLE

This pipeline, shown in Figure 11-8 is the light green line segment from Site H to the Affinity Water service reservoir near Luton.

The pipeline route is [redacted]m in length and will be laid in twin 560OD HDPE or similar. The ground rises relatively steadily from Site H until just southeast of Eaton Bray when the profile is dominated by the Dunstable Downs which rise to c235m ASL. Beyond the crest of the downs the ground slopes back down to around 180m ASL. The pipes will be directionally drilled up the Dunstable Downs scarp to avoid affecting the designated sites and National Trust land holdings.

Figure 11-8 Current Possible Route Corridor for Pipeline Site H Potable from Site B to AfW Service Reservoir

11.10 SITE P POTABLE

This pipeline, shown on Figure 11-9 is the light blue line segment from Site P to the AfW service reservoir.

Figure 11-9 Current Possible Route Corridor for Pipeline Site P Potable from Site P to AfW Service Reservoir

The pipeline route is c[redacted]m in length and will be laid in twin 560OD HDPE or similar. The ground rises relatively steadily from Site Q until just southeast of Eaton Bray when the profile is dominated by the Dunstable Downs which rise to c235m ASL. Beyond the crest of the downs the ground slopes back down to around 180m ASL. The pipes will be directionally drilled up the Dunstable Downs scarp to avoid affecting the designated sites and National Trust land holdings.

11.11 SITE Q POTABLE

This pipeline, shown on Figure 11-10 is the green line segment from Site Q to the AfW service reservoir.

Figure 11-10 Current Possible Route Corridor for Pipeline Site Q Potable from Site Q to AfW Service Reservoir

The pipeline route is [redacted]m in length and will be laid in twin 560OD HDPE or similar. The ground rises relatively steadily from Site P until just southeast of Eaton Bray when the profile is dominated by the Dunstable Downs which rise to c235m ASL. Beyond the crest of the downs the ground slopes back down to around 180m ASL. The pipes will be directionally drilled up the Dunstable Downs scarp to avoid affecting the designated sites and National Trust land holdings.

12. CONSTRUCTION PROGRAMME

12.1 INTRODUCTION

Whilst the final scheme layout is still to be confirmed following non-statutory consultation there are a number of options which remain under consideration.

Therefore, a detailed programme, with input from the ECI Contractor, has not been attempted and we have relied upon our Gate 2 assumptions for rates of progress, with durations of activities modified to the extent that the design has evolved since then.

There are many elements common to each option and our assumptions about construction rates are common for each of these. Therefore, our approach to developing an outline programme has been to develop construction durations for each of the work sections and to compare overall programmes for the different works to assess where any significant time differences related to the scopes of work lie.

12.2 WORK ELEMENTS FOR EACH OPTION

Table 121 outlines the work elements for each of the current candidate options are shown. The work elements are colour-coded as follows:

Green	These are common elements with identical construction durations.
Yellow	These have marginal differences which may not affect the overall duration.
Red	These have notable differences which may affect the overall duration.

Option Name	Site B	Site H	Site H/Site P	Site H/Site Q
Description	Abstraction just south of Milton Keynes, storage reservoir and treatment works at Site B, high lift pumping station, potable water pipeline to AfW service reservoir near Luton, booster station at Site Q.	Abstraction just south of Leighton Buzzard, storage reservoir and treatment works at Site H, high lift pumping station, potable water pipeline to AfW service reservoir near Luton.	Abstraction just south of Leighton Buzzard, storage reservoir at Site H, high lift pumping station to Site P, treatment works at Site P, high lift pumping station at Site P, potable water pipeline to AfW service reservoir near Luton	Abstraction just south of Leighton Buzzard, storage reservoir at Site H, high lift pumping station to Site P, treatment works at Site P, high lift pumping station at Site P, potable water pipeline to AfW service
Discharge at Atherstone	Common Item	Common Item	Common Item	Common Item
Gravity Bypasses	Common Item c2km of pipeline	Common Item c2km of pipeline	Common Item c2km of pipeline	Common Item c2km of pipeline
Pumped Bypasses	5 nr c4300m of pipeline 3 x low power PStn 2 x large power PStns	8Nr c4700m of pipeline 6 x low power PStn 2 x large power PStns	8Nr c4700m of pipeline 6 x low power PStn 2 x large power PStns	8Nr c4700m of pipeline 6 x low power PStn 2 x large power PStns
Canal Raising Works	Common Item c104km	Common Item c104km	Common Item c104km	Common Item c104km
Daventry and Drayton Works	Common Item c3500m pipeline New Daventry Outlet Mods to inlet Mods to outlet to GUC	Common Item c3500m pipeline New Daventry Outlet Mods to inlet Mods to outlet to GUC	Common Item c3500m pipeline New Daventry Outlet Mods to inlet Mods to outlet to GUC	Common Item c3500m pipeline New Daventry Outlet Mods to inlet Mods to outlet to GUC
Abstraction	Common Item Inlet structure Low lift PStn Screen structure Pipelines <1km	Common Item Inlet structure Low lift PStn Screen structure Pipelines <1km	Common Item Inlet structure Low lift PStn Screen structure Pipelines <1km	Common Item Inlet structure Low lift PStn Screen structure Pipelines <1km

Option Name	Site B	Site H	Site H/Site P	Site H/Site Q
Bank Side Storage	575Ml earth bank Spillway Spill drain (<1km) Waste drain (<1km) Booster Stn Pipelines (<0.5km)	575Ml earth bank Spillway Spill drain (<1km) Waste drain (<1km) Booster Stn Pipelines (<0.5km)	575Ml earth bank Spillway Spill drain (<1km) Waste drain (<1km) High Lift PStn Pipelines (4.6km)	575Ml earth bank Spillway Spill drain (<1km) Waste drain (<1km) High Lift PStn Pipelines (4.2km)
Treatment Works	c 2ha plant SUTW (<1km) Effluent pipe	c 2ha plant SUTW (<1km) Effluent pipe	c 2ha plant SUTW (2.5km) Effluent pipe	c 2ha plant SUTW (2.5km) Effluent pipe
Potable Water Delivery	High Lift PStn Booster PStn Pipeline (c30km)	High Lift PStn Pipeline (c16.5km)	High Lift PStn Pipeline (c14.8km)	High Lift PStn Pipeline (c13.5km)

Table 12-1 Construction Elements of Each Option

ASSUMED RATES OF PROGRESS FOR CONSTRUCTION

Atherstone Discharge Structure

The construction period for this structure will be primarily affected by the access to the site for material deliveries and the location of the contractor's area. Access for either location still under consideration will be challenging.

If the site in town is selected a contractor area outside of the residential area will probably be required as there is limited space at the site itself. Therefore, materials deliveries from the contractor area to the works site will need to be carefully managed if the residential street is to be used; some deliveries by canal may be indicated subject to windows of availability on the canal.

If the site to the south is selected there may be more space temporarily available local to the discharge structure but access will either be shared with the contractor laying the Minworth – Atherstone pipeline or will need creating, maintaining and making good through the residential area. For the purposes of planning, it is assumed that sharing the access with the pipeline contractor will be manageable through programming of the activities of the two contractors so as not to cause conflict, since neither of these two work elements will be on the critical path for the project as a whole.

A duration of 15 months has been assumed from letting the contract to wet commissioning. There may need to be a separate system commissioning later to align with availability of water from the Minworth AWTP and system storage for the GUC SRO.

The construction period will need review by the ECI once the preferred site is selected.

Canal Bank Raising

If the canal bank raising extends for over 100km it is likely to be the works element that defines the overall programme for construction and therefore getting a clear agreement on the amount of bank raising that is essential is critical.

The current “worst case” based on the Hydraulics Consultant’s latest model and available topographical survey of the banks and towpath requires in excess of 100km of bank raising with increases in height of between 50mm and 500mm.

The Trust has confirmed that there may be significant periods when it will not be possible to work on the canal banks or towpath to avoid affecting birds nesting, other wildlife impacts, and the need to provide its network for navigation by boaters and towpath users, as well as ensuring compatibility with other works undertaken by or contracted by the Trust.

The current assumption is that a production rate during the work periods available may be sustained at an average of 80m/day. To sustain this rate, several teams working at different locations along the canal will be required, with careful logistics to ensure that, where the canal is to be blocked for any time, the number of working hours by appropriate teams can be optimised along with the logistics to support them.

Our current proposals assume:

- multiple local contractors familiar with canal access and techniques.
- mobile welfare only, no permanent site set-up except for hub centres for major deliveries and storage.
- small deliveries and small plant.
- multiple existing access points.
- the canal is available for transport of materials, floating welfare and removal of waste.

These assumptions must be tested by the ECI Contractor when it has been agreed how much bank raising will be needed and the locations. Even at a rate of 80m/day, it will take over 5 years to cover 100km of raising. Prior to any work at each selected location access arrangements will need to have been secured and agreements with riparian owners as to the style and finish of any works that obtrude into their land.

Treatment Works at the Southern End of the GUC SRO

The treatment works is proposed to be located at any one of the 4 current candidate sites (Site B, Site H, Site P or Site Q).

All the candidate sites are understood from the desk-based studies to be geologically benign, with material which is capable of safe excavation, of sufficient strength to allow most of the treatment works process units to be erected on pad foundations without the need for piling, low risk of contamination and with low risk of groundwater or surface water affecting works.

The main differences between the sites as regards construction programme of the treatment works are outlined in Table 12-2:

	Site B	Site H	Site P	Site Q
Access	Ready access off an A road	Access needs upgrading to avoid local conflicts	Ready access close to an A road	Ready access close to an A road
Laydown Area	Candidate site is large and sufficient	Candidate site will be quite tight	Candidate site is sufficient	Candidate site is sufficient
Utilities Conflicts	HP Gas main crosses north of site	2nr HV power lines cross the site	None noted	None noted
Flooding Risk	Low surface/river flood risks	Low surface/river flood risks	Low surface/river flood risks	Low surface/river flood risks
Power Supply	Close to urban centre	Rural location	Close to urban centre	Close to urban centre
Interference with other contractors	Site is sufficiently large to cater for reservoir and treatment works contractor	Site is restricted and will need careful management	Site is sufficiently large (to cater for treatment works contractor only).	Site is sufficiently large (to cater treatment works contractor only).
Raw Water Pipelines	Short delivery pipeline, low lift pump station	Short delivery pipeline, low lift pump station	>3.5km delivery pipeline, high lift pump station	>3.5km delivery pipeline, high lift pump station

Table 12-2 Difference in Treatment Work Sites

The construction of the treatment works is estimated at 30 months to completion of wet commissioning with the probable need for a system commissioning period following wet commissioning. The period allowed is relatively generous and the access and laydown areas for Site H are not considered to significantly affect the overall programme.

The additional pipelines and booster stations required for Sites P and Q can be constructed in parallel to the other works and need not increase the overall programme for construction for these sites.

Daventry and Drayton Works

With the exception of the pumping station at the canal side of Braunston Lock 1 none of the works for Daventry and Drayton interfere with any of the other planned works for GUC SRO.

The constraints to programme are therefore relatively loose with the need only to have the works available for the overall system commissioning.

These works should take around 18-20 months allowing for mobilisation, pipeline installation, reservoir works outlet works and wet commissioning and thus need not be on the critical path.

Bankside Storage

The earthworks for creating the embankment will be the primary driver of the construction of the bankside storage.

Both of the current candidate sites are understood from the desk-based studies to be geologically benign, with material which can be excavated and placed with large earthmoving equipment, low risk of contamination and with low risk of groundwater or surface water affecting works.

Other principal aspects of the work will be the:

- laying and testing of the geomembrane liner and its protective layers.
- construction of the inlet works which will be built over the embankment.
- construction of the offtake/valve tower and culvert under the embankment.
- installation and testing of the pipework, valves and controls in the offtake tower/culvert.
- construction of the spillway over the embankment and the spilled water conveyance to the neighbouring water body.
- landscaping and restoration.

The main construction steps will be:

- Site set-up/mobilisation 3 months
- Topsoil strip and storage for re-use 2 months
- Bulk excavation for reservoir pit 8 months
- Foundation treatment for embankment area 4 months
- Installation of inlet, outlet and overflow structures 8 months
- Bulk laying and compaction of fill for embankments 15 months
- Reservoir base preparation including trimming, base material, installation of any underdrainage/leakage monitoring systems 6 months
- Reservoir lining installation including joint sealing, joint testing, laying of protection 6 months
- Embankment trimming, shaping and landscaping 4 months
- Ancillaries including fencing, access roads, access control, measurement and control/metering chambers and communications systems, power supplies. 8 months.

Given the size of the site many of these activities will run concurrently with an overall estimated construction period of 30 months to a stage where the reservoir would be ready for filling. Activities such as the ancillaries can be installed during pre-filling and filling activities.

Pipelines

Progress assumptions for large diameter pipelines are:

- Assume first delivery 12 weeks after order.
- Pipes are [redacted] m long.
- For [redacted] mm pipes a maximum of 4 pipes can be delivered by standard HGV.
- Assumed productivity is 60m per day using two teams.

Thus, the contractor would need:

- 3 deliveries per day.
- 300 productive days.
- Additional time is required for major crossings.
- Additional time for testing and commissioning.
- Additional time for enabling works at multiple locations.

- Lost days to bad weather.
- Shutdown at Christmas and Easter.
- Five day working week.

These assumptions have been used in developing outline construction programmes for the various pipelines and pipeline options.

Gravity Bypasses

Gravity bypasses are intended to be [redacted]mm diameter with inlet/outlet structures and intermediate manholes as required by the pipe route. In general, it is assumed that the installation time for a bypass will be dominated by the construction and fitting out of the inlet and outlet structures.

These will require shutting down the towpath locally, and a major excavation partially obstructing the canal. Careful planning of these works will be required to minimise disruption to canal and towpath users, avoid affecting bird nesting and other wildlife impacts as well as ensuring compatibility with other works undertaken by or contracted by the Trust as well as the need to keep the canal open for navigation as much as possible. Recent works undertaken on behalf of the Trust for canal bank repairs required mobilisation and re-mobilisation to avoid such periods.

The estimated time for installation of each pair of inlet/outlet structures is 12 months allowing for interruption of the work during high traffic periods and other environmental requirements.

Installation of the bypasses would need to be staggered rather than purely sequential so that the proposed overall duration would be:

For Site B option (8 bypasses)	48 months assuming two teams operating
For Site H option (8 bypasses)	48 months assuming two teams operating

Bypass Pumping Stations

From the Gate 2 work we have assumed 8-10 months for construction of the stations and pipelines, installation of MEICA equipment.

Wet commissioning can take place immediately in completion subject to provision of the electricity supply, with final system commissioning possible when the discharge structure at Atherstone and the Minworth AWTP supply are available.

Subject to agreement from the Environment Agency to allow transferred water to be discharged to the environment the canal transfer pumping system commission would be possible even if the treatment works at the southern end of the GUC SRO and associated systems for accepting the water into AfW's network are not yet commissioned. Otherwise, system commissioning would need to wait.

Installation of the pumping stations would need to be staggered rather than purely sequential so that the proposed overall duration would be:

For Site B option (3* stations)	28 months assuming one team operating.
For Site H option (8* stations)	42 months assuming two teams operating.

*Excludes Braunston, included in Daventry & Drayton construction works above.

Potable Water Delivery

Each of the currently proposed potable water delivery systems comprises:

- High lift pumping station
- Directional drill up the Dunstable Downs
- Potable transfer pipeline – between [redacted] km and [redacted] km
- Booster station for the route from Site B

The construction programme for each option will differ only in the duration of construction of the delivery pipelines; the directional drill and the additional booster station will be undertaken in parallel with the pipeline installation.

On the assumption that all contracts will be implemented using the same number of pipeline teams the difference in programme duration will largely lie in the additional length of pipe to be installed.

Using the above assumptions the estimated durations for each route are:

- Site B Potable 52 months
- Site H Potable 30 months
- Site P Potable* 27 months
- Site Q Potable* 26 months

*Raw water transfer from Site H constructed in parallel reduces total programme when compared to Site H only.

12.3 CONSTRUCTION PROGRAMME

Main risks to programme:

- Procurement of long lead items – specifically large valves, MCCs, power supplies, specialist process units etc.
- Pipeline logistics – specifically time between first order and first delivery to site and then sufficient weekly/monthly deliveries to maintain programme.
- Identifying and procuring suitable quantities of material for bank raising.
- Existing Trust contract and Charter constraints on towpath closures (e.g. fibre optic cables, access for public, private & rented mooring use etc.)
- Ground conditions – will need to be assessed in detail following survey results.
- Identifying suitable temporary storage and disposal routes for excavated material – especially contaminated material (no GI yet to confirm volumes) and any large volumes required for the raw water storage. Currently layout on candidate sites is based on balanced cut & fill but the programme would be significantly increased if significant disposal off site is required.
- Commissioning of the WTW – Minworth water will be available from October 2031. Assuming the canal sections are commissioned quickly and the storage is filled before the end of 2031, wet commissioning of the WTW can commence in early 2033. The duration of commissioning will depend on the WQ (to be reviewed in Gate 4 as current design based on Site F sampling), availability of suitable disposal of commissioning water etc.
- Works that could require the canal to be closed can currently only be undertaken during the Trust's winter works period – generally between November and March, and in accordance with the Trust's through routes protocols and Christmas opening requirements, which may further restrict available working

windows. Works that require the canal to be restricted but still open to navigation, could be undertaken outside the November to March period.
- Environmental protest or legal challenges during construction that adversely affect project delivery and/or programme.

Main assumptions:

- Contractor has a month (month zero on the programme) for mobilisation and design start.
- Canal work will start in month 1 to set up the temporary works required to access the sites (e.g. site access, compounds etc.) – access routes agreed at DCO/Planning stage.
- Canal bank work is based on the Trust standard details and construction specifications therefore assumed minimal contractor design required before work commences.
- Power supply connections and network capacity has been reserved separately to construction programme.
- Raw water storage layout and work at Drayton and Daventry reservoirs has already been accepted by the QCE under the Reservoir Act requirements (subject to contractor design change proposals).
- Contractual terms with the Trust and other landowners for land purchase are agreed in a timely manner and there are no issues following GI, environmental, topographical, UXO, utility, or heritage surveys.
- No environmental protest/legal challenges during construction.
- No environmental constraints to programme included – e.g. relocation/exclusion period for newts, water voles, badgers, bats etc.

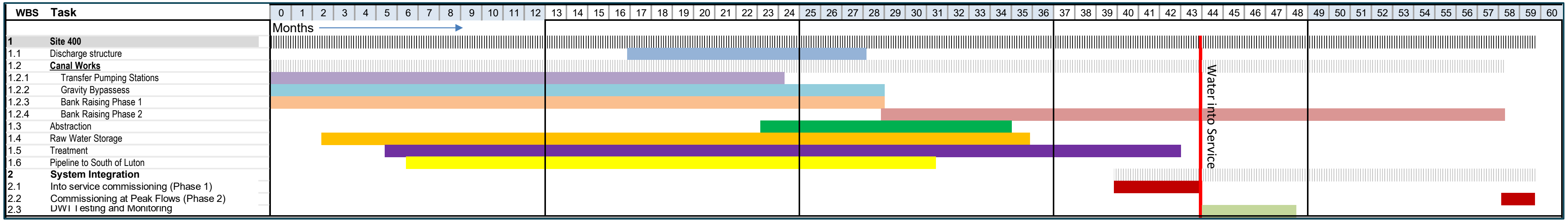


Figure 12-1 Site B Construction Programme

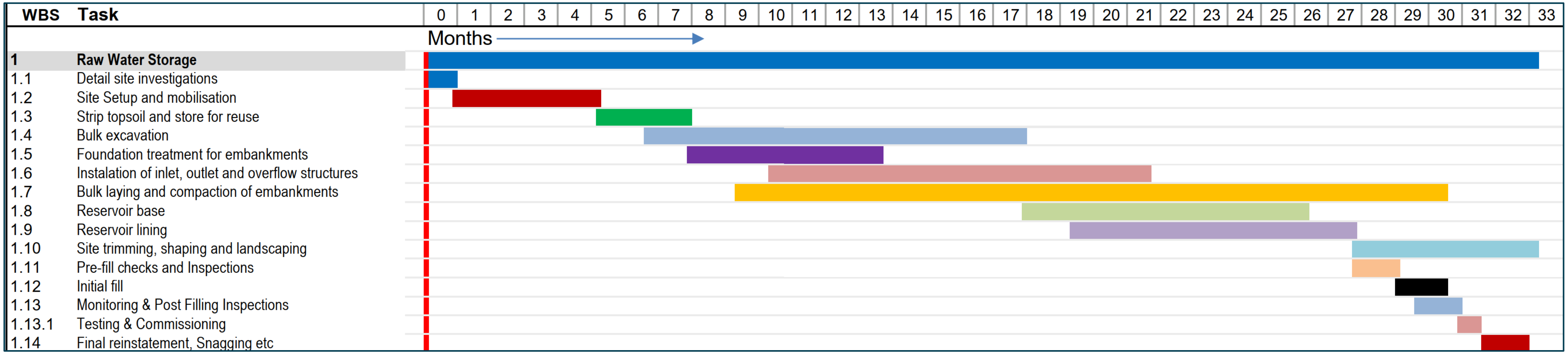


Figure 12-2 Raw Water Storage Programme

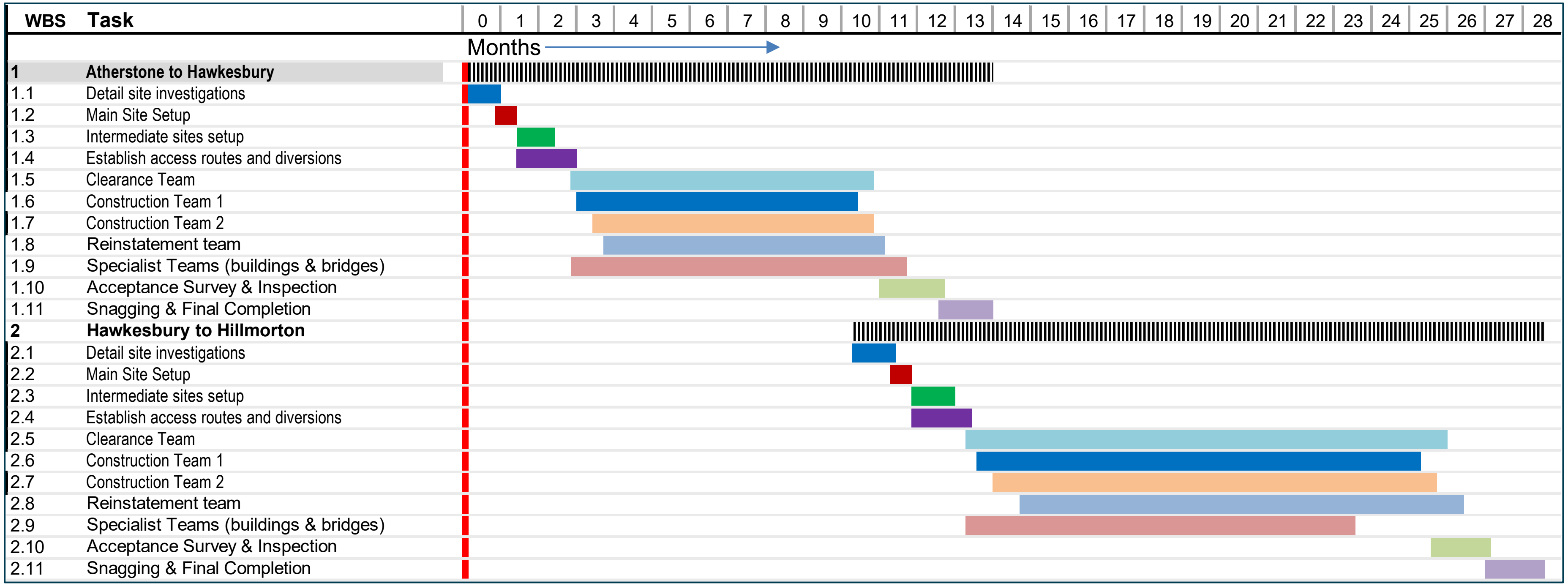


Table 12-3 Canal Bank Raising Phase 1

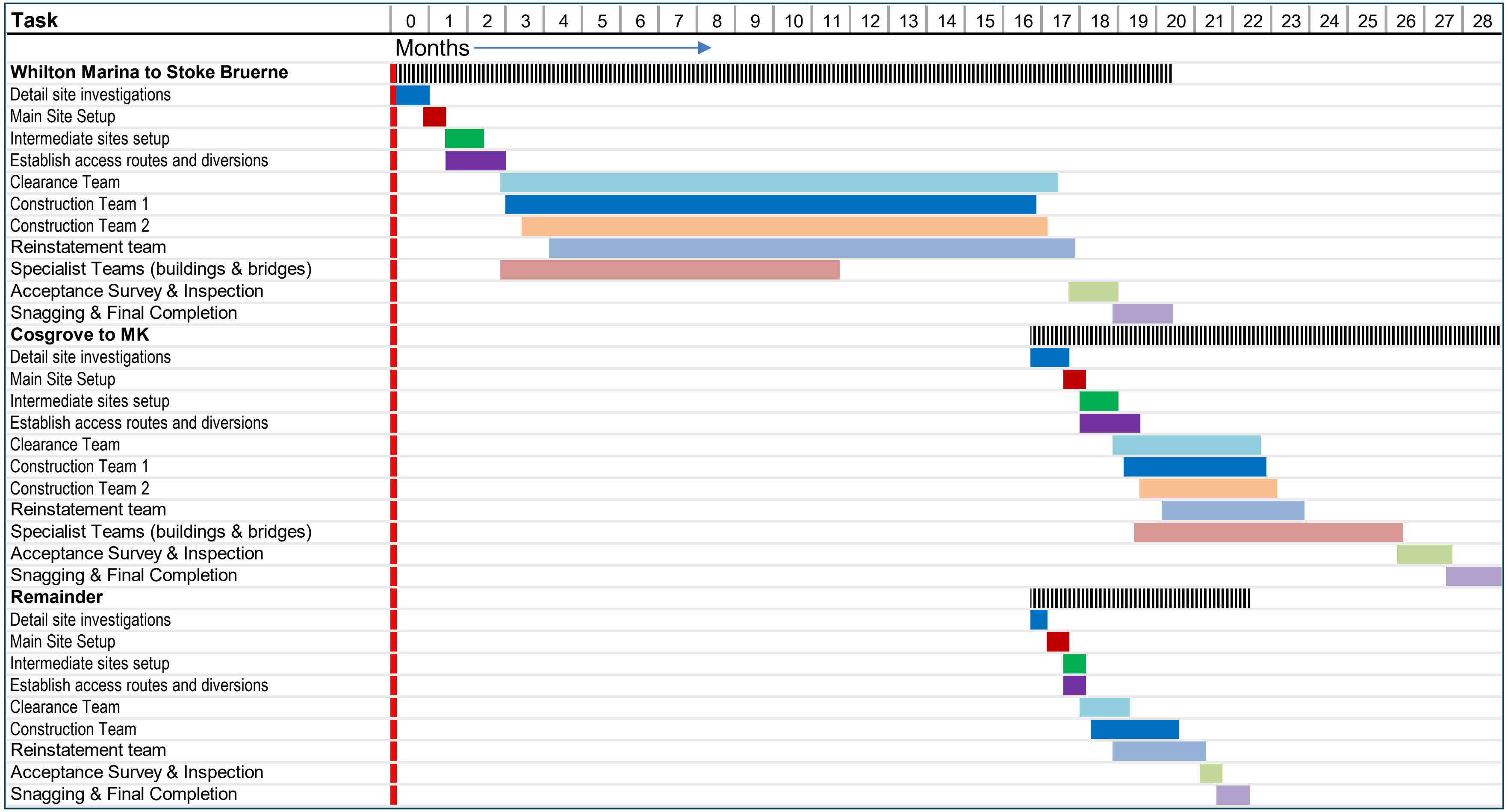


Table 12-4 Canal Bank Raising Phase 2

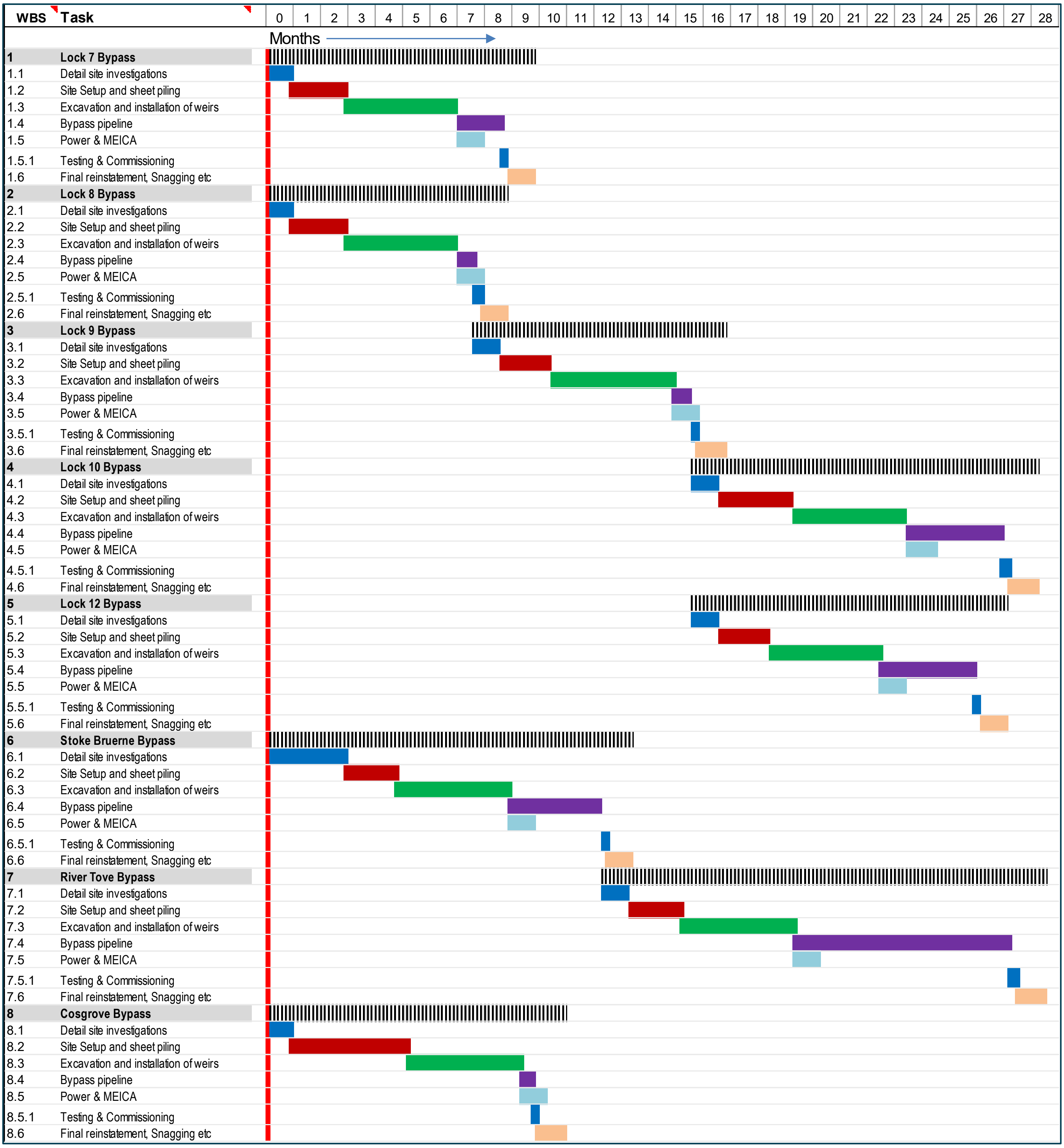


Figure 12-3 Gravity Bypass Programme

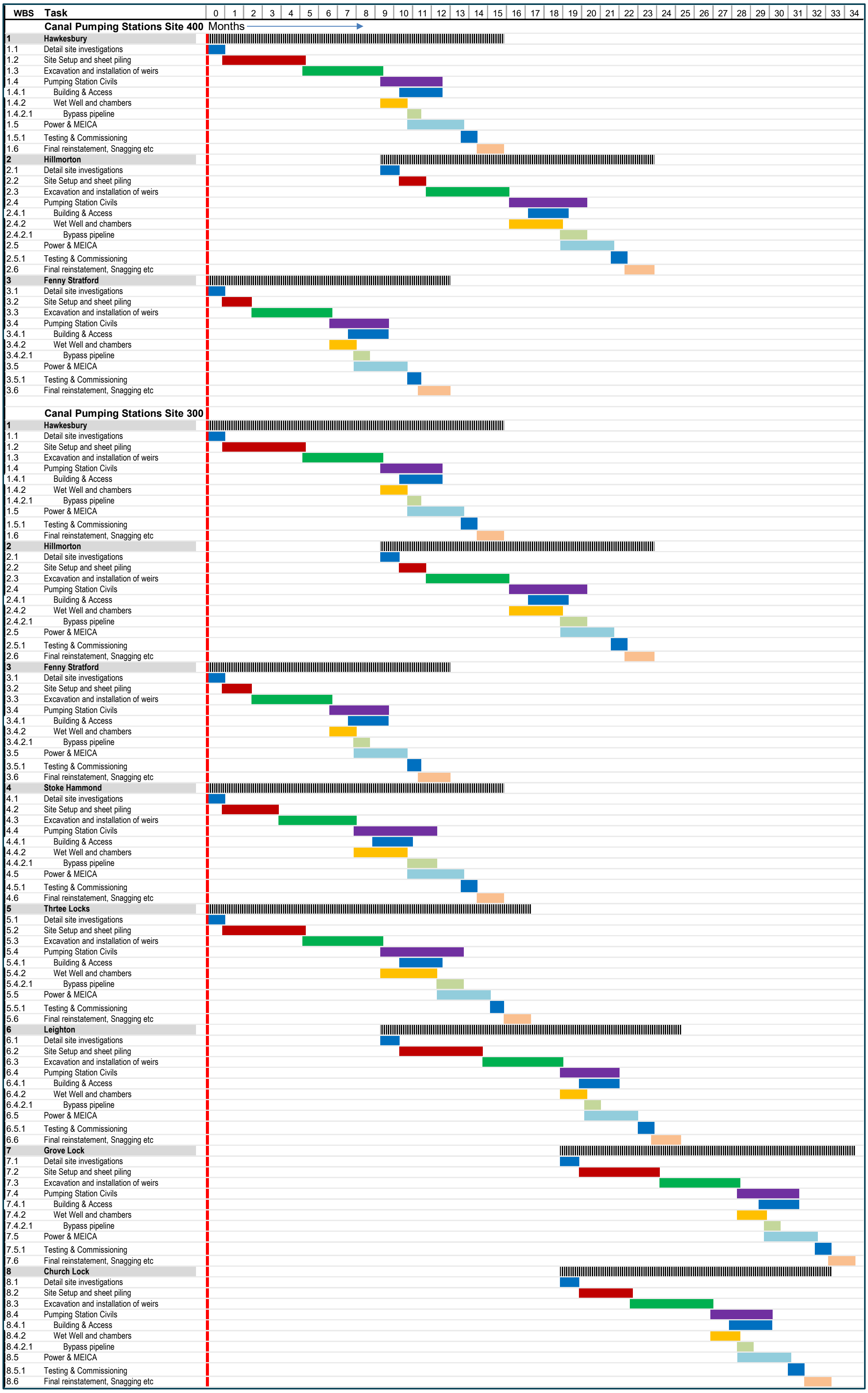


Figure 12-4 Pumped Bypasses

13. COSTS

13.1 INTRODUCTION

Costs have been estimated based on the Gate 3 work, where this has modified the Gate 2 work. The necessary review of the options prior to non-statutory consultation has resulted in more options to be costed than were established at Gate 2. The level of detail has therefore not increased in some areas and in order to make useful cost comparisons in some cases the level of detail has been kept fairly high level. The risk allowances, both from an estimate of Optimism Bias and from the risk register assessment, remain relatively high reflecting the level of detail available.

Below is a report of how the costs have evolved since the start of the development process.

13.2 COST EVOLUTION

As the GUCT has developed the scope and level of understanding of risks has evolved.

13.2.1 Gate 1

At Gate 1 costs were estimated for:

- 3nr Transfer route options from Minworth to various locations on the GUC.
- A transfer pumping station and pipeline to take the recycled water from Minworth AWTP to the discharge locations on the GUC.
- 8nr abstraction, raw water transfer and treatment works site options. All potential sites were located south of Tring, close to Affinity Water's supply area and strategic storage and distribution systems.
- 2 days of bankside storage.
- A membrane based potable water treatment plant at the southern sites with no post treatment to suit water chemistry needs when blending with existing water supplies in Affinity Water's supply area.
- 4 hours potable water buffer storage at the potable water treatment works sites and additional storage at the service reservoir sites to which the new potable water would be delivered.
- An outline assessment of the canal works required (bank raising, lock modifications, tunnel and bridge modifications) based on some very early study on hydraulic capacity by others.
- An initial assessment of the number of bypass pumping stations and gravity bypasses needed, on the assumption that there would be one bypass required for each lock and no optimised arrangement to aggregate such bypasses where economically preferable.

The costs and carbon were for high level comparison purposes and the operating philosophy was assumed as peak flow (115Ml/d) all year round. Net present values of costs and carbon were calculated over an 80 year period including a 7 year construction and commissioning period.

Costs were largely calculated from Affinity Water's planning cost model, with additional cost rates for the canal raising being extracted from a previous report by others using

Environment Agency unit costs data for flood embankment work and updated to 2020 using cost inflation factors from public domain, and costs for the bankside storage work developed separately from recent similar earthmoving works.

Acknowledging the lack of certainty and the relatively low level of detail at the time of the reporting, a significant allowance was made for Optimism Bias (c 40%) both for capital and operational cost estimates.

13.2.2 Gate 2

At Gate 2 costs were estimated for:

- A new treatment unit at Severn Trent's (ST) Minworth WwRC to take up to 115Ml/d of flow from the current recycled water stream and treat to a standard suitable for discharge into the GUC. The design and costs for these works was undertaken by others and was not included in this report.
- A new pumping station and raw water pipeline to take the treated recycled water c 20 km almost due east from Minworth to a discharge point on the GUC near Atherstone. The design and costs for these works were included in the Gate 2 report.
- Works on the GUC as required to accommodate the increased flows and associated increased water elevation, including some bank, wall and towpath raising, and gravity and pumped lock bypasses to transfer the flow southwards. From the hydraulic modelling undertaken to the date of the report the canal banks would need c9km of bank raising (up to 100mm) for flows up to c58Ml/d, but would need c100km of canal bank raising, up to 250mm in places, for the design flow of 115Ml/d. The number of lock bypasses was substantially reduced both through optimising the number of multiple lock bypasses and also due to the reduced length of canal to be affected as the abstraction point was now located north of Tring thereby avoiding a large number of locks needed to accomplish the rise to the Tring summit.
- A new abstraction works (screened intake and pumping station) a short distance south of an example site at Leighton Buzzard, transferring flow into a new raw water storage reservoir of c 5 days full flow capacity.
- A new water treatment works to take water from the raw water storage and treat to potable water standard compatible with the current treated water in AfW's system.
- A new treated water reservoir at the treatment works site, a new pumping station and a new potable water transmission pipeline to an existing AfW underground reservoir near Luton, c14km to the east.

The scheme was designed to be able to transfer up to 115Ml/d but all elements able to operate at a range of flows to suit demands from AfW. The detailed design of the operating system to allow this was not undertaken but the principles are clear. It is important that the scheme can run at a "tickover" rate to ensure that the mechanical, electrical and process elements are kept in action and the pipelines are allowed to operate at a sweetening flow. As a result the pumps and treatment systems were sized to allow partial operation.

The costs and carbon were for concept design purposes and the operating philosophy was altered to reflect a tickover flow of 25% of peak flow ramping up over 4 months from March to June to peak flow (115Mld) for 4 months and then ramping down over 3 months. Net present values of costs and carbon were calculated over an 80 year period including a 5 year construction and commissioning period.

Costs were largely calculated using rates from the CESMM published database (adjusted for inflation to the 2022 price base) and Affinity Water's planning cost model. Quantities for the cost build up were developed in a GIS system and take off used existing standard details (e.g. the Trust standard details for canal edge repairs).

No geotechnical or topographical survey was obtained for any of the proposed works nor was any site walkover, environmental survey or liaison with landowners, since the preferred scheme option was still undecided. Nonetheless, allowing for the slightly greater detail available in some areas of the design the Optimism Bias was modified for different elements of the work, ranging from 15% up c 35%, with the higher values for the bankside storage and treatment works where the impact of lack of GI and topographic survey would have the greatest impact on uncertainty. A risk assessment was also undertaken to allocate costs and time risks to specific identified construction and programme risks, meaning the overall cost contingency remained at a similar level as for Gate 1. Future work in Gate 3 including geotechnical, topographical, environmental survey and stakeholder engagement was expected to allow reduction in Optimism Bias and a review and update on specific identified risks.

13.2.3 Gate 3

For Gate 3 the same sub-divisions of the scheme were retained for comparison with Gate 2. These were:

- Discharge to canal (from the Minworth AWTP via the Minworth to Atherstone Transfer Pipeline – see separate Minworth SRO Consultant Gate 3 report).
- Grand Union Canal, further sub-divided into:
    - Pumped Bypasses – diverting transfer flows around uphill locks.
    - Gravity Bypasses – allowing transfer flows to bypass downhill locks.
    - Canal work, further sub-divided into:
- Bank Raising – i.e. to maintain freeboard during transfer.
- Bridges – to maintain air-draught during transfer.
- Locks – adjustments to lock gates for higher water levels.
- Existing Weir Adjustments – raising for higher water levels.
- Widening – removal of constrictions to maintain navigational velocities.
- Storage – now expanded to include the transfer from Braunston to Daventry and Drayton Reservoirs, in addition to the bankside storage at a WTW Site.
- Abstraction – including overflow from canal, screening and pumping into bankside storage.
- Water Treatment, and
- Transfer of treated water to an existing clean water storage site south of Luton.

Through Gate 1 and Gate 2, several options had been developed at each location. For Gate 3, to improve cost certainty and inform other scheme activities (e.g. assessment of impacts on environment, identification of potential temporary construction compounds and access etc.) generic "concepts" for pumping stations, bypasses, storage and process units that can be used to generate quantities for assessment were developed. These generic concepts will need review in Gate 4 to confirm they are applicable in the locations that will be taken forward into the planning application and procurement processes. This concept design used publicly available Laser Imaging Detection and Ranging (LIDAR) surveys and small localised point cloud surveys to create 3D models of existing conditions (see Figure 13-1 3D Model of Hawkesbury Lock as an example). These models were then used to identify the following:

- Heritage features for future consultation and assessment.
- Canal operational features for retention or diversion (e.g. water points, mooring points, Elsan points etc.
- Existing surface finishes (e.g. stone sets, slabs etc) and space restrictions – see Figure 13-2 Existing surface and space restrictions at Hawkesbury Turnover Bridge as an example.
- Tree canopy and vegetation extents.
- Topographic features such as slope steepness, ditches etc.

The concept design, developed in 2D at Gate 2, could then be overlaid to further identify:

- Clashes – service to be diverted, paths to be re-routed etc.
- Vegetation to be assessed – e.g. extent of pruning, BNG and mitigation measures etc.
- Potential cut and fill volumes.
- Potential construction risks and temporary works (including access and compound areas).

Using the above information, the generic concept 3D models were updated (e.g. see Figure 13-1 as an example) and a bill of quantities generated for costing and carbon assessment purposes (Figure 14-4). Construction costs were applied using data from recent similar projects, commercial cost databases and supplier quotes.

At Gate 4, following consultation on options and detailed survey information, these estimates will need updating.

Pipeline costs were developed using LIDAR to generate long section drawings for several options. At Gate 3, there are no preferred abstraction sites or connection routes. However, to be able to assess the range of costs and impacts and to identify areas of risk to be further developed at Gate 4, the following pipeline corridors were assessed at a high level:

- Routes from south of Milton Keynes to navigate around Leighton Buzzard.
- Routes from south of Leighton Buzzard to deliver potable water into the AfW area.
- Reassessment of the Gate 2 routes for baseline comparison.

Operational costs, as at Gate 2, are dominated by chemical (water treatment) and electricity (pumping). Using the updated Hydraulic Consultant's models, the revised treatment works design (see Section 10 above) and elevation data from the 3D models and long section, operational costs have been calculated.

Costs estimates are summarised in the Tables provided in Section 13.3.

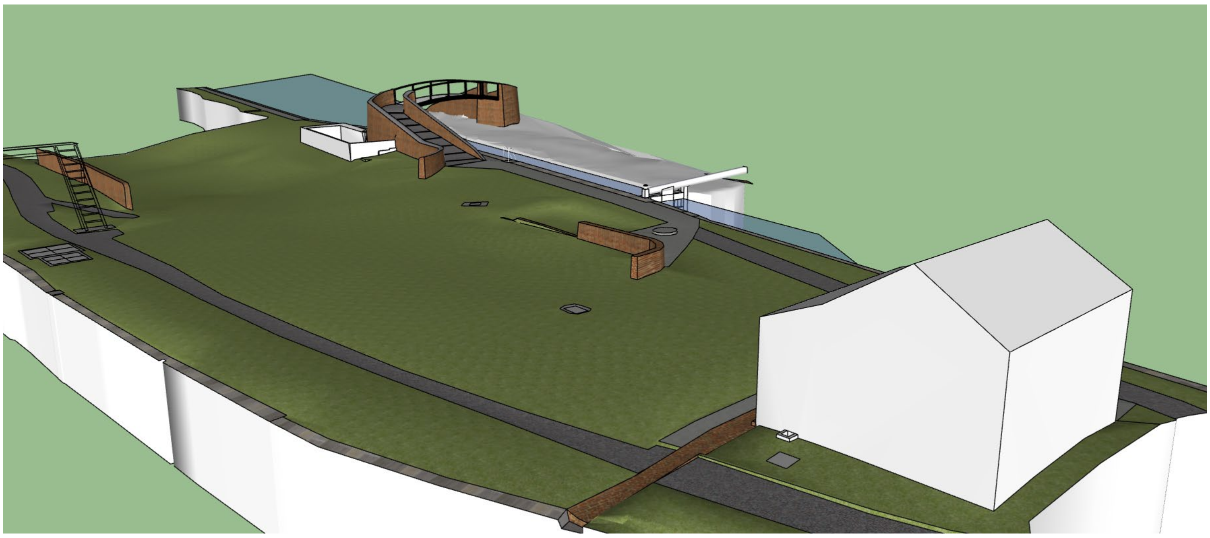


Figure 13-1 3D Model of Hawkesbury Lock

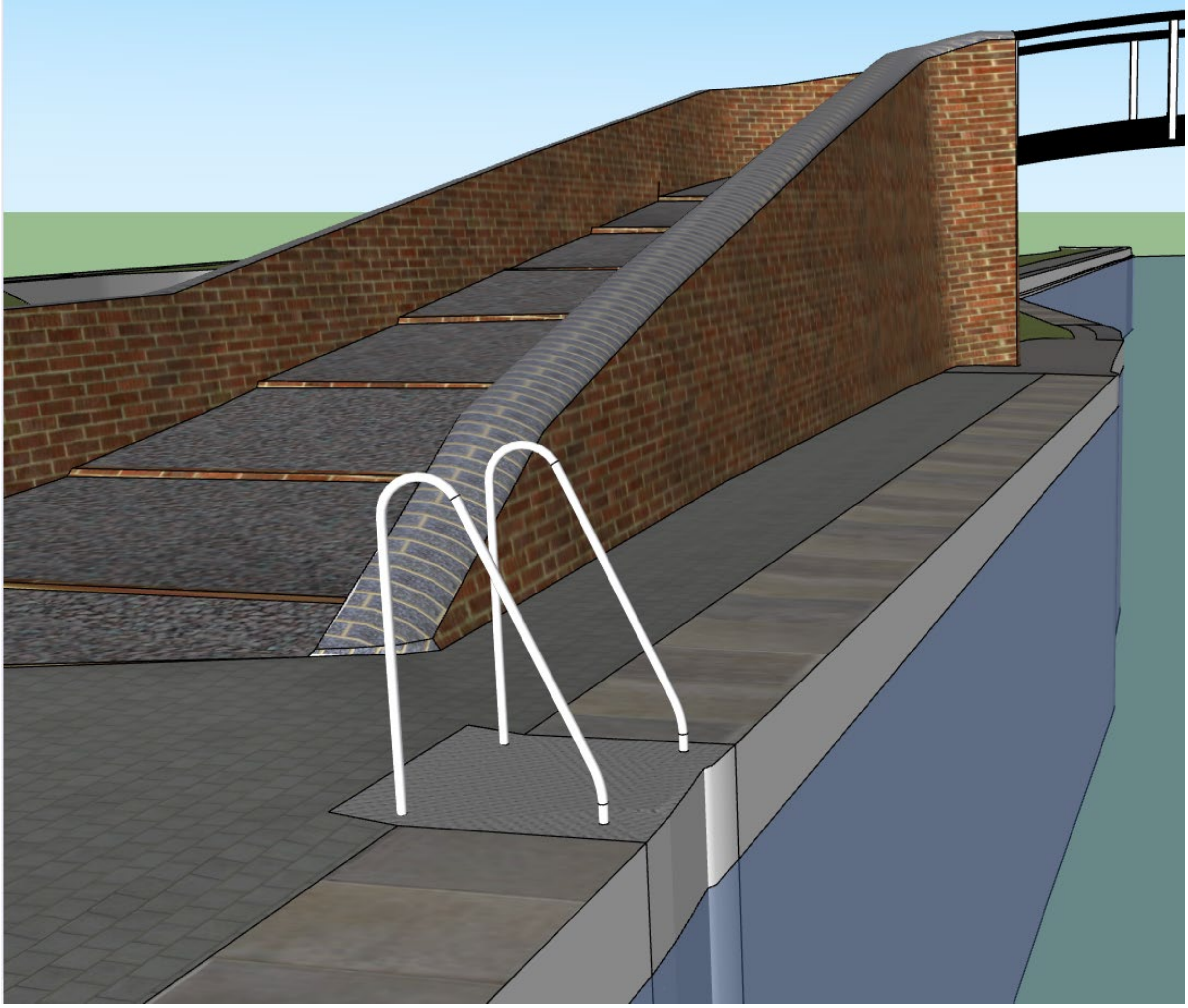


Figure 13-2 Existing surface and space restrictions at Hawkesbury Turnover Bridge

13.3 COST SUMMARY TABLES

Discharge Point

Although there are several locations the discharge structure could be constructed, they are all located within a short distance between Atherstone top lock and Hartshill. All locations of the canal edge along this section have similar constraints. Therefore, costs were developed using an “notional” layout that could be applied in multiple locations. At Gate 4, when a preferred location has been selected, the design will need to be updated for site specific constraints and estimates updated.

Scenario	CAPEX (£m)	OPEX (£m)*	NPV (£m)	OB (£m)
Atherstone	[redacted]	[redacted]	[redacted]	[redacted]

**Includes REPEX*

Table 13-1 Discharge Point Cost Summary

Canal Pumped Bypasses

Three scenarios were considered for canal pumping stations:

- Abstracting south of Milton Keynes only requires 4 pumping stations along the canal.
- The original Gate 2 scenario required 7 pumping stations.
- Abstraction south of Leighton Buzzard would require 9 pumping stations.

The cost of transferring flows from the canal into storage are included in other sections (e.g. from Braunston to Drayton and Daventry is included in Table 13-6, and from the abstraction point into the bankside storage is included in Table 13-5).

Scenario	CAPEX (£m)	OPEX (£m)*	NPV (£m)	OB (£m)
South Of Milton Keynes	[redacted]	[redacted]	[redacted]	[redacted]
Gate 2	[redacted]	[redacted]	[redacted]	[redacted]
South Of Leighton Buzzard	[redacted]	[redacted]	[redacted]	[redacted]

**Includes REPEX*

Table 13-2 Canal Pumping Station Cost Summary

Canal Gravity Bypasses

Bypass weirs are required where there are downhill locks where the canal is falling from the north to the south. All these locations are in the central section of the GUC SRO and are therefore common to all scenarios considered.

Scenario	CAPEX (£m)	OPEX (£m)*	NPV (£m)	OB (£m)
Bypasses	[redacted]	[redacted]	[redacted]	[redacted]

**Includes REPEX*

Table 13-3 Gravity Bypass Cost Summary

Canal Banks and Existing Structures

The impact of the transfer flows on existing canal structures (e.g. towpaths, bridges, locks, weirs etc.) is proportional to the length of the canal pound (i.e. distance between locks). Longer pounds will require the canal banks to be raised higher and over longer distances than short pounds. For the GUC SRO, all the long pounds are north of Milton Keynes. The cost estimate and associated programme for construction can vary significantly with the assumptions used in the hydraulic model (e.g. lining roughness value, amount of vegetation present, antecedent conditions etc.). The values range from a conservative assumption of 104km of bank raising to 58km or less.

There are several operating scenarios that have differing levels of impact on the need for bank raising. At Gate 4, work will be undertaken to refine these scenarios to minimise the impact (i.e. reducing the amount and extent of bank raising will reduce the impact on navigation, public use, landowners etc.) and there are likely to be stop-lock options that could reduce bank raising further (i.e. splitting long pounds into short pounds to reduce maximum water levels). A mid-range estimate has therefore been used for this costing assessment.

All the bank raising is confined to canal pounds north of Milton Keynes and therefore is not a differentiator for abstraction site selection.

Scenario	CAPEX (£m)#	OPEX (£m)*	NPV (£m)	OB (£m)
Canal Work	[redacted]	[redacted]	[redacted]	[redacted]

**Includes REPEX*

Table 13-4 Canal Work Cost Summary

#Note: CAPEX includes for associated work for waste weirs, bridges and lock gates to accommodate the increased bank and water levels.

Abstraction

There are several options for location of an abstraction site, linked to suitable locations for bankside storage and treatment works (i.e. space, topography, existing services, flood risk etc.). At each of the locations the canal side constraints are similar. At Gate 3 there are not enough detailed surveys (e.g. ground investigation, topographic, EIA etc.) to differentiate for costing purposes. Therefore a “notional” layout (see Figure 93 Conceptual Typical Layout for Abstraction Point) was developed for costing purposes. At Gate 4 the layout and estimate will need updating depending on the agreed locations for abstraction, overflow and screen return water discharges, access and transfer routes to the bankside storage etc.

Scenario	CAPEX (£m)	OPEX (£m)*	NPV (£m)	OB (£m)
Abstraction	[redacted]	[redacted]	[redacted]	[redacted]

**Includes REPEX*

Table 13-5 Abstraction Cost Summary

Storage

Following the Gate 2 review, additional storage has been identified at the existing reservoirs of Drayton and Daventry (see Section 7.3) to supplement the bankside storage adjacent to the WTW. A preliminary assessment of the existing reservoirs has identified low impact options that could be developed at Gate 4 to achieve the stated aim of 11 days total storage available for the GUC SRO (i.e. 6 days from existing reservoirs plus 5 days from new bankside storage). At Gate 4, following confirmation of the storage requirement, operating philosophy and the undertaking of detailed surveys, more detailed designs can be developed.

As there is no preferred site for the WTW and storage location and no detailed ground investigation, only a notional storage design can be developed. Costs are therefore based on a balanced cut and fill design with minimal import of embankment material (i.e. assumes the site selected at Gate 4 will be suitable for this approach). Allowances have been made for a new site entrance from an adjacent highway, but actual access arrangements will need to be agreed following consultation and the estimate updated.

Scenario	CAPEX (£m)	OPEX (£m)*	NPV (£m)	OB (£m)
Storage	[redacted]	[redacted]	[redacted]	[redacted]

**Includes REPEX*

Table 13-6 Storage Cost Summary

Treatment

The new water treatment works will be located at a site still to be selected. For costing purposes therefore, the notional layout shown in Figure 101 has been used for all scenarios considered.

At Gate 4, following ground investigation and topographic surveys, a more site-specific layout can be developed. The main impact on costs from any site selection will be most significant on the operational electricity costs (i.e. interstage pumping) and chemical usage from any water quality differences from the baseline used.

The costs are based on the water quality data gathered for the Gate 2 site and the interstage pumping is based on an assumed level platform for construction. Potential locations south of the Gate 2 location are likely to have similar water quality (i.e. water quality at the Gate 2 site will be transferred by the bypass pumping stations) and map data available indicates relatively level areas. Potential sites north of the Gate 2 sites are more varied in topography and likely to have a different water quality profile but from available data the candidate sites are not extreme in their variance and therefore the use of a single cost estimate for WTW to cover all scenarios is not unreasonable at this stage.

Scenario	CAPEX (£m)	OPEX (£m)*	NPV (£m)	OB (£m)
Treatment	[redacted]	[redacted]	[redacted]	[redacted]

**Includes REPEX*

Table 13-7 Treatment Cost Summary

Transfer Pipelines

A preferred abstraction site has not been chosen. This means that it is difficult to reduce the number of pipeline route options to a manageable number for evaluating the risk and impacts to be identified. Therefore, after a high-level review of potential routes the following five scenarios were chosen for development in sufficient detail to allow costing, carbon and programme risks to be identified. The five scenarios are:

- Treated water transfer pumps and pipeline from canal pound “GU Pound 22-23” to a clean water storage location south of Luton. This pound is the first pound south of Milton Keynes and is 4.8km long. All the candidate sites in the Milton Keynes will be abstracting water from this pound. This scenario would give the longest transfer route.

- Gate 2 site – the transfer route previously evaluated and updated after Gate 3 investigation (e.g. constructability, geotechnical desktop studies etc.).
- Treated water transfer pumps and pipeline from canal pound "GU Pound 29-30" to a clean water storage location south of Luton. This pound is 2.8km long. This is the last pound moving south that is large enough (i.e. enough volume) to be able to accommodate abstraction without potentially impacting navigation (i.e. fluctuations in water levels) and being north of the Chiltern AONB. South of this pound there are also 9 locks in relatively short succession as the canal rises to the Tring Summit. Each of these locks would require an additional pumped bypass.
- Split site 1. Pound "GU Pound 29-30" is in a rural area with access and site service constraints. Although these constraints can be overcome an alternative scenario would be to abstract from this pound into bankside storage and then transfer raw water to a treatment works at a location with better access and site services (e.g. existing high voltage power supply). Candidate sites closer to Leighton Buzzard existing development have been identified.
- Split site 2. This is the same scenario as Split Site 1 but with a different candidate site for comparison.

Costs in Table 138 include for the pump and operational costs. Energy use, flow rates being equal, are a function of pipeline characteristics (e.g. material, diameter, length etc.) and topography (i.e. static head to overcome etc.). It is therefore more appropriate to include them in with the pipeline that at the treatment works. All the scenarios have a termination point south of Luton. This requires all pipeline routes to pass over the same high point (i.e. Chilton escarpment). This results in the pipeline length only accounting for a maximum of 20% of the energy required, most of the pumping energy being required to overcome static head (i.e. the candidate sites are all have the same start level +20m but all must pump over a high point of approximately 240m). The Split sites also have inter-site pumping in addition to the transfer pumping requirements.

At Gate 4, once a preferred site has been chosen, more detailed route analysis will be required to finalise pipeline details. At Gate 4, it would also be possible to look at optimising pumping and pipeline characteristics. For example, longer pipelines can benefit (capital costs and electricity use) from being split by using booster stations at strategic locations, but this would need to be balanced with the need for additional above ground structures and system resilience etc.

Scenario	CAPEX (£m)	OPEX (£m)*	NPV (£m)	OB (£m)
Pound 22-23	[redacted]	[redacted]	[redacted]	[redacted]
Site F	[redacted]	[redacted]	[redacted]	[redacted]
Pound 29-30	[redacted]	[redacted]	[redacted]	[redacted]
Split Site P	[redacted]	[redacted]	[redacted]	[redacted]
Split Site Q	[redacted]	[redacted]	[redacted]	[redacted]

**Includes REPEX*

Table 13-8 Pipeline Cost Summary

Scenario Comparison

The scenarios are all similar in CAPEX and OPEX costs, within +5% of each other. With many of the elements between the scenarios (e.g. bank raising, storage etc.) being common across all scenarios, the differences become a trade-off between longer below ground pipeline routes against longer canal transfer routes (i.e. more canal pumped bypasses).

At Gate 4, following consultation and more detailed survey information being available (e.g. EIA surveys etc.) and estimates being updated, other differentiators may become more dominant. However, from an engineering perspective there is no clear preference for site selection given the current assumptions and available data.

Scenario	CAPEX (£m)	OPEX (£m)*	NPV (£m)	OB (£m)
Site B	[redacted]	[redacted]	[redacted]	[redacted]
Site F	[redacted]	[redacted]	[redacted]	[redacted]
Site H	[redacted]	[redacted]	[redacted]	[redacted]

**Includes REPEX*

Table 13-9 Scenario Cost Comparison

13.4 COST CHANGES FROM GATE 2

The cost summary from the Gate 2 report is shown in Table 1310 and the current Gate 3 cost summary is shown in Table 1311. The majority of the OPEX cost variance can be explained by the difference in electricity cost rate use. At Gate 2 a rate of [redacted]/MWh was used. This figure has been updated to 190/MWh for Gate 3. If the same rate from Gate 2 is used, then the total OPEX estimate at Gate 3 would reduce to £[redacted]m. The remainder of the difference is then due to the introduction of the additional storage provided by Drayton and Daventry, more specifically the pumping cost of diverting flows from the canal at Braunston and pumping up into the reservoirs.

Component	CAPEX (£m)	OPEX (£m)	NPV (£m)	OB included (£m)
Discharge	[redacted]	[redacted]	[redacted]	[redacted]
Canal	[redacted]	[redacted]	[redacted]	[redacted]
Abstraction	[redacted]	[redacted]	[redacted]	[redacted]
Storage	[redacted]	[redacted]	[redacted]	[redacted]
Treatment	[redacted]	[redacted]	[redacted]	[redacted]
Distribution	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]

Table 13-10 Cost Summary Reported in Gate 2 Report

Component	CAPEX (£m)	OPEX (£m)	NPV (£m)	OB included (£m)
Discharge	[redacted]	[redacted]	[redacted]	[redacted]
Canal	[redacted]	[redacted]	[redacted]	[redacted]
Abstraction	[redacted]	[redacted]	[redacted]	[redacted]
Storage	[redacted]	[redacted]	[redacted]	[redacted]
Treatment	[redacted]	[redacted]	[redacted]	[redacted]
Distribution	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]

Table 13-11 Cost Summary Gate 3

The main changes in the CAPEX estimate values are discussed as follows:

Discharge

- New configuration and increased size. The Gate 3 discharge configuration has been updated to a more general configuration that can be used at multiple locations. A facility to bypass the turbines at low and peak flows has been added.
- The flow control in Gate 2 was assumed to be at the break tank, this has now been changed to flow control valves at the discharge structure to suit the control philosophy proposed by the Minworth SRO Consultant for the safe operation of the Minworth AWTP and pipeline.
- To allow for flexibility in locating the structure along the Atherstone pound, allowance for access and site services was required above that at Gate 2.
- Investigations for potential feed connections for any hydroelectricity generated resulted in longer connection routes.

Pumping stations

- Increased excavation and filling - Gate 2 estimates only used visual data, with significant areas being overgrown and not available for access. Gate 3 estimates have used limited topographical surveys and LIDAR to more accurately identify the likely extent of excavation and fill required.

- Increased allowances for managing works site access and working adjacent to the canal.
- Structures have increased in size after updated hydraulic design information from the Hydraulics Consultant, including results from modelling of the flows and flow velocities associated with the use of the inlets and outlets, taking account of layout, screens and velocity constraints.
- Power costs from DNO higher than standard (especially Hillmorton).

Canal

- Updated hydraulic model from the Hydraulics Consultant has led to increased bank heights in various locations and extended the work needed, taking account of current actual water levels for operating zones and more specifically accounting for branch canals/side arms.
- Updated hydraulic model showed some increased impacts at locks due to backwater effects when operating the locks at the same time as the transfer.

Storage

- No GI has been undertaken but the bank side storage at Gate 2 was proposed to be on land previously used for quarrying, so some account was made for the uncertainty around potential contamination from the backfilled materials. Options for storage are now on agricultural land which has been assessed from the desk top study to have significantly lower risk.
- Option sites are less steep than those assessed at Gate 2 therefore embankment height can be reduced making working easier.
- Options proposed for Daventry and Drayton maximise existing overflows and minimise work on embankment thereby reducing cost and risk.

Abstraction

- Greater discharge pipe length and/or overflow length will be needed depending on the site chosen. Gate 2 costed option was close to the canal and had shorter abstraction and overflow conveyance routes than the other options.
- Cost for separate site access has been added for each option site. At Gate 2 the assumption was that access was available through WTW site.

Treatment

- The treatment works will need new construction and operation access at all proposed sites. The Gate 2 site had an existing suitable access.
- Process has been updated to account for updated WQ data from the canal and the revised assessment by the Minworth SRO Consultant of the output from the Minworth AWTP. Also to account for AfW and DWI consultations relating to latest guidance on Drinking Water Safety Plans.
- The latest layout has a reduced footprint.

Distribution

- The proposed Gate 2 pipeline from Site F to the existing AfW service reservoir near Luton was relatively short and followed a lower elevation route. Current pipeline options from Site B, Site H, Site P and Site Q are longer than the proposed Gate 2 route and have a higher maximum elevation. This means increased capital costs and higher operations costs.

General

- Price base has been updated from 2022 to 2024.
- Increased electricity cost/information (47 % since 2022) Head increase (from updated hydraulic model which increased the water levels in some locations) requires higher power output for the bypass pumping stations in addition to the increase for the distribution pipeline. Potential for change in CAPEX (also impacts carbon calculations in Section 14).
- GI is needed to confirm the construction method and depths of all chambers. The current design assumes the need for a large mass concrete plug to resist flotation. There is the potential for cost and carbon reduction and programme efficiency.
- Topographic survey is needed to confirm pipe lines and level. LIDAR has been used but in some areas the last available data is from 2010-14. LIDAR is suitable for planning purposes only.
- Construction Programme (see Section 12) - currently assumes at least 5 years but if this were required to be reduced it is likely the acceleration would increase costs. If the bank raising were to be reduced as noted earlier in the report notable reductions in cost and time would be available.
- Availability of specialist skills and equipment such as that required for other SROs, other/ongoing canal work, large diameter pipes in large quantities, may put pressure on the supply chain resulting in cost increases.
- Optimisation of pumping station efficiency is needed to match most the likely "normal" operating philosophy. There should be opportunities for matching equipment more closely to the utilisation curve and probability of use, which could give significant power and carbon savings.
- Bank raising methods need to be agreed with the Trust and the Environmental Consultant and confirmed with the riparian owners. These will need to achieve a balance between ecology and land access. For example, the use of more sheet piling may be quicker and less disruptive to install but has lower ecological values and higher carbon.
- Availability of materials for bank raising is a risk identified at Gate 2 and needs consideration during next design steps.
- Maintenance strategy needs review. Current REPEX assessment is based on industry standard replacement periods. Proactive maintenance and monitoring can extend asset life and reduce costs.
- Condition survey of canal lining has not been undertaken. The current cost estimate assumes no significant lengths of lining need replacing. Some leakage assessment has been undertaken by the Hydraulics Consultant with the Trust, with no significant concerns raised from this limited work.
- Feedback from non-statutory consultations and consultations with riparian owners will be required.
- Costs will need updating for the new WTW and the storage site following consultation and detail surveys. Gate 3 based on a site just south of Milton Keynes but if a further south site is chosen:

- Canal management costs increase – i.e. the number of canal pumping stations increases.
- Pipeline cost decrease – i.e. distance to AfW connection point south of Luton decreases.
- Storage cost increases – i.e. the southern site is less easy to develop due to access and topography.
- Water quality and therefore chemical use changes as the southern site is more affected by water entering the canal from a local stream which may be affected by agricultural runoff and sediment.

14. CARBON

14.1 INTRODUCTION

This section is designed to assist the Grand Union Canal Strategic Resource Option (GUC SRO) project team in understanding Whole Life Carbon (WLC) emissions, and how the engineering solutions being developed are helping to minimise emissions.

As the project develops through its lifecycle to further support and prioritise proactive carbon reduction, WSP recommend the development of a comprehensive Carbon Management System (CMS) aligned to 2080:2023 Carbon Management in Infrastructure and Built Environment[2]. The primary objective of a CMS is to provide a structured framework for capturing and managing WLC emissions data. This section of the report will specifically concentrate on addressing Scope 3 Carbon emissions[3].

The implementation of the CMS should span across the GUC SRO's entire value chain and extend to every stage of project delivery. The overarching goal is to promote collaboration among the project teams, clients, and the supply chain, fostering a culture of innovation centred on carbon reduction. The CMS will enable GUC SRO and its supply chain to better understand, capture, monitor and evaluate their emissions to further reduce and report its WLC emissions.

This initiative supports the twin objectives of reducing both WLC emissions and project delivery costs, whilst also encouraging the adoption of low-carbon solutions. Introducing a CMS, GUC SRO will be able to track, engage or evaluate and monitor their carbon emissions across the WLC stage. By adopting an approach in line with PAS 2080:2023, GUC SRO can demonstrate its commitment to the carbon reduction initiative, thereby meeting government policies[4] and remain in line with UK Government's ambition to be Net Zero carbon by 2050.

14.2 WHOLE LIFE CARBON EMISSIONS

Carbon emissions arising from the built environment are attributable to the operational emissions (Scopes 1 and 2) of the built assets and their construction embodied emissions (Scope 3). For the GUC SRO operational emissions result from energy consumption in the day-to-day running of assets, while embodied emissions arise from the production, procurement, and installation of materials and components. These also include emissions from maintenance, repair, replacement, demolition, and disposal throughout the asset's lifecycle.

Considering Scope 1, 2, and 3 emissions over a project's expected life cycle constitutes the whole life approach. The whole life emissions should also include emissions removals wherever they occur.

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[2] PAS 2080:2023 Carbon Management in Infrastructure | BSI (bsigroup.com)

[3] The CMS proposed in Scope 3 should be considered for WLC, however this technical annex focusses on capital carbon at each stage of the project lifecycle.

[4] The Paris Agreement | UNFCCC, Climate Change 2021: The Physical Science Basis | Climate Change 2021: The Physical Science Basis (ipcc.ch), CC 2023 Progress Report Government Response, 1. Why Net Zero - GOV.UK (www.gov.uk)

14.2.1 Scope 3 Emissions

Scope 3 emissions, as defined in the Greenhouse Gas (GHG) Protocol[5], refer to those indirectly produced by an organisation, stemming from sources not owned or controlled by the organisation itself. These emissions do not directly arise from GUC SRO initiated activities but occur within their supply chain; for example operational use carbon from electricity for pumping. Scope 3 emissions can be separated into 'upstream' and 'downstream' emissions, whereby upstream emissions are indirect GHG emissions related to purchased or acquired goods and services and downstream emissions are indirect GHG emissions related to sold goods and services[6]. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; waste materials; and use of sold products and services.

Scope 3 is typically where most of an organisation's carbon emissions occur and can be challenging to measure, if not factored into procurement and contractual requirements and delivery information management systems.

14.2.2 Hotspots Identifications

The quantification of carbon during the early stages of the project offers the potential to identify likely carbon emissions 'hotspots' and the opportunity to influence the design. Previous GUC SRO carbon baselines have been calculated via cost estimates, accounting for carbon from "cradle" to "end-of-life"[7]. Owing to the early stage of the options design and carbon modelling, it is important to account for tolerance within the estimates and degree of uncertainty associated with cost estimates provided at early outline stage. For GUC SRO the carbon estimation calculations have helped identify areas of medium and high carbon emissions hotspots across the proposed outline scheme. These are provided in Table 14-1.[8]

[5] Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf (ghgprotocol.org)

[6] Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf (ghgprotocol.org)

[7] This would typically capture 70-80% of the scheme's whole life carbon. This has been following in line with BS EN 15978 Life Cycles A1 through to B5.

[8] Note, estimated emissions associated with each of the hotspots has not been provided due to their aggregation not having been completed at a scheme level; the hotspots provided are a summary of the carbon hotspots that are identified from the description of the schemes and the options presented in the GUC SRO Gate 2 Annex A1.11 Cost and Carbon report.

Activity	Hotspot	Key Emissions Sources	WLC Boundary[9]	Anticipated Carbon Impact (High, Medium, Low)
Pipeline Construction	Manufacturing and transportation of pipeline materials, excavation, and installation.	Steel or plastic pipes, concrete, aggregate.	A1 - A5	High
Pumping Stations	Energy consumption for installation and operation.	Concrete, steel, electrical components	A1 - B7	High
Water Treatment	Energy and chemicals required for treating water.	Chemicals, steel, concrete.	A1 - B5	High
Access	Energy-intensive production and transportation of surfacing materials.	Surfacing, Stone.	A1 - A5	Medium

Table 14-1 Hotspots in the GUC SRO Scheme[10]

14.3 CARBON MANAGEMENT SYSTEM

14.3.1 Role of the Carbon Management System (CMS)

A CMS should be an integral part of the GUC SRO's approach to managing the project as carbon emissions will impact all stages of project delivery. As a minimum a CMS must align with the GUC SRO's overarching Net Zero strategy and ambition. The following key aspects are recommended in delivering a comprehensive CMS:

- GUC SRO's CMS should adhere to the PAS 2080:2023 standard for Carbon Management in Buildings and Infrastructure, ensuring a compliant and successful approach to managing carbon emissions.
- Prioritisation of Direct Emission Reductions - Focus on direct methods to reduce emissions rather than relying on carbon credits or trading.
- Standard Practices and Continuous Improvement - Establish standard 'business as usual' carbon management practices while also identifying areas for continuous improvement.
- Action and Commitment Across the Value Chain - Detail specific actions and commitments that address every segment of the GUC SRO's value chain to lay the groundwork for developing early reduction and offset strategies.
- Regular Reviews - Ensure the CMS is reviewed regularly to stay aligned with the GUC SRO's overarching carbon management frameworks and sustainability goals.

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[9] Figure 4.2, p56 BS EN 15978 lifecycle stages, "Guidance Document for PAS2080" - 2023-03-29-pas_2080_guidance_document_april_2023.pdf (ice.org.uk)

[10] Note, estimated emissions associated with each of the hotspots has not been provided due to their aggregation not having been completed at a scheme level; the hotspots provided are a summary of the carbon hotspots that are identified from the description of the schemes and the options presented in the GUC SRO G2 Annex A1.11 Cost and Carbon report.

14.3.2 CMS Overview

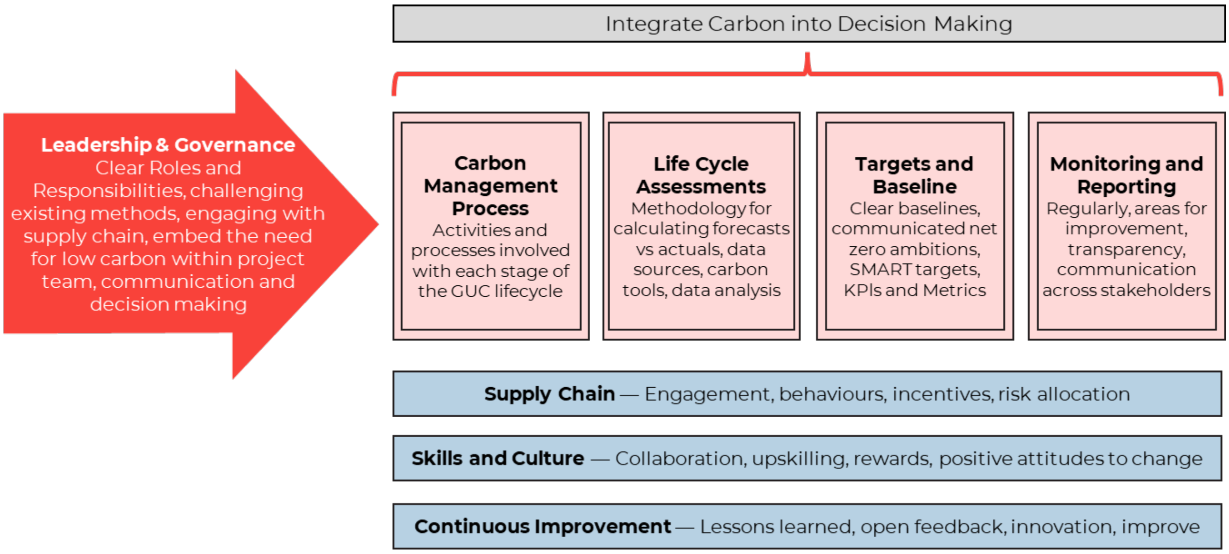

Figure 14-1 Carbon Management System Overview

Figure 141 illustrates how the CMS lifecycle operates, showing how people, processes, tools, and the value chain work together to achieve a low carbon GUC SRO. The CMS relies on strong leadership, clear roles and responsibilities, a defined strategy, and carbon management processes. Carbon management is integrated into every stage of the project lifecycle, emphasising skills development and cultural embedding. This ensures all stakeholders are equipped to contribute to carbon reduction. Figure 2 below shows the value chain members identified in PAS2080:2030.

Targets and baselines set goals for carbon reduction in design and construction aligned with the GUC ambitions. The Assurance and Data Collection processes, outlined in section 14.5 below, track carbon performance throughout the GUC SRO's development and delivery, assessing risks and opportunities.

Procurement practices incorporate carbon policies into contracts and ensure the availability of resource and carbon data. As procurement and operational plans are developed, uncertainty will reduce. Continuous improvement involves learning from past experiences to enhance carbon management practices within the project lifecycle.

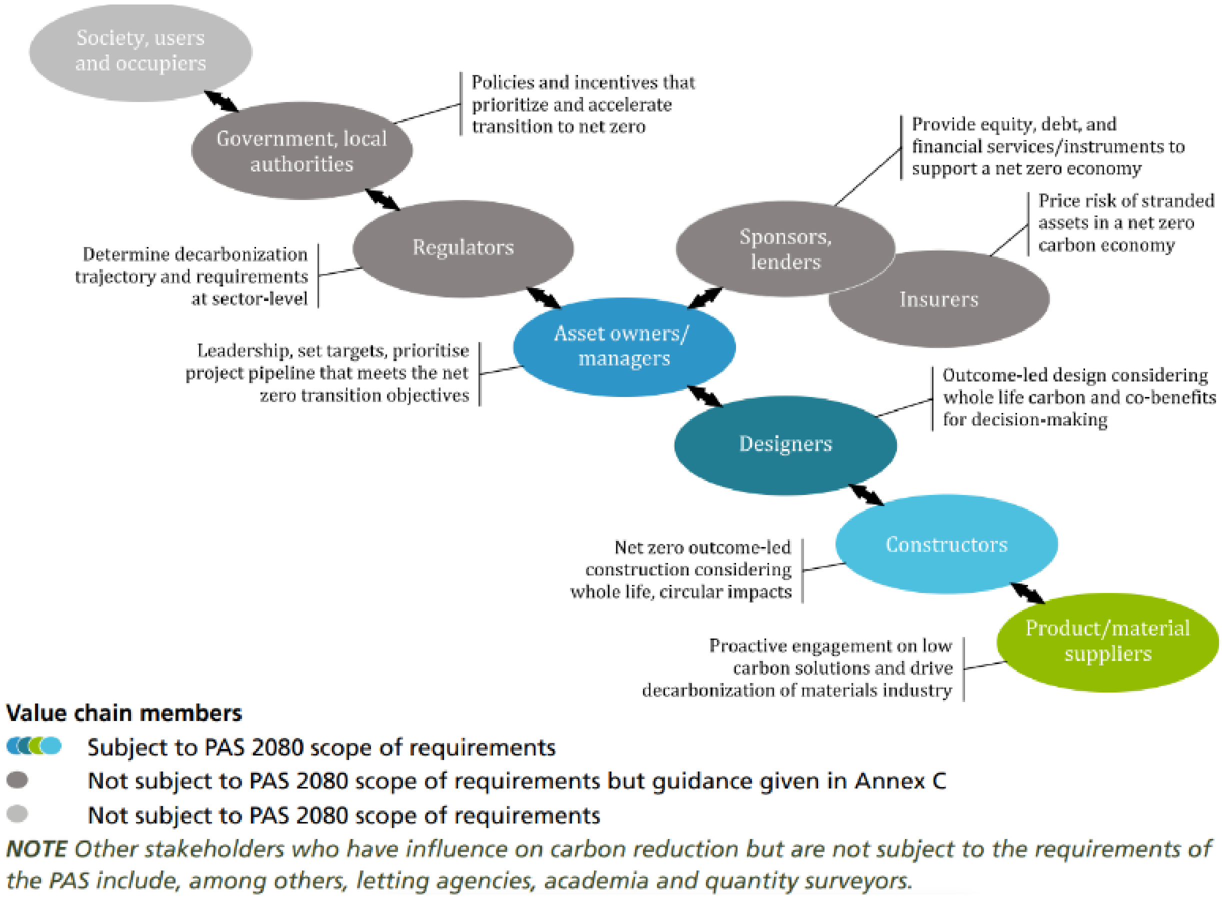

Figure 14-2 Value Chain member in the built environment and their roles in carbon management

(Source: PAS2080:2030 Carbon Management in Infrastructure and Built Environment)

14.3.3 CMS Structure

Figure 14-3 outlines the proposed CMS structure and highlights the key activities and processes to be carried out for a major capital project delivery. The key stages of the project lifecycle are defined as:

- Strategy
- Option identification
- Option selection
- Preliminary Design
- Construction Preparation
- Construction
- Commissioning and Handover
- Closeout and Asset Operation.

These stages are linked to the stages of PAS2080:2023. In addition, the CMS structure shown below identifies how project stages link in with the pre-existing RAPID gated process[11].

[11] For further detail on the four RAPID gated stages, please refer to the following: PR19-final-determinations-Strategic-regional-water-resource-solutions-appendix.pdf (ofwat.gov.uk)

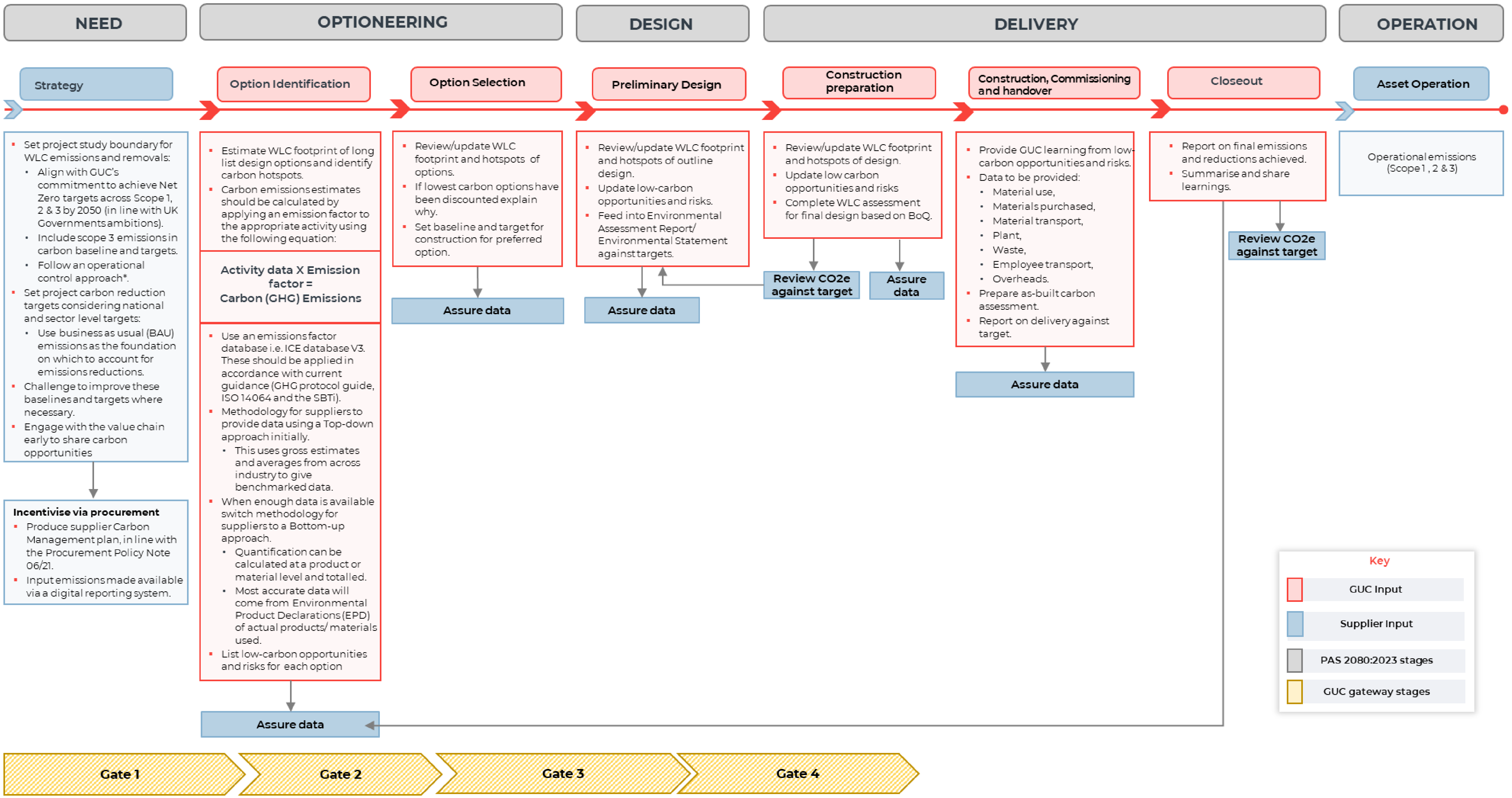

Figure 14-3 Carbon Management System Structure

14.3.4 CMS Benefits

The CMS is critical for effectively managing and reducing emissions across the entire lifecycle of the GUC SRO. It enables the developing organisations to comprehensively assess whole-life carbon impacts and help deliver the following benefits:

- Extensive Data Collection - Develop systems for collecting extensive data from all stages of the project lifecycle.
- Early Strategy Formulation - Use collected data to formulate reduction and offset strategies at the early stages of project planning.
- Integration of Carbon Considerations - Ensure carbon considerations are integrated into all phases of project planning, design, construction, operation, and maintenance.
- Decision-Making Tool - Leverage the CMS as a crucial tool in investment decision-making to enhance the GUC SRO's ability to meet sustainability targets and reduce environmental impact; and
- By embedding these actions into the CMS, the GUC SRO can enhance its carbon management efficacy and align more closely with its sustainability objectives.

14.4 LEADERSHIP AND GOVERNANCE

A CMS, when implemented is essential for tracking and reporting carbon emissions throughout the project's lifecycle. A CMS is a flexible management system that is reviewed and updated regularly to ensure it remains effective and relevant. It is vital for organisation and project leadership to prioritise carbon management and integrate it into all decision-making processes, to capitalise on the early-stage opportunities for carbon reduction and maximise efficient delivery. All individuals and organisations involved in the GUC SRO project would have roles to play in ensuring the accuracy of carbon reporting and in striving towards the goal of net zero carbon emissions.

Within the CMS the leadership and governance section would outline who is responsible and accountable for managing carbon across the GUC SRO project. Establishing clear responsibilities and accountability would create a well-defined process for addressing issues. This process should be integrated into the existing management systems. Regular reviews of how the CMS is governed should be conducted, maintaining an open channel for feedback. Such a collaborative approach can enhance the system and carbon management practices, promoting teamwork.

The leadership and governance structure plays a crucial role in ensuring that implementation decisions have the most significant impact on carbon emissions. The CMS the provides oversight of governance responsibilities held by leaders who are empowered to direct actions in alignment with carbon reduction objectives. It is critical that carbon considerations are heavily weighted and prioritised in all decisions throughout the GUC SRO project. The CMS governance structure is to ensure that reducing carbon emissions is prioritised within decision making whilst balancing other project goals and objectives.

14.5 ASSURANCE AND DATA COLLECTION

A strong assurance process provides the GUC SRO with the necessary level of confidence that the WLC inventory is complete, accurate, consistent, transparent, relevant, and without material mis-statements[12]. Enhancing internal carbon accounting and reporting practices generate the opportunity for greater stakeholder engagement and sharing of reported information. Outlining a clear internal and external audit trail system allows for the disclosure of any relevant assumptions and appropriate references to the accounting and calculation methodologies and data sources used. The assurance framework built into the CMS supports the assessment of future projects that can be implemented to reduce carbon emissions by:

- Helping identify the eligibility criteria for carbon reduction interventions and clarifying the expected carbon impact as a result.
- Explaining the measures put in place to track the carbon performance of the single assets within the GUC SRO and enabling comparison of carbon emissions; and
- Developing a methodology for evaluating an asset's carbon emissions against its baseline to inform the selection of future similar projects.

14.6 ROLE OF THE SUPPLY CHAIN

The supply chains play a crucial role in providing resource information associated with project delivery such as: materials, components, and equipment, all of which can impact the GUCT's WLC emissions. Working closely with supplier chains, to raise awareness and educate on best procurement practices, is vital to take informed low carbon decisions through the project lifecycle. Suppliers should be encouraged to adopt transparent sustainability targets and key performance indicators (KPIs), implement changes, measure progress, and provide regular updates, to both support the GUCT project and its clients' goals and ambitions.

There is an upward trend of including more specific information relating to climate change and Net Zero targets within procurement and contracts. It is recommended that the GUCT project incorporate Net Zero targets into their procurement processes and use digital systems for tracking supply chain emissions. Proactive procurement actions can positively influence suppliers to reduce their GHG emissions at different gateway stages of the project. Setting GUCT interim or milestone targets throughout the delivery stages for suppliers to meet or exceed can be further supported by incentives or disincentives within commercial arrangements. These procurement and commercial arrangements are to better manage supplier delivery, providing clear responsibilities and timelines for data reporting preferably via digital systems; and use of performance management and targets within contractual conditions with direct financial impacts based on carbon performance, such as a pain/gain share mechanism for meeting or failing specified targets. To enhance supply chain transparency and monitoring, digital systems should be used to track and automate data, focusing on a 'data from source' approach for detailed reporting on fuel consumption, water usage, etc. This approach increases traceability and assists in emission reduction, potentially leading to certification that validates GUC sustainability commitments.

14.6.1 Procurement & PAS 2080:2023 (Clause 10)

PAS 2080:2023 specifies WLC management in buildings and infrastructure, providing a structured framework for organisations within the value chain to effectively manage and reduce carbon emissions. This fosters collaboration, enhances transparency, and helps

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[12] Adapted from ISO 14064-3 "specification with guidance for the validation and verification of greenhouse gas assertions" (2005) Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf (ghgprotocol.org)

meet client and governmental requirements. The procurement process, guided by ISO 20400 and PAS 2080:2023, plays a pivotal role in driving carbon reductions throughout project delivery. This includes promoting collaborative behaviours, tender selection that considers carbon management capabilities, setting clear targets, establishing meaningful baselines, and incentivising absolute carbon reductions within a consistent framework.

14.7 INNOVATION

Innovation plays a key role in effectively integrating carbon considerations into decision-making processes. The following five key principles are provided to support GUCT's innovative efforts and reinforce commitment to incorporating carbon considerations:

- Innovation Responds to Need – Successful innovations are driven more by addressing specific needs than by technological advancements. Recognising innovation opportunities requires a deep understanding of GUCT's business needs and those of the supply chain, leading to decentralized decision-making for research and innovation.
- Align Innovation Efforts with Strategic Priorities – Align innovation efforts with the strategic priorities of your organization to select opportunities that will have the most significant positive impact on clients, communities, and our business.
- Work with the Entire Value Chain to Co-create Innovation – Innovation is most impactful when co-created with the entire value chain, encouraging engagement and co-investment to enhance relationships and reputation.
- Use Project-Based Innovation as a Platform – Innovation in practice serves as a proof of concept upon which GUCT should build. By utilising the inherent maturity of project-based innovations, GUCT can reduce investment risk and the need for supplementary investment.
- Value All Outcomes of Innovation – Every innovation necessitates investment. Recognising diverse contributions to investment places value on both the direct commercial benefits and indirect outcomes such as reputational enhancement, skills development, and strategic relationship building, all of which are crucial in fostering innovation; and
- Incorporating the following technical innovation approaches into the CMS further demonstrates PAS 2080:2023 alignment by promoting continuous improvement, precision in measurement, and the adoption of circular economy principles
- Work with the Trust and partners in Gate 4 to develop an architectural strategy and set of design requirements relating to the visual impact of any above ground structures to be located on or adjacent to the Trusts land.

14.7.1 Potential Low Carbon Innovations

When reviewing WLC in the GUCT, a carbon reduction approach in the design process must be considered, this includes assessing multiple low carbon innovation options. Whilst current design/concept models assume the 'traditional' or conservative approach in relation to carbon emissions, the innovations outlined in **Table 14-2** offer potential alternatives which will reduce embodied and operational carbon.[13]

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[13] The innovation options listed here, prioritise the hotspot areas covered in section 2.2

Innovation Category	Related Activity	Innovation Type	Details	Carbon Reduction Potential	Anticipated Reduction Impact
Steel	**Pipeline Construction, Pumping Stations, Crossings Construction**	Recycled content in steel reinforcement	Steel with higher recycled content has lower A1-A3 emissions compared to iron ore-based steel. Primary steel is made using a basic oxygen furnace (BOF) or an electric arc furnace (EAF).	BOF can use up to 30% scrap, while EAF can use up to 100% scrap. Global average scrap content is 0.376kg/kg, compared to a UK estimate of 0.94kg/kg. $kgCO_2e$/kg steel are 2.04 and 0.76 respectively.	Medium
		Procuring and specifying lower carbon steel	Choose steelwork contractors who meet RQSC requirements, hold the BCSA Sustainability Charter, and are members of SteelZero or CO_2nstructZero. Opt for companies with certified environmental management systems, responsible sourcing policies, and specific EPDs. Prefer producers committed to decarbonisation in line with net zero targets, certified by ResponsibleSteel, and/or have science based GHG reduction targets. Set carbon intensity targets for structural steel, considering both BF-BOF and EAF processes.	Primary steel can be made using a basic oxygen furnace (BOF) or an electric arc furnace (EAF). Steel with higher recycled content has lower emissions, and the EAF process is easier to decarbonise using renewable electricity.	Medium
		Reduce steel sheet piling	Sheet piles which use lighter Z section designs and combination long and shorter piles are available, which reduce the steel needed for a sheet pile wall.	Designs can save up to 35% to 40% of steel used in comparison to regular retaining wall supports.	Medium
Concrete	**Pipeline Construction, Pumping Stations, Crossings Construction, Water Treatment, Surfacing.**	Use of limestone as a supplementary cementitious material	Limestone used in producing ordinary Portland Cement (OPC) and a partial replacement in powdered form can reduce emissions by avoiding limestone calcination when added raw to blended cement or during concrete production. Optimal limestone replacement refines concrete pore structure, enhancing durability. Commercially available Portland cements typically contain up to 5% limestone, with variants like CEM II/A-L, CEM II/B-L, and CEM II/A-LL, denoting high purity limestone cements.	Limestone is naturally abundant in the UK - no long-term supply chain constraints. Use can result in embodied carbon reduction. From Inventory of Carbon and Energy database v3 published in 2019 for cement: - UK average cement mix: 0.832 $kgCO_2e$/kg - CEM I OPC: 0.912 $kgCO_2e$/kg - CEM II/A-L & CEM II/A-LL - 13% limestone: 0.799 kgCO2e/kg - CEM II/B-L & CEM II/B-LL- 28% limestone: 0.664 kgCO2e/kg	High
		Bio-Cements	Bio-cements are produced by specialised bacteria which secrete cementitious materials in mimicry of natural systems such as coral reefs. These are not bulk cements but used with normal cements to promote crack healing (self-healing concretes).	Carbon reduction is from longer service life from use of such products.	High
		Calcium sulphoaluminate cement (CSA)	SAC is known as a low energy and carbon cement as it can be produced at lower temperatures, lower lime content and improved grindability compared to OPC. It can be used in conjunction with Portland cement.	Compared with standard cement preparation, CSA processing emits less than half the CO_2 (less than 20% in some cases) because the level of limestone in the raw material mix is lower and the working temperature is 200 °C cooler.	High
		Concrete admixtures	Admixtures are used to both increase workability and reduce the water/cement ratio, and hence increase strength and reduce permeability of hardened concrete, without increasing cement content. Chemical admixtures can reduce the cost of construction, modify properties of hardened concrete, ensure quality of concrete during mixing/transporting/ placing/curing, and overcome certain emergencies during concrete operations.	When considered appropriately, admixtures can reduce the cement content required in mix designs, contributing to a reduction of the overall concrete A1-3 CO_2e emissions.	High
		3D printing concrete structures	Use of 3D printing techniques to produce commonly used precast concrete elements	3-D items may be more easily designed, produced, constructed and replicated, with some potential for lowering the carbon associated with manufacture and construction of the items.	High
		High strength concrete ground support linings	Use of high strength concretes potentially allows the thickness of support linings to be reduced; relatively this reduces the required amount of concrete and cementitious binder used, as well as excavation volumes.	Significant reductions in cement binder and excavation volumes from minimising liner thickness will provide a substantial reduction in carbon.	High
Plant and Equipment	**Pipeline Construction, Pumping Stations, Crossings Construction, Surfacing, Maintenance, Repair & Replacement**	Hybrid and Electric Construction Equipment	Utilising hybrid or fully electric construction machinery instead of traditional diesel-powered equipment. This includes excavators, loaders, and cranes powered by batteries or hybrid engines.	Significant reduction in emissions, potentially cutting emissions by 30-50% compared to conventional diesel equipment.	High
		Hydrogen-powered plant	Plant powered by hydrogen combustion engines could be used on our SRN instead of traditional fuel plant.	The use of green hydrogen as a zero CO_2 fuel to drive a combustion engine will remove the CO_2 released from the engine usage itself. There may still be carbon associated with the design and manufacture of the plant.	Medium
		Biofuel-Powered Machinery	Switching from diesel to biofuels (such as biodiesel or hydrotreated vegetable oil) for powering construction equipment.	Moderate to high, with potential CO_2 reductions of up to 80% depending on the biofuel source and blend.	Medium

Innovation Category	Related Activity	Innovation Type	Details	Carbon Reduction Potential	Anticipated Reduction Impact
		Remote Monitoring and Automation	Implementing remote monitoring and automated control systems to optimize equipment usage and reduce idling times.	Moderate, with potential reductions in fuel consumption and emissions by up to 20%.	Medium
		Site cabins	Implement site accommodation units with advanced insulation, energy-efficient HVAC systems, and LED lighting. Incorporate solar panels and battery storage to reduce reliance on grid power, providing essential facilities and amenities to workers on construction sites, events, and remote locations.	Medium, through significant reductions in energy use and associated emissions.	Medium
		Use of autonomous drone and ground services	Utilising autonomous drone and ground services for construction and maintenance activities network management and incident responses.	Improved incident response with improved maintenance efficiency (use of materials, resources etc.).	Medium
		Minimise erosion and run off	Excavation work can cause soil erosion and sediment runoff, which can impact nearby water sources and aquatic habitats. To prevent this, the use of silt fences, sediment basins, and erosion control blankets, should be implemented	Measures promote vegetation growth, aiding in carbon sequestration, while reducing construction site disturbance, minimising the need for additional excavation and preserving natural landforms.	Medium
		Augmented reality glasses	Augmented reality glasses, such as the ones developed by DAQRI and SCOPE, can provide workers with the necessary information on how to repair a product and best handle hazardous waste. This technology can provide remote, on-the ground interactions between experts and non-experts.	Real-time information and warnings on hazards allow safer working environment and reduce need for additional personal to physically visit the site, reducing commuter/ transport emission. Allow upskilling for site staff to learn information to reduce errors and prevent environmental incidents. Increased efficiency. Real-time feedback on excavated profile	Medium
		Right first time	Following the 5S planning and implementation methodology (sort, set in order, sweep, standardize, and sustain). Eliminating waste through better upfront planning. Equipping construction workers with the tools and capabilities to perform their tasks. Eliminating defects will reduce waste. Defects registers will show if this is BAU and highlight areas for improvement.	Reduction in impact due to shortened and more efficient construction process, and lower chance of required refurbishment or repair works before scheduled.	Medium
		Low carbon procurement	Seek to procure goods, services, works and utilities with a reduced carbon footprint throughout their life cycle and/or leading to the reduction of the overall organizational carbon footprint when considering its direct and indirect emissions.	Direct carbon reduction if assets are constructed with reduced embodied carbon materials.	High
		Advanced robotics - electrification of equipment	Construction excavation robots such as ULC Robotics, SGN elextric excavation robot. Autonomous excavation system to protect workers and residents. Combines a powerful industrial robot, an all-electric track drive system, below-ground locating sensors, artificial intelligence, machine vision, and new vacuum excavation methods for safer, faster autonomous road work projects.	Improve the efficiency/ productivity (cost savings), safety (reduce environment incidents), and lower the environmental impact and cost of utility excavations.	Medium
Transport	**Transport, Pipeline Construction, Pumping Stations, Crossings Construction**	Use of EVs	Using electric vehicles and developing on-site charging infrastructure for electric vehicles can reduce the carbon emissions associated with transportation. Mandate electric, or as minimum hybrid, vehicles on site.	EVs are responsible for considerably lower emissions over their lifetime than conventional (internal combustion engine) vehicles. Up to 66% of emissions reduced	Medium
		Optimising transport routes	HGVs set to drive at optimum times and closer together in a 'train' like convoy which reduces drag. Platooning is the linking of two or three trucks in convoy.	Truck platooning allows trucks to follow each other closely, thereby reducing air drag and improving fuel economy.	Medium
		Local procurement	Sourcing materials and services from suppliers within close proximity to the project site to reduce transportation distances and associated emissions.	Significantly reduces emissions from transportation of materials and equipment.	Medium
		Reduce staff transport emissions	Promote use of means of transport such as electric vehicles, public transport and staff cycling schemes to reduce the carbon footprint of staff transport on sites.	Carbon reductions from less vehicles being used to transport people, e.g. 20 people on a single bus is better than 20 single cars as a lot less carbon emissions	Medium
		Minimise the payload to transport vehicle weight ratio	Modern powered machinery is very heavy compared to the payload weight transported, this provides flexibility and convenience, but inherently most of the work done, and energy consumed will be from moving the vehicle rather than the payload.	Consider the installation of static conveyors and lightweight rail-based truck systems over scoop trams and dumper trucks to minimise energy usage.	Medium
		Intelligent sensor monitoring	Implementation of smart sensors and artificial intelligence (AI) to remotely monitor pumping stations, allowing for optimised maintenance schedules and efficient pump operation.	Indirect reduction through improved pump efficiency and fewer physical site visits, leading to lower overall energy use and emissions.	Medium
		High-efficiency pump replacements	Replace older, less efficient pumps with modern high-efficiency models that consume less power while maintaining or increasing capacity.	Medium to high, depending on the efficiency gains of the new pumps; can save up to 65 tonnes CO2/year per large pump installation.	Medium

Innovation Category	Related Activity	Innovation Type	Details	Carbon Reduction Potential	Anticipated Reduction Impact
Operational Power	Operational Power	Solar farm	The use of on-site renewable energy sources like wind, solar, and hydropower reduces reliance on the grid, enhancing energy security and independence. Specifically solar, utilising the water surface for a floating solar farm, could potentially generate up to 10% of the treatment works' energy needs.	Increasing the renewable energy generation reduce carbon emissions. Renewable energy sources like solar and wind power do not produce carbon emissions as part of the electricity generation process and can provide 90% of carbon reductions. If on-site produced, saves having to procure from a suitable supplier.	Medium
		Hydropower	For hydropower, energy recovery at the Atherstone discharge point and Locks 16-20 of the Stoke Bruerne Flight bypass offers local benefits. Alternatively, energy generation could arrive through Micro-hydropower	Hydropower includes potential use for recharging electric vehicles and canal boats, with an estimated annual potential of 2,700MWh based on current technology and assumed flow profiles. Micro-hydropower generation of energy form drainage outflows using miniature turbines.	Medium
		Energy assessment	Use energy performance assessments (BS EN 13201-5) and consider how the energy assessments could be set as KPI's.	Carbon reduction achieved through reduced energy demand.	Medium
		Low carbon lighting	Energy-efficient lighting, such as LED bulbs, and implementing lighting control systems provide energy savings, lower maintenance costs and reduced cooling requirements	Help reduce energy consumption and carbon emissions.	Medium
		Circular Economy	Full adoption of circular economy for products which looks to ensure equipment can be maintained, repaired, upgraded, repurposed at end of life etc.	Carbon reduction achieved through reduced energy demand.	Medium
		Low carbon heating	Electrification of heating to shift away from fossil fuel-based heating systems by adopting renewable energy source alternatives.	Emissions are shifted from fossil-fuel systems to electric heating options, so less energy is required and less carbon intensive.	Medium
		Smart metering	Move from un-metered suppliers relying on an inventory system to smart metering so the precise energy load is known	Carbon reduction reduced through accurate measurement of energy use.	Medium

Table 14-2 Low Carbon Innovations Related to Hotspots

14.8 CARBON CALCULATIONS

14.8.1 Carbon Assessment Scope

Stage	WLC Boundary	Typical Activity	Excluded	Included
Pre - Construction	A0	Land/design/consultation	☑	
Product	A1-A3	Manufacture and transport to site.		☑
Construction	A4	Transport of concrete & materials.		☑
	A4	Staff commuting	☑	
	A5	Construction		☑
Use	B1-B4	Use of facilities		☑
	B5	Refurbishment	☑	
	B6	Operational Energy		☑
	B7	Operational Water	☑	
	B8-B9	Utilisation of other processes & infrastructure	☑	
End of Life	C1-C4	Demolition and recycling/disposal etc.	☑	
Benefits beyond system boundary	D1-D2	Energy recovery/exported, re-use/recycling	☑	

Table 14-3 Carbon Assessment Scope

Although operational use carbon from electricity for pumping etc. would be reported by the site operator as a Scope 2 emissions[14] (e.g. indirect emissions for purchase of electricity from a utility company by the user) it would be reported by AfW as Scope 3. Scope 3 emissions are indirect emissions that occur in an organisation's value chain but are not directly controlled by them. They can include emissions from the transportation of goods, the use of sold products, and the generation of electricity by suppliers (see 14.2.1).

14.8.2 Carbon Calculation Methodology

At Gate 3, AfW provided their carbon modelling tool for use in building up the scheme carbon calculations. The same quantities used in generating the scheme costs were run through the model (see Figure 14-4) to generate the construction and operating carbon values for each scheme component (e.g. pumping stations). These values were then given the same asset category as their corresponding CAPEX value and run through the same process as the cost data to generate the Whole Life Carbon. The main differences in generating the carbon and CAPEX tables were:

- OB not applied to carbon values.
- No discounting factors applied to construction or replacement carbon values.
- Electricity emission factors (i.e. Commercial Public Section “Grid Average” from Table 1 BEIS modelling data tables 1-19) applied to energy use.

[14] Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf (ghgprotocol.org)

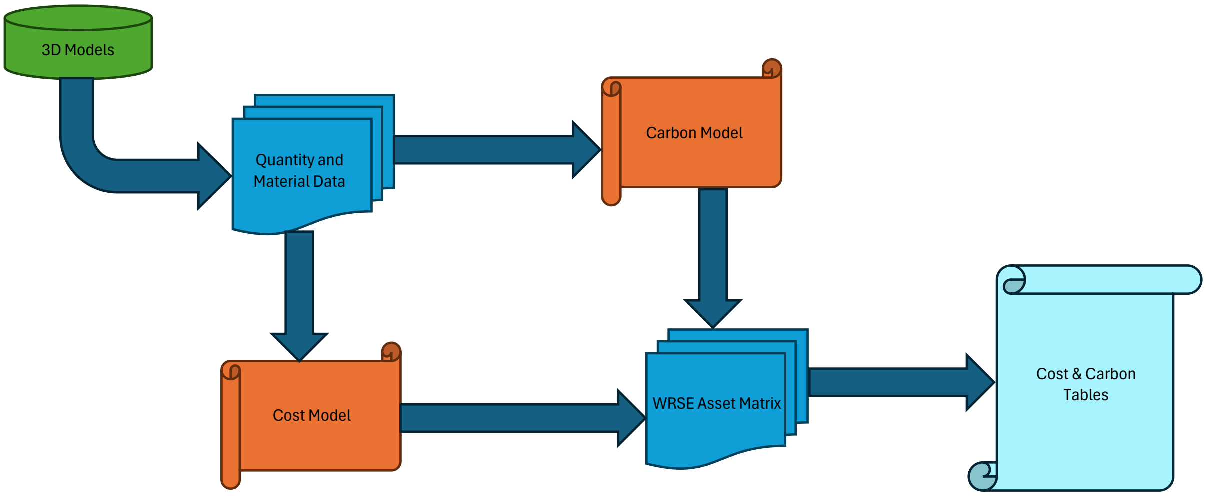

Figure 14-4 Carbon & Cost Calculation Flowchart.

At this stage of the Gate 3 process there are still multiple options available and no confirmed site layouts. Carbon estimates, in line with the cost estimates, are therefore subject to large uncertainties that will require further refinement at Gate 4. These uncertainties are linked to the following:

- Ground conditions – these will influence suitable material choices, extent of temporary works, extent of ground remediation (if any), foundation size, structural loading etc. Ground investigations will be required at Gate 4.
- Site location and environmental – this will influence access length and type of access and potential remediation/compensation/BNG work etc. Data from the EIA process will be required at Gate 4.
- Site selection and agreed land availability – this will influence bankside storage and water treatment site construction volumes (e.g. excavated and imported material volumes). Following consultation and site selection, carbon and cost calculation will need to be updated.
- Pipeline route selection – this will influence construction material volumes (e.g. pipeline depth, length etc.), proportion of open-cut to trenchless construction methods, and topographical impacts (e.g. pumping heads, support/thrust restrain, slope stability etc.). Detail route surveys will be required at Gate 4.
- Procurement strategy – a carbon strategy is being developed.
- Operating strategy – this will have a major impact on canal bank and storage once the extent of the work is agreed.

The work at Gate 3 has therefore been to concentrate on developing generic “concepts” for pumping stations, bypasses, storage and process units that can be used to generate quantities for assessment. These generic concepts will need review in Gate 4 to confirm they are applicable in the locations that will be taken forward into the planning application and procurement processes.

In developing these generic layouts some site-specific issues have been included that differentiates the sites, both in costs and carbon. The following figures illustrate this point:

Figure 14-5 shows variation in embodied carbon for a selection of pumping station sites. The variations are driven by:

- Number of locks to bypass – Hillmorton pumping station will need to bypass three sets of locks and therefore the embodied carbon is higher because of the length of pipeline required.
- Associated site/compound assets required – any pumping station located on a water treatment site (e.g. Site B) would not need the same level of site work (e.g. would not need a separate access or security facilities etc.)
- Complexity and size of non-civil works – for example at Hawkesbury and Fenny Stratford the pumping stations only need to lift over a small height difference around one lock structure whereas the abstraction pumping station requires screening and lifting flows into the bankside storage.

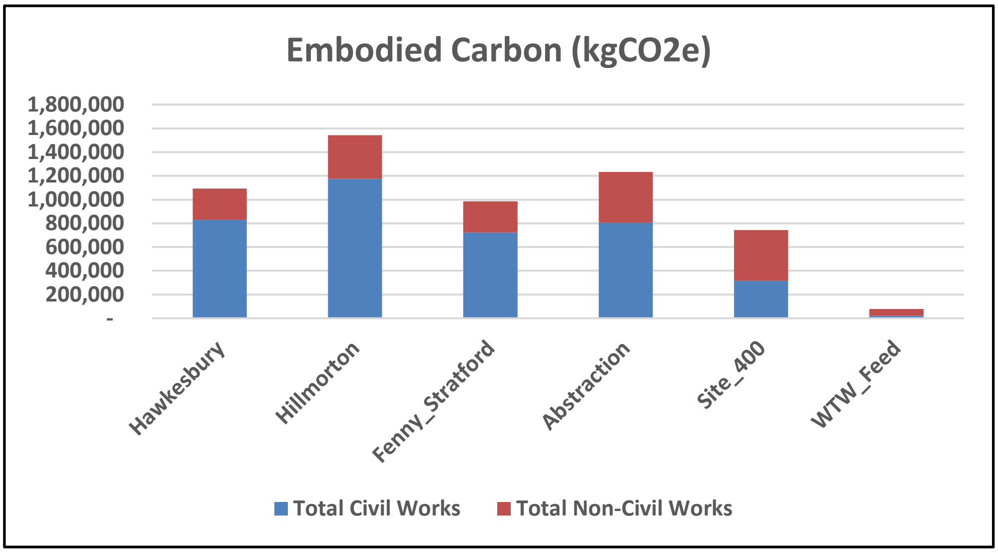

Figure 14-5 Carbon Comparison of a Selection of Pumping Stations

Figure 14-6 shows variations in embodied carbon for the gravity bypasses. The variations are driven by:

- Access restrictions – Cosgrove and Lock 10 are further away from existing access points and will need significantly longer new access track construction regardless of the access route selected.
- Bypass length – bypasses at Lock 7, 8 and 9 only bypass a single lock and therefore the bypass pipeline will be significantly shorter that those required for Locks 10, 12 and Locks 16-20 of the Stoke Bruerne flight, regardless of the routes selected.

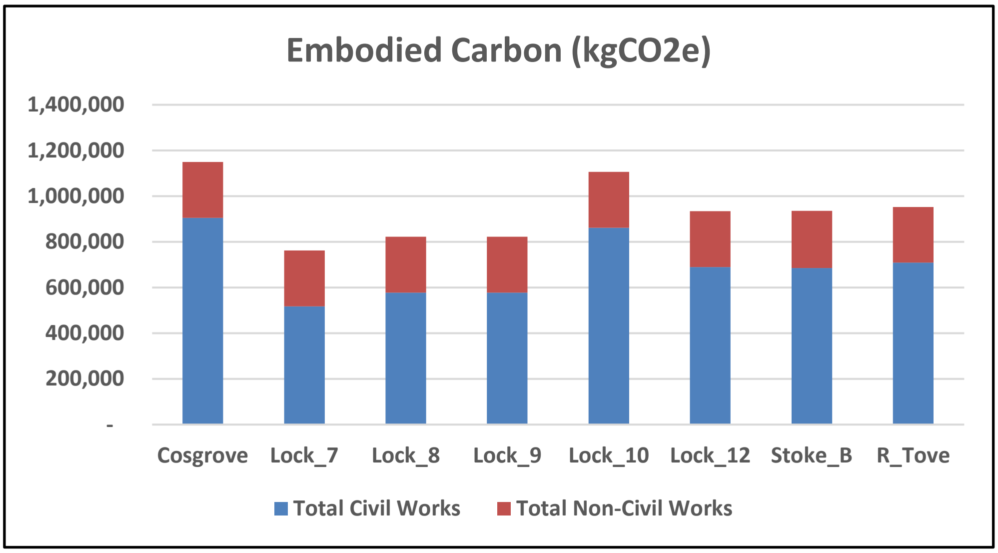

Figure 14-6 Carbon comparison of Gravity Bypasses.

14.8.3 Carbon Calculation Summary

The carbon summary is given in Table 14-4 and can be compared to the summary from Gate 2 in Table 14-5.

Component	Construction (tCO_2e)	Replacement (tCO2e)	Operation (tCO2e)	Whole Life (tCO2e)
Discharge	1,939	1,463	0	3,402
Canal	37,563	38,115	310	75,989
Abstraction	1,554	1,199	266	3,019
Storage	23,026	6,861	1,711	31,598
Treatment	71,810	236,585	954,405	1,262,800
Distribution	12,467	3,058	2,423	17,947
Total	**148,359**	**287,281**	**959,115**	**1,394,755**

Table 14-4 Gate 3 Carbon Summary

The values have not changed significantly from Gate 2, as base quantity data is similarly based on generic concept layouts in both cases, but the main differences can be summarised as:

- Canal bank raising lengths, and therefore material required, has increased based on updated hydraulic model results.
- Storage now includes additional 6 days capacity provided by Drayton and Daventry (D&D) Reservoirs. The use of D&D now requires pumping up into the reservoirs and therefore storage has increased operational carbon (at Gate 2 operational carbon was included in the abstraction component for pumping into the bankside storage only).
- The Gate 2 location for bankside storage was in an areas of historic sand extraction (i.e. quarry) and subsequent unknown landfill use. The carbon estimate therefore included significant allowance for disposal of potentially contaminate material, land remediation (e.g. vibrated stone columns) and import of clean material for embankment construction. The current sites being

considered do not have these issues and therefore have a much reduced construction carbon estimate.

- The site considered at Gate 2 (no longer available) had the storage and treatment works elevated above the abstraction point. Sites being considered at Gate 3 have significantly reduced or zero elevation difference between abstraction and bankside storage.
- The treatment works design has developed based on a flat generic site layout. This requires significant interstage pumping (the Gate 2 site layout followed the land contours). The process detail has also developed. The operating carbon is, as at Gate 2, dominated by chemical use. Therefore, although the construction and replacement carbon has increased (i.e. more pumps and process units to construct and replace) the overall Whole Life Carbon is similar due to reduction in chemical use.

Component	Construction (tCO_2e)	Replacement (tCO2e)	Operation (tCO2e)	Whole Life (tCO2e)
Discharge	1,959	551	0	2,510
Canal	28,673	41,360	10,743	80,776
Abstraction	1,959	1,335	17,098	20,392
Storage*	53,783	6,307	0	60,090
Treatment	45,752	145,336	1,033,122	1,224,210
Distribution	16,305	2,075	341,269	359,649
Total	**148,431**	**196,964**	**1,402,232**	**1,747,627**

Table 14-5 Gate 2 Carbon Summary

NOTE: - Only 5 days storage was considered at Gate 2, therefore Drayton & Daventry (D&D) was not part of the Gate 2 scheme.

14.8.4 Hot Spots and Uncertainties

Discharge Point

Most of the construction carbon for the discharge is linked to creating the weir connection into the canal (46%) and the structure for the pipes and control valves (26%).

The main uncertainty is related to location and the upstream work. In creating the carbon and cost estimates access to the site will be created as part of the upstream pipeline work to avoid double counting. The layout will need updating once a site location and access has been agreed.

Pumping Stations

Most of the construction carbon for the pumping stations is linked to creating the weir connections (2 no) into the canal (44%) and general site work for access, cut and fill etc. (26%).

The main uncertainties for the pumping stations are ground conditions, access and heritage considerations. Current carbon and cost calculations have a generic brick finish to buildings but this may need updating following consultation and EIA heritage review at Gate 4.

Gravity Bypass Weirs

Most of the construction carbon for the bypass weirs is linked to creating the weir connections (2 no) into the canal (57%). There are then variations depending on the site location. The more remote sites have a significant proportion of the construction carbon (e.g. up to 40%) linked with providing a new access whereas, at sites that bypass multiple locks (e.g. Locks 16-20 of the Stoke Bruerne Flight bypass) the carbon linked to the pipeline is a significant proportion (e.g. up to 34%).

The main uncertainty for gravity bypasses is the agreement for access for construction and maintenance.

Canal Work

Carbon for the canal work is dominated by the material required for raising the canal banks. The same approach as at Gate 2 has been used to calculate embodied carbon for the canal works. Additional surveys were undertaken at Gate 3 to further investigate the canal bank condition and edge type (required for refining the selection of bank raising type etc.) but these were not completed in time to update the Gate 3 carbon calculations. Additional work at Gate 4 will be required, in conjunction with the ECI team, to refine the bank raising details.

The increase in the carbon over the Gate 2 figures is wholly down to the increase in bank raising lengths following the updated hydraulic model results. There are however multiple hydraulic scenarios that would reduce the length of bank raising required (e.g. increase channel weed management, identifying and removing constrictions, operational changes etc.). These scenarios are under review as part of early Gate 4 activities. The reported carbon at Gate 3 is therefore considered a “worst case” assuming no improvement in channel hydraulics.

Abstraction

The carbon for the abstraction point will be influenced by the site selection. However, assuming a layout like that developed for Site F (i.e. canal abstraction separate from the treatment works site and therefore requiring a separate site access and compound etc.), most of the construction carbon is split three ways between access and compound (30%), civil work for the eel/fish screens (20%) and the connection to the canal (37%).

The main uncertainties are around site selection and screening requirements to be agreed at Gate 4.

Storage

Most of the construction carbon for the bankside storage is linked to the material movement required for construction of the embankments and lining (77%).

Most of the construction carbon for the existing Drayton and Daventry storage is linked to the pipeline from Braunston (66%).

The main uncertainty is around site selection that will impact quantities for bankside storage and investigations into the impact on D&D of any proposed change of use. Ground investigations at Gate 4 will be critical in assess both uncertainties.

Water Treatment

Most of the construction carbon for the treatment works is linked to the process units (69%) and pipework (21%). The design will however need to be reviewed at Gate 4.

The main uncertainty is around water quality impacts from site selection and changes in the canal over time (e.g. as Minworth water becomes more dominant etc.). Work is ongoing regarding water quality modelling and will be investigated further at Gate 4.

Transfer

The transfer is almost exclusively pipeline and therefore the construction carbon is 85% pipe laying.

The main uncertainty is the route selection. Following consultation and EIA surveys, these uncertainties can be reassessed.

CARBON STRATEGY AND SENSITIVITY ANALYSIS AT GATE 4

A carbon strategy is being prepared as part of the Gate 4 work already underway.

Following feedback from the consultation process and the survey work planned for Gate 4 (e.g. GI, additional topographic surveys, ECI review etc.) the engineering carbon calculations will need to be updated for the following categories:

- Option selection – There is still significant uncertainty regarding site and pipeline route selection and therefore it is not possible to differentiate between options based on some elements of the carbon calculations. For example, there is currently insufficient information to allow any differentiation in WTW and bankside storage layout or design at the proposed sites. Following ground investigation, one of the sites may require significantly greater foundations and therefore a higher carbon impact but this is unknown risk at this stage. Once data is available (i.e. consultation, planning, heritage, ground information etc.) to allow a shortlist selection of options, carbon calculations can be updated to help in the selection of the preferred option to take forward.

- Preliminary Design - There is still significant uncertainty regarding elements of the design (e.g. heritage requirements, ground conditions, water quality impacts on treatment chemical usage etc.) and therefore it is not possible to undertake a meaningful sensitivity analysis. For example, the choice of suitable concrete grades is dependent on ground conditions (e.g. chemical exposure, foundation extents etc.) and the selection of building style is dependent on heritage reviews yet to be undertaken. During Gate 4 a review of design requirements and standards will be undertaken, the carbon calculations can then be updated to include sensitivity analysis including material choice, construction techniques, and architectural finishes etc.

- Construction Preparation - There is still significant uncertainty regarding elements of temporary works (e.g. construction compound areas etc.), BNG and opportunities for wider benefits etc. Where these issues can be defined during Gate 4 their impacts can be included in updated carbon calculations and sensitivity analysis.

- Construction, Commissioning and Handover – These elements will need to be included in the overall strategy following option selection, design review and the wider project requirements.

15. RISKS

Risks have been quantified and costed using the same probabilistic method used at Gate 2 (i.e. follows Section 3.2 of the RICS Guidance Note – "Management of risk"[15]). This includes the estimate costs of mitigation and the expected costs if risks materialise.

At Gate 4, when a preferred option has been selected and uncertainty related to baseline data has been reduced (i.e. geotechnical, topographic, water quality etc.), a Monte Carlo assessment will be possible.

The current risk register covers all options and all locations still under review and therefore has a relatively high overall value and uncertainty. For this reason, the risks have been sub-divided into scheme elements (e.g. Discharge, Abstraction, Storage etc.) and further sub-divided into locations.

The sub-division of risks allows the risks to be presented in the summary Table 15-1. The full risk table is provided in Appendix K.

The following have been excluded from the assessment of risk as being outside the scope of Engineering Risks:

- Planning, EIA, stakeholder engagement etc.
- Permits, licences and approvals.
- 3rd party (e.g. ST, The Trust etc.).
- Internal AFW risks.
- Legal and Financial support.
- Tax and other liabilities (e.g. insurances, utility charges etc.).
- Commodity/Economic/Political cycles (e.g. future cost of electricity, import costs of chemicals, steel costs etc.)
- End of life risks (e.g. scrap value, decommissioning, land sale etc.)

It is assumed that these will however be accounted for in separate Gate 3 reports.

The following have been excluded from the assessment of risk as being PMB Business Risks:

- Funding risks (e.g. the ability of the project to access finance throughout the project life cycle etc.)
- Procurement risk (e.g. the impact of contract type and tender process on costs etc.)
- Performance risk (e.g. quality of workmanship requires rebuild of an element of the project etc.)
- External supply chain issues (e.g. Ever Given blockage of Suez Canal, war in Ukraine etc.)

The above either have insufficient information at this stage for the risk to be assessed or are outside the control of the project team. It is assumed that these will however be accounted for in the contingency plan developed at the wider business case level.

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[15] Management of Risk 1st Edition – Royal Institute of Chartered Surveyors 2015

How Risk is Allocated in the Gate 3 Cost Estimates

There are three broad categories of risk that have been accounted for within the estimated costs shown in Section 13. These are:

- Construction (CAPEX) Risks – these are risks associated with the known assumptions, construction methods and level of design detail used in preparing the cost estimates. Examples would be the method of bank raising assumed in a particular pound or the type of boundary reinstatement required.
- Optimism Bias (OB) – A separate allowance as a percentage (%OB) of the CAPEX and REPEX cost. Optimism bias is the systematic tendency to be over-optimistic about key project parameters, including capital costs, operating costs, project duration and benefits delivery.
- Uncertainty/Unknown Risks/Contingency – e.g. risk associated with current data gaps. These are time limited and can be removed or updated following work undertaken during Gate 4. Examples would be the extent of contamination at sites requiring specialist treatment or a change in pipeline route following consultation. These risks are captured in a separate risk log and where appropriate they would either influence the level of %OB used (see ACWG Cost Methodology Section 3[16]) or be used to determine the level of detail required at Gate 4 to remove/mitigate the risk (e.g. the extent of ground investigation to be undertaken).

The interaction between risk, optimism bias and contingency

After an assessment of the potential risk and optimism bias costs active decisions can be made to invest time and money in reducing these (e.g. additional surveys and investigations etc.) or specified sums can be put aside as contingency to respond if risks materialise etc. The setting of contingency planning and budgets is assumed to be part of the overall business plan and therefore not covered in this report.

How Risk Has Changed from Gate 2

1. Construction (CAPEX) risk as a percentage of the construction items has generally reduced with the design detail improvement. For example, at Gate 2 for Abstraction the percentage was 51%. This has reduced to 34% at Gate 3. The absolute figure has however increased slightly (£1.54m v £1.43m) due to the increase in base construction cost estimate.
2. OB percentage adjustments have remained the same. Although the level of design detail has increased the key uncertainties remain broadly the same to be resolved at Gate 4 (e.g. site selection, pipeline routes, ground investigations, treatment technologies to be used etc.). Items from this category can only be removed after a detailed risk review or early contractor involvement to quantify both the risk and the likely mitigation. The contributory factors that would lead to a reduction of OB are:
    a. identification and clarification of stakeholder requirements (during and post consultation).
    b. more realistic scoping when selecting the shortlisted options.
    c. risk mitigation and management of access and environmental constraints.

[16] Cost Consistency Methodology – Technical Note and Methodology February 2022 REF 412624 | CC-400 | E

3. Uncertainty and Unknown Risks stay broadly the same. Although work has progressed to allow the designs to be improved (e.g. CFD modelling of weirs, more detailed hydraulic modelling etc.), key decisions on site selection and significant data gaps will still be required through Gate 4 to reduce the risk profiles of the scheme. The key areas to be addressed include:
    a. WTW Site location, and therefore subsequent layout and foundation assessment can commence etc.
    b. Bankside storage location, especially if different from the WTW location.
    c. Pipeline route selection, linked with WTW site selection but also there are multiple options per site selection option.
    d. Ground Investigations to update construction assumptions etc.
    e. EIA surveys.
    f. Access arrangements, especially for bank raising.

Commercially sensitive information redacted

Risk Breakdown of Gate 3 Option

	CAPEX (£)		REPEX (£)	OPEX (£)	TOTAL (£)	OB (£)		NPV (£)
Component	Risk	Construction Items			=CAPEX+REPEX+ OPEX	%OB	=%OB* (CAPEX+REPEX)	
Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Pumping Stations	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Weirs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Canal	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Storage	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Abstraction	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Treatment	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Distribution	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Summary	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
	CAPEX Total = [redacted]							

Table 15-1 Risk Allowance in Cost Estimate

The highest level of construction (CAPEX) risk is associated with the canal work. Although this work is relatively repetitive and low technology, because of the long length and sequential working restrictions, the assumptions made in building up the estimate compound relatively quickly.

The highest level of OB is associated with the Water Treatment Works. The unknowns and uncertainty identified (see Risk Log) are factored into a higher %OB allowance than the other components of the scheme.

Commercially sensitive information redacted

Risk Timeframe	Total Raw Risk (£)	Current Max EMV (£)	Current Min EMV (£)	Current Most Likely EMV (£)	Description of Main Risks Driving Total
Gate 4	[redacted]	[redacted]	[redacted]	[redacted]	Data and decision gaps.
DCO/Planning	[redacted]	[redacted]	[redacted]	[redacted]	Land required for Gate 3 layouts, access and environmental mitigation.
Contractor Design	[redacted]	[redacted]	[redacted]	[redacted]	Canal raising techniques chosen
Construction	[redacted]	[redacted]	[redacted]	[redacted]	One element of the scheme has delay (e.g. failure of commissioning)
Commissioning	[redacted]	[redacted]	[redacted]	[redacted]	Innovative technology used in design to treat raw water quality parameters delaying commissioning.
Operation	[redacted]	[redacted]	[redacted]	[redacted]	The in-operational demand is different to the assumed demand profile used in design.
	[redacted]	[redacted]	[redacted]	[redacted]	

Table 15-2 Risk Summary by Timeframe

Over 63% of the identified (raw) risk is associated with decisions and data gaps that will be actioned through the Gate 4 and DCO/Planning process before the scheme goes to tender. The Expected Monetary Value (EMV) is the outcome of looking at the impact of a risk and the likely probability of that risk occurring assuming the risk is suitably managed.

An example of the time limited risks and how these have been incorporated into the cost estimates is the identified access issues at Hillmorton Locks. The current access to the site is via a low and narrow underpass beneath the mainline railway. The raw risk would be that a new access would need to be constructed from the north resulting in significant disruption (i.e. potential temporary floating bridge to cross the canal etc.). Site review by the ECI Contractor has confirmed that, with suitable traffic management and choice of construction plant, the existing access can be used. The cost estimate therefore assumes this is the access that will be used, with suitable risk allowance for traffic management, impact on productivity (i.e. size of plant used etc.) but the residual EMV value has helped factor the OB allowance. Following Gate 4 and DCO/Planning work that is underway, land and access agreements can then progress and the OB allowance will be suitably reduced to reflect the updated risk review.

16. REVIEW OF WORK DEFINED AS NEEDED IN GATE 2 BY SCHEME PROPONENTS AND RAPID

16.1 INTRODUCTION

As reported in Section 2 above there was a range of uncertainties at Gate 2 that were proposed to be further considered during the Gate 3 studies and a set of questions and areas requiring attention set out by RAPID in their Final Decisions reports.

16.2 AREAS INTENDED TO BE ADDRESSED AT GATE 3

In Table 16-1 below these areas are specifically listed out and where responses have been made these are identified and the evidence indicated in the report and appendices. Where the areas have not been addressed or only partially addressed this is also indicated and where appropriate the work necessary to resolve the issues is allocated to Gate 4 and/or subsequent stages of development.

16.3 RAPID FINAL GATE 2 QUESTIONS AND AREAS REQUIRING ATTENTION

In Table 16-2 below these areas are specifically listed out and where responses have been made these are identified and the evidence indicated in the report and appendices. Where the areas have not been addressed or only partially addressed this is also indicated and where appropriate the work necessary to resolve the issues is allocated to Gate 4 and/or subsequent stages of development.

AREAS INTENDED TO BE ADDRESSED AT GATE 3		
ITEM	**ACTION TAKEN**	**Reference**
Land Referencing, Access and Surveys		
Site notices to be made on unregistered land requesting those with an interest in the land to make contact.	All Land Referencing work and access applications are being undertaken by the Planning team.	
Collation of information required to inform the development of the proposals and the Book of Reference.	All Land Referencing work and access applications are being undertaken by the Planning team.	
Contacting land interests to secure agreement where access is required for engineering and ecological surveys.	All Land Referencing work and access applications are being undertaken by the Planning team.	
Engaging with persons with an interest in land in accordance with s 42(1)(d) of the Planning Act 2008	All Land Referencing work and access applications are being undertaken by the Planning team.	
Planning, Operation and Control		
A more detailed concept to be developed giving the configuration of the operating and control system to allow all elements to be able to operate at a range of flows to suit demands from AfW to be further investigated.	Technical note was produced but responsibility for developing the Operation and Control Philosophy has been taken up by Affinity Water and the Trust. A summary of the control philosophy from this work is contained in Section 4 and has been reflected at high level into the concept designs for pumping stations and treatment works. ***To be further reviewed in future stages.***	Section 4.5
Phasing options have not been studied in depth as there remains significant uncertainty around demand patterns. Additional work with AfW to review the impact of strategic operating decisions will be required.	Engineering team has been instructed to focus on a single phase as the current modelling from WRSE are reported by Affinity Water shows that it is likely that the full scheme will need to be available as early as possible. ***Options remain to be determined by the Trust and Affinity Water such as delaying any canal bank modifications until after the scheme has commenced work and making only strictly necessary modification as proven by operation.***	Section 13
Further assessment at Gate 3, preferably including input from an Early Contractor Involvement (ECI), will allow the preparation of a costed Monte Carlo appreciation of residual risks to replace the Optimism Bias allowance.	This work has been delayed as the scheme is still in option comparison stage prior to consultation to allow a preferred site to be proposed. ECI has been engaged to consider access constraints along the canal only. ***Costs to be further considered for reduction of OB when preferred scheme is agreed.***	

AREAS INTENDED TO BE ADDRESSED AT GATE 3		
ITEM	**ACTION TAKEN**	**Reference**
The choice of whether the works should be consented through Development Consent Order (DCO) or the more conventional Town and County Planning Act (TCPA) approach is still under review.	Affinity Water and Planning and Legal Advisors have determined that the scheme shall be consented through DCO process and all work is being done on this current assumption.	Section 1.4
Confirm integration of Minworth Pumping Station with Minworth Treatment Works extension.	This now in scope of Minworth SRO Engineering Team. Refer to Jacobs' report.	Jacobs Operational Philosophy Report (in Appendix A to the Minworth STO Gate 3 Annex A1)
Working with the ECI contractor to establish the least risk programme of works.	This work has been delayed as the scheme is still in option comparison stage prior to consultation to allow a preferred site to be proposed. ECI has been engaged to consider access constraints along the canal only. ***Programme to be further considered for optimisation when preferred scheme is agreed.***	Section 10
Pipeline Routes		
Further refinement of the routes will be undertaken for Gate 3 based on a range of variables such as length, energy requirement, material type, pressure rating, carbon budget, capital cost etc.	The Minworth Atherstone pipeline is now in scope of Minworth SRO Engineering Team. Refer to Jacobs' report. Whilst the location of the treatment works is still under consideration further optimisation of pipelines for all the route options is still to be undertaken.	Jacobs Operational Philosophy Report (in Appendix A to the Minworth STO Gate 3 Annex A1)

AREAS INTENDED TO BE ADDRESSED AT GATE 3		
ITEM	**ACTION TAKEN**	**Reference**
At Gate 3 early engagement with HS2 and the utilities companies will be required to accurately plot a route from Minworth to Atherstone.	This now in scope of Minworth SRO Engineering Team. Refer to Jacobs' report.	Jacobs Operational Philosophy Report (in Appendix A to the Minworth STO Gate 3 Annex A1)
More detailed, field-based survey will be used during Gate 3 studies to make the next stage of assessment to allow the route, necessary mitigations and costs to be confirmed. This will require consultation with the relevant stakeholders (e.g. Natural England etc.) before final quantities can be agreed.	The Minworth Atherstone pipeline is now in scope of Minworth SRO Engineering Team. Refer to Jacobs' report. Whilst the location of the treatment works is still under consideration further optimisation of pipelines for all the route options is still to be undertaken	Jacobs Operational Philosophy Report (in Appendix A to the Minworth STO Gate 3 Annex A1)
Engagement with HS2 design teams to agree crossing point and constraint details.	This now in scope of Minworth SRO Engineering Team. Refer to Jacobs' report.	Jacobs Operational Philosophy Report (in Appendix A to the Minworth STO Gate 3 Annex A1)
Discharge Point		

AREAS INTENDED TO BE ADDRESSED AT GATE 3		
ITEM	**ACTION TAKEN**	**Reference**
The final position will be fixed based on Gate 3 detailed studies of ground conditions, local bathymetry and any velocity constraints.	Discharge point location now in scope of Engineering Team for Minworth SRO and DCO team. Concept design of layout of discharge point completed ***(subject to location***)	Section 5
Include further evaluation of energy recovery options (e.g. potentially more efficient turbine types and arrangements) can be developed.	A review of options has been undertaken and reported on, but final selection of equipment will depend to some extent on proximity to grid connection. ***To be reviewed when site selected.***	Section 5
Canal		
A more detailed model is being developed by Hydraulic Consultant (using Aquator and Flood Modeller) for use in the design of the preferred option at Gate 3.	Model has been developed but remains under development. Refer to Hydraulic Consultant report	GUC SRO Gate 3 Annex A4.2 Hydraulic Modelling Report
Sites have been selected by inspection of local mapping and are not supported by any detailed studies which will be carried out in the Gate 3 study period.	Land availability is to be confirmed when preferred scheme is proposed by others after consultation. ***To be further considered in liaison with Planning and Environmental teams in future stages.***	
Canal bypass pumping stations; the arrangement of pumps to achieve the required range of flows efficiently will be investigated further at Gate 3, to include:	Pumping station layouts have been concept designed and drawings prepared. Pumps have been sized based on assumed transfer pipeline dimensions and route. ***To be reviewed and revised by suppliers when duties/pipe routes confirmed.***	Section 6
Confirm strategy of fixed, dual or VSD pumps.	Pump arrangements and pump types have been selected based on current information. ***To be reviewed and revised by suppliers when duties/pipe routes confirmed.***	Section 6
Confirm layout and design. At Gate 3 various alternative layouts can be evaluated once land availability is confirmed.	Land availability is to be confirmed when preferred scheme is proposed by others after consultation. ***To be further considered in liaison with Planning and Environmental teams in future stages.***	
Modelling of flow patterns such as pump on and off levels.	Pump arrangements and pump types have been selected based on current information. ***To be reviewed and revised by suppliers when duties/pipe routes confirmed.***	Section 6

AREAS INTENDED TO BE ADDRESSED AT GATE 3		
ITEM	**ACTION TAKEN**	**Reference**
Gravity bypass design studies will be needed to revisit assumptions in line with the findings from the Hydraulic Consultant model which is being undertaken at Gate 2.	Intak/outlet and pipeline layouts have been concept designed and drawings prepared. based on assumed transfer pipeline dimensions and route. ***To be reviewed and revised pipe routes confirmed***	Section 6
Consultation with the Local Planning Authority will be required at Gate 3 for agreement on constraints around listed structures.	Initial consultation with the Trust's Heritage team has indicated low risk of significant constraints**. To be reviewed when formal consultation is undertaken with LPA.**	Section 6
Surveys to confirm construction type and potential for habitat creation.	Environmental services are out of Engineering scope and will be led by Planning and Environmental teams.	
Engagement with landowners for access and discussion regarding habitat creation.	Consultation services are out of Engineering scope and will be led and provided by DCO and Planning Team	
Potential additional access options have been identified (e.g. potential connections to adjacent footpaths etc.) that could be investigated at Gate 3.	Consultation services are out of Engineering scope and will be led and provided by DCO and Planning Team	
Confirm towpath design with the Trust and agree management (e.g. planting shelves and dredging) along different lengths. Stakeholder engagement at Gate 3 to confirm proposed construction methods and locations.	This work has remained in abeyance as the scheme development remains at a high level with cost and carbon assessments being used for comparison purposes only as noted in Section 12 and 13. ***To be further considered when preferred scheme layout is adopted***	Section 11 and Section 12
Investigation of material supply volumes required and specifically availability of sufficient suitable timber.	This work has remained in abeyance as the scheme development remains at a high level with costs and programme assessments being used for comparison purposes only as noted in Section 11 and 12. ***To be further considered when preferred scheme layout is adopted***	Section 11 and Section 12
Bankside Storage and Treatment		

AREAS INTENDED TO BE ADDRESSED AT GATE 3		
ITEM	**ACTION TAKEN**	**Reference**
To balance the potential volume required for storage with the abstraction and treatment capacity, it has been assumed the provision of 5 days storage would suffice in a single element (i.e. not split into multiple storage elements), requiring a useable volume for the reservoir of 575 Ml (575,000 m^3.). The wider need for storage will need confirming with AfW.	Work by others has confirmed that additional storage is required. AfW have instructed that 11 days of full flow rate (115Mld) storage will be sufficient with 6 days storage to be provided by changing operating mode at the Trust's Daventry and Drayton reservoirs. Design work to allow transfer of water to the reservoirs and to safely return the water when needed has been done. ***When the operational philosophy is approved some review may be necessary.***	Section 7.
Treatment Works Process optimisation following Gate 3 water quality modelling.	Treatment works process train has been extensively reviewed based on available data. ***As more WQ data become available the process train may need review***. EPC will ultimately be responsible for treatment plant performance.	Section 8.
At Gate 3, using updated water quality parameters, the type of chemicals used and dosing volumes will be investigated further.	Reviewed and revised in accordance with process train review. ***As more WQ data become available the process train may need review***. EPC will ultimately be responsible for treatment plant performance.	Section 8
At Gate 3, alternative processes, media and chemicals will be evaluated.	An outline assessment of alternative processes has been undertaken but final decisions will depend on the future water quality assessment and the EPC designer.	Section 8
General and Project Wide Actions		
At Gate 3, engagement with specialist concrete suppliers to maximise the carbon saving of using low carbon concrete.	This work has remained in abeyance as the scheme development remains at a high level with cost and carbon assessments being used for comparison purposes only as noted in Section 13. ***To be further considered when preferred scheme layout is adopted***	Section 12
Site Specific FRA.	Undertaken for all potential abstraction, reservoir and treatment works sites.	Section 7, and detailed reports in Appendix G.
Consultation for construction work access and pipeline routes with landowners.	On hold largely, with work to be done by DCO team when preferred sites selected following consultation.	
Stakeholder engagement with landowners.	On hold largely, with work to be done by DCO team when preferred sites selected following consultation	

AREAS INTENDED TO BE ADDRESSED AT GATE 3		
ITEM	**ACTION TAKEN**	**Reference**
At Gate 3 the potential for using the scheme for local flood alleviation could be investigated.	As part of the Operational Philosophy development lead by Affinity Water and the Trust it has been instructed that the system should be designed to operate to not amend existing flood risk. ***To be further considered during later stages when digital twin allows further investigation of control sensitivity***	Section 4, Table 4.2
At Gate 3, through consultation with the Trust (canal safety), the Environment Agency (work around the River Ouzel) and specialist contractors (construction staff safety) alternative construction methods with lower WLC impacts can be investigated.	The ECI review is currently still under way and no reporting is yet available. Until there is a preferred scheme following consultation and adoption of necessary modifications from the consultation this activity cannot proceed. ***To be further considered when preferred scheme layout is adopted.***	
At Gate 3 the following technologies and their potential application on site will be evaluated further: – water source heat pumps, – algae harvesting, – photo voltaic floating cells.	This work has remained in abeyance as the scheme development remains at a high level with cost and carbon assessments being used for comparison purposes only as noted in Section 13. ***To be further considered when preferred scheme layout is adopted***	Section 12
At Gate 3 more detailed layouts and evaluation of alternative materials (e.g. Glulam structural frame versus steel) and the potential for sequestering will be investigated.	This work has remained in abeyance as the scheme development remains at a high level with cost and carbon assessments being used for comparison purposes only as noted in Section 13. ***To be further considered when preferred scheme layout is adopted.***	Section 12

Table 16-1 Statement of resolution of Areas Intended to be Addressed at Gate 3

RAPID FINAL GATE 2 QUESTIONS AND AREAS REQUIRING ATTENTION			
ITEM	**DESCRIPTION**	**ACTION TAKEN**	**REFERENCE**
Priority Action			
1	Evidence of efficient spend	Affinity Water's action.	
Actions to be addressed in Gate 3			
1	Solution Design. Confirm it is in accordance with ST and AfW WRMP and Regional Plans	Affinity Water's action.	
2	Solution Design. Provide updates on design to Environment Agency regarding design and operation of storage in scheme.	Affinity Water's action	
3	Evaluation of Costs & Benefits. Update Natural Capital Assessment so valuation of ecosystem benefits are comparable. Rationale for scoping out recreation and requires additional explanation and amenity enhancement should be assessed quantitatively.	Not in Engineering Team scope, but work in abeyance until preferred scheme has been selected following consultation. ***To be reviewed by Planning, Environmental and Engineering team in future stages.***	
4	Programme & Planning. Risk remains from the potential impact on water quality and compliance with the Water Framework Directive and environmental standards. Mitigation to reduce this risk is planned in the form of further modelling, monitoring and trial treatment programmes. Delivery of this mitigation should be completed by December 2023. For the treatment programme this means that the bench trial package should be completed by this date, to allow time for unresolved risks to be managed by the end of gate 3	The bench trial test has been completed but did not start until December 2023 as a suitable laboratory, capable of measuring to the required Level of Detection, was not available. The bench trials have demonstrated the relative treatability of the current water quality taken from GUC near Grove Lock but risks remain regarding the acceptability to the Environment Agency of discharge of the proposed quality of the source water and the acceptability to the DWI of the resultant treated water quality. ***Further monitoring, modelling and pilot plant testing will be required when the abstraction location is fixed and when the regulators determine the acceptable risk profile.***	Section 8

RAPID FINAL GATE 2 QUESTIONS AND AREAS REQUIRING ATTENTION			
ITEM	**DESCRIPTION**	**ACTION TAKEN**	**REFERENCE**
5	Programme & Planning. Further engage with Ofwat regarding the proposed commercial arrangements – specifically the approach to delivering the required work to the Canal & River Trust's assets. We expect that for gate three you will also be carrying out market engagement on the approach and would like you to engage with RAPID on feedback from the market prior to gate three. Review technical discreteness assessment following Ofwat's forthcoming consultation on updated guidance and provide an updated assessment.	Affinity Water's action. A commercial adviser has been commissioned by Affinity Water and early market engagement has been undertaken in May 2024. Feedback in respect of work on the Canal & River Trust's assets has primarily been about closer definition of the work being required and concern regarding access. There is some opportunity to reduce the work to the canal and thereby reduce risks relating to riparian owners. ***To be reviewed by Affinity Water, Canal & River Trust, Hydraulics Consultant, Planning, Environmental and Engineering team in future stages.***	Section 6.2.2
6	Environment: Protected species (notably including water voles) surveys to be included in further assessment work. Consultation with the Environment Agency and Natural England on scope of surveys is necessary. Potential impacts on habitats and features of Local Wildlife Sites which the scheme has the potential to impact should be investigated in gate three. Develop the Water Framework Directive assessment with further monitoring and updated River Basin Management Plan data.	This work is now in the Environmental Consultant's scope and surveys (including water vole surveys) have informed the hydraulic modelling and assessment. ***Further monitoring and mitigation designs will be required, led by Planning and Environmental consultants in liaison with the Engineering team.***	

RAPID FINAL GATE 2 QUESTIONS AND AREAS REQUIRING ATTENTION			
ITEM	**DESCRIPTION**	**ACTION TAKEN**	**REFERENCE**
7	Environment. Further investigation into sediment mobilisation is necessary Investigate the correlation between sediment mobility with the release of contaminant into the water through the operation of the transfer scheme causing sediment disturbance. Refine hydrological modelling of the Grand Union Canal, as per Final Modelling Report recommendations and through engagement with the Environment Agency, to better understand potential impacts. Refine Water Quality Modelling, as per recommendations in the Point of Discharge WQ Assessment and through engagement with the Environment Agency, to better understand potential impacts.	These aspects are not in Engineering team scope and Hydraulics consultant is responsible for all. Sediment mobility due to the operation of the transfer is understood from the modelling to be low impact since the routine operation of locks and barge motors expose the canal water and sediment to higher shear flows/mobilisation flows than the gentle transitions caused by the controlled modulations of the transfer. ***WQ modelling by Hydraulics consultant will need further assessment when the final treatment process at Minworth and the preferred location of abstraction are agreed. Engineering team may need to revise potable water treatment process.***	
8	Environment. Investigate pollution risk and potential impacts from various scenarios causing pollution events in gate three.	These aspects are not in Engineering team scope and are being dealt with by the Trust, Affinity Water and Hydraulics consultant. Initial considerations indicated that pollution events in the canal are low frequency and low impact. Bankside storage of 5 days at full flow rate should provide significant protection to the system when allied to water quality monitors in the canal. ***Will need further assessment of the risk of pollution inputs when the location of the abstraction is finalised and further assessment of the sensitivity of the potable water treatment process to a range of pollution taking account of operational rules and the Trust's arrangements for dealing with pollution.***	

RAPID FINAL GATE 2 QUESTIONS AND AREAS REQUIRING ATTENTION			
ITEM	**DESCRIPTION**	**ACTION TAKEN**	**REFERENCE**
9	Environment. Continue to investigate areas of INNS risk. Engage with the Environment Agency for scope of this work. Provide evidence to confirm treatment process will eliminate INNS from discharge into the canal.	This aspect is in the scope of the Minworth SRO. The Minworth WwRC report show that the risk of INNS transfer is low with the process provided to treat pre-screened recycled water and a biological/chemical treatment train which should reliably eliminate organic matter and flora/fauna. Refer to Jacobs' report.	Jacobs' report (A7W13155-DM-REP-10035, June21 2024)
10	Environment. Recommendations made by the Environment Agency and Natural England through gate two engagement should be used to inform gate three environmental work.	The Environment and Planning Teams have been engaging with the National Assessment Unit to ensure appropriate input to the design and focus of the studies.	
11	Environment. Improve the carbon assessment through clearer presentation on cost estimation and evidence thereof, and costs being mitigated by focussing on carbon. Uncertainty range, and mitigation, is expected to be presented in future assessments.	Cost and carbon assessment work is still at a high level while the scheme options remain at a comparison stage. Discussion of the best areas for managing carbon at minimum cost is included in Section 12. ***This work will be further extended with more detail in future stages when the preferred scheme is selected following consultation***.	Section 11 and Section 12
Recommendations			
1	Solution Design. More detailed utilisation profiles should be provided at gate three. Uncertainty and assumptions with utilisation profiles should be made clear.	Affinity Water has reported on the latest regional modelling (WRSE and WRE) modifying the gate two utilisation profiles. The intention remains to have a low tickover flow all year, governed by the minimum flow requirement of the transfer element most sensitive to flow (biological treatment process at Minworth). For higher demand periods, June to September, the flow will be gently ramped up over May to summer flow rates and gently ramped down over October. These are currently expected to be Normal Year 60Mld, Dry Year 80Mld and Drought Year between 100 and 115Mld. These Normal Year profile is used in the assessment of operating costs and carbon. Uncertainties about the actual frequency of Dry and Drought Year flow rates and durations will always remain.	Section 4.5

RAPID FINAL GATE 2 QUESTIONS AND AREAS REQUIRING ATTENTION			
ITEM	**DESCRIPTION**	**ACTION TAKEN**	**REFERENCE**
2	Solution Design. Acknowledgement of Level of Service is recommended for future submissions. The Level of Service against which the water resource benefit is calculated should be explained.	Affinity Water is responsible for assessing end reporting on the water resource benefit in their Water Resources Management Plan. The resource benefit in DO terms is currently estimated from the Affinity Water system resource model at 100Mld at a 1 in 500 AEP drought Level of Service.	
3	Solution Design. We would like to see evidence of proactive engagement with the Forestry Commission on solution design and site location.	Engagement with third parties is not in scope of Engineering team and is being undertaken by Planning and Environment teams. Original site and route searches have avoided all ancient and Forestry Commission woodlands.	
4	Evaluation of Costs & Benefits. Include descriptions and tables to show how cost estimates, including total planning period indicative option costs (net present value) for the preferred option, have changed between each gate. Provide more detail on how uncertainty has been taken into account when calculating deployable output	These can be included but the scheme has changed quite considerably in scope and detail since commencement and there is still not a preferred option. DO calculations are in Affinity Water's scope.	
5	Environment. Refine pipeline route in gate three to minimise potential impact on sites such as priority habitats and ancient woodland. Explore dredging as an alternative to bank raising. Provide more detail on how uncertainty has been taken into account when calculating carbon values.	Pipeline routes are associated with WTW site selection that is ongoing. Pipeline route assessment will be part of Gate 4 scope. Dredging silts back to the approximate level of the original puddle lining surface is viable and would reduce the hydraulic gradient along a canal pound. However, this is a business as usual part of canal maintenance, with a cycle of silt build up over several years followed by dredging to remove excess silt depths. As part of this process the issue of appropriate disposal of dredged material needs to be addressed. Any dredging into or below the puddle liner would likely impact on the effectiveness of the liner to retain water and could potentially increase water losses via seepage and leakage. The volume of silt available is therefore limited. Dredging as a substitute for bank raising has therefore been discounted. Uncertainty in carbon values is discussed in Section 14.8.4	

RAPID FINAL GATE 2 QUESTIONS AND AREAS REQUIRING ATTENTION			
ITEM	**DESCRIPTION**	**ACTION TAKEN**	**REFERENCE**
6	Solution Design. We recommend the solution owner continues to engage with Historic England on the work required to consider the historic environment. We recommend that the programme of planned investigations and assessments is reviewed regularly with Historic England.	Heritage is part of the EIA scope for Gate 4.	

Table 16-2 Statement of resolution of RAPID Final Gate 2 Questions and Areas Requiring Attention

RAPID FINAL GATE 2 QUESTIONS AND AREAS REQUIRING ATTENTION			
ITEM	**DESCRIPTION**	**ACTION TAKEN**	**REFERENCE**
6	Solution Design. We recommend the solution owner continues to engage with Historic England on the work required to consider the historic environment. We recommend that the programme of planned investigations and assessments is reviewed regularly with Historic England.	Heritage is part of the EIA scope for Gate 4.	

Table 16-2 Statement of resolution of RAPID Final Gate 2 Questions and Areas Requiring Attention

17. WORK TO BE UNDERTAKEN IN GATE 4

17.1 INTRODUCTION

Work to be undertaken at Gate 4 is discussed throughout the above sections but also included below as a summary:

Selection of Preferred Scheme

The current stage of scheme development still has several options under examination and consultation. Selecting a single preferred scheme will allow finer definition of many of the outstanding items listed below. The selection process is being led by the DCO/Planning Consultant.

Land Referencing, Access and Surveys

This work is to be led by others but the Engineering Consultant will need to be in close liaison to ensure that the sites are appropriate and, where modifications to the available sites are imposed, that designs take account of such imposed changes. Work to be done will include:

- Site notices on unregistered land requesting those with an interest in the land to make contact.
- Collation of information to inform the development of the proposals and the Book of Reference
- Contacting land interests to secure agreement where access is required for engineering and ecological surveys.
- Engaging with persons with an interest in land in accordance with s 42(1)(d) of the Planning Act 2008

Planning, Operation and Control

This work will be led by AfW, ST and the Trust with the support of the Engineering Consultant and Hydraulics Consultant and others. The Hydraulics Consultant is to further refine the hydraulic model and to develop a digital twin which will allow more sophisticated assessment of control options.

A more detailed concept to be developed to refine the range of operating regimes taking account of current and future situations including emergency conditions. Closer definition of the control rules and associated control system to allow all elements to be able to operate safely and effectively at a range of flows to suit demands from AfW.

Consideration by the Trust and AfW of the impact of the operating regimes on water levels and the resulting need for canal bank raising. There would be significant benefit in reducing the length and height of bank raising but this benefit needs a careful assessment of the resulting change in risk from and to the canal from running the system at a potentially reduced freeboard.

Further assessment at Gate 4, including input from the ECI contractor, to prepare a costed Monte Carlo appreciation of residual risks to replace the Optimism Bias allowance.

Finalisation of the Drinking Water Quality Risk Assessment and the Drinking Water Safety Plan based on the latest water quality data and modelling. Revision of the potable water treatment process and waste management routes to allow the water abstracted from the canal to be safely treated to the appropriate standard.

Review the design of the Minworth AWTP to assess options to avoid increasing sulphate, bromate and nitrate in the canal water and to compare such options against the requirement to upgrade the process at the new potable treatment works at the southern end of the GUC SRO to be able to meet the potable water requirements from the Drinking Water Safety Plan.

Working with the ECI contractor to establish the least risk programme of works, finalise access proposals to allow the red line boundary to be confirmed, agree likely construction traffic to allow development of traffic management plan assessment for the ESIA.

Pipeline Routes

Further refinement of the preferred pipeline route will be undertaken during Gate 4 considering a range of variables such as length, operating regimes/patterns, energy requirement, material type, pressure rating, carbon budget, capital cost, maintenance etc. More detailed, field-based survey (geotechnical, topographic, ecological) will be made during Gate 4 to define the route (plan and profile), road and drainage channel crossings, any directional drilling need and valving/washouts/air-valves. Necessary mitigations and costs to be confirmed. This will require consultation with the relevant stakeholders (e.g. Natural England, landowners, local authorities etc.) before final route and quantities can be agreed.

Discharge Point

The final position to be fixed based on output from the Minworth SRO Consultant's pipeline routing and non-statutory consultation. The location will also require detailed studies of ground conditions, local bathymetry and hydraulic modelling by the Hydraulics Consultant to assess the risks of and mitigations for any velocity constraints relating to the outfall of water from the structure.

Development with the ECI of feasible access routes and logistics/laydown areas to confirm the redline, to allow costs/programme to be refined and for traffic impact and noise impact assessments to be completed. Consideration of post works rehabilitation and completion of permanent operations access.

Further evaluation of energy recovery and energy export options.

Agreement with the local Distribution Network Operator (DNO) on the size, cost, timing and location of the energy connection to the new structure.

Development of the architectural palette/finishes for the building works.

Development of landscaping and BNG works to suit the site and local area.

Canal Banks and Structures

Further refinement of the detailed hydraulic model and digital twin to be developed by Hydraulics Consultant for use in the design of the preferred option at Gate 3.

Bank raising sites and methods of raising have been selected by inspection of local mapping only meaning detailed topographical, geotechnical and environmental studies will be required to be carried out once the required lengths of canal bank raising have been agreed. Extensive liaison will be required with riparian landowners, the Trust, canal users/general public, clubs/societies and other parties interested by virtue of assets affected.

Options for reducing bank raising extents to be evaluated including investigations to determine the feasibility and location of new stop locks.

Confirm towpath design with the Trust and agree management (e.g. planting shelves and dredging) along different lengths. Stakeholder engagement to confirm proposed construction methods and locations.

Investigation of material supply volumes required and specifically availability of sufficient suitable timber.

Further review and design assessments of amendments to the existing Trust weirs (inlet and waste weirs) following their survey and inspection, heritage assessment and integration into the hydraulic model and digital twin to refine the design to suit hydraulic requirements.

Review and design assessment of any modifications agreed with the Trust to locks and third-party property (marinas, warehouses, residences etc) to suit the future operating water level regimes. Liaison with landowners, business owners, heritage interests and other interested parties.

Review and design assessment of any modifications agreed with the Trust to bridges or tunnels to restore air draught and or manage any canal water flow velocity impacts.

Development with the ECI, the Trust, Natural England, the Environment Agency and riparian owners of access routes, laydown areas and construction programme to minimise negative impact and optimise benefits including landscaping, restoration, social benefits and BNG.

Canal Bypasses

The currently proposed bypasses have been selected by inspection of local mapping only meaning detailed topographical, geotechnical and environmental studies will be required to be carried out once the proposed options have been consulted upon and agreed as between the Trust, riparian landowners, canal users/general public, clubs/societies and other parties interested by virtue of assets affected.

Location and layout of canal bypass pumping stations and associated inlet and outlet weirs. This requires liaison with the Trust, landowners, etc to agree and input from ECI to confirm acceptable access, contractor laydown areas and construction programme.

Confirm with DNOs the energy connection size, location, timing and cost.

Consultation with the Local Planning Authority and other Heritage interests for agreement on constraints around listed structures, other heritage assets and features of historic interest.

Working with OEMs, refine the arrangement of pumps to achieve the required range of flows efficiently. This will include:

- Confirm flow regimes and review with OEMs to consider any constraints.
- Confirm strategy of fixed, dual or VSD pumps and requirements for standby for the anticipated flow regimes and develop outline control philosophy.
- Confirm layout and finalise the structural, piping and appropriate architectural design once land availability is confirmed.
- Modelling of flow patterns such as pump on and off levels and review duty points and plant efficiency.

Review gravity bypass designs in line with land availability and latest hydraulic model output for the agreed flow regimes. Refine designs of inlet and outlet structures and confirm pipeline routes.

Work with Environmental Consultant and Land Consultant to undertake surveys to confirm construction type and potential for habitat creation.

Engagement with landowners for access and discussion regarding habitat creation.

Identify and design potential additional social benefit/access options (e.g. potential connections to adjacent footpaths etc.) for discussion and agreement.

Storage - South

Agree preliminary layout of the works at the selected southern abstraction site working with the DCO/Planning Consultant, the Environmental Consultant and AfW.

Procure and undertake geotechnical, topographical and environmental surveys at the abstraction site to confirm preferred layout.

Finalise design for abstraction pumping station, screens and screenings return, pipelines, valves and access (construction and permanent) including structural and architectural design.

Develop balance cut and fill plan, cross sections, excavation/placement plan and construction sequence and programme with support of ECI.

Develop designs for inlet works, outlet works (offtake tower, piping/valves, booster station if any and culvert), spillway and bottom outlet/spillway flow conveyance.

Review designs with DCO/Planning Consultant, the Environmental Consultant and AfW for consideration regarding further consultation with landowners and statutory consultees.

Finalise layouts, designs, plans and landscape works. Work with ECI to develop acceptable access options, contractor laydown areas, work plan and programme to inform costs and risks register.

Storage – Daventry and Drayton

Agree preliminary layout of the works for the Braunston abstraction site, the new pumping station(s), the transfer and bypass pipelines, the outfall structures to the reservoirs and to the GUC downstream of Braunston Tunnel, the revised outlet works and outlet channels to the GUC. All of these to be agreed in consultation with the DCO/Planning Consultant, the Environmental Consultant, the Trust and AfW.

Procure and undertake geotechnical, topographical and environmental surveys at the relevant site and along the selected routes to confirm preferred layout.

Finalise design for all new assets and access (construction and permanent) including structural and architectural design.

Develop pumping station plans and sections, pipeline plans and profiles, valve chamber drawings, outlet structure plans and construction sequences and programme with support of ECI.

Review designs with DCO/Planning Consultant, the Environmental Consultant, the Trust and AfW for consideration regarding further consultation with landowners and statutory consultees.

Review and agree with the Trust and the project team, the operating philosophy and flow split between reservoirs and bypass, for resilience purposes.

Finalise layouts, designs, plans and landscape works. Work with ECI to develop acceptable access options, contractor laydown areas, work plan and programme to inform costs and risks register.

Treatment

Treatment Works Process optimisation following latest water quality modelling, including a review of the type of chemicals used and dosing volumes alternative processes, media and chemicals.

Following site selection and in liaison with the team developing site layouts, prepare initial site-specific layout, develop required geotechnical and topographical survey and create optimised works layout.

Review pumps and motors and develop schedule of electrical demands, I/O schedules and outline operation and control philosophy, taking account of agreed flow regimes and patterns and optimising energy demands against flows and available buffer storage.

Create works plans and sections, pipeline plans and profiles, valve chamber drawings, chemical storage and process unit sizing/plans, construction and permanent access, electrical energy connections size, location and construction sequences and programme with support of ECI.

Undertake pilot plant review of technology and validate treatment of source water to required standard.

General and Project Wide Actions

Engagement with specialist concrete suppliers to maximise the carbon saving of using low carbon concrete.

Update all Site Specific FRAs to account for latest topographical information and asset layouts.

Work with DCO/Planning Consultant and Environmental Consultant regarding construction work access and pipeline routes with landowners.

Review and develop designs in consultation with the Trust and project team, to consider where possible the opportunity for the integration and reuse of existing canal assets and materials; for example pumping stations.

Through consultation with the Trust (canal safety), The Environment Agency (work around the River Ouzel) and specialist contractors (construction staff safety) alternative construction methods with lower WLC impacts can be investigated.

Further consider following technologies and their potential application on site will be evaluated further:

- Water source heat pumps,
- Algae harvesting,
- Photo voltaic floating cells

Carbon

Review layouts and evaluation of alternative materials (e.g. Glulam structural frame verses steel) and the potential for sequestering will be investigated.

Review selected site layouts to assess potential for reuse of existing materials and incorporation of existing assets to reduce the need for new build.

Appendix A - ACWG Design Principle Assessment

See GUC SRO Annex A1 Appendix A

Appendix B - Discharge Structure Plans

See GUC SRO Annex A1 Appendix B

Appendix C - Bank Raising Plans

See GUC SRO Annex A1 Appendix C

Appendix D - Bank Detail – Canal & River Trust Cross Sections

See GUC SRO Annex A1 Appendix D

Appendix E - Geotechnical Desk Studies

See GUC SRO Annex A1 Appendix E

Appendix F - Daventry and Drayton Basis of Design

See GUC SRO Annex A1 Appendix F

Appendix G - Flood Risk Assessments

See GUC SRO Annex A1 Appendix G

Appendix H - Treatment Work Concept Design Report and DWSP

See GUC SRO Annex A1 Appendix H

Appendix I - Pipeline Technical Notes

See GUC SRO Annex A1 Appendix I

Appendix J - Biodiversity Net Gain

See GUC SRO Annex A1 Appendix J

Appendix K - Risk Register

See GUC SRO Annex A1 Appendix K

Appendix L - Bankside Storage

See GUC SRO Annex A1 Appendix L

Grand Union
Canal Transfer