Thames to Affinity Transfer

SRO

Technical Supporting Document A3b

Carbon Strategy Report

Beckton Reuse Indirect Option

Notice

Position Statement

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

Disclaimer

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

Contents

Figures and Tables

1. Introduction

1.1 This report provides an overview of how carbon emissions have been managed through the RAPID Gate 2 process for the Thames to Affinity Transfer (T2AT) scheme. The report covers how whole life carbon emissions have been estimated to provide a breakdown of carbon hotspots and how these have informed focus on mitigation measures on the scheme alongside other drivers. The carbon management approach has been conducted in line with the latest RAPID Gate 2 guidance report.

1.2 This report forms part of a suite of technical documents that support the main T2AT RAPID Gate 2 report. The list of documents that make up the submission, along with a short synopsis of the contents may be found in the main T2AT RAPID Gate 2 report.

1.3 The Thames to Affinity Transfer (T2AT) has the potential to deliver significant water security benefits but could also be a significant source of carbon emissions through its construction and operation. The Gate 2 design process has continued to consider the carbon impact of the scheme, including quantifying the impact of design decisions made during Gate 2 and identification of opportunities to further mitigate whole life emissions as the scheme progresses to later design stages and eventually construction.

1.4 For the Gate 2 submission, RAPID Strategic regional water resource solutions guidance for Gate 2[1] reporting requires submissions to include:

- assessment of whole life carbon cost of the solution and absolute carbon in tCO_2e[2]
- demonstration of use of relevant policy, frameworks and approaches to drive down carbon emissions
- description of how solutions are embracing innovative designs and opportunities to generate or use renewable energy and/or potential to sequester carbon and explore joint opportunities
- assessment of key emission areas (scope 1, 2 and 3), considerations for reduction and inclusions of material selection choice (including explanation of where low carbon materials have been discounted)
- consideration of the impact between cost and carbon reduction

1.5 This report summarises the outputs of the whole life carbon assessment, broken down into capital carbon, operational carbon and expected capital replacements. Whilst capital replacements have been considered, the quantified assessment does not include for estimating the potential impact of decommissioning the scheme at the end of its operational life, as this is expected to be over 100 years and the systems in place to re-use, recycle or dispose of these assets will be substantially different in

[1] Strategic regional water resource solutions guidance for gate two https://www.ofwat.gov.uk/wp-content/uploads/2022/02/Strategic-regional-water-resource-solutions-guidance-for-gate-two_Feb_2022.pdf

[2] Where 'carbon' and 'carbon emissions' are referred to in the report, this is referring to CO_2e which accounts for all greenhouse gas emissions in one metric.

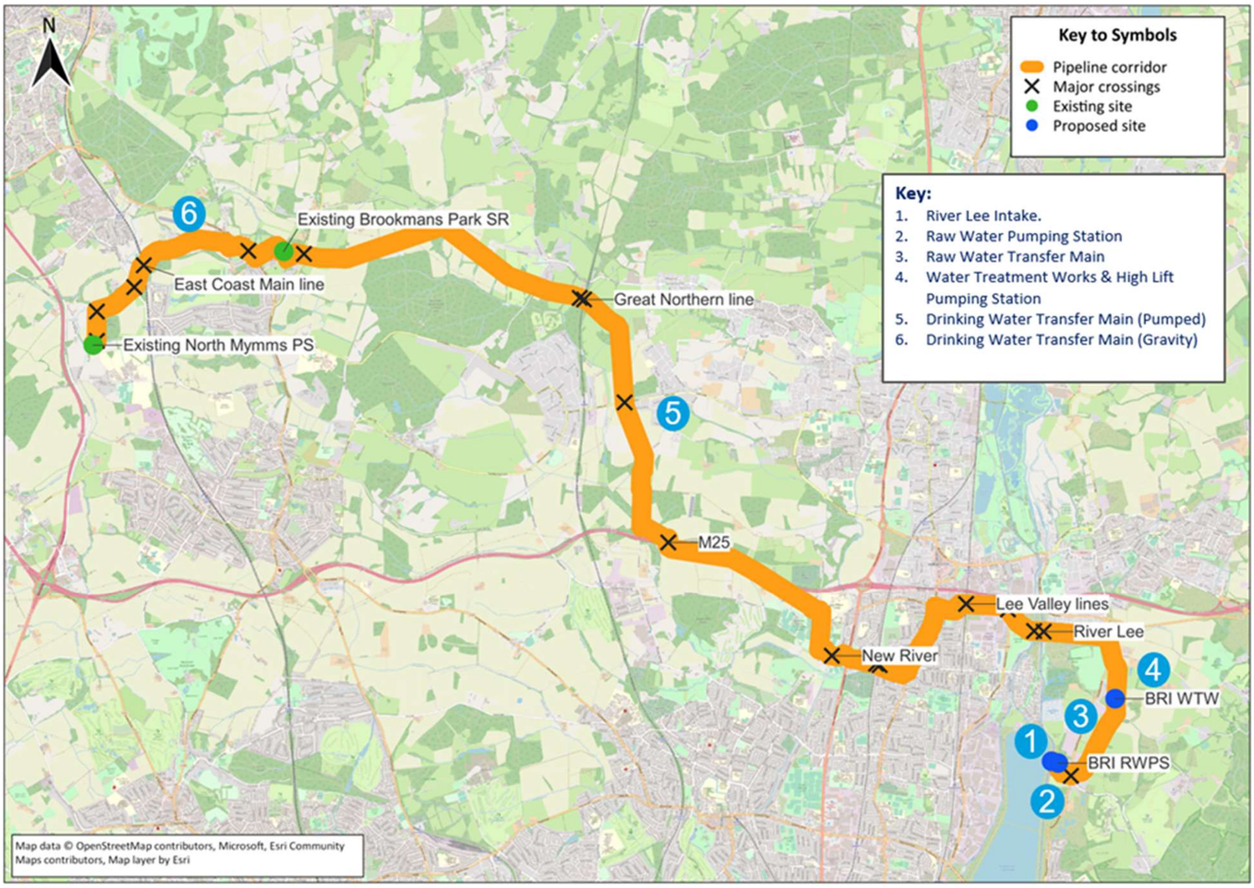
approach and carbon intensity to what they are currently.

1.6 It also identifies how design approaches during Gate 2 have considered carbon emissions and what impact this has had, as well as what key areas of mitigation opportunities remain for consideration at later design stages.

1.1 Scheme overview

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

Figure 1.1: Scheme Overview



1.8 Raw water for the T2AT Beckton Reuse Indirect (BRI) option will be abstracted from the River Lee flood relief channel. As the natural flow in the river is insufficient, the operation of the scheme will be dependent on recycled water being fed into the river from the Beckton Water Recycling option of the London Effluent Reuse SRO. Implementation of this option is therefore a pre-requisite for the T2AT BRI, hence the name of this T2AT option.

1.9 The Beckton Water Recycling option of the London Effluent Reuse SRO entails the construction of an advanced water recycling plant (AWRP) at Thames Water's Beckton Sewage Treatment Plant. The recycled water will be conveyed via tunnel to the existing Lockwood pumping station site, with a second tunnel from the Lockwood site to pump the recycled water to discharge into the river Lee upstream of the King George V reservoir abstraction point (KGV river Lee Intake).

1.10 At the River Lee flood relief channel intake, the concept design proposes a passive wedge wire screen located in the riverbed. The necessary equipment for backflushing or "airburst" will be housed away from the riverbank to ensure that there is minimal visual intrusion at the intake site. However it is anticipated that, as a minimum, an access track and kiosk for monitoring will be required on the riverbank. The passive screens and connecting pipework will be configured such that half of the screens can be taken out of service for maintenance when required.

1.11 Water will flow by gravity within buried pipes to a new raw water pumping station (BRI-RWPS) set back from the riverbank.

1.12 The raw water will be conveyed in a new buried transfer main (BRI-RWTM) to a new water treatment works (BRI-WTW). Drinking water produced by the WTW will pass through a storage tank before entering a high-lift pumping station (BRI-HLPS), from where it will be conveyed via a buried drinking water transfer main (BRI-DWTM) to an existing service reservoir (SR) in the vicinity of Brookmans Park.

1.13 A proportion of the water will then be able to flow under gravity to the existing booster pumping station in the vicinity of North Mymms.

1.14 There are several major crossings along the route of the drinking water pipelines including the M25 motorway, four railway lines and three major watercourses within the Lee Valley. However, the main technical challenge to constructing the selected pipeline route is that it passes through the dense urban area of Enfield.

1.15 The main delivery point for the T2AT BRI option is an existing SR in the vicinity of Brookmans Park, which is a distribution hub within the Affinity Water network. Modifications to the network downstream from the reservoir, which will be required to distribute the additional water to customers, are currently being determined by Affinity Water and form part of their wider water resources planning and investment programme.

1.16 For Gate 2, the following design details have been assumed:

- Ductile Iron pipe material
- Pipe diameter of 800 and 1200mm for the 50Ml/d and 100Ml/d alternatives, respectively

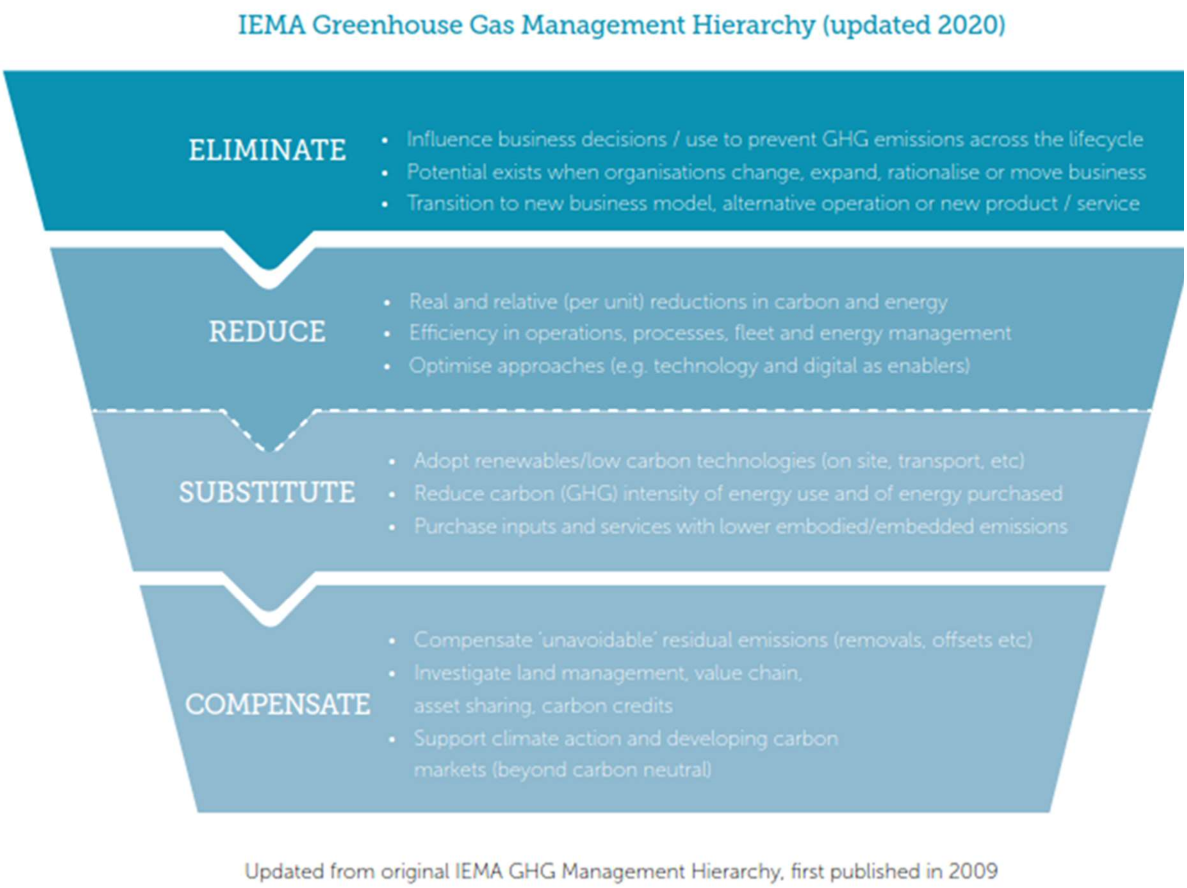
1.17 A full description of the option is provided in Technical supporting document A1b - Concept Design Report.

1.2 Carbon approach overview

1.18 The T2AT has followed PAS2080 principles in its carbon management approach. It has looked to understand the baseline carbon impact of the scheme through quantifying its carbon impact, it has used the quantified assessment to establish carbon hotspots and then prioritised its design mitigation efforts at the carbon hotspot areas. All carbon footprints presented are in CO_2 equivalents, meaning that the global warming potential of all six greenhouse gasses have been allowed for.

1.19 The T2AT scheme has prioritised efforts to reduce emissions rather than focus on emissions mitigation through offsetting. It also acknowledges that a significant proportion of its emissions in construction and operation are considered Scope 3 emissions and outside of the direct control of the companies and designers delivering the scheme. However, the scheme also acknowledges the significant opportunity to work with the supply chain prior to the delivery of the scheme to support accelerated decarbonisation of external systems and supply chains to help reduce the carbon impact of the scheme. The T2AT has followed the IEMA emissions reduction hierarchy shown in Figure 1.2 to identify opportunities to mitigate carbon impacts of the scheme. This aligns well with the carbon reduction hierarchy from PAS2080 and helps focus efforts on reducing emissions rather than offsetting them.

Figure 1.2: IEMA Greenhouse Gas Management Hierarchy



Source: IEMA, 2020

1.20 The carbon mitigation strategy has focussed efforts during Gate 2 on areas where the largest and most efficient reductions can be made. This has been informed through updating the baseline quantification with the latest design information for the scheme to identify the key capital and operational carbon hotspots for the scheme.

1.21 The mitigation efforts have been split into two areas:

- Opportunities directly under the control of the design team, including areas which can reduce emissions through design decisions that can be embedded and costed into the scheme.
- Longer term opportunities where the scheme and sector can influence external systems and supply chains to decarbonise major components of the scheme – these longer-term mitigation opportunities have been covered by a collaborative project commissioned by the All Company Working Group (ACWG) which has identified a consistent view across SROs how these external systems may decarbonise in the future to inform future decarbonisation potential and engagement priorities for individual SROs.

1.22 T2AT has already undertaken assessment of carbon contributions and opportunities for net zero at the RAPID Gate 1 stage which resulted in identifying the options with the highest carbon footprints. For RAPID Gate 2, the following has been conducted:

- Develop overall evidence-based carbon reduction strategy, that will continue to update assessments and challenge hotspots at later Gate stages
- Carbon design challenge workshops
- Identification of carbon mitigation measures to be embed into current design
- Develop carbon mitigation plan for RAPID Gate 3 and beyond

1.3 Uncertainty in Carbon Estimates

1.23 There is inherent uncertainty in carbon estimating due to the developing maturity of carbon accounting practices and associated data. There is also additional uncertainty driven by scope uncertainty associated with level of design information available at given stages within project lifecycle.

1.24 There is currently no standardised or established guidance to assess uncertainty in carbon estimates in a consistent way and the directly applying the range of uncertainty associated with cost estimates and optimism bias would likely overstate the level of uncertainty associated with the Gate 2 carbon estimate.

1.25 Whilst further ongoing work is required at a carbon estimating and accounting discipline level and within the infrastructure sector to establish a more formalised approach to assessing carbon uncertainty, for the Gate 2 estimate a range of +/-30% has been applied based on expert judgement. This uncertainty range looks to account for:

- Uncertainty in carbon factors related to the quality and representativeness of industry level emissions factors to the specific activities undertaken and materials used on the SESRO scheme
- Scope uncertainty associated with ensuring the carbon estimate has captured all scope requirements to fully deliver the scheme.

1.26 It is expected that these uncertainty estimates will be reviewed and refined at Gate 3 and build on any further industry wide efforts to assess uncertainty in carbon estimating to apply and standardised approach across SRO carbon estimates.

2. Capital Carbon

2.1 Under the Greenhouse Gas Protocol, capital carbon emissions from construction are typically categorised as Scope 3 emissions of the sector/organisation. Capital carbon emissions are a result of materials (extraction and processing), manufacture and transportation, associated with construction and maintenance activities. Asset construction and maintenance will be a significant emissions source for most SROs and quantification of these emissions is a key element to identifying efficient mitigation opportunities. This section provides an overview of the capital carbon emissions estimate undertaken for the T2AT and key hotspots identified.

2.1 Capital Carbon Estimate Components

2.2 Capital carbon assessment was conducted using the option development phase design and aligned with asset scope inputs used to develop Gate 2 costs. The asset information used for costing was aligned to Mott MacDonald carbon model data to enable an estimate of capital carbon. The assessment can be updated and improved in later design stages as the design progresses. Assessments were completed for pipelines, crossings, WTW and pumping. The Gate 2 assessment was predominantly comprised of open trench pipe, major crossings, pumping stations and treatment processes.

2.3 Mott MacDonald carbon models have been used to determine capital carbon emissions. These models have been developed using water industry engineering knowledge and supplier information. Models utilise emissions factors from the Inventory of Carbon and Energy (ICE) and Civil Engineering Standard Method of Measurement (CESMM4) Carbon & Price Book 2013 which aligns to different aspects of capital delivery and covers the cradle to built asset aspect of lifecycle assessment (module A1-A5). As an example, construction activities such as excavation and reinstatement of pipeline routes, use multiple emissions factors from CESMM4 Carbon & Price Book. Whereas, the ICE inventory is used for construction materials, such as Ductile Iron (DI) or Steel pipes.

2.4 Table 2.1 shows the detail given for carbon assessment and modelling for the 50Ml/d size, the assets and models were the same for the 100Ml/d alternative.

Table 2.1: Summary of key quantities and models used for carbon assessment of the 50Ml/d alternative

Scheme area	Item	Quantity for 50Ml/d design	Modelled emissions (tCO_2e)
Water treatment works	Surge vessel	3 x 60m^3	62
	Booster pumping	3 x 630kW	145
	Pre-treatment dosing	57.5 Ml/d	66

	Filtration (rapid and GAC)	59 Ml/d and 58 Ml/d respectively	2547
	Clarification	60 Ml/d	1414
	Ozonation tank	806 m^3	477
	Service reservoir	19533 m^3	3442
	Sludge treatment	14,375 m^3	261
	Ozonation	60 Ml/d	117
	UV	57.5 Ml/d	174
	Other ancilliaries	Various	5593
Pumping Stations	Booster Pumping	4 x 110 kW	68
	Surge vessels	3 x 10 m^3	16
	Road	1200 m	94
	Shaft	15m diameter	526
	Other ancilliaries	Various	545
Transfer	Pipeline	800mm	20,362
	Tunnel	1650mm diameter	8921
	Shaft	8600mm diameter	

2.5 Modelling assumptions:

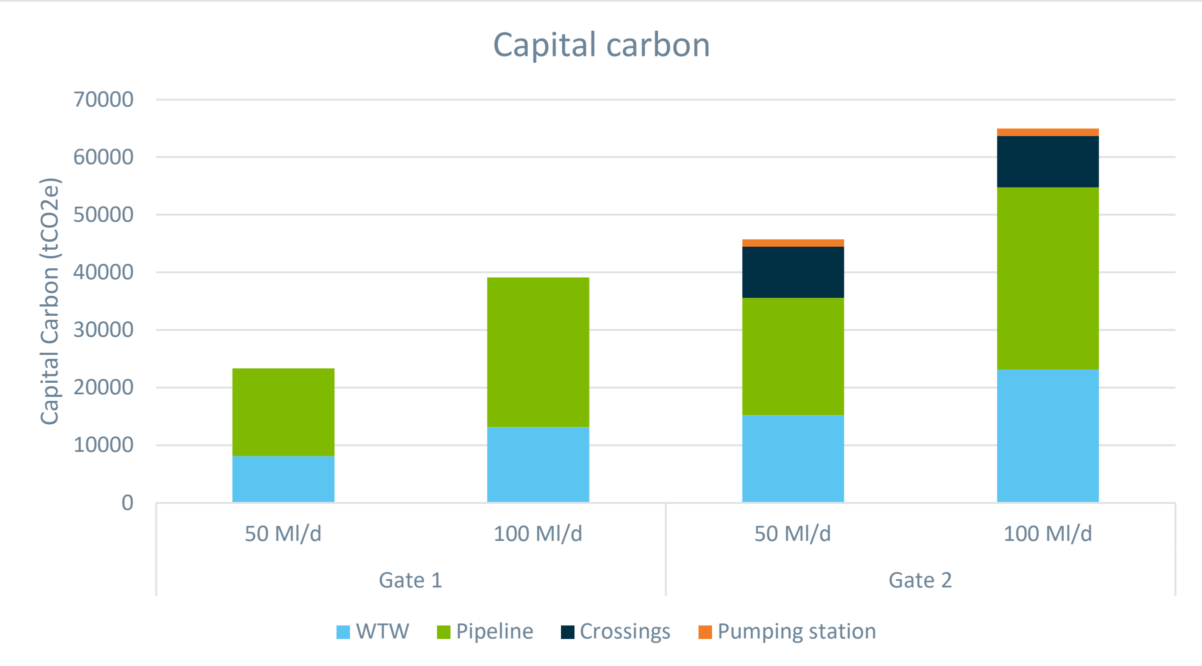
- Major crossings have been modelled as two shafts, one at either end of the crossing (a single launch and a single reception shaft) connected by two tunnels, these each then have a single ductile iron pipe through them. The diameter of the shafts and tunnels has been aligned with those used for cost estimating.
- Shafts have been modelled to be in either fields or urban environments dependent on location of the proposed shafts and has been aligned to the costing of the shafts.

2.2 Summary of Capital Carbon Estimate

2.6 Figure 2.1, shows the total capital carbon for the 50 and 100Ml/d designs. The Gate 1 values have been included for comparison. The capital carbon emissions have increased from Gate 1 to Gate 2 predominantly due to an increase in capacity of both WTW and pipelines by 15% following additional modelling. It should be noted this increase in emissions also delivers additional outcomes, which include providing a new source of water further into the Affinity Water network (via the Brookmans Park to North Mymms connection), reducing water scarcity and improving overall resilience for the customer. A summary of the changes include:

- For WTW, further design development at Gate 2 has led to additional tanks such as ozone contact tanks, surge vessels and increases in storage volume, all leading to increased capital carbon emissions from Gate 1.
- The pipeline diameters have increased from Gate 1, from 700m to 800mm and 1000mm and 1200mm leading to an increase in capacity of 15%. There is also an increase in the total pipe route of ~5km to account for the additional link from Brookmans Park to North Mymms. Lastly, the number and type of crossings required has also increased capital emissions compared to the Gate 1 estimate.

Figure 2.1: Total Capital Carbon for 100Ml/d and 50Ml/d average deployable output (ADO) alternatives



2.2.1 Capital carbon hotspots

2.2.1.1 Pipelines

2.7 The transfer main accounts for the largest proportion of the capital carbon emissions at over 40% in both the 50 and 100Ml/d alternatives. The pipeline was predominantly made up of large diameter ductile iron pipe installed via open cut trenches through fields and urban areas. The crossings are accounted for separately. The capital carbon emissions associated with pipeline construction result predominantly from the embodied carbon (Scope 3) of the pipe material itself (65% for 800mm pipe and 71% for 1200mm pipeline in roads, and over 80% for both sizes when installed in fields). Backfill/reinstatement (Scope 3) become the next hotspots followed by the emissions from excavation (Scope 1 for the contractor) all contributing less than 20% of emissions.

2.2.1.2 Treatment works

2.8 The water treatment works accounted for the next carbon hotspot at 33% and 35% for the 50 and 100Ml/d Average Deployable Output (ADO) alternatives, respectively. The capital carbon emissions were driven by aspects of the treatment process that comprise of predominantly civil components such as potable water storage and tanks for processes like UV treatment and filtration. These assets are dominated by concrete and steel reinforcement in the structures, at this stage the embodied carbon of these materials (Scope 3) has been estimated based on typical UK concrete mixes and standard reinforcement quantities. There will be further opportunities to seek alternative construction materials, such as optimising concrete mix choices and reinforcement types, closer to the detailed design and delivery stages.

2.2.1.3 Other assets

2.9 The pipeline crossings were included as a separate category to highlight the impact on the overall scheme. They account for between 10 and 20% of capital carbon emissions for both sizes of the option. Crossings were modelled as having a shaft at either end connected by concrete tunnels and hence require substantial amounts of excavation and reinforced concrete (Scope 3) driving the high emissions.

2.10 The pumping station category in the capital carbon assessment contributes less than 5% of capital carbon emissions of the whole scheme. This will also be considered through the scheme design iterations but have not been identified as a major hotspot at this stage.

3. Operational Carbon

3.1 An operational carbon assessment has been undertaken for the T2AT scheme. These emissions would be considered as Scope 1 and 2 emissions of an organisation under the GHG Protocol, which cover direct and indirect emissions, respectively. Direct emissions in the water sector result from treatment process emissions, fossil fuel use and owned or leased transport emissions. Indirect energy emissions are the purchase and use of grid electricity by water company assets notably for water and wastewater pumping and treatment, as well as use in buildings. Chemical consumption is covered under Scope 3 emissions. For the T2AT scheme the major operations emissions areas are indirect Scope 2 emissions for electricity use and Scope 3 emissions associated with chemical consumption.

3.1 Operational Carbon Estimate Components

3.2 Operational carbon assessment covers the Scope 2 emissions, indirect electricity consumption and Scope 3 chemicals usage of the scheme. These elements can be derived from asset information such as power rating of a pump and assumed run-time or calculated chemicals usage for treating flow and have been based on operational consumables aligned with the opex estimate.

3.3 Key emissions factors used for the operational carbon assessment are:

- Forecast grid carbon intensity for future years utilises projected emissions factors from the BEIS Green Book Data Tables 1-19, using commercial/public sector values from table 1.
- Chemical emissions factors are collated from the UKWIR Carbon Accounting Workbook, which uses University of Manchester CCalC v2.0 and ASTEE Annex 5 data sources.
- Defra report electricity emissions factor for 2021 (scope 1 and 3)

3.4 The carbon impact of maintenance and staff labour have been excluded as they are considered negligible, relative to electricity consumption and chemical usage.

3.5 An operational utilisation scenario assessment has been conducted assuming the scenarios below:

Figure 3.1: Utilisation frequency profile for the 100Ml/d ADO alternative

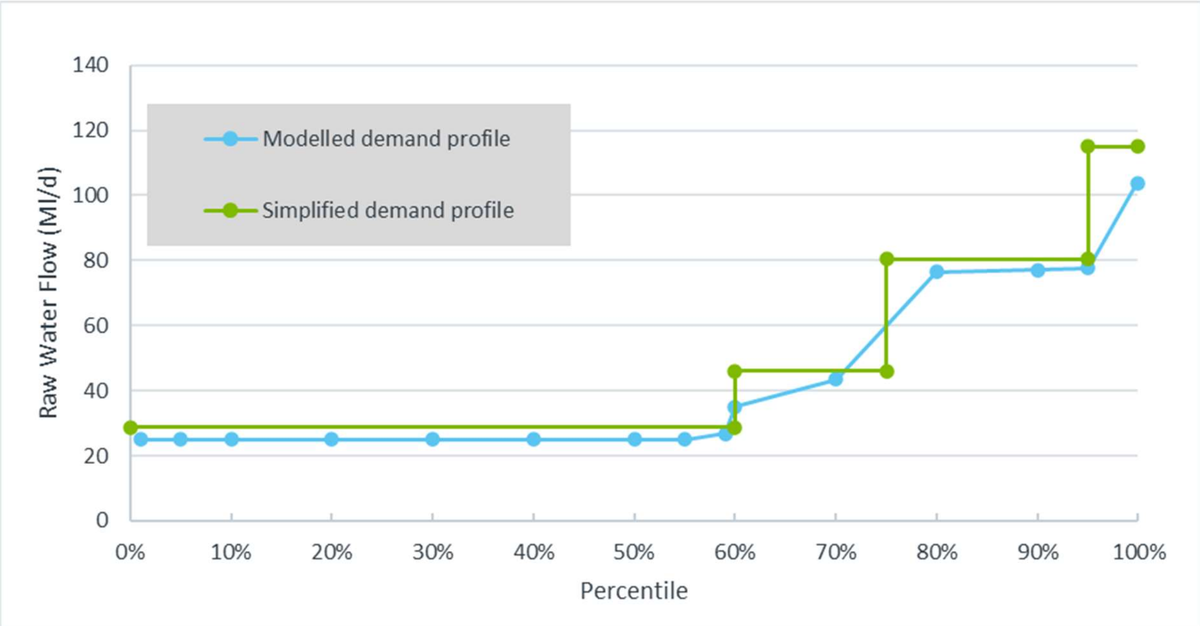


Table 3.1: Simplified utilisation profile for 50Ml/d (ADO) and 100Ml/d ADO alternatives resulting in 40% average utilisation for the scheme

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

3.6 For the purposes of calculating Operation carbon for the T2AT scheme, the utilisation profile has been simplified as shown by the green line in Figure 3.1. The simplified utilisation profile for each alternative is shown in tabular form in Table 3.1. Note that the average utilisation is 40% for both alternatives, given the sum product of the capacity usage proportion and time spent at each capacity. This profile has been generated by network wide modelling, indicating how much T2AT would be used under a variety of different scenarios. The utilisation profile will continue to be refined during future gateways. Further details of the modelling that supports this utilisation profile can be found in Section 4.4 of Technical Supporting Document (A1b) - Concept Design Report.

3.2 Summary of Operational Carbon Estimate

3.7 The operational carbon for the scheme is largely driven by purchased electricity (Scope 2), and is therefore heavily dependent on the grid emission factor. To illustrate this, **Error! Reference source not found.** displays the total operational carbon emissions for each option at three different time frames:

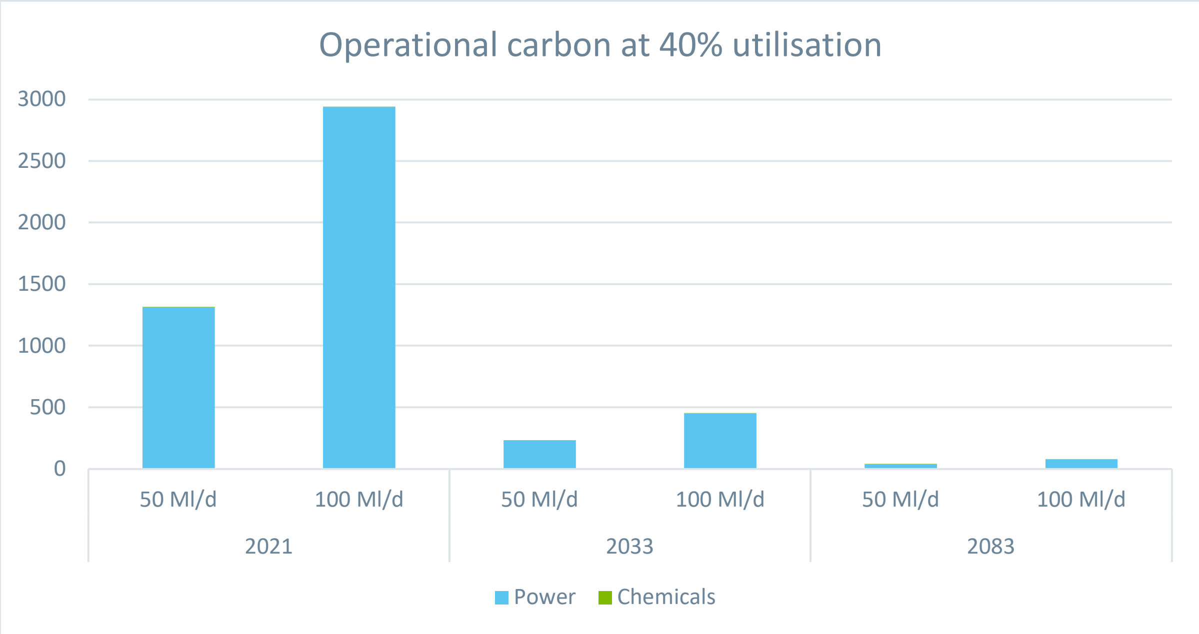
- Present day (2021) assuming DEFRA's 2021 emission factor for grid electricity-consumption of 0.231 kgCO_2e/kWh. (note this is not feasible as the scheme cannot be built immediately, but is shown for illustrative purposes)
- 2033 using BEIS grid carbon intensity forecasts of 0.021 kgCO_2e/kWh
- 2083 using BEIS grid carbon intensity forecasts of 0.007 kgCO_2e/kWh

3.8 The results show that operational emissions follow the same trend as capital carbon emissions, with operational emissions increasing with option capacity (50Ml/d vs 100Ml/d).

3.9 The comparison of the 2033 and 2083 time frames show the effect of grid decarbonisation on reducing operational emissions. The modelling and decision making on which SRO options will be required is yet to be completed, but early indications suggest that the option is unlikely to be required before 2033.

3.10 Non-electricity related sources (chemicals) are assumed not to decarbonise. This is in alignment with Committee of Climate Change 6th Carbon Budget allowances that the chemical sector will be a difficult to decarbonise sector. There has also been no available data to reference what rate of decarbonisation would be appropriate for these chemicals and hence a conservative approach of no emissions reduction is used for this assessment. Despite this conservative approach, the results (Figure 3.2) still show that emissions from chemicals result in 0.4% of operational emissions for the 2033 timeframe, and only increase to 2.4% for the 2083 timeframe.

Figure 3.2: Operational carbon for 40% average utilisation profile at the ADO of 100Ml/d and 50Ml/d



3.2.1 Operational carbon hotspots

3.11 As discussed above, electricity consumption for pumping is the significant contributor to operational emissions of the T2AT. Over time, the 2083 emissions from electricity reduce significantly to 33% of operational emissions post-commissioning, in 2033, and around 3% of emissions from present day values. This is because of the decarbonisation of the electricity grid rather than reduction in electricity usage.

3.12 There are proactive steps the T2AT will need to take to continue to improve the energy efficiency of the scheme and consider opportunities to utilise renewables to self-generate as part of the scheme at later Gate stages. Despite significant forecasted grid decarbonisation, major infrastructure schemes should consider how they generate a proportion of their own demand and continue to drive energy efficiency. This is because the larger the national demand for electricity the more difficult it will be to generate enough renewables to substantially decarbonise the grid.

4. Whole Life Carbon

4.1 The whole life carbon assessment incorporates the outputs from the capital and operational assessment, outlined in sections 2.1 to 3.2, as well as the capital carbon emissions associated with capital replacement and land use change.

4.2 Whole life costs have been assessed over 80 years, to include a 6-year pre-construction period followed by a 5-year construction period ending in 2033[3]. This is followed by 69 years of operation. To align with costing, the whole-life carbon assessment has also been assessed over the same timeframe. Operational carbon and capital carbon replacement emissions are assumed to start after the 5-year construction period.

4.1 Capital Replacements

4.3 Capital replacement carbon has been calculated by assigning a standard asset life category, and associated predicted asset life (years), obtained from the ACWG Cost Consistency report to each asset input line for cost and carbon. A full capital replacement has then been assumed at the end of the predicted asset life. Table 4.1 shows the proposed standard asset life classes used.

Table 4.1: Asset life classes used from ACWG Cost Consistency report

Category	Period
M&E (Mechanical and Electrical) Works on Pumping Stations and Treatment Works (20)	20
Treatment and Pumping Station Civils (incl. Intakes) (60)	60
ICA (Instrumentation, Control & Automation) (10)	10
Power Supply (25)	25
Roads and Car Parks (60)	60
Fencing (10)	10
Pipelines (100)	100
Land (Non depreciating)	100
Brick/Concrete Office Structures (50)	50
Reinforced Concrete Tanks / Service Reservoirs (80)	80

[3] For illustrative purposes only

4.2 Land use change and carbon sequestration

4.4 Construction of the works will require changing existing land use. In the case of above ground assets, a permanent change of land use has been assumed. In the case of below ground assets, only a temporary removal of land use has been assumed, as habitats are expected to be reinstated or compensated. This assumption has been used in the natural capital assessment (Section 16.3.2.1 of the Environmental Appraisal Report).

4.5 As part of the natural capital assessment, the footprint of the works was compared against the existing land use types using open data sources. GIS mapping facilitated the measurement of areas per land use type, and these were cross-linked to carbon sequestration rates for typical land uses (Table 4.2). The output of this exercise was calculating the tonnes of carbon sequestered each year from the existing habitat.

4.6 An assessment was then made of which habitats would be restored (following the temporarily loss of habitats for construction of belowground assets), and which would be completely lost (as result of the construction of aboveground permanent assets). For woodland and forest habitat, it was assumed that 75% of their original carbon sequestration capacity would be restored for those habitats that were temporarily lost and then reinstated / compensated. This results in a carbon sequestration rate post construction, which is less than the existing case.

4.7 The difference between these two values represents the amount of carbon which is "emitted" as a result of the scheme (it is not emitted so much as this amount is no longer sequestered). A summary of the values and the assumptions in the carbon sequestration are provided in Table 4.2 and Table 4.3. To be consistent with the costing, at the time of writing, standard mitigation for reinstating/compensating lost habitat has been assumed, however no environmental enhancements have been included (such as habitat proposals to meet the biodiversity net gain requirement). This will form part of the Gate 3 design, representing a further opportunity for carbon reduction.

Table 4.2: Carbon sequestration rate assumptions

Land use type	Carbon sequestration rate (tCO2e/ha/yr)	Land use type	Carbon sequestration rate (tCO2e/ha/yr)
Woodland – deciduous	4.97	Grassland	0.397
Woodland – coniferous	12.66	Heathland	0.7
Arable land	0.107	Shrub	0.7
Pastoral land	0.397	Saltmarsh	5.188
Peatland – undamaged	4.11	Urban	0
Peatland – Overgrazed	-0.1	Green Urban	0.397

Peatland – Rotationally burnt	-3.66		
Peatland – Extracted	-4.87		

Source: Taken directly from [Exploring the economics of land use change for increasing resilience to climate change in England](#) (Climate Change Committee, 2018), page 114 Table C-4.

Table 4.3: Pre and post carbon sequestration rates based on land use changes

Category	Annual sequestration	Comments
Total sequestration rate per year before construction	48.09 tCO2e/year	Represents the carbon sequestration from the undisturbed site. Assumed to be disturbed in equal portion for each year of construction (e.g. on year 1, 20% of this value is emitted per year, on year 2, 40%, etc).
Total sequestration rate following construction (and habitat growth)	39.11 tCO2e/year	This number incorporates only 75% of habitat being restored for below ground assets may survive, and that 0% of above ground assets will have habitat restored.
Net "emissions" per year during operation	8.98 tCO2e/year	This value is the amount of carbon 'emitted' per year for every year of construction. It is assumed to be reached 5 years after completion of construction, allowing enough time for habitats to reach full maturity.

Note: At this stage it is not considered appropriate to do a time series analysis of how long different habitats will take to mature. This can be done at Gate 3 when the exact habitat to be lost is known. Therefore a simple linear curve has been assumed progressing the sequestration rates from full disturbance to full restored value.

4.3 Summary of Whole Life Carbon Estimate

4.8 A summary of the whole life carbon emissions is presented in Table 4.4below.

Table 4.4: Summary of the whole life carbon emissions

Category	50Ml/d	% of total emissions*	100Ml/d	% of total emissions*
Capital (tCO2e)	45,700	56%	65,000	40%

Capital replacements (tCO2e)	25,500	31%	38,200	24%
Operational electricity (tCO2e)	9,700	12%	57,100	35%
Operational chemicals (tCO2e)	160	0.2%	340	0.2%
Land use change (tCO2e)	860	1%	860	0.5%
Total (tCO2e)	81,920		161,500	
***columns do not add up to 100% due to rounding of values**				

Figure 4.1: Annual Emissions for 50 Ml/d ADO alternative

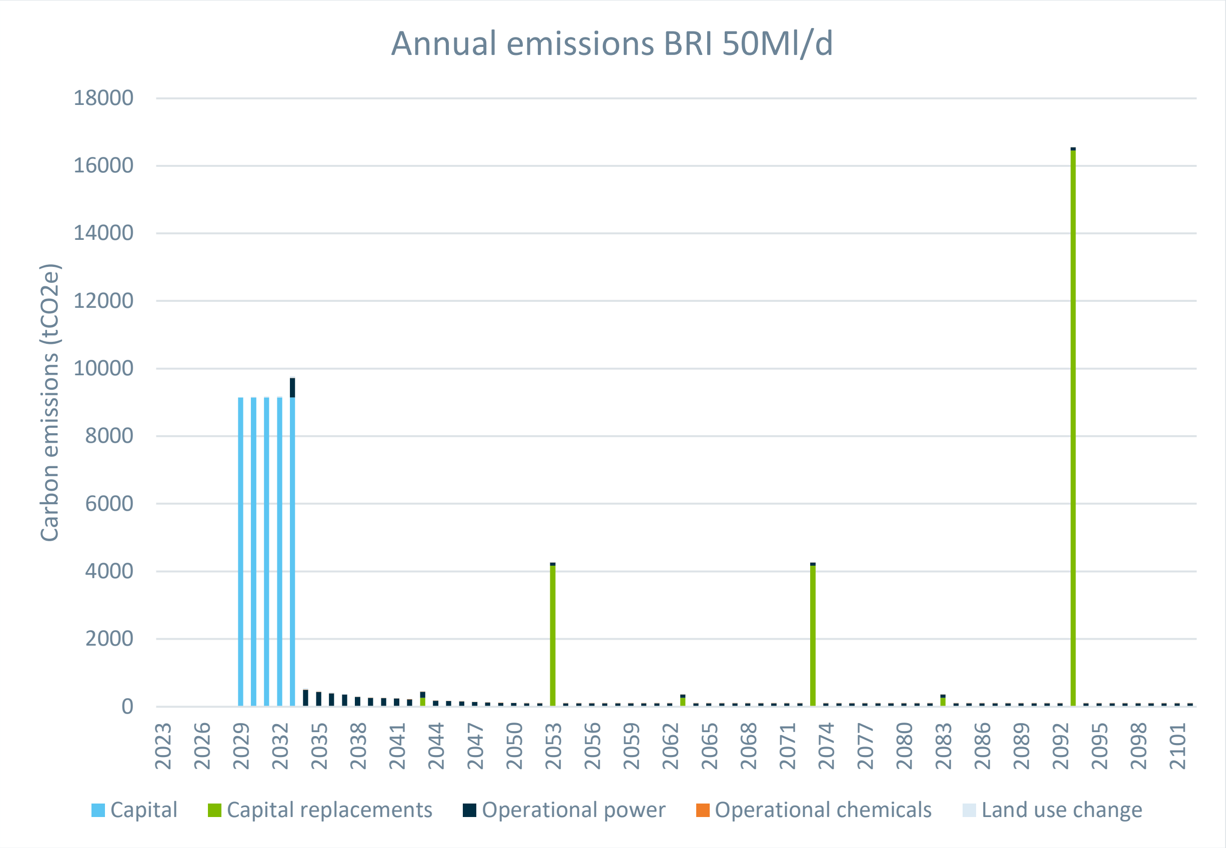


Figure 4.2: Cumulative Emissions for 50 Ml/d ADO alternative

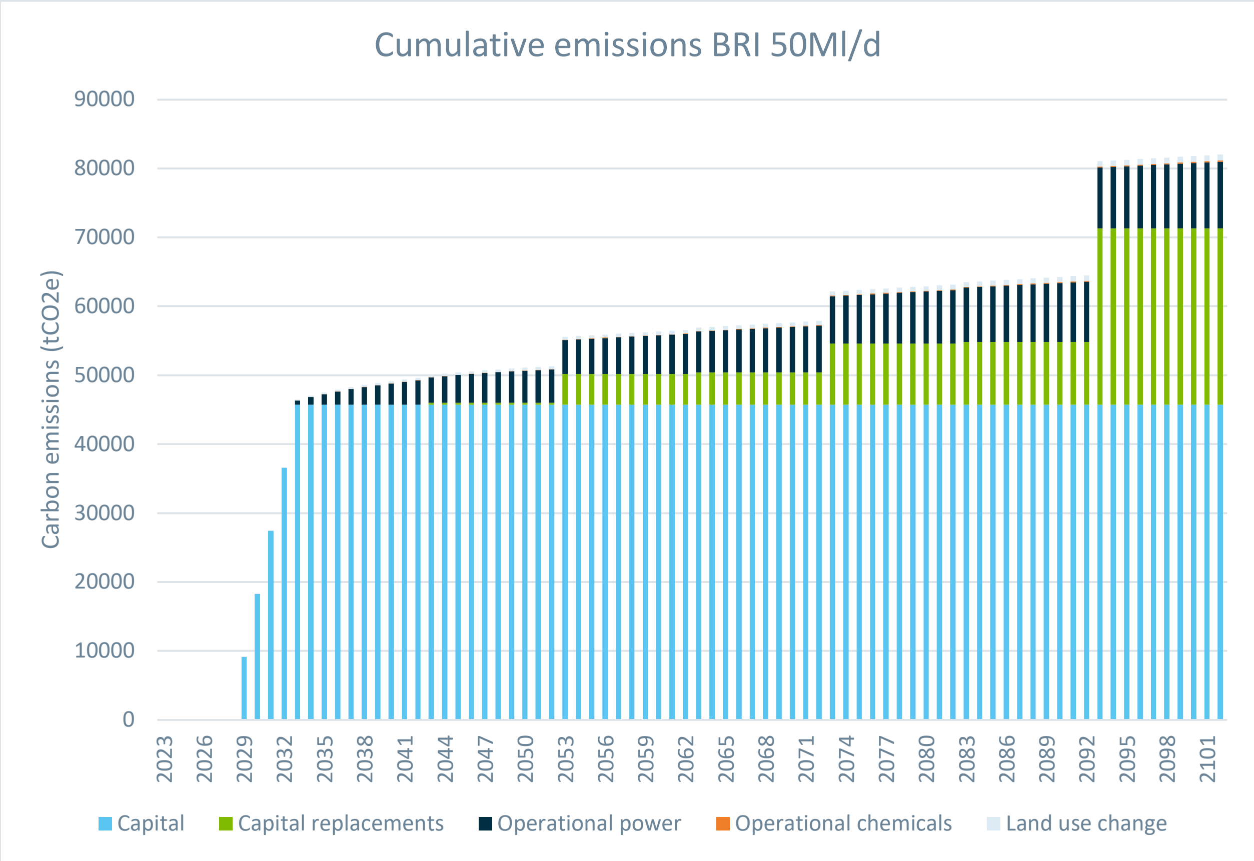


Figure 4.3: Annual Emissions for 100 Ml/d ADO alternative

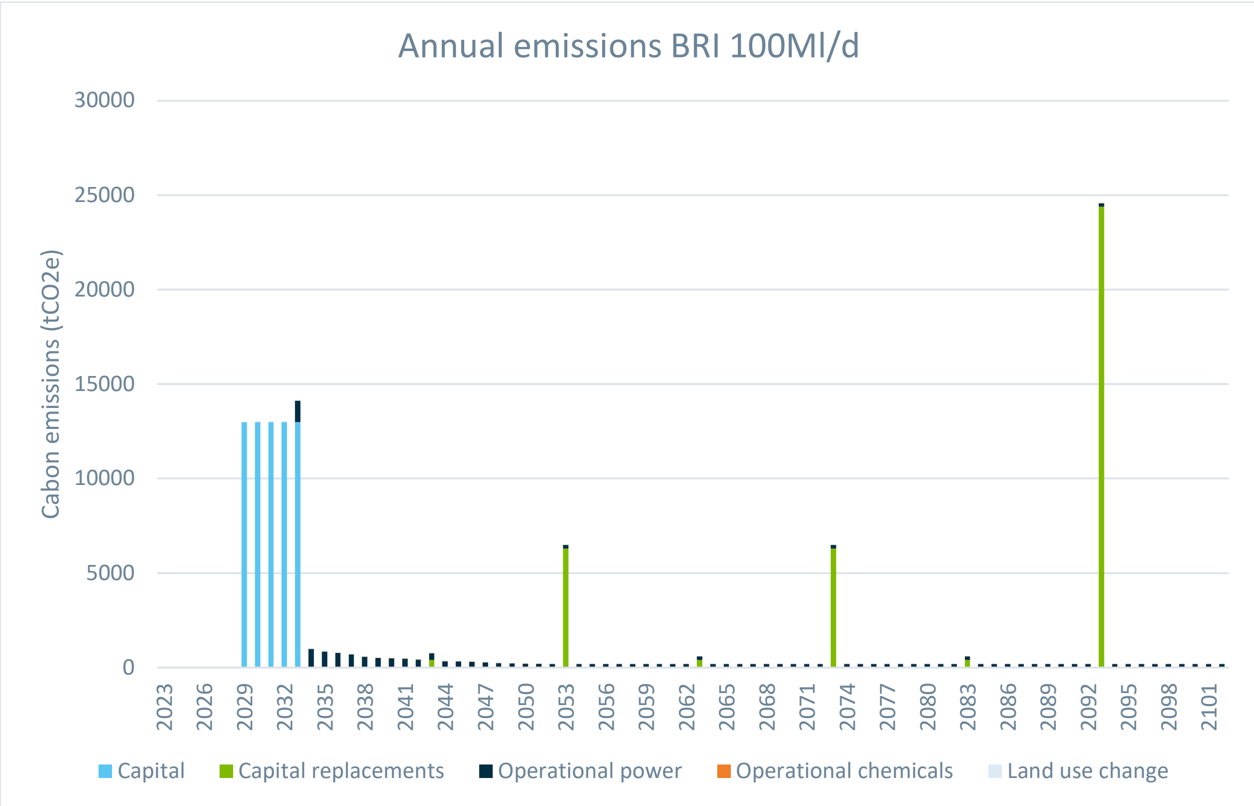
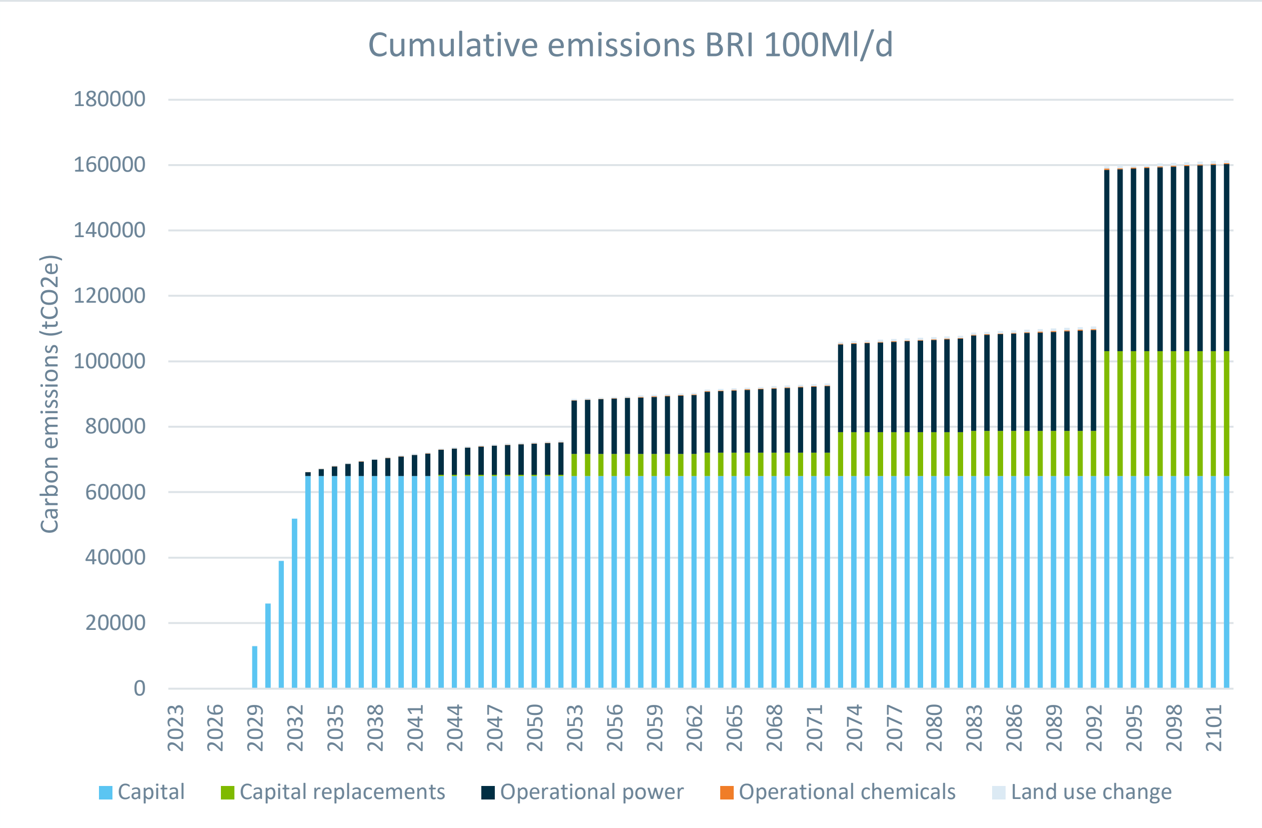


Figure 4.4: Cumulative Emissions for 100 Ml/d ADO alternative



4.4 Cost of Carbon

4.9 Whole life carbon emissions have also been monetised using BEIS Green Book Data Tables 1-19[4], Table 3. The monetisation of carbon has been built into the regional planning appraisal approach to account for the carbon impact of different schemes. Table 4.5 summarises the whole life carbon net present value over 80 years of each of the option sizes.

4.10 The net present value has been calculated by multiplying the estimated emissions in each year by the carbon cost in each year and applying the green book standard discount rate. The table summarises the carbon cost under the low, central, and high values. The central values have been used in the regional planning appraisal process.

Table 4.5: Cost of carbon

	Low	Central	High
50 Ml/d	£7,000,000	£14,000,000	£21,100,000
100 Ml/d	£10,300,000	£20,600,000	£30,900,000

[4] data-tables-1-19.xlsx (live.com)

5. ACWG Assessment

5.1 The All Company Working Group (ACWG) commissioned Mott MacDonald to develop potential decarbonisation opportunities through building clever or building efficiently measures for typical SROs. Build-nothing and build-less options in the PAS 2080 carbon reduction hierarchy (or 'Eliminate' and 'reduce' measures as noted in the IEMA framework shown in Figure 1.2) are site specific and will have been considered through the earlier stages of the delivery process, as part of regional planning and design development stages.

5.2 As noted in Section 4, the majority of whole life emissions arise from capital carbon, with secondary hotspots being capital replacements and operational carbon (pumping). As set out in Section 1.23, most of the capital carbon arises from the embodied carbon of the pipeline material.

5.3 The ACWG report showed that the production of the pipeline material (large temperatures required in the steel and iron making processes) accounts for the majority of emission of a typical pipeline scheme (70%). Installation of the pipelines, both emissions from site plant and embodied carbon of imported fill, also accounts for a sizeable portion of emission (10-25%). The Gate 2 design has selected a ductile iron pipe material, which has the highest embodied emissions of pipe options. There is therefore the opportunity reduce emissions as discussed below.

5.1 Mitigation options identified by ACWG

5.4 The ACWG considered two routes of decarbonisation for pipeline SROs. Firstly, each material is assumed to decarbonise into the future with improvements in manufacturing and possible feedstock switching. Secondly, different materials are presented relative to a baseline case of a ductile iron pipe, indicating that switching pipe materials can offer large carbon savings.

Three different scenarios were considered (worst, middle, and best case), across three timelines for when construction could occur. As it is likely that construction of T2AT will occur before 2060, only the first two time frames will be considered in this report.

5.5 Table 5.1 shows a summary of the mitigation options available to this project for the "middle case".

Table 5.1: ACWG pipeline alternative carbon savings (middle case savings)

Item	Pipeline Option- Including material capital carbon and installation capital carbon	2025-2040	2040-2060
Medium Diameter (DN800) Baseline: ductile iron construction using today's methods	DI	7%	39%
	HPPE	24%	59%
	Steel	25%	60%
	MO-PVC	51%	82%
	GRP	53%	89%
Large diameter (DN1400/1800) Baseline: Steel construction using today's methods	Steel	9%	25%
	DI	-3%	20%
	GRP	71%	84%

5.6 The capital carbon savings presented above were for a typical pipeline SRO indicating the scale of savings available. Of course there is a large degree of uncertainty when using any of these carbon saving potentials, as each scheme is slightly different:

- The number and length of crossings may be different,
- The quantities of the other structures (intakes, WTW, pump stations, etc) in relation to the length of pipeline,
- The embodied carbon of the pipe material can all vary by the time construction begins

5.7 A specific 'degree' of uncertainty is difficult to quantify without exploring the specific design assumptions within each SRO and assumptions used in the ACWG report. For simplicity we present the savings based on the percent savings quoted in the ACWG report to provide an indicative scale of possible reductions, with uncertainty allowed for in the overall uncertainty range (Section 1) used for all of the estimates in this report.

5.8 Another area to reduce carbon is in the WTW capital carbon. As shown in Figure 2.1 this amounts to roughly a third of capital carbon emissions on this SRO. As such, the carbon saving opportunities presented in the ACWG report for reuse schemes is presented here (Table 5.2).

Table 5.2: ACWG Desal alternative carbon savings (considered similar for reuse)

Item	Scenario	2025-2040	2040-2060
Desal WTW Capital Carbon	Worst Case	19%	21%

Baseline: is defined as a do nothing approach, whereby the desal plant is constructed with convention plant used today, put in operation by 2025	Mid Case	29%	35%
	Best Case	46%	61%

5.2 Mitigation measures proposed for T2AT

5.9 Two mitigation approaches from the ACWG are proposed for consideration in Gate 3 (Table 5.3): The first approach changes the pipe material from DI to steel, whereas the second approach maintains the DI pipeline. Both approaches propose utilising low carbon construction materials for the water treatment works.

5.10 To achieve the 'middle case' scenario above requires overcoming supply chain challenges over the next six years, as well as internal review by the Water Companies on which pipe materials are considered acceptable for performance and resilience. Table 5.3 summarises some of the actions required.

Table 5.3: Two possible mitigation approaches based on ACWG report

	Alternative 1 – Steel used for pipeline, WTW and pump stations use low carbon materials	Alternative 2 – DI used for pipeline, WTW and pump stations use low carbon materials
Direct control of water companies	Water companies to review internal standards, performance trade-offs with operations staff, and decide if steel is a suitable material	Business as usual, no modification needed.
Direct control of supply chain	Engage with supply chain to achieve the improvements noted for DI, and "rebuild of plants with advanced steel production technology"	Engage with supply chain to "increase deployment of stove flue or top gas recycling in most blast furnace basic oxygen furnace sites"

Source: Quotations taken directly from ACWG report

5.11 To decarbonise ductile iron and steel production, improvements in the manufacturing process are required. Most of the embodied emissions within the pipe material arise from the high temperatures required, and the 'use of carbon as a chemical reductant'[5]. Decarbonising this will require efficiency gains in manufacturing, and in some cases decarbonisation of heat and power.

5.12 The decarbonisation of built assets, such as buildings, tanks and piling, is also assessed in the ACWG report. Achieving the middle case will require engagement

[5] ACWG report, 2022

with the supply chain and in particular contractors, to explore and possibly mandate the use of concrete with 'alkali-activated cementitious materials (AACMs) based on calcined clays or volcanic ash'5. For rebar, utilising 'rebar with a high recycled content as it is produced via a secondary electric arc furnace, instead of the primary basic oxygen furnace', along with 'increased deployment of stove flue or top gas recycling in most BF-BOF sites'5.

5.13 These material changes are likely to require early engagement with contractors to test the feasibility of sourcing these materials, and modifying procurement routes and contract specifications, to ensure low carbon materials are used in construction.

5.14 The carbon savings which would be achieved from implementing alternative 1, is shown for the 50Ml/d and 100Ml/d options in Figure 5.1 and Figure 5.2

Figure 5.1: Emission savings if ACWG savings for switching from DI to Steel and lower carbon construction materials for WTWs applied (50MLD)

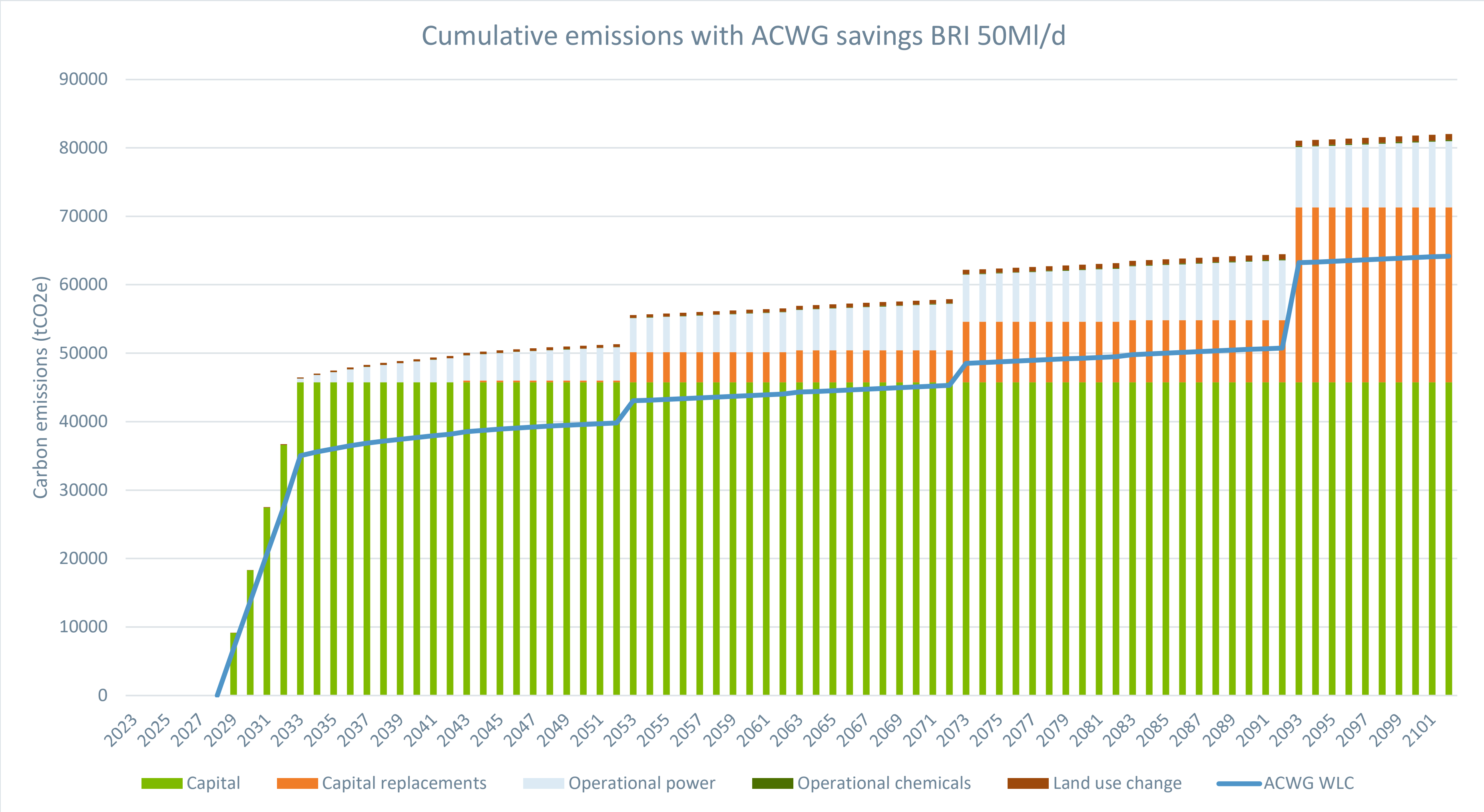
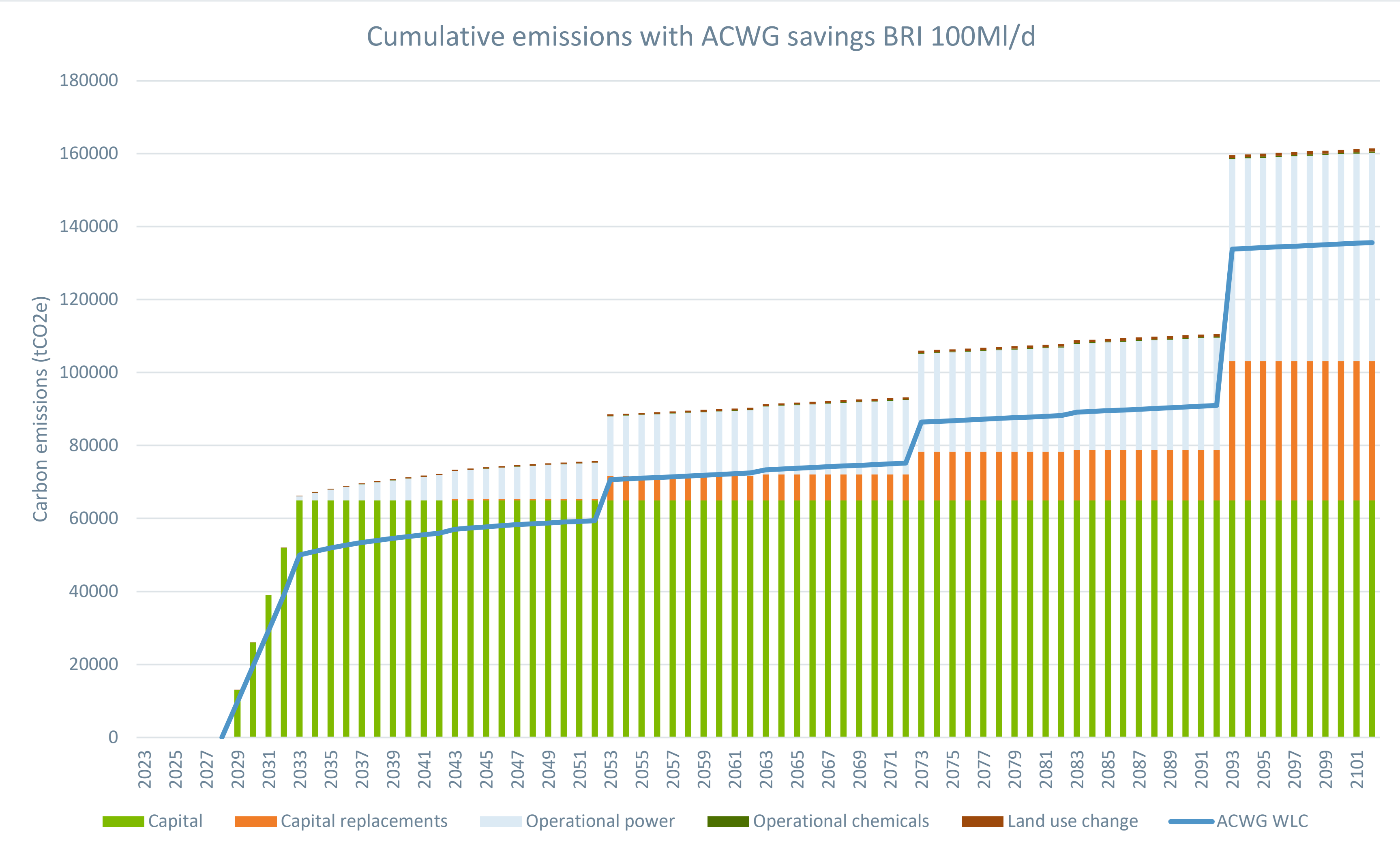


Figure 5.2: Emission savings if only ACWG savings for lower carbon construction materials for WTWs applied (100MLD)



6. Carbon Mitigation Strategy

6.1 The carbon assessment and analysis presented above has been used to inform focus areas for carbon mitigation efforts. Some of these have already been implemented as part of the development of the Gate 2 design, while others are identified as future strategic priorities. If T2AT is to continue to the next stage of design development, the carbon mitigation strategy will also need to advance. This would involve acting on recommendations from the ACWG study (discussed in Section **Error! Reference source not found.**) including engagement with relevant external stakeholders.

6.2 Section **Error! Reference source not found.** below summarises capital carbon mitigation measures already considered as well as those identified for consideration and the next stage of design development. Mitigation measures are presented for operational carbon in Section **Error! Reference source not found.**. The estimated potential savings and targets for the next stage of design development, are then summarised in Section **Error! Reference source not found.**. An initial stakeholder engagement plan is outlined in Section 6.5 which, if implemented, could help broaden the dialogue and promote early collaboration to drive emissions reductions.

6.1 Capital Carbon Mitigation Strategy

6.3 Carbon mitigation opportunities have been identified during Gate 1 and Gate 2 for 'eliminate' and 'reduce' stages in the carbon reduction hierarchy (Figure 1.2). In Gate 3, we expect some 'reduce' opportunities to still be presented, but primarily 'substitute' mitigation measures to dominate. These range in potential impact and feasibility with some being relatively easy to implement, and others requiring further work to understand their feasibility:

- **[Substitute] Material selection:** This accounts for around half of capital emissions. Ductile iron (DI) has a relatively high carbon intensity per metre unit length of pipe material compared to steel and composite pipes, such as glass fibre reinforced plastic (GRP). The material selection has predominantly been driven by its reliability and the diameter of the pipe required, with ductile iron considered typical at these diameters and reliable. Whilst PE pipes can feasibly be used and manufactured at this diameter, they would need to be made bespoke and would require substantial wall thicknesses to provide similar performance. Steel and GRP pipes are an option that will be further explored at later design stages (including the different bedding requirements needed), and would need careful consideration by the Water Companies in reviewing their assets standards, to inform specification preparation for the construction contract.
- **[Reduce] Water treatment works:** Although overall land requirement of the WTWs has increased, where possible processes have been optimised from Gate 1 to reduce the land footprint, such as use of lamella clarifiers from dissolved air flotation. However there is opportunity to optimise the design of chosen construction material to reduce use of high carbon materials such as concrete or allow for lower carbon materials at further Gate stages.

- **[Reduce] Pipe size (diameter):** The pipeline diameter has been optimised and selected based on 100% utilisation at 100% capacity. Whole life cost was the primary driver of the optimisation which would be expected to align with carbon. There is the opportunity for further review as the expected utilisation is lower, which could result in a smaller diameter pipe leading to capital carbon savings through both material (embodied) and installation savings. The optimisation process could be completed again, but this time using carbon as the primary driver instead of cost.
- **[Reduce] Infrastructure crossings:** As part of the pipeline route, the number of open cut crossings has been minimised predominantly to reduce disruption to the traffic network and the riverine environment. The major crossings construction has been determined to be trenchless (micro-tunnelling) with shafts at either side. There are deemed to be no feasible alternative installation methods at present due to the pipe diameter and disruption to the transport network. Consideration could be given at Gate 3 to not installing dual tunnels at every trenchless crossing.
- **[Substitute] Backfill and reinstatement:** Another aspect of pipeline installation is the backfill material. Where possible, use of as-dug material will be used for backfilling which reduces carbon emissions. To not overstate the carbon savings, the Gate 2 carbon assessment assumes imported backfill for the pipe surround and as-dug material for the remaining trench, except where traversing through contaminated ground (where all backfill is assumed to be imported). Once further detail is known at later Gate stages, an updated assessment of the imported material required for the pipeline can be made and could potentially lead to carbon savings.
- **[Substitute] Electricity supply provision:** A further design optimisation opportunity would be to reduce the electricity supply infrastructure for pumping stations. At Gate 2, pumping stations have been designed to have a dual supply. There is the opportunity to optimise this to a single supply for the high and low-lift pump stations. This can be explored at Gate 3 where discussions need to account for the risk to the operation of the SRO and the balance of carbon emissions associated with standby generators.
- **[Reduce] Waste minimisation:** Adopting construction techniques, e.g. modular or off-site manufacture options can help reduce the amount of waste associated with construction projects, whilst potentially reducing carbon emissions, improving health and safety and overall operational performance of assets. Having a robust waste management plan and engaging other potential users of surplus excavations can help reduce emissions associated with waste disposal, but is an activity likely to be implemented post Gate 3.

6.4 Of note, the route of the T2AT BRI pipeline is deemed to be the shortest practicable, endeavouring to minimise environmental impact on designated protected sites and has been optimised to reduce cost. In the next design stages a significant reduction in length is unlikely and has therefore not been relied upon for carbon savings.

6.2 Operational Carbon Mitigation Opportunities

6.5 Operational carbon mitigation will largely depend on procurement partners and supply chain. As with the capital carbon, hotspot analysis was conducted at Gate 1 based on various assumptions.

6.3 Operational Carbon Reduction Mitigation Strategy

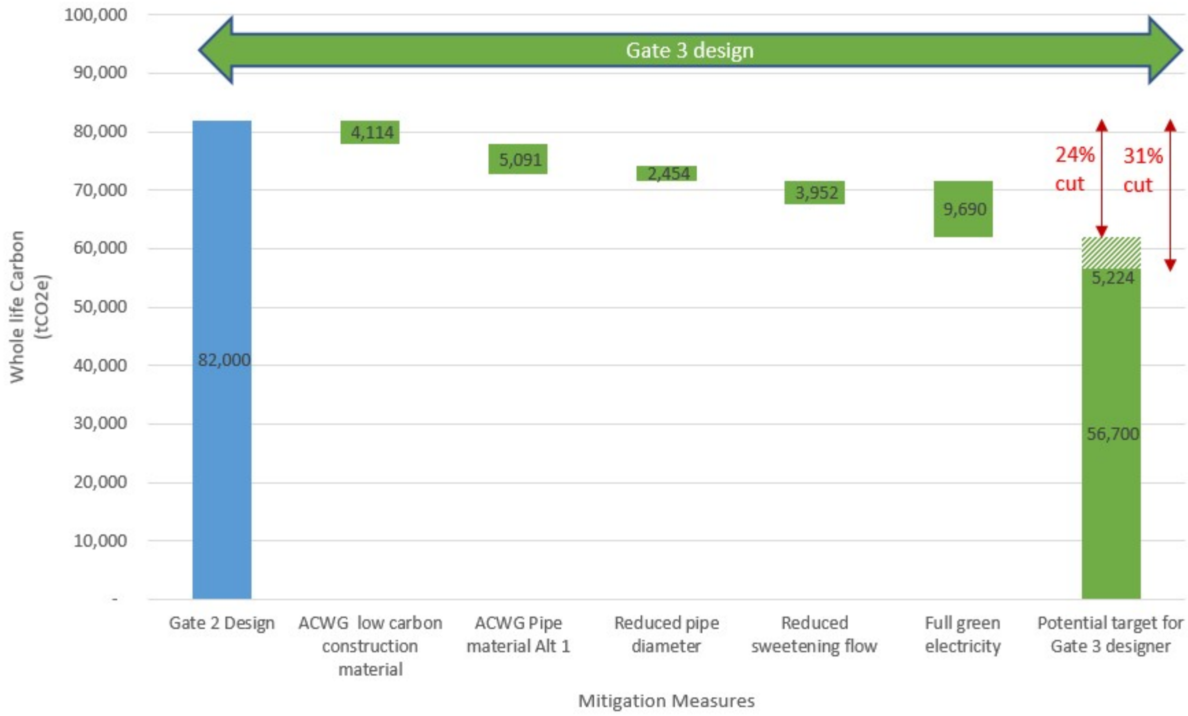
6.6 Reducing operational carbon will be based on the following hotspot mitigation areas:

- **Sweetening flow scenario:** Testing flow scenarios to allow for a reduction in minimum flow could offer carbon savings. As shown in the utilisation profile, the pipeline runs at a minimum flow of 25% of total capacity for 60% of the time (Figure 3.1). Reducing the minimum sweetening flow to 15% or even 10% of full capacity, would reduce chemical and energy requirements. However, any reduction in the minimum flow into supply provided by T2AT would need to be made up for by increasing the supply from other sources. The net reduction in operational carbon for the network, will therefore be less than the savings presented for T2AT.
- **Optimising energy efficiency and maintenance activities to prolong asset life/performance:** Capital replacements form a sizeable chunk of the carbon footprint, and therefore exploring materials and plants which last longer could provide carbon savings. For example, consideration could be given to utilising new LED UV lamps, which have a lower energy consumption and longer design lives.
- **Low carbon electricity and decarbonised electricity procurement choices:** Organisations can also procure green electricity through their suppliers, which when market-based reporting can be used to zero out the electricity generation emissions of grid electricity. This requires the purchase of Renewable Energy Guarantees of Origin (REGO) certificates and comes at a premium over standard electricity tariffs in most cases.
- **Renewable Energy Generation:** There are opportunities to generate renewable energy through installation of solar panels and wind turbines across the option. Areas considered to date have been:
- **Solar panels installed on the process units of the water treatment works,** provided the technology improves to reduce leakage issues with tank roofs as has been noticed in previous projects. Hence this relies on technology developments to enable the opportunity.
- **Wind turbines at the service reservoirs** since they are on elevated ground however this is not a prospect solely for T2AT and should explored with other stakeholders.

6.4 Whole Life Carbon Mitigation

6.7 The opportunities for carbon mitigation have been outlined in Figure 6.1, resulting in a range of carbon saving potential for the Gate 3 design. These estimates are indicative, with an expectation that detailed analysis can take place in Gate 3 to confirm exact numbers and assess which measures should be included. The primary message from the below figure is the scale of whole life carbon savings available, and what the Gate 3 design should strive to achieve.

Figure 6.1: Opportunities for carbon reduction from Gate 2 to Gate 3 (50Ml/d option shown)



6.8 'ACWG pipe material alternative 1' estimated based on pipeline switched to steel, and engagement with supply chain leading to a 25% reduction in pipeline capital carbon (crossings excluded). 'ACWG low carbon construction material' estimated based on 25% reduction of WTW and pumping stations capital carbon (crossings excluded), based on assumed low carbon tanks, buildings and piling emission savings from the desalination and reuse section of ACWG report. 'Reduced pipe diameter' estimated based on assuming pipe diameter reduces from 800mm to 700mm. 'Reduced sweetening flow' based on electricity emissions savings generated by using 15% capacity as the minimum instead of 25%. 'Full green electricity' savings represent the full carbon emissions from operational power over the life of the project.

6.9 Some of the mitigation measures above are not mutually exclusive, and therefore are not vertically aligned. For example, if steel is used as part of the 'ACWG pipe material Alt 1', then the savings from also 'reducing pipe diameter' will be smaller than those shown above which were based on DI. Similarly, if 'reduced sweetening flow' is implemented, then the savings shown for 'full green electricity' would decrease as there would be less electricity consumed. To account for this potential 'double dipping', hatched bars are shown to indicate potential overlap from multiple interventions being implemented. The above estimates are inherently uncertain in the scale of emissions reductions they will achieve and certainty within the estimating process themselves. These provide an indicative view to help support focus areas for emissions reductions and inform supply chain engagement rather than setting specific targets to be achieved at later gate stages.

6.10 When considering the alignment of the T2AT scheme with national climate targets this becomes difficult. This is because UK has embedded achieving net zero by 2050 into law, and also includes interim targets of a 68% reduction by 2030 and a 78% reduction by 2035 from 1990 levels. However these are economy-wide reductions, with some sectors (e.g. electricity generation) budgeted to make significant decarbonisation, and others (e.g. petrochemicals) expected to make only modest carbon reductions. The targets of 68% refer to the aggregate for the entire economy, and notably only cover territorial emissions (embodied emissions in imported goods are excluded) and refer to cuts from 1990s levels.

6.11 Therefore we believe the scheme's ambitions remain to:

- Minimise carbon intensity of operational activities (Scope 1 and 2) on the scheme to support the Water Company's commitment to NetZero by 2030. Contribute to company or regional level offsetting plans to target residual operational emissions (this will be at an organisational level rather than a scheme level).
- Reduce capital carbon emissions (Scope 3) as much as possible in a cost effective and efficient manner. This will see the Water Companies supporting the overall UK target of achieving NetZero by 2050 at an economy scale.

6.12 The savings presented above relate to a net present value of £3.7M in terms of carbon costs[6]. In Gate 3, the capital costs of delivering mitigation measures should be compared against the resulting carbon savings, helping determine which measures are best to pursue. This assessment will require stakeholder engagement, described in the next section.

6.13 In some instances carbon mitigation measures would increase the financial cost of the scheme. Agreement from multiple parties would be needed to ensure carbon savings opportunities are not missed during efforts to reduce capital costs and to identify how net-zero alignment could be best funded.

6.5 Stakeholder Engagement Plan

6.14 Mitigating carbon requires breaking away from the business as usual approach to delivering infrastructure. Doing this will require engagement with a wide range of stakeholders, both to generate new ideas and to overcome the barriers with mitigation measures. Table 6.1 provides a brief summary to indicate who might be required.

[6] This is calculated by multiplying the estimated emission reduction in each year by the BEIS Green Book central estimate for carbon cost in each year and applying the green book standard discount rate.

Table 6.1: Stakeholder Engagement Matrix

Mitigation measure	Accountable	Wider stakeholders
Low carbon pipeline materials	Client / Gate 3 designer	Contractors Pipe suppliers
Low carbon construction materials	Client / Gate 3 designer	Contractors Concrete suppliers Structural steel suppliers
Reduced pipe diameter	Client	Gate 3 designer
Reduced sweetening flow	Client	Gate 3 designer
Full green electricity	Client	
Crossings reductions	Client / Gate 3 designer	Contractor
Waste minimisation	Contractor	
Optimising energy efficiency and maintenance activities	Client / gate 3 designer	Contractor
Renewable energy generation	Client	Gate 3 designer

6.15 Low carbon pipe materials and low carbon construction materials have already been discussed in Section 5. To achieve real carbon reductions contract preparation is likely to be a strong vehicle for creating the right market incentives for prospective contractors to engage with their suppliers to source low carbon alternatives. One approach could be developing appropriate material carbon intensity specifications thereby levelling the playing field for all suppliers bidding on the scheme. The scheme would then require steps embedded within the procurement process to ensure that materials and products meet carbon intensity specification requirements.

6.16 Reduced sweetening flow and full green electricity also show significant carbon reduction potential. The sweetening flow hinges heavily on what is a sensible minimum flow through the pipeline and the WTW. This is directly within the control of the asset owner, but would need to be considered with where the balance of water would come from in the network and the carbon intensity of that source. Full green electricity is also a client decision, and should be considered on a regional basis as part of the Water Company's specific net zero implementation strategy.

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