South East Strategic Reservoir Option (SESRO)

Supporting Document A2

Carbon Report

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Standard Gate three submission for SESRO SRO

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 the suite of documents that make up the 'Gate 3 submission.' Gate 3 of the RAPID programme represents a checkpoint on the way to solutions being prepared for consent applications. The intention at this stage is to provide RAPID with an update on activities being undertaken in preparation for consent application submission; activities' progress including programme through to completion; and consideration of specific activities to address particular risks or issues associated with a solution. The regulatory gated process does not form part of the consenting process and will not determine whether an SRO is granted planning consent.
- Given the stage of the SROs in the planning process, the information presented in the Gate 3 submission includes material or data which is still in the course of completion, pending further engagement, consultation, design development and technical / environmental assessment. Final proposals will be presented as part of consent applications in due course.
- The project information captured in this document reflects a design freeze in October 2024 following the non-statutory consultation, to meet the requirements of RAPID's gated process. Since then, the design has continued to evolve which includes further work with Affinity Water and Southern Water partners to form agreed requirements for the development consent application, such as the incorporation of Southern Water's proposed water treatment works into the SESRO consent. You can find the latest information about the design and development of the project at https://thames-sro.co.uk/projects/sesro/.

Disclaimer

This document has been written in line with the requirements of the RAPID Gate 3 Guidance (v3, January 2024) and to comply with the regulatory process pursuant to Thames Water's, Southern 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, the co-sponsors 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.

Revision history

Version	Date	Submitted at
1.0	21-07-2025	RAPID submission

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Glossary

Terms and acronyms	Definition
ACWG	All Company Working Group (water companies involved in Strategic Resource Option schemes)
CARES	Certification Authority for Reinforcing Steels
CESMM4	Civil Engineering Standard Method of Measurement Carbon & Price Book 2013
DCO	Development Control Order
DESNZ	Department for Energy Security and Net Zero
DWI	Drinking Water Inspectorate
EA	Environment Agency
EIA	Environmental Impact Assessment
GHG	Greenhouse gases
ICE	Inventory of Carbon and Energy
IEMA	Institute of Environmental Management and Assessment
MEICA	Mechanical, Electrical, Instrumentation, Controls and Automation
NPS	National Policy Statement (in this report this refers to the NPS for Water Resources)
NPV	Net Present Value
PINS	Planning Inspectorate
PV	Photovoltaic solar panels or plant
RAPID	Regulators' Alliance for Progressing Infrastructure Development
Reservoir Tunnel	Tunnel between the SESRO pumping station and the main tower
River Tunnel	Tunnel between the SESRO pumping station and the inlet/outfall
SESRO	South East Strategic Reservoir Option
SiPR	Water Industry (Specified Infrastructure Projects) (English Undertakers) Regulations 2013
SRO	Strategic Resource Option
STT	Severn Thames Transfer
SWOX	Swindon and Oxfordshire WRZ

T2AT	Thames to Affinity Transfer SRO
T2ST	Thames to Southern Transfer SRO
TBM	Tunnel Boring Machine
UKWIR	UK Water Industry Research
WEEE	Waste Electrical and Electronic Equipment
WRMP24	Water Resources Management Plan 2024
WRSE	Water Resources South East
WRZ	Water Resources Zone
WTW	Water Treatment Works

1 Introduction and Context

1.1 Introduction and Context

1.1.1 Under the Water Industry Act 1991, every water company must prepare and maintain a Water Resources Management Plan (WRMP). This plan is updated every five years and sets out how companies are required to produce WRMPs every five years. The water-stressed status of south-east England was recognised by Ofwat (the Water Services Regulation Authority) following submission of the WRMP 2019 (Various Water Companies, 2019), and subsequently, funding was provided for water companies to investigate, then develop SROs that will benefit customers and the wider society and help protect and enhance the environment. Thames Water's WRMP 2024 was published on 18 October 2024, following a direction to publish from the Secretary of State in August 2024. The WRMP24 aligns with the revised draft Water Resources South East (WRSE) regional plan and establishes the need for a new 150Mm3 reservoir (the South East Strategic Reservoir Option, or SESRO) that will primarily supply Thames Water, Southern Water and Affinity Water customers.

1.2 SESRO

1.2.1 In 2019, Ofwat provided funding for water companies to investigate and develop new large scale Strategic Resource Options (SROs) which are expected to play a crucial role in meeting long-term water needs, particularly in the south east which is described as "seriously water stressed". SESRO is a strategically important SRO which requires development by multiple partners for wider regional benefit beyond one company's supply boundaries. This type of scheme is lengthy and complex to consent and develop. In accordance with Thames Water's WRMP, SESRO is required to be operational by 2040.

1.3 RAPID

1.3.1 RAPID, a joint team made up of the three water regulators: Ofwat, the Environment Agency (EA) and the Drinking Water Inspectorate (DWI), was set up to support and oversee the progress of SROs. At PR19, Ofwat introduced a new gated process for which RAPID provides advisory oversight. At each gate, RAPID assesses the progress made in the development of each solution and provides recommendations to Ofwat on whether to release the next tranche of funding to continue scheme development. This process allows comparison of the solutions at regular intervals, and has clear checkpoints, or 'gates', to assess progress and determine which solutions should be taken forward for further work.

1.3.2 Each scheme passes through a series of governance 'gates', enabling key information to be presented and an assessment made on whether the scheme should continue for further development. The gates, for a standard SRO, set out by Ofwat in PR19 are as follows:

- Gate one – initial feasibility, design and multi-solution decision making.
- Gate two – detailed feasibility, design and multi-solution decision making.
- Gate three – finalised feasibility, pre-planning investigations and planning applications
- Gate four – planning application, procurement strategy and land purchase.

1.4 Structure of Report

1.4.1 This report has been prepared to provide technical supporting information for the SESRO SRO gate three submission to RAPID. This report is Supporting Document A2, Carbon. An overview of the SESRO project is provided in the gate three main report to RAPID (primarily, in Section 2).

1.4.2 The structure of this supporting document is as follows:

- Section 1 – describes background and context
- Section 2 – describes the gate three capital carbon estimate
- Section 3 – describes the gate three operational carbon estimate
- Section 4 – describes other emissions
- Section 5 – describes the gate three whole life carbon estimate
- Section 6 – describes the carbon management strategy for gate three

1.5 Carbon[1] Management Overview

1.5.1 SESRO has the potential to deliver water security benefits but is also an important source of greenhouse gas (GHG) or carbon emissions through its construction and operational phases.

1.5.2 To align with the latest RAPID gate three guidance this carbon report focuses on the assessment of carbon emissions and management strategies for reduction and includes:

- Consideration of the Kyoto Protocol seven greenhouse gasses (GHG). All carbon values are expressed in carbon dioxide equivalent units covering all Kyoto Protocol GHGs.
- A carbon assessment of key emission areas (scope 1, 2 and 3). This report clarifies which emissions areas have been assessed to reflect the gate three design stage and which emissions areas have not been assessed with supporting commentary.
- An assessment of the cost of whole life carbon emissions of the gate three design, using the UK Government carbon price information.

[1] The term carbon is being used throughout this report. The term carbon is used instead of greenhouse gases, since this term is often used in infrastructure planning.

- A discussion of whole life carbon reduction opportunities that have been considered during gate three and supporting commentary.
- Cross referencing of other gate three submission documents as appropriate, such as the natural capital report.
- A demonstration of how relevant policy frameworks and approaches to drive down carbon emissions have been considered during gate three, including PAS2080:2023, other relevant standards, UKWIR reports on GHG emissions, All Company Working Group (ACWG)[2] relevant reports, as well as other guidance included in the RAPID gate three guidance.
- A discussion around engaging the supply chain to develop further lower carbon opportunities in subsequent phases of the scheme.

1.5.3 To respond to the above requirements, this report provides an overview of the capital carbon emissions (Section 2), operational carbon emissions (Section 3) and other direct emissions and removal opportunities (Section 4). These have subsequently been used to present the whole life carbon emissions of the scheme (Section 5). Section 6 discusses the carbon mitigation analysis undertaken as part of gate three to identify whole life carbon reductions. This section also highlights current knowledge gaps and gives an overview of relevant ongoing work that is taking place and will continue to take place in subsequent phases of the scheme.

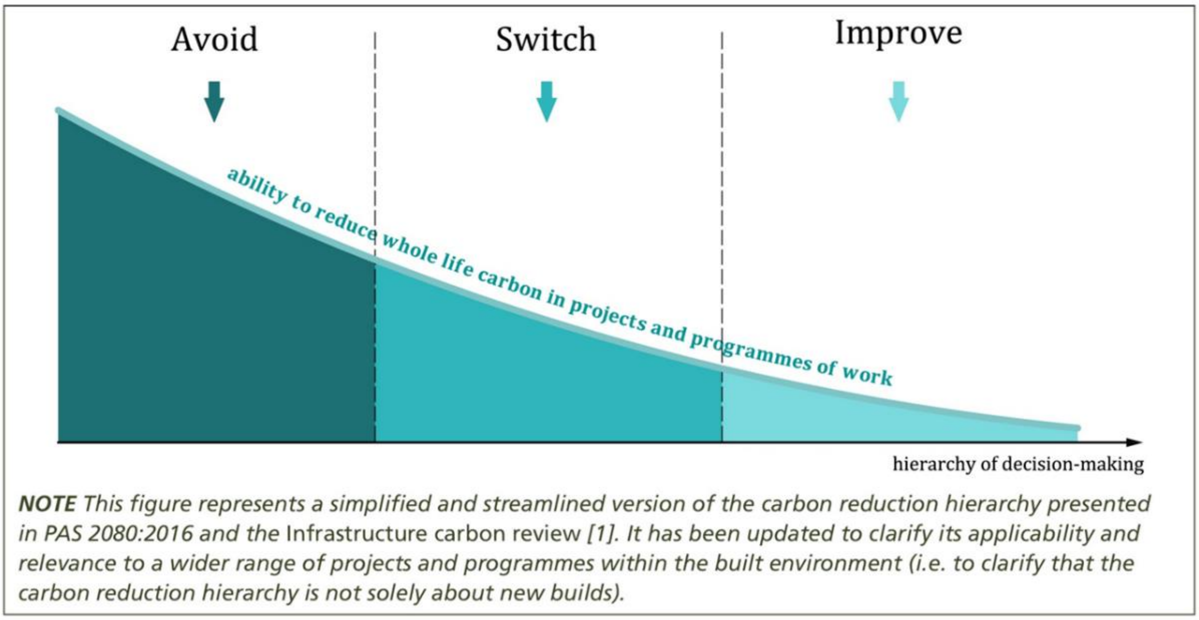
1.5.4 The whole life carbon assessment and mitigation approach for SESRO has followed good industry guidance mainly PAS2080:2023 and the IEMA emissions reduction hierarchy to identify opportunities to mitigate carbon impacts of the scheme.

1.5.5 The PAS2080:2023 carbon reduction hierarchy shown in Figure 1 has been followed as a guide to a series of low carbon challenge workshops with all gate three design teams. This was to identify low carbon alternatives for whole life carbon.

[2] ACWG – All Company Working Group, the group of water companies involved in SRO projects

Figure 1 – PAS2080:2023 Carbon Reduction Hierarchy

Figure 5 – Carbon reduction hierarchy



1.5.6 It is acknowledged that a large proportion of capital and operational carbon emissions over the whole life of the SESRO scheme are considered to be Scope 3 emissions (capital carbon). These are mainly outside of the direct control of the water companies; however, Thames Water does have a level of influence in reducing/avoiding such emissions by working closely with the supply chain throughout the procurement process. For example, the availability, at sufficient scale, of alternative fuels and construction plant for the earthworks and haulage activities associated with reservoir construction are a key area for engagement to enable decarbonisation of the SESRO scheme.

1.5.7 The carbon emissions mitigation efforts have been categorised in the following areas:

- Opportunities directly under the control of the project team, including areas which can reduce emissions through design decisions that can be embedded and costed into the scheme. These have been identified at the current design stage, through holding low carbon challenge workshops with the gate three design teams and captured in this report. The design teams that were engaged for identifying low carbon opportunities include:
  - Earthworks
  - Tunnels/Conveyance System
  - Roads and bridges
  - Natural capital
  - Water quality (in reservoir)
  - Energy

- In addition to opportunities integrated through the design process, a number of other opportunities are being investigated, such as options for integrating additional renewable energy systems.
- Longer term opportunities where the scheme and sector can influence external systems and supply chains to decarbonise major components of the scheme such as alternative construction materials and construction fuels. These longer-term mitigation opportunities have been informed by current industry good practices, including the All Company Working Group decarbonisation study as well as recent developments followed by different infrastructure asset owners. Longer term opportunities are being assessed following a scenario-led approach and are to be investigated further through subsequent development phases of the SESRO scheme.

1.5.8 The goal for the SESRO carbon management approach is to:

- Align to the decarbonisation requirements found in the National Policy Statement for Water Resources Infrastructure (NPS)[3]. This report provides commentary on how the carbon management approach in gate three and beyond aligns to the NPS requirements. The approach covers aspects such as decarbonisation level of ambition, whole life carbon emissions assessment, low carbon opportunities as well as GHG removals.
- Establish a carbon baseline to be able to compare progress for reducing whole life carbon against any agreed level of decarbonisation ambition. The gate three whole life carbon assessment presented in this report is an update of the whole life carbon emissions impact since the gate two design. The gate three whole life carbon estimate is not a carbon baseline (starting point) or a decarbonisation level of ambition. Current ongoing work on the decarbonisation level of ambition will continue in the next phases of the SESRO scheme.
- Align to latest guidance and emissions factor sources quoted in the RAPID guidance and wider industry. The aim is to ensure that the assessment is done at a sufficient level of detail to inform decisions for reducing the whole life carbon emissions of the scheme.
- Transparently communicate design assumptions, sources of emissions factors and scope and boundary of emissions included and excluded at the current design stage.
- Draw insights from the whole life carbon assessment to communicate major emissions hotspot sources with relevant stakeholders and value chain

[3] https://assets.publishing.service.gov.uk/media/6437e3a2f4d420000cd4a1a7/E02879931_National_Policy_Statement_for_Water_Resources.pdf

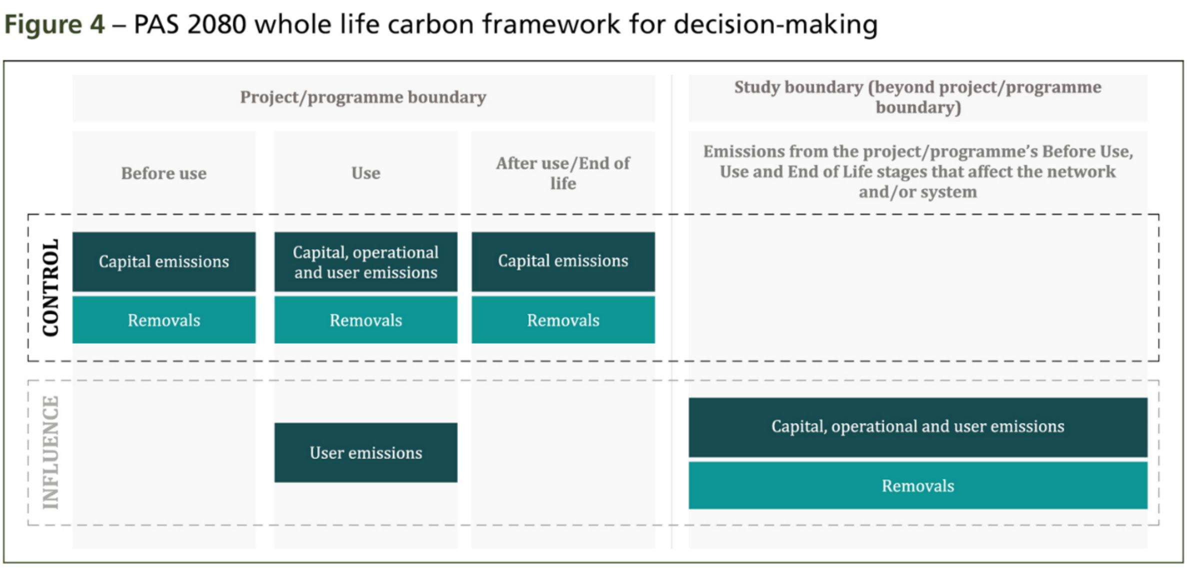
members to inform subsequent management efforts for reducing whole life carbon emissions.
- Communicate actions that have already been incorporated into the design to mitigate whole life carbon emissions.
- Communicate future recommendations for the project team to further mitigate whole life carbon emissions at later stages of the scheme development.
- Support the establishment of a stakeholder engagement plan that demonstrates how the SESRO scheme (in future stages) could influence external systems to support carbon reduction ambitions, whilst acknowledging these will remain outside of the project team's control.
- Highlight uncertainties in the assessment of whole life carbon emissions and provide commentary of additional cost impacts for implementing various decarbonisation measures and how these uncertainties will be monitored over time.

1.5.9 In the next stages of design development for SESRO it would be necessary to continue to evaluate water sector and water company goals for carbon reductions in line with sector and national net-zero commitments alongside the cost implications of decarbonisation.

1.6 Scope for emission sources during gate three

1.6.1 The scope and boundary of the whole life emissions framework used when developing the gate three whole life carbon assessment is based on PAS2080:2023. This is shown in Figure 2

Figure 2 – PAS2080:2023 Whole life carbon management framework for decision-making



1.6.2 This report comments on current knowledge gaps for understanding emissions in different emissions categories. The study boundary considered for the carbon emissions assessment is the provisional planning boundary of the SESRO scheme used for EIA Scoping with the exception of the T2ST Water Treatment Works (WTW), where the carbon will be reported in the T2ST gate three submission. Nevertheless, commentary is provided for any emissions impacts beyond the planning boundary, where these are applicable to SESRO.

1.6.3 The emissions sources covered in the gate three whole life carbon assessment are summarised in Figure 3.

1.6.4 As SESRO is a strategic resource it interacts with other water resources projects as summarised below:

- Thames to Southern Transfer (T2ST) – this scheme will deliver a treated water transfer to the Southern Water area with a new water treatment works (WTW) on the SESRO site. The SESRO design includes pumps in the pumping station and a pipeline to the WTW as well as a pipeline from the WTW to the southern boundary of the site. Carbon emissions from the WTW form part of the T2ST SRO project and will be included in the T2ST gate three report.
- Swindon and Oxfordshire (SWOX) Raw Water Transfer – a raw water transfer to the existing Thames Water Farmoor Reservoir in the local Swindon and Oxfordshire (SWOX) Water resources zone.
- SWOX WTW and potable water transfer – this is a potential future scheme that is on an adaptive pathway in WRMP24. Space will be reserved on the SESRO site for a WTW and space will be provided in the SESRO pumping station to install pumps in the future. The implementation of this scheme does not form part of the SESRO DCO and the related carbon is not assessed.
- Thames to Affinity Transfer (T2AT) SRO – This scheme will abstract water returned to the river from SESRO and therefore it is not included in this whole life carbon assessment.

Figure 3 – Whole life emissions sources included and excluded in gate three

	Capital emissions	Operational emissions	End of life emissions	Direct emissions/ removals
Inclusions	• New assets and activities in Gate 3 design • Diversions of existing assets • Removal of existing solar PV plants	• Operation of assets • Capital maintenance / replacement • Flow demands for T2ST, Farmoor • Hydroturbine power generation	• Decommissioning, removal and disposal of existing PV plants in the site vicinity	• Sequestration from landscaping works
Exclusions	• T2ST WTW assets	• Visitor transport emissions • Heating of water for end use • Renewable energy generation outside new hydro-turbines	• Removal, recycle, reuse, recovery or returning of new assets following the end of operating life of the scheme.	• Direct emissions sources from land use change

1.6.5 The emissions categories that have been considered in gate three focus on categories that support decision-making for whole life carbon reductions. For example, the user carbon associated with heating water in the home as a result of the SESRO scheme has not been quantified as it is linked to the scheme's deployable output that was defined in the WRMP and is the same output when compared to alternative water resource options.

1.6.6 The capital carbon emissions for the pumping station includes the pumps for transfers to T2ST and Farmoor. The operational emissions due to pumping flows for T2ST and Farmoor are also included.

1.6.7 Some user emissions categories have not been included in the gate three assessment and will need to be considered in relevant subsequent phases of the project. These involve renewable energy export options (to wider system) from the SESRO site boundary as well as transport emissions associated with operation, maintenance and visitor travel activities.

1.6.8 Given the long life of this water supply asset (there are reservoirs that have been in use for well over a hundred years), the end of life emissions of the reservoir site have not been quantified nor have any scenarios involving alternative future uses of the same land been considered. End of life scenarios for shorter life asset types (such as MEICA assets and some civil structures) could be explored in subsequent design phases of the scheme, when considering ways to recycle and reuse such asset types. This approach is in line with current industry guidance in the water sector (UKWIR, 2024[4]).

[4] UKWIR, Supporting whole life carbon reduction, 2024 - https://ukwir.org/supporting-whole life-carbon-reduction

1.6.9 Direct emissions sources from land use change have not been quantified in gate three due to the current high uncertainty of such emissions. All other construction activities have been included in the capital carbon estimate. Section 6 includes further commentary and proposals for future consideration.

1.6.10 The carbon emissions shown in Figure 3 above are discussed further in this report.

- Section 2 – capital carbon emissions
- Section 3 – operational carbon emissions
- Section 4 – other direct emissions and removals
- Section 5 – whole life carbon emissions

1.6.11 Gate three project development has included optioneering and creation of an interim landscape and environmental master plan, which were subject to public consultation and EIA Scoping in summer 2024. Engineering design development continued in parallel with the public consultation and EIA Scoping to inform gate three cost and carbon estimating. Any design changes required in response to the consultation or scoping decision will be incorporated after gate three.

1.6.12 Design changes from gate two to gate three are summarised in the main gate three report and supporting document A1, Basis of Design. The design and construction activities used to inform the whole life carbon emissions of the gate three estimate, including any carbon mitigation opportunities, reflect the gate three design.

1.7 Uncertainty in modelling whole life carbon emissions

1.7.1 There is inherent uncertainty in carbon estimating due to the developing maturity of carbon accounting practices as well as associated activity, emissions factor data and the science behind some emissions sources – such as emissions associated with land use change (direct emissions and sequestration opportunities). There is also additional uncertainty driven by scope uncertainty associated with level of design information available at given stages within the scheme lifecycle.

1.7.2 There is currently no standardised or established guidance in the water sector to assess uncertainty in carbon estimates in a consistent way and directly applying the range of uncertainty associated with cost estimates (as well as associated allowances for optimism bias) would likely overstate the level of uncertainty associated with the gate three carbon estimate. Hence, in the carbon estimate there has been no allowance made for uncertainty.

1.7.3 The approach for estimating uncertainty will continue to be reviewed and refined at future stages of SESRO design development, including any further industry wide efforts to assess uncertainty in carbon estimating.

2 Capital Carbon

2.1 Definition, scope and boundaries

2.1.1 Under the Greenhouse Gas Protocol, capital carbon emissions from construction are typically categorised as Scope 3 emissions of the sector/organisation. Capital carbon emissions from construction and maintenance activities are the result of materials (extraction and processing), manufacturing effort, transportation, and any disposal of construction waste. The capital carbon assessments within this section cover lifecycle modules A1-A5 (as per BS EN 17472:2022 "Sustainability of construction works. Sustainability assessment of civil engineering works. Calculation methods"[5]) and consider the embodied carbon of materials used as well as associated construction activities to take the reservoir to its commissioning stage. The assessments also considered a cradle-to-built asset boundary (as per UKWIR, 2012[6]).

2.1.2 The scheme boundary considered for the capital carbon assessment considers the study boundary referenced in Section 1.6.2.

2.1.3 The assets and construction activities included in the gate three capital carbon assessment are described in the main gate three technical report and supporting documents: A1 - Basis of Design, A3 - Cost Report and D - Project Management Plan. The main asset groups and activities included in the capital carbon assessment are summarised in Table 1 below.

[5] https://knowledge.bsigroup.com/products/sustainability-of-construction-works-sustainability-assessment-of-civil-engineering-works-calculation-methods?version=standard

[6] UKWIR, A framework for accounting for embodied carbon in water industry assets, 2012

Table 1 – Asset groups and activities included in capital carbon assessment

Inclusions	Exclusions
• Enabling works, diversions • Embankment and earthworks • Tunnels and shafts construction (including capital carbon impacts of consumed components of the tunnel boring machine (TBM) as well as power consumption by the TBM during tunnelling). • Temporary and permanent roads • Civil structures, pumping station • Pipelines • MEICA • Landscaping • Temporary rail sidings • Decommissioning of existing solar PV plant • Temporary site compounds • Construction plant fuel consumption – assumes all are diesel fuelled • Materials transportation fuel emissions • Hydro turbines • Buildings (including recreational buildings) • Power consumption for commissioning and initial impounding	• T2ST WTW (as the design of T2ST WTW is under development and will be reported in T2ST SRO submissions). • Other SROs and assets outside the gate three SESRO design. • Capital carbon of construction plant and other vehicles involved in construction activities (as these will be re-used on other projects apart from SESRO).

2.2 Modelling approach

2.2.1 A capital carbon assessment has been carried out using current design information alongside the breakdown of asset scope inputs used for the gate three cost estimate. The asset information used for costing was aligned to carbon models developed based on industry standard data to enable an estimate of capital carbon.

2.2.2 The assessment for the reservoir construction activities has predominantly used carbon emissions rates from Civil Engineering Standard Method of Measurement (CESMM4) Carbon & Price Book 2013, published by the Institution of Civil Engineers (referred to in this report as the CESMM4 database). These cover activities such as topsoil stripping, excavation, stockpiling and placing of excavated materials.

2.2.3 Additionally, bespoke carbon models have been used to estimate capital carbon emissions for other asset types as well as to refine, where possible and where further analysis has been undertaken as part of the gate three design, the carbon emissions associated with construction activities. These models have been developed using typical industry generic designs and supplier information for products and materials, alongside emissions factor data from the Inventory of Carbon and Energy (ICE).

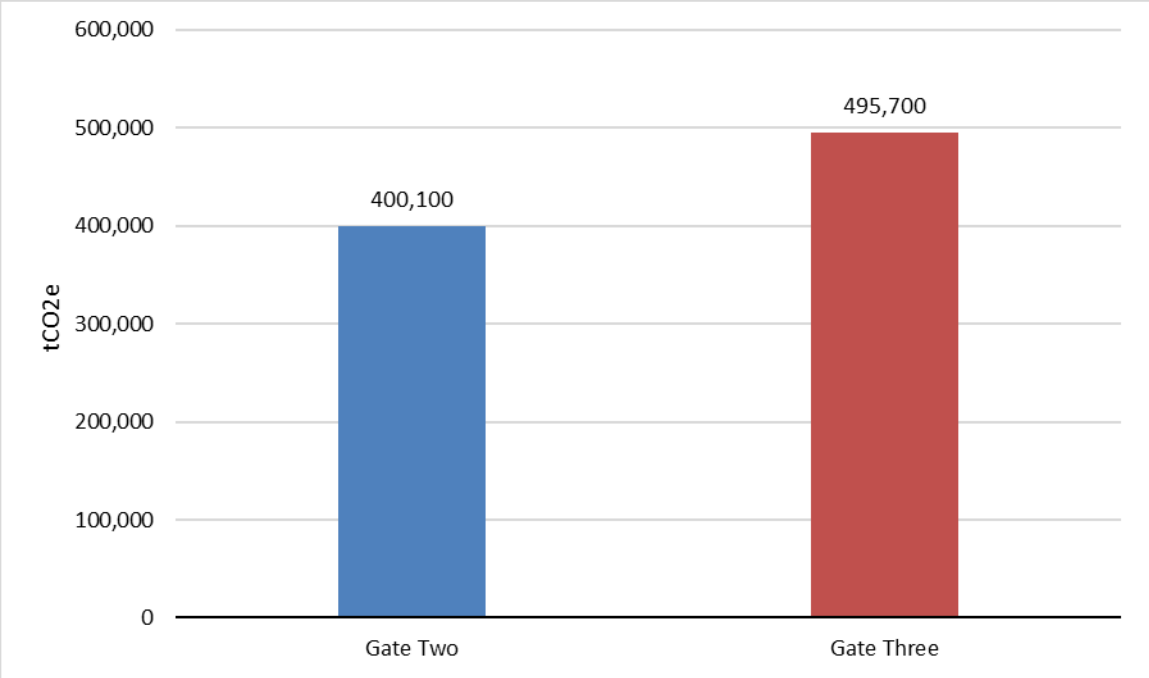
2.2.4 For smaller asset types, such as buildings and some ancillary works, where no detailed design information was available during gate three, capital carbon/cost intensities have been used to fill in the gaps. Separate capital carbon/cost intensities for civil works and MEICA, with units in tCO2e/£ million of capex, have been derived by dividing the total carbon emissions for items modelled in detail (using CESMM4 data or bespoke carbon models) by the total capex for the modelled items.

2.2.5 Over time, as more detail is built into material specifications and specific locations of supply, it is expected that more supplier specific emissions data could be used in place of industry generic emissions inventories.

2.3 Summary of capital carbon assessment and hotspots – gate three update

2.3.1 The gate three design capital carbon estimate is 495,700tCO2e. This is 24% higher than the gate two capital carbon estimate of 400,100tCO2e, a significant increase carbon emissions which is largely the result of design changes since gate two. Figure 4 shows how the total capital carbon estimate compares between gate two and gate three.

Figure 4 – Comparison of total gate two and gate three capital carbon estimates



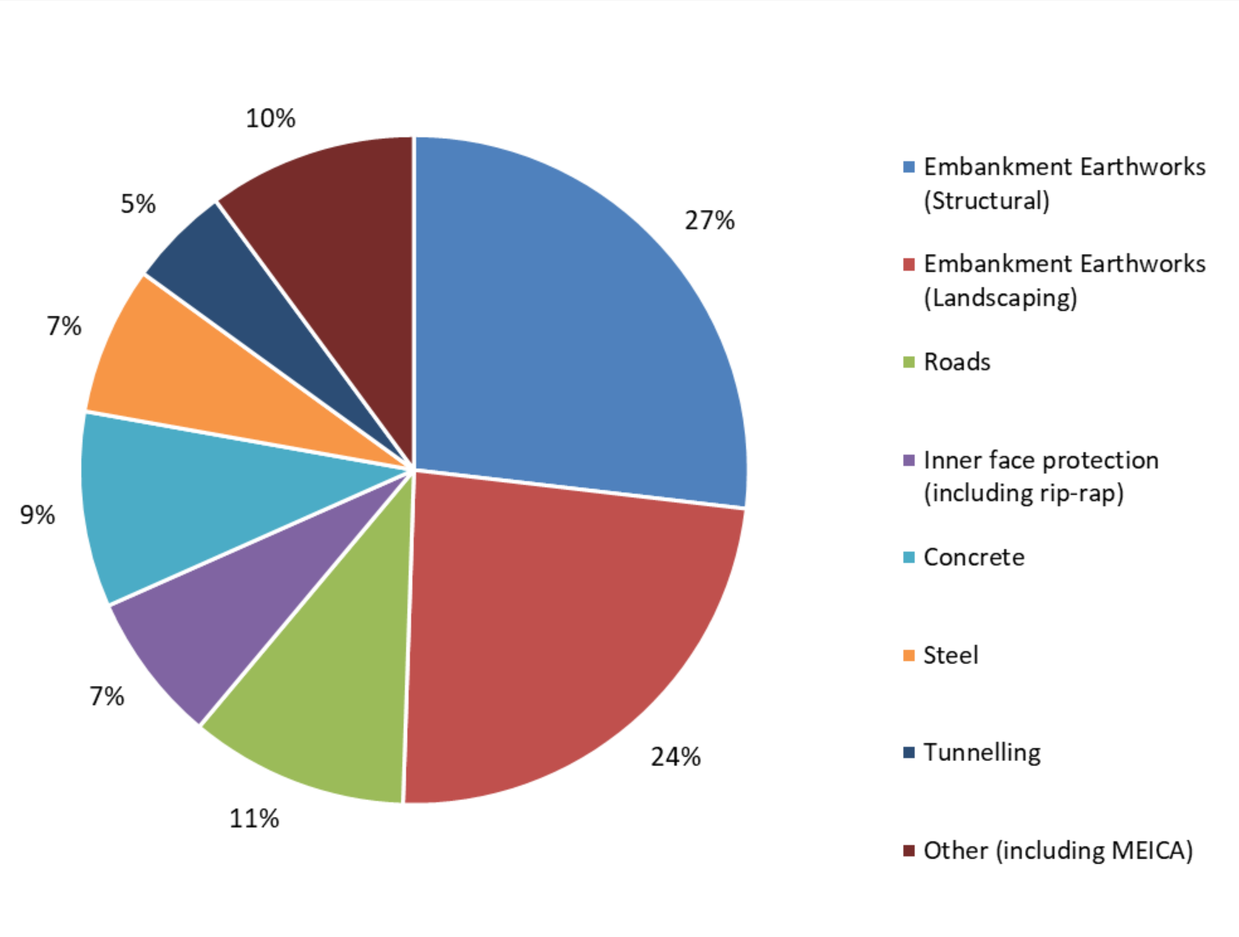
2.3.2 The differences between the gate three and gate two capital carbon assessment can be attributed to changes in design and improved modelling detail. Significant factors include the following:

- Changes in design assumptions, particularly increasing size of major structures to accommodate the gate three design requirement for the reservoir to be able to release flows to water treatment works at the same time as filling the reservoir from the River Thames. Also, an increase to the river tunnel diameter to enable emergency drawdown exclusively through the tunnel rather than tunnel and surface water channel.
- Better understanding of assets and construction activities during gate three as the design and construction effort are further refined. Such changes are reflected in the capital carbon modelling approach in gate three where additional asset and construction activities are modelled and, in some cases, different emissions factors are being used to better reflect such activities.

2.3.3 Some design differences such as increasing the size of the tunnels and major pumping structures to accommodate new flows to the water treatment works have resulted in higher capital carbon emissions. Low carbon opportunities and design and constructability efficiencies have resulted in some carbon emissions reductions in some areas. More granular design data have resulted in using different and more appropriate carbon models in the gate three stage, increasing the overall capital carbon estimate. Specific differences relevant to the different assets and activities are discussed in more detail below.

2.3.4 The main capital carbon hotspots in the gate three design are shown in Figure 5. It is noted that capital carbon associated with transportation is included within the reported hotspots and not separately itemised.

Figure 5 – Gate three design capital carbon hotspots



2.3.5 The largest capital carbon hotspot are the emissions associated with the embankment works accounting for 51% of the total capital carbon of the SESRO scheme (250,500tCO2e). The main components of the embankment works consist of:

- Earthworks associated with the excavation, handling and material filling for the reservoir structure (133,100tCO2e)
- Earthworks associated with the landscaping design (117,400tCO2e)

2.3.6 Other components of the embankment include:

- Rip rap for the reservoir face protection, involving importing and placing stone (11,650 tCO2e).
- Bedding and inner face protection of the reservoir involving importing and placing sands and gravels (6,180 tCO2e).
- Embankment and overall site drainage involving importing and placing sands and gravels (18,120 tCO2e).

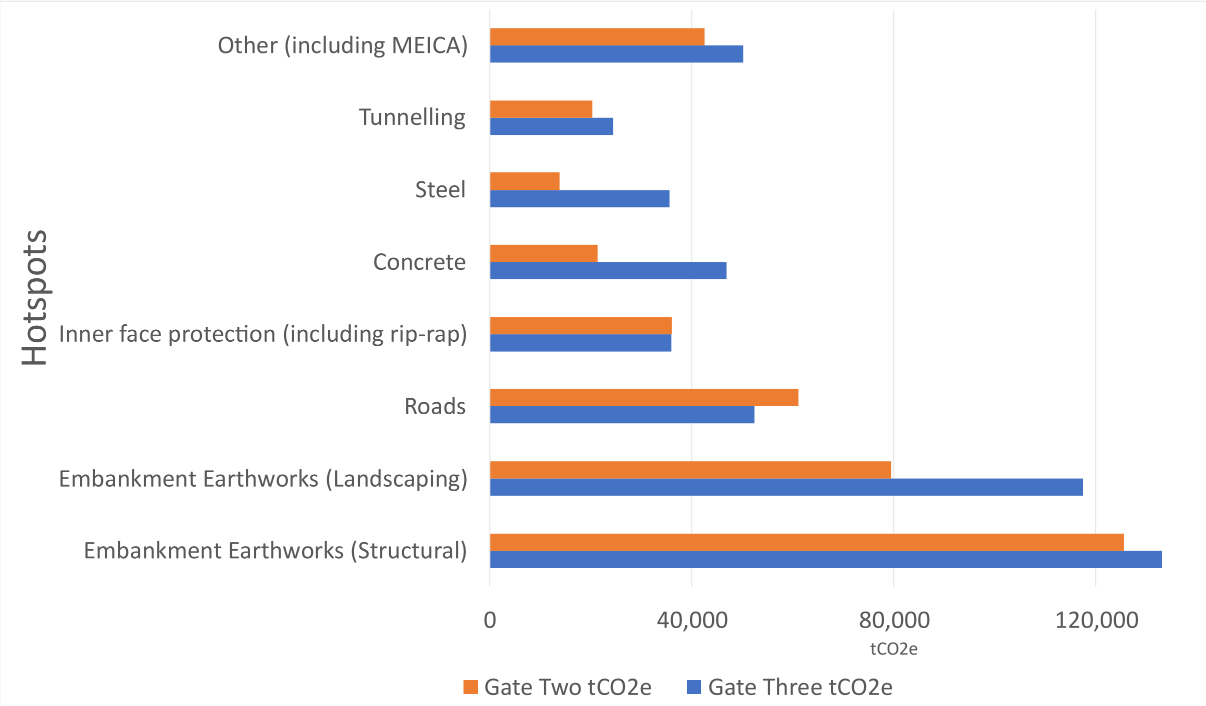
2.3.7 The second largest single hotspot is the emissions associated with the main hydraulic structures and other structures particularly involving concrete and steel in construction. These account for approximately 17% of the total capital carbon (82,500 tCO2e).

2.3.8 Other major capital carbon hotspots are (1) the roads and bridge structures, including permanent roads, temporary haul roads across the reservoir site and bridges for the new roads and the various watercourse crossings, accounting for 11% of the total capital carbon (52,400 tCO2e) and (2) the construction effort and materials for the tunnel construction, nearly 6% of the total capital carbon (24,300 tCO2e) including the excavation by the TBM (tunnel boring machine) and the tunnel grouting).

2.3.9 The "other" category in Figure 5 accounting for approximately 10% of the capital carbon (or 50,100tCO2e) includes enabling works (including diversion of existing utilities), buildings, pipework, rail sidings and materials handling area, and general MEICA assets. It also includes the decommissioning and offsite disposal of the existing solar Photo Voltaic (PV) plant. The additional emissions arising from the loss of renewable energy generation in the grid due to the decommissioning of the existing solar PV plants are not included in the capital carbon emissions. These additional emissions as a result of lost generation are summarised in Section 4.4 (Emissions impact from SESRO beyond the project boundary).

2.3.10 The gate three capital carbon hotspots are broadly similar in distribution to the gate two hotspots. Figure 6 shows how the gate three capital carbon hotspots compare to the gate two capital carbon estimate.

Figure 6 – Comparison of capital carbon hotspots between gate two and gate three



Embankment Works – Gate three update

2.3.11 During gate three, the design has evolved with additional analysis, together with further optimisation of construction activities, material quantities and material types associated with the embankment construction.

2.3.12 The shape and embankment heights at gate three remain consistent with those of gate two. However, the overall material usage has been reduced by nearly half between the two gates. Further design updates and more detailed specifications have enabled the selection of more suitable carbon models. Despite these improvements, emissions associated with embankment construction have consistently remained at 60% of total capital emissions. A significant change in the line items is the separation of sand and gravel materials, which were previously grouped together as gravel in gate two. This adjustment has allowed for more accurate carbon emissions calculations in gate three. The inclusion of dig-and-replace techniques and the efficient movement of excavated material around the site have also helped mitigate the increase in carbon emissions.

2.3.13 The landscaping design has significantly evolved from gate two to gate three. Initially, gate two focused primarily on substantial excavation and material filling. In contrast, gate three features a more refined design with additional line items and detailed specifications for elements such as floating rafts, ponds, and hedgerows. This refinement has led to a more precise selection of carbon models. However, it is important to note that a more detailed assessment is required. The current evaluation does not account for land-use changes and the associated carbon emissions or sequestration. A discussion around other emissions associated with land use change is provided in Section 4 of this report.

2.3.14 For the bedding, inner face protection and drainage (including rip rap) there is no overall change in the capital carbon estimate since gate two. Despite increases in the inner face protection materials (due to design changes), additional design efficiencies have resulted in the optimisation of site drainage material quantities. Further granularity in the design solutions has also enabled more appropriate selection of emissions rates from the CESMM4 database and bespoke carbon models (using ICE Bath database emissions factors).

2.3.15 Although the main construction effort activities (embankment and wider construction activities and enabling works in the planning boundary) have been modelled using the CESMM4 database and other bespoke models to fill in any gaps, during gate three, progress has also been made in assessing the different types of construction plant to be used (including capacity, hourly fuel consumption, and output rates). Although this exercise is ongoing and will continue to be developed with the scheme's constructability advisor in subsequent phases of the scheme, some high-level assumptions and scenarios have been explored during gate three to inform potential carbon mitigation scenarios for construction fuels. These have not been included in the revised gate three estimate as the information is still very high level and incomplete. Nevertheless, this work on potential alternative construction fuel scenarios is discussed in Section 6 of this report.

Structures (concrete and steel) – Gate three update

2.3.16 The main structures required for SESRO are the river intake/outfall structure, the pumping station, shafts and the reservoir inlet/outlet towers. Concrete and steel are the major capital carbon hotspots for these main structures. The capital carbon emissions associated with the materials and construction effort for the main structures have increased since the gate two estimate.

2.3.17 The main reason for the increasing emissions from concrete in gate three are the increased structure sizes (shafts, pumping station and main tower). These have increased to provide space for the pumps, pipelines and valving necessary to deliver water to T2ST, Swindon and Oxfordshire (SWOX) Raw Water Transfer and potentially SWOX potable water transfer whilst filling the reservoir, as well as to facilitate the updated emergency drawdown arrangements (included in the gate three design but still subject to the outcome of the summer 2024 consultation). However, further granularity in the gate three design has enabled better understanding and targeting of carbon models for concrete strengths (C40/50 and C32/40) which give a less conservative carbon estimate than the industry generic concrete mixes used in gate two.

2.3.18 Emissions associated with steel reinforcement in major structures remain similar to those at gate two. Higher design granularity and improved emissions factors from the CARES specification, which uses the latest industry average of 97.8% recycled content in steel reinforcement, has partly mitigated the increase in emissions due to the increased size of the structures since gate two.

2.3.19 As the design progresses over time there will be further opportunities to optimise the concrete mixes used and also explore lower carbon cement replacement products. See Section 6 for further discussion around mitigation opportunities.

Roads and bridges – Gate three update

2.3.20 The gate three capital carbon estimate is 8,700 tCO_2e lower for the roads and bridges hotspot when compared to the gate two estimate. The gate three design has been optimised further to select different road surfacing materials (such as hot-rolled asphalt) and reduce design quantities. The gate two design assumptions included concrete surfacing for all roads with more conservative indicative designs. Furthermore, the temporary haul roads identified in gate two have been assumed to be converted into permanent roads in gate three - such reuse resulting in avoided emissions.

2.3.21 Further design detail for the bridge structures in gate three has resulted in more accurate carbon modelling (using industry benchmarks for superstructure and substructure) which has resulted in a relatively small increase in the capital carbon emissions. However, the overall impact for the roads and bridges category is lower capital carbon emissions when compared to the gate two estimate.

Tunnelling – Gate three update

2.3.22 The capital carbon associated with the tunnelling (including lining and grouting) has resulted in an increase of approximately 4,000tCO_2e when compared to gate two.

2.3.23 The main change from gate two has been the increase in the tunnel diameters to accommodate the additional flows and connectivity design assumptions in gate 3 three and addition of 1.4km of secondary lining. The internal diameter of the River Tunnel has increased from 4.2m to 6m in the gate three design (confirmation of this change is subject to the outcome of the summer 2024 public consultation), which nearly doubles the excavation quantities per metre of tunnel as well as increasing the TBM size and energy consumption. The River Tunnel has also increased in length by 100m. Furthermore, the transport distance and method for the TBM has been assessed further, enabling more accurate modelling of potential transport emissions for the TBM from its place of manufacture. These activities have been modelled in greater detail for gate three using bespoke carbon models, as opposed to gate two where a single CESMM4 database rate was used. These increases have been partly mitigated by assuming that the TBM will now be powered using grid electricity rather than diesel fuelled generators.

2.3.24 Other low carbon solutions embedded in the gate three design include reuse of spoil excavated from the tunnelling works (reducing transport emissions off site).

Other Categories – Gate three update

2.3.25 Additional items modelled in the gate three design include buildings (above site structures and recreational buildings), MEICA and ancillary items. The carbon emissions for these have been modelled using capital carbon/cost intensities values (see Section 2.2 for further details of this approach). The gate three capital carbon estimates are 7,600tCO_2e higher than estimated at gate two.

2.3.26 The steel category in the graph, includes steel pipes and other structural steel items not included in the reinforced concrete structures

2.3.27 There are existing solar PV plants within the SESRO planning boundary which began operating in 2014 and would have an estimated annual energy yield in 2029/30 of approximately 67 GWh/year. Construction of SESRO would require these solar PV plants to be decommissioned or relocated.

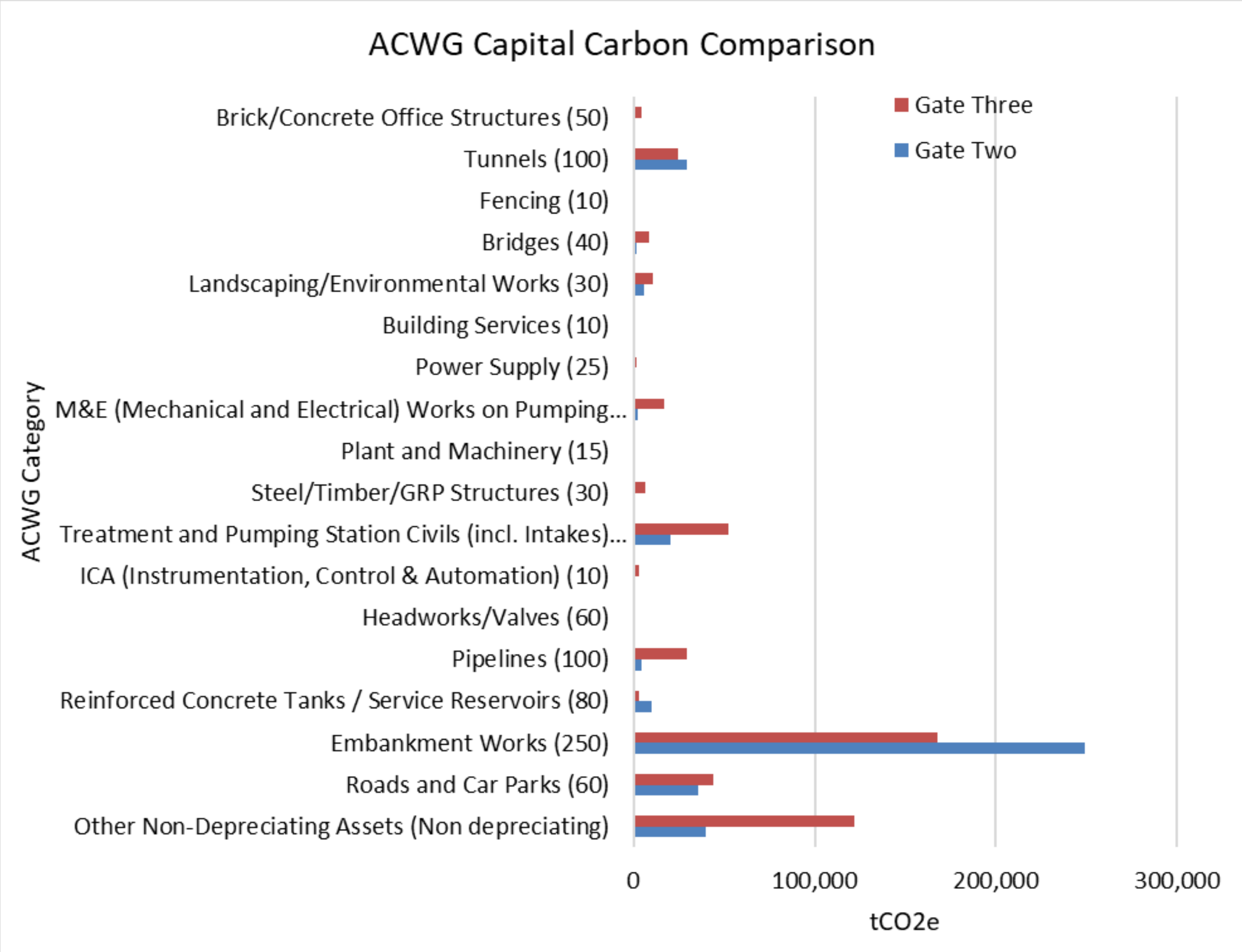
2.3.28 The gate three capital carbon estimate has assumed that the existing PV plants will be fully decommissioned to accommodate the SESRO scheme. However, options for the existing solar farms are currently being explored and will be advanced in the gate four work. The decommissioning and disposal off site of approximately 600,000 individual solar panels across the three existing solar farms, as well as the supporting infrastructure which includes 674km of electrical wiring would result in an additional capital carbon impact of 3,370 tCO_2e. Gate three assumes that the electrical wiring would be recycled at the closest WEEE (waste electric and electronic equipment) recycling centre (Drayton Waste and Recycling Centre), whereas the PV panels would be disposed of to an approved PV panel recycling company.

2.3.29 The early decommissioning of the existing solar PV plants would result in the loss of 67 GWh/year annual renewable energy generation for the region (based on estimated yield in 2029/30). Replacing this energy through the national grid supply would result in total emissions of approximately 16,750 tCO_2e, over the period from decommissioning in 2029/30 until 2039 (the expected end of asset life based on a typical operational life of 25 years). Thames Water is currently investigating wider renewable energy scenarios that could be considered for the project, including solar PV (land based and floating options) as well as other renewable energy technologies.

2.3.30 All 'other' categories in the capital carbon assessment contribute less than 5% of the total capital carbon emissions. While these are not identified as major hotspots within this report, their emissions impact would need to continue to be optimised during later stages of design development.

2.3.31 For completeness, the difference in the capital carbon assessments between gate two and gate three grouped under the different ACWG asset categories, is shown in Figure 7 below. There are some differences in the categorisation of emissions between the ACWG classification and the comparison of the carbon hotspots shown above.

Figure 7 – Comparison of capital carbon in the different ACWG categories



Notes:

1) *For both gate two and gate three, the enabling works, including utilities diversions and temporary works, have been included with the 'Other Non-Depreciating Assets category.*
2) *Some categories, such as building services and fencing, have very low embodied carbon emissions and hence appear zero in the above figure.*
3) *Values in brackets are assumed asset lives for each category.*

2.4 Replacement Capital Carbon Assessment - Approach

2.4.1 SESRO consists of a variety of different asset types, each with a typical design (or asset) life. Hence, there would be a need to replace certain components of the scheme at different times over the operating period of SESRO.

2.4.2 The ACWG has outlined a set of 'asset life categories' into which the components of the schemes are assigned. This is to enable a more consistent assessment of the need to replace certain components at the end of their asset life across all SROs. The ACWG categories that have been used for SESRO and their associated asset life are presented in Figure 7, next to each category Assets are assumed to be replaced at the end of their asset life and the initial modelled capital carbon for construction of that asset is repeated at that time.

2.4.3 Capital replacements do not assume any future decarbonisation of materials or construction effort and this assumption should be reviewed in subsequent phases of the scheme development.

2.4.4 The gate three carbon emissions associated with capital replacement of assets over 65 years (the extent of the operational period included in the model) are 219,600 tCO_2e. These are shown in the whole life carbon emissions profile of the scheme in Section 5 of this report.

Table 2 - Breakdown of Whole Life Carbon Assessment

ACWG Asset Life Category	Asset Life (years)
Embankment Works	250
Other Non-Depreciating Assets (Non depreciating)	n/a
Roads and Car Parks	60
Tunnels	100
Treatment and Pumping Station Civils (incl. Intakes)	60
Reinforced Concrete Tanks / Service Reservoirs	80
Landscaping/Environmental Works	30
Pipelines	100
M&E (Mechanical and Electrical) Works on Pumping Stations and Treatment Works	20
Bridges	40
Steel/Timber/GRP Structures	30
Weirs	100
Building services	10
Fencing	10
Land (Non depreciating)	-

2.5 Low carbon opportunities (capital carbon) embedded in the gate three design

2.5.1 Embankment:

- Design improvements enabling increased use of material excavated on site for construction of the embankments, reducing the need for imported materials

- Improved landscaping design enabling more efficient cut-and-fill balance for landscaping works resulting in a 50% decrease in material quantities to move around the site, which helps reduce haulage emissions
- Refinement of volume of rip rap
- Refinement of volumes of sand and gravel for site and embankment drainage

2.5.2 Tunnels:

- Reuse of arisings from tunnelling works. Not likely to be used for structural fill but perhaps for landscaping and other embankment works. Where possible, the storage location or placement location of clay shall be determined with the aim of reducing transportation distances.
- Use of curve joints instead of flat joints can help reduce the size of the segments, which in turn reduces the volume of concrete. It also reduces the required strength of the concrete which reduces cement usage.

2.5.3 Structures:

- Introduction of tension piles in tower shaft and pumping stations over large thick base slabs to prevent uplift
- Base slab for the river shaft uses the in-situ ground to resist uplift, thus avoiding large volumes of concrete
- Caterpillar structure (a series of circular structures pieced together) rather than a traditional rectangular structure for the pumping station, requires less propping and reduces volume of concrete
- Pre-cast sections for cover slabs for the shafts and other elements. Precast concrete has only been used for smaller elements, rather than in the main structures, hence the reductions in carbon emissions has been limited.

2.5.4 Conveyance:

- Using the reservoir inlet pump for reservoir recirculation, removed the need for 4no. 13,900 l/s pumps.

2.5.5 Roads

- Some temporary haul roads now proposed to be converted into permanent roads after construction is completed, hence reducing construction effort for permanent roads
- Paving parking spaces now proposed to be paved using ‘grasscrete’ rather than fully paved
- Implementing nature-based solutions for drainage, thus reducing use of hard engineering solutions and their associated materials (concrete)
- A summary of the low capital carbon solutions considered and embedded in the gate three design through a series of carbon challenge design workshops

that followed the PAS2080:2023 carbon reduction hierarchy, are summarised here.

3 Operational Carbon

3.1 Definition, scope and boundaries

3.1.1 An operational carbon assessment has been undertaken for the SESRO 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 product of purchase and use of grid electricity by water companies notably for water and wastewater pumping and treatment as well as use in buildings. Under the BS EN 17472:2022 “Sustainability of construction works. Sustainability assessment of civil engineering works. Calculation methods” life cycle modules, the operational carbon assessment covers use stages B1-B6 modules.

3.2 Modelling approach

3.2.1 The operational carbon assessment for SESRO is based on the power and operational maintenance requirements of the scheme and has been aligned to the input quantities in the operating cost estimate. Specific components are as follows:

- Power consumed (for pumping water to the reservoir, the air diffuser system and miscellaneous ancillary assets)
- Power generated – by the hydro turbine during periods when the reservoir releases water to the River Thames
- Maintenance – annual/regular routine operational maintenance activities for civil and MEICA assets

3.2.2 The operational carbon emissions associated with the potential facilities (i.e. café, visitor centre, education centre, recreational facility and water sports centre) are excluded at this stage.

3.2.3 Year 1 of operation for SESRO is assumed to occur in 2040 and the analysis models operational carbon emissions over a 65-year period.

3.2.4 Grid electricity requirements for pumping water (to fill the reservoir and to transfer water to other uses) are modelled using a theoretical “high utilisation” (conservative) scenario defined in the gate three supporting document A1, Basis of Design[7]. The modelling assumptions are as follows:

- Required pumping of 1000Ml/d to refill the reservoir from the River Thames for 99 days in a year
- Required pumping (where gravity discharge is not possible) of 74Ml/d to T2ST for 365 days in a year
- Required pumping of 24Ml/d for raw water transfer to SWOX Raw Water Transfer for 365 days in a year
- Release of 237Ml/d to the River Thames for 266 days in a year

3.2.5 The operational emissions associated with annual / routine operational maintenance activities for civil and MEICA assets are estimated using an approximate approach based on percentages of the capital carbon emissions estimated for civil and MEICA assets. This assessment will need to be refined at future stages of design development with a bottom-up estimate to account for typical products, materials and transport fuels required for operational maintenance.

3.2.6 Emissions due to power consumption (and emissions reduction due to power generation) used for the operational carbon assessment are based on forecasts for electricity grid carbon intensities (in kgCO2e/kWh) for future years published by DESNZ (Table 1-19 version published in Nov. 2023[8], using 'grid average' 'commercial/public sector' values which are also shown on Figure 10).

3.3 Summary of operational carbon assessment and hotspots – Gate three update

3.3.1 For SESRO, initially, the highest proportion of operational emissions are due to grid electricity consumption (mostly due to pumping) with a smaller contribution from annual operational maintenance activities. However, as the power grid decarbonises further, annual emissions due to grid electricity consumption are forecast to fall and eventually be below those for annual operational maintenance activities and lower overall for the 65-year analysis period.

3.3.2 The operational carbon emissions of the SESRO scheme are greater over a 65-year modelled period when compared with the gate two operational emissions estimate. A comparison is shown in Figure 8.

3.3.3 The main differences between the gate two and gate three operational carbon estimates are due to further development of the assumptions for the additional flows and operating regime of SESRO. The reduction in the total emissions

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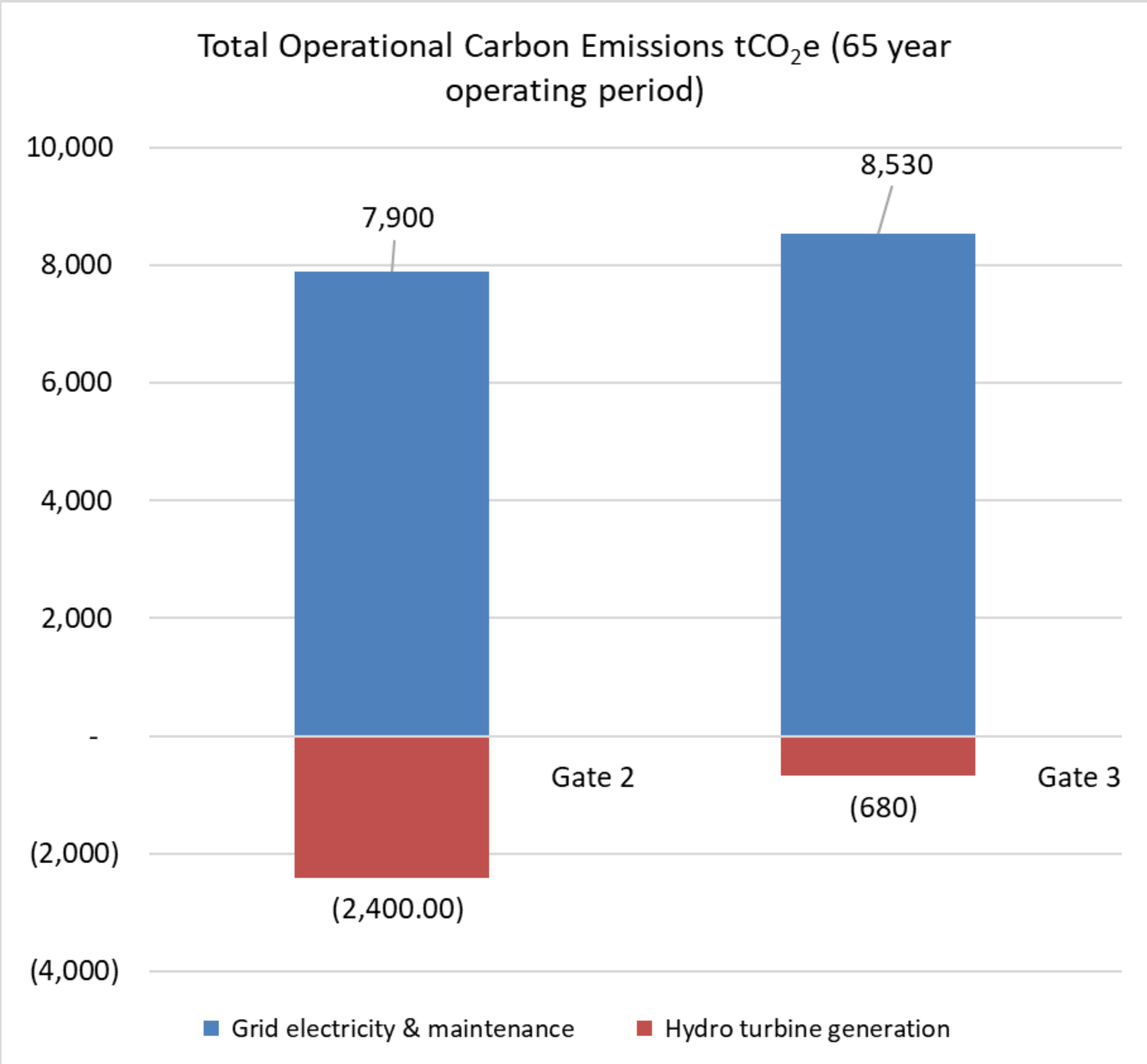
[7] SESRO Gate 3, A1, Basis of Design Report, J696-DN-A01A-ZZZZ-RP-ZD-100021, 2025

[8] https://assets.publishing.service.gov.uk/media/6567994fcc1ec5000d8eef17/data-tables-1-19.xlsx

avoided by the installation of the hydro turbines is due to a reduced flow through the turbines back to the River Thames (since the gate three design assumes that more flow is transferred to T2ST and SWOX which occurs upstream of the hydro turbine).

Figure 8 – Operational carbon emissions comparison between gate two and gate three



3.3.4 The grid emissions factor forecast has also been updated by DESNZ during gate two and gate three (the more recent version was published in November 2023 which was used in the gate three operational carbon estimate).

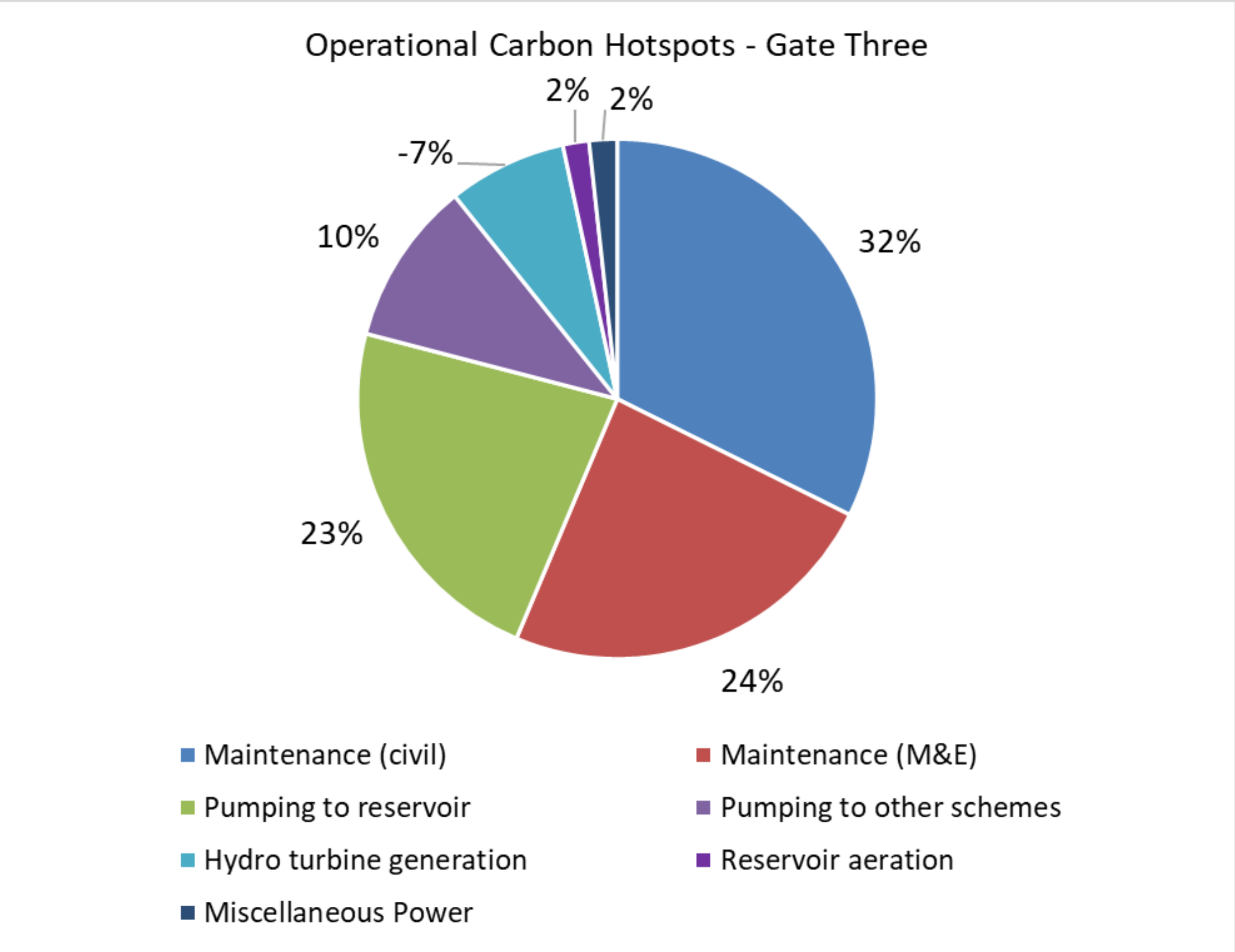
3.3.5 The annual operational carbon hotspots over the whole 65-year modelled period for operational emissions are shown in Figure 9.

3.3.6 Pumping water into the reservoir accounts for almost 25% of the operational carbon emissions over the 65-year modelled operating period (2,090 tCO2e).

3.3.7 Power for operating the transfer pumps to other schemes and the reservoir aeration alongside other miscellaneous power requirements contributes 15% of the operational carbon emissions over the 65-year modelled operating period (1,250 tCO_2e).

3.3.8 Power generation by the hydro turbine reduces total operational carbon emissions by 8% (680 tCO_2e). This is equivalent to 20% of total emissions due to power consumption).

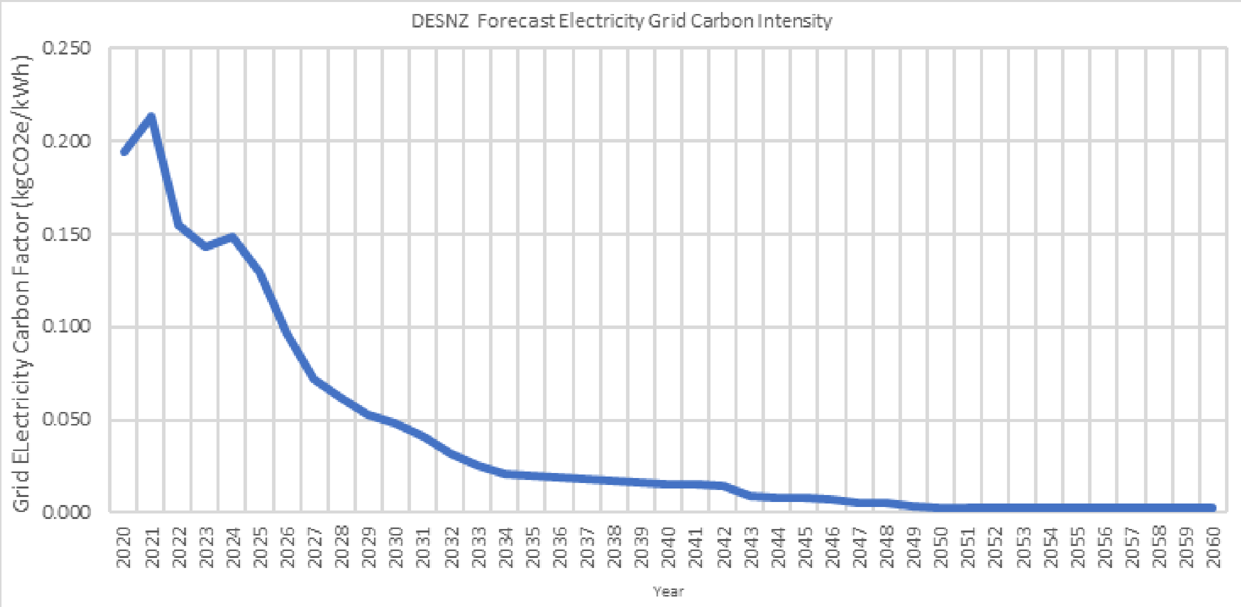
Figure 9 – Operational carbon emissions hotspots over the 65-year modelled period



Note, Figure 9 does not include emissions reduction due to power generation by the hydro turbine.

3.3.9 Figure 10 illustrates the impact of forecast electricity grid decarbonisation. There is expected to be a 90% decrease in annual power carbon emissions between 2024 and 2040 and it is predicted that the grid will have largely decarbonised by around 2050.

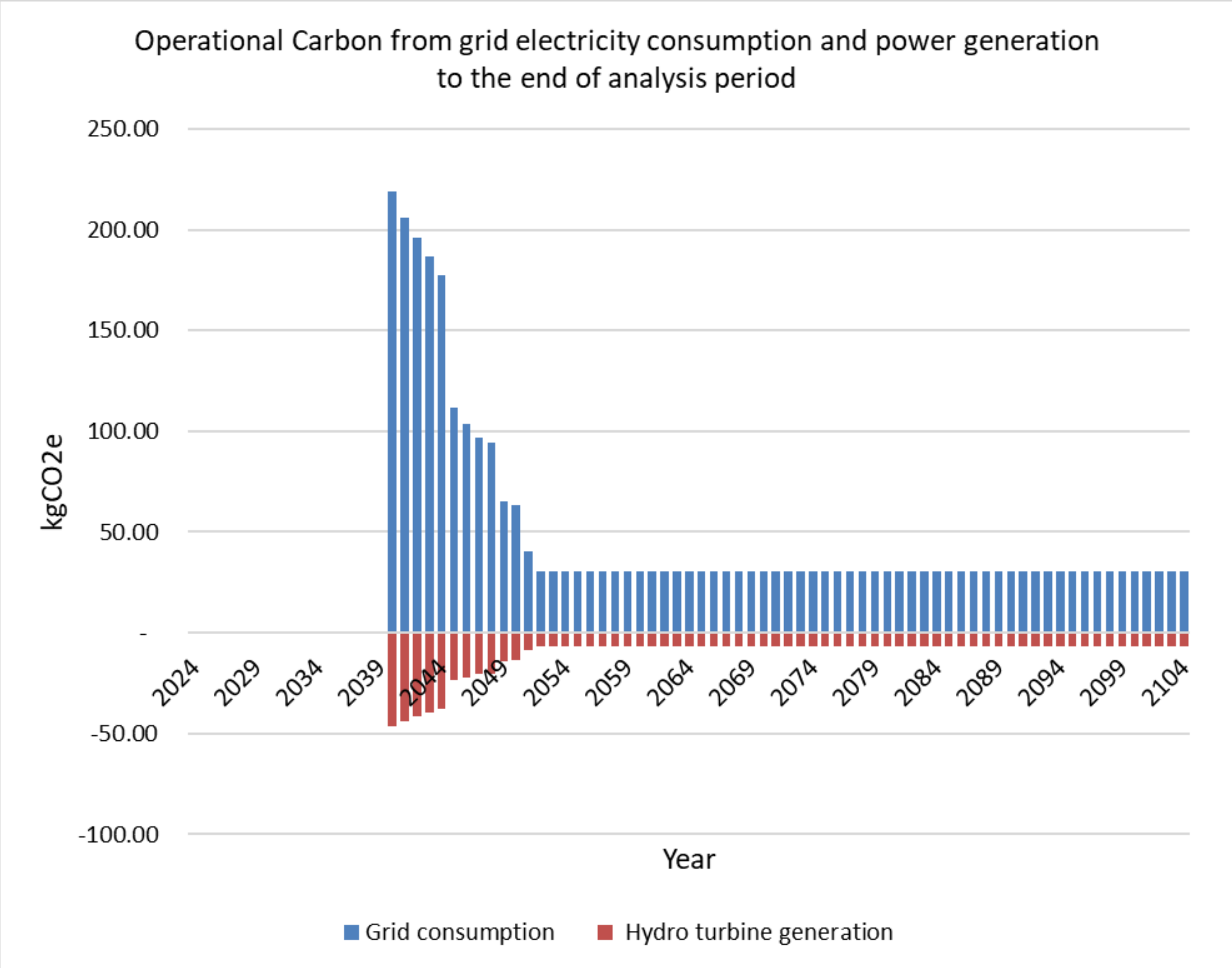
Figure 10 – DESNZ Forecast Electricity Grid Carbon Intensity



3.3.10 As noted in Section 3.1 and shown on Figure 10, over time, the significance of power related carbon emissions are expected to decrease as grid decarbonisation projects take effect. The earliest expected operating year for the SESRO scheme would be 2040. By this time, it is expected that the electricity grid carbon emission intensity should be approximately 12% of its current (2025) level.

3.3.11 The annual profiles of grid electricity and renewable energy generated by the hydro turbine are shown in Figure 11. It can be seen that from year 2050 when the electricity grid is due to be decarbonised the main source of power related emissions are the grid transmission and distribution losses, which remain steady until the end of the SESRO operational carbon analysis period. The avoided emissions from the hydro turbine generation are relatively small and from 2050 they offset 20% of the annual operational carbon emissions from grid electricity.

Figure 11 – Effect of Grid Decarbonisation on Operational Carbon Emissions over the 65-year modelled period



3.3.12 In the context of the Government 2050 Net Zero target, major infrastructure schemes, such as SESRO, are encouraged to consider how they can generate renewable energy to meet a proportion of their own demand and continue to drive energy efficiency. This is to help reduce the pressure on the national electricity grid which will need to significantly increase in capacity to accommodate the wider national efforts to electrify transport and heat as part of meeting the national Net Zero target.

3.3.13 While the current SESRO design already incorporates hydropower turbines, there would be proactive steps required during subsequent design stages to improve the energy efficiency of the scheme. For example, there could be opportunities to generate more energy on-site from other renewable sources such as solar photovoltaic plants. Further consideration will be given to additional renewable energy opportunities in subsequent phases of the scheme's development.

3.3.14 Over 65-year modelled operational period and considering future grid decarbonisation, the largest operational emissions hotspot will be the annual maintenance (5,190 tCO2e over the 65 years).

3.3.15 Regular maintenance activities include:

- Valves (greasing of spindles, ensuring regular operation, replacement of gland packing (occasional), painting (occasional)
- Pro-active maintenance of M&E equipment, such as, pumps, blowers, generators, water mixing plant and instrumentation (check power connections, check for leakage/damage, greasing/oil)
- Turbines (inspection of electrical cabinet and gearbox, oil/lubrication, rotor blade servicing, alignment)
- Maintaining roads (e.g., resurfacing access roads as required)
- Landscape management and associated fuel use
- Security fencing inspections and repair
- Transport fuel consumption for the maintenance visits
- Embodied carbon associated with the limited amounts of grease and M&E replacement parts required.

3.3.16 As the scheme development progresses the assessment of the frequency and scale of emissions associated with each of the above activities will need to be further refined and lower carbon alternatives will be considered.

3.4 Low carbon opportunities (operational carbon) embedded in the gate three design

3.4.1 With respect to operational carbon emissions, the low carbon opportunities embedded in the gate three design are:

- A hydro turbine to generate renewable electricity. Although the UK electricity grid is forecast to be decarbonised by 2050, the UK national decarbonisation plans encourage the adoption of more decentralised renewable energy generation throughout the UK from different renewable energy sources.
- An optimised operating regime for the reservoir. However, the design of the scheme is expected to be refined further in subsequent phases and during the detailed design stage where there are opportunities to consider further energy efficiency measures and optimised maintenance.
- There is an ongoing renewable energy study being undertaken for SESRO to explore the potential for additional renewable energy sources such as solar, considering site considerations and potential constraints.

3.4.2 A summary of the wider carbon mitigation strategy for SESRO is included in Section 6 of this report.

4 Other Emissions Areas

4.1 Introduction

4.1.1 This section summarises relevant carbon emissions areas not covered in previous sections of this report. It covers direct carbon emissions from land use change, removals as well as any carbon emissions impact from the SESRO scheme beyond the provisional planning boundary. Considering such emissions is in line with the PAS2080:2023 carbon management framework for decision-making.

4.1.2 As summarised in Section 1 of this report, further consideration has been given in the emission sources that are likely to affect the decision-making process for reducing the whole life carbon of the SESRO scheme. These are summarised below, together with any knowledge gaps for relevant emissions sources that have not been assessed in gate three.

4.2 Direct emissions sources from land use change

4.2.1 During gate three, consideration has been given to a further potentially important carbon hotspot associated with land use change – from converting current agricultural land into a reservoir.

4.2.2 There are still uncertainties in the science behind the direct emissions from the reservoir including emissions impacts during the drawdown and filling of the reservoir. This will be considered as understanding develops across the water industry in subsequent stages of the scheme.

4.2.3 Another direct emissions related area that has not been assessed during gate three is the emissions associated with excavating soils (within and beyond the vicinity of the site) that may cause disruption in the carbon balance stored in the soil.

4.2.4 It is recommended that the emissions impacts from land use change and from carbon balance in the soil during construction and post-construction are further considered in subsequent phases of the scheme to better understand if they are likely to be a significant carbon hotspot or not.

4.3 GHG removals

4.3.1 As part of the gate three design, carbon is likely to be sequestered (or removed) from changes in land use associated with the landscaping on the site. Natural capital analysis has been completed to support gate three including consideration of whole life carbon sequestration opportunities from the landscape design, see Section 8.2 of the main gate three report for further information. These emissions removals are not currently shown in the whole life carbon profile summarised in Section 5.

4.4 Emissions impact from SESRO beyond the project boundary

4.4.1 The likely emissions sources beyond the SESRO project boundary are summarised below.

4.4.2 Higher emissions impact in the wider system associated with the loss of renewable energy generation due to decommissioning the existing solar PV plants to allow for the SESRO construction. The existing PV plants would be expected to reach end of life around 2039 (based on a typical operational life of 25 years). It is assumed that the PV plants would need to be decommissioned by year 2029/30 to allow for the SESRO enabling works. The estimated total emissions impact due to lost renewable energy generation between 2029/30 and 2039 would be approx. 16,750 tCO2e. The carbon impact has been assessed using the same DESNZ grid decarbonisation scenario summarised in Section 3.

4.4.3 Thames Water is currently investigating other renewable options and scenarios, as well as associated cost impact, for replacing the lost renewable energy generation and for exporting renewable energy to the electricity grid. Solar, floating solar and other technologies are being considered. Further updates will be presented at gate four.

4.4.4 Emissions associated with transport activities during the operational phase of the project (maintenance, operation and visitors). These will need to be assessed in more detail during subsequent phases of the project. It is unlikely to result in a major carbon hotspot, however, there could be mitigation measures to be considered for the operational and maintenance stage of the scheme.

4.4.5 Any transport emissions for importing materials on site during construction as well as other construction related activities are included in the capital carbon and capital replacement carbon assessments.

4.4.6 Emissions associated with heating water in the home (user emissions). These emissions are not being assessed in gate three as they would be common to any water resource option providing the required deployable output (agreed as part of the WRMP and regional planning process) and hence would not be a differentiator in the decision-making process for SESRO.

5 Whole Life Carbon

5.1 Modelling approach

5.1.1 The outputs from the capital and operational carbon assessments provided in Sections 2 and 3 in this report have been used to derive whole life carbon emissions estimates for the gate three design.

5.1.2 In order to align with whole life cost estimates, the whole life carbon for SESRO presented in this report has been assessed over 80 years, which includes the following phases:

5.1.3 Pre-construction Phase (assumed to be completed by December 2028) during which carbon emissions are assumed to be negligible.

5.1.4 Construction and Commissioning Phase (assumed January 2029 to March 2040) during which the capital carbon emissions described in Section 2 occur.

5.1.5 Operation and Asset Replacement Phase (assumed to be 65 years) during which the replacement capital carbon emissions described in Section 2 occur alongside the annual operational carbon emissions described in Section 3.

5.1.6 Use of an 80 year analysis period (which results in a 65-year modelled operating period) is in accordance with ACWG guidance for assessing the whole life cost and carbon of SROs on a consistent basis. The length of the analysis period is not related to the operating life of the whole SESRO scheme.

5.1.7 Given the long life of the water supply outcome (being more than 65 years and likely to be over 100 years), end of life emissions scenarios for the reservoir site have not been quantified nor have any scenarios modelling alternative future uses of the same land been considered. End of life scenarios for shorter life asset types (such as MEICA assets and some civil structures) could be explored in subsequent phases of the scheme during the detailed design, when considering ways to recycle and reuse such asset types. This approach is in line with current industry guidance in the water sector (UKWIR,2024)[9].

5.2 Whole life carbon emissions

5.2.1 A summary of estimated whole life carbon emissions is presented in Figure 12. A summary of estimated cumulative whole life carbon emissions is presented in

[9] Supporting Whole life Carbon Reduction: Practices, Evidence Base and Data 2024, UKWIR (Authors, Stantec, Mott MacDonald)

Figure 13.

Figure 12 – SESRO Whole life carbon emissions by category (tCO_2e/year)

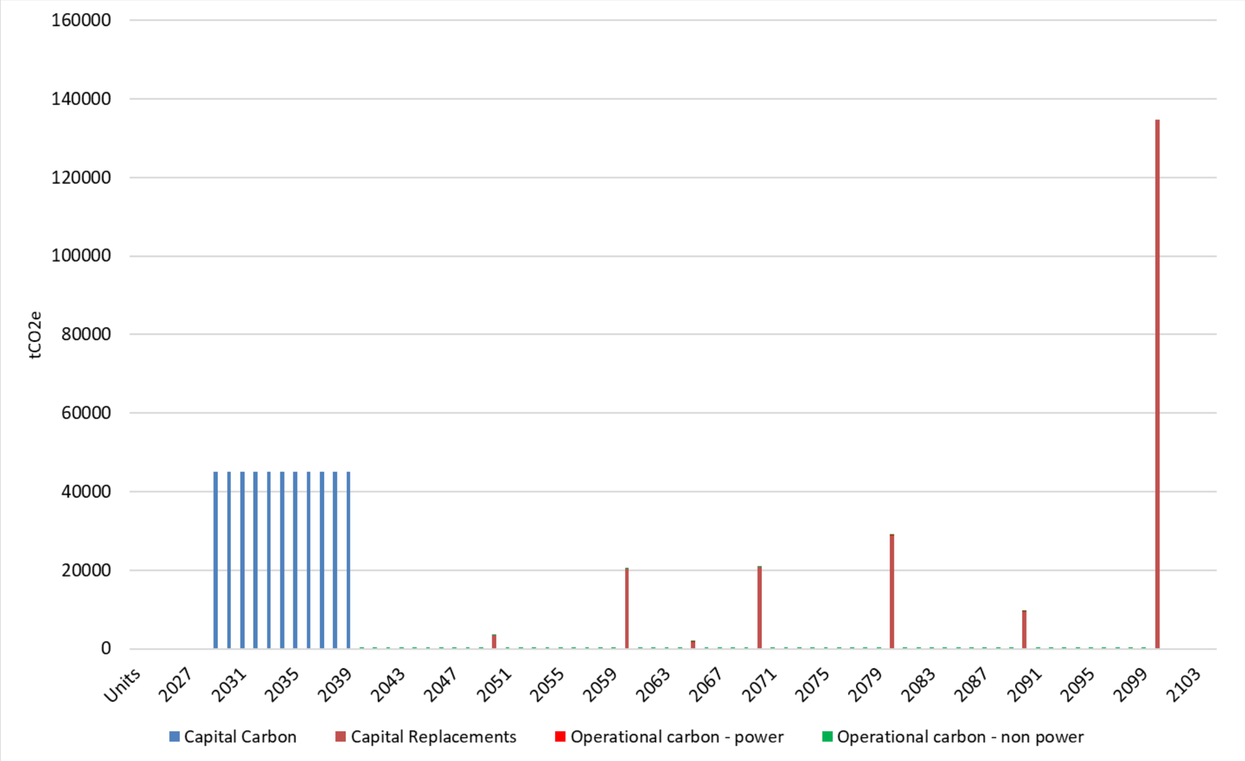
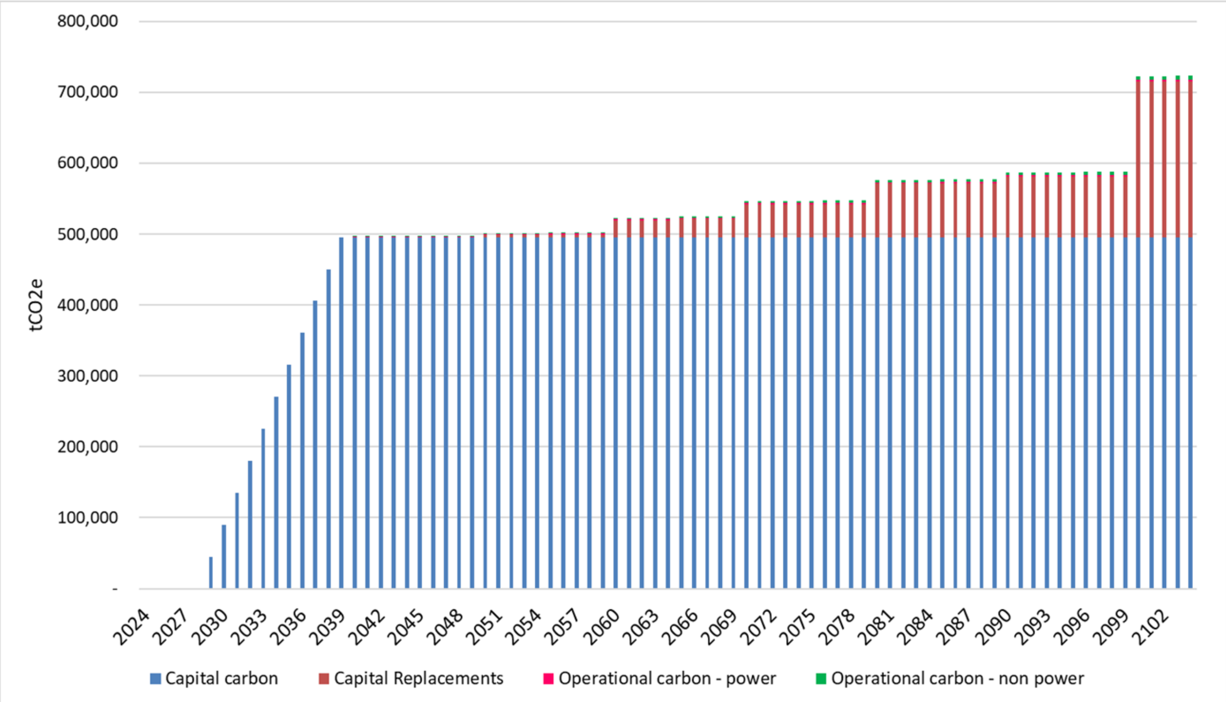


Figure 13 – SESRO Whole life carbon emissions by category (tCO_2e/year)



5.2.2 Table 3 shows a summary of the estimated whole life carbon gate three estimate (over the same 80-year analysis period as used for the cost assessment).

5.2.3 The data in Table 3 shows the initial capital carbon emissions of the reservoir account for approximately 69% of emissions across the whole life carbon estimate, with a further 30% associated with capital replacements of the assets across the 80-year analysis period.

5.2.4 The operational carbon emissions are associated with maintenance (non-power related) and power consumption (power related), account for approximately 1% of the estimated whole life carbon emissions (over the 80-year analysis period). Emissions from grid electricity consumptions are very small compared to the overall whole life carbon of the scheme. They are also decreasing over time due to the gradual decarbonisation of the UK electricity grid over the analysis period.

5.2.5 The large capital replacement emissions in 2100 are associated with the replacement of large civil components, such as roads, the river intake/outfall structure and the pumping station, which have been assumed to have an asset life of 60 years.

Table 3 - Breakdown of Whole Life Carbon Assessment

Category	Carbon Emissions (tCO2e)
Capital carbon	495,700
Capital replacement carbon	219,600
Operational carbon – power	2,660
Operational carbon - non power	5,190
Total whole life carbon (80 years)	**723,150**

5.3 Whole life carbon cost – net present value (NPV)

5.3.1 Whole life carbon emissions have also been monetised using the Green Book Data Tables 1-19[10], 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 summarises the whole life carbon NPV over 80 years (15 years planning and construction followed by 65 years operation).

5.3.2 The NPV has been calculated by multiplying the estimated emissions in each year by the carbon cost in each year (using the Green Book low, central, and high scenario values) and applying the Green Book standard discount rate. The sum of these values then provides the carbon NPV over 80 years. Table 4 summarises the carbon cost under the low, central, and high scenario values.

[10] Electricity emissions factors to 2100, Department for Business, Energy & Industrial Strategy (https://assets.publishing.service.gov.uk/media/6567994fcc1ec5000d8eef17/data-tables-1-19.xlsx)

Table 4 - Whole Life Carbon Cost NPV (High utilisation scenario)

Carbon Emissions - Net Present Values (£m)			
	Low carbon value scenario	Central carbon value scenario	High carbon value scenario
Reservoir high utilisation scenario	65.50	131.01	196.47

6 Carbon Management Strategy and Future Work

6.1 SESRO carbon management strategy

6.1.1 The SESRO carbon management strategy follows good industry guidance for managing carbon in major infrastructure projects. As part of the EIA Scoping process the NPS carbon management considerations have been taken into account to target low carbon opportunities. The PAS2080:2023 framework has been considered to inform the scheme's carbon management enablers, such as target-setting, baselines, assessment principles, whole life emissions scope and boundary – including beyond the project boundary considerations – as well as supply chain engagement.

6.2 Target setting and baselines

6.2.1 The NPS does not state a specific carbon reduction target. The main requirements relevant to target setting are for the scheme to align to the national net zero target by 2050 and to reduce emissions as far as reasonably practicable.

6.2.2 There is ongoing work to better understand what an ambitious whole life target for the SESRO scheme would be and how it would take into account wider criteria to inform the best value options for the scheme. This also includes affordability considerations for customers. National decarbonisation trajectories, current good industry practices, including the Construction Leadership Council 5 client carbon commitments[11], the Thames Water decarbonisation targets, regional net zero plans and the ACWG SRO decarbonisation scenarios are being considered to help inform an appropriate whole life carbon reduction target for SESRO.

6.2.3 Updates on the targets will be reported in future phases of the scheme.

6.2.4 Similarly to target-setting, the whole life carbon assessment estimates can be further refined to inform the selection of appropriate baselines for whole life carbon emissions. Further work is needed to ensure an appropriate baseline is set to help drive carbon reductions whilst maintaining flexibility throughout the planning and procurement process.

6.3 Consideration of appropriate carbon mitigation measures

6.3.1 The NPS requires water resources schemes to demonstrate the consideration of

[11] https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2024/04/Five-Client-Carbon-Commitments-29.04.24.pdf

appropriate carbon mitigation measures. The PAS2080:2023 carbon reduction hierarchy (aligned with the IEMA guidance) has been used to identify and explore additional low carbon opportunities for the main whole life hotspots of the scheme. Sections 2 and 3 list the low carbon opportunities embedded in the gate three design whilst Section 6.4 to 6.6 (and Appendix A) provide a list of additional opportunities for the design teams to consider and analyse further in subsequent phases of the design.

6.3.2 The carbon value challenge process followed in gate three will help inform a more targeted engagement in future phases of the scheme with design teams, the supply chain and other stakeholders to help target carbon reductions. Some examples of additional low carbon opportunities that could be considered together with the supply chain are summarised below. Further analysis will be required in future scheme phases on the cost impact of such solutions and other benefits.

6.4 Additional capital carbon reduction opportunities

6.4.1 Alternative construction fuels:

- One of the largest capital carbon hotspots identified in gate two was the emissions associated with diesel fuelled construction plant used for the enabling works, reservoir embankment and landscaping. During gate three, further engagement with the supply chain has been undertaken (including the gate three constructability advisor as well as construction plant manufacturers) to better understand what alternative fuels the scheme could consider and analyse further.
- This work is still ongoing and further refinement in the design is required to better understand the type of construction plant to be used on site, as well as the cost impact and technical viability of alternative fuels. However, a high level scenario analysis shows that by considering the use of a mix of alternative and lower carbon fuels such as green hydrogen or HVO (hydrogenated vegetable oils) for larger plant and grid electricity for smaller plant, up to 20% - 50% of construction fuel emissions could be avoided, when compared to the current default fuel use (diesel). This is an area for further consideration in subsequent phases to better understand the costs as well as availability of such fuels and plant in the market.

6.4.2 Alternative materials:

- Lower carbon alternatives for the concrete, steel and road surfacing materials could be considered further in future phases of the scheme to better understand the potential for avoiding further capital carbon emissions. This work is still ongoing and a more targeted engagement with the supply chain is required to understand the technical viability, costs and availability of lower carbon concrete mixes and steel. However, high level scenarios indicate that a reduction of up to 9,000 tCO_2e and 20,000tCO_2e, for concrete and steel, respectively, could be achieved. A more targeted engagement with the supply chain is required to confirm the technical viability and scale of lower carbon concrete, steel and other materials.

6.5 Additional operational carbon reduction opportunities

6.5.1 Further work is currently underway assessing additional renewable energy opportunities to be considered within the provisional SESRO planning boundary, including the costs and benefits of deploying solar and other technologies for onsite use or export of electricity to the grid.

6.6 Proposals for future phases

6.6.1 It is proposed that future work in subsequent phases is targeted to inform the following areas:

- The whole life carbon reduction target of the scheme and an appropriate baseline.
- The procurement process needed to help ensure that low carbon alternatives presented in this report are considered by the supply chain (incl. alternative fuels, construction materials and further design and construction activity optimisation).
- Current emissions knowledge gaps, such as direct emissions, that could inform further engagement with other stakeholders in the catchment/region to see whether these can be managed over time, if they are concluded to be a major hotspot.
- The cost viability and other benefits of all whole life carbon mitigation measures being considered, including opportunities that require upfront investment to deliver. These include alternative construction fuels and renewable energy generation systems, among others.
- The balance between carbon emissions and other decision-making criteria such as cost, climate resilience, ecology and social benefits.
- Further consideration of whether asset lives can be extended beyond the durations in the ACWG guidance. This is to understand whether the short and medium capital carbon replacement impacts could be reduced further.
- Offsetting considerations for SESRO to assess whether any viable offsetting measures could be adopted.
- Reducing uncertainty in modelling of whole life emissions by developing improved granularity in the key activities and assets for the major whole life carbon hotspots.
- A monitoring strategy and continual improvement plan to ensure that the deployment of low carbon solutions continues to be considered in all future phases of the scheme and that understanding of uncertain emissions areas continues to improve over time.

Appendix A – Low carbon opportunities identified for future stages of design

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
Optimising grout volume	Optimising the grout volume used behind the concrete liner	Tunnels	Design	Improve		Medium
Secondary lining	Design for tunnels can be reviewed to assess the possibility of removing or reducing the secondary lining - Secondary lining is part of river tunnel	Tunnels	Design	Improve	Internal pressures dictate the need for secondary lining	Uncategorised
Challenge water tightness/crack width area	Larger crack widths would allow for less reinforcement	Tunnels	Design	Improve	Design standards for crack widths	Medium
Type of excavations for shallow structures	Open trench or stepped excavation for shallow structures, use of sheet piling or trench boxes potentially could enable some carbon savings	Tunnels	Construction	Improve		Low
Shaft size optimisation	Optimising the size of shafts based on design limitations	Tunnels	Low carbon materials	Improve	Design has already revised shaft sizes at gate three	Low

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
Alternatives to steel fibres in concrete	Looking at the possibility of using plastic fibres instead of steel fibres for reinforcement wherever possible	Tunnels	Low carbon materials	Switch	Design must meet technical and structural specifications. Testing would be required	Medium
Alternative materials for grout mix	Use alternative materials in grouts	Tunnels	Low carbon materials	Switch		Medium
Utilise low carbon concrete mixes	Specifying low carbon concrete mixes for non-structural fills for the shaft and tunnel sections	Tunnels	Low carbon materials	Switch		Medium
Main tower shaft geometry	Review internal arrangement and operational requirements and assesses if reducing footprint for full or part of height is possible. Review if thickness change is practical over the height.	Tunnels	Design	Improve	Impact on operational efficiency/ safety to be reviewed	Medium

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
General - design optimisation reducing thickness or rebar quantities	Early design stage used simplified analysis. Detailed design to enable optimisation of thickness and/or rebar quantities for structures, or refinement for areas of structures, e.g. change reinforcement over shaft height, optimise thickness/ reinforcement over the length of the reservoir tunnel.	Tunnels	Design	Improve		Medium
Reduce import material distance	Reducing the distance of material imports to reduce fuel consumption, minimise double handling of materials and waste	Embankments	Transport of materials	Improve		High
Alternative fuels - HVOs	Replacement of traditional fuels with HVOs, which can be used in existing plant	Embankments	Construction	Switch		High
Alternative fuels - biofuels	Replacement of traditional fuels with biofuels, which can be used in existing plant	Embankments	Construction	Switch		Medium

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
Alternative fuels - electricity	Replacement of traditional fuels with electric power, which can be used in existing plant	Embankments	Construction	Switch	Limitations with how long electric plant will last on charge and where the power be taken from (renewables sources)?	Medium
Alternative fuels – hybrid	Using a combination of alternative fuels, rather than limited to one type, to maximise opportunities	Embankments	Construction	Switch		Medium
Plant size	Optimising the size of plant to the requirements. Reducing the energy input needed for larger plant vehicles	Embankments	Construction	Improve		High
Automation	Automating excavation/transportation/backfilling plant and process	Embankments	Construction	Improve		High

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
Use of conveyor Belt	Using conveyor belts on site for material transport instead of construction plant or vehicles	Embankments	Construction	Improve	General rule of thumb for anything less than 10km, dumpers are the most efficient at transporting materials	Medium
3D wind/wave modelling	Optimising the embankment height and designing out the need for a wave wall, reducing structural requirements and materials. Refining the embankment height to suit approach fetch rather than a single continuous crest elevation	Embankments	Design	Avoid		High
3D wind/wave modelling	Optimising the inner face protection, potentially reducing the volume of rip-rap	Embankments	Design	Improve		High
Construction sequencing	Refining the construction sequencing to minimise double handling of materials, reducing plant movements within site	Embankments	Design	Improve		Medium

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
Trial embankment	Design optimisation following trial embankment, to understand ground conditions better to inform embankment design	Embankments	Design	Improve	The opportunity to change the design of the embankment will be constrained post-DCO	Low
Earthworks specification	Refining earthworks specification and method following compaction trial, minimising plant movement per unit embankment volume	Embankments	Design	Improve		High
Use of the 'Observational Method' (OM)	Implementing observational method during construction to refine design of the embankments - could lead to increase in slope gradients or reduce dig and replace if ground conditions are more favourable than assumed in design	Embankments	Design	Improve	The implementation of OM will potentially need some commercial incentivisation to encourage all parties to propose changes to the design that provide a benefit to the scheme	Uncategorized

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
Soil stabilisation	Stabilising excavated soil for the construction of roads, if the soil is not suitable, reduce use of imported materials	Roads	Design	Improve	Dependent on the quality of in-situ soils and the level of effort required to improve the properties of the soil	Medium
Soil make up	Re-use of existing soil for road make up and reduce level of imported materials	Roads	Design	Improve		Medium
Road hierarchy and design	Understanding the hierarchy of different roads and their technical specifications. Different road types will require different construction and surfacing designs. Standardisation of road types may enable a more efficient and low carbon design	Roads	Design	Improve		Medium

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
Utilities diversion	Diversion of 133 KV which is proposed to go underground. Consider whether the diversion can be above ground to reduce excavation and road crossings	Roads	Design	Switch	Site constraints may require the diversion to be underground	High
Construction sequencing	Refine the construction sequencing of roads to maximise access into more land parcels, to reduce the number of temporary bridges needed	Roads	Construction	Improve	Complex construction sequencing to tie into the rest of the works. Some roads are needed before work on the borrow pit is needed	Uncategorised
Rationalising haul roads	Reducing number of haul roads, linked to construction sequencing and reducing haul distances or double handling of materials	Roads	Design	Improve		Medium

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
Earthworks season	Maximise earthworks season - construction sequence related, reduce inefficiencies with earthwork movements	Roads	Soil Handling	Improve		Uncategorised
Programme optimisation	Optimising the programme to manage cut and fill for roads and drainage	Roads	Design	Improve		Uncategorised
Use of local borrow pits, mines, quarries	Locally sourcing from borrow pits, mines, quarries for construction material such as aggregates. Type 3 (permeable stone)?	Roads	Low carbon materials	Switch	Choosing the right materials for the road design, based on structural and technical specifications, may require more processing and testing	Medium
On-site processing	On-site processing plant for potential recycling/reuse of material from existing road/parking decommissioning	Roads	Low carbon materials	Switch		Uncategorised

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
Cement content	Reducing the cement content in concrete by changing the concrete specification or design of structures (e.g. using hollow structures wherever possible)	Roads	Low carbon materials	Improve		Medium
Soil storage	The storage time of soil should be optimised based on the carbon content in the soil, limiting the emissions from soil.	Landscaping / Natural Capital	Soil handling	Improve	Emissions from soil need to be understood and investigated further	Low
Compost/mulch volume optimisation	Compost/mulch used for vegetation growth must be optimised reducing the emissions from excess organic matter.	Landscaping / Natural Capital	Design	Improve		Low

Intervention	Details of intervention	Workstream	Opportunity type	PAS2080 Carbon reduction hierarchy level	Potential limitations	Carbon Reduction Potential
Reduce disturbance of soils	Emissions are released through disturbance of soils, through churning up. Therefore during construction aim to reduce disturbance to the soil as much as possible	Landscaping / Natural Capital	Soil handling	Improve	The reduction in emissions is likely to be low compared to the baseline scenario where the soil is already being disturbed through agricultural activity	Low

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