Cost and Carbon Report

North West Transfer SRO Cost & Carbon Report

14 November 2022

NWT-G02-008-001 Rev 01

United Utilities

Water for the North West

Contents

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1. Executive Summary

1.1.1 This cost report summarises UUs methods in the generation of all costs associated with the North West Transfer Strategic Resources Option (NWT SRO) Full Solution, in alignment with the guidance provided in the 'Cost Contingency Methodology – Rev E' published by Mott Macdonald.

1.1.2 The NWT SRO comprises two principal elements of work, namely the Vyrnwy Aqueduct (VA) Enabling Works and United Utilities' Sources (UUS). The two elements of work are very different in nature and this has necessitated different approaches to be taken in the estimation of construction costs. The design of the UU Sources sub-options have been developed using a process block diagram (PBD) approach. The resulting PBDs have then formed an estimating brief, to enable costs for common types of asset to be estimated from cost curves. The construction works proposed

1.1.3 Capital Expenditure (Capex), Operational Expenditure (Opex) and Average Incremental Costs (AIC) have been generated for UUS and VA Enabling Works for the North West Transfer (NWT) SRO. The cost estimates have been derived from the conceptual designs prepared for Gate 2.

1.1.4 Cost estimates have been produced for the main options and sub-options, detailed below, that constitute the NWT Full Solution:

- Vyrnwy Aqueduct Enabling Works
    - STTA4 – 205 Ml/d
- UU Sources

(Full Solution)

- WR102b
- WR107a2
- WR107b
- WR111
- WR113
- WR149
- WR076
- WR015
- WR049d

(Reserve options)

- WR105a1
- WR106b
- STT041b
- WR144

NB. The cost estimates for the UU Sources reserve sub-options are not detailed in this report.

1.1.5 To provide cost estimates for the UU Sources, the following activities have been undertaken:

- Review of the feasibility design
- Update of designs and yardsticks using UU's latest costing tools (system generated Capex and Opex).

1.1.6 To provide cost estimates for the Vyrnwy Aqueduct Enabling Works, the following activities have been undertaken:

- Review of the feasibility design
- Updated estimating brief which breaks down each scope element into sufficient WBS and discipline to facilitate a bottom-up estimate to be developed for the capital expenditure.

1.1.7 These cost summaries do not include the new Raw Water By-pass scope or Shrewsbury connection upgrade (increase from 16Ml/d to 25Ml/d) as these are addressed in the scope of other SROs. Details of the NWT SRO solution scope are presented in the Conceptual Design Reports for the UU Sources and VA Enabling Works elements.

1.1.8 A summary of the Capex and Opex costs for these options is included in Table 1 below.

Table 1 - Capex & Opex

NWT SRO Element	Sub-option ID	Capacity	Capex (including risk)	Risk	Optimism Bias	Total G2 Capex	G2 Fixed Opex	G2 Variable Opex
Units		Ml/d	£M	£M	£M	£M	£M/ annum	£/Ml
UU Sources	**WR102b**	17	45.37	1.31	11.58	56.95	0.12	77.87
	WR107a2	10	17.51	0.5	4.47	21.98	0.04	188.86
	WR107b	12	59.75	1.63	15.26	75.01	0.11	170.53
	WR111	9	14.99	0.42	3.83	18.82	0.04	96.43
	WR113	3	7.13	0.19	1.82	8.95	0.01	69.07
	WR149	13	26.33	0.76	6.72	33.05	0.06	75.84
	WR076	25	81.81	2.37	22.91	104.72	0.22	135.18
	WR015	40	123.55	3.59	34.6	158.15	0.28	148.87
	WR049d	40	157.63	4.61	44.14	201.76	0.36	325.33
Vyrnwy Aqueduct Enabling Works	**STT A4**	205	144.83	9.54	28.19	173.07	0.32	4.31

1.1.9 Capex and Opex costs have been combined over the default assumed asset life of 80 years, to determine NPV and AIC comparators and establish which options represent best value for customers. All SROs used the methodology agreed by the All Company Working Group (ACWG) to ensure consistency of approach across options. The table below shows a summary of the AIC outputs for each option associated with NWT SRO.

Table 2* - AIC Outputs

NWT SRO Element	Sub-option ID	Capacity	Total planning period option benefit - Capacity (NPV)	Total planning period indicative capital cost of option (Capex NPV)	Total planning period indicative operating cost of option (Opex NPV)	Total planning period indicative option cost (NPV)	Average Incremental Cost (AIC) at utilised capacity
Units		Ml/d	Ml	£M	£M	£M	p/m³
UU Sources	**WR102b**	17	19,932	80.17	4.05	84.21	423
	WR107a2	10	10,943	26.71	2.86	29.57	270
	WR107b	12	12,038	75.71	4.31	80.02	665
	WR111	9	31,657	27.58	3.91	31.49	99
	WR113	3	13,835	10.42	1.27	11.69	84
	WR149	13	27,436	41.43	3.45	44.88	164
	WR076	25	42,992	129.45	10.45	139.90	325
	WR015	40	65,660	179.25	15.82	195.07	297

NWT SRO Element	Sub-option ID	Capacity	Total planning period option benefit - Capacity (NPV)	Total planning period indicative capital cost of option (Capex NPV)	Total planning period indicative operating cost of option (Opex NPV)	Total planning period indicative option cost (NPV)	Average Incremental Cost (AIC) at utilised capacity
	WR049d	40	43,773	220.38	21.95	242.33	554
Vyrnwy Aqueduct Enabling Works	**STT A4**	205	240,362	217	8	225	94

*Table updated 10/03/2023.

2. Introduction

2.1.1 During periods of drought in the South East of England the River Severn to River Thames Transfer (STT) Strategic Water Resources Option (SRO) would convey raw water from the River Severn into the River Thames via an Interconnector. The source of the water would be a combination of un-supported flows from the River Severn, and supported flows from source support elements. The source support elements are North West Transfer (NWT SRO), Mythe Abstraction License transfer, Netheridge Sewage Treatment Works (all Severn Trent Sources SRO) and Minworth inter-catchment transfer (Minworth SRO). The NWT SRO is also capable of supplying Severn Trent Water directly via a connection into Shrewsbury.

2.1.2 The North West Transfer (NWT) SRO is to ensure UU can maintain supply resilience and levels of service to customers while transferring up to 205 Ml/d of water from the Vyrnwy system for up to 15% of the time over a long-term average (maximum continuous trade duration of 250 days).

2.1.3 The NWT SRO comprises two main elements; modifications to the Vyrnwy supply system to enable raw water to be redirected to the River Vyrnwy or Severn, as supporting flow to STT, and the commissioning and treatment of water from new sources to facilitate out of area transfers. The NWT solution relies upon construction of a new River Vyrnwy bypass pipeline and upgrading of the existing emergency connection between the Vyrnwy treated water aqueduct and Shelton WTW (Severn Trent Water), both of which are being promoted under the STT SRO. The conceptual designs of these associated elements are discussed in the Gate 2 submission for STT.

2.1.4 Lake Vyrnwy is a resilient, high quality and cost-effective raw water supply to a large number of customers, as part of an integrated conjunctive supply system, which enables water released for transfer to be replaced using other existing sources. Depending on demand conditions, UU's supply network could operate in this mode, without the Lake Vyrnwy supply, for several weeks. However, the additional pressure placed on other water sources would increase the likelihood of imposing customer restrictions, and damaging the environment. The purpose of the UU Sources element of the NWT SRO is to mitigate the adverse impacts on supply resilience.

2.1.5 A key feature of the integrated conjunctive system is that water supplies can be replenished at any point within the system, and not necessarily be located near to the point of transfer. This allows us to develop more cost effective, resilient options in less environmentally sensitive areas. It also means that if an option is discounted in the future, it may easily be substituted with another.

2.1.6 This report details the methodology used for the costing of the UU Sources and VA Enabling Works elements of the NWT SRO, based on 'Cost Contingency Methodology – Rev E' published by Mott Macdonald.

3. Capex Costing

3.1 Methodology

UU Sources

Approach and Data sources

3.1.1 Estimates have been generated with UU's estimating tool to generate capital and operational expenditure figures per source option. The exercise aligns to the Cost Consistency Methodology, Rev E. Costs are presented at financial year 2020/21 prices to enable direct comparison between SROs and between the cost estimates made for Gates 1 and 2.

3.1.2 Costs produced from the UU estimating tool relate to a formula associated with each cost element. The costs are driven by cost curves that have been developed for various common asset types. Each element of a solution is represented by a process block in a Process Block Diagram (PBD), for which key variables are defined by the designers. These parameters are then applied to the appropriate cost curve to develop a yardstick construction cost for that element. The PBDs summarise the designed solution and have been checked and reviewed by each discipline (process, civil, mechanical, and electrical) to build up the conceptual designs.

3.1.3 A series of automated equations generate indirect costs which are applied to the direct construction totals to generate a total project value. Where the required yardstick value was outside the database, the costing teams used a bottom-up approach to generate the costs.

3.1.4 These indirect costs are based upon analyses of historical project data and cover the following areas:

- **Contractor Add-ons** – These are costs that are incurred by the contractor during the lifecycle of the project. These costs comprise items such as preliminaries, staff, design, risk, solution growth, fees, overheads, etc.
- **Tender to Outturn Cost** – An assessment of historical UU project outcomes indicates that project outturn capital costs exceed contract award values by 4% on average. This tender-to-outturn cost uplift has been adopted for Gate 2, pending completion of a quantitative costed risk assessment in Gate 3.
- **Client Add-ons** - This covers costs incurred by UU in the delivery of a capital project which are outside of the main contract scope of works and encompass all the associated internal and external UU costs required to deliver a total project. These costs have been generated using information held within UU accounting system which records all actual costs in relation to internal man-hours and external orders against unique project code and structure. These include:
  - Miscellaneous bespoke additional client delivery costs
  - UU Operations (Maintenance)
  - UU Operations (Non Maintenance)
  - Third Party Design
  - Surveys Non Cost Base
  - Surveys Costs
  - Services Diversions
  - Telemetry
  - Consumable Chemicals
  - Electrical Supply to Site - REC
  - Planning Valuation Environmental
  - Land Purchase
  - Project External Works
  - UU Insurance
  - Miscellaneous additional Client Add-on
  - UU Capital Overheads

3.1.5 The estimates were defined by UU's Estimating Team as Level 2 estimates, meaning its typical purpose is screening, concept, or study. Under the Association for Advancement of Cost Engineering (AACE) International Cost Estimate Classification System, the estimates are classed as Class 4 estimates with approximately –15% to +50% accuracy range.

3.2 Base Date

3.2.1 All costs are presented at 2020/21 base date for consistency, as suggested by the ACWG. The costs were derived by using historical 2017/18 cost database inflated to FY20-21 using the CPIH index.

3.2.2 These cost estimates are not representative of current market conditions as observed in current projects. Specifically, the estimates are based at financial year 2020/21 and include a 40% provision for contractor's indirect costs.

3.2.3 The base Capex costs for the UU Sources sub-options are summarised below:

Table 3 - Capex Costs for UUS

Sub-option ID	Capacity	G2 Capex including risk	Risk
	Ml/d	£M	£M
WR102b	17	45.37	1.31
WR107a2	10	17.51	0.5
WR107b	12	59.75	1.63
WR111	9	14.99	0.42
WR113	3	7.13	0.19
WR149	13	26.33	0.76
WR076	25	81.81	2.37
WR015	40	123.55	3.59
WR049d	40	157.63	4.61

3.2.4 27 sub-options were considered at Gate 1, however the majority of these were discounted during assessment in Gate 2, and only four of the sub-options considered at Gate 1 have been adopted in the NWT Full Solution. In order to achieve the required minimum backfill of 167 Ml/d, further sub-options were included in the Gate 2 assessment that were more costly to implement. Therefore, the total cost of the Full Solution portfolio has increased from that considered at Gate 1.

3.2.5 There are several factors that have contributed to the costs for the individual options to be different and therefore the overall costs increasing:

- For Gate 2, United Utilities is able to offer a maximum transfer rate of 205 Ml/d, which is an increase of 25 Ml/d above that offered at Gate 1. This will require an increase in backfill volume to the UU supply system from 113 Ml/d (Gate 1) to 167 Ml/d.
- Several of the sub-options identified at Gate 1 were discounted following further assessment, as they were found not be to be feasible or did not add additional treatment capacity to contribute towards the short-term resilience of UU's system. Therefore, alternative options were selected to match the deployable output requirements in line with Water Resource Modelling. These sources

were selected by aligning water trading scenarios with the WRMP and identify a preferred long list to appraise.

- More detailed engineering work at Gate 2 has revealed additional scope because of changes or factors previously unidentified. Additional hydraulic, geotechnical, and geo-environmental assessments have been included in Gate 2 designs which have increased the level of accuracy in the designs and in turn have identified additional items of scope which have been added.
- Optimism bias has been revised for Gate 2.

3.2.6 Only four of the water source sub-options considered at Gate 1 have been adopted in the NWT Full Solution. Table 1 presents a comparison of estimated capital costs for these sub-options between Gate 1 and Gate 2.

Table 4 - Gate 1 vs Gate 2 Sub-option Capital Cost Comparison

Sub-option ID	Capacity	Total G2 Capex	Total G1 Capex	Change G1 to G2	G2 Fixed Opex	G1 Fixed Opex	G2 Variable Opex	G1 Variable Opex	Comments
Units	Ml/d	£M	£M	%	£M/ annum	£M/ annum	£/Ml	£/Ml	
WR102b	17	57.16	40.27	+42%	0.12	0.08	77.87	51.84	Changes in scope include: Additional treatment units based on updated water quality information, additional land purchase allowance adjacent to existing assets to address space issues on site.
WR113	3	8.98	8.53	+5%	0.01	0.01	69.07	95.30	Changes in scope include: Additional land purchase on adjacent land to fit additional new pressure filters and new borehole drill.
WR149	13	33.17	37.72	-12%	0.06	0.08	75.84	76.23	Additional treatment process units and reduction of unit sizing to fit within footprint.
WR076	25	104.72	84.82	+23%	0.22	0.17	135.18	78.81	Changes in scope include: Route changes from WTW to supply, additional measures in place to work around MAHP, additional land purchase to increase footprint of WTW, new breaking tank on site and additional storage and omitting the use of Dunham Massey SR.
WR105a 2 (Reserve sub-option)	4.5	26.39	25.06	+5%	0.05	0.12	24.49	24.07	Changes in scope include: New location for WTW identified to avoid local site and planning issues. Additional pipe, valves and fittings updated accordingly.

Notes:

3.2.7 The capacity of sub-option WR113 was assessed as 6 Ml/d at Gate 1 and 3 Ml/d at Gate 2.

3.2.8 The Gate 1 estimates were carried out based on a high-level scope with limited information (desktop feasibility study) and were carried out using a top-down approach with generic costs from UU's estimating database. The Gate 2 cost estimates have been developed from a more refined scope of works.

3.3 Vyrnwy Aqueduct Enabling Works

Approach and Data sources

3.3.1 The VA enabling works entails modifications to Oswestry WTW to enable flows to be redirected away from the existing Vyrnwy treated water aqueduct for transfer out of area. In order to provide continued supply to UU customers served via the Vyrnwy Aqueduct, the Aqueduct will be recharged using treated water from an alternative source. This will require flows to be reversed by pumping during periods of transfer.

3.3.2 Making major modifications to an operational aqueduct is a highly bespoke operation, which cannot be represented using a process block diagram approach. Instead, a highly detailed estimating brief was developed to enable a bottom-up costing approach to be adopted.

3.3.3 Indirect costs are based upon analyses of historical project data and cover the following areas:

- **Contractor Add-ons** – These are costs that are incurred by the contractor during the lifecycle of the project. These costs comprise items such as preliminaries, staff, design, risk, solution growth, fees, overheads, etc.
- **Tender to Outturn Cost** – An assessment of historical UU project outcomes indicates that project outturn capital costs exceed contract award values by 10% on average. This tender-to-outturn cost uplift has been adopted for Gate 2, pending completion of a quantitative costed risk assessment in Gate 3.
- **Client Add-ons** - This covers costs incurred by UU in the delivery of a capital project which are outside of the main contract scope of works and encompass all the associated internal and external UU costs required to deliver a total project. These costs have been generated using information held within UU accounting system which records all actual costs in relation to internal man-hours and external orders against unique project code and structure.

3.4 Base Date

3.4.1 Costs are presented at 2020/21 base date for consistency as suggested the ACWG. The deflation factors used for CAPEX and OPEX have also been agreed with the ACWG and are based on the figures used by the WRSE draft regional plan modelling team. Inflation factors will require updating for Gate 3, as current inflation is well above the figures predicted when these indices were developed.

3.4.2 These cost estimates include a 40% provision for contractor's indirect costs.

3.4.3 The base Capex cost estimated for the Gate 2 conceptual design is summarised below:

Table 5 - Base Capex Costs

Sub-option ID	Capacity	G2 Capex (including risk)	Risk
Units	Ml/d	£m	£m
STT A4	205.00	144.83	9.54

3.4.4 The configuration of the Gate 2 solution differs significantly from that proposed at Gate 1, which has culminated in a more efficient design. The Gate 2 solution is able to support transfers of up to 205 Ml/d for a comparable cost to the solution proposed at Gate 1.

3.4.5 The cost estimates are generally lower than previous estimates at Gate 1, although facilitating higher trades (205 Ml/d vs 180 Ml/d). The following factors that contributed to the options to be different and therefore the overall costs changing:

- A more detailed engineering assessment at Gate 2 has revealed additional scope and opportunities in the valve chambers that UU are exploring.

4. Costed Risk

4.1.1 Gate 2 cost estimates include a Tender to Outturn cost uplift figure, pending completion of a quantified costed risk assessment in Gate 3. The Tender to Outturn costs represent the historical average variance between contract award values and outturn costs.

4.1.2 The 4% tender to outturn figure for UU Sources was derived by analysis of projects delivered, ensuring benchmarking of UU prices post PR19 – this is now the standard approach in UU.

4.1.3 The Vyrnwy aqueduct estimate has a 10% tender to outturn uplift, which has been assessed based on the level of scope provided and analysis of similar projects delivered by UU.

4.1.4 A summary of the costed risk figures included in the Gate 2 estimates can be seen in the table below.

Table 6 - Summary of tender to outturn uplift provision made in lieu of costed risk

Element	Sub-option Name	Capacity	Tender to Outturn provisions (In lieu of costed risk)
UU Sources	**Units**	Ml/d	£m
	WR102b	17	1.31
	WR107a2	10	0.5
	WR107b	12	1.63
	WR111	9	0.42
	WR113	3	0.19
	WR149	13	0.76
	WR076	25	2.37
	WR015	40	3.59
	WR049d	40	4.61
Vyrnwy 205 Ml/d Solution	**STT A4**	205	9.54

5. Optimism Bias

5.1.1 Optimism Bias (OB) has been derived using the methodology outlined in the Cost Consistency Methodology – Technical Note and Methodology Revision E Issued February 2022. Optimism bias has then been added to the above in line with the methodology of the ACWG as noted below.

5.1.2 The optimism bias for UU Source sub-options was scored as either 26% or 28 % with the procurement strategy being a key differentiator. Sub-options that were assessed to be a somewhat suitable for procurement via the Direct Procurement for Customers route scored higher.

5.1.3 An optimism bias of 19% was assessed for the Vyrnwy Aqueduct Enabling Works. This is reflective of the fact the Vyrnwy Aqueduct is an existing operational asset, and the planning for construction works would have fewer unknown variables.

5.1.4 It is important to highlight that Gate 1 OB values are only available for the four UU Sources sub-options that were considered in both Gates 1 and 2.

5.1.5 The Optimism Bias figure presented for Gate 2 UUS and Vyrnwy are presented in the table below.

Table 7 - Optimism Bias figure*

Element	Sub-option Name	Capacity	G2 Optimism Bias Percentage	G2 Optimism Bias	G1 Optimism Bias Percentage
	Units	Ml/d	%	£M	
UU Sources	**WR102b**	17	26%	11.58	23%
	WR107a2	10	26%	4.47	n/a
	WR107b	12	26%	15.26	n/a
	WR111	9	26%	3.83	n/a
	WR113	3	26%	1.82	23%
	WR149	13	26%	6.72	23%
	WR076	25	28%	22.91	23%
	WR015	40	28%	34.6	n/a
	WR049d	40	28%	44.14	n/a
Vyrnwy 205 Ml/d Solution	**STT A4**	205	19%	28.19	27%

*Table updated 10/03/2023.

6. Capex Benchmarking

6.1.1 Cost estimates for the UU sources and Vyrnwy Aqueduct Enabling Works elements of work were produced using UU's estimating database which was developed for PR19 and is being used currently for PR24. The cost models are based on a detailed analysis of tender returns up to financial year 2017/18, and have been benchmarked internally against relevant recent projects at UU.

6.1.2 The Gate 2 cost estimates for the NWT SRO were further validated using best practice benchmarking methodologies adopted from the Royal Institute of Chartered Surveyors and Infrastructure Projects Authority. The objectives of the exercise were to benchmark the NWT Gate 2 cost estimates against the historical performance of peer companies to enhance the confidence in solution deliverability. The metrics are based upon benchmarking of key construction activities against historical project cost data, and allocation of normalised project uplifts covering main-contractor and client On-Costs and Overheads, Estimating Uncertainty, Tender-to-Out-Turn costs, Sites Specific Complexity and Constraint uplifts and Corporate Overheads to achieve a robust benchmark across the holistic cost stack.

6.1.3 The exercise covered cost estimates for the nine preferred UU Source sub-options and four reserve sub-options.

6.2 Key Findings

Table 8 - Cost Stack

Cost Stack Element	UU	BM Lower	BM Medium	BM Upper
Benchmarked	£ 245,512,562	£ 215,984,792	£ 263,669,115	£ 328,391,014
UnBenchmarked (Pro Rata'd)	£ 119,213,152	£ 104,875,399	£ 128,029,401	£ 159,456,314

Direct Works Total	**£**	**364,725,714**	**£**	**320,860,191**	**£**	**391,698,516**	**£**	**487,847,328**
Additional Items	£	37,527,151		**Incl'**		**Incl'**		**Incl'**
Contractor & Client Indirects	£	248,753,172	£	226,591,467	£	361,694,410	£	468,333,435
TtOR	£	22,526,160	£	6,569,420	£	17,930,752	£	43,984,315
Corporate OH	£	101,029,830	£	55,402,108	£	77,132,368	£	100,016,508
Indirects (Incl' Corp OH)	**£**	**409,836,314**	**£**	**288,562,994**	**£**	**456,757,529**	**£**	**612,334,258**
Total	**£**	**774,562,028.00**	**£**	**609,423,185**	**£**	**848,456,046**	**£**	**1,100,181,586**
				-21%		10%		42%

Note. BM – Industry benchmark position

6.2.1 The NWT estimate has been costed competitively, but is considered to be deliverable by comparison with industry benchmarks. The UU estimate is <10% below the median industry position, 27% above the industry lower position and 30% below industry benchmark higher position. The UU estimate for direct works (£365m) plus the adjustment value for Additional Items (£38m) totals £403m. This is within £11m (3%) of the industry median benchmark of £392m. The Main Contractor and Client Indirects (£249m) is benchmarking £113m (31%) below the current market assessment of industry median benchmark of £362m. This represents a deliverability risk area of cost within the estimate.

6.3 Confidence

6.3.1 Of the benchmarked elements the following confidence bandings have been allocated (based on value of interventions benchmarked):

Table 9 - Benchmarked Elements

Confidence Grading	Percentage Coverage
High	22%
Medium	60%
Low	18%

6.3.2 High confidence reflects interventions where:

- several (3+) data sources with highly aligned coverage rules have been used within the benchmark, and;
- UU interventions have fallen within the extrapolated range of the unified cost model.

6.3.3 Medium confidence reflects interventions where:

- limited (3- but 1+) data sources with aligned coverage rules have been used within the benchmark,
- the ranges of the unified cost model have been extrapolated to align with UU interventions, and/or limited number of high confidence actual data sources have been used to benchmark the costs owing to novelty/specialism.

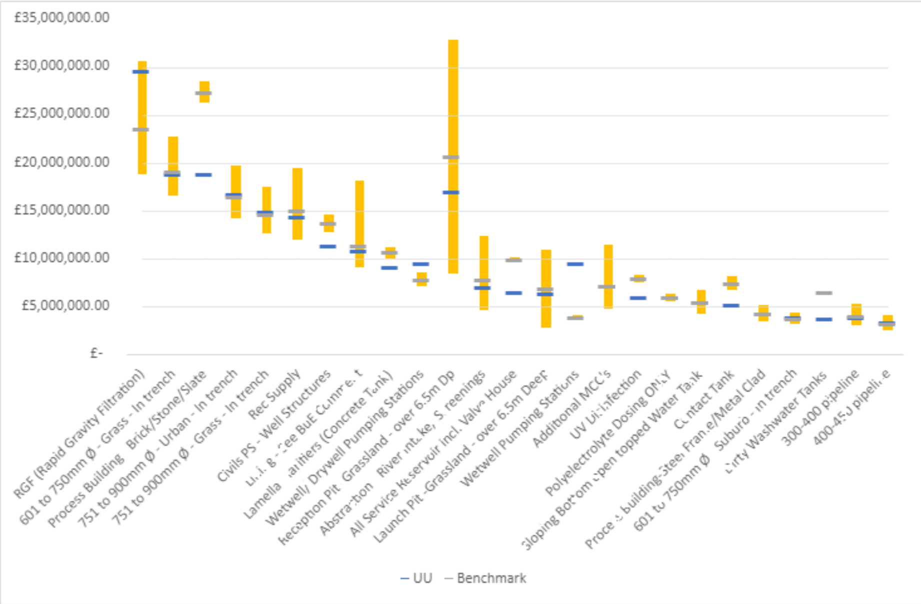
6.3.4 Low confidence reflects interventions where:

- Based on Subject Matter Expertise, rather than actual verified data points, or:
- Order of Magnitude costing approach due to lack of intervention yardsticks (e.g., use of Number (qty) or Sum).

Direct Works Elements Findings

6.3.5 The majority of cumulative intervention estimates were found to fall within the normalised range of the external benchmarks as illustrated in Figure 1 below;

Figure 1 NWT Cost estimates benchmarked against typical UK industry costs



7. Opex costing

7.1.1 Opex figures have been derived using a similar methodology to the Capex. Estimates have been generated with UU's estimating tool to generate operational expenditure figures (fixed and variable). The exercise aligns to the Cost Consistency Methodology, revision E, and latest update (via email on 12th July 2022) which refers to the preference to produce estimates to FY 2020/21 to enable direct comparison between SROs and between Gate 1 and 2. Note that only four of the UU Sources sub-options considered at Gate 1 have been adopted within the NWT Full Solution.

7.1.2 Costs have been produced from the UU estimating tool relate to a formula associated with each cost element. The costs are driven by cost curves that have been developed for various common asset types. Each element of a solution is represented by a process block in a Process Block Diagram (PBD) or costed element in briefing pack, for which key variables are defined by the designers. These parameters are then applied to the appropriate cost curve to develop a yardstick construction cost for that element.

7.1.3 All Opex costs are indicative only due to the multitude of variations, especially operational regimes employed. Fixed Opex figures refers to the fixed yearly operational costs required to operate the sub-options. Variable Opex figures refers to the variable costs associated with running the sub-options per Megalitre (e.g., Electricity, chemicals).

7.1.4 The values for Opex do not include manpower or staff associated with running the plant. These will be reviewed in a regional context during Gate 3.

7.1.5 A summary of fixed and variable Opex can be seen in the table below.

Table 10 - Fixed and Variable Opex

Option Name	Capacity	G2 Fixed Opex	G2 Variable Opex	G1 Fixed Opex	G1 Variable Opex
Units	Ml/d	£M/ annum	£/Ml	£M/ annum	£/Ml
WR102b	17	0.12	77.87	0.08	51.84
WR107a2	10	0.04	188.86	n/a	n/a
WR107b	12	0.11	170.53	n/a	n/a

Option Name	Capacity	G2 Fixed Opex	G2 Variable Opex	G1 Fixed Opex	G1 Variable Opex
WR111	9	0.04	96.43	n/a	n/a
WR113	3	0.01	69.07	0.01	95.30
WR149	13	0.06	75.84	0.08	76.23
WR076	25	0.22	135.18	0.17	78.81
WR015	40	0.28	148.87	n/a	n/a
WR049d	40	0.36	325.33	n/a	n/a
Vyrnwy 205 Ml/d Solution (STT A4)	205	0.32	4.31	n/a	n/a

8. Carbon

Regulatory Context

Ofwat's Net Zero Principles

8.1.1 As the water services regulation authority, responsible for economic regulation of the privatised water and sewerage industry in England, Ofwat have recently committed to strengthening the sector's approach to climate change mitigation and adaptation, whilst building on the companies' previous Public Interest Commitment (PIC) to achieving net zero (GHG) emissions by 2030.

8.1.2 Within their position paper Ofwat outline three key areas that are crucial for the water sector to achieving net zero:

- Expecting companies' plans to align with national government net zero targets.
- Action on net zero should address operational and embodied GHG emissions in parallel.
- Companies need to prioritise the reduction of GHG emissions before the use of offsets as set out in the GHG Management Hierarchy.

8.1.3 Ofwat have outlined their expectations for water utility companies to reduce both their operational and embodied emissions by 2030 for the following reasons:

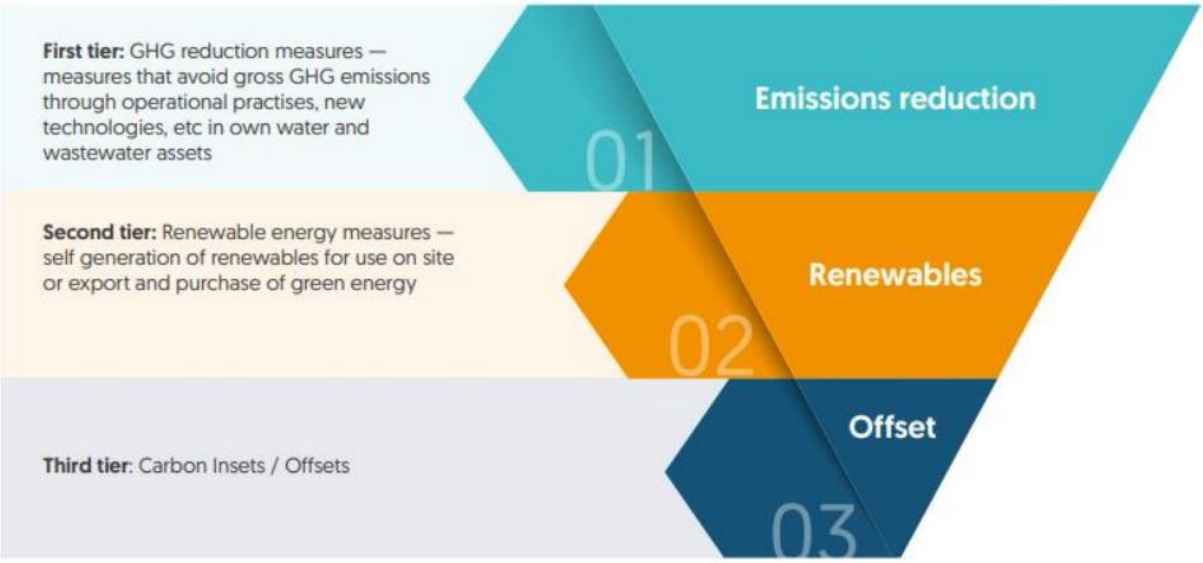
- Both operational and embodied GHG emissions must be reduced for government net zero targets to be achieved.
- Requiring action on both types of GHG emissions will help to ensure one source of emissions is not acted and reported on to the detriment of the wider environment and future generations.
- A parallel approach to reducing both operational and embodied GHG emissions will help to safeguard against decisions being taken in isolation such that operational emissions are prioritised ahead of action on embodied GHG emissions risking the unnecessary early replacement of assets to reduce operational emissions.

Innovation and cost savings can be maximised with solutions which address both sources of emissions.

Water UK Net Zero 2030 Routemap

8.1.4 In April 2019, UK water companies agreed to a Public Interest Commitment, which included committing to achieve net zero operational carbon1 for the sector by 2030. The Net Zero Routemap was produced to provide strategic guidance and options to decarbonise the sector. A baseline was established from historical emissions, finding that the main source of operational emissions was from power use, primarily using grid based electricity. This was followed by process emissions, predominantly methane (CH_4) and nitrous oxide (N_2O) from wastewater and sludge treatment processes. The Routemap analysed three 'pathways' to illustrate how effective different approaches to net zero could be in the context of future market forces, supply chains, policy and the availability of funding. These were created to align with the emissions reduction hierarchy, which is a means of prioritising decarbonisation interventions by encouraging tangible emissions reductions before pursuing renewable technology or offsets. This is detailed in Figure X below:

Figure 2 - Emissions reduction hierarchy



8.1.5 A summary of each pathway is detailed below:

- Demand led – decarbonisation focused on the application of energy efficiency and demand reduction. Renewables and other technologies are applied at a lower scale, followed by offsets.
- Technology led – assumed the acceleration of technological innovations, with large investments in renewables, process technologies and sustainable transport systems, targeting decarbonisation in the largest emissions contributing areas.
- Removals led – low adoption of emissions reduction and renewable technologies, leading to the need for natural sequestration solutions: insets, offsets and purchased offsets. This pathway focuses on natural sequestrations within water companies' own land and UK territory.

8.1.6 Due to the high proportion of operational emissions coming from the use of grid-based electricity and from process emissions, the route map identified the technology led pathway as having the highest percentage reduction against the baseline before requiring offsets. However, this comes at the highest cost, requiring investment in innovation planning, technology acceleration and business case development. The removals led pathway was the least effective option, requiring significant effort by the sector to accelerate natural sequestration solutions without achieving a benefit until after 2030. There was also uncertainty around savings from peatland restoration towards 2050, as climate change poses a risk to their ability to sequester carbon, despite having significant savings in the short term. Overall, the route map highlights the need for a holistic approach to net zero, which prioritises technology and demand reduction, with removals being used only to offset the hardest-to-abate areas in the water sector.

United Utilities Carbon Strategy

8.1.7 UU has a strong track record of playing our part to mitigate climate change and have reduced scope 1 and 2 emissions by over 70% since 2005/06, largely through substantial investment in renewable power generation and green energy procurement. Our ambition and commitments are based on international guidance and climate science and we were delighted in July 2021 that our four near-term science-based targets were verified by the Science Based Targets initiative (SBTi). In October 2021, the remainder of our purchased electricity switched to a renewable tariff backed by Renewable Energy Guarantees of

Origin certificates, meaning that in the future 100% of our purchased electricity will be from renewable sources enabling us to deliver on our carbon pledge and our SBT. The SBTi Net Zero Standard was launched in late 2021 and we have committed to validate our 2050 ambition to this standard when we revise and revalidate our near-term targets in advance of 2025.

8.1.8 As well as our company-specific science-based targets, we share the UK water sector ambition for a defined set of operational emissions to be net zero from 2030 as set out in the Water UK's Net Zero 2030 Routemap. Note that this target has a smaller scope than SBTi and allows use of purchased credits, using agreed offsetting principles consistent with the GHG Management Hierarchy. Water UK's Net Zero 2030 Routemap is 20 years ahead of the UK Government's own legally binding target of 2050 and forms the world's first detailed plan to get an entire industry sector to net zero. We are also actively contributing to the ACWG Carbon Task & Finish Group which is aiming to develop a consistent carbon ambition across all SRO projects.

NWT Carbon Costing

8.1.9 Construction/embodied carbon for each sub-option has been quantified using the UU carbon estimating tool. This tool was developed using the guidance in the UKWIR (2012) Framework for accounting for embodied carbon in water industry assets (12/CL/01/15) and the Bath University Inventory of Carbon & Energy v3.0. The tool contains a database of 'cradle to gate' emissions factors for commonly used construction materials (e.g. aggregates, different forms of cement, mortar and concrete, and materials such as glass steel and timber.) The quantity (volume, length or weight as appropriate) of each material element is multiplied by the emissions factor in the tool to give an estimate of greenhouse gas emissions from the use of that material in the construction of the sub-option. Given that the SRO is at concept design stage, a number of assumptions have been used in the estimates of quantities.The cumulative emissions for all material emissions forms the emissions from capital expenditure/embedded emissions. The development of the option designs between Gate 1 and Gate 2 has reduced the level of uncertainty in the quantification of carbon, and this will continue to be reduced as we move from concept design to detailed design during Gate 3.

8.1.10 Whole life operational carbon was quantified from estimated emissions from annual operational activities for the whole life term. These include emissions from use of energy including in vehicles (scope 1 and 2) and chemicals (scope 3). Operational emissions can be categorised as fixed or variable. Fixed operational carbon relates to any emission that is independent of the volume of water delivered (e.g. daily impact of keeping a plant operational). Variable operational carbon relates to any carbon proportional to the volume of water delivered (e.g. pumping efforts or chemicals).

8.1.11 The table below presents the estimated whole life carbon cost of the SRO broken into embodied and operational greenhouse gas emissions, expressed as tCO2e, for each of the sub-options and Full Solution. This emissions estimate is the scaled by a carbon value in £GBP per tCO2e, in accordance with Supplementary Guidance to the HM Treasury Green Book, entitled Valuation of Energy Use and Greenhouse Gas Emissions. The NPV carbon cost for the NWT SRO Full Solution is £408 M.

Table 11 - Whole Life Carbon Costs

Option ID	Option Name	Implementation Related Carbon (Tonnes CO2e)	Operation Related Carbon excluding power (Fixed + Variable) (Tonnes CO2e/year)	Carbon Costs NPV (£m)
STTA4	NWT_VYRNWY	23,135.00	360.00	9
WR015	SWN_RIVER IRWELL	50,142.87	7,072.29	77
WR111	GWE_WOODFORD	2,834.40	1,394.72	14
WR113	GWE_TYTHERINGTON	3,807.23	523.86	6
WR149	ITC_WIGAN	8,856.76	2,057.83	21
WR076	SWN_RIVER BOLLIN	35,349.23	4,017.39	46

Option ID	Option Name	Implementation Related Carbon (Tonnes CO2e)	Operation Related Carbon excluding power (Fixed + Variable) (Tonnes CO2e/year)	Carbon Costs NPV (£m)
WR049d	SWN_RIVER RIBBLE 49d	58,768.74	14,905.03	152
WR107a2	GWE_AUGHTON PARK a2	5,480.80	2,387.08	23
WR102b	GWE_WIDNES	11,005.71	5,004.25	49
WR107b	GWE_RANDLES BRIDGE	18,637.25	742.29	11
Total	Full Solution	218,017.99	38,464.74	408
WR105a	GWE_LYMM a1	5,995.88	552.87	n/a
WR106b	GWE_WALTON_2	12,173.45	2,106.04	n/a
WR144	SWN_RIVER TAME	4,100.53	3,226.12	n/a
STT041b	SWN_RIVER IRWELL_ROCH	65,197.49	9,810.59	n/a

Note: Discounted Carbon Costs have not been calculated for the reserve Sub-options

8.1.12 We have minimised the carbon impacts (and other environmental impacts) of the NWT SRO by choosing, where possible, to use or modify existing infrastructure, rather than constructing new pipelines, abstraction boreholes, water treatments works etc. The most significant example of this is using the existing Vyrnwy Aqueduct pipelines to move water southwards from the source sub-options, rather than constructing additional pipelines.

8.1.13 There are two key points in the solution design where the carbon emissions resulting from the SRO can be influenced.

8.1.14 Firstly during the choice of Full Solution by including the estimated construction and operational carbon emissions in the best value assessment of all of the sub-options. This has been undertaken in Gate 2 and is described in Section 4 of the Gate 2 Submission.

8.1.15 Secondly, now that the Full Solution has been identified there are opportunities to reduce the impact of that solution, for instance though the use of lower emission products/materials, efficient use and reuse of resources, and inclusion of opportunities to sequester carbon as part of, or alongside, the SRO (for instance linked to achieving biodiversity net gain). As the SRO moves from concept design to detailed design during Gate 3 these opportunities will be incorporated into the design of the SRO.

9. Net Present Value (NPV) and Average Incremental Cost (AIC)

9.1.1 The Average Incremental Cost (AIC) is a metric to present the unit cost of the extra water available for use or demand saving from a particular option. AIC is calculated as the Net Present Value (NPV) of the capital (including maintenance and replacement costs, as well as the cost to finance the capital) and operating costs of the option, divided by the net present value of the extra water available for use or demand saving. The lower the AIC value, the more cost effective the source.

9.1.2 AIC is one of the simplest, aggregated options appraisal techniques and, with expert judgement, allows the creation of a best value portfolio of options.

9.1.3 The key assumptions included in this estimation are listed below:

- Optimism Bias and risk provision are included in the CAPEX estimates
- A provision for Biodiversity Net Gain is include in the CAPEX estimates
- Spend profiles are indicative only to facilitate multi-solution decision making and will be refined in Gate 3

- UUS sub-options will be operated at the annual average utilisation, as estimated by the Water Resource Optimisation Model
- The VA Enabling Works will be operated at a notional utilisation of 15%
- Calculations include M&E asset replacements in accordance with the Asset Life in the WRSE templates
- The NPV for each sub-option was calculated over a total project duration of 80 years using the Treasury Test Discount rate as set out in the HM Treasury "Green Book" (Appraisal and Evaluation in Central Government, HM Treasury 2003). This is 3.5% for years 0-30 of the appraisal period, 3.0% for years 31-75, and 2.5% for years 76-125
- Financing costs are calculated as a stream of annual costs over the life of the option using a Weighted Average Cost of Capital (WACC) of 2.92% which is the WRMP24 CPIH stripped wholesale WACC value.
- The net present value of all costs has been calculated using the 'HM Treasury's Green Book Guidance'. This is 3.5% for years 0 to 30 of the appraisal period, 3.0% for years 31 to 75, and 2.5% for years 76 to 125.

9.1.4 The NPV and AIC values for UU Sources and VA Enabling Works are presented in the table below;

Table 12 - NPV & AIC*

Option Name	Capacity	Total planning period option benefit - Capacity (NPV)	Total planning period indicative capital cost of option (Capex NPV)	Total planning period indicative operating cost of option (Opex NPV)	Total planning period indicative option cost (NPV)	Average Incremental Cost at Capacity (AIC)
Units	Ml/d	Ml	£M	£M	£M	p/m³
WR102b	17	19,932	80.17	4.05	84.21	423
WR107a2	10	10,943	26.71	2.86	29.57	270
WR107b	12	12,038	75.71	4.31	80.02	665
WR111	9	31,657	27.58	3.91	31.49	99
WR113	3	13,835	10.42	1.27	11.69	84
WR149	13	27,436	41.43	3.45	44.88	164
WR076	25	42,992	129.45	10.45	139.90	325
WR015	40	65,660	179.25	15.82	195.07	297
WR049d	40	43,773	220.38	21.95	242.33	554
STT A4	205	240,362	217	8	225	94

*Table updated 10/03/2023.

10. Full Solution Portfolio

10.1.1 A 205 Ml/d transfer portfolio has been created in collaboration with the water resources work stream in NWT to create a Full Solution. The table below summarises costs for the NWT Full Solution for UU Sources and Vyrnwy enabling works as well as comparing Gate 1 figures.

Table 13 - Costs for NWT Full Solution*

	Units	UU Sources Gate 1	UU Sources Gate 2	% Change	Vyrnwy Enabling Works Gate 1	Vyrnwy Enabling Works Gate 2	% Change	Gate 2 Full Solution Total
Capacity	Ml/d	113.00	167.00	48%	180.00	205.00	14%	
Capex								
Base Capex (includes risk)	£M	255.39	534.07	109%	140.75	144.87	3%	678.94
Risk	£M	7.23	15.53	113%	3.82	9.54	150%	25.08
Optimism Bias (OB)	£M	58.74	145.31	147%	38.00	28.19	-26%	
Total Capex (including risk + OB)	£M	314.14	679.38	116%	178.75	173.07	-3%	852.45
Opex								
Fixed	£M/annum	0.72	1.24	73%	0.21	0.32	52%	1.56
Variable	£/Ml	77.62	175.58	126%	65.61	4.31	-93%	179.89
AIC								
Total planning period option benefit (NPV)	Ml	1,168,376	268,267	-77%	1,616,500	240,362	-85%	508,629
Total planning period indicative capital cost of option (Capex NPV)	£M	424.79	791.08	86%	159.71	217.08	36%	1,008.16
Total planning period indicative operating cost of option (Opex NPV)	£M	108.63	68.07	-37%	111.36	7.88	-93%	75.96
Total planning period indicative option cost (NPV)	£M	533.43	859.16	61%	271.07	224.96	-17%	1,084.12
Average Incremental Cost (AIC)	p/m³	45.70	372.79	599%	16.7	94.00	463%	466.79

*Table updated 10/03/2023.

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