GARD initial response to

Gate 1 reports on

Strategic Resource Options

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GARD Initial Response to Gate 1 Reports on Strategic Resource Options

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Summary

This report is GARD's first response to the Gate 1 reports which were published on RAPID's web-site on 5th July 2021. We understand that, following RAPID's review of the Gate 1 reports and recommendations to Ofwat, there will be a 'representation period' from mid-September to early October for stakeholders to comment. To fit with this programme, GARD will make two responses to the Gate 1 documents:

- Firstly, this initial response which is intended to be in time to influence RAPID's assessment of the Gate 1 submissions and their recommendations to Ofwat.
- Secondly, by early October in response to the request for representations, taking account of RAPID's published reviews of the Gate 1 proposals, and their recommendations for Gate 2 investigations

This first response focuses on the key matters which we think RAPID should address in making their recommendations to Ofwat. These matters are summarised below and cross-referenced to the main report which provides more detail and supporting evidence.

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Selection of strategic options for Gate 2

We propose that London desalination options are reinstated in the Gate 2 investigations. We do not understand why these options were excluded from the Gate 1 investigations. Desalination options of up to 300 Ml/d were considered feasible in Thames Water's WRMP19 and were selected in some of their programme scenarios, but not in the final preferred plan. In view of the large deficits now being considered by WRSE, London desalination options should be properly investigated in Gate 2, building on the large amount of work on this option for WRMP19. 11-12

The Thames Water to Southern Water transfer should be excluded from Gate 2. In our opinion, this transfer makes no strategic sense. The major strategic problem faced by all UK supplies is the concentration of most of the population in the driest part of the country – the South East of England, especially London and the Thames Valley. Therefore, it seems irresponsible for Thames Water to contemplate selling water to Southern Water, exporting water out of the Thames Valley where it is already in such short supply. 40

General weaknesses in the Gate 1 reports

Deployable output assessments

There is no transparency in the option deployable output assessments, which are crucial for assessing option cost effectiveness and comparative performance. Deployable outputs are quoted in the Gate 1 reports, but without supporting evidence. RAPID should insist that more detailed information on derivation of deployable outputs is made 12

publicly available in time for the stakeholder 'representation period' in mid-September, including details of modelling output, as we have proposed in Section 2.2.

Cost transparency

There is no transparency in the Gate 1 cost estimates. The reports show capital, operating and total NPV costs for each strategic resource option and sub-option, but no further details are provided. For the strategic transfer options, there are no total costs that would allow comparison with Abingdon reservoir costs. The cost presentations in the Gate 1 reports are meaningless to stakeholders. RAPID should insist that more detailed cost information is made publicly available in time for the stakeholder 'representation period' in mid-September, in the format that we have suggested in Section 2.3. 13

In RAPID's reports to Ofwat with recommendations for Gate 2, we would like to see evidence that detailed cost information has been made available to RAPID and scrutinised in detail. 14

Stochastic data

We have four major concerns over the reliability of the stochastic river flow data that have been widely used for assessing deployable outputs:

- The modelling that generates river flows from weather data is unavoidably inaccurate in groundwater dominated catchments like the Thames valley.
- The base period for generating the stochastic weather, 1950 to 1997, contains no long duration droughts like 1921/22 and 1933/34 which are the most serious for London's supplies in the past 100 years.
- The base period excludes weather since 1997, the period of most rapid climate change. 15-17
- The generated Thames and Severn river flows may not reflect the large geological difference in the catchments which govern a lot of the benefits of the Severn to Thames transfer.

RAPID's review of the Gate 1 reports should highlight these weaknesses and specify further work needed at Gate 2 to understand and manage the uncertainty inherent in the use of stochastic data, taking note of the suggestions we have made in Section 2.4.

Carbon costing

The Gate 1 reports are poor on the subject of the Carbon costing of strategic options. In some cases we could find no carbon footprint information at all. Even where the carbon assessments are included, there are several generic shortcomings in the data presented: 17-19

- there is mostly a lack of cited evidence to back-up quoted figures
- there is a lack of transparency of the content and derivation of 'embodied'

('capital' or 'construction') carbon figures

- there is mostly a lack of transparency over the operational scenarios for the Operational carbon budgets

We believe RAPID should insist on all reports being brought up to the same standard in carbon assessment *at this Gate* (not waiting for Gate 2 submissions). 19

The carbon assessment for comparing resource options must consider (for a 75 year planning time horizon) the technological developments which will occur to decarbonise both operation and construction of water infrastructure.

For operational carbon, it could be argued that the combined effect of the ongoing UK Grid decarbonisation, and the commitment of the UK Water Industry to 'net zero' carbon operation by 2030, both render the consideration of *Operational Carbon* costs to be a negligible factor in the comparison of different projects.

The situation is much different for *Embodied Carbon*, as there is no accepted roadmap to decarbonisation of construction materials and construction equipment. 19

The carbon footprints of the strategic resource option types are a mix of high and low embodied/operational carbon. Therefore, RAPID should insist that the reports set out the assumptions and give the breakdown between materials, equipment and transport emissions. Once this is given, the *regulators* (RAPID) then should determine the technology scenario for decarbonisation, based on the best expert advice. Option comparisons should assume this scenario and should be subject to sensitivity testing.

Abingdon Reservoir (SESRO)

The quoted deployable output of the 150Mm^3 Abingdon reservoir is 293 Ml/d, compared with our estimate of 180-220 Ml/d. The major differences arise from assessment of the reservoir's performance in long duration droughts and the allowance for emergency storage. GARD has raised these differences repeatedly and in detail with Thames Water, WRSE and RAPID, but our concerns have not been addressed. 19

We propose that for Gate 2 RAPID should commission a comprehensive independent audit of Thames Water's assessment of Abingdon reservoir's deployable output, including its resilience to long duration droughts and emergency storage provision, taking account of the detailed criticisms that GARD has raised. 21

The assessed deployable output for Abingdon reservoir allows for only 2% losses in the Thames for water transferred to London. No evidence has been presented to justify this figure, which is far lower than the 20% losses being considered for regulation releases from Vyrnwy reservoir into the River Severn. RAPID should require full and transparent 21

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investigation of the Thames regulation losses for Gate 2, using similar methods to those being adopted to assess River Severn regulation losses.

Abingdon reservoir is said to score very well for 'Adaptability'. A large reservoir cannot be scaled back, or even paused if the circumstances change in the water demand. The damage to the local area cannot be undone, without huge cost, once it has been visited on the site. RAPID should insist that the purported 'Adaptability' should not be allowed to remain as a listed benefit. 21

The Gate 1 report says the latest flood modelling shows the reservoir would lead to a reduction in flood risk for Abingdon. It is difficult to see how this could be the case, so RAPID should require the flooding report to be made available for public scrutiny prior to the start of the 'representation period' in mid-September. 22

We consider the Gate 1 assessments of the environmental impacts of Abingdon reservoir to be superficial, biased and inconsistent with references to risk elsewhere in the report. The bias is demonstrated by the downplaying of very significant construction impacts of the 10-year project on the biodiversity and landscape of the area (classed as '*Moderate Adverse*'), and the total omission of any estimation of the effects of round-the-clock noise, light pollution and transport dislocation on the residents of the area. 22

The Gate 1 report recognizes the *'High'* risk of the developing the project due to local and environmental concerns, with a history of (successful) legal challenge and consistent local authorities' opposition to the scheme, at all levels from parish to county. These are supposed to be mitigated to '*Medium*' after the formation of '*local collaborative partnerships*' to '*help explain the scheme to local residents and ensure that local issues are understood*'. This is completely unrealistic. '*Local collaborative partnerships*', if indeed they can be formed, are unlikely to reduce the already well-informed local opposition, especially as the new housing development in the area since the 2010 Public Inquiry has encroached ever closer to the reservoir footprint and made the impact on communities even higher. 24-25

RAPID should ensure that this is recognised and the risk of local opposition is not underestimated in option assessment metrics for Gate 2.

London Water Reuse options

The Gate 1 report considers Mogden reuse options of up to only 200 Ml/d capacity. The dry weather flow from Mogden STW is about 450 Ml/d, but the Gate 1 report provides no explanation of why reuse options have been restricted to 200 Ml/d. RAPID should require larger Mogden reuse options in Gate 2, probably up to 450 Ml/d in the case of 25

the Teddington DRA option.

In GARD's response to the Thames Water's revised draft WRMP19, we proposed various options for reuse of up to 450 Ml/d of Mogden effluent and assessed their deployable output and means of mitigating environmental impacts. The deployable outputs of these options are about double those suggested for the Mogden reuse options in the Gate 1 report. RAPID should require the options proposed by GARD to be properly investigated in Gate 2. 26

Severn to Thames transfer options

There are five Gate 1 reports covering the various components of the Severn to Thames transfer option. With multiple Gate 1 reports, each with different deployable outputs and costs, there is no clear picture of overall deployable outputs and costs of the strategic resource option and its sub-options. For Gate 2, RAPID should require all the STT components to be combined to form a single strategic resource option. 27

We are pleased to see that the unsupported Severn to Thames transfer is being considered as a feasible first phase of development of the STT, despite Thames Water's claim in WRMP19 that it was not a feasible option. However, we are sceptical of the quoted deployable output of only 80 Ml/d. This is an example of the detailed model output which should be available to stakeholders on request, as we have proposed in Section 2.2 of this report. 27

However, consideration should also be given to an enhanced first STT phase combining the unsupported transfer with support from Mythe and bringing in Vyrnwy regulation to a level that requires minimal new source development for United Utilities. This option could be implemented rapidly and would 'buy time' while the actual future need and the effects of climate change can be observed. The option could be operational by the early 2030s and would facilitate early relief of chalk stream over-abstraction 34

The Gate 1 reports consider a maximum regulation release of only 180 Ml/d from Vyrnwy reservoir to the River Severn. In GARD's response to Thames Water's revised draft WRMP19, we showed that, with regulation releases of 350 Ml/d, Vyrnwy reservoir and a 500 Ml/d capacity transfer could provide roughly double the deployable output gain if the regulation release is restricted to 180 Ml/d. In our opinion, the restriction of the regulation release to only 180 Ml/d is a major failing of the Gate 1 investigations. RAPID should require releases of up to 400 Ml/d to be considered in Gate 2. 27-28

As well as restricting the regulation release to 180 Ml/d, the Gate 1 STT analysis assumes that only 75 Ml/d can be released directly into the River Vyrnwy. It is understood that regulation releases larger than 75 Ml/d into the River Vyrnwy would not be acceptable to 28

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Natural Resources Wales because of the possible impact on juvenile salmonids.	
The flow regime downstream of Vyrnwy dam is already highly unnatural, with prolonged periods of low compensation flows in the summer and flood storage releases of about 400 Ml/d in autumn. In our opinion, the flow regime with regulation releases would actually be more suited to juvenile salmonids than the current flows. Evidence to support our view is provided by the large regulation releases from Llyn Celyn dam in the upper Dee catchment. These releases are larger than the Vyrnwy releases that we have suggested, yet are approved by Natural Resources Wales. The juvenile salmon population downstream of Llyn Celyn dam is as good as or better than other parts of the River Dee.	29-30
RAPID should recommend that one of the STT options considered for Gate 2 should allow for regulation releases of up to, say, 400 Ml/d directly into the River Vyrnwy. The STT investigation team should look for means of mitigating any impact on fisheries by short term variations in the regulation release to give a more natural pattern of flow variation. The acceptability of this option should then be considered by NRW, working collaboratively with the STT investigation team.	31
The Gate 1 reports assume 20% regulation losses in the River Severn, but loss investigations are continuing. We are sceptical of such a high loss allowance and suspect it does not take account of the water balance and where the water from such high losses might go. In Section 2.3 we have made various suggestions for further investigation of these losses, including looking at experience from other major regulation schemes like the River Dee, the Rivers Elan/Wye, Kielder/Tyne and Ely Ouse to Essex. RAPID should ensure that these suggestions are taken up by the STT team.	32
In view of the significance of the Deerhurst hands off flow for the deployable output and cost-effectiveness of STT options, RAPID should require the Deerhurst hands-off flow to be the subject of a rigorous and transparent investigation in Gate 2.	31
The Gate 1 report for Minworth sources says that the maximum amount considered for transfer via the STT is 115 Ml/d, with a further transfer of up to 100 Ml/d via the Grand Union Canal transfer – a total maximum use of 215 Ml/d. The Minworth dry weather flow is over 400 Ml/d, so releases of much more than 115 Ml/d could be used to support the STT, with more still being available for the Grand Union Canal transfer. RAPID should require that options for larger use of Minworth STW for supporting the STT should be considered in Gate 2, particularly for options that use the 500 Ml/d capacity transfer from the Severn to the Thames.	33
The five Gate 1 STT reports include the vital topic of who will be responsible for the construction of the transfer infrastructure, its ownership and its subsequent operation. Although considerable thought has gone into this, there appears to have been little	34

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collaboration between the different investigation teams and the water companies. There is no consistent view on how the scheme should be procured, owned and operated. RAPID should recommends to Ofwat the immediate establishment of a working party to consider all the procurement, ownership and operation options for the STT and to recommend a unified approach. This working party should comprise members from each water company, the water regulators and representatives from each component investigation team. The working party should be required to report by the issue of the Gate 2 submissions. 35

Thames Water to Affinity Water transfer options

The Gate 1 report says the transfer could use three potential sources of water – the Abingdon reservoir, the Severn to Thames transfer or London reuse schemes. In our opinion, this report has been heavily biased in favour of using Abingdon reservoir. An example is the dismissal of the Severn to Thames transfer as a water source for some of the options and the complete rejection of the unsupported STT transfer because of *"unmitigated reduction in Thames Water's storage volume in London".* 35

We do not accept this reason for rejecting the STT as a source. Whether supported or unsupported, the STT supplies additional water to the lower Thames to refill the existing reservoirs in droughts, thereby reducing the drawdown of the reservoirs. Therefore, it does not create a need for more storage. The only way to assess the viability of the STT, whether supported or unsupported, as the source of water for the Thames to Affinity transfer is proper modelling of the gain in deployable output. 36

RAPID should insist that the unsupported STT is added to the potential sources for investigation in Gate 2, and that deployable output of the STT source options are assessed using the same modelling approach as all the other source options.

We are pleased to see that the Gate 1 report recognises the benefits to London's supplies from effluent returns from Affinity Water's increased supplies and from enhanced flows in chalk streams. We look forward to seeing the assessment of these benefits.

However, we are alarmed by the suggestion that the recovery of water from effluent returns and enhanced chalk stream flows is only 10-50% of the supply transferred to Affinity. We do not accept that the returns to London via STW effluent and enhanced chalk stream flows can be as low as this. 36

We are also alarmed by the reference to the creation of *"an algorithm that can feed into the RSS water resources model and evaluate the DO benefit from abstraction reductions"*. This risks creation of a "black box" which will hide the detail of this very important part 36

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of the Thames to Affinity transfer and the "Chalk Streams First" proposal.

We ask that RAPID insist on full and early availability of this work, including access to the underlying model output.

We are concerned that the Thames to Affinity Gate 1 report has been written with a strong bias in favour of Abingdon reservoir as the source of water. We have shown a number of examples in Section 3.4. RAPID should not allow the water companies to pre-judge the outcome of the option appraisals which will follow in the preparation of WRSE's regional plan and in the Gate 2 assessments. 36-37

Grand Union Canal transfer options

The Gate 1 report for the Grand Union Canal option has only considered transfers of up to 100 Ml/d to meet the needs of Affinity Water. There appears to have been no consideration of larger transfer to supply Thames Water, even though Minworth STW has a dry weather flow of over 400 Ml/d.

The Grand Union canal passes through the lower Colne valley from where water could feed into the lower Thames reservoirs, delivering at least 300 Ml/d deployable output to London. If there are environmental constraints to passing the transfer into the River Colne, an alternative would be for some of Affinity Water's existing supplies to be used to supply Thames Water's North London supply areas, with replacement water for Affinity Water's supplies coming from the enlarged GUC transfer. 37-38

RAPID should require the 300 Ml/d GUC transfer option supplying both Affinity Water and London to be included in the Gate 2 investigations.

Anglian Water to Affinity Water transfers

These schemes, including the South Lincolnshire reservoir and the Fens reservoir, are evidently at an early stage of development, so for this first phase of GARD's response to the Gate 1 reports we have not reviewed them in detail.

However, we would like to draw RAPID's attention to the level of detail of costs presented in the Fens reservoir report. Costs are shown at present day prices without discounting. Scheme components are costed separately. Optimism bias is shown separately and the basis is explained. If Abingdon reservoir and other option costs were presented in a similarly transparent way, it would be possible to make valid comparisons of the cost estimates and form some judgment of the validity of the estimates. RAPID should use this precedent to insist on more transparency of option costs. 39

1. Introduction

On 5th July 2021, RAPID posted a number of Gate 1 reports on their web-site, which GARD has downloaded as listed below:

Name	Size
Abingdon reservoir (SESRO) Gate 1	1,982 KB
Anglian to Affinity transfer Gate 1	3,275 KB
Fens Reservoir Gate 1	4,108 KB
Grand Union Canal transfer Gate 1	3,406 KB
London reuse Gate 1	2,097 KB
Minworth STW resource Gate 1	3,099 KB
Severn to Thames transfer Gate 1	1,695 KB
Severn Trent sources Gate 1	2,630 KB
South Lincs reservoir Gate 1	6,839 KB
Thames to Affinity Transfer Gate 1	2,923 KB
Thames to Southern transfer Gate 1	1,091 KB
UU sources Gate 1	2,869 KB
Vyrnwy Aqueduct Gate 1	3,333 KB
West Country North sources accelerated Gate 1 (Sep 2020)	506 KB
West Country South-sources-and-transfers Gate 1	1,935 KB
West Country South-Southern Water Transfer Gate 1	1,733 KB

RAPID's web-site does not appear to specify the next steps in the Gate 1 appraisal process, but the following description has been found on Thames Water's web-site[1]:

What happens next

- RAPID will assess the Gate 1 submissions and make recommendations to Ofwat for each solution assessed.
- Ofwat will consider these recommendations and publish a draft decision (14 September 2021).
- A representation period will run from mid-September to early October. Detailed information on how to make a representation will be published by Ofwat as part of their draft decision on each solution.
- At the end of the representation period RAPID will review the representations received and make further recommendations to Ofwat
- Ofwat will publish its final decision (16 November 2021).

To fit with this programme, GARD will make two responses to the Gate 1 documents:

- Firstly, this initial response which is intended to be in time to influence RAPID's assessment of the Gate 1 submissions and their recommendations to Ofwat.

[1] https://www.thameswater.co.uk/about-us/regulation/water-resources#looking

- Secondly, by early October in response to the request for representations, taking account of RAPID's published reviews of the Gate 1 proposals, and their recommendations for Gate 2 investigations, which we assume will be publicly available for the 'representation period', as they were for Southern Water's accelerated Gate 1 submissions.

This first response, based on an initial quick review of the Gate 1 reports, focuses on the key matters which we think RAPID should address in making their recommendations to Ofwat for the options to be carried forward into Gate 2 and the scope of their investigation.

For the second, more comprehensive response (ie our "representation" using RAPID's terminology), we will cover also RAPID's comments on the Gate 1 documents and recommendations for Gate 2, which will presumably be published in mid September at the same time as Ofwat's draft decision. There will be more focus on the key options and on the scope of the Gate 2 investigations.

This paper does not cover the three Gate 1 reports for the West Country North and South Sources. GARD's comments on these strategic resource options were covered by our report on Southern Water's accelerated Gate 1 submissions sent to RAPID on 28th January 2021[2].

[2] GARD review of Southern Water Gate 1 submissions, submitted to RAPID on 28th January 2021

2. General comments applicable to all strategic resource options

2.1 Absence of London desalination options

We have been surprised to find there are no desalination schemes for London in the Gate 1 strategic options. Checking back, we see that London desalination was also excluded from the Ofwat list of strategic options in the appendix to the WRMP19 final determination[3].

Several London desalination options, up to 300 Ml/d, were considered in Thames Water's 2nd draft WRMP19 and one or more were selected in TW's various programmes for scheme development to meet demands up to 2100. However, in the preferred plan in TW's revised dWRMP19, the Severn to Thames Transfer was preferred to both desalination and reuse when a second major scheme was needed in the 2080s. With the WRMP 19 deficit forecast, there was no need for a third major scheme, so the only desalination or reuse scheme in TW's preferred plan was the small Deephams 45 Ml/d reuse scheme.

The Executive Summary to Thames Water's final WRMP19 (after the Ofwat determination which in effect approved the preferred plan in the 2nd draft dWRMP) says[4]

> *"Desalination is discounted as inferior on cost and environmental grounds, compared to the available re-use options"*

However, there was no such statement in Thames Water's revised draft WRMP19, which was subject to public consultation. In fact, there were several statements in the revised draft WRMP19 suggesting that desalination might be preferred to other major option types in some circumstances, for example:

> *"10.211 [Referring to the least cost programme] In the medium and long-term desalination is initially selected, then re-use, then a reservoir."*
>
> *"10.226 The Multi-objective environmental benefit run selects a desalination plant to meet the extra need to provide resilience in 2030 and then a reservoir."*
>
> *"10.240 A number of the other larger strategic options are also selected in three or four of the programmes. Beckton desalination is chosen in four programmes. Beckton wastewater reuse and the Severn-Thames transfer are selected in three programmes."*
>
> *"10.282 The programmes optimised for resilience not surprisingly both have lower risk at higher cost. MultiObj_RES and NearO_RES both build the Severn-Thames transfer together with reuse or desalination"*

[3] PR19 Final Determinations. Strategic Regional Water Resource Solutions Appendix, Table 3.2 Ofwat December 2019.

[4] Thames Water Final WRMP19, Technical Report, paragraph 0.200

"10.292 In general, if the predicted deficits are worse than the base case then the outputs tend to favour the construction of a desalination plant instead of small options before 2030."

We have included these excerpts from Thames Water's revised draft WRMP19 simply to demonstrate that there was no conclusive evidence in the WRMP19 investigations to justify exclusion of London desalination from the strategic resource options being considered in Gate 1.

Now, WRSE are looking at much larger deficits in the South East than those considered in WRMP19 and the major London reuse schemes are being considered at Gate 1, but the London desalination schemes are excluded. The major London reuse schemes are in the Ofwat PR19 list of strategic options, despite not being in TW's preferred plan for WRMP2019, but the desalination schemes are not. **In our opinion, this is a major weakness in the Gate 1 investigations, which needs to be rectified by bringing all the London desalination options back into the Gate 2 investigations.**

If it is argued that it is too late to bring back options which have not been investigated for Gate 1, we would counter by saying the level of detail in the investigations for London desalination for WRMP 19 is a lot more than currently exists for other strategic options proposed for Gate 2, for example, the GUC transfer and the two East Anglia reservoir options.

2.2 Lack of transparency of Deployable Output assessments

The deployable outputs for all the strategic resource options are crucial for assessing their cost effectiveness. Deployable outputs are quoted in the Gate 1 reports, usually in the cost and benefit tables in Chapter 10, but no evidence is provided to justify the quoted figures. In our opinion this evidence should be available for scrutiny, for example:

- The assumptions made and data used in simulation modelling of the Abingdon, South Lincolnshire and Fens reservoir options, with modelled output data being made available for inspection
- The justification of the amounts of effluent available for reuse from the Beckton, Deephams, Mogden, Minworth and Netheridge STWs
- The justification of the assumed transfer capacity of the Stroudwater and Grand Union canals

In absence of this information in the Gate 1 reports, how will RAPID and stakeholders determine whether the quoted deployable outputs are justified? We propose that RAPID insists that more detailed information on derivation of deployable outputs is made publicly

available in time for the stakeholder 'representation period' in mid-September. Full details of the model output used to generate deployable outputs for individual options should be made available if requested by stakeholders. RAPID should ensure that this facility is made available to stakeholders.

In Section 3 of this response, we will comment further on the deployable output assessments for individual strategic resource options.

2.3 Lack of transparency of cost estimates

The Gate 1 reports show capital, operating and total NPV costs for each strategic resource option and sub-option, but no further details are provided. For the transfer options, source costs and transfer costs are presented individually, with no total scheme costs that would allow comparison with other strategic resource options. It is impossible to assess the validity of option costs or comparative option costs. It is not known whether more cost information has been made available to RAPID, but the cost presentations in the Gate 1 reports are meaningless to stakeholders. For that reason, in Section 3 of this report, we have not yet commented on the detail of the costs of the strategic resource options presented in the Gate 1 reports.

There should be transparency in the presentation of costs to show how NPVs have been derived. For each strategic resource option or sub-option, there should be a table showing capital and operating cost at present day prices for each proposed scheme in each year of the programme up to 2100, similar to the example below:

Costs in £ million	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034		2097	2098	2099	Totals
Sub-option A costs at 2021 prices															
Capital cost	50	100	150	100							etc, for each year with operating costs rising as demands on schemes increase				**400.0**
Carbon cost	1.0	2.0	3.0	2.0	2.5	2.5	2.6	2.6	2.6	2.6		2.0	2.0	2.0	**147.4**
Energy operating cost					5.0	5.1	5.1	5.2	5.2	5.3		9.8	9.9	10.0	**513.4**
Other Operating cost					3.0	3.0	3.1	3.1	3.1	3.2		5.9	6.0	6.0	**308.0**
Total sub-option cost at 2021 prices	51.0	102.0	153.0	102.0	10.5	10.6	10.7	10.8	10.9	11.0		17.7	17.9	18.1	1368.9
Sub-option NPV cost after discounting	51.0	98.4	142.5	91.7	9.1	8.9	8.6	8.4	8.2	8.0		1.4	1.3	1.3	**663.9**

Note: in this example NPV costs have been discounted back to 2025 at 3.5% pa

Figure 1 - Example of transparent breakdown of programme NPV costs

In our opinion, it is not acceptable for the NPV costs of the sub-option shown in Figure 1 to be stated simply as £664 million. There needs to be transparency of how the NPV cost has been determined, showing the annual breakdown of capital and operating costs at present day prices. There would be no exposure of commercial cost information if costs are presented in this way, so "commercial confidentiality" should not be used as an excuse to hide this information from stakeholders. We note that in the Gate 1 report for the Fens reservoir, the capital costs at present day prices are quoted for each scheme component, with optimism bias shown separately (see excerpt in Section 3.6 of this report). This has set a precedent which should be followed in presentation of all option costs.

For each scheme, capital cost estimates at present day prices should be broken down, as a

minimum, into:

- Construction cost of each component (as for the Fens reservoir)
- Engineering design and supervision cost
- Land acquisition
- Water company management cost
- Optimism bias

There should be evidence provided to justify the allowances for engineering design, land acquisition, etc. This cost information was made available at the Public Inquiry into Thames Water's WRMP in 2010 and showed that estimates for these costs could be a large and highly questionable proportion of total estimated scheme costs – they should be made available for scrutiny.

For the operating costs, there should be evidence showing the assumptions for annual scheme output used to calculate the energy and other costs dependent on scheme use. Such evidence is also necessary to justify the figures given in the Gate 1 reports for the 'operational' carbon budgets.

The outputs for each scheme in each year of operation up to 2100 will need to be varied according to the forecast deficit in that year (which will vary with each demand growth scenario), whilst prioritising scheme usage to minimise energy and carbon costs. It will be important that scheme usage each year reflects the reality that the higher energy use schemes like transfers, water re-cycling and desalination will only be used in drought years.

The scheme outputs for each scheme in each year should be visible in the tabulation of programme costs up to 2100.

The unit cost of energy should be stated, including assumptions for future changes. There should be clarity in the assumptions for carbon costs including allowances made for de-carbonisation of energy supplies. We note in this respect that there is a commitment from Water UK to a 'net zero' operational carbon scenario by 2030 (see Section 2.5), and this needs to be evaluated and its effects made transparent in the carbon budget information. There should be justification of assumptions for the fixed operating costs.

It seems inevitable that cost will be the dominant factor in determining strategic resource options in the 'Best Value' programme. Therefore, transparency of costs is vital if stakeholders are genuinely to contribute to selection of options and to give confidence that the outcome has been fair and unbiased.

We propose that RAPID insists that more detailed cost information is made publicly available in time for the stakeholder 'representation period' in mid-September. In RAPID's reports to Ofwat with recommendations for Gate 2, we would also like to see evidence that detailed cost information has been made available to RAPID and scrutinised in detail.

2.4 Reliability of stochastic flow data

We understand that the assessment of deployable output and drought resilience of the strategic options has used daily river flow data modelled using 19,200 years (400 runs x 48 years) of stochastically generated weather data. We have four major concerns over the reliability of these data when comparing the performance of strategic resource options:

1. River flow data generated by hydrological modelling in a groundwater dominated catchment like the River Thames are highly unreliable. Even with a full regional groundwater model, modelling of daily river flows from a few decades of recorded weather data is inaccurate and time consuming. If the modelling has to cope with 19,200 years of stochastically generated weather data, a much simpler rainfall/run-off model has to be used, introducing a lot more inaccuracy.

2. The 19,200 years of stochastically generated weather data have been based on just 48 years of recorded data from 1950 to 1997. Consequently, the historic basis of the stochastic data excludes the three most severe droughts of the last century for London's supplies (1921/22, 1933/34 and 1943/44, all extending deep into a second autumn/winter). There were no long duration droughts in 1950 to 1997 – the most severe drought in the period, 1975/76, was of only 16 months duration (May 1975 to September 1976). Therefore, the historic period used to generate the stochastic weather data contains no long duration droughts – the type of drought in which Abingdon reservoir has little resilience.

3. By excluding the 24 years since 1997, the base period for generating the stochastic weather does not cover the recent years of most rapid climate change. The 19,200 years of generated weather will not reflect the recent changes in UK weather, particularly the tendency for wetter winters which will have led to more summer flow in chalk streams, with potentially significant impacts on the deployable output of the different types of strategic resource options.

4. One of the major benefits from the Severn to Thames transfer option stems from the geological differences between the Severn and Thames catchments. Much of the Thames catchment is in chalk and limestone, in which the high porosity absorbs rainfall and greatly slows recovery of river flows after droughts. Flows in the River Severn recover much faster in droughts, so can be used to bring relief when River Thames droughts extend deep into the autumn as they did in 1921 and 1934, the two most severe droughts of the past 100 years. The hydrological modelling used to generate 19,200 years of river flows in both the Severn and the Thames needs to accurately reflect this vital geological difference. We doubt that this is within the capability of the river flow/run-off modelling being used.

These concerns were expressed in more detail in GARD's response to WRSE's consultation on

their Method Statements for stochastic data generation and hydrological modelling. The relevant excerpts from these are given in Appendix A, including evidence showing the extent of inaccuracy of some of the previously used stochastically generated river flow data, particularly the flow data used by Southern Water in their evidence for the Public Inquiry into proposed changes to Rivers Test and Itchen abstraction licences in 2018. Discrepancies of the magnitude shown in the flows generated for the Rivers Test and Itchen would lead to major inaccuracies if they were to occur in flows used in WRSE's regional system simulator.

The difficulties described above will inevitably be experienced in the latest hydrological modelling – ie the absence of climate data covering historic droughts and the computational burden of applying the more accurate rainfall/run-off modelling techniques over thousands of years of stochastic weather data. These difficulties will be widespread over the south-east region, including the lower River Thames.

In our opinion, the Gate 1 reports should have acknowledged the degree of uncertainty in the generated stochastic data and the assessments of deployable outputs. They should have specified how the uncertainty will be quantified. The uncertainty estimates should have been carried forward into sensitivity tests of the impacts on the deployable output of the strategic resource options and their drought resilience, especially in long duration droughts. In their recommendations for Gate 2 work, the Gate 1 reports make no reference to activities to understand the uncertainty in the stochastic flow records and measures to address this uncertainty, for example sensitivity testing.

In our opinion, RAPID's review of the Gate 1 reports should highlight this weakness in the Gate 1 reports and specify further work needed at Gate 2 to understand and manage the uncertainty inherent in the use of stochastic data. This work should include:

1. For the rainfall/run-off model used to convert the weather data into daily river flows used for assessing deployable output, presentation of data comparing the modelled historic daily flows with naturalised gauged daily flows. These comparisons should include hydrographs comparing modelled and gauged flows in all the historic droughts, and flow duration curves comparing modelled and gauged flows annually and seasonally.

2. For the stochastic data used in assessing the deployable output of each option, annual and seasonal flow duration curves comparing the flows modelled using stochastic weather data with naturalised gauge flows.

3. For each strategic resource option, comparison of the deployable obtained using modelled historic flow data with the deployable output obtained using gauged flow data.

4. Using the data obtained from the validation assessments described, the range of uncertainty in deployable output should be assessed and used in sensitivity tests comparing strategic options and resource development programmes.

5. The uncertainty in deployable output should also be recognised in the risk assessment for each option.

We also propose that RAPID should insist that a full century of climate data is used to generate the stochastic climate data and river flows, ie including the actual climate of 1998-2019 (up to the most recent available data). This would ensure inclusion of data from the period when climate change has been most significant. WRSE propose to use only 48 years of historic data 1950-1997, as the basis for generating the stochastic data. This is unsatisfactory a) because it will miss the two most severe droughts of the past 100 years (1921/22 and 1933/34), and b) it will miss the most recent 20 years of rapid climate change.

RAPID should require the generation of the stochastic weather data and modelled river flows to be fully transparent in Gate 2, including detailed reporting on the methods used and underlying assumptions, with full details of data validation that we have proposed above. All the generated 19,200 years of daily flow data should be made available for stakeholder scrutiny.

2.5 Lack of transparency and shortcomings in carbon costing estimates

In general, the Gate 1 reports are poor on the subject of the Carbon costing of strategic options. In some cases (eg. Grand Union Canal) we could find no carbon footprint information at all. We believe RAPID should insist on all reports being brought up to the same standard in this respect *at this Gate* (not waiting for Gate 2 submissions). Our knowledge of the preliminary nature of these sections of the reports, gained from video conference discussions and email responses, would indicate the process of levelling up the information should not be onerous.

Even where the carbon assessments are included, there are several generic shortcomings in the data presented:

- there is mostly a lack of cited evidence to back-up quoted figures
- there is a lack of transparency of the content and derivation of 'embodied' ('capital' or 'construction') carbon figures
- there is mostly a lack of transparency over the operational scenarios for the Operational carbon budgets
- there is lack of background regarding the implicit assumptions about technology development of scenarios towards decarbonisation.

Lack of cited evidence and databases

The databases used for the calculation of embodied carbon in the construction are, in general, not quoted. In some cases (eg. the South Lincolnshire Reservoir) it is stated that the CESMM4 handbook is used for bill of materials etc. Response to enquiries by email (WRSE to GARD 14th July) have established that the WRSE-related projects such as Abingdon reservoir, London Re-use and STT, have used the ICE/University of Bath version 3 Handbook of material carbon content. The databases used should be indicated explicitly in all reports.

As things stand, none of the reporting would come up to the best applicable standards, such as PAS 2080[5], including as it does standards for declaration of data validation and disclosure. We think such compliance, or to a similar standard, should be mandatory.

Lack of transparency regarding the content of the embodied carbon figures

The sources such as the ICE/UoB Handbook deal with the construction materials used on a project. There is nothing in this or CESMM4 which gives a method of calculation of the emissions caused by construction equipment, or transport of material to site. If there are allowances for such sources of embodied carbon in the reported figures, they are not stated, nor is a breakdown available. This is an important point, because heavy construction and earth-moving plant currently has very high emissions, and there is no roadmap for the move to decarbonising this source. In the case of projects which could be constructed in the period up to 2040 it is imperative to have a proper evaluation of this source of embodied carbon, and to have it transparently set-out.

Lack of transparency on the operational scenarios for the Operational carbon budgets

The operational scenarios assumed behind the calculation of the Operational carbon budgets are hardly presented in any detail, and the breakdown into elements of the different strategic sources is almost entirely absent. A notable exception of the breakdown into elements are the figures given in table 5 of the South Lincolnshire Reservoir report. This compares to the complete lack of detail in the SESRO report, a strange state of affairs considering the former is relatively recent in conceptual development, whilst the latter is more than a quarter of a century in gestation. The lack of detail does not stop Thames Water from quoting operational carbon values to 6 significant figures. It is however completely opaque why the difference in operational carbon required for full operation of the South Lincolnshire Reservoir (between 25000 and 29000 tCO_2e/year[6]), and the operational carbon

[5] PAS2080 – https://www.carbontrust.com/what-we-do/assurance-and-certification/pas-2080-carbon-management-in-infrastructure

[6] Figures in table 5 of the South Lincolnshire Reservoir Gate 1 report

for the SESRO project (derived figure of around 1400 tCO_2e/year[7]), is so large. This is in spite of both calculations citing the same reference.[8] We believe RAPID should demand to see transparent working, such as provided by the South Lincolnshire Reservoir report, and should demand that this is accessible to Stakeholders.

Lack of transparency regarding the implicit assumptions about allowing for technology development of scenarios towards decarbonisation

The process for assessing comparative Strategic Water Resources must consider (for a 75 year planning time horizon) the technological developments which will occur to decarbonise both operation and construction of water infrastructure.

There is absolutely no transparency in what has been assumed for either the operational of the construction carbon for any of the water sources.

For operational carbon, it could be argued that the combined effect of the ongoing UK Grid decarbonisation, and the commitment of the UK Water Industry to 'net zero' carbon operation by 2030[9], both render the consideration of *Operational Carbon* costs to be a negligible factor in the comparison of different projects. This applies increasingly as the likely delivery date of options progresses, and, even if the Water Industry's commitment contains an (admitted) caveat that 20-30% of the decarbonisation comes from 'carbon trading' type actions (so not a real decarbonisation in global terms), it is still true that the Operational Carbon will become a vanishingly small parameter.

The situation is much different for *Embodied Carbon*, as there is no accepted roadmap to decarbonisation of construction materials and construction equipment. It is thus imperative here to set out the assumptions and give the breakdown between materials, equipment and transport emissions. Once this is given, the *regulators* (RAPID) then should determine the technology scenario for decarbonisation, based on the best expert advice.

[7] Derived from table 12 of the SESRO Gate 1 report – figure quoted in report is 'per Ml' – we have assumed for this calculation that the reservoir supplies 290 Ml/day for 365 days per year.
[8] UKWIR Carbon Accounting Workbook v14.
[9] https://www.water.org.uk/routemap2030/wp-content/uploads/2020/11/Water-UK-Net-Zero-2030-Routemap.pdf

3. Comments on individual options

3.1 Abingdon reservoir (SESRO)

The deployable output and resilience of the reservoir in long droughts

The 'benefit' of the 150 Mm3 reservoir, ie its deployable output, is quoted as 293 Ml/d in Table 4 of the Gate 1 report, which is close to the 294 Ml/d value quoted in Thames Water's WRMP19. The resilience of this water supply, referred to in the paragraph 10.13 quoted above is based on work which is open to criticism and doubt.

Table 17 of the Gate 1 report, which summarises proposed Gate 2 activities, makes no reference to any further work on yield and drought resilience. In other words, it seems that everything GARD has said previously about the yield and drought resilience of Abingdon reservoir has been ignored. Our position on this is summarised in the attached briefing note sent to RAPID in October 2020, included as Appendix B to this report, and in our response to WRSE's resilience consultation[10], in essence:

- GARD's assessment of the 1:500 year yield gain from Abingdon reservoir is about 180-220 Ml/d, after allowing for long duration droughts in the stochastic flow record and allowing 20% emergency storage as per typical UK practice.
- Thames Water's yield assessment is unreliable because it only looked at 25% of the droughts in the available 15,600 years of stochastic data, and used inappropriate methods of drought selection and yield analysis.
- The flows in Thames Water's analysis were compounded by averaging the yields assessed for individual droughts, so the very low yields in long duration droughts were disguised by higher yields in some other droughts.
- Thames Water's yield assessment only allowed for 9,000 Ml (6%) emergency storage in Abingdon reservoir. This was justified by saying it complies with their policy of 30 days emergency storage, as for the London reservoirs. However, London's reservoirs, which allow for 24% emergency storage, would maintain supplies for at least 60 days in severe droughts, not 30 days.

This was discussed with RAPID at a meeting on 22nd October 2020, at which RAPID appeared to understand GARD's points and seemed inclined to take them up with WRSE and Thames Water. However, it seems that RAPID's seemingly encouraging response to GARD's concerns has had no effect on the Gate 1 studies of Abingdon reservoir.

[10] GARD response To WRSE's consultation on securing resilient water resources for South East England, July 2020 http://www.gard-oxon.org.uk/downloads/GARD%20report%20for%20WRSE%20resilience%20consultation%20Final%206.7.20.pdf

We propose that for Gate 2 RAPID should commission a comprehensive independent audit of Thames Water's assessment of Abingdon reservoir's deployable output, including its resilience to long duration droughts and emergency storage provision, taking account of the detailed criticisms that GARD has raised.

It should be noted that the Gate 1 report recognises in paragraph 2.17 that there is no benefit from combined use of the reservoir and Severn to Thames transfer – the STT does not solve the problem of lack of winter water for refilling the reservoir in long droughts.

Reservoir water quality and emergency storage

Paragraph 5.26 of the Gate 1 report lists a number of potential water quality problems in the reservoir, including algal growth. Paragraph 6.5 on page 20 refers to the need for turnover of stored water and "*challenging environmental constraints on filling".* However, there is no reference to the algal problems likely in the very shallow water which would exist for months in long duration droughts, especially if emergency storage has to be used. The possible mitigation measures listed in paragraph 5.27 include "abstraction timing" ie avoiding periods of poor water quality in the Thames. This would lead to even more limitation of the water available to refill the reservoir.

Losses between Abingdon reservoir and London

In all WRMPs since 2009, when considering Abingdon reservoir there has been an allowance of only 2% losses in the Thames for water transferred via the regulation from the reservoir to London. To our knowledge, no evidence has been presented to justify this figure, which is far lower than the 20% losses being considered for regulation releases from Vyrnwy reservoir.

Losses between Abingdon and London would also apply for Severn to Thames transfer releases, so would not affect comparison of the STT and Abingdon reservoir options. However, for fair comparison of Abingdon reservoir with other strategic resource options like London reuse, the Grand Union canal transfer and transfers from Anglian Water reservoirs, it is important that the losses from regulation releases in the Thames are properly assessed.

Therefore, RAPID should require full and transparent investigation of the Thames regulation losses for Gate 2. These investigations should involve similar methodologies and rigor to the investigations of Severn regulation losses, including trial release from Farmoor reservoir. Part of the investigation should include a direct comparison of the loss assumptions in the Rivers Severn and Thames to give confidence that the losses in both rivers are being assessed even-handedly.

The purported 'Adaptability' of the Abingdon Reservoir proposal

Paragraph 10.13 of the Gate 1 report says:

"SESRO scores very well for the 'Reliability' and 'Adaptability', providing resilient and beneficial new water supply assets, but less well on the 'Evolvability' metrics, as infrastructure at this scale is not easily modularised and it has a very long 'lead-in' time".

The difference between 'Evolvability' and 'Adaptability' has already been identified in Ofwat's response to WRSE's consultation on Resilience Methodology as very small[11], and GARD believes that, cited academic papers notwithstanding[12], the two metrics cannot be disentangled. An infrastructure project at the scale of the reservoir cannot be scaled back, or even paused if the circumstances change in the water demand. The dis-beneficial damage to the area (to which we come below) cannot be undone, without huge cost, once it has been visited on the site. GARD is strongly of the opinion that this purported 'Adaptability' should not be allowed to remain as a listed benefit.

Impact of the reservoir on flooding

Table 3 on page 12 of the Gate 1 report says the latest flood modelling shows the reservoir would lead to a reduction in flood risk for Abingdon. It is difficult to see how this could be the case, so the flooding report needs to be made available for public scrutiny prior to the start of the 'representation period' in mid-September. In the reports prepared for Thames Water, which backed up the WRMP19 submission, the reservoirs above 75 Mm^3 in size received a 'Red' rating as it was stated that there was insufficient flood storage area on the reservoir site to compensate for the loss of floodplain. It is notable that, the 'new' flood characteristics are in part attributed to '*…rain falling on the reservoir surface area being removed from the Ock catchment'.* This rainfall was an entirely negligible factor in the 2007 flooding of the villages (especially East Hanney and Steventon) around the reservoir's edge, and it is highly likely that, with East Hanney's floodplain in particular being sealed by the reservoir footprint, any future flooding of the villages would be much worse.

The skewed environmental and social impact assessment of the reservoir

The Strategic Environmental Assessment presented in section 5.2 and table 5 (pages 14-16 of the Gate 1 report) manages the threefold achievement of being superficial, biased and inconsistent with references to risk elsewhere in the report.

The downplaying of very significant construction impacts of a 10-year project on both the biodiversity and landscape of the area (classed as '*Moderate Adverse*'), and the total omission of any estimation of the effects of round-the-clock noise, light pollution and transport dislocation on the residents of the area, are testimony to the bias of the report's

[11] https://www.wrse.org.uk/media/qybbxsqw/resilience-framework-response-to-feedback-03-august-2020_final.pdf

[12] https://www.sciencedirect.com/science/article/abs/pii/S2468312419300070

authors. The allocation of '*Major Beneficial*' rating to the Leisure and Amenity possibilities[13], whilst the purpose of the reservoir (water supply) receives a '*Moderate Beneficial*' mark is a stunning mis-use of the English language and logic. There is then the double counting of the same major benefit amenities in the '*Moderate Beneficial*' rating for Material assets.
We note that the Risk Register listing in table 10 highlights a '*High*' risk rating to the use of the scheme for recreation at all. This is hardly surprising, since the 'new' recreation opportunities which the reservoir brings[14] are water-based, and there is hardly a groundswell of demand for further water-based recreational opportunities, given the proximity of the Thames and Farmoor Reservoir and various converted gravel excavation lakes. The leisure aspect demand seems extremely poorly-researched for a project with such a long gestation (now nearly a quarter of a century). Also, as we note below, the recreational use might also be severely compromised by carbon budget and invasive species issues.

The inconsistencies abound in the cross referencing of the SEA to other sections. We list some below:

- The SEA notes the '*Moderate Adverse*' effect on local water bodies in operation, yet the Water Flow Directive assessment (section 5.8) retains a ***high*** impact score for deterioration for the River Ock *even after the mitigations are in place*. Even allowing that further work before Gate 2 might yield better mitigation schemes, the current rating should be '*Major Adverse'* for this assessment. The report's authors are clearly worried about this issue, as it rates one of the highest project risk ratings in the listing of table 10 – hardly consistent with a Moderate Adverse rating in the SEA.
- The Invasive Non-native species (INNS) assessment for the reservoir (section 5.11) is that it is '*Medium Risk*' for all options. The only mitigation appears to be full removal of the Recreational Access to the site, ie. the total abandonment of the supposed Major Beneficial aspect of the SEA.
- The natural Capital Assessment (NCA) of the Reservoir is assessed as an overall positive gain, but this seems (section 5.16) to be largely based on the enhanced recreational value. It is admitted that there will be a lag in realisation of any NCA benefit, whereas the NCA losses (the loss of food production, heritage and biodiversity), would in fact, precede by more than a decade the realisation of *any* NCA benefit. It is noteworthy that the NCA benefits are admitted to be higher for the smaller (75 Mm^3 and 100 Mm^3) variants, so, even for reservoir proponents, the optimum size is much smaller than the 'preferred' SESRO version.
- The Risk Register table 10 allocates a '*very high*' likelihood to the uncertainty of the assessment of the environmental impacts of the scheme, '*…particularly on aquatic, terrestrial biodiversity, landscape, air quality and noise and heritage/archaeology'*. Actually, is there anything else to be uncertain of? We think this is a very eloquent

[13] They remain just possibilities and have never been seriously put forward in any design.
[14] The reservoir area already has ample paths and bridleways for land-based recreation,

testimony to the superficiality of the SEA, and a huge indictment of the quality of the environmental assessment of a project which, one can only repeat, has been in gestation for a quarter of a century.

Carbon costs

We have already covered general issues relating to the assessment of Carbon costing in the Gate 1 report cohort (see section 2.5 above), and the criticisms of general:

- lack of cited evidence to back-up quoted figures;
- lack of transparency of the content of embedded carbon figures (breakdown over materials, transport and construction equipment emissions);
- lack of background assumptions about technology development scenarios towards decarbonisation of materials, vehicle emissions and the grid, and
- spuriously accurate presentation of numerical values.

all apply to the Abingdon Reservoir Gate 1 report.

The 6-figure accuracy of the quoted embodied carbon figures in table 12 would imply a fairly comprehensive design, bill of materials and plan of construction. Yet there is not even a background conceptual design referenced and it is difficult to see how the embodied carbon figures should scale with contained volume. It is, in any case, difficult to see how the phased options could have a higher embodied carbon than the one-phase equivalents, especially as the second phase would be many years delayed and would hence benefit from progress in decarbonised construction materials and technology development towards, eg. hydrogen-powered earth-moving construction vehicles. These figures need to be justified by background documentation, which RAPID and Stakeholders should demand to see.

Other aspects of operational carbon costs have been covered in section 2.5 above, but we note that the designated reservoir area now has a significant presence of solar arrays, so the project would *reduce* the renewable energy-supply to the grid unless floating solar arrays were included in the finished scheme (to the detriment of recreational use). Details of this, and how its impact on leisure access and facilities, are needed from the scheme proponents.

References to collaboration with local stakeholders to enhance benefits and reduce risks

It will be obvious to all that there is significant local opposition to the SESRO project, with a history of (successful) legal challenge and consistent local authorities' opposition to the scheme, at all levels from parish to county. Table 10, on pages 27-28 lists a number of '*High*' risks relating to local and environmental concerns. These are supposed to be mitigated to '*Medium*' after the formation of '*local collaborative partnerships*' to '*help explain the scheme to local residents and ensure that local issues are understood*'. This gives a completely unrealistic view of what the local opposition is all about. The opposition is based on a very complete understanding of the project (after years of Thames Water 'roadshows'

and ‘drop-in exhibitions’ and exhaustive debate in all local authority *fora*). The customer feedback quoted in section 8.2 of the report where reservoirs are ‘*the most preferred of new supply options due to familiarity, and a view that that reservoirs are a ‘natural’ way to provide large volumes of water*’ does not survive close encounter with , and knowledge of, a project which, being completely embanked, uniquely large in size, and forming a permanent artificial visual impact on the locality, is anything but natural. ‘*Local collaborative partnerships*’, if indeed they can be formed, are unlikely to change this, especially as the new housing development in the area since the 2010 Public Inquiry has encroached ever closer to the reservoir footprint and made the impact on communities even higher. In addition, we would add that such local partnerships cannot alter the impact and harm to bio-diversity and landscape, and cannot impact significantly on the noise and disruption from the project.

3.2 London water re-use options

The range of reuse options and sub-options considered in Gate 1

Section 1.2 of the Gate 1 reuse report and its accompanying table identifies the following options and sub-options:

- Beckton STW – reuse of up to 300 Ml/d, with various phased sub-options
- Mogden STW – reuse of 200 Ml/d, with three sub-options including the Teddington Direct River Abstraction option that was rejected by Thames Water in WRMP19

We agree that it is reasonable to consider a 300 Ml/d scheme for Beckton reuse. However, we do not agree the limitation of the Mogden reuse options to a maximum of 200 Ml/d. The recorded outflows from Mogden STW in 2016 are shown in Figure 3[15]:

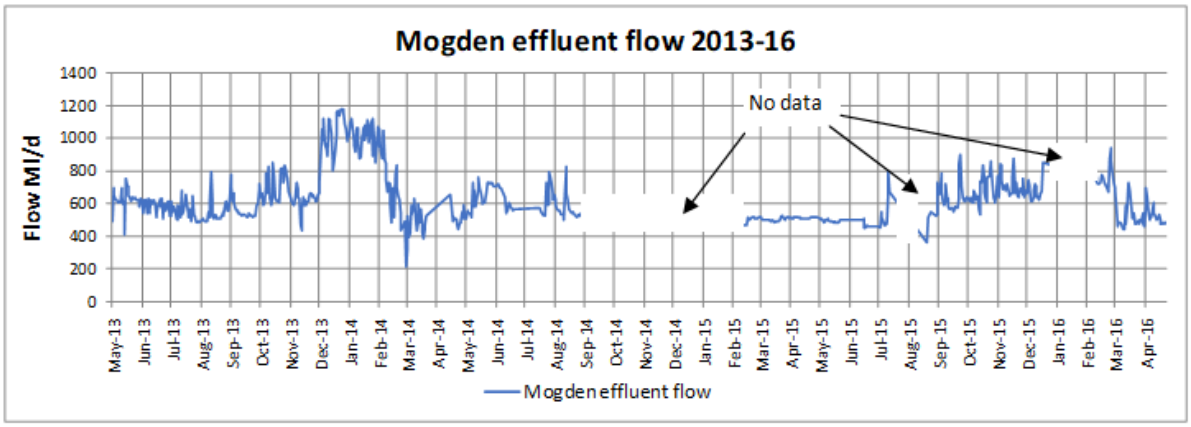


Figure 2 - Recorded effluent outflows from Mogden STW 2013-2016

The dry weather flow from Mogden is about 450 Ml/d, so larger reuse options should be considered in Gate 2, probably up to 450 Ml/d in the case of the Teddington DRA option.

[15] Data provided to GARD by Thames Water 22.10.18

Teddington DRA options

In GARD's response to the Thames Water's revised draft WRMP19, we proposed various options for reuse of up to 450 Ml/d of Mogden effluent and assessed their deployable output and means of mitigating environmental impacts. The deployable outputs of these options are about double those suggested for the Mogden reuse options in the Gate 1 report. RAPID should require the options proposed by GARD to be properly investigated in Gate 2.

Deployable output of reuse options

Deployable output of London reuse options were presented in Table 2-1 of the Gate 1 report as below:

Table 2-1 Elements of the London Effluent Reuse SRO System and their DO values

Scheme Capacity (Ml/d)	Deployable Output Benefit (Ml/d)			
	Beckton Effluent Reuse	Mogden Effluent Reuse	Mogden South Sewer	Teddington DRA
50	46	46	46	46
75	-	-	-	67
100	89	88	-	92
150	130	129	-	134
200	172	169	-	-
300	252	-	-	-
Note: Combinations of options are feasible with in-combination DO				

There are no details provided of the modelling which determined these values or the underlying assumptions. As proposed in Section 2.2 of this response, RAPID should require this information to be made available for stakeholders prior to the 'representation period'.

We are particularly interested to see whether an extra allowance for emergency storage has been made for the London reservoirs to allow for uncertainty in the reuse output, as it is for surface water sourced options without reservoir storage. In our opinion, no additional emergency storage is needed for the reuse options because their output is not weather dependent and is guaranteed in droughts.

3.3 Severn to Thames transfer option and associated sources

Gate 1 reports related to the Severn to Thames transfer (STT)

This section of our report covers the five Gate 1 reports for the Severn to Thames transfer, Vyrnwy Aqueduct, UU sources, Minworth STW source (in part) and Severn Trent sources. There are further comments on the use of Minworth STW as a source in our Section 3.4 on the Grand Union canal transfer.

In our opinion, it is unnecessary and confusing to have separate Gate 1 reports on the Severn to Thames aqueduct and each of the various sources of water for transfer, and for the replacement sources for the donor water companies. There is a single strategic resource option – transferring water from the Severn catchment to the Thames catchment – so there should be a single report covering all the scheme components and sub-options. With multiple Gate 1 reports, each with different deployable outputs and costs, there is no clear picture of overall deployable outputs and costs of the strategic resource option and its sub-options.

We note that in Section 13, page 39 of the Gate 1 report on UU sources it says:

> *"We recommend that the UUS and VA SROs are merged post Gate 1 to provide a single coherent transfer strategy"*

In our opinion, these components of the STT should be combined with the aqueduct and Severn Trent sources to form a single strategic resource option for Gate 2. RAPID should insist on this.

The unsupported Severn to Thames transfer

We are pleased to see that the unsupported Severn to Thames transfer is being considered as a feasible first phase of development of the STT, despite Thames Water's claim in WRMP19 that the unsupported transfer was not a feasible option. We agree with Table 2-2 of the STT Gate 1 report, which shows the unsupported transfer as a first development phase, followed by support from Mythe and then from Vyrnwy reservoir discharging into the Vyrnwy.

However, we are sceptical of the deployable output of only 80 Ml/d for the unsupported transfer which is quoted on page 18 paragraph 7.5 of the STT Gate 1 report. We would like to see full details of the model output that generated this figure. This is an example of the detailed model output which should be available to stakeholders on request, as we have proposed in Section 2.2 of this report.

The magnitude of regulation releases from Vyrnwy reservoir

The Gate 1 reports for both the STT and the Vyrnwy aqueduct consider a maximum regulation release of only 180 Ml/d from Vyrnwy reservoir to the River Severn. In our opinion, restriction of the regulation release to only 180 Ml/d is a major failing of the Gate 1 investigations, which should be rectified in Gate 2.

Our understanding is that the 180 Ml/d maximum release was based on the 180 Ml/d deployable output of Vyrnwy reservoir when operated as a continuous direct supply. However, regulation release are required for only part of the year, even in severe droughts, so Vyrnwy reservoir has the storage capacity to support much larger regulation releases than 180 Ml/d.

In GARD's response to Thames Water's revised draft WRMP19, we showed that with regulation releases of 350 Ml/d, Vyrnwy reservoir and a 500 Ml/d capacity transfer could provide 416 Ml/d of deployable output for London, based on historic flow data since 1920. This is roughly double the London deployable output gain achievable if the regulation release is restricted to 180 Ml/d. The relevant extract from GARD's WRMP19 response is given in Appendix C to this report.

In view of GARD's previously presented evidence on this, we are extremely disappointed that regulation releases larger than 180 Ml/d have not been considered in the Gate 1 reports. There is no evidence provided to justify limiting the regulation release to 180 Ml/d. However, in recent discussions with the STT investigation team, it appeared that they were open to considering larger regulation releases. RAPID should recommend that releases of up to 400 Ml/d are considered in Gate 2.

Magnitude of discharges allowed into the River Vyrnwy

As well as restricting the regulation release to 180 Ml/d, the Gate 1 STT analysis assumes that only 75 Ml/d can be released directly into the River Vyrnwy, as stated on page 1 paragraph 1.6:

> *The initial assessment of the volume of Lake Vyrnwy water permitted for direct release into the River Vyrnwy concluded that at least an additional 75Ml/d can be released. Further work will investigate opportunities to increase this volume. Should direct releases increase, then the capacity of the bypass may reduce accordingly.*

From recent GARD discussions with the STT investigation team, it seems that regulation releases larger than 75 Ml/d into the River Vyrnwy would not be acceptable to Natural Resources Wales because of the possible impact of higher releases on salmonid spawning and juveniles.

The impact of releasing 350 Ml/d on flows below Vyrnwy dam is shown on Figure 2 below, which is taken from modelling of the 350 Ml/d regulation scheme proposed by GARD for WRMP19 and described in Appendix C to this report. The upper plot shows flow duration curves for April to September, when most regulation takes place, and the lower plot compares flows in the drought of 1934 with the natural flows in 2007 and 2008, two naturally wet years:

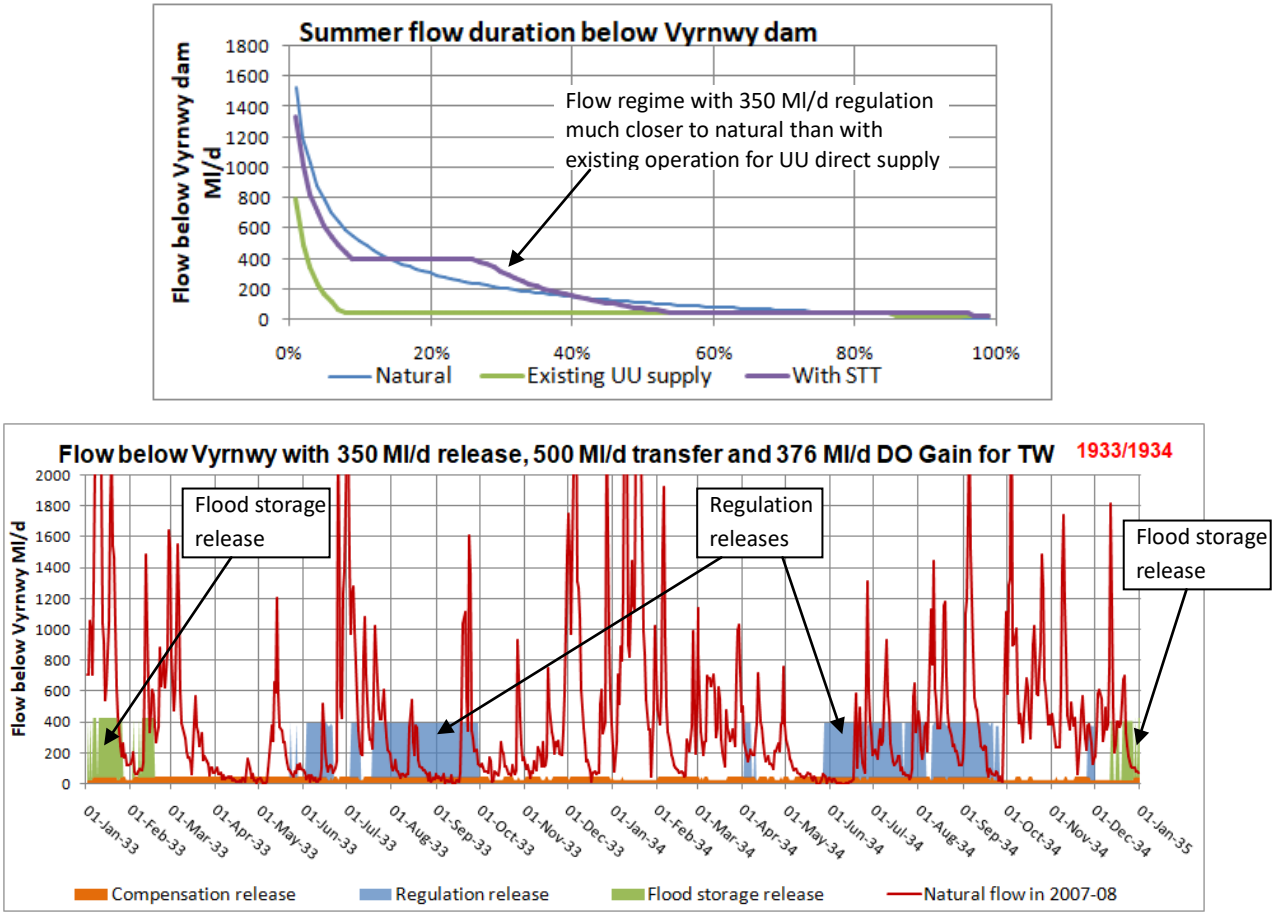


Figure 3 - Impact of 350 Ml/d regulation on flows below Vyrnwy dam

The flow-duration plot shows that the April to September flow regime would be much closer to natural than at present when flows are continuously at the 25-45 Ml/d compensation level. In geomorphological terms, this would be a marked improvement on the existing flow regime. The regulated summer flow of nearly 400 Ml/d in a drought like 1934 would be unnaturally high as a continuous flow, but comparable to natural flows in wet summers like 2007 and 2008, albeit lacking the natural variation. At present, Vyrnwy dam flood storage releases of about 400 Ml/d are made in most autumns and winters to lower the reservoir water level for flood retention – these releases are approved by NRW and deemed not to adversely affect the fisheries.

Evidence to justify larger releases into the Vyrnwy is provided by the example of regulation releases from Llyn Celyn into the Afon Tryweryn in the upper Dee catchment. Regulation releases of up to 700 Ml/d (8 cumecs) have been made into the Afon Tryweryn continuously for many weeks per year since the construction of Llyn Celyn in the 1960s. This can be seen on Figure 3 below showing the impact of Llyn Celyn releases on Afon Tryweryn flows in 2006, a moderately dry year. On most days of regulation, the releases are subject to a within-day variation to give a peak release of about 800 Ml/d (9.4 cumecs) for the benefit of recreational canoeing and rafting, giving highly unnatural within-day flow fluctuations.

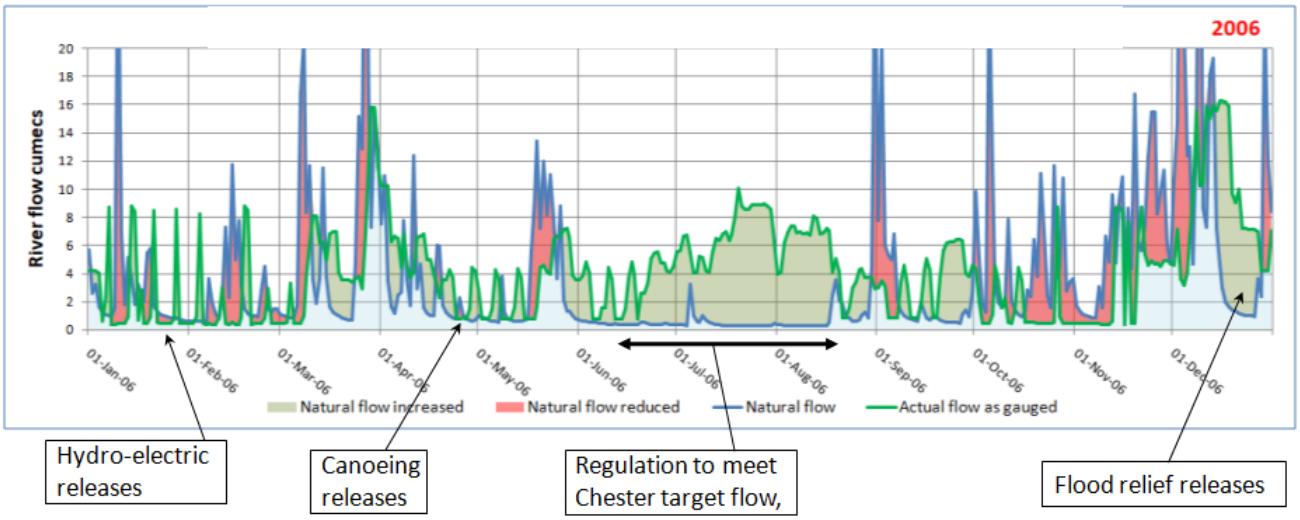


Figure 4 - Changes to flows due to regulation of up to 800 Ml/d below Llyn Celyn dam

This flow regime, including the large within-day fluctuations, is supported by NRW and it was approved by them in their Review of Consents for the Habitats Directive, under which the whole River Dee is protected.

Part of the justification for accepting the extremely unnatural Afon Tryweryn flow regime is that it supports a healthy population of juvenile salmon, as shown in Figure 5[16]:

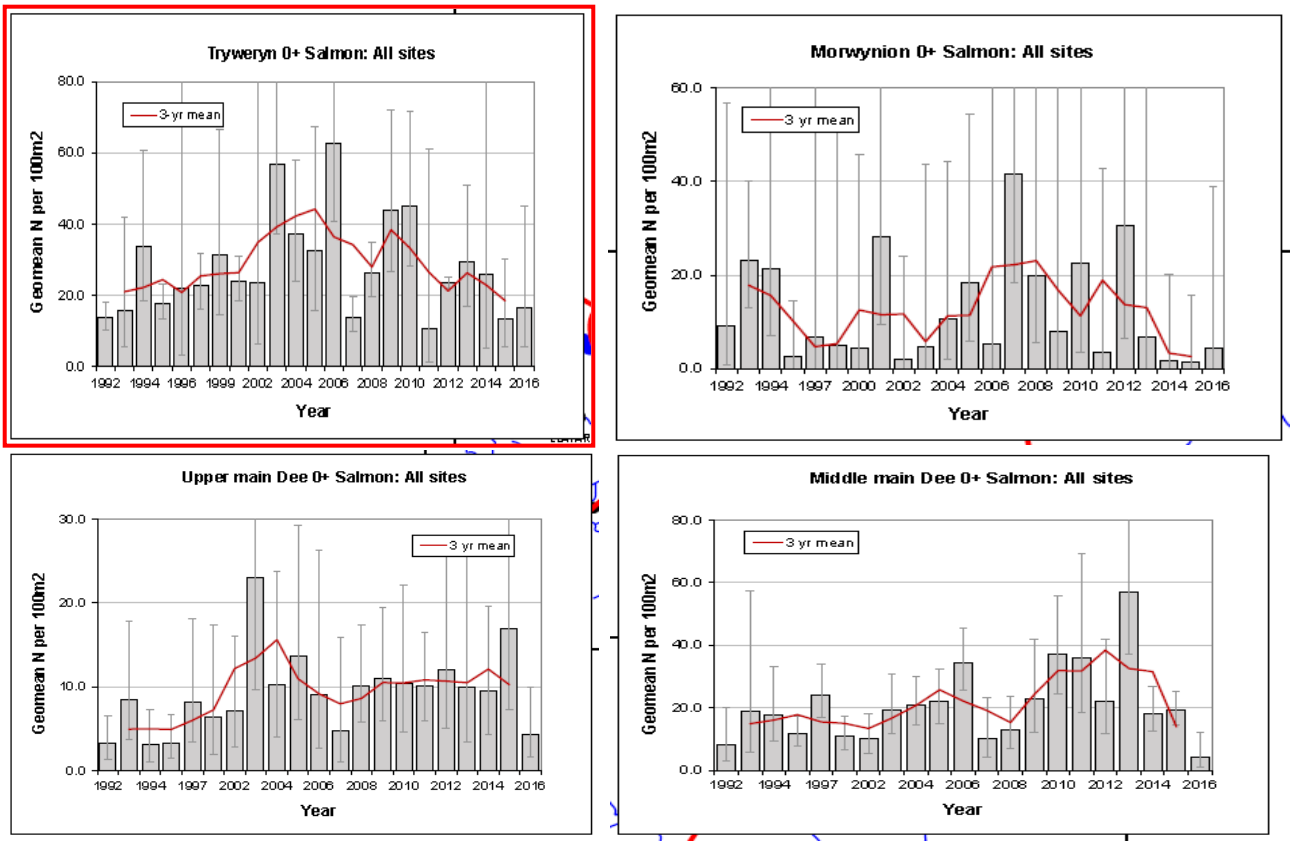


Figure 5 - Comparison of juvenile salmon densities in the Dee catchment

[16] Dee stock assessment angler report. NRW, 2016

Figure 5 shows that the juvenile salmon densities in the Afon Tryweryn (highlighted) are similar to other parts of the Dee catchment, despite a flow regime that is a lot more unnatural than the flows would be below Llyn Vyrnwy with 350 Ml/d regulation. The River Vyrnwy catchment area at the dam is 94 km^2, compared with 60 km^2 for Llyn Celyn. Therefore, it seems irrational that regulation releases of up to 800 Ml/d are considered acceptable in the Afon Tryweryn, but only 75 Ml/d can be released into the Vyrnwy, which has a 50% larger catchment area. It should also be noted that several substantial tributaries join the River Vyrnwy not far downstream of the dam, so the flow regime changes below the dam are soon dissipated by the incoming natural flows.

Arguably, the regulated flows in the River Vyrnwy in droughts would be better for juvenile salmonid productivity than the present protracted compensation flows of only 25-45 Ml/d. There would also be scope for varying the regulation releases, say from 200 to 500 Ml/d to give some flow variation more akin to natural. With a 500 Ml/d transfer capacity at Deerhurst, there is a lot of scope for short term variations in the releases without any reduction in the overall volume of water transferred to the Thames

We propose that one of the STT options considered for Gate 2 should allow for regulation releases of up to, say, 400 Ml/d directly into the River Vyrnwy. The STT investigation team should look for means of mitigating any impact on fisheries by short term variations in the regulation release to give a more natural pattern of flow variation. The acceptability of this option should then be considered by NRW, working collaboratively with the STT investigation team, taking account of:

- The frequency and duration of regulation releases in wet, average and dry years
- The mitigation provided by varying release patterns to be more natural
- The known impacts and benefits of regulation releases from other dams like Llyn Celyn, Caban Coch in the Elan valley and Kielder reservoir, whose regulation releases are considered beneficial to salmonid fisheries[17] [18].

We propose that RAPID recommends Gate 2 investigation of options with regulation releases of up to 400 Ml/d directly into the River Vyrnwy.

Deerhurst abstraction constraints and hands-off flow

We are please to see in Section 1.8 of the STT Gate 1 report that a 'put and take' arrangement has been agreed by EA and NRW for the abstraction at Deerhurst of regulation water into the River Severn, subject to agreement of losses. We applaud this common sense approach.

[17] The effects of Kielder Reservoir on the ecology of the River North Tyne. Newcastle University 1989.
[18] The role of regulating releases and natural spates on salmonid migration in the River Tyne, North East England. David Archer et al, BHS 19th Hydrology Symposium, 2008.

Since the WRMP19 investigations of the STT, the total hands-off flow at Deerhurst is understood to have been increased from 1850 Ml/d to 2560 Ml/d, with some partial restrictions in abstraction when flow is less than 3330 Ml/d. This is likely to have substantially reduced the deployable out of STT options, but there is no mention of this crucial information in the Gate 1 report and no evidence is provided to justify the new hands-off flow.

In view of the significance of the Deerhurst hands off flow for the deployable output and cost-effectiveness of STT options, RAPID should require the Deerhurst hands-off flow to be the subject of a rigorous and transparent investigation in Gate 2. This investigation should take account of the frequency and duration of the abstractions for the STT at Deerhurst and consider variations in the abstraction constraints, possibly on a seasonal basis, that might allow more water to be taken at Deerhurst without unacceptable impacts. RAPID should require this investigation to be undertaken collaboratively with the existing STT investigation team, so that the implications of changing the hands-off flow are fully understood by both the ecologists seeking to protect the Severn estuary and the engineers looking to maximise the benefits of STT options.

Losses in the River Severn

It is understood that regulation losses of 20% between Vyrnwy dam and Deerhurst have been assumed to date, but investigations of the losses will continue into Gate 2. From work that GARD has done looking at evidence of losses in historic flow records[19], we believe that the true losses are much less than 20%, especially during the long duration regulation releases that will be needed in droughts that determine the scheme deployable output.

We have not seen any report on the Severn loss investigations to date, but we think it should include:

- A 'water balance' approach to assessing the losses – there is no black hole into which the 'lost' water disappears, so water seeping into the river banks and bed must eventually emerge into some part of the River Severn or its estuary.
- Assessment of the reduced losses that will continue during long duration droughts, once the initial take-up of water in river bank gravels is complete.
- Assessment of the gains in River Severn flows due to water seeping from the banks back into the river on cessation of regulation – this water will still be available for the STT without regulation support.

[19] GARD review of River Severn Losses, Appendix A to GARD's response to consultation on Thames Water's revised draft WRMP 19, November 2018 https://www.gard-oxon.org.uk/downloads/GARD%20%20response%20to%202nd%20Consultation%20on%20TW%20draft%20WRMP%20Rev%2029.11.18.pdf

- Experience of regulation losses in other major regulation schemes such as the River Dee, the Rivers Elan/Wye, Kielder/Tyne and Ely Ouse to Essex.

RAPID should ensure that this work is part of the Gate 2 investigations.

In Section 3.1 of this report, we have pointed out that allowance for regulation losses between Abingdon reservoir and London is only 2%. RAPID should ensure that in Gate 2 there is a consistent approach to assessing regulation losses for all the transfer schemes.

The use of Minworth treated effluent to support the STT

Section 2.5 of the Gate 1 report for Minworth sources says that the maximum amount considered for transfer via the STT is 115 Ml/d, with a further transfer of up to 100 Ml/d via the Grand Union Canal transfer, giving a total maximum use of 215 Ml/d.

Our understanding is that the dry weather flow from Minworth STW is over 400 Ml/d, so releases of much more than 115 Ml/d could be used to support the STT, with more still being available for the Grand Union Canal transfer. The Gate 1 report offers no explanation for the restriction on use of the Minworth source to well below its dry weather flow capacity. However, Section 2.4 of the Minworth Gate 1 report says that the maximum use of the Minworth source has yet to be determined and further ecological and hydrological investigations will be undertaken for Gate 2. These investigations should take account of:

- Most of the water treated at Minworth STW originates from reservoirs in the upper Wye and Severn catchments and from the River Severn itself – very little of the 400 Ml/d dry weather flow originates from the catchment of the River Tame, into which Minworth STW discharges. Therefore reducing the effluent discharge in to the River Tame will lead to a more natural flow regime in the river.

- Diverting Minworth effluent back to the River Severn, via the River Avon, will return water originating in the Severn back to its natural source river, rather than exporting it to the Tame and Trent – a more natural process.

Pending the findings of investigations of the maximum use of the Minworth source, we propose that options for much larger use of Minworth STW for supporting the STT should be considered, particularly for options that use the 500 Ml/d capacity transfer from the Severn to the Thames.

Transfer via the Cotswold canal

We have no comment on use of the Cotswold canal as the aqueduct for the STT, other than saying we would support its use if it can be shown that a 300 Ml/d transfer is sufficient and the canal is a better option than transferring via the pipeline from Deerhurst.

Phasing of STT support options

We are pleased to see that the paragraph 1.4 of the STT Gate 1 report says

> *The diversity of [support] sources means they can be developed in a phased manner to meet the ultimate demand profile as determined by the regional planning.*

We support the phasing approach shown Table 2-2 of the STT Gate 1 report:

Table 2-2: Initial optimised phasing of STT elements

Phase	Pipeline Interconnector	Canal Interconnector
1	Unsupported flow	Unsupported flow
2	Mythe Abstraction Licence	Mythe Abstraction Licence
3	Vyrnwy Release step 1	Netheridge Wastewater Treatment Works
4	Vyrnwy Release step 2	Vyrnwy Release step 1
5	Netheridge Wastewater Treatment Works	Vyrnwy Release step 2
6	Shrewsbury Redeployment step 5	Shrewsbury Redeployment step 5
7	Minworth Effluent	Minworth Effluent
7	Build River Vyrnwy Bypass Pipeline (80Ml/d) and Vyrnwy Release step 3	Build River Vyrnwy Bypass Pipeline (80Ml/d) and Vyrnwy Release step 3
9	Vyrnwy Release step 4	Vyrnwy Release step 4

However, consideration should also be given to an enhanced first phase combining phases 1 to 3 in Table 2-2, bringing in Vyrnwy regulation to a level that requires minimal new source development for United Utilities. This option could be implemented rapidly and would 'buy time' while the actual future need and the effects of climate change can be observed. The option would facilitate early relief of chalk stream over-abstraction

We are disappointed that the Gate 1 report has no tabulation of the costs and deployable outputs for each phase of the development shown in Table 2-2 and for the total cost and deployable output after each phase is commissioned. We propose that RAPID requires the water companies to provide this information in time for inclusion in RAPID's recommendation reports for Ofwat and for review by stakeholders in the 'representation period'.

Procurement and operation of the STT

The five Gate 1 reports covering the Severn to Thames transfer and its support options each contain a Section 6 entitled 'Initial Outline of procurement and operation strategy'. These sections of the reports cover the vital topic of who will be responsible for the construction of the transfer infrastructure, its ownership and its subsequent operation. Reading these sections of the reports it is evident that considerable thought has gone into procurement and operation (particularly in the STT Gate 1 report), but there has been little collaboration between the different investigation teams and the water companies involved. There is no consistent view on how the STT and its components should be procured, owned and operated.

We propose that RAPID recommends to Ofwat the immediate establishment of a working party to consider all the procurement, ownership and operation options for the STT and to recommend a unified approach. This working party should comprise members from each water company, the water regulators and representatives from each component investigation team. The working party should be required to report by the end of Gate 2.

3.4 Thames to Affinity transfers

Options considered

Paragraph 2.2 of the Gate 1 report says the transfer could use three potential sources of water – the Abingdon reservoir, the Severn to Thames transfer or London reuse schemes. In our opinion, demand saving schemes, both leakage control and demand management (more metering), would also be sources of supply for the transfer, particularly if the transfer is by connection to the existing London reservoirs. In that case, the transfer to Affinity Water in effect moves some of Affinity Water's supply zone in to London supply zone.

Figure 1 in the Gate 1 report says that the Abingdon reservoir (SESRO) is the only possible water source if the transfer to Affinity is direct from an existing London reservoir, as per this extract from Figure 1:

Option name	Source	Abstraction	Conveyance	Treatment
Existing Thames Reservoir (ETR)*	SESRO	A4. Existing Thames Reservoir	Raw transfer to Iver, existing tunnel Treated water to Harefield	T2. Iver

* linked to SESRO only to avoid unmitigated reduction in Thames Water's storage volume in London

We do not agree that the STT cannot be used to support this option because of *"unmitigated reduction in Thames Water's storage volume in London".* The STT supplies additional water to the lower Thames to refill the existing reservoirs in droughts, thereby reducing the reservoir drawdown. Therefore, it does not create a need for more storage. This option should not have been rejected without proper modelling and assessment of its deployable output

RAPID should require the option of STT being the source for Affinity's supply direct from an existing reservoir to be properly modelled and the deployable output assessed on the same basis as all the other options shown on Figure 1 of the Gate 1 report.

We also note that paragraph 2.15 rejects the use of the unsupported STT as the source for any of the Thames to Affinity transfer options. The reason given is:

> *"Affinity Water's system currently lacks raw water storage, and the water resource modelling has shown that the main requirement for new water is in dry years during the period of summer demand. The unsupported transfer is not reliable during this period due to the Hands Off Flow constraints, so the scheme would require storage in order to*

be used for Affinity. The total storage required for the 100Ml/d option is in the order of 10% of Thames Water's existing reservoirs. Thames' planned outages for the purposes of reservoir maintenance involve similar storage loss and require significant planning to enable the outage to take place, with increased risk to security of supply. To allow for a similar additional loss of storage would create an unacceptable risk to Thames Water's security of supply in London".

We do not agree with this reasoning. As for supported STT options, the unsupported STT supplies additional water to the lower Thames to refill the existing reservoirs, reducing reservoir drawdown. Therefore, it does not create a need for more storage – it meets additional demand and compensates by providing more refill. The only way to assess the viability of the unsupported STT as the source of water for the Thames to Affinity transfer is to model the gain in deployable output in the same way as all the other options.

RAPID should insist that the unsupported STT is added to the potential sources for investigation in Gate 2, with the deployable output assessed using the same modelling approach as all the other options.

Benefits from enhanced chalk stream flows and effluent returns chalk streams

We are pleased to see that paragraphs 4.12 and 4.13, with Table 4, recognises the benefits to London's supplies from effluent returns from Anglian Water's increased supplies and from enhanced flows in chalk streams. We look forward to seeing full detail of the assessment of these benefits, which paragraph 4.13 says are due "in the early part of Gate 2".

However, we are alarmed by the statement in paragraph 10.8 which says:

"The evaluation completed indicates that if AFW needed 50Ml/d of Deployable Output (DO) from TW's London WRZ, then this may actually only require between approximately 25 and 45 Ml/d of lost DO from the donor zone."

This suggests that the recovery of water from effluent returns and enhanced chalk stream flows is only 10-50% of the supply transferred to Affinity. We do not accept that the returns to London via STW effluent and enhanced chalk stream flows can be as low as this.

We are also alarmed by the reference in paragraph 4.13 to creation of *"an algorithm that can feed into the RSS water resources model and evaluate the DO benefit from abstraction reductions"*. This risks creation of a "black box" which will hide the detail of this very important part of the Thames to Affinity transfer and the "Chalk Streams First" proposal.

We ask that RAPID insist on full and early availability of this work, including access to the underlying model output.

Bias on the Abingdon reservoir as superior to other source options

We are concerned that the Thames to Affinity Gate 1 report has been written with a strong bias

in favour of Abingdon reservoir as the source of water. There are numerous examples of this:

- Unjustified rejection of the unsupported STT in paragraph 2.15, as mentioned earlier
- No recognition that the STT or reuse can supply the source water at least 5 years earlier than the Abingdon reservoir
- Paragraph 10.4 says the lowest NPV and AIC is for the ETR option, ie with Abingdon reservoir as the source. How can this be said when the costs of support from STT options are not yet available (there are 5 separate Gate 1 reports on the various components of STT options and consolidated costs for single STT schemes are not available)?
- Table 5 refers to major negative operational carbon impacts of the reuse and STT sources (even though these will be reduced by decarbonisation of electricity supplies), but does not mention the large embodied carbon impact of Abingdon reservoir.
- Paragraph 10.7 says that the ETR option (ie Abingdon reservoir) will have the lowest carbon footprint – this evidently ignores the embodied carbon for the reservoir which is the largest of any of the strategic resource options.
- Paragraph 5.22 says "The environmental impact from the construction of each option would be similar across all options, with the ETR option (ie support from Abingdon reservoir) performing best overall". This does not appear to have considered the local construction impact of Abingdon reservoir.
- On page 5, the ETR option, ie with support only available from Abingdon reservoir, is said to be best for capital cost, environmental impact and carbon footprint. How can this be justified in view of the points mentioned above?

RAPID should not allow the water companies to pre-judge the outcome of the option appraisals which will follow in the preparation of WRSE's regional plan and Gate 2.

3.5 Grand Union Canal transfer option and associated sources

Scope of the Grand Union Canal options

The Gate 1 report for the Grand Union Canal Option has been prepared by Severn Trent Water, Affinity Water and the Canal and Rivers Trust. There has been no involvement of Thames Water. The 100 Ml/d maximum transfer appears to have been selected to meet Affinity Water's needs without consideration of Thames Water's needs for London.

The Grand Union Canal was the major artery of the canal system, linking Birmingham to London. Therefore, we would expect its transfer capacity to be at least as much as the 300 Ml/d transfer capacity ascribed for the Cotswold canal when used as an aqueduct for the

Severn to Thames Transfer. Minworth STW, which is the main water source for the GUC transfer has a dry weather flow of over 400 Ml/d, so would be able to supply sufficient water for a 300 Ml/d transfer for London.

The Grand Union canal passes through the lower Colne valley from where water could be discharged into the River Thames upstream of some of the abstraction points feeding the lower Thames reservoirs. This is an option that could deliver at least 300 Ml/d deployable output to London.

We appreciate that the Grand Union canal combines with the River Bulbourne south of Tring and then the lower River Colne, both chalk streams. This could be a constraint to the option of the GUC delivering to the London reservoir via the lower River Colne. In that case, an alternative would be for some of Affinity Water's existing supplies to be used to supply Thames Water's North London supply areas, with replacement water for Affinity Water's supplies coming from the enlarged GUC transfer

RAPID should require the 300 Ml/d GUC transfer option supplying both Affinity Water and London to be included in the Gate 2 investigations.

Benefits to London via GUC supplies to Affinity Water

About 75% of water supplied to Affinity Water via the GUC transfer will become available for supplying London through:

- Treated effluents from Maple Cross, Rye Meads and East Hyde STWs which treat most of the effluent arising from Affinity's supplies north of London
- Enhanced flows in chalk streams when the supplies to Affinity Water are used to replace over-abstraction from chalk boreholes

This very substantial benefit of the GUC option is partially recognised in paragraph 2.22 of the Gate 1 report which says:

> *A significant proportion of the demand that AfW will be supplying from the scheme will be returned to either the River Colne or River Lee upstream of TWUL's intakes, as a routine part of the wastewater system operation. In reality, the impact on TWUL depends on the net balance between supply and demand for AfW in comparison to the base year. It cannot therefore be ascribed to a specific scheme, and has been incorporated into the WRSE best value modelling as a percentage of the change in the base year demand, which occurs irrespective of which schemes meet any increases in demand.*

Whereas we accept the reasoning that benefits from Affinity Water's effluents are equally applicable to all resource options (and the benefits from enhanced chalk stream flows), this doesn't take account of the "new water" that the GUC transfer brings into the lower Thames

region, where the fundamental problem is lack of water. Abingdon reservoir brings no "new water" to the lower Thames.

Benefit of the GUC transfer option for chalk streams

The GUC transfer can provide a water source for alleviation of chalk-stream over-abstraction by 2034, according to paragraph 1.23 of the Gate 1 report. This is at least 5 years earlier than the date for the Abingdon reservoir to supply water, after allowing two years for the reservoir to fill. This point should be emphasised in assessing the GUC transfer benefits.

3.6 Anglian to Affinity transfers

The transfers from Anglian Water to Affinity are covered by three Gate 1 reports – Anglian to Affinity transfer, South Lincolnshire reservoir and Fens reservoir. These schemes are evidently at an early stage of development, so for this first phase of GARD's response to the Gate 1 reports we have not reviewed them in detail.

However, we would like to draw RAPID's attention to the level of detail of capital costs presented in Tables 1 and 2 of the Fens reservoir Gate 1 report:

Table 1: Overview of capital costs

Scheme element	Baseline (£M)	Multisector (£M)
Public water supply (PWS) reservoir	366	366
Farm reservoirs	–	76
Flood storage area	–	89
Wetlands	–	46
Fens Reservoir WTW	107	107
Pipelines (combined)	390	390
Optimism Bias	344	453
Total cost (£M)	1,207	1,527

Table 2: Overall estimate of average annual operational costs

Scheme element	Fens Base (£M/y)	Fens Multisector (£M/y)
PWS reservoir	0	0
Pipelines and pumping stations	7.4	7.4
Fens WTW	5.3	5.3
FSA, wetlands and farm reservoir	0	.73
Total	12.65	13.38

These tables present costs at, presumably, present day prices without discounting. Scheme components are costed separately. Optimism bias is shown separately and the basis is explained in paragraph 4.2.2. The reservoir is of a similar bunded construction to Abingdon reservoir, but much smaller. If Abingdon reservoir costs were presented in a similarly transparent way, it would be possible to make valid comparisons of the cost estimates and

form some judgement of the validity of the costs estimates. The same applies to the cost estimates of all the strategic resource options.

We ask RAPID to insist on more transparency of option costs, citing this example as a precedent.

We have already noted a similar precedent set by this report in the transparency of Operational Carbon costs (see section 2.5), and ask RAPID to insist on similar transparency from all reports on this parameter.

3.7 Transfers from Thames Water to Southern Water

This option considers transfers of up to 200 Ml/d from Thames Water to Southern Water.

In our opinion, a transfer from the Thames catchment to Southern Water makes no strategic sense. The major strategic problem faced by all UK supplies is the concentration of most of the population in the driest part of the country – the South East of England, especially London and the Thames Valley, ie Thames Water and Affinity water's supply areas. Therefore, it seems irresponsible for Thames Water to contemplate selling water to Southern Water, exporting water out of the Thames catchment where it is already in such short supply.

It seems to us that the proposal to transfer water to Southern Water is part of Thames Water's attempts to justify the construction of Abingdon reservoir, by calling it the "South East Strategic Resource Option". The sole purpose of Abingdon reservoir, if it can be justified at all, should be to supply customers in the Thames valley. It should not be used as a factory selling water to customers outside the Thames valley.

We can see that there could be some merit in considering transfer of water coming into the River Thames from the Severn to Thames transfer, because this would be a genuine inter-regional transfer, connecting Southern Water to sources located in the wetter part of the country, particularly Wales. However, if this was the case, the participating water companies should include Severn Trent Water and United Utilities.

From the costs presented in the Gate 1 reports, it is difficult to see how use of the Severn to Thames transfer to supply Southern Water could be cost effective, when the cost of the transfer pipelines from the Thames to Southern Water are added to the STT costs. If Southern Water has a genuine need for more water, beyond the more local sources considered in Southern Water's Gate 1 reports, surely this could come from more desalination at locations on the south coast? Southern Water is already moving ahead with a desalination strategic option, and the lessons learned from construction and operation of this would be valuable for the further development of the most climate-change resilient of all water infrastructure options to supply the south-east.

We propose that RAPID should recommend to Ofwat that the Thames to Southern transfer should not be further investigated in Gate 2.

Appendix A - GARD comments on WRSE's stochastic data methodology[20]

1. Stochastic Climate Datasets

The new stochastic climate data are to be generated from only 48 years of historic records, 1950-1997, compared to the 78 years of records, 1920-1997, which were typically used to generate stochastic data for WRMP19. The reduced length of historic records used in the new analysis has been justified in paragraph 2.5 on the grounds of the use of more climate drivers than previously and better-quality data for the additional climate drivers being available only from 1950. Paragraph 2.10 acknowledges that some water companies may have used historic data up to 2019, but does not explain why data since 1997 are not being used in WRSE's analysis.

Figure A1 shows the periods of climate data used for the WRMP19 and WRSE stochastic data generation, in the context of global temperature changes since 1880[21], highlighting the rapid changes since 1997:

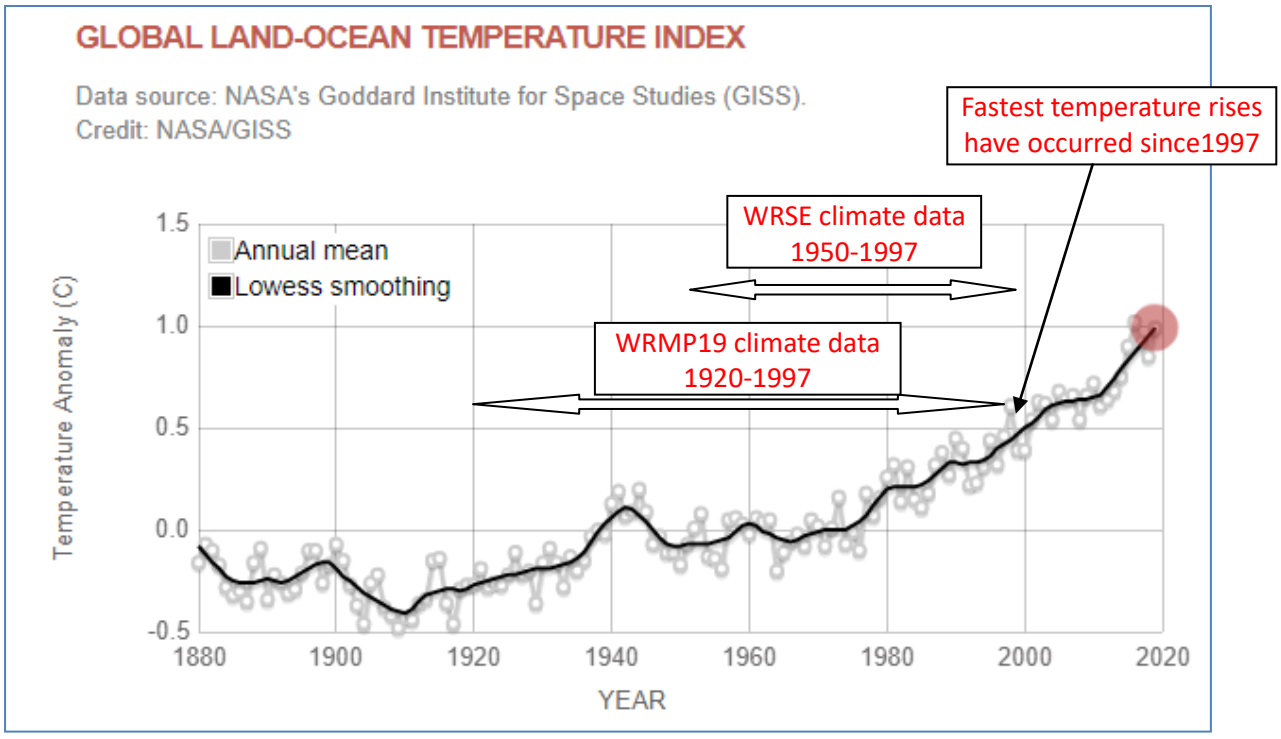


Figure A1 - WRMP19 and WRSE historic data periods in the context of global temperature changes since 1880

Use of historic climate data only for 1950-1997 means the exclusion of:

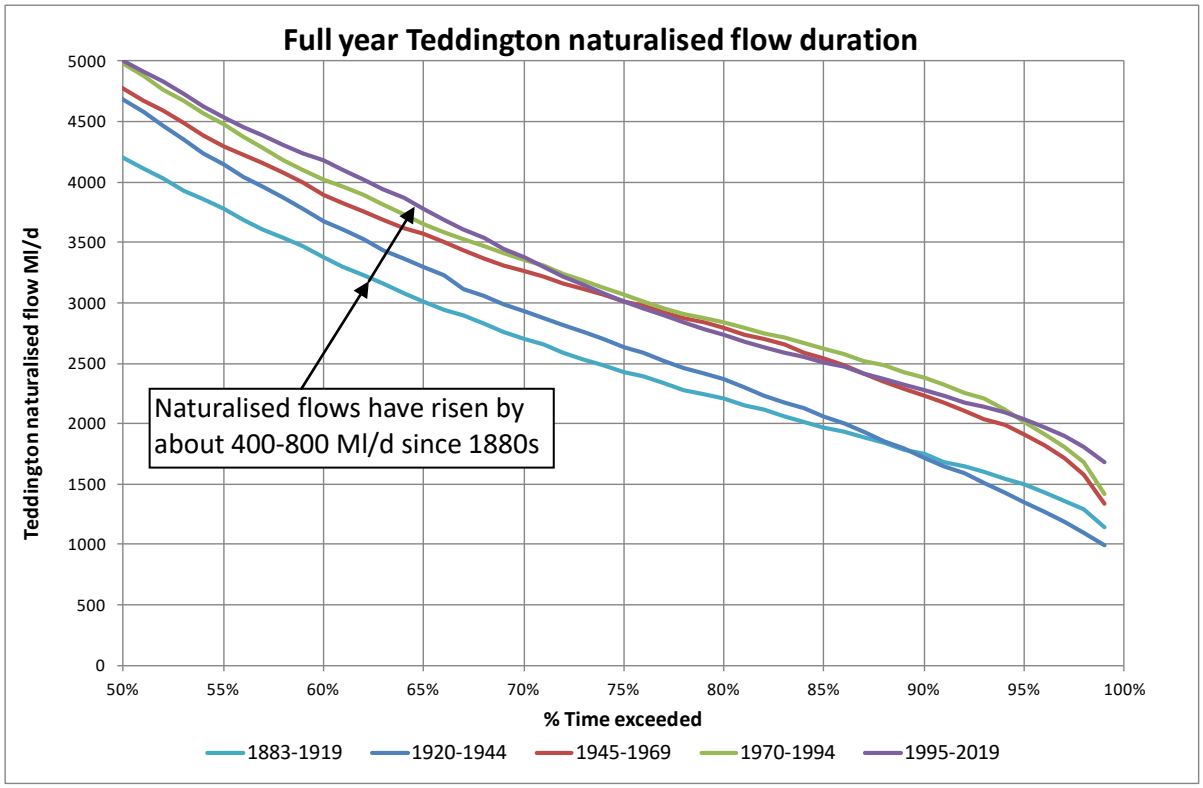
[20] GARD comments on WRSE Method Statements, February 2021
[21] https://climate.nasa.gov/vital-signs/global-temperature/

- the past 20 years of most rapid climate change
- the droughts of 1921/22, 1933/34 and 1943/44, the three most severe droughts of the past 100 years for London's supplies

Therefore, the period 1950-1997 seems an unsatisfactory basis for generating the stochastic data, lacking both the period of extreme low flows pre-1950, with several long duration droughts, and the recent period of most rapid climate change.

The exclusion of the droughts of 1921/22 and 1933/34 is of particular concern, because they both extended into the winter and London reservoir storage would not have started to recover until 20th January 1922 or 5th December 1934 respectively. The most severe drought in WRSE's selected history, 1950-1997, was 1975/76 in which reservoir levels started to recover on 23rd September 1976. The period 1950-1997 contained no severe droughts extending into late autumn/winter like 1921 and 1934, so it seems likely that this type of long drought would not be adequately represented in the 19,200 year stochastic record. We also note that the drought of 2011/12 which extended to early 2012 is also excluded from the historic base period.

Figure A2 shows changes in the flow-duration characteristics of naturalised flows in the Thames at Teddington since 1885, ie the same period as Figure A1:



Note: data from naturalised Kingston flows on NRFA website, which allow for lower Thames abstractions, but

not abstractions or effluent returns upstream of Windsor [22]

Figure A2 - Changes in Lower Thames naturalised flow durations since 1883

Over the past 140 years, the naturalised flow data show steady growth of about 400-800 Ml/d in water available in the lower Thames for London's reservoir-based supplies, although we recognise that there are some doubts over the reliability of the data from the early part of the record and the method of naturalisation does not take account of the abstractions and effluent returns above Windsor (relatively small as net values)[23].

From this, it appears that selection of different periods of historic climate data as the basis for generating the stochastic data could have a material effect on the stochastically generated climate data and, consequently, on the flows generated by the hydrological modelling.

The supporting report "WRSE Regional Climate Data Tools", referred to on page 3 of the method statement, has analysed differences in stochastically generated rainfall data arising from the use of 1950-1997 instead of 1920-1997 as the historic base data. The report concludes that[24]:

"The analysis concluded that while the 1950s model does not include some of the key droughts in the 20th Century, in most cases this model performed as good as, or marginally better, when viewed against the observed data in the 20th Century."

From the data presented in Appendix B of the supporting report, it seems that the differences in the modelled data using the different historic base periods are potentially significant as shown in the data extracted for WRSE model validation in Table A1[25]:

			Rainfall mm		
	Region	Return Period (years)	Observed	20th Century model	1950s model
April-Sep	WRSE	50	195.5	207.0	190.3
	WRSE	100	176.8	191.1	171.0
	WRSE	200	160.5	177.3	154.1
	WRSE	500	141.4	161.3	134.5
Oct-Mar	WRSE	50	260.1	273.9	280.8
	WRSE	100	237.7	254.5	262.3
	WRSE	200	218.2	237.6	246.3
	WRSE	500	195.5	218.1	227.7

Table A1 - Comparison of validation data for stochastic rainfall generated from historic data from 1950-97 or 1920-97

[22] NRFA web-site, Kingston naturalised data download https://nrfa.ceh.ac.uk/data/station/meanflow/39001
[23] As noted on the NRFA web-site
[24] WRSE Regional Climate Data Tools,
[25] WRSE Regional Climate Data Tools report Appendix B.4.3, pages 47/48

The differences in observed data and the two sets of modelled data shown in Table A1 appear likely to have a significant effect on river flows generated by the hydrological model and on deployable output of supplies. We also note the inevitable unreliability of the "observed" data for 1:200 and 1:500 rainfall generated from records of less than 50 years duration.

The supporting "climate data tools" report refers extensively to the need for "bias correction" and differences between different types of climate model. It is clear that, even with the high degree of professional skill that has evidently gone into the stochastic modelling, there is a large and unavoidable element of uncertainty in the generated stochastic climate data.

In our opinion, the degree of uncertainty in the stochastic modelling should be acknowledged, quantified and carried forward into sensitivity tests of the impacts on the deployable output of existing supplies and new scheme options.

We also propose that the base historic data should include all available data since 1997, thereby covering the recent period of rapid climate change.

2. Method Statement on Hydrological Modelling

Lack of detail in the method statement

The method statement on hydrological modelling is disappointing. It contains virtually no information on how the stochastic climate data are to be converted into river flows for use in the regional system simulator model (RSS). In fairness, WRSE recognise this in their summary to the method statement, paragraph 3.2:

"In general, at the time of writing, models and methods are still in the development phase, and so a general overview of methods that will be developed and applied has been given, rather than a detailed description of models and methods."

There are numerous references to work being undertaken by water companies and other parties, but no detail is supplied, for example:

Paragraph 2.2:

"In some cases, existing company hydrological models exist which are suitable for providing flows for use in the WRSE regional simulation model. …. Please see WRSE-commissioned report(s) (HR Wallingford, to be written, WRSE file tbc) for technical details about the models used, calibration methods and calibration results for new models which have been produced."

Paragraph 2.15:

"As outlined above, it is important that the impact of abstractions on river flows is considered appropriately within water resources models. …. For full details of the

methodology, please see the technical report (WRSE commissioned HR Wallingford report, not yet written, WRSE file tbc).”

Paragraph 2.19:

“As such, work has been undertaken in which an analytical modelling approach has been used to determine the impact of groundwater abstractions on river flows. ….There will not be a specific method statement on this approach, but a technical report will be written (HR Wallingford report, not yet written, WRSE file tbc). “

In our opinion this is highly unsatisfactory. The reports referred to above are, in effect, method statements and they should be made available for comment before their findings are used to generate river flows for use in the regional system simulator.

The hydrological modelling method statement gives the impression that WRSE have ducked responsibility for the validity of the river flows generated by the hydrological modelling for use in WRSE’s regional system simulator model, for example (Paragraph 2.8):

“The generation of flows has been considered as being outside of the remit of the WRSE regional system simulator (RSS) project. Water companies are responsible for providing flow inputs to the WRSE RSS and water company technical leads are responsible for ensuring that the impacts of abstractions and discharges have been accounted for, but have not been double counted within their sub-model area(s) (e.g. advising/checking on representation of effluent returns and impacts of abstraction within the model and ensuring that flow inputs are appropriate.”

and Paragraph 2.30:

“Since companies are producing hydrological data for the RSS, it is largely incumbent on companies to note key assumptions used in their hydrological modelling. WRSE will collate assumptions on aspects of hydrological modelling which apply across the region (e.g. denaturalisation) but cannot know all assumptions that companies will need to make. “

Need for transparent validation of the stochastic modelling

In our opinion, WRSE should adopt an active and transparent approach to checking the validity of the river flow data used in their regional system simulator to ensure that their modelling of regional supplies is not “rubbish in, rubbish out”. This is of particular importance in the south-east region because of the dominance of groundwater-fed flows in most of the rivers. Modelling of groundwater-fed river flows from climatic data is difficult and unreliable, even when dealing with historic periods of a few decades duration. If the modelling has to be done for thousands of years, it becomes a lot more difficult and unreliable due to the excessive computer run times entailed.

An illustration of the difficulty can be seen in the case study of Southern Water’s modelling of flows in the Rivers Test and Itchen for the Public Inquiry into Itchen licence changes in 2018. The validity of flows generated by various versions of hydrological models is shown in

Figure A3, which is extracted from the Modelling Statement of Common Ground (SOCG) produced jointly by the EA, Southern Water and Fish Legal for the Inquir

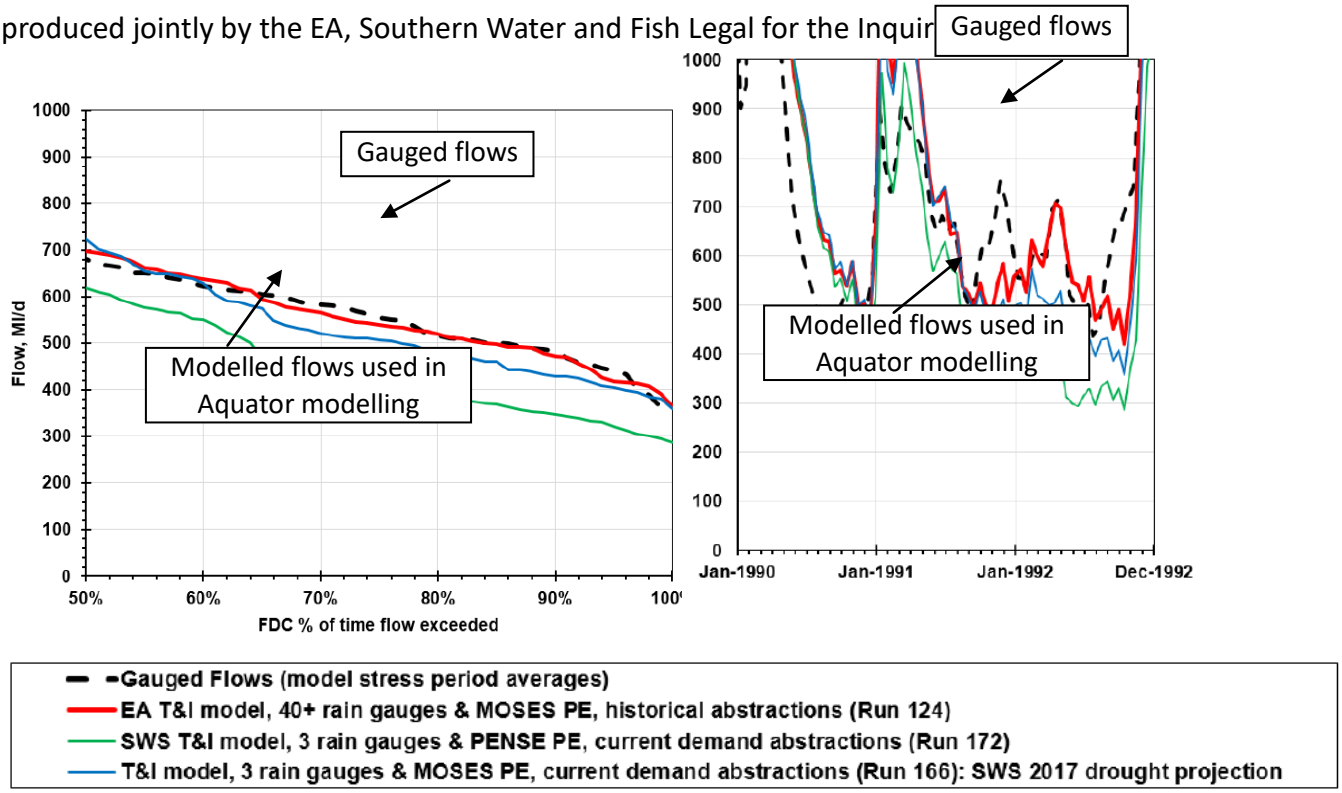


Figure A3 - Differences in versions of hydrologically modelled flows on the lower River Test

Southern Water's Aquator modelling used the worst version of the hydrological modelling, the green line shown in Figure A3, for the reasons explained in the SOCG as follows[27]:

> The Aquator modelling has had to use the least well calibrated (1970 – 2011) version based on the simpler three-rain gauge and PENSE PE inputs, because this is the only version able to cover the major historic droughts of 1921/22, 1933/34 and 1943/44 and the only version able to generate the stochastic droughts of various probabilities which are a key component of SWSs case.

Discrepancies of the magnitude shown in Figure A3 (ie. the differences between the green modelled flows and the black dashed gauged flows) would lead to major inaccuracies if they were to occur in flows used in WRSE's regional system simulator. The difficulties described above will inevitably be experienced in the latest hydrological modelling – ie the absence of climate data covering historic droughts and the computational burden of applying the more accurate modelling techniques over thousands of years of stochastic climate data. These difficulties will be widespread over the south-east region, including the lower River Thames.

Therefore, we think the hydrologic modelling method statement should stipulate the type of validation that will be applied to the modelled river flow data before they are used by WRSE

[26] Statement of Common Ground – Modelling, Figures 5 and 6, EA, Southern Water & Fish Legal, February 2018
[27] Ibid paragraph 44

in the regional system simulator. We propose that the validation should include:

- Hydrographs of modelled flows using recorded climate data vs gauged river flows at all key locations and covering all the major droughts, ie similar to the right-hand plot in Figure A3.
- Flow duration plots comparing full year and seasonal flow durations generated from the historic climate data with the flow durations for the gauged data (or for naturalised gauged flows, allowing for historic abstractions and returns).
- Flow duration plots comparing full year and seasonal flow durations of all the stochastically generated flows with the flow durations for the gauged data (or for naturalised gauged flows), ie similar to the left-hand plot in Figure A3.
- Statistical analysis of variances between modelled and gauged flows, for the modelled flow durations using both historic and stochastic climate data, and for full year and seasonal flow durations.

We also propose that the method statement should specify the acceptable error standard between modelled and gauged flows. The method statement should state what action will be taken if the modelled flows do not comply with the error standard, as seems likely to be the case in some instances.

In assessing climate change impacts, the hydrological models will be required to generate river flows for scenarios of seasonal climate change, for example wetter winters and drier summers. For this reason, it is important the hydrological modelling is validated on a flow duration basis for seasonal flows, not just total flows.

Validation of lower Severn and lower Thames flows

The seasonal validation of modelled river flows will also be important for river flows generated for modelling Severn-Thames transfer options. A major potential benefit of the Severn-Thames transfer option arises from the different geology and hydrological characteristics of the Severn and Thames catchments. The Thames catchment is largely underlain by porous chalk and limestone, whereas the Severn is underlain mostly by relatively impermeable strata. Consequently, when wet weather resumes in the autumn after long droughts, flows recover in the lower Severn much faster than in the lower Thames. This phenomenon can be seen in all the major droughts of the past 100 years[28].

GARD's responses to Thames Water's WRMP consultations have argued that Thames Water's modelling of Severn-Thames transfer options has under-estimated the scheme yields because the hydrologically modelled river flows did not take adequate account of the differences in geology and catchment characteristics referred to above[29] [30]. Our arguments

[28] GARD response to Thames Water's first WRMP19 consultation, Appendix B, April 2018 http://www.gard-oxon.org.uk/downloads/GARD%20response%20to%20Affinity%20final%20-v3-23-04-19.pdf
[29] GARD response to Thames Water's first WRMP19 consultation, pages 89-94

have been rejected by Thames Water for reasons that we do not accept. However, now that newly generated stochastic data are to be used in WRSE's modelling of Severn-Thames transfer options, we request that particular attention and transparency is given to the validation of hydrologically modelled flows in the lower rivers Severn and Thames, especially in the September-October period when the benefits of the Severn's different geology are manifest.

[30] GARD response to Thames Water's second consultation on WRMP19, pages 86-91 http://www.gard-oxon.org.uk/downloads/GARD%20%20response%20to%202nd%20Consultation%20on%20TW%20draft%20WRMP%20Rev%2029.11.18.pdf

Appendix B - The yield and drought resilience of Abingdon reservoir

As submitted by GARD to RAPID in October 2020, following WRSE's consultation on resilience of strategic options

1. GARD's evidence in WRSE's resilience consultation

GARD's response to WRSE's consultation on their resilience framework included a 48-page report analysing the performance of Abingdon reservoir using Thames Water's 15,600 years of stochastically generated data. The findings of our report can be summarised as:

Abingdon reservoir yield

GARD's assessment of the yield gain from Abingdon reservoir is about 180-220 Ml/d. This compares with 294 Ml/d assumed in Thames Water's WRMP and 275 Ml/d in Atkins' Technical Note, May 2018.[31]

Thames Water's yield assessment is unreliable because it only looked at 25% of the droughts in the available 15,600 years of stochastic data, and used inappropriate methods of drought selection and yield analysis. These flaws were compounded by averaging the yields assessed for individual droughts, so the very low yields in long duration droughts were disguised by higher yields in some other droughts.[32]

Emergency storage provision

Thames Water's yield assessment only allowed for 9,000 Ml (6%) emergency storage in Abingdon reservoir. This was justified by saying it complies with their policy of 30 days emergency storage, as for the London reservoirs. However, analysis of rates of depletion of London's reservoirs in severe droughts shows that the 24% emergency storage provision would maintain supplies for at least 60 days, not 30 days.[33]

In view of the high degree of resilience expected from London's supplies and the vulnerability of Abingdon reservoir to long duration droughts, GARD's 180-220 Ml/d yield estimates allow for 20% emergency storage in Abingdon reservoir, ie 30,000 Ml. This would be a pragmatic risk management measure and in line with other UK reservoirs. If the emergency storage is increased to 30,000 Ml (20%), the yield gain is reduced by about 15%, ie by about 30-40 Ml/d.[34]

A larger emergency storage allowance would also address concerns about extremely poor quality water being released into the Thames from the last 6% of storage in the large flat bottomed reservoir, with an average depth of about 1.5m over a 6 km^2area.

[31] See GARD supporting report, pages 22 and 39
[32] See GARD supporting report, page 9
[33] See GARD supporting report, page 34
[34] See GARD supporting report, page 36

Resilience in long duration droughts

There are 25 long duration droughts in the 15,600 year stochastic record in which the yield gain from Abingdon reservoir is less than 240 Ml/d (with Thames Water's assumption of only 6% of emergency storage). All but 6 of these droughts have return periods of between 100 years and 500 years for Abingdon reservoir's gross yield – they are not especially rare events in the context of a resilience design standard of 1:500 years. In all of these droughts, if a yield gain of 294 Ml/d is needed (as assumed in Thames Water's WRMP), the Level 4 supply cuts with Abingdon reservoir would be much longer than they would be with the existing supplies at current levels of demand. This is a major failing in Abingdon reservoir's drought resilience.[35]

Low Abingdon reservoir storage in the spring is a common feature of all the long duration droughts in which the Abingdon reservoir yield is much reduced. Our analysis shows that there is a 1: 50 year probability that Abingdon reservoir will be less than half full at the start of summer and a 1:100 year probability that it would be less than 1/3rd full. Although, a severe drought will not necessarily then occur, there will still be a big threat of Level 4 supply cuts later in the year.[36]

The above highlights the essential problem in relying on a 'supplementary' water resource which itself shares the climatic problems of the water resource zones being supplied. An equivalent situation would simply not arise with a 'climate proof' back-up such as desalination.

It is easy to imagine the sense of panic, and the potential waste of administrative and technical effort in arranging back-ups, that would prevail when Abingdon reservoir is nearly empty at the start of summer, and the consequent economic damage, even if Level 4 supply cuts are not eventually needed because of a wet summer. This needs to be assessed in WRSE's resilience analysis.[37]

Our analysis shows that Abingdon reservoir would have some excessively long periods of being drawn down: over 3 years between refills, at about 1:100 year return period, over 5 years at about 1:600 years, and sometimes up to 8 years between refills. It is unusual for major reservoirs for public water supplies to be designed to have draw-down periods of over 2 years. In the context of London's supplies being required to have a resilience of 1:500 years, the acceptability of the frequencies of draw-downs in excess of 3 years seems highly questionable.[38]

[35] See GARD supporting report, page 25
[36] See GARD supporting report, page 32
[37] See GARD supporting report, page 32
[38] See GARD supporting report, page 33

Recommendations for WRSE's further resilience analysis in GARD's separate report[39]

Much of the weakness of Thames Water's resilience analysis to date stems from failure to convert the 15,600 years of stochastic climate data into reliable flow records for the River Thames. Generation of 15,600 years of reliable river flow records, with and without climate change, should be a top priority in WRSE's further work on resilience. WRSE will be using 400 x 48 years = 19,200 years of stochastic climate data converted into river flows by hydrological modelling (good). However, we are concerned about the reliability of the data and lack of detail of how they will be validated, both for the stochastic climate data and the modelling of river flows.

We also propose that a full century of climate data is used to generate the stochastic climate data and river flows, ie including the actual climate of 2000-2019 (up to the most recent available data). This would ensure inclusion of data from the period when climate change has been most significant. WRSE propose to use only 48 years of historic data 1950-1997, as the basis for generating the stochastic data. This is unsatisfactory a) because it will miss the two most severe droughts of the past 100 years (1921/22 and 1933/34), and b) it will miss the most recent 20 years of rapid climate change.

The slow running of Thames Water's WARMS model has been a major constraint in assessing the resilience of London's supplies. A model capable of simulating operation of the supplies in individual droughts in a few seconds, rather than the hours currently needed by WARMS, should be a priority in WRSE's programme of model development. WRSE say their new regional simulation model will be able to cope with multiple runs of 19,200 years of daily data (good), but run times still a constraint.

The increased frequency, duration and economic cost of Level 4 supply restrictions with Abingdon reservoir in long duration droughts should be properly analysed and taken into account when comparing the economic benefits of Abingdon reservoir with other water resource options. The resilience method statement does not consider the differing capability of option types to keep delivering water in the event of a drought worse than 1:500 years, or to assess the economic benefits of this.

WRSE's continuing resilience investigations should also address:

The operational control rules for Abingdon reservoir in conjunction with the London reservoirs. This should include revisions to the Lower Thames Operating Agreement that take into account the storage remaining in Abingdon reservoir. The acceptability of multi-year periods of draw-down of Abingdon reservoir. The investigation should take account of international best practice for water supplies for major cities and the acceptability of the long periods of Level 3 supply restrictions that might be needed during periods of extended draw down of Abingdon reservoir. This is not covered in the resilience method statement.

[39] See GARD supporting report, pages 39-40

2. WRSE's response

In WRSE's response to their consultation, there was no reference to GARD's detailed criticism of Thames Water's analysis of the yield and drought resilience of Abingdon reservoir. There was no indication of what further work might be undertaken to address GARD's concerns, beyond the following statement[40]:

"As outlined in our response to Question 1, we'll continue to work on the development of the framework, with an emphasis on the systems analysis and how this is translated into a resilience shift. This will need to include further work on the balance of empirical evidence and objective and subjective metrics."

This lack of detailed response was raised in a recent GARD/WRSE meeting. WRSE explained that the assessment of new resources was the responsibility of the water companies and WRSE had no role in checking the validity of their work. However, WRSE said that GARD's response has been seen by the water companies, so they can respond as they see fit.

WRSE's Addendum report on the scope of their simulation modelling contains the following table summarising the modelling approach to be used by water company models feeding into WRSE's own simulator (extract showing Thames Water's modelling)[41]:

Table 4-1 - WRSE company calibration and validation procedures

Company	Performance metric	Priority	Calibration / validation approach	Acceptance criteria	Roles and responsibilities
Thames (WARMS2)	River flows	High	2006-10 (recent and dry) Compare flow duration curves / statistics versus actual 15 locations (5 on the Thames) Semi-naturalised	Good statistical fit Focus on dry period (low flow stats)	Independent review (consultant)
	Reservoir levels	Med	2006-10	Qualitative	Thames team
			Representative demand in London		
	Aquifer levels	Med	Plan to compare to observed		
Thames (IRAS)	DO – drought libraries	High (in use)	DO Vs WARMS2 Adjusted IRAS DO to WARMS2 for investment planning (Linear regression) Hydrology lumped vs WARMS2 – impact on calibration	Qualitative	Independent review (consultant)
	River flows	High (in development)	Compared against actual data		

This table suggests that Thames Water plan to continue with their past approach to yield and resilience assessment. This includes their use of inappropriately selected drought libraries and averaging of yields which disguise the poor performance of Abingdon reservoir

[40] WRSE response to consultation on their resilience framework, page 11, August 2020
[41] WRSE Addendum to Simulator Scoping Report, Table 4-1, pdf pages 9-10, 19th February 2020

in long duration droughts.

The Addendum to WRSE's scoping report was dated February 2020, so the approach may have been subsequently refined. For example, the recently published methodologies on stochastic data sets and climate change propose changes in the historic period of record used to generate the stochastic data (but still excluding the wet winters of the past 20 years). However, Thames Water has not contacted GARD to discuss our response, so it still seems likely that most of GARD's concerns have been ignored.

Appendix C - GARD proposal for STT/Vyrnwy option in WRMP19

7.7 GARD proposal for STT supported mainly by Vyrnwy reservoir

United Utilities' final WRMP shows an 81 Ml/d loss of yield from their own supplies for the option of making releases of up to 180 Ml/d to support the STT[42], allowing them to retain about 100 Ml/d of the available Vyrnwy yield for their own use. No consideration appears to have been given to making regulation releases larger than 180 Ml/d from Vyrnwy reservoir, which would provide more yield for Thames Water, but require United Utilities to give up more of their own yield. When questioned at stakeholder meetings, Thames Water's response was that 180 Ml/d of regulation was the hydrological limit that could be provided by Vyrnwy reservoir. As stated earlier, Thames Water now also say that releasing more than 180 Ml/d would be an unacceptable risk to United Utilities.

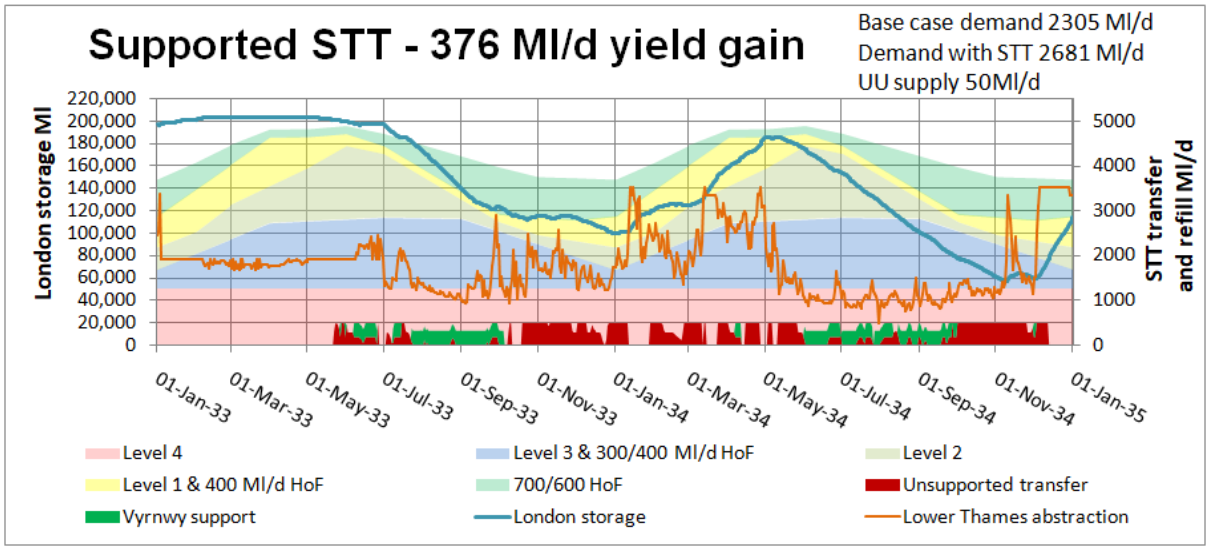
In GARD's opinion, this is not correct – more yield could be made available to Thames Water, while still providing a smaller but guaranteed yield to United Utilities. We note that the AIC costs per m^3 of United Utilities replacement sources are a lot less than Thames Water's, typically less than 60p/m^3(from United Utilities Table WRP6)[43] compared with 110-250p/m^3 for Thames Water. We also note from the same WRP table, that United Utilities have over 400 Ml/d of potential new sources not already included in their preferred plan, with AIC costs less than 60 p/m^3. Therefore, it seems likely that releasing more of Vyrnwy's yield for transfer to Thames Water would be a cost effective option. This has been repeatedly proposed by GARD and repeatedly ignored by Thames Water, with no adequate justification provided.

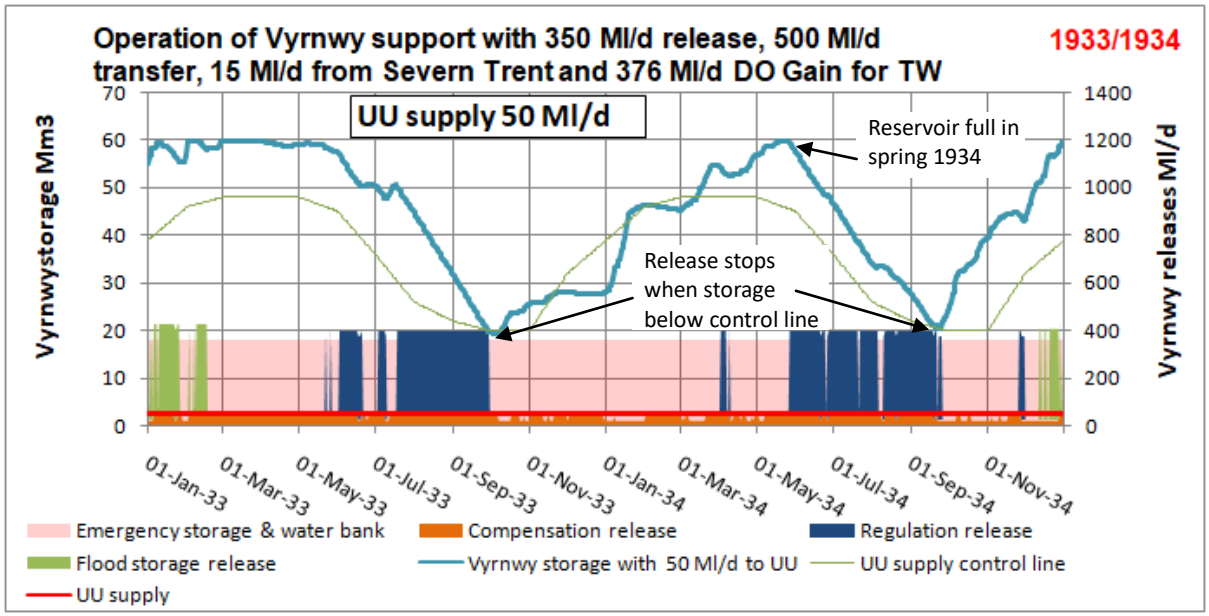
GARD's proposal for options making releases larger than 180 Ml/d from Vyrnwy was described in our report of December 2015[44], as well as in our response to Thames Water's first draft WRMP. We have proposed that regulation releases of up to 400 Ml/d could be made with reduced yield to United Utilities which would be guaranteed by a Vyrnwy reservoir control line below which no regulation releases would be made. To illustrate this, GARD has modelled the following options:

	Yield gain for TW
• 300 Ml/d regulation with 100 Ml/d for UU and 500 Ml/d STT	336 Ml/d
• 350 Ml/d regulation with 50 Ml/d for UU and 500 Ml/d STT	376 Ml/d
• 350 Ml/d regulation with zero yield for UU and 500 Ml/d STT	416 Ml/d

The modelled operation with United Utilities' guaranteed yield reduced to 50 Ml/d and 350 Ml/d regulation, giving a Thames Water yield of 376 Ml/d, is shown in Figure 7-7:

[42] United Utilities final WRMP, Table WRP6 for Strategic Zone
[43] United Utilities final WRMP, Table WRP6 for Strategic Zone. United Utilities, October 2018
[44] 'Modelling of the use of Vyrnwy Reservoir to support the Severn-Thames transfer'.GARD. December 2015





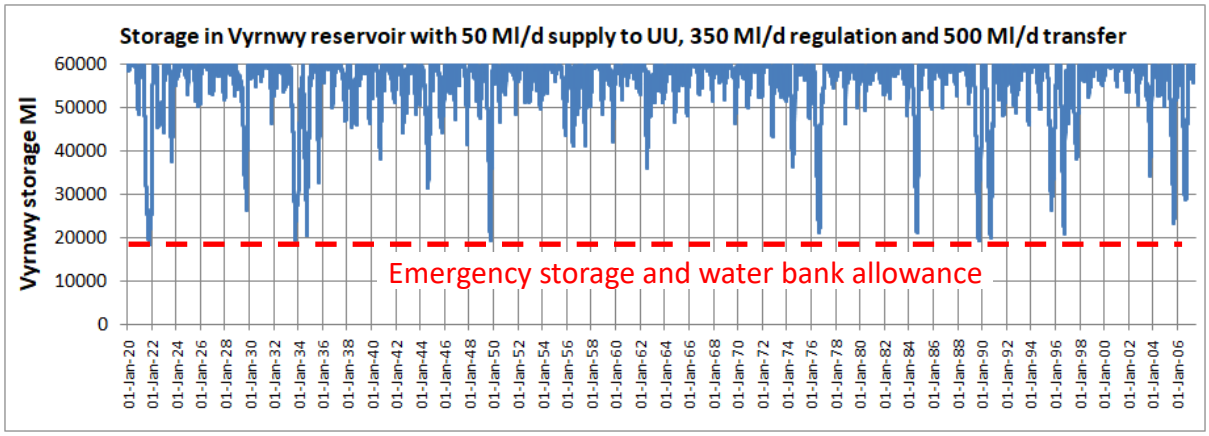


Figure 7-1 Operation of 500 Ml/d STT with 350 Ml/d Vyrnwy support & 15 Ml/d Myth

The 50 Ml/d yield still available to United Utilities is about 50 Ml/d less than for the 180

Ml/d release option considered in Thames Water's revised draft WRMP.

It should be noted that, with the 350 Ml/d release option, Vyrnwy reservoir would completely re-fill in spring 1934, whereas with the 180 Ml/d release version the reservoir would only be 60% full in spring 1934 – winter refill of Vyrnwy reservoir would be much improved because there would only be a 50 Ml/d draw on the reservoir through much of the winter. Therefore, from the perspectives of both Thames Water and United Utilities, this option would be more resilient against longer duration droughts.