GARD response to

Ofwat's Consultation on
Draft Ofwat Gate 2 Decision

Volume 1 – Main report and appendices

11th May 2023

GARD
[redacted]

GARD Review of Draft Ofwat Gate 2 Decisions

Volume 1 – Main response and appendices

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Summary

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1. Scope of this response

In this report GARD is responding to Ofwat's consultations on their Gate 2 decisions on Strategic Resources Options (SROs) for new water supplies. Our report focuses on the two main SROs, the proposed Abingdon reservoir (SESRO) and the Severn to Thames transfer, and on the crucial decision on which of these two main options should be developed first. Our report also addresses some of the other SROs, but in less detail.

In addition to our responses to the Ofwat Gate 2 decision on individual SROs, we have 17
included in Section 2 a review of the need and development sequence for SROs, because we need to set the context for our comments on the Ofwat decisions on the Abingdon reservoir and Severn to Thames transfer options.

We have also included in Section 8 our proposals for some actions that we think are needed from RAPID, Ofwat and the Environment Agency to insure that Gate 3 decisions are properly informed by evidence on some crucial matters.

Many of the points we are making about Ofwat's Gate 2 decisions in this response have previously been raised by GARD in correspondence and meetings with RAPID and Ofwat. As these points have mostly not been addressed in the Gate 2 reports or in Ofwat's
decisions, we must assume that RAPID have considered our points and concluded that 18
they were invalid. Following publication of Ofwat's final Gate 2 decisions, we anticipate a Freedom of Information request for evidence of how our points have been addressed.

2. The need for more water

In GARD's opinion, a reasonably cautious assessment of water supply needs in the south east shows that neither Abingdon reservoir nor the STT is needed if Thames Water and
Affinity Water meet government leakage and PCC targets and abstraction reductions are 19-26
realistically prioritised. Therefore, the only reason for building either of these schemes is as insurance against failure to meet those targets, or as a 'hedge' against a more extreme turn of events in the changing climate.

However, we accept that there is a risk that leakage and PCC targets may not be met, so we have proposed that one or other of Abingdon reservoir or the STT should proceed as
insurance against failure to achieve the leakage/PCC targets, or climate change and 19
population growth rising faster than forecast. We have suggested that the amount of this "insurance" should be in the region of 100-200 Ml/d.

The largest source of over-estimated deficits is abstraction reductions for environmental
improvements. In our opinion, allowances for sustainability reductions in the WRMPs are 19
unrealistically large and not economically or environmentally justifiable, especially when

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the costs and impacts of replacement sources are taken into account. However, we propose that some universally accepted reductions in sensitive chalk streams should be brought forward to the early 2030s, without needing to wait for Abingdon reservoir.

In view of the dominance of environmental improvements in deficit forecasts, we propose that no decisions should be taken on the need and choice of new resource schemes until the proper and transparent prioritisation of abstraction reductions has been completed. 20

3. Ofwat's Gate 2 decision report on Abingdon reservoir

Ofwat have assessed the quality of the Gate 2 report as 'Good' in every aspect, but we consider it to be 'Poor' in each of the assessment categories. 27

Solution Design

The embankment forming Abingdon reservoir would be up to 10km long and 25m high, with around 40 million m^3 of earthfill and rip-rap rock protection, making it by far the largest embankment dam ever built in the UK. Earthfill embankment dams are technically difficult to design and construct, particularly homogeneous clay embankments like that proposed for Abingdon reservoir. The Gate 2 concept design report contains minimal information on the design of the embankment and there is no evidence that the crucial geotechnical design has been addressed in any meaningful detail. 28

The proposed Abingdon reservoir still only allows 6% of emergency storage, as compared to typically 20% for other major UK reservoirs. The last 6% of water will probably be of very poor water quality and is likely to be unusable. Increasing the dead and emergency storages to more prudent amounts would reduce the yield of the reservoir by about 15%. This matter has previously been raised in GARD discussion with RAPID, but it has not been addressed in the Gate 2 report and is not referred to in Ofwat's report. 29

GARD believes the 1m height of the embankment crest above maximum water level is too low. We believe that Thames Water and its partners need to publish the freeboard calculations, and that this should be assessed by experts at Gate 3. 30

The length of the embankment, the large volume stored and the proximity to local villages make Abingdon reservoir a higher-than-normal safety hazard for reservoir-wall breach. We propose that a full dam break analysis and associated flood map should be undertaken before progression of the reservoir SRO to Gate 3. 31

The Gate 2 reports do not address terrorist threats to the reservoir despite Thames Water's intention to allow easy public access for leisure, thereby supposedly generating 'Natural Capital' benefits. We propose that expert evaluation of terrorist threat to the reservoir should be made before progression to Gate 3. 34

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Although the Gate 2 report refers to assessments of fluvial flooding using Environment Agency models, there are few details. We have no confidence in an assertion of 'limited impact'. We call for the data collection to inform this modelling to be put in place at the earliest opportunity and for a full examination of the validated modelling to occur before the reservoir is allowed to proceed to Gate 3. 36

Reservoir deployable output and resilience

In our opinion, Thames Water's stochastic river flow data and Pywr modelling are not fit for the purpose of assessing the deployable output and drought resilience of Abingdon reservoir. The deficiencies are the poor validation between Pywr modelling and Thames Water's modelling, and the inability of the 19,200 years of stochastic river flows to include long duration droughts of the type in which Abingdon reservoir has poor resilience. 38

The Pywr model grossly overestimates the winter flow recovery during 18-month droughts like 1933-34 and 1943-44. This deeply affects evaluation of the Abingdon reservoir and Severn Thames transfer options – over-estimation of winter flow recovery disguises the reservoir's lack of resilience in long duration droughts and reduces the benefit of the unsupported transfers from the Severn. 40

The use of historic climate data only for 1950-1997 to generate stochastic flows has excluded the three most severe droughts of the past 100 years, as well as the past 25 years of most rapid climate change. Therefore, the Pywr modelling cannot generate the type of long drought that tests the resilience of Abingdon reservoir. This problem was previously identified by WRSE who advised that artificial weather series should be used to represent prolonged drought events. Despite this advice and the known concerns over long droughts, Thames Water has failed to do this. The impact of long duration droughts on deployable output of the reservoir has not been assessed. GARD's analysis using an artificial drought sequence shows catastrophic failure of London's supplies and reduction of the deployable output of the 150 Mm^3 reservoir from 285 Ml/d to 163 Ml/d. 41

In addition to failure to consider resilience to long duration drought, we have found the following flaws in Thames Water's deployable output assessments:

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	150 Mm^3 reservoir	100 Mm^3 reservoir
DO with climate change as WRMP24	271 Ml/d	185 Ml/d
Less Double counting of droughts	-6 Ml/d	-4 Ml/d
Wrong value of Culham MRF	-2 Ml/d	-1 Ml/d
Wrong climate change scenario	-19 Ml/d	-16 Ml/d
Inadequate dead & emergency storage	-44 Ml/d	-25 Ml/d
Corrected Deployable Output	**200 Ml/d**	**139 Ml/d**

We conclude that taking account of these flaws and the lack of resilience to long droughts, the deployable output of Abingdon reservoir is probably only about 50% of the values claimed by Thames Water. None of this appears to have been considered in Ofwat's 45 Gate 2 decision report, despite these issues having been raised by GARD in previous consultation responses and discussions with RAPID.

Reservoir costs and carbon footprint

The evaluation of reservoir costs in the Gate 2 documents is poor in three respects:

- lack of transparency in the cost information presented 47
- errors in the calculations
- no calculation of the *true total costs* of the reservoir to customers arising from linking customer bills to the Regulated Asset Base of the supplying companies

Our analysis shows that the NPC cost of the 100 Mm^3 reservoir should be £1.571m, which is £270m higher than Thames water's estimate of £1,301m. 50

The Gate 2 reports claim potential reduction in the carbon budget figures through technological developments and carbon sequestration. From our analysis we conclude that the low-carbon earthmoving equipment is highly unlikely to be available for building the embankment and an alternative 'low-carbon' construction phase for the reservoir is 53 unrealistic. We also conclude that the carbon sequestration 'opportunities' are limited and uncertain, and not larger than local initiatives (funded by new DEFRA rules and Local Authorities) could achieve without the reservoir at vastly lower cost.

There is increasing evidence that greenhouse gas emissions are substantial from large reservoirs. These emissions potentially dwarf the rather low Operating Carbon figure for 54 the Reservoir. These issues are completely absent from the RAPID Gate 2 reports, and must be evaluated for Gate 3.

Reservoir programme and planning 54

As with all major civil engineering projects, Abingdon reservoir carries a high risk of

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programme and cost over-runs. For a homogeneous clay embankment dam, the main risks arise from the design and construction of the embankment and its foundations. Normally, management of this risk would entail extensive geotechnical investigations, including a trial borrow pit and embankment, before the pre-tender design and the start of the tender process, but there is no evidence of this in the Gate 2 reports. We propose that Ofwat calls for detailed geotechnical investigation to be undertaken as part of the Gate 3 activities and before any decision is taken to proceed to Gate 4.

We have found no evidence of construction planning in the Gate 2 documentation. The Abingdon reservoir site is hemmed in by surrounding villages, with little spare land available for construction facilities or for the pipeline route, water treatment works and pumping station for the Thames to Southern transfer. Ofwat should call for detailed construction planning to be undertaken for Gate 3, including design layouts of all construction facilities and temporary works.

The Gate 2 documentation appears contains no serious estimate of the time taken to fill the reservoir after completion of construction. What little detail there is contains a major error through using a Culham minimum required flow of 450 Ml/d instead of 1450 Ml/d. The absence of probabilistic estimates of times needed for initial filling of the reservoir is a major weakness in the Gate 2 reporting. 56

We propose that the actions needed to rectify the deficiencies in planning the reservoir should be specified in detail in Ofwat's final Gate 2 decision report. 57

Environmental reporting for the reservoir

In our opinion, the environmental reporting for the reservoir is extremely poor, being superficial, lacking in evidence and biased to exaggerate the benefits of the reservoir and downplay its negative impacts. Our criticisms are: 58

1. The Natural Capital Assessment gives an over-optimistic portrayal with 'brochure culture' taking over. Recent presentations to local communities have presented potential amenities as fact, despite a complete lack of any supporting evidence as to how, or by whom, these will be provided. The creation of a '*Lake and Standing water*' does not automatically have positive Natural Capital value, when it is a large bunded reservoir with an all-round concrete wall and rip-rap-enclosed shorelines. It has far less Natural Capital possibility than 'classic' flooded valley reservoirs with more natural shorelines. 58

2. The Biodiversity Net Gain assessment for the reservoir suffers from many aspirational and unfounded assertions of habitat creation with many 59

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inconsistencies and errors.

3. The Gate 2 environmental reporting contains nothing *new* on the very serious issues of noise, air pollution and traffic impacts, over and above what was in the roundly-criticised Gate 1 document. These are all major impacts on the local area, especially for the villages in close proximity to the reservoir site. Ofwat's Gate 2 decision report should require these aspects to be addressed in detail in Gate 3, in consultation with local authorities 60

Drinking water quality and river water quality impacts of the reservoir

The Gate 2 report claims incorrectly that regulation releases from the reservoir will rarely make up more than 50% of the flow immediately downstream of the outfall. Examination of gauge records shows that during severe droughts releases will comprise almost the entire flow for much of the summer. The depth of water in the reservoir will be less than 5m in severe droughts, which is likely to cause severe algal growth and water quality problems, especially as most of the filling of the reservoir will take place at times of high flows in winter, when water quality in the Thames is likely to be poor due to CSO spillage. The water used to fill the reservoir is likely to have high nutrient loadings and will encourage algal growth. None of this appears to have been taken into account by the Gate 2 water quality assessments. It is a major failing which needs to be addressed in Gate 3. 61

We would comment that this failing in the Gate 2 assessment of reservoir is typical of the bias in favour of Abingdon reservoir and against the Severn to Thames transfer in the Gate 2 reporting. Whereas, the likely water quality problems for Abingdon reservoir appear to have been given minimal attention, a highly risk-averse approach has been taken for Severn to Thames transfer water quality, with assumptions of costly treatment being needed for all the transferred water. 62

Board Statement and Assurance

Ofwat's Gate 2 decision report has rated the Board Statement and Assurance for the reservoir as 'Good', but we consider it to have been poor. Ofwat's assessment appears to have been based on the Board Statement's assurance that the Gate 2 work was externally reviewed by Atkins Ltd. 63

We note that Atkins Ltd have been extensively involved in development of previous Thames Water's WRMPs and were also responsible for Water UK's 2016 report on water resources long term planning which suggested the huge future water deficits that eventually led to Ofwat's £470 million SRO programme. Therefore, in GARD's opinion, Atkins should not have been considered to be an impartial external assurer. The boards of Thames Water and Affinity Water should have been well aware of this conflict of interest. 64

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Ofwat recommendations for Gate 3

We think that Ofwat's recommendations for Gate 3 actions should specifically cover the deficiencies in the Gate 2 reports that we have summarised above. These are listed in Section 3.8 of this response and cover:

1. Geotechnical design of the dam and associated site investigations.
2. Provisions for dead and emergency storage and the acceptability of water quality in the reservoir at times of extreme drought and near-emergency drawdown.
3. An independent assessment of freeboard provision.
4. Dam break analysis and publication of maps of potential areas flooded.
5. Expert analysis of terrorism threat and need to limit access.
6. Surface and groundwater flooding impact of the reservoir.
7. Independent expert review of the stochastic data and Pywr modelling used to determine Abingdon reservoir and drought resilience. 64
8. Reassessment of the Natural Capital, Biological Net Gain and Strategic Environment Assessments.
9. Construction planning to a sufficient level of detail to allow preparation of plans for layout of temporary facilities and permanent works at the reservoir site.
10. Probabilistic assessment of time to fill the reservoir after completion of construction, based on historic flow records, not the unreliable stochastic data.

A number of these Gate 3 activities should be independent expert assessments of Thames Water and Affinity Water's work. If this is left to the water companies to arrange, we think the assessments will be biased by conflicts of interest. We propose that, even if this work is funded by the water companies, Ofwat should share responsibility for selection and appointment of the experts. Their reports should be made directly to Ofwat, not to the water companies.

4. Ofwat's Gate 2 decision report on the Severn to Thames transfer

Ofwat have produced separate Gate 2 decision reports for the aqueduct and the various support sources for the Severn to Thames transfer. Whereas we appreciate that this 66
approach matches the separate SROs identified at the start of the £470 million investigation programme, it does not allow the Severn to Thames Transfer to be assessed as a single coherent scheme. GARD advocated the need for the STT to be viewed as a

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single scheme in our response to Ofwat's Gate 1 decisions and it is disappointing that this has not been recognised in the Gate 2 work or Ofwat's Gate 2 decisions.

Ofwat have rated the quality of the STT Gate 2 reporting as good in most categories and satisfactory in others. In our opinion, the Gate 2 reporting on the STT and its various components is satisfactory rather than good, but a lot better than the Gate 2 reporting on Abingdon reservoir. 66

Capacity and phasing of the STT scheme

We think that the initial STT aqueduct capacity of 500 Ml/d, as put forward in Thames Water's preferred plan for their draft WRMP, is too high. We think it inconceivable that this amount of transfer would ever be needed, especially if abstraction reductions for improved river flows are properly prioritised, with account taken of the costs and environmental impacts of replacement sources.

We suggest that a 300 Ml/d aqueduct capacity would be sufficient for a reasonable insurance against climate change and population growth being much worse than expected. A 300 Ml/d aqueduct could also be provided by the Cotswold canal transfer, with its potential for a lot of secondary benefits through the canal restoration. 67

In our response to Thames Water's WRMP consultation, we proposed that the first phase of the scheme should comprise the 300 Ml/d aqueduct with support from Netheridge and Minworth WWTW effluent. However, we recognise that there could be a case for using some or all of the support available from Vyrnwy reservoir before introducing the Minworth support.

We propose that Ofwat's Gate 2 decision report should specify an interim checkpoint in Gate 3 in which the capacity, transfer method (pipeline or Cotswold canal) and sequence of support sources are pinned down. This would require cost estimates to be prepared for the scheme as a whole and would allow a proper comparison with Abingdon reservoir.

The needed for extra treatment of Netheridge and Minworth WwTW effluent

The Gate 2 reports for the Netheridge and Minworth support components both assume that additional, costly and carbon intensive treatment of the WwTW effluent is needed. The Gate 2 report on the use of Netheridge WwTW effluent considers the need for additional treatment and concludes that avoiding the treatment reduces the NPC cost by £163 million. This would make a large difference to the comparative costings of the STT and Abingdon reservoir options. There must also be a question over the need for additional treatment of Minworth WwTW effluent. We propose that Ofwat's Gate 2 decision report should require a separate, properly evidenced and transparent report on 68

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the need for additional treatment at the Netheridge and Minworth WwTWs.

Amount of regulation release discharged to the River Vyrnwy

The Gate 2 report on the NW transfer options says that the maximum amount of STT regulation release into the River Vyrnwy has been reduced to just 25 Ml/d. Previously, the maximum amount of discharge allowed was 75 Ml/d. In our response to Ofwat's Gate 1 decisions we disputed the need for this limit and provided evidence that the flow regime with substantial regulation releases would actually be more natural and better suited to juvenile salmonids than the current flows. We propose that Ofwat's Gate 2 decision report should require a properly evidenced and transparent report determining the amount of regulation release that can be discharged into the River Vyrnwy. 69

STT deployable output and operational use

GARD's modelling of operation of the STT shows significantly higher deployable outputs for unsupported transfers and lower average operational use than the Pywr modelling. Our modelling shows that the 1:100 year DO of the unsupported 300 Ml/d transfer should be 129 Ml/d compared to Thames Water's figure of about 90 Ml/d. The under-estimation of unsupported deployable outputs is highly significant because the unsupported transfer would be a viable first phase of the STT, not dependent on the Minworth or Vyrnwy support sources. It would allow all the Chilterns chalk stream abstraction reductions to go ahead as soon as the Severn to Thames aqueduct is built, potentially in the early 2030s. 70

We propose that Ofwat's Gate 2 decision report should state that the independent review we have advocated for the stochastic data and Pywr modelling of Abingdon reservoir should include the assessment of deployable output of the unsupported STT.

The need for Vyrnwy replacement sources

Thames Water's WRMP appears to have assumed that at least 80% of the nominal support from Vyrnwy reservoir will require replacement of deployable output through new United Utilities sources. GARD's modelling shows that only about 50% replacement deployable output is needed. This would mean that the costs of STT options with Vyrnwy support may have been inflated by the cost of up to about 70 Ml/d of unnecessary replacement sources. Ofwat's Gate 2 decision report should require a properly evidenced and transparent assessment of the amount of United Utilities replacement sources needed for the various options for Vyrnwy support for the STT. 71

STT system costs and carbon

The System costs for STT and the Opex carbon are grossly overestimated in the Gate 2 reports. This is partly a reflection of the lack of co-ordination of the different parts of the 71

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STT schemes, and, as a result inconsistent approaches and assumptions abound.

Opex costs for a ‘STT Phase 1’ have been compared in a near like-for-like manner with the Abingdon 100 Mm^3 option. The ‘STT Phase 1’ comprises the ‘Deerhurst 300’ pipeline, Netheridge and Minworth WwTWs, and has a deployable output slightly higher than the Abingdon 100 (the latter as per Thames Water, not GARD’s calculation). The Gate 2 reports calculate Opex as though the STT were operating for 100% at full flow.

GARD’s modelling shows 6% unsupported operation and 5-8% supported operation. As can be imagined this results in a huge drop in Opex costs.

The NPC for the STT Phase 1, calculated using GARD’s system operation usage, is £1,309m. 82
This is £262m lower than the Abingdon 100, corrected for errors as above.

Errors in calculating the Opex carbon for the STT options in the Gate 2 reports come from the assumed 100% operation (as noted above), the lack of consideration of opportunities for energy recovery in the schemes, and the assumption of no decarbonisation technology trajectory for the chemical input into the purification.

However, a serious error comes from an assumption that the STT Opex carbon is counted from a start date in the 2020s, which is completely unfeasible for a project whose planning shows an earliest start date in 2035. This assumed operation whilst the grid is still decarbonising seriously overestimates Opex carbon. The combined effect of the errors and omissions is a reduction of at least 50% in calculated Grid 2 Opex carbon.

Comparison of Opex Carbon for STT and the Abingdon Reservoir is completely unsatisfactory. The following is needed before Gate 3:

1. Comparison over the same planning period for both Abingdon and STT, from their earliest feasible start dates (2035 for STT, and 2040 for Abingdon)
2. Realistic operational use figures for STT.
3. Evaluation of the Reservoir Greenhouse gas emission carbon for inclusion in the Reservoir Opex carbon. 84
4. Inclusion of energy recovery possibilities in the STT components.
5. Evaluation of water treatment power requirements for the Abingdon Reservoir.
6. A proper Road-map evaluation of the possibilities of decarbonisation of the chemical production – consistent with the Grid decarbonisation assumptions used.

Ofwat recommendations for Gate 3

We propose a number of additions to Ofwat’s requirements for Gate 3 actions, addressing

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the matters raised above. These include an interim Gate 3 checkpoint at which the matters below are addressed in a properly evidenced and transparent way:

1. Definition of the transfer capacity, transfer method (pipeline or Cotswold canal) and sequence of support sources. 86

2. The need for additional treatment at Netheridge and Minworth WWTWs, including consideration of potential disproportionality of costs.

3. Limitation on the amount of regulation release that can be discharged into the River Vyrnwy.

4. Independent review of the stochastic data and Pywr of the STT, including the assessment of deployable output of the unsupported STT.

5. Assessment of the amount of United Utilities replacement sources needed for the various options for Vyrnwy support for the STT.

6. A 'fast track' implementation programme to facilitate early chalk stream flow re-naturalisation in the Thames valley.

7. The over-arching co-ordination of *comparative evaluation* of all STT options should be tasked to an in-house RAPID team. The major task would be validation of STT NPC and the Opex carbon analysis supervision.

8. Carbon comparison of the STT with the Abingdon Reservoir.

5. Ofwat's Gate 2 decision report on the Thames to Affinity transfer

Sourcing the T2AT transfer water by direct connection to an existing reservoir and the London supply system was proposed by GARD during the finalisation of PR19 and referenced by Ofwat in the appendix to its final PR19 determination, which defined the scope of the SRO investigations. The matter was raised again in our response to Ofwat's T2AT Gate 1 decision report. Although this was acknowledged in Ofwat's final Gate 1 decision report, there was no specific action recommended and nothing more has been done. 87

We consider the continuing failure of Ofwat and the water companies to address this matter to be extremely disappointing and propose that it is addressed specifically in Ofwat's final Gate 2 decision report. 88

GARD recognises the uncertainty in the amount of flow recovery from the planned chalk stream abstraction reductions that can be converted into additional deployable output from London's reservoirs. However, this uncertainty can be managed, and with a possible 89

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net increase in deployable output from downstream reservoirs, if the chalk aquifer is used
for drought support schemes similar to the existing West Berkshire Groundwater Scheme.
We propose that Ofwat's Gate 2 decision report should require a Gate 3 investigation of
the WBGWS concept in the Chilterns chalk streams as part of the continuing Thames to
Affinity transfer development.

6. Ofwat's Gate 2 decision report on the Thames to Southern transfer

In GARD's opinion the Thames to Southern transfer is not needed. The primary drivers for
the scheme are the perceived need to reduce groundwater abstractions in the upper 92
Itchen and Test valleys and the removal of lower Test and Itchen drought permits from
Southern Water's drought plan.

The CaBA report on abstraction reductions as a % of catchment recharge concluded that 94
no abstraction reductions were needed in the upper Itchen and Test valleys.

The drought permits would only rarely give substantial reductions in abstractions and it is
hard to see how the occasional benefits could justify the huge c.£2 billion cost of the
scheme and the export of scarce water out of the Thames valley. GARD proposes that the 95
Thames to Southern transfer should be abandoned at Gate 2 due to its minimal benefit
and disproportionate cost.

7. Ofwat's Gate 2 decision reports on other London options

The Grand Union Canal transfer

We welcome the plan for Affinity Water to complete at least Phase 1 of the GUC transfer
by 2031. This would bring "new water" into the chalk catchments which ultimately feed
Thames Water's London's reservoirs. The "new water" coming into the Thames catchment
via the GUC transfer emanates from Minworth STW effluent and is therefore totally
resilient against severe drought and climate change, unlike Abingdon reservoir.

Although our analysis shows that a 50 Ml/d GUC transfer would be more than enough for 99
Affinity Water's needs and re-naturalising chalk stream flows, there would be additional
security of supplies for both Affinity and Thames Water, if the GUC carrying capacity can be
increased to 100 Ml/d at relatively little additional capital cost, via the 'Phase 2' of the
scheme. Our view is that this phase should be brought forward for completion by 2035.
Operating costs would only be on an as needed basis.

Therefore, we propose that Ofwat's final Gate 2 decision should require investigation of
bringing the completion of the full 100 Ml/d transfer scheme to its earliest feasible date
and by 2035 at the latest.

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The Teddington DRA scheme and Deephams reuse schemes

GARD welcomes the planned Teddington DRA scheme delivering at least 67 Ml/d of deployable output for London as per Thames Water's preferred plan. The early construction of this scheme would ensure water availability from London's supplies to be transferred to Affinity Water, allowing early re-naturalisation of Colne and Lea chalk stream flows.

In our response to Thames Water's draft WRMP19 in November 2018, we criticised the abandonment of the Teddington DRA scheme and the environmental evidence on which 100
that was based (largely temperature effects). We are, therefore, pleased to see that the scheme has now been reconsidered and put forward again, albeit in a much smaller form than we consider its ultimate potential to be.

If more water was genuinely needed for London, we believe that a much larger version of the Teddington DRA should be reconsidered, making better use of the c. 400 Ml/d output of Mogden STW. Therefore, we propose that Ofwat's final Gate 2 decision report should require that the Teddington DRA scheme now proposed should also be considered as the first stage of a potentially larger scheme**.**

The 45 Ml/d Deephams reuse scheme was included for early implementation in Thames Water's WRMP 19, but has now been pushed back to after 2060 because of concerns over lower river flows and water quality, linking it to the timing of reductions in Thames Water's abstractions on the lower Lea. GARD's reassessment of Thames Water's supply demand balance shows that there would be spare headroom to bring forward reductions in TW's lower Lea abstractions to 2040, especially if the second phase of the GUC transfer is implemented early, as we propose. Therefore, the Deephams reuse scheme could be brought forward to 2040 if needed.

As Thames Water's quoted AIC costs for the Deephams reuse scheme are less than Abingdon reservoir, we propose that Ofwat's final Gate 2 report on London recycling options should include the 45 Ml/d Deephams scheme as a Strategic Resource Option in the Gate 3 investigations, with a target completion date of 2040.

8. Proposed actions for RAPID, Ofwat and the EA for Gate 3

The need for realism in the need for Abingdon reservoir or STT

Our analysis shows that neither Abingdon reservoir nor the Severn to Thames transfer 102
would be needed if the water companies meet their leakage and PCC targets and there is a realistic approach to abstraction reductions. We believe this scenario is much more likely than the extreme deficit growths used as the central planning assumption in the

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WRSE and water company plans.

However, we accept that there is a risk that leakage and PCC targets may not be met, so we have proposed that one SRO should proceed as insurance against failure to achieve the leakage/PCC targets, or climate change and population growth rising faster than forecast. We have suggested that the amount of this "insurance" should be in the region of 100-200 Ml/d.

We propose that Ofwat should specify the amount of deployable output needed from a first phase of development of an SRO in the upper Thames, assuming that the needs of Southern Water (which we have shown to be small and met at best value by local provision) are not to be factored in. The water companies should then be asked to focus on the best means of providing this additional resource, with emphasis on adaptability, upgradeability and drought resilience being placed alongside ***full*** cost and carbon footprint implications. 102

We believe that Ofwat and RAPID need to take more control of discarding of schemes by water companies. So far, the only schemes to have been ruled out are the Fawley desalination and the Anglian to Affinity transfer, both due to Water Companies' refusal to include them. We have thus lost two highly drought resilient and forward-looking schemes of the sort envisaged by the National Infrastructure Commission.

The need for justification and prioritisation of abstraction reductions

We have shown that the largest source of over-estimated deficits is abstraction reductions for environmental improvements. In our opinion, allowances for sustainability reductions in all the water companies' plans are unrealistically large and not economically or environmentally justifiable, especially when the costs and impacts of replacement sources are taken into account. 103

We propose that as early as possible in Gate 3, there should be the proper and transparent prioritisation of abstraction reductions, taking account of the cost and environmental impact of replacement sources**.** This process should include interested stakeholders who have already made similar suggestions, including the Chalk Streams First group and Oxfordshire County Council. No Gate 3 decisions should be taken on the need and choice of new resource schemes until this has been done.

The need for direct comparison of the Abingdon and STT options 103

The choice between Abingdon reservoir and the Severn to Thames transfer as the first major scheme to be developed should be a crucial outcome of Ofwat's £470 million investigation programme. At present, there is no clarity whatsoever in how Abingdon reservoir has become the first choice scheme in the draft WRMPs. The decision appears to

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have come from WRSE's draft regional plan, which is utterly lacking in transparency.

Although there is a reasonable amount of cost detail in the Gate 2 reports, there is no consistency in how option costs are presented, making option comparisons extremely difficult. For the Severn to Thames transfer, the costs of the aqueduct and support components are scattered in different reports in different formats, making assembly of a total scheme costs difficult and unreliable. 104

In our opinion, the chaotic presentation of costs in the Gate 2 reports and the absence of any transparent option cost comparisons is a major failing in Ofwat's investigation programme to date.

We propose that as soon as possible in Gate 3, the water companies should be instructed to collaborate in producing a detailed and publicly available like-for-like comparison of the Abingdon reservoir and STT options, with a common deployable output (eg the 100 - 200 Ml/d "insurance" we suggest above) and a common date for start of operation, probably 2040, which is the earliest possible date for completion and filling of Abingdon reservoir. We believe this should be actively co-ordinated and led by an in-house RAPID team, so that a common approach is achieved and the Gate 3 process does not open with divergent justifications.

The need for EA evidence to support their decisions

Throughout the Strategic Resource Option investigations, there have been a number of Environment Agency decisions which have had a profound influence on the design of the SROs and their costs. We propose that, as part of the supporting evidence needed in Gate 3, the Environment Agency should provide detailed, publicly available evidence for the following:

1. The Deerhurst and Culham minimum required flows.
2. The 25 Ml/d limitation on the amount of regulation releases discharged to the River Vyrnwy. 104
3. The need for treatment of effluent from Netheridge and Minworth STWs.
4. The need for treatment of STT water at Deerhurst before transfer through the aqueduct.
5. The acceptability of discharging water from Abingdon reservoir into the River Thames without treatment, when reservoir storage is less than 15% in droughts.
6. The restriction of the Teddington DRA scheme to a maximum 100 Ml/d discharge

Refer to page no.

of Mogden STW effluent.

We propose that in preparing the supporting evidence for these decisions, the Environment Agency should liaise with the water companies to understand the implications of their decisions on SRO deployable outputs and costs. Presentation of the deployable output and cost implications should form part of the supporting evidence.

1. Introduction

1.1 GARD's role

Group Against Reservoir Development (GARD) is a community-based organisation representing local residents and businesses, mainly in the South Oxfordshire villages of Steventon, Drayton, East and West Hanney and Marcham, who would be affected by Thames Water's plans to build a major new reservoir near Abingdon.

GARD campaigns against this inappropriate reservoir solution and in favour of sustainable water resource options such as effluent reuse and raw water transfer from Severn to Thames. We also strongly support demand-side measures to reduce leakage of water and efficient use strategies, including metering. GARD's membership includes many technically-qualified people, and we are advised by Water Industry professionals. GARD's website is at http://www.abingdonreservoir.org.uk/.

1.2 The scope of this response

In this report GARD is responding to Ofwat's consultations on their Gate 2 decisions on Strategic Resources Options (SROs) for new water supplies. Our report focuses on the two main SROs, the proposed Abingdon reservoir (SESRO) and the Severn to Thames transfer, and on the crucial decision on which of these two main options should be developed first. Our report also addresses some of the other SROs, but in less detail.

GARD has already responded in detail to the consultations on WRSE's regional plan for the South East and on the Water Resource Management Plans of Thames Water and Affinity Water. All these responses can be seen in full on GARD's web-site[1]. In the main text of this response to Ofwat, we have included summaries of many of the points that we made in these earlier consultation responses and we have included some full extracts in Appendices, so that supporting evidence is readily viewable by Ofwat. We have also provided in Volume 2 of this response a full copy of our Addendum to our response to Thames Water's draft WRMP consultation, which includes supporting evidence for our views on the validity of stochastic river flow data and Pywr modelling.

In addition to our responses to the Ofwat Gate 2 decision on individual SROs, we have included in Section 2 a review of the need and development sequence for SROs because we need to set the context for our comments on the Ofwat decisions on the Abingdon reservoir and Severn to Thames transfer options.

We have also included in Section 8 our proposals for some actions that are needed from RAPID, Ofwat and the Environment Agency to insure that Gate 3 decisions are properly informed by evidence on some crucial matters.

[1] GARD, documents to download https://www.abingdonreservoir.org.uk/downloads.html

1.3 Matters previously raised with RAPID and Ofwat

Many of the points we are making about Ofwat's Gate 2 decisions in this response have previously been raised by GARD in correspondence and meetings with RAPID and Ofwat. Some evidence of this is included in Appendix A and will be referred to in other parts of this response.

It is disappointing that most of the points we have made in previous discussions have not been addressed, either in the Gate 2 reports or in Ofwat's Gate 2 decisions. In a letter to GARD dated 20th September 2020 (copy in Appendix A) in response to GARD's concerns about various technical aspects of water company reports, RAPID's Managing Director, wrote as follows:

> *"I explained in my letter of 22 June 2020 that RAPID's gated process would include a requirement for third party technical assurance. This will form part of the companies' submissions and so would be by consultants engaged by the companies.*
>
> *RAPID will be making an assessment of information provided by companies about their solutions for the purposes of the gated process. RAPID's assessments will inform RAPID's recommendations to Ofwat regarding Ofwat's funding decisions in this process. The team of assessors will comprise members of the RAPID team and external consultants instructed by RAPID."*

As many of the points that we have made in the past have not been addressed, either in the Gate 2 reports or in Ofwat's Gate 2 decisions, we must assume that RAPID's team of assessors have considered our points and concluded that they were invalid. Following publication of Ofwat's final Gate 2 decisions, we anticipate making a Freedom of Information request to Ofwat to provide evidence of how our points have been addressed, including reports prepared by your team of assessors.

2. The need and development sequence for strategic resource options

2.1 The overall need for major new supplies in the South East

In GARD's opinion, a reasonably cautious assessment of water supply needs in the south east shows that neither Abingdon reservoir nor the STT is needed if Thames Water and Affinity Water meet government leakage and PCC targets and abstraction reductions are realistically prioritised. Therefore, the only reason for building either of these schemes is as insurance against failure to meet those targets, or as a 'hedge' against a more extreme turn of events in the changing climate of the south east.

In our opinion, the magnitude of the 'insurance' deployable output from new supplies should be in the region of 100 -200 Ml/d. The amount of 'insurance' is dependent on the degree of risk that the Government thinks is acceptable, so we recommend that Ofwat should specify the amount of 'insurance' required, rather than leaving the decision to water companies.

2.2 Thames Water and Affinity Water future baseline deficits

GARD's conclusions on baseline deficits

In our responses to the water companies' WRMPs, we concluded that they have over-estimated their baseline deficits in 2075 by about 750 Ml/d, equivalent to about 4 Abingdon reservoirs:

- 430 Ml/d in the London water resource zone
- 33 Ml/d in the SWOX water resource zone
- 90 Ml/d in the other TW's Thames valley water resource zones
- 200 Ml/d in Affinity Water's Central Zone

Evidence to justify the make-up of these over-estimates is summarised below with more detail provided in Appendices B to D. Details of GARD's derivation of the total over-estimated baseline deficits above are given in Appendix E.

It should be noted that the over-estimates referred to above are only in the magnitude of the baseline deficits and they do not consider the adequacy of water company plans for reductions in leakage and per capita consumption. These are considered in Section 2.3 of this response.

Over-estimation of abstraction reductions for environmental improvements

The largest source of over-estimated deficits is abstraction reductions for environmental improvements. In our opinion, allowances for sustainability reductions in the all the water companies' plans are unrealistically large and not economically or environmentally justifiable, especially when the costs and impacts of replacement sources are taken into account. Appendix A contains extracts from our WRMP consultation responses giving evidence on the amount of over-estimation of loss of deployable output from abstraction reductions.

If the abstraction reductions are focused on the ecologically sensitive chalk streams, as proposed by the CaBA chalk stream group, the loss of deployable output would be about 270 Ml/d less than Thames Water's allowance and 86 Ml/d less than Affinity Water's allowance. GARD proposes that the remaining and much needed reductions in ecologically sensitive chalk streams should be brought forward to the early 2030s, without needing to wait for Abingdon Reservoir.

In view of the dominance of abstraction reductions for environmental improvements in deficit forecasts, GARD proposes that no decisions should be taken on the need and choice of new resource schemes until the proper and transparent prioritisation of abstraction reductions has been completed, taking account of the cost and environmental impact of replacement sources.

Population growth forecasts

We estimate that Thames Water and Affinity Water's need for new sources due to population growth have been over-estimated by a total of about 300 Ml/d.

The 2020 Office of National Statistics (ONS) population projection for England indicates that Thames Water's population figures are too high by 1.2 million by 2050 and 1.8 million by 2100. We think it would be reasonable, ie reasonably cautious, to make a central planning assumption for population growth as for the ONS 2020 forecast for England, with an added 30% increase in the growth rate as a safety factor. This reduces Thames Water's 2075 deficits by about 190 Ml/d.

Our calculations show that the Affinity Water population estimates may be over-stated by 632,000 by 2050 and 742,000 by 2080. At the baseline PCC of about 150 l/head/day, that is equivalent to an over-forecast of the baseline deficit by 95 Ml/d in 2040 and 111 Ml/d by 2080.

Detailed evidence on the over-prediction of population growth from our Thames Water and Affinity Water WRMP consultation responses is given in Appendix C.

Climate change allowances

The records of the past 100 years show no evidence of a reduction in Thames Water's London deployable due to climate change and suggest that wetter winters and higher groundwater levels at the start of summer are <u>increasing</u> the deployable output of London's supplies. The historic evidence suggests the 'Low' climate change impact scenario is much more likely than the 'High' scenario. We can see no justification for the 'High' scenario being the central planning assumption for the climate change allowance in the preferred plan. We propose that it would be reasonably cautious to assume the 'Medium' scenario as the central planning assumption. This reduces the London deficit in 2075 by about 70 Ml/d.

Evidence for this is given in Appendix D.

Resilience standard

GARD accepts the need to increase the resilience of supplies to maintain supplies in a 1 in 500 year drought. Prior to WRMP19, supplies were planned to withstand a "worst historic" drought, roughly equivalent to a 1 in 100 year drought. The loss of deployable output due to switching from the 1 in 100 to 1 in 500 year resilience standard is 266 Ml/d for Thames Water's London zone, but minimal for zones outside London which are mainly supplied by groundwater.

2.3 GARD reassessment of need for Strategic Resource Options

Meeting baseline deficits – the balance between demand reductions and new supplies

Section 2.2 of this response provides evidence that the baseline deficits in areas that could be supplied by Abingdon reservoir or the STT have been over-estimated by about 750 Ml/d. The needs for major new sources of supply will also depend on:

- planned additional PCC reduction
- planned additional leakage reduction
- the amount of planned export from Thames Water to Affinity Water
- the amount of planned export from Thames Water to Southern Water

The plans for these are reviewed below, leading to the conclusion that Abingdon reservoir or the STT are only needed as insurance against Thames Water and Affinity Water failing to meet leakage and PCC targets.

Future PCC reductions

Thames Water falls far short of achieving the Government's PCC target of 110 l/person/day by 2050, especially in the London zone. This contrasts with United Utilities' plan to meet the PCC target in their Strategic Zone, which covers a comparably large and heavily urbanised region, including Manchester and Liverpool. If the 110 l/person/day target is met in London by 2050, the need for new sources in 2050 is reduced by 134 Ml/d. Outside London in Thames Water's Thames valley zones, achievement of the PCC target by 2050 would save a further 26 Ml/d compared with Thames Water's plan – a total saving of 160 Ml/d.

Affinity Water's assumptions for reducing per capita consumption are also too slow and fail to meet the Government's 110 l/h/d target – the combination of excessive planned population growth and inadequate PCC reduction inflates the deficit by about 120 Ml/d by 2075.

Evidence for the inadequacy of Thames Water and Affinity Water's plans for PCC reduction is in Appendix F.

Future leakage reductions

Most of Thames Water's proposed leakage reductions are in London, where the planned reduction is 60% and well ahead of the Government's 50% reduction target. However, Thames Water's proposed leakage reductions in the zones outside London are all well short of the 50% target, including just 14% in SWOX zone. Outside London, the planned leakages in 2050 are still in the range 90 to 135 l/property/day and far higher than the typical 40 l/property/day planned elsewhere in the South East. GARD proposes that leakage in zones outside London should be reduced to 40 litres/property/day by 2050 to be in line with the leakages planned by other SE water companies. This would give a total saving of 74 Ml/d in the zones outside London compared to Thames Water's plan.

Evidence for this is given in Appendix G.

Affinity Water's planned leakage reduction falls 3% short of the Government target of 50% reduction by 2050, relative to a 2017 base leakage, equivalent to a 5 Ml/d shortfall. This is relatively insignificant.

The need for the Thames to Southern transfer

In GARD's opinion the Thames to Southern transfer is not needed. The primary drivers for the scheme are the perceived need to reduce groundwater abstractions in the upper Itchen and Test valleys and the removal of lower Test and Itchen drought orders from Southern Water's drought plan. The CaBA report on abstraction reductions as a % of catchment recharge concluded that no abstraction reductions were needed in the upper Itchen and Test valleys. The drought orders would only rarely give substantial reductions in abstractions and it is hard to see how the occasional benefits could justify the huge c.£2 billion cost of the scheme. **GARD proposes that the Thames to Southern transfer should be abandoned at Gate 2 due to its minimal benefit and disproportionate cost.**

Evidence to justify the abandonment of the Thames to Southern transfer is given in Appendix H.

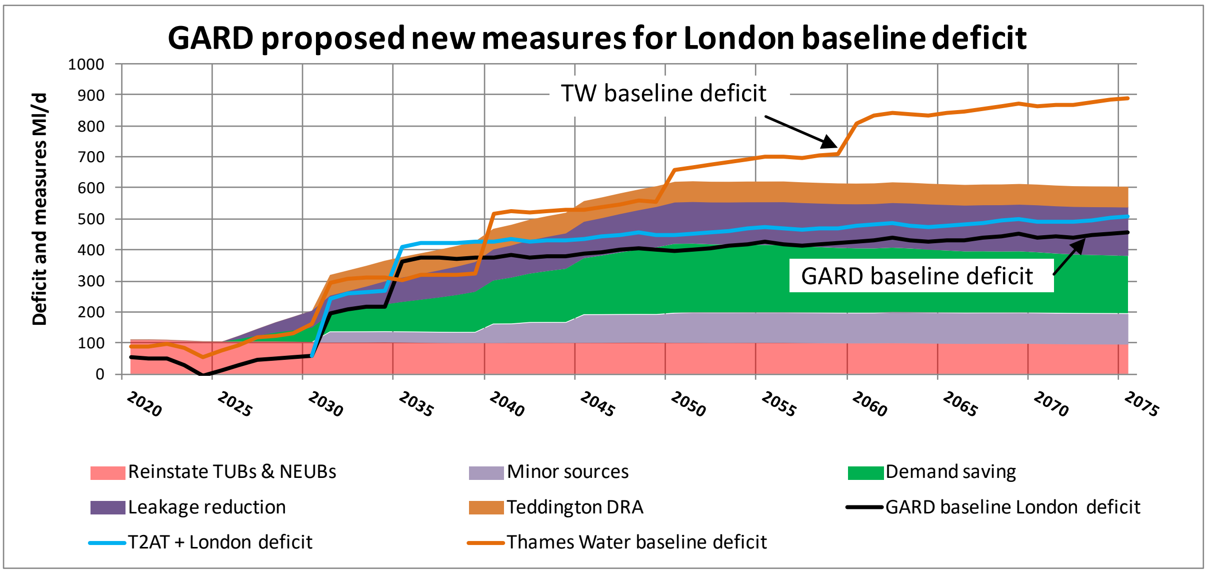
The need for the Thames to Affinity transfer

In our response to Affinity Water's WRMP, we showed that all their needs to 2075 could be met by a 50 Ml/d Thames to Affinity transfer combined with the Grand Union Canal transfer and metering to achieve the Government's 110 l/p/day PCC target. GARD proposes that the 50 Ml/d transfer should be brought forward to the early 2030s, connecting Affinity Water to the reservoirs in Thames Water's London supply system. This would allow all the planned upper Colne/Lea chalk stream reductions to be in place by the early 2030s. Supporting evidence of the need for only 50 Ml/d of Thames to Affinity transfer is given in Appendix I.

The Chalk Streams First report on re-naturalising chalk stream flows showed deployable output recovery should be around 60% of the abstraction reductions and not the 17% assumed in Thames Water and Affinity Water's plans. This substantially reduces the Thames to Affinity transfer's net demand on London's supply system. GARD recognises that there is uncertainty in the amount of deployable output recovery and suggests that an insurance against recovery being less than expected should be provided by introduction of drought support schemes in the upper Colne and Lea chalk streams similar to the existing West Berkshire Groundwater Scheme.

Thames Water's need for new supply sources

Details of GARD's reassessment of measures needed to meet the re-appraised baseline deficits are given in Appendix J. The measures needed to meet the re-appraised London baseline deficit are illustrated below:



Notes: 1. London leakage reduction, reinstatement of TUBs and NEUBs, minor sources and Teddington DRA are all as per the current Thames Water draft WRMP

2. Demand savings assume compliance with the 110 l/person/day PCC target

3. The GARD re-appraised London baseline deficit is as described in Section 2.2 of this response

Figure 1 - GARD proposed measures for re-appraised London baseline deficits

GARD's analysis, with no allowance for chalk stream flow recovery, shows that neither Abingdon reservoir nor the Severn to Thames transfer is required to meet the needs of London and Affinity Water, even bringing forward the 1:500 year resilience to 2035. Without Abingdon reservoir or the Severn to Thames transfer, there would be a surplus of about 150 Ml/d in London's supplies continuously from 2040, if leakage and PCC reduction are on a trajectory to meet the Government targets by 2050. This shows the danger of creating a costly and environmentally damaging white elephant, if a decision to build Abingdon reservoir is made in the current cycle of business planning.

However, GARD recognises that there is uncertainty over the amount and timing of the leakage and PCC reductions. Therefore, it could be prudent to provide extra supply capacity *as early as possible to* give a cushion against accelerating climate change and bring forward the date for 1 in 500 year drought resilience. On that basis, we propose the following schemes should go ahead, even if not strictly needed under our realistic assessment of reduced future needs:

- By early 2030s: the Teddington DRA scheme (67 Ml/d), the first phase of the GUC transfer (50 Ml/d) and the 50 Ml/d Thames to Affinity transfer to allow early chalk stream relief
- By 2035/36: the 1st phase of the 300 Ml/d (pipeline capacity) Severn-Thames transfer and the 2nd phase of GUC transfer, if not included in the first phase GUC transfer

Thus about 300-400 Ml/d of 'over-provision' would be deployed early to 'hedge' against climate change or population growth being substantially higher than the forecasts.

Even with the loss of 35 Ml/d due to the planned reduction in abstractions for filling Farmoor in 2050, there would be a surplus in SWOX zone if the Government's leakage and PCC targets are met. There would be no need for any supply from either Abingdon reservoir or the Severn to Thames transfer.

However, recognising the uncertainty over Thames Water's ability to meet these targets, the early construction of the Severn to Thames aqueduct with at least Netheridge support would provide insurance against Thames Water's failure to meet the targets, as we have proposed for the London zone.

GARD's reassessment shows that no new resources are needed for the Thames valley zones, even with the planned abstraction reductions in the Wey, Enbourne and Misbourne brought forward to 2025-35, as shown in Figure E3 in Appendix E.

Double provision of supply security through inflation of headroom allowances

In addition to the improved security of supply from the change to the 1:500 year resilience standard, the WRMPs include target headroom as a buffer to deal with uncertainty in the supply demand balance. Thames Water's allowances for target headroom are shown in Figure 2:

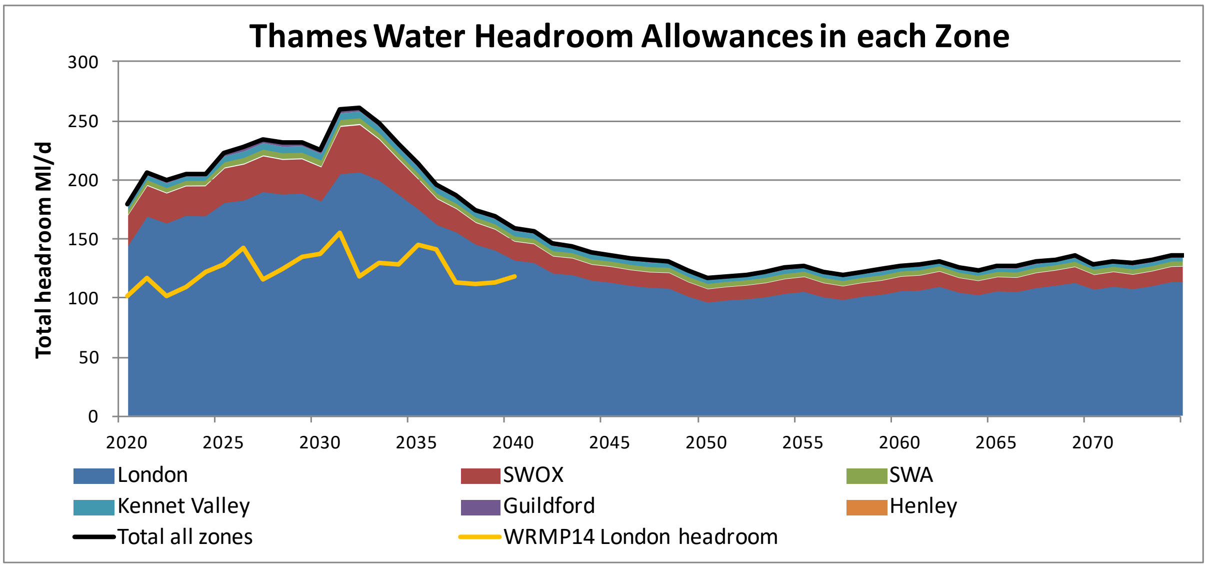


Figure 2 - Target headroom allowances in each Thames Water supply zone

Figure 14 shows the large headroom allowances in the London and SWOX zones, corresponding to about 8% of present deployable output. Figure 14 also shows the London zone headroom allowance in Thames Water WRMP in 2014[2]. This allowance was mostly about 50 Ml/d less than the latest London zone headroom. Moreover, WRMP14 only provided for the 'worst historic' drought, probably about a 1:100 year event, with the possibility of a drought more severe than historic allowed for in the headroom. This was probably the most important component of the headroom prior to adoption of the 1:500 year resilience standard. However, now that the resilience standard has been raised to 1 in 500 years, there is little need for headroom to accommodate the possibility of even more severe droughts.

Therefore, the increased headroom combined with the increased resilience standard, is a double provision of the safety factor against severe droughts. The assumed loss of 266 Ml/d in London deployable output due to the resilience change, combined with an increase in headroom, represents a very large increase in security of supplies to London.

In addition, Thames Water has yet more buffering in its preferred plan through:

- Assumption of the 'High' scenario for losses of DO for environmental improvements
- Assumption of the 'High' population growth scenario
- Assumption of the 'High' climate change scenario
- Assumption of downgrading of Gateway desalination plant output from 150 Ml/d to 100 Ml/d throughout the planning period
- Assumption of inability to meet the Government's 110 l/p/day PCC targets
- Lack of any attempt to meet the Government's 50% leakage targets outside London

Overall, this represents a huge over-provision of safety margins in Thames Water's plan. This should all be taken into account by Ofwat in considering the justification of the need for Strategic Resource Options and the danger of building costly and environmentally damaging replacement sources.

2.4 Selection of the first major new source for development

If a major new source is needed for the South East, a decision will need to be made on which comes first – Abingdon reservoir or the Severn to Thames transfer. The water company WRMPs all appear to have decided that Abingdon reservoir should be the next major source development. However, minimal evidence is presented to justify this decision, instead referring to work done by WRSE, for example in Thames Water's WRMP[3]:

> *"The WRSE investment model considered costs across all nine future pathways and delivery of the 150Mm3 SESRO option in 2040 was given by the model as the lowest cost solution when considering the nine future pathways."*

[2] Thames Water WRMP14 tables London zone Final Plan Supply worksheet
[3] Thames Water WRMP24, paragraph 11.56, 3rd bullet

WRSE's non-statutory regional plan page 29[4] says:

> "*Our work shows both SESRO and STT are needed but the reservoir is a better first option. This is because the reservoir has lower running costs. The plans with the reservoir developed first are less expensive and have lower carbon emissions."*

And also on page 29:

> *"For the reported pathway, a plan without SESRO would cost £500 million more than the best value plan and have significantly higher carbon costs."*

We can find no further justification anywhere in WRSE's main report or technical annexes. There is simply no cost information supplied. Even a 1566-page technical annex titled "*Investment model draft regional plan results*" and an 83-page technical annex titled "*Option Appraisal*" are totally devoid of costs of options and there are no cost comparisons presented as evidence to show the supposed lower cost of Abingdon reservoir.

Although there is now a fair amount of cost detail available in the Gate 2 reports for the strategic options, there are no option cost comparisons to justify the selection of options and their sequence of development. These comparisons might be expected to be prominently available in regional plans and the WRMPs, but there are none to be seen. ***This is a major failing in transparency which needs to be addressed in Gate3.***

We propose that Ofwat should specify that the Gate 3 activities should include a transparent, evidence-based appraisal of which comes first, the Severn to Thames transfer or Abingdon reservoir. This should include transparent and detailed cost and carbon comparisons that consider the range of actual operational use that might be needed, bearing in mind that the main driver for any new major scheme is insurance against failure to meet leakage and PCC targets, and more extreme climate change scenarios.

The transparent justification of the choice between Abingdon reservoir and the Severn to Thames transfer should be undertaken jointly by the water companies as part of the statutory WRMP process under the supervision of Ofwat. It should not be left to WRSE which lies outside the statutory WRMP process.

[4] https://www.wrse.org.uk/media/va1bz21z/10306a_wrse-bv-plan-2022final_online.pdf

3. Abingdon reservoir

3.1 Overall assessment of Abingdon reservoir Gate 2 reporting

Ofwat have described the quality of the Gate 2 report on Abingdon reservoir as *"a good submission that meets expectations of gate two"*[5]. Their assessment against various criteria is shown below (copied from Figure 3 in Ofwat's report):

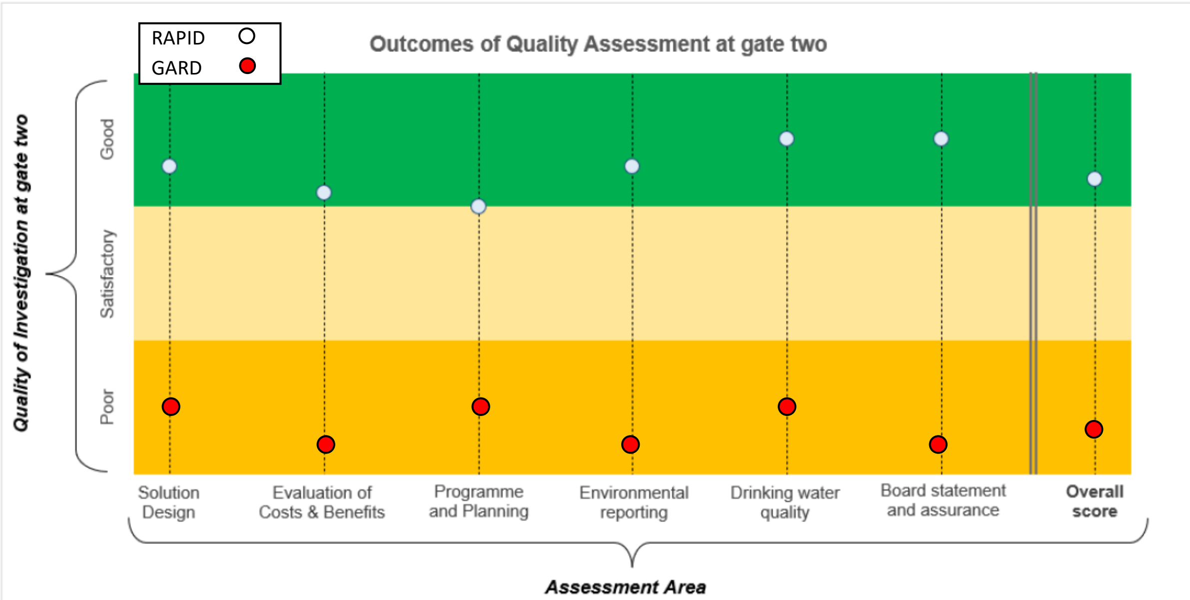


Figure 3 - RAPID and GARD quality scores for Abingdon reservoir Gate 2 report

We strongly disagree with Ofwat's assessment, marking the Gate 2 report as poor in all the assessed categories, as shown in Figure 3. In the following sections, we have provided brief comments on each of these categories, with supporting evidence in Appendices.

3.2 Abingdon reservoir solution design

Ofwat's Gate 2 decision report comments on the design as follows[6]:

> *"We consider Thames Water and Affinity Water to have provided sufficient evidence of progress in developing the solution design for gate two; SESRO solution design meets gate two requirements. Interactions with other solutions is well described.*
>
> *However, the submission is focused on the 150Mm^3 option, despite a 100Mm^3 option having been selected through best value planning. The 150Mm^3 option is very well developed, with a master plan as well as comprehensive infrastructure requirements. If a 100Mm^3 option is taken forward, it will need to be developed to the same standard so that appropriate environmental assessment can be undertaken."*

From this, it appears that Ofwat have not reviewed the technical aspects of the design

[5] Ofwat Gate 2 Report on SESRO, page 11
[6] Ibid, page 12

which we consider to be inadequate for the reasons given in the following sections.

3.2.1 Embankment design

The embankment forming Abingdon reservoir would be up to 10km long and 25m high, with around 40 million m^3 of clay fill, drainage layers and upstream riprap. In terms of fill volume, it would be by far the largest embankment dam ever built in the UK. Earth fill embankment dams are technically difficult to design and construct, particularly homogeneous clay embankments like that proposed for Abingdon reservoir, being prone to instability problems due to the difficulty of controlling the moisture content of the clay fill. The most recent major earth dam built in UK, Carsington dam, failed during construction[7] [8] and is a reminder of what can go wrong. Thames Water's London reservoirs have had to have reduced deployable output arising from restrictions on their rate of filling due to embankment instability problems[9]. The 10km length of the Abingdon reservoir embankment makes this type of problem more likely.

The Gate 2 concept design report (CDR) conveys no sense of appreciation of the technical difficulty and risk associated with design and construction of the embankment. It contains minimal information on the design of the embankment. There is a sketch plan showing the location of the reservoir in relation to surrounding villages (CDR Figure 1.1) and sketch cross-sections of the embankment and borrow pit (CDR Figure 2.1). There is recognition that design and construction has to meet the provisions of the Reservoirs Act 1975 and has to be supervised by an "All Reservoirs Panel" engineer appointed by the Secretary of State. There are general statements about the need for drainage layers and upstream wave protection, but only at basic text book level.

However, there is no evidence in the CDR report that the crucial geotechnical design of the embankment and its foundations has been addressed in any meaningful detail. It may be that more design detail is available, but not revealed for reasons of security, but there is no indication of this in the Concept Design Report.

All dams leak to some extent and require drainage systems to collect and safely lead away the leakage. Although the CDR report refers to drainage layers, there is no estimate of the amount of leakage. In an embankment 10km long, the amount of leakage could significantly reduce deployable output. This is not addressed.

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[7] Carsington dam reconstruction https://www.ice.org.uk/what-is-civil-engineering/what-do-civil-engineers-do/carsington-dam-reconstruction

[8] Carsington dam failure, Skempton & Vaughan, ICE Geotechnique, 1994 https://www.icevirtuallibrary.com/doi/pdf/10.1680/geot.1995.45.4.719

[9] Thames Water response to GARD queries on WARMS modelling , C:\Users\L1TAIT\Documents\WR Stakeholder Engagement\GARD\Thames Water Response to GARD WARMS2 Queries 130215.docx

The CDR report makes no reference to plans for a trial embankment before finalising the design and start of construction. This is normally standard practice for embankment dams. For example, even for the much smaller planned Havant Thicket reservoir[10], Portsmouth Water is currently building and testing a trial embankment. This should be progressed in Gate 3.

3.2.2 Dead and emergency storage allowances

In our main response to the consultation on Thames Water's WRMP24, we proposed that the planned 6% emergency storage allowances for Abingdon reservoir should be increased to be in line with the emergency storage allowance in other major UK reservoirs[11]. It is also vital that all of the water in emergency storage should be of sufficiently good water quality to be useable, recognising the increased threat of algal blooms and poor reservoir water quality in severe droughts, especially with climate change.

Therefore, we propose that the allowances for dead and emergency storage should be:

- Dead water should be based on an average residual water depth of 5m, not an average depth of 2.5m as proposed by TW
- Emergency storage should be 15% of live storage to be in line with Llyn Brianne, Clywedog and the Welsh Dee regulating reservoirs

With these proposals for dead storage and emergency storage, GARD's modelling shows that the deployable outputs for the 150 Mm^3 and 100 Mm^3 reservoirs would reduce by 44 Ml/d and 25 Ml/d respectively.

Our evidence to support this is in Appendix K, based on extracts from an Addendum to GARD's response to Thames Water's WRMP consultation, following late receipt of requested information on Pywr modelling.

The issues surrounding dead and emergency storage have been raised previously by GARD, for example in a letter to RAPID dated 19th August 2020 (copy in Appendix A) and in slides presented in a meeting on 22nd October 2020 between Mr Paul Hickey of RAPID and GARD's consultant, Mr John Lawson (copy of slides in Appendix A). We would, therefore, have expected that this would have been serious consideration in Ofwat's Gate 2 decision report

The amount of dead and emergency storage has a profound effect on the viability of Abingdon reservoir, both in terms of its deployable output and for the water quality within the reservoir and released into the River Thames during droughts. It is, therefore, disappointing to find no reference to it in Ofwat's Gate 2 decision. We recognise that Ofwat's Gate 2 decision requires some further work on reservoir water quality in Gate 3, as below:

> *"We expect to see further monitoring for emerging contaminants of concern and a*

[10] https://www.geplus.co.uk/news/havant-thicket-reservoir-project-makes-progress-on-trial-embankment-13-04-2023/
[11] GARD response to consultation on Thames Water's WRMP, Section 4.2.3, page 71

programme of work to review risks around reservoir mixing and thermal stratification."[12]

"Drinking water quality: Provide a programme of work to clarify the review and mitigation of the reservoir's mixing and thermal stratification risks."[13]

However, these actions appear to refer to general issues of water quality in the reservoir and they do not address the specific issue of water quality in the "dregs" of the reservoir at the end of an extreme drought, when the depth of water in the lake will be less than the 5m depth that Thames Water themselves say is the minimum needed for adequate water quality (see Appendix K, first page).

Ofwat's Gate 2 report makes no reference to the adequacy of the emergency storage provision or to substantial loss of deployable output if the emergency storage is increased to amounts comparable to the provisions in other major UK reservoirs. We will comment further on this in Section 3.3.1 of this response.

3.2.3 Design of the height of the Freeboard

Figure 2.1 of the Gate 2 Conceptual Design Report shows Reservoir cross sections and indicates that the crest of the reservoir will have the following characteristics:

Crest 8m wide with cycle/footpath, low
wave wall available for seating. Crest level
1m higher than maximum water level.

GARD believes the height of the crest above maximum water level is too low. This opinion has also been expressed by ex-Reservoir Panel engineers to whom we have shown the design. GARD made an analysis of the Freeboard Height using available references, and this was submitted to Thames Water in our dWRMP24 response.[14] This response is attached to this document as Appendix L, which gives the details behind our figures quoted below.

GARD used the design advice document from HR Wallingford relating to reservoir crest design.[15] In common with other sources, the design recommendations cover design against overtopping in a period of subjection to the "*50-year wind*", ie the wind conditions expected (from historical measurements) to occur once in every 50 years. At present, there are no clear predictions from climate change models about the frequency of high winds, so we adopt this standard. There are (SR459, equation 2.3) factors to apply to the wind values according to:

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[12] Ofwat Gate 2 decision report, page 14
[13] Ibid, Appendix A page 22
[14] https://www.gard-oxon.org.uk/downloads/21.3.23%20GARD%20response%20to%20TW%20WRMP%2021.3.23.pdf, section 4.5.5
[15] *Reservoir Dams: wave conditions, wave over-topping and slab protection,* A J Yarde, L S Banyard and N W H Allsop, HR Wallingford report SR459 (1996)

- the '*fetch*' or distance over open water of the wind before it reaches the retaining wall (as wind speeds up over open water) – a significant quantity for Abingdon reservoir, as there are distances of around 2.5 km or more over open water in the 100 Mm^3 version, and longer for the 150 Mm^3reservoir;
- the '*duration*' of the wind speed (20-30 mins is considered appropriate for reservoirs – the wind speed map being quoted as averaged over one-hour) – shorter durations give higher waves;
- the '*altitude'* of the reservoir (wind speed maps are at ground level);
- the '*repeat time*' of the significant wind (we take 100 years as reasonable considering the reservoir lifetime, but this only results in a 5% increase);
- the *'direction'* of the prevailing wind, relative to the measurement direction (relative to 240°, or WSW) – this is irrelevant for an 'all-round embankment like Abingdon.

The combined effects of these factors is to change the relevant wind speed for Abingdon from 20 m/s to 27 m/s.[16] This feeds into calculation of the *significant wave height* for Abingdon. The significant wave height becomes (see Appendix L) $H = 0.67m$

SR459 considers that a factor for '*no wave surcharge carry over'* of 1.67 should be applied to the significant height giving a wave design height of 1.15 m This value can be lowered by facing the run up with rip-rap (as in the Abingdon Conceptual Design) and, for a 1 in 6 slope (as CDR) with rip-rap a factor of 0.6 is used (figure 3.1 of SR459) leading to a final wave design height of H_D = 0.69 m.

If we take from SR459 the value for 'safe' overtopping of the wall as 2 l/s/metre wall length, ***we derive from H_D a freeboard height of around 1.5 m.*** (again details in Appendix L). This still seems low, but is higher than the CDR value, which relates to a larger sized-Reservoir of 150 Mm^3. Our figures have been established in technically correct, albeit relatively simple fashion.

We believe that Thames Water and its partners need to publish the calculations behind their selection of a 1.0m high crest, and that this should be assessed by independent experts at Gate 3.

3.2.4 Dam Break analysis and Emergency evacuation/drawdown

The *Likelihood* of a major fault developing in a dam wall constructed under modern practice is regarded as '*unlikely' or 'rare',* but nevertheless given the *high impact* of such a fault, the *Risk* (as usually evaluated as a 'product' of *Likelihood x Risk*) has to be evaluated, and there

[16] This corresponds to the upper end of Storm Force 10 on the Beaufort Scale. It is somewhat higher (10-20%) than the *mean* inland wind speeds recorded in the south-east in the October 1987 Storms.

is an obligation for owners proposing to build dams to establish the effects of a major catastrophic breach on the local population and infrastructure. Dams are classified as '*High Risk*' in the relevant legislation[17] if they have an above-ground volume of greater than 10,000m^3. In this case the process has to involve the provisions of the Reservoirs Act of 1975. The 100 Mm^3 Abingdon Design has an above-ground water volume of at least 67 Mm^3 (taking the Thames Water quoted 'borrow pit' in the Conceptual Design), so it clearly is a '*High Risk*' facility within the terms of the Act.

GARD believes that, given the 25-year history of the Abingdon Reservoir proposal, the Risks of a major dam breach should have been analysed long ago, and presented for expert assessment.

We believe that the production and assessment of this Risk should be evaluated by RAPID, using independent experts, in a transparent way, BEFORE there is any progression of the Reservoir SRO to Gate 3, via an interim checkpoint.

In the absence of any presented analysis by Thames Water, GARD employed the formulae and procedures in the Defra advice on assessing safety on 'small dams'[18] (<25,000m^3 as defined in Defra's methodology), from which formulae and procedures can be used to scope out the situation for larger dams. GARD has employed these formulae and procedures to give an assessment of the area and severity of damage for a catastrophic dam wall breach (as defined in Defra's methodology).The details were submitted to Thames Water in the GARD response.[19] The relevant section is attached as Appendix M.

There are special issues which make the Abingdon reservoir a higher-than-normal safety hazard regarding reservoir-wall breach are:

- the much longer perimeter impounding wall of this reservoir (around 8.7 Km for the Abingdon 100 design) compared to most impounding wall dams[20];
- the size of the above-ground water volume compared to the majority of reservoirs, exacerbating the length of emergency drawdown, and emergency evacuation period;
- the issue of accelerating climate-change and its rising temperatures on the micro-fissure creation in the embankment;

[17] https://assets.publishing.service.gov.uk/media/603390fc8fa8f54334a5a673/small_reservoirs_simplified_risk_assessment_methodology_guidance.pdf
[18] https://assets.publishing.service.gov.uk/media/603390fc8fa8f54334a5a673/small_reservoirs_simplified_risk_assessment_methodology_guidance.pdf
[19] https://www.gard-oxon.org.uk/downloads/21.3.23%20GARD%20response%20to%20TW%20WRMP%2021.3.23.pdf sections 4.5.3
[20] Most earth dam wall reservoirs have only a front wall of only 400-500m. Even the only other comparable size reservoirs (Kielder and Rutland Water) have impounding walls of around 1 km length.

- the relative proximity of some surrounding communities, especially when one considers the '*all-round*' nature of the possibility of a breach

GARD's calculations are still in a relatively simple form, and are not suitable to produce detailed maps of the calculated flooding/damage/fatalities. However, we note our main conclusions from (Appendix M - Appendix M1 section) are[21]:

1. Several locations are at '*High Risk*' from a breach. These locations are the 'perimeter communities' nearest the reservoir crest (the edges of Steventon, East Hanney and the South Drayton houses south of the A34).

2. Many locations can be defined as safe from either flood or damage, by simple equations considerations and on examination of the area contour map. Most of this safety arises because of the inability of even catastrophic flood to flow a significant distance 'uphill'.

3. There are areas labelled as '*Medium Risk*', or '*Flood risk*' (the latter without fatality). These are, in general, communities at a greater distance than the peripheral communities, but where the water from a breach in general will flow 'downhill'. For such communities, given the duration of the flow from a catastrophic breach (over 3 hours) we believe flooding, albeit without high damage, cannot be ruled out.

4. Finally, there is a very significant set of communities where the flood water will have to flow via the River Ock and into the Thames. Appendix M makes comments about these (South Abingdon, Culham, Sutton Courtenay, Appleford). These communities will almost certainly be in the flood-affected zone, but the flow situation, with curved trajectories, and with gravitational acceleration of the flood fighting against a complex friction force slowing over variable terrain and through built-up areas, is simply too complex for the models used in Appendix M.

The communities covered in paras 1,3 and 4 above will almost certainly lie in the Reservoir Flood Risk Area, as defined in the EA's maps.[22] It is these areas which would have to be evacuated in the event of a major fault being detected. Such an event happened in the case of a much older earth dam at Whaley Bridge, Derbyshire[23] in 2019. The 1500 population of the town of Whaley Bridge spent 6 days out of their homes whilst the threatened breach was made safe.

Appendix M gives the communities in the 'long list' in danger of some level of flooding or damage from a major breach somewhere around the 'Abingdon 100' perimeter, would include Steventon, East Hanney, Drayton, Marcham, Milton, parts of South Abingdon,

[21] Definitions of '*High', 'Medium'* and *'Flood'* Risk are given in Appendix J, where it will be seen that High Risk involves significant fatalities
[22] https://check-long-term-flood-risk.service.gov.uk/map
[23] https://www.bbc.co.uk/news/uk-england-derbyshire-53580768

Culham, Sutton Courtenay and Appleford.

All the communities listed in the 'long-list' are expected to be in a potential Flood Risk Area. Flood zones for major reservoirs can be very extensive. The example of Rutland Water is shown in Appendix M.

The evacuation duration for a community threatened by the major breach would be potentially long (the Whaley Bridge episode lasted much longer than anticipated). At an emergency drawdown rate of 1 m per day, as quoted above, it would take 10-15 days to bring the reservoir water level to something which could be regarded as safe. Thus, in the worst case, 10-20,000 people would have to be provided with emergency accommodation for up to a fortnight. **GARD is calling for a full assessment of the Flood Map to be made at an interim checkpoint before the reservoir is allowed to pass through to RAPID Gate 3.**

As described in Appendix M, we note that the amount of water passing through the pipes in an emergency drain-down is around 63 m^3/sec, assuming a 1 m per day drawdown of the 100 Mm^3 reservoir, which is more than the natural flow-rate of the Thames at Sutton Courtenay for about 85% of the year.[24] Thus, the flooding effect of the Emergency Drain-down itself needs evaluation at this stage.

Emergency drawdown itself is not an easily solved problem for a reservoir as large as Abingdon 100 or 150. Appendix M shows how it took 40 years after its construction to solve the emergency drawdown system for Rutland Water.[25] The emergency drawdown of one of the most modern dams in England was inadequate for at least 40 years. This shows the dangers of not considering the safety systems at an early stage.

3.2.5 Terrorism as a threat to the reservoir security

The issue of a terrorist threat to the reservoir, as to all water infrastructure, is not something that should be taken lightly. One would expect Thames Water to have sought advice on this from the relevant authorities, even at this stage. Whilst one might not expect the advice to be made public, there are nevertheless aspects which one would expect to see informing the Conceptual Design, even at this stage. The most important of these aspects, from the point of view of Thames Water trying to paint the reservoir as part of a 'Best Value Plan' relate to the effect on visitor access to the reservoir site, something which figures heavily in Thames Water's attempts to attribute positive '*Natural Capital*' outcome to constructing the reservoir. As was admitted in the RAPID Gate 1 documents for the

[24] https://nrfa.ceh.ac.uk/data/station/meanflow/39046

.[25] https://britishdams.org/2012conf/papers/Construction-newdamsandupgrades/Papers/6.6%20Tam%20-%20Improving%20Anglian%20Waters%20emergency%20response%20for%20reservoir%20safety.pdf - references therein.

Abingdon Reservoir[26]:

> *"The reported positive change in natural capital value is primarily due to the significant increase in Recreation value expected for the site, which outweighs the decrease in ecosystem value of food production – although improvements in all the other services are also reported in comparison to the baseline, without recreation they are insufficient both alone and in combination to outweigh the loss in Food production value;"*

The positive Natural Capital assessment is essential to the Best Value argument, and even more to Thames Water's attempts to spin a positive view of the reservoir (always seen in juxtaposition with pictures of sailing boats).

GARD has taken advice from an expert in counter-terrorism issues relating to Infrastructure. Although this briefing is 'off the record', we included an outline as part of GARD's Thames Water response. This is attached as Appendix N.

GARD believes that an expert evaluation of the issues of terrorist threat to the reservoir should be made at Gate 3, and that this should be shared with people at an appropriate level of security clearance/ responsibility. This cohort should certainly include local officials and elected representatives.

3.2.6 Flooding Safety

The Gate 1 report on Abingdon reservoir claimed that the latest flood modelling showed the reservoir would lead to a reduction in flood risk for Abingdon.[27] It is difficult to see how this could be the case, particularly as Thames Water had not (and still have not) released this modelling. In the Thames Water WRMP19 submission back-up reports, the reservoirs above 75 Mm^3 size received 'Red' ratings[28] as it was stated there was insufficient flood storage area on the reservoir site to compensate for the loss of floodplain.

An examination of the Gate 2 reports show that the situation has not moved forward significantly, in spite of local calls for a rigorous examination of flood-risks. This is of course, mainly the fault of Thames and Affinity Water, but is also just one example of the lack of response by RAPID to stakeholder concerns.

The real problem, of course, is that there is still an approach, even at this stage where a 'conceptual design' is claimed, that is dominated by modelling. As the '*Conceptual Design*

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[26] https://www.thameswater.co.uk/media -library/home/about-us/regulation/water-resources/strategic-resource-solutions/new-reservoir-in-oxfordshire/environmental-assessment-report.pdf – sect 11.1.5, p 163

[27] https://www.gard-oxon.org.uk/downloads/july%202021%20-%20gate-one-submission-sesro.pdf – downloaded November 2021.

[28] Thames Water WRMP19 Resource Options. Reservoir Feasibility Report, Appendix V, July 2017 – but re-released July 2018, Thames Water Utilities Ltd . Appendices R, S and T

Report' says (para 4.30 and 4.31)[29] :

> *"To allow updates to the fluvial flood modelling in Gate 3 it is recommended that a topographic survey along the main watercourses is carried out. This would include sections of the River Ock and key tributaries that are within the model extent. River gauge flow monitoring at selected locations across the model extent is also recommended.*
>
> *A range of flood return periods and durations would need to be considered in the Gate 3 modelling. Therefore, the basis for the hydrology should be agreed with the Environment Agency. This would also include for potential future changes to climate change uplifts*."

Further down, on *Groundwater Flood effects*, the CDR admits[30] (para 4.35):

> *"There is considerable uncertainty in the conceptual understanding of groundwater flows and hence the modelling that has been undertaken to date, which is not informed by observation data."*

The report suggests many sets of measurements to undertake. GARD obviously supports the gathering of data, and does not believe that the models being used will be believable unless they are validated by data. We are however, *very late* in this process. We are 25 years into the proposal of the Abingdon Reservoir project, including an examination at a Public Inquiry in 2010, at which these matters were raised and criticised. **In GARD's view, the Abingdon Reservoir project should NOT proceed to Gate 3 without an interim expert examination of modelling validated by acquired data.**

Lack of data does not stop the Abingdon Reservoir proposers making tendentious claims for the Reservoir's '*potentially beneficial*' effects on both Fluvial and Groundwater flooding. That these are either still to be validated, or can be shown to be negligible, does not stop them being fed-through in 'sound-bite' form to Environmental Assessment documents (and hence into the 'brochure-style' documents which the public see).

Although the main Abingdon Reservoir Gate 2 document[31] cites (para 4.24) assessments of fluvial flooding using Environment Agency 'River Ock' models, the details are absent, in spite of a reference that they can be found in the Gate 2 Appendix 1 technical document,[32] there are precious few details. We address these claims in Appendix O. In summary:

[29] Thames Water and Affinity Water. South East Strategic Reservoir Option (SESRO) Supporting Document A-1: Concept Design Report (2022) "CDR" paras 4.30 and 4.31

[30] CDR para 4.35

[31] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/SESRO-Gate-2-Main-Report-FINAL.pdf para 4.24

[32] Thames Water and Affinity Water. South East Strategic Reservoir Option (SESRO) Supporting Document A-1: Concept Design Report (2022);

1. The severe fluvial floods in the area have a 1 in 60 year (NOT 1 in 100 year as assumed) frequency, even without climate change, and in the last two major events (1947 and 2007) the rainfall fell over a huge catchment area, of which the reservoir surface area forms only a small part.

2. The cited flooding study of the River Ock (1 in 100 year) seems to yield increased Ock flows which are somewhat lower (perhaps 10-15%) than can be inferred from the *recorded* behaviour of the Thames in the 2007 flood (the 1 in 60 year flood in the area). A lower flood flow from the Ock results from the model with the Reservoir in place. This is attributed to the rainfall caught by the Reservoir on the surface area within its bunds, which is removed from the Ock flow. Plausible numerical back-up is provided by the model for this hypothesis, but *this only works if the rainfall falls on the area uniformly including the reservoir surface.* If the bulk falls (as is often the case) in the part of the catchment closer to the downs and upstream of the watercourses crossing the Reservoir area, then this mechanism would be inadequate, and worse flooding could very well result.

3. With the Reservoir present there would be the additional water source of run-off from the bunds (mentioned in the Abingdon Reservoir Environmental Report in 2021). Such run-off from a similar height hill above Steventon copse was one of the principal sources of flooding in the 2007 incident in Steventon. This should be modelled to establish whether the run-off phenomena encountered in the 2007 floods would be exacerbated by the Reservoir presence.

4. The Main Gate 2 Report perpetrates further completely over-optimistic assertions. For instance, in para 4.30,[33] it mentions the 'opportunity' of:

   - *"Changing the operating protocols of the [reservoir operation] scheme, to abstract during peak flood periods to help attenuate the downstream flood hydrograph"*

   but almost immediately has to admit that:

   - *"Modelling suggests that this alternative pumping arrangement could result in a reduction of up to 550 Ml/d (2 −2.5%) to the peak of large floods at Culham".*

   This negligible effect can easily be seen for, eg. the 2007 flood. The Thames flow at Culham reached (see Appendix O) values of 192 m^3 /sec.[34] This is to be compared with the maximum pumping capability of the Abingdon Reservoir of 1000 Ml/day (ie. 11 m^3/sec). The Thames flow exceeded 100 m^3/sec for 11 consecutive days, by which time over 1 billion litres of turbid, low-quality water would have been pumped by the Reservoir with knock-on consequences.

[33] SESRO Gate-2-Main-Report-FINAL pata 4.30
[34] https://nrfa.ceh.ac.uk/data/station/liveData/39046

5. On *Groundwater Flood effects*, we observe it is completely unsatisfactory to admit to:

   - *"…considerable uncertainty in the conceptual understanding of groundwater flows and hence the modelling that has been undertaken to date, which is not informed by observation data."*

   We have to repeat that this is after 25 years of project proposals. All the issues were aired at the 2010 Public Inquiry and Thames Water (which had arranged access to the area before then) should have answers[35]. Their modelling says (para 2.101 of Conceptual Design Report)[36]:

   - *"Limited impacts on groundwater levels are expected at Steventon, East Hanney and West Hanney; however, the preliminary modelling indicates that the presence of the reservoir may lead to an increase in groundwater levels around Drayton. Further model development and investigation into the impacts to the east of the reservoir will be undertaken at Gate 3 as more data is collected and becomes available to inform the modelling*."

We have no confidence in an assertion of 'limited impact' by Thames Water, and the word limited is not even used for Drayton. **GARD calls for the data collection to inform this modelling to be put in place at the earliest opportunity and for a full examination of the validated modelling to occur BEFORE the Abingdon Reservoir is allowed to proceed to Gate 3.**

3.3 Evaluation of costs and benefits

3.3.1 Abingdon reservoir deployable output and drought resilience

The Gate 2 reporting on costs and benefits of Abingdon reservoir have been assessed by Ofwat as 'good', as shown on Figure 3. The benefits include the deployable output and drought resilience of the reservoir. In GARD's opinion, the water companies' Gate 2 reporting on these aspects is extremely poor for the reasons described in this section.

GARD's response to the consultation on Thames Water's draft WRMP24 was incomplete for various topics that were dependent on receipt of Thames Water's new Pywr model output, which were requested through EIR-22-23-390 on 12th December 2022. The requested data were not received in full until 22nd March 2023, the day after Thames Water's WRMP consultation closed. Therefore, GARD prepared an Addendum to their consultation response, which was submitted to Thames Water on 2nd May 2023. The Addendum covered the following topics:

[35] There is a very worrying trend in evidence here, that Thames Water appear to have no mechanism for retention of expertise and knowledge gained from previous investigations.
[36] CDR para 2.101

- Review of validation of Pywr and GARD modelling, using previous Thames Water's previous WARMS2 modelling as a benchmark
- Review of validity of stochastically generated river flow data
- Review of Abingdon reservoir deployable output (DO) and drought resilience
- Review of Severn to Thames Transfer (STT) deployable output

These are all matters that have a fundamental bearing on the viability of the proposed Abingdon reservoir and its selection as the first major new source to be developed, ahead of the Severn to Thames transfer. The findings have a material effect on the validity of Ofwat's decisions on the Gate 2 reports and the proposals for Gate 3. Therefore we have included the Addendum as volume 2 of this response and request that Ofwat considers it as an integral part of our response to their Gate 2 decisions. We have summarised the Addendum findings in this section of our response.

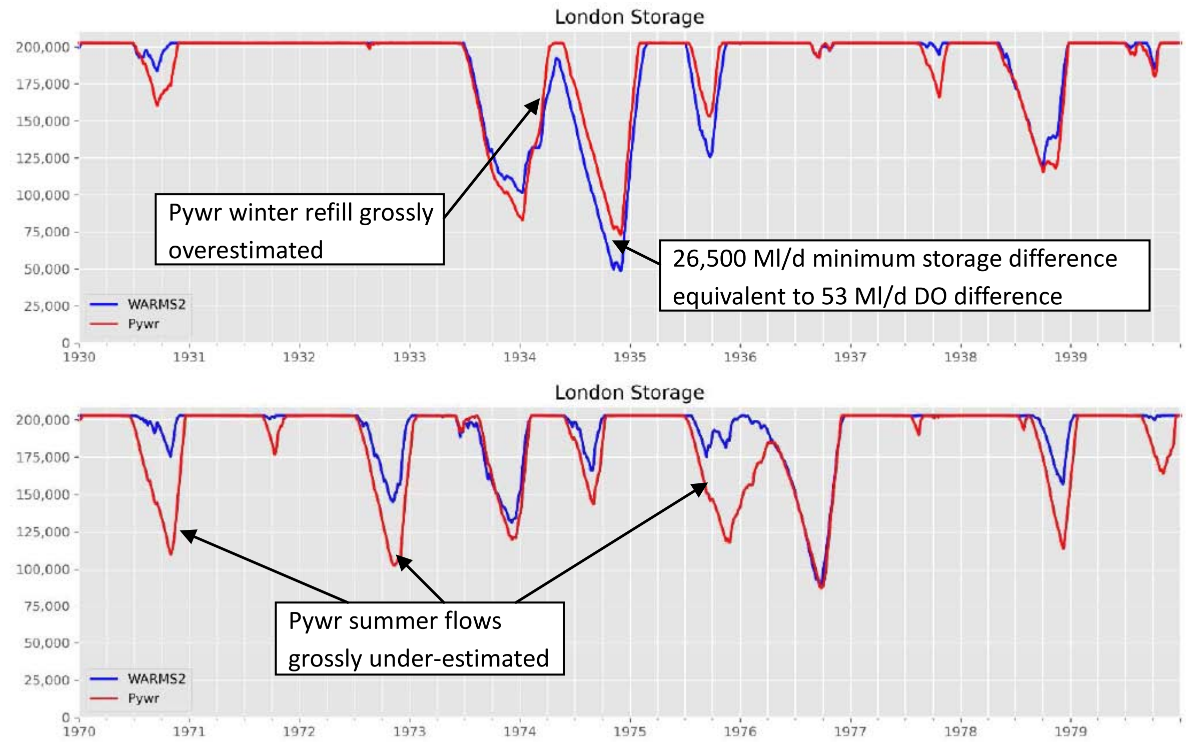
Validity of stochastic river flow data and Pywr modelling

In our opinion, the stochastic river flow data and Pywr modelling are not fit for the purpose of assessing the deployable output and drought resilience of Abingdon reservoir. The deficiencies are:

1. The mis-match between Pywr modelling and Thames Water's WARMS2 modelling of the London supply system, when simulating its performance in the major droughts of the past 100 years using historic weather data.

2. The inability of the 19,200 years of stochastically generated river flows to include long duration droughts of the type in which Abingdon reservoir has poor resilience.

In critical droughts there is a very poor match between WARMS2 historic simulations and Thames Water's Pywr output when it uses different historic flows from the same hydrological model that generated the 19,200 years of stochastic river flow data:



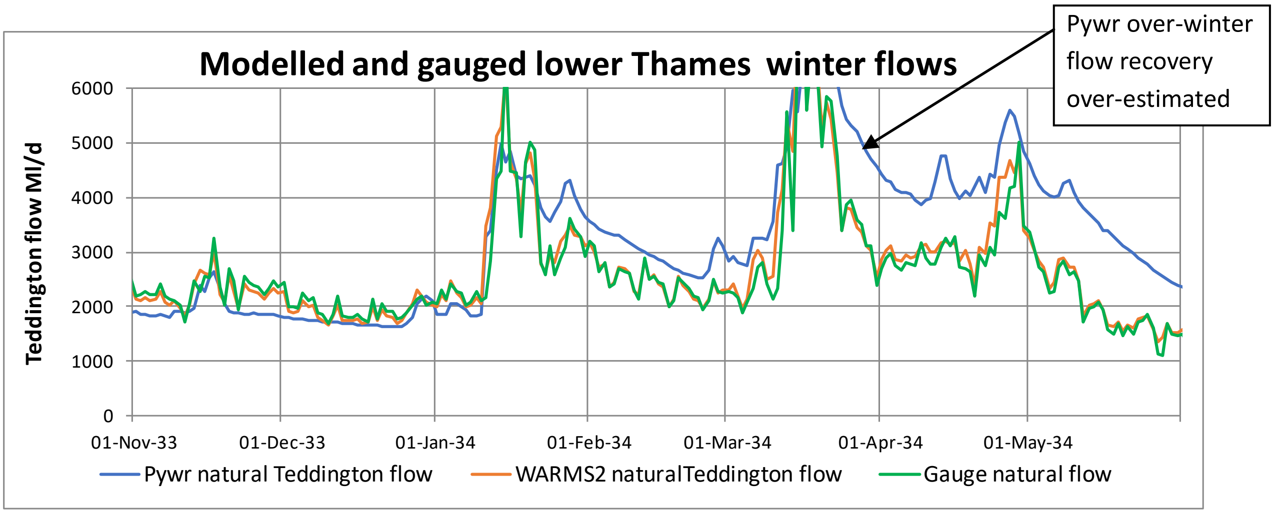
Note: plots copied from Figure I-7 of Appendix I to Thames Water's WRMP

Figure 4 - Pywr and WARMS2 modelling of London storage in historic droughts

Thames Water says that the plots above show "a close agreement between Pywr and WARMS2 outputs for key drought periods"[37]. In our opinion the agreement is extremely poor and the differences in modelled drawdowns in critical droughts will lead to big errors in assessing deployable outputs. For example, the Pywr maximum London reservoir drawdowns in the drought of 1933-34 about 26,500 Ml less than the WARMS2 modelled drawdowns, equivalent to over-estimating the London deployable output by about 53 Ml/d. There are similar differences in modelling of the 1943-44 drought[38].

The main reason for the extremely poor fit between Pywr and WARMS2 modelling is the large differences between the WARMS2 historic flows and the historic flows generated by the hydrological model that created the stochastic flow data, particularly during the winters of 18-month droughts, as shown below:

[37] Thames Water WRMP Appendix I, paragraph I.128
[38] Volume 2 Addendum Figure 4



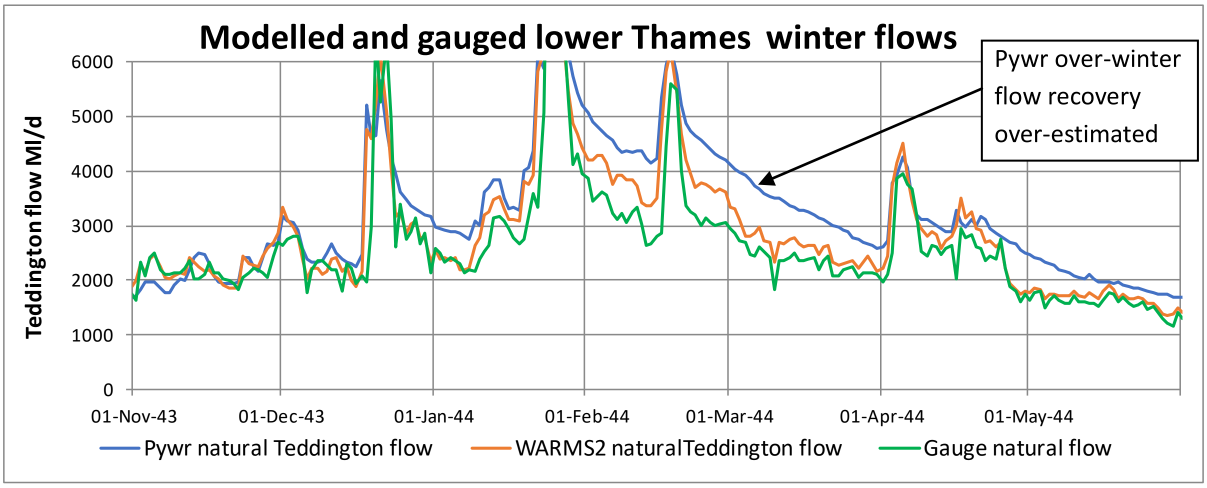


Figure 5 - Modelled and gauged natural winter flows in 2-year droughts

The Pywr model grossly overestimates the winter flow recovery during the 18-month droughts of 1933-34 and 1943-44. The WARMS2 modelling of the naturalised flows is a much better fit to the naturalised gauged flows, although there is some over-estimation of flow recovery in the winter of the 1943-44 drought.

The Pywr model over-estimation of winter flow recovery after droughts has profound implications for assessing the deployable output of Abingdon reservoir and STT options:

- For Abingdon reservoir, the over-estimation of winter flow recovery disguises the reservoir's lack of resilience in long duration droughts.
- For the Severn to Thames transfer, over estimation of winter flow recovery in the Thames diminishes the benefit of the unsupported transfer

In addition to the over-estimation of winter flow recovery for stochastic flows, we have major concerns about the use of the 48 year period 1950 to 1997 as the basis for generating 19,200 years of stochastic river flows. The use of historic climate data only for 1950-1997 means the exclusion of the three most severe droughts of the past 100 years (1921, 1933-34 and 1943-44), as well as the past 25 years of most rapid climate change.

Analysis of Pywr model output shows that about 75% of all severe droughts in the 19,200 year record occur in the nominal year 1976, which is the most severe drought in the historic record for 1950-1997. This is shown below[39]:

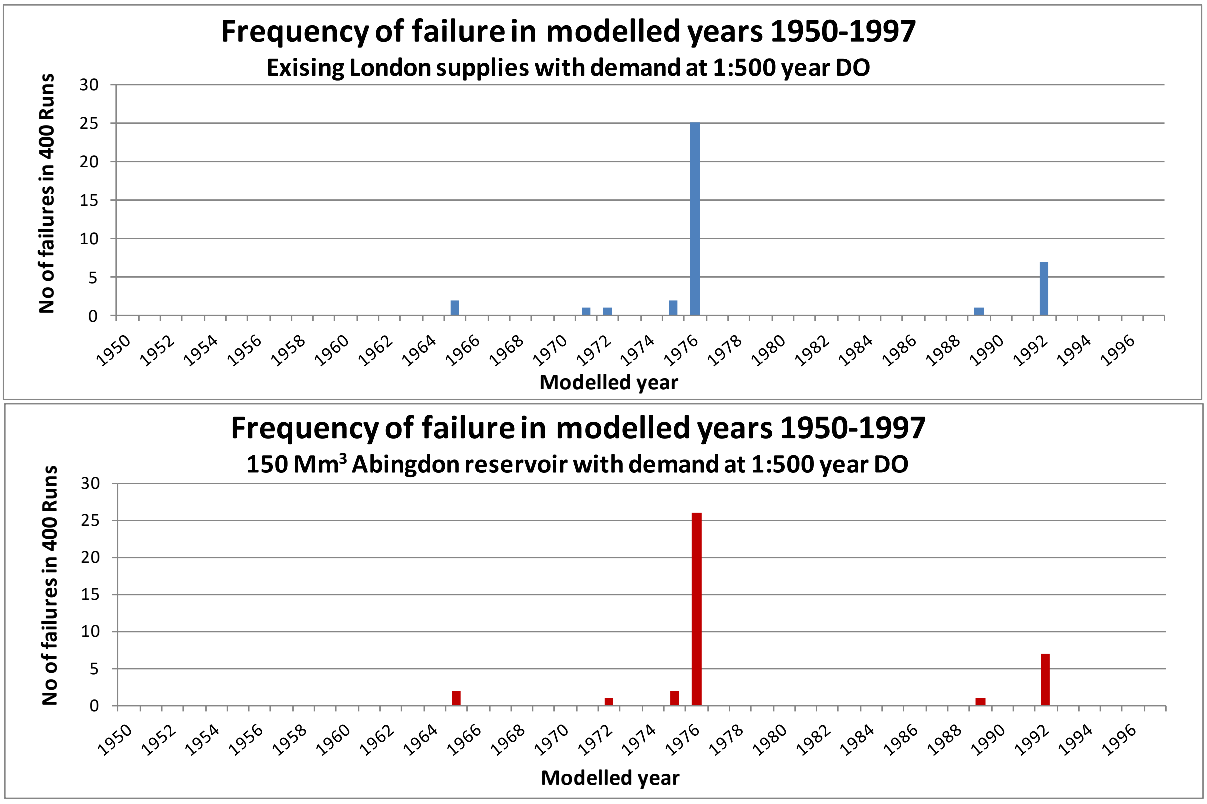


Figure 6 - Pywr modelled frequencies of supply failure in each year of stochastic data

This plot shows that 27 of the 37 droughts of more than 1:500 year severity occurred in the modelled years 1975-76. The remaining 10 droughts occurred in lesser droughts in the historic record, like 1991-92. The patterns of 'year of failure' are almost identical in the Pywr 19,200 year simulations of existing London supplies and existing supplies with Abingdon reservoir, in each case replicating the pattern of historic droughts in the period 1950-97 – much the most severe historic drought in this period was 1975-76.

It is evident that the method of generating the 19,200 years of flow data – 'training' them on the historic period 1950 to 1997 – replicates the pattern of droughts in the historic record. The historic drought of 1975-76 was not particularly severe because it ended in September 1976, whereas the droughts of 1921, 1934 and 1944 extended into the winter. The historic drought of 1975-76 was not preceded or followed by dry years. Therefore, the Pywr modelling cannot generate the type of long drought that tests the resilience of Abingdon reservoir.

The use of the historic period 1950 to 1997 to 'train' the 19,200 years of stochastic data also excludes the most recent 25 years of data during which climate change has accelerated. In

[39] Basis of plot derivation as per Volume 2 Addendum page 19

our opinion, the base historic data should have included all available climate data since 1997, thereby covering the recent period of rapid climate change. Evidence showing how River Thames flows have changed over time is shown on pages 22-23 of the Addendum in volume 2 of this response.

The problem of the stochastic data excluding long droughts was identified in WRSE's method statement on stochastic climate data in 2020. They advised that "*Companies may complement the stochastic dataset with drought artificial weather series to represent prolonged drought events (which the stochastic generator will not have been trained on)*" [40].

Despite this advice and the known concerns over long droughts, Thames Water has failed to consider any artificial weather series to represent prolonged drought events. The impact of long duration droughts on the deployable output of Abingdon reservoir has not been assessed in the WRMPs or the Gate 2 reports.

By re-ordering the sequence of dry years in the historic record, it can be shown that Abingdon reservoir would fail to deliver its expected deployable output in a succession of dry years preceding a major drought. For example, if the historic drought of July 1933 to November 1934 had been preceded by the historic river flows of July 1996 to June 1997, the effect on Abingdon reservoir trying to deliver its expected 285 Ml/d deployable output (without climate change) would be as shown by GARD's modelling below:

[40] WRSE Method Statement on Stochastic Climate Datasets: Consultation Version, July 2020, paragraph 2.7

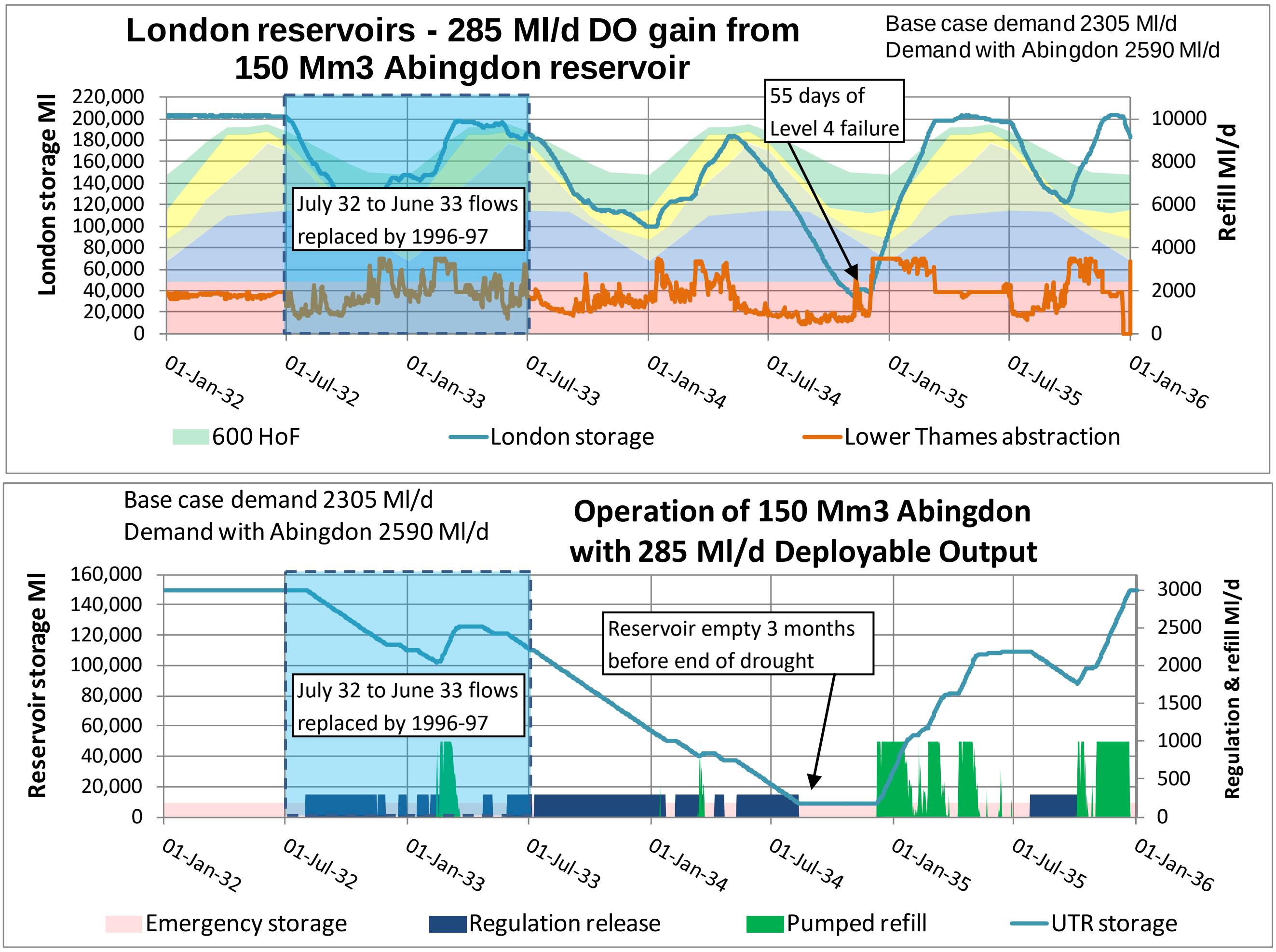


Figure 7 - Abingdon reservoir in artificially extended historic 1934 drought

In this scenario, replacing the historic flows of mid-1932 to mid-1933 with the historic flows of mid-1996 to mid-1997 would lead to 55 days of Level 4 failures for London's supplies, with Abingdon reservoir being empty 3 months before the end of the drought. This would be a catastrophic failure of London's supplies, with Level 4 restrictions starting in August 1934 at the peak of the tourism season. In this seemingly plausible scenario, the deployable output that can be sustained by the 150 Mm^3 Abingdon reservoir is only 163 Ml/d, not 285 Ml/d.

We conclude that, if proper consideration is given to the occurrence of long duration droughts, the deployable output of Abingdon reservoir would be far less than that claimed by Thames Water, perhaps in the region of only 50% of the claimed amounts. In the 5 years since WRMP19, Thames Water have failed to address the concerns previously raised by GARD, even after the validity of the concerns had been acknowledged by WRSE in their method statement on generating stochastic climate datasets in 2020.

Other flaws in Abingdon reservoir deployable output assessment

Our inspection of the Pywr model output, when eventually received, has revealed more faults in the assessment of deployable output of Abingdon reservoir:

1. In assessing frequency of failure in the 19,200 years of records, droughts in which failures extend into two different years have been counted as two failures instead of one. This error causes the deployable output of the Abingdon reservoir (without climate change) to be over-estimated by 6 Ml/d for the 150 Mm^3 reservoir and 4 Ml/d for the 100 Mm^3 reservoir (page 30 of Addendum in volume 2).

2. In another serious Pywr modelling error, when refilling Abingdon reservoir the minimum required flow (MRF) in the River Thames at Culham is set at only 450 Ml/d instead of the correct value of 1450 Ml/d. TW recognises this error and provides a correction in an appendix to the modelling technical report, showing that it only reduces deployable output by 2 Ml/d. Our modelling shows a similar DO reduction due to this error, when simulating stochastic versions of the 1975-76 drought.

3. However, although the Culham MRF error does not appear to have a big impact on Abingdon reservoir deployable output, it can greatly affect the speed of reservoir refilling after droughts. For some of the relatively few droughts in the stochastic record which are not versions of the 1976 drought, GARD's modelling shows that Abingdon reservoir is less than half full at the start of the next summer and vulnerable to failure if another dry summer follows – similar to the failure shown in Figure 7.

4. In Thames Water's main WRMP report, the widely quoted deployable outputs for Abingdon reservoir are 271 Ml/d for the 150 Mm^3 reservoir and 185 Ml/d for the 100 Mm^3 reservoir. These are TW's assessments for the 'median' climate change scenario. However, TW's preferred plan assumes the 'high' climate change scenario, so the assessed DOs for Abingdon reservoir should also be for the 'high' climate change scenario. Using TW's figures, the deployable output of the 150 Mm^3 reservoir with 'high' climate change allowance should have been 252 Ml/d, not 271 Ml/d. The equivalent deployable output of the 100 Mm^3 reservoir with 'high' climate change should have been 169 Ml/d, not 185 Ml/d (see page 34 of Addendum in volume 2).

5. In Section 3.2.2 of this response we propose that the allowances for dead and storage should be an average residual water depth of 5m, not 2.5m as proposed by TW and emergency storage should be 15% of live storage to be in line with other UK regulating reservoirs, not 6% as proposed by Thames Water. These changes reduce the deployable outputs for the 150 Mm^3 and 100 Mm^3 reservoir by 44 Ml/d and 25 Ml/d respectively (see page 40 of Addendum in volume 2).

Taken together, these flaws in Thames Water's assessment substantially reduce the deployable output of Abingdon reservoir, as shown below:

	150 Mm^3 reservoir	100 Mm^3 reservoir
DO with climate change as WRMP24	271 Ml/d	185 Ml/d
Less Double counting of droughts	-6 Ml/d	-4 Ml/d
Wrong value of Culham MRF	-2 Ml/d	-1 Ml/d
Wrong climate change scenario	-19 Ml/d	-16 Ml/d
Inadequate dead & emergency storage	-44 Ml/d	-25 Ml/d
Corrected Deployable Output	**200 Ml/d**	**139 Ml/d**

Table 1 - GARD proposed changes to reservoir DO (excluding long drought resilience)

The deployable output of Abingdon reservoir will be a lot less than shown in the table above, perhaps only half these values, when proper consideration has been given to the likelihood of a sequence of dry years which prevent the reservoir from being full at the start of a major drought or delay its refilling after a major drought, as shown by the example in Figure 7.

Inadequacy of previous Ofwat responses to criticism of deployable output assessments

The major weakness in the 19,200 years of stochastic river flow data and their significance for the deployable output and resilience to long droughts of Abingdon reservoir have been repeatedly pointed out to RAPID by GARD, for example:

1. GARD letter and attachment to RAPID on 19th August 2020 (copies of both in Appendix A)
2. Slides presented in a meeting between GARD and RAPID on 22nd October 2020 (copies in Appendix A)
3. Appendices A and B in GARD's response to Ofwat's draft Gate 1 decisions in November 2021 https://www.abingdonreservoir.org.uk/downloads/GARD%20Final%20combined%20Response%20to%20Gate%201%2018.11.21.pdf
4. GARD letter to RAPID on 13th January 2022, taking issue with Ofwat's final Gate 1 response to our criticisms of the stochastic data (copy in Appendix A)

In our letter to RAPID in January 2022, we criticised Ofwat's approach to our concerns which merely said *"We will pass on the specific points raised to solution owners for consideration as they develop their deployable output assessments further"* [41]. As we pointed out in our letter, we don't think that the validity of stochastic data is an issue just for solution owners,

[41] Ofwat report on final Gate 1 decisions on SESRO, Section 3.2.2, page 22 https://www.ofwat.gov.uk/wp-content/uploads/2022/01/Standard-gate-one-final-decision-for-South-East-Strategic-Reservoir-Option_Final.pdf

ie the water companies. RAPID and Ofwat should be concerned that their entire decision making is based on unreliable stochastic data that has been generated nationally under their auspices for use by all water companies. If the stochastic data are substantially inaccurate, as we think they are, the validity of the entire £470 million investigation programme is undermined.

Following publication of Ofwat's final Gate 2 decisions, we will use a Freedom of Information request to ask for detailed evidence of how this matter has been addressed in Ofwat's assessments of the Gate 2 reports and the proposals for Gate 3. We will expect to see copies of reports prepared by RAPID's technical assessors, which we should include an independent assessment of the points made in this section of our response and the supporting evidence provided by the Addendum in volume 2.

3.3.2 Abingdon reservoir costs

The evaluation of the costs of the Abingdon Reservoir in the Gate 2 documents is poor in three respects:

1. There is a lack of transparency in the cost information presented.
2. When GARD have managed to obtain supplementary information from Thames Water, we have uncovered many errors in the calculations. This applies to both the Reservoir options and the various elements of the Severn-Thames Transfer (we will cover the latter in section 4)
3. Finally, there is no attempt to calculate the *true total costs* of the Reservoir to customers arising from Ofwat's own formulae for linking customer bills to the Regulated Asset Base of the supplying companies. That this is not present in the cost balance is entirely a consequence of Ofwat's omitting it in the terms of reference. However, the cost is a real cost, and an important issue of Inter-generational Equity. GARD have thus formed a financial model and calculated this cost. We include this below. It was a part of our response to Thames Water's dWRMP24 consultation. ***We are calling on RAPID to insist on the presentation of this cost <u>for all Strategic Resource Options</u>*** as an 'Addendum' to Gate 2 (ie. before the Gate 3).

Cost transparency

The presentation of costs in this round of the WRMP is much more detailed than in previous WRMPs and is in a similar format to that previously proposed by GARD. We believe this to be an influence of the existence of the RAPID process, and are grateful for RAPID's efforts to make this happen. However, making cost information available is not the same as presenting it transparently to justify choices between options. Failure to present the cost comparisons clearly is almost as bad as failing to provide cost data at all. We have thus been very critical of the cost comparisons in the WRSE draft Regional Plan and the Thames Water dWRMP24. The costs in these consultations are not consistent with those in the RAPID Gate 2 documents. However, we have been informed that the Gate 2 documents are more up-to-date. We therefore concentrate on Gate 2 costs[42] for this numerical analysis.

Item	In Gate 2 cost report
Initial construction cost	£1,244 million
Costed risk	£286 million
Optimism bias	£347 million
Total capital cost	£1,877 million
Opex in Gate 2 report	£4.3m/year
NPV with Gate 2 opex [modelled at 38% utilisation)	**£1,295 million**
NPV with Gate 2 opex (at 100% utilisation)	**£1,301 million**

Table 2 - Differences between Abingdon reservoir costs in Gate 2 reports and cost table

The costs of these options have been copied from the cost tables in the Gate 2 document.[43] We note that, as operational costs are relatively low for the Reservoir, the percentage utilisation over the planning period out to 2100 is relatively unimportant.

These costs are taken from the '*WRMP24 Environment Agency format*' tables in the Gate 2 Appendix.[44] However, these tables calculate *Net Present Cost (NPC)* and not *Net Present Value (NPV).* GARD were surprised by this confusion. Net Present Value is a reasonably well defined and well understood concept and a relatively common way of calculating comparative costs. In contrast, Net Present Cost as defined by and mandated by Ofwat and the EA is an extremely unusual concept and one that is not suited to evaluating the costs of major long duration capital projects.

GARD made a request, on 15th January 2023, for additional information from WRSE and Thames Water to enable us to confirm the details of the calculation of NPC for Abingdon 100 Mm^3 option. This information was only provided on 14th April, too late for us to use in our dWRMP24 response, but, whilst we have had limited time to use the understanding gained, we have been able to analyse the calculation of NPC for SESRO [and to calculate NPC's for GARD's preferred STT options]. ***This delay is a major failing in transparency.***

Suitability of NPC as a cost comparison and errors in calculating NPC

We have commented on the unsuitability of NPC in our response to WRSE. NPC as mandated by Ofwat and the EA is a very peculiar and flawed methodology.[45] Specifically, it

[42] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/A-2---SESRO-Cost-Report.pdf

[43] SESRO Gate 2 Cost Report, table 7-2.
[44] SESRO Gate 2 Cost Report, page 28 (in Appendix B)
[45] https://www.gard-oxon.org.uk/downloads/Final%20GARD%20Response%20to%20WRSE%2022%202%2023%20v4.pdf
See Appendix B - *Criticism of Net Present Cost as a comparator for project costs*, p82

is not fit for its intended purpose of comparing the costs of the principal alternatives in the RAPID process for the South East.

GARD intends to take these deficiencies up with RAPID in the near future, but for the present, we have worked with the NPCs calculated for the Abingdon Reservoir and the STT, and concentrate on the errors in the calculation of the NPC figures presented in Thames Water's tables. The details of these errors are given in Appendix Q, and we present the numerical results here.

Below is a breakdown of errors and inconsistencies that GARD have identified:

1. Thames Water did not include *depreciation on Costed Risk* in their SESRO NPC calculation[46]. We can see no valid reason for omitting it. Costed risk totals £286m, and the annual depreciation on it is £2.6m p.a. Thus, £**189**m of depreciation has been omitted in the 80-year planning horizon of the RAPID and dWRMP processes. GARD calculate the impact of this on the NPC to be an understatement of **£17m.**

2. As GARD pointed out in Appendix B of its WRSE response, possibly the clearest deficiency in the NPC methodology when used to evaluate projects with a long life, is that it just cuts off after 80 years - ignoring any cash flows beyond that time and any value remaining in the assets after 80 years. Thames Water's information on 14th April confirmed that the Regulated Capital Value of Abingdon Reservoir 100 at the end of their 80-year planning period (2102-3) was **£1,380 million**[47]. This value and all costs incurred after 2102-03 have been entirely omitted from the NPC-based evaluation of the Reservoir. To adjust for this omission in a minimum fashion we add this value discounted by the factor used in 2102-03 to calculate a NPC. This adds **£128.8m** to the NPC of the reservoir.

3. Another bias in the NPC calculation, which acts to favour Reservoir options over other SROs, arises because longer construction period and later operation start date. Opex and depreciation costs are neither recorded, nor included in the NPC calculation, until 2037-38, when the asset is in use. By 2037-38, the NPC methodology reduces all such costs by a factor of **62%.** The NPC methodology completely ignores the timing of the initial capex which has all been incurred before that date. Thus, for Abingdon only 66 years of Opex and depreciation are included within the 80 year planning horizon and included in the calculation of NPC. This compares, for example, to 70 years of Opex and depreciation that are included for the STT because of its shorter construction period and earlier in use date (2035-36). This deficiency in the NPC methodology is hard to correct for, especially, given the limited time available. However, since a very relevant choice for the SROs is the

[46] In the spreadsheet provided by Thames Water on 14th April, "SESRO 100 - Financing Cost Query Check 13Apr23", Note 1 in cell B35 states that "Finance Cost …. excludes any Risk depreciation".
[47] This is in agreement with GARD's financial model calculation.

relative timing of the implementation of Abingdon and STT, in attempt to compare like with like, GARD have added an additional 4 years to the NPC calculation for SESRO (extending it to 2106-7). This certainly understates the correction required, but adds **£20m** to the NPC of the reservoir.

4. The start year for discounting the 80-year time frame for Abingdon is 2022-23. In contrast, the start date for STT is 2024-25 Thus, in any given year in the planning period, the discount factors for different SROs are out of synch. As Appendix Q shows, this 2-year difference in start date has the effect of reducing the NPC calculated for Abingdon 100 Mm^3 by **£104m** when compared to the NPCs calculated for the STT variants. Consequently, £104m needs to be added to the Abingdon NPC to make it consistent with the STT. This highly material change illustrates the importance of RAPID ensuring consistency of approach between the SROs.

5. Thus, as in table 2 below the Abingdon Reservoir 100 NPC should be **£1.571m,** that **is £270m** higher**,** when the above adjustments are applied to correct errors and to evaluate the Reservoir on the same basis as STT.

Starting NPC per TW		**1,300,855,737**
Adjustments		
1 Include depreciation on Costed Risk	16,759,631	1,317,615,368
2 Include impact of RCV in final year	128,772,080	1,446,387,447
3 Adjust for 70 year in use period	19,807,808	1,466,195,255
4 Adjust for consistent start date	104,429,757	1,570,625,012
Total Adjustments	269,769,275	
Final NPC per GARD		**1,570,625,012**

Table 3 - Re-evaluation of Abingdon 100 to correct errors and align with STT calculation

Abingdon Reservoir plans do not appear to have been worked on for many years. Specifically, the cost estimates appear to be based upon high level work done several years ago. We anticipate an increase in these costs analogous to the increase in the Thames Tideway Tunnel, when costs doubled from £2bn to £4bn when detailed work was done after the project was approved.[48]

True costs of Strategic Infrastructure to customers and true benefits to water company shareholders

The 'costs' of Water Resource Management Plans never include a discussion of the effect of including ***Regulatory Capital Value (RCV)*** of Companies in the charges to water customers,

[48] New Civil Engineer "Thames Tunnel sewer costs rise up to £2bn" 16th September 2010

according to the formulae set up by Ofwat. It is surprising that in a process that attempts to assemble factual information on a level playing field, such as that set up by RAPID, that such costs (which are very real to customers) are not calculated and compared. We cover this in some detail in Appendix R (first submitted as 'Appendix C' part of the GARD response to Thames Water's dWRMP24[49]). In short, the inclusion of RCV-related items in Ofwat's Pricing formula has the following effects:

1. There is a fundamental and extremely perverse incentive in the Water Industry regulatory regime that encourages investment in "big concrete" projects as the solution to any and all problems.

2. All expenditure by a Water Company that can be classified as being of a capital nature, including building a reservoir and the costs of developing proposals for any such capital asset, is added to the water company's ***Regulatory Capital Value (RCV)*** *and the company has a statutory right to make a return on that RCV in real terms in all future years.*

3. These regulatory incentives specifically *favour very long-life assets such as a reservoir in contrast to alternative methods of securing water.* The alternatives to the reservoir include the Severn to Thames Transfer, desalination and fixing leaks. All these alternatives involve lower capital expenditure and shorter life assets. Consequently, these alternatives have lower Regulatory Capital Values and look less attractive from the perspective of Water Company shareholders.

4. For an Abingdon reservoir, Water Company shareholders would still be earning their guaranteed real return on the reservoir in 250 years' time. The asset lifetimes used for regulatory return calculations (and for accounting depreciation) significantly favour reservoirs (250-year life) over tunnels, pipelines and other water network assets (80 – 100 year lives).

5. Almost all Water Companies have highly geared balance sheets with very high levels of borrowings. These borrowings which have all been incurred since privatisation have largely been used to fund payments to previous shareholders. As a consequence of their corporate structures and high borrowings, most Water Companies have paid very low levels of corporation tax, if any at all, for many years.

GARD's Financial Model

GARD created a financial model using cost and other data contained in the RAPID Gate 2 document for the Abingdon Reservoir and the Thames Water dWRMP. The model also used data from the Competition and Markets Authority's (CMA) determination on the elements

[49] https://www.gard-oxon.org.uk/downloads/21.3.23%20GARD%20response%20to%20TW%20WRMP%2021.3.23.pdf

of WACC. GARD have used this model to calculate the cashflows arising from over the 250-year life of the reservoir, 2022 to 2285. We note briefly:[50]

- *The increase in Shareholder Value that would immediately arise and benefit the Shareholders* in the three Water Companies who would jointly own the reservoir if the Abingdon 100 Mm^3 were to be given the go ahead (Thames Water, Affinity Water and Southern Water), would be £846 million. This arises from the return on the increase in Regulated Capital Value (RCV) resulting from the £1,878 million Capital Expenditure on the reservoir, discounted back to the present. All these numbers are fixed in 2022 currency.

- GARD separately calculated the increase in Shareholder Value that would arise if the same amount of money identified as the initial construction cost of the reservoir, £1,878 million, were instead to be spent on increased operating expenses over the same period to reduce leakage and/or to reduce per capita consumption. We believe that the answer is zero.

- There is therefore a ***staggering £846 million incentive*** within the Regulatory Regime to build the reservoir rather than to accelerate the reduction of leakage and the reduction of consumption.

- Additionally, ***Water Company customers would pay a huge cost for the reservoir: we calculate £4,829 million over 80-year WRSE planning horizon*** and £13,673 million over the 250-year life of the reservoir. Again, all these numbers are fixed in 2022 currency.

- In contrast, the additional cost that Water Company customers would pay for an additional £1,878 million of operating expenditure to reduce leakage and to reduce demand is only £1,878 million. ***The Reservoir would therefore cost customers an additional £3,041 million over the 80-year planning horizon. This increase in cost to customers is a result of the return on Regulated Capital Value allowed to water company shareholders.***

GARD have used £1,878 million here to illustrate the differing financial consequences to customers of the same value of expenditure on different things. These aspects of costs to consumers need to be:

- made explicit in any evaluation of dWRMP and Regional Plans;

- *used in a metric* as input to the establishment of a Best Value Plan. In some senses the '*Inter-generational Equity*' (IGEQ) metric could be a place to start. However, at present, the explicit use of an IGEQ metric seems not to be in the Thames Water

[50] GARD will be sharing the spreadsheet with RAPID, WRSE and Thames Water.

Best Value Plan calculation, whilst the use of IGEQ in WRSE's Plan only includes costs based on NPV discounting.[51] GARD has previously called for inclusion of the financial effects of RCV in the IGEQ metric.[52]

Our findings re-iterate our view that the building of the reservoir is on all measures worse than the alternative examined here of reducing leakage and consumption: it is more expensive and specifically more expensive for customers, has a materially worse carbon footprint, is more environmentally damaging, is less resilient and, specifically, less drought resilient.

3.3.3 Abingdon reservoir carbon footprint

Abingdon reservoir is the Strategic Resource Option with the largest carbon footprint in the construction phase ('*Embodied carbon*' or '*capital carbon*') and the 150 Mm^3 version has the largest of these footprints (at 403 $ktCO_2eq$). Moreover, when considering carbon impacts Abingdon should only be compared with a '*like for like*' deployable output (DO) scheme. If the overall scheme in the comparison is one which can be implemented in stages, then a feasible first stage with DO equal to Abingdon reservoir should be used in the comparison. The Severn Thames Transfer (STT) is an easily phase-able scheme, but Thames Water avoids direct comparisons, tending to compare the *whole STT network* with Abingdon reservoir.

The Gate 2 reports claim potential reduction in the carbon budget figures through technological developments and carbon sequestration. The capital carbon budget for the Reservoir comes dominantly (60-70% for the 100Mm^3 and 150Mm^3 versions- see Appendix P, section 5) from earthmoving and construction and transport equipment. From our analysis in Appendix P, we conclude that the low-carbon earthmoving equipment is highly unlikely to be available for building the embankment and an alternative 'low-carbon' construction phase for the reservoir is unrealistic. We also conclude that the carbon sequestration 'opportunities' are limited and uncertain, and not larger than local initiatives (funded by new DEFRA rules and Local Authorities) could achieve without the reservoir at vastly lower cost.

Whilst it is GARD's view that the Thames to Southern transfer scheme should not be progressed, the carbon budgets for the associated water treatment works should be included with the reservoir budget, as the justification of the reservoir requires the Thames to Southern transfer as part of its case.

In our opinion, treatment of returned water to the Thames might be needed to deal with the risk that the water quality in the reservoir after a prolonged drought would be very poor and laden with algal bloom.

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[51] https://www.wrse.org.uk/media/1g3jh5vs/wrse-best-value-plan-doc-final.pdf
[52] See response to Thames Water dWRMP19: https://www.gard-oxon.org.uk/downloads/GARD%20%20response%20to%202nd%20Consultation%20on%20TW%20draft%20WRMP%20Rev%2029.11.18.pdf

Around 40 MW of solar farm generating capacity is lost by construction of the reservoir. The Gate 2 reports make it clear[53] that there is no intention to re-site these on the post-construction site and a floating solar farm is now ruled out by Thames Water.[54] The generating loss caused by the destruction of the solar panels needs to be factored into the carbon balance for the project (it is unlikely that the panels can be usefully located to another site, and may well end up being scrapped).

In Appendix P we show evidence that greenhouse gas emissions are substantial from large reservoirs. The evidence is increasing that reservoirs do not sequester carbon. These emissions, from published sources quoted in Appendix P, could be in the region of 1.0 – 6.5 ktCO_2eq per year. This adds up to an enormous (65 – 390 ktCO_2eq) over the 65-year planning period, potentially dwarfing the rather low Operating Carbon figure (4 ktCO_2eq) These issues are completely absent from consideration in both the Thames Water dWRMP documents and the RAPID Gate 2 reports.

GARD calls for the GHG emissions for Abingdon reservoir to be included with the reservoir budget, and a statement regarding the treatment of water pumped into the Reservoir and the policy for extraction from the Thames at times of sewage spills to be explicitly included.

3.4 Abingdon reservoir programme and planning

Ofwat's Gate 2 decision report rates the Programme and Planning as 'Good' (but only just above satisfactory). We consider it to be 'Poor' for the reasons set out below.

The SESRO supporting document F-1: Project Delivery Plan shows the programme below for the pre-construction phase of Abingdon reservoir:

[53] Table 6.8 of SESRO Gate 2 main report
[54] Statements (by Phil Stride of Thames Water) at the Thames Water 'drop-in', Steventon, 18th February 2023.

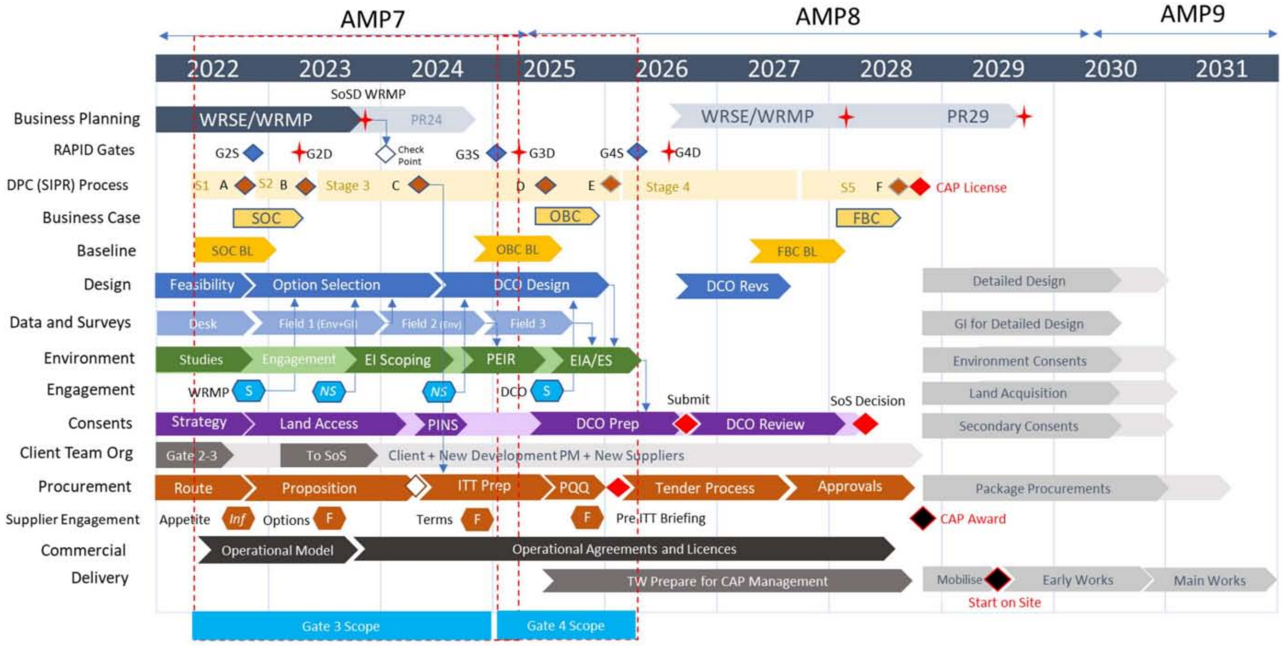


Figure 8 - Thames Water's pre-construction programme for Abingdon reservoir

As with all major civil engineering projects, especially those involving complex geotechnical engineering, Abingdon reservoir carries a high risk of programme and cost over-runs. For a homogeneous clay embankment dam, with a25 m high embankment of up to 10 km length, the risks are particularly high. The main risks are associated with the design and construction of the embankment and its foundations, for the reasons set out in Section 3.2.1. We are surprised to see that these risks are not identified in the project risk register contained in the Project Delivery Plan (Table 4.1):

Table 4.1: Summary of Programme Level Risk Register at Gate 2 (highest risks pre-mitigation only)

Risk Theme	Details	Pre-Mitigation Risk	Proposed Mitigation	Post-Mitigation Risk
Environment	There is a risk to hydromorphology and aquatic receptors due to the discharge effect from reservoir flow.		The effect of the discharge to be assessed through 1D and 2D hydrodynamic modelling and velocity analysis and continued development of design of abstraction / discharge structure to minimise localised impacts. Consideration of water quality management and mitigation for reservoir, informed by complex CFD and algal bloom predictive modelling.	
Environment	There is a risk in attaining WFD compliance in either the River Thames water body or the River Ock waterbodies.		Ongoing water quality and aquatic ecology monitoring; Hydrodynamic modelling and water quality assessment will help update mitigation strategy and WFD assessment, as appropriate	
Environment	Abstraction and discharge impacts from SESRO might have impacts on fish habitat and migration habits in the affected reaches		Ongoing water quality and aquatic ecology monitoring; Hydrological and water quality assessment and modelling; Continued development of design of abstraction / discharge structure to minimise localised impacts. Fisheries impact assessment at Gate 2 as explicit part of Aquatic Environmental Appraisal Report.	
Environment	Challenges in ensuring that scheme can deliver the required Biodiversity Net Gain.		Work completed for Gate 2 suggests that sufficient ditch habitat can be created on-site to manage this BNG risk without the need for off-site works, but to be confirmed as site baseline data is extended in next phase of works. Further assessment of BNG requirements will be required as scheme design progresses to determine exact length of linear terrestrial habitat required and incorporate into scheme requirements.	
Environment	Stakeholder perceptions on landscape impacts		Initial landscape and visual impact assessment, including close liaison with Natural England and North Wessex Downs AONB to ensure design sympathetic to AONB management strategy. Development of initial landscape and visual impact assessment for Gate 2 and build principles into Master Plan, in close liaison with OCC, VoWH and AONB landscape specialists.	
Land/Planning	Failure to secure all of the powers and land rights sought in the DCO – which would render implementation more difficult at the very least.		The Book of Reference and Land Plans will be kept under regular review. A fully-articulated case will be made to justify the compulsory acquisition powers and land rights sought in the DCO.	
Land/Planning	The DCO application is not accepted for examination.		Extensive pre-application consultations will be undertaken to pass the 'adequacy of consultation' test at the DCO acceptance stage. The DCO application will comprise a comprehensive array of documentation produced by experienced practitioners in accordance with relevant regulations including the Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 and the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.	
Programme	Dependency between Final WRMP24 publication and statutory DCO consultation.		Mitigated via proactive stakeholder engagement for WRMP24 and close alignment of the scheme need, timing and scale to Regional (WRSE) Plan and WRMP24. Current critical path programme analysis suggests that delay on final WRMP24 to March 2025 will not delay subsequent DCO submission.	

Figure 9 - Abingdon reservoir programme risk register

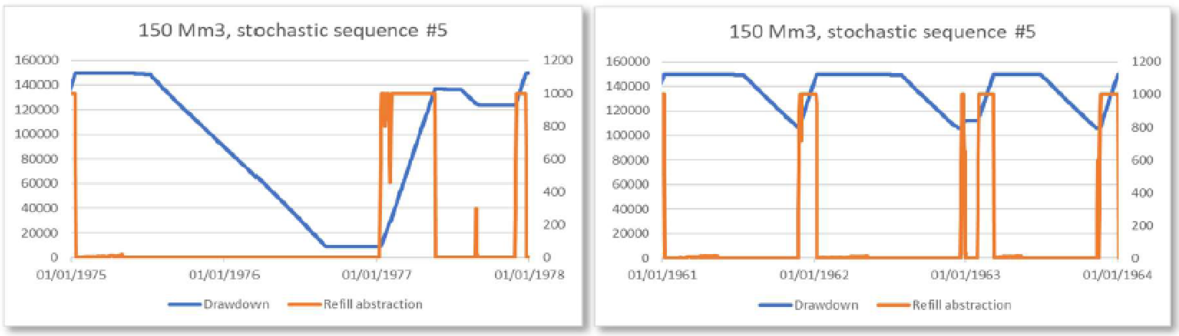
Management of dam construction and programme over-run risks normally entails extensive geotechnical investigations, including a trial borrow pit and embankment, before the pre-tender design and the start of the tender process. We can see no evidence of planning of the geotechnical investigations, either in the SESRO Gate 2 reports or on the programme shown in Figure 8.

We suggest that Ofwat calls for detailed geotechnical investigation to be undertaken as part of the Gate 3 activities and before any decision is taken to proceed to Gate 4.

We have found no evidence of construction planning in the Gate 2 documentation. The Abingdon reservoir site is hemmed in by surrounding villages, with little spare land available for construction offices, staff facilities, car parks, plant and material storage, workshops, concrete batching plants, railway sidings, etc. If the Thames to Southern transfer is to be included, the pipeline route, water treatment works and pumping station will also need to be shoe-horned into the construction site. Ofwat should call for detailed construction planning to be undertaken for Gate 3, including design layouts of all construction facilities and temporary works. Details of these should be made available for public view during Gate 3.

The Gate 2 documentation appears to contain no serious estimate of the time taken to fill the reservoir after completion of construction. However, the Gate 2 report makes highly misleading claims of rapid refill after droughts, stating that *"even after a long period of extreme drought and drawdown, refill is still achieved within 5 months"*[55] and illustrating this with examples from the Pywr modelling as below:

Figure 4.1 SESRO drawdown and refill – extreme drought (left) compared to standard operation (r



** Note, primary y-axis is drawdown (Ml) and secondary y-axis is refill abstraction (Ml/d)*

Figure 10 - SESRO drawdown and refill plots from Pywr modelling

The technical note on Pywr modelling for Abingdon reservoir states that the Minimum Required Flow (MRF) at the Culham abstraction point for refilling the reservoir was erroneously assumed to be 450 Ml/d instead of 1450 Ml/d[56]. This error makes a big difference to the speed of filling the reservoir because we know that in dry years the 1450 Ml/d MRF prevents any significant filling of the reservoir (see example on Figures 7 and

[55] SESRO Gate 2 report paragraph 4.3
[56] Technical Note Enhanced Modelling of SESRO and Thames to Affinity Transfer Schemes, footnote 2, page 3

more examples in Figures 17, 18 and 19 in the volume 2 Addendum). The absence of probabilistic estimates of times needed for initial filling of the reservoir is a major weakness in the Gate 2 reporting.

Ofwat's report justifies their 'Good' assessment as follows[57]:

> *"We consider the evidence provided by Thames Water and Affinity Water regarding the programme and planning and risks and issues for SESRO to be of sufficient detail and quality for gate two. Risks and mitigation descriptions are satisfactory and meet expectations for gate two. There are currently no environmental showstoppers identified that would prevent SESRO from progressing. While the programme and planning score has been marked down as requirements that solution owners were funded to meet have not been met, we have made a decision that there is no longer a need for value for money assessments for RAPID solutions and therefore no associated gate two action is required."*

We are surprised that Ofwat's report has not picked up the absence of construction planning in their assessment (or any of the other deficiencies that we have identified). However, we note that their recommended Gate 3 actions include[58]:

> *"More information to RAPID's satisfaction to be provided on wider key risks and mitigations around construction and procurement"*

We propose that Ofwat should reassess the 'Programme and planning' score as 'Poor' and that the actions needed to rectify the deficiencies in Gate 3 should be specified in detail in Appendix A of Ofwat's final decision report.

3.5 Environmental reporting

Ofwat rates the Gate 2 environmental reporting as 'Good'. In our opinion, the environmental reporting is extremely poor, being superficial, lacking in evidence and biased to exaggerate the benefits of the reservoir and downplay its negative impacts. We have summarised our views below and included a detailed assessment in Appendix P.

Ofwat justifies the 'Good' rating through the following brief text:

> *"We consider Thames Water and Affinity Water to have provided sufficient evidence of embodied and operational carbon commitments for gate two; the carbon assessment meets expectations.*
>
> *The environmental assessment completed for SESRO for gate two meets expectations in almost all areas. As most work to date has focused on the 150Mm3 option, many of the assessments will need to be repeated for the smaller option if taken forward, as well as being further refined with additional monitoring and modelling proposed for gate three.*

[57] Ofwat Gate 2 decision report Section 3.4.4.
[58] Ofwat Gate 3 decision report, Appendix A, Action no 5

The Environment Agency will continue to work with Thames Water to develop and refine the flood risk modelling and LVIA methodology."

In our opinion, if the Gate 2 environmental reporting is considered to meet expectations, Ofwat's expectations are set far too low, bearing in mind the huge scale of the reservoir construction and its impact on the local communities and environment. If the Environment Agency is going to continue to work with Thames water on flooding and landscape impact assessments, there needs to be far more detailed and transparent analysis made publicly available.

Our views on the environmental reporting, as detailed in Appendix P are summarised below:

3.5.1 Natural Capital Assessment

The key problem with this analysis is the over-optimistic portrayal of the post-construction situation with 'brochure culture' taking over. Recent presentations to local communities have heightened our concerns, with several presentations on potential amenities presented as fact, despite a complete lack of any supporting evidence as to how, or by who, these will be provided.

We do not accept that the creation of a '*Lake and Standing water*' has a positive NC value, whatever its actual *natural* state is. The value attributed to this NCA item is not a straightforward value, and, as GARD highlighted in our response to the WRSE draft Regional Plan[59]:

"*The reality is that reservoirs do have very different possibilities of exploitation for 'Natural Capital'. It does not take much imagination to realise that large bunded reservoirs with all-round concrete walls and extensive rip-rap-enclosed shorelines and possible security and invasive species issues, have less Natural Capital possibility than 'classic' flooded valley reservoirs with more natural shorelines. WRSE quote the values for Recreation and Amenity as:*

Havant Thicket	*£335,412*
Abingdon 100Mm^3	*£249,021"*

Havant Thicket holds 8.7 Mm^3 of water, and is in no way comparable to Abingdon on all other criteria, but the simple result that the NCA Recreation and Amenity for a small classic reservoir (with an area of 1.6 km^2 a construction phase of about 3 years,[60]) will result in 50% more Recreation and Amenity value than the Abingdon project with a capital cost more than 10 times higher, a construction phase 3 times longer and an area nearly 4 times larger. The

[59] https://www.gard-oxon.org.uk/downloads/Final%20GARD%20Response%20to%20WRSE%2022%202%2023%20v4.pdf section 4.3.6

[60] https://havant-thicket-reservoir.uk.engagementhq.com/planning-and-construction/widgets/44605/faqs#question13305

implication is that the NCA Recreation and Amenity value of Abingdon reservoir is nowhere near as high as a much smaller classic reservoir, and would, on its own, be regarded as poor value for money.

Furthermore, we note, as explained in Appendix P, that there are simply no guidelines on the calculation of the NCA Metric for *'Recreation and Amenity value*', and this has allowed Thames Water and its partners to claim very large monetised benefit (sufficient to outweigh all the negative NCA metrics) with no transparent justification and not even the limited discussion and presentation given for the other NCA metrics (such as Food Production, Natural Hazard Regulation, Air Pollutant Removal, Water Purification etc). Other problems in the NCA evaluation, as discussed in Appendix P are: the use of the project's own hydraulic modelling, not that of the EA (contrast the statements in section 3.2.6) to evaluate '*Natural Hazard Management*'; the fact that the '*Carbon Sequestration'* predicted takes more than 25 years to have any non-negligible positive value; the casual dismissal of site construction's and its aftermath's effects on '*Water Purification'*; and the over-optimistic and unfounded benefit from returning part of the site to agriculture in order to minimise the highly negative effect on '*Food production*' from the Reservoir's construction.

3.5.2 Biodiversity Net Gain Assessment

In the assessment of Biodiversity, there seems to be no attempt to discuss the effects of '*scale-length*' of habitat destruction, or '*time-duration*' of disturbance. Both are important when considering the prospect of returning 110% of the pre-construction site biodiversity (necessary for a net gain of 10% to comply with DEFRA guidelines). Clearly the site bio-diversity is completely shattered for a decade, and over a scale-length that is large compared to the radius of most invertebrates and small mammals

From our analysis in Appendix P, we conclude that:

- the Biodiversity Net Gain assessment for the reservoir suffers from many aspirational and unfounded assertions of habitat creation;
- in the case of the dWRMP documents, there are many inconsistencies and errors;
- there is a lack of transparency in the BNG documents (it should not be necessary for stakeholders to plough through Excel spreadsheets of values to get an informed view of the issues);
- at least some of the errors and inconsistencies, and some of the opaqueness is removed if the stakeholder reads the RAPID Gate 2 documents.

Thames Water should be asked to revisit this work and make it consistent with the RAPID Gate 2 documentation in accuracy and transparency.

3.5.3 Strategic Environmental Assessment

GARD is not explicitly commenting on the SEAs of the Reservoir, except where comparisons with the Severn to Thames Transfer are concerned. This is partly because aspects of the SEAs are doubly analysed and counted in other assessments, eg. those covered in Sections 2 and 3 above, or by carbon footprint and sequestration analyses as discussed in Section 4 below. It is also because, as GARD has observed on many occasions, there are hopelessly exaggerated, unproven assessments of any possible benefit of the Reservoir (eg. the recreational and tourism value, or the biodiversity enhancement without a design plan), coupled with a sharp tendency to downplay any dis-benefits (eg, the very long and disruptive construction period). In spite of GARD's comments over the years, this has never been acknowledged or seriously addressed. This seems to be perpetrated in the Rapid Gate 2 documents.[61]

In our view, the SEA has only improved by the findings of the newer methods of NCA and BNG analysis. This is to be welcomed, although we still see enough evidence of 'company spin' creeping in. ***GARD believes that RAPID should insist on a more transparent demonstration of the thinking behind the SEA markings, and needs to mount a much stronger challenge***.

3.5.4 Lack of assessment of noise, air pollution and traffic impacts

The Gate 2 environmental reporting contains nothing *new* on the very serious issues of noise, air pollution and traffic impacts, over and above what was in the roundly-criticised Gate 1 document. These are all major impacts on the local area, especially for the villages in close proximity to the reservoir site.

The Gate 2 reports limit themselves to a '*Moderate Adverse*' designation of the problem in the summary table 4-1 of the SEA Appendix.[62] The accompanying text paragraphs contain no indication of the scale of the problem for surrounding villages, and contain baseless assertions that one or another of the issues for '*Human Receptors*' of the various pollution aspects will be minimised by careful planning. The same table allocates a '*Major adverse*' rating to the Permanent Landscape effects. There has been no serious interaction with the relevant local organisations to understand concerns, and it is certainly not clear that the proposed overnight ban on site clearance and construction noise activities has been taken onboard in the planning of the Reservoir project (see section 3.4).

Ofwat's Gate 2 decision report should require these aspects to be addressed in detail in Gate 3, in consultation with local authorities

[61] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/B-7---SESRO-SEA.pdf

[62] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/B-7---SESRO-SEA.pdf table 4-1.

3.6 Drinking water quality and river water quality impacts

Ofwat's Gate 2 decision report rates the Gate2 assessment of drinking water quality as 'Good' and justifies it as below:

> *"We consider that there is sufficient evidence of progress in the drinking water quality and risk assessment and future work around Drinking Water Safety Plans for gate two. We expect to see further monitoring for emerging contaminants of concern and a programme of work to review risks around reservoir mixing and thermal stratification."*

Appendix A of Ofwat's report requires some more work in Gate 3, but focused only on the reservoir water quality and not on the impact of regulation releases into the River Thames:

> *"Provide a programme of work to clarify the review and mitigation of the reservoir's mixing and thermal stratification risks."*

Water quality is covered in the SESRO Gate 2 Technical Annex C and we rate the assessment of risks to drinking water quality and impacts on river water quality as 'Extremely Poor'. For example, Technical Annex C states:

> *"Although SESRO will modify flows, the bulk of the river flow at most times will continue to be existing natural river flow (Figure 2.2). Even when fully operational, SESRO will rarely make up more than 50% of the flow immediately downstream of the outfall, and this proportion will diminish downstream as tributaries add more flow. Consequently, the water quality risk in the River Thames will for many chemicals remain much the same as before."*

The Figure 2.2 referred to above is reproduced below:

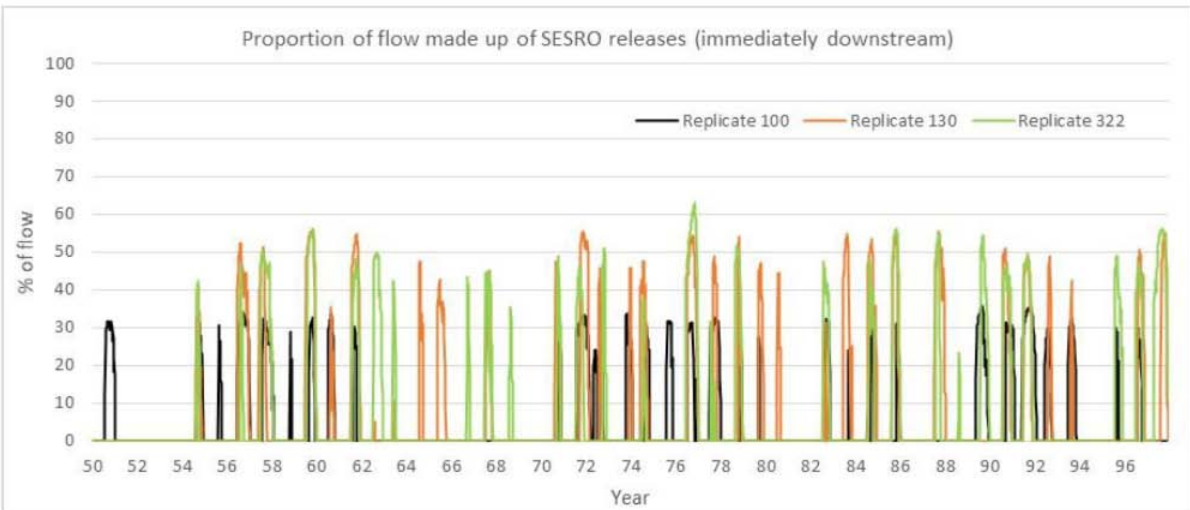


Figure 11- Proportion of Abingdon reservoir releases in river flow downstream

We do not know how the figure above was generated, but it is clear from the NRFA web-site for flows at Days Weir a few kilometres downstream of the reservoir, that for several months in a severe drought a 321 Ml/d regulation release from Abingdon reservoir would be a much larger proportion than 50% of the flow at Days Weir:

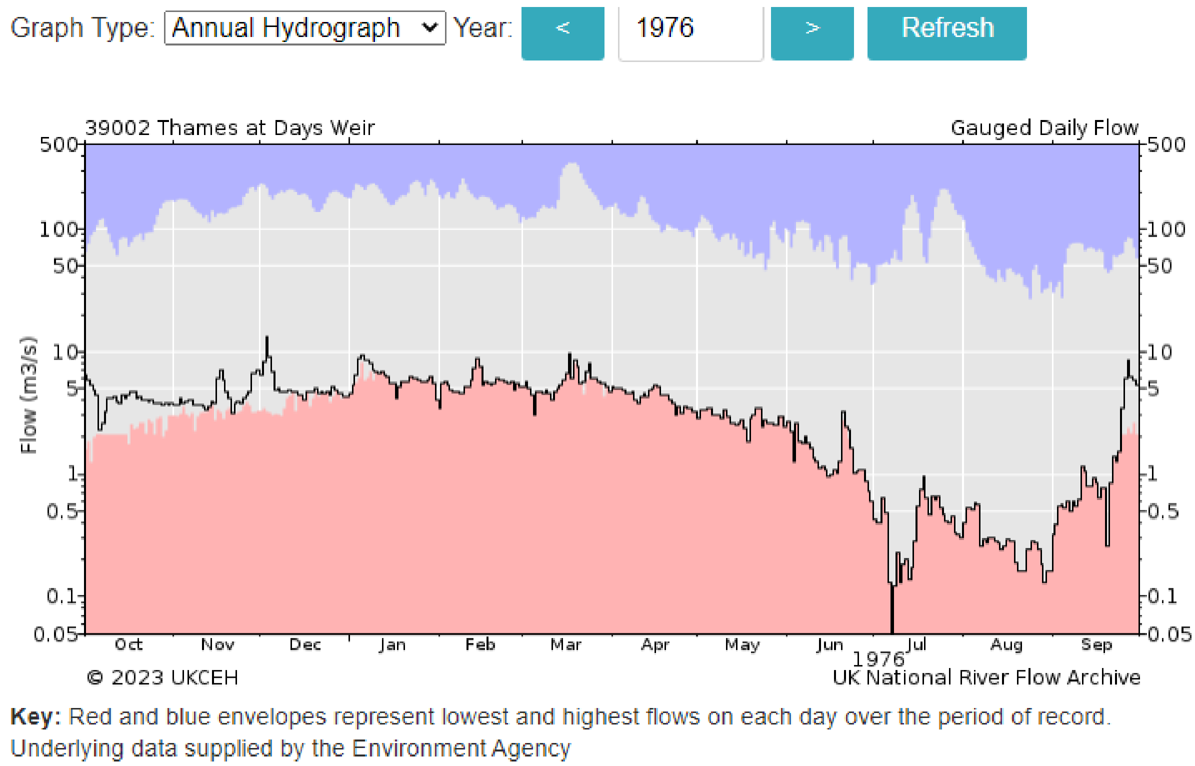


Figure 12 - NRFA flow summary for Days Weir flows in 1976 drought

This shows flows at Days Weir could be less than 0.2 m^3/s or 20 Ml/d, so the 321 Ml/d regulation release would comprise almost the entire flow for much of the summer. As pointed out in Section 3.2.2 and Section 3.4 of the Addendum in volume 2, the depth of water in the reservoir will be less than 5m in severe droughts, which Thames Water's consultants have said is likely to cause severe algal growth and water quality problems[63].

We also point out that, with the Culham minimum required flow set at the relatively high value of 1450 Ml/d, most of the filling of Abingdon reservoir will have to take place at times of high flows in winter, when water quality in the Thames is likely to be poor due to CSO spillage. The water used to fill the reservoir is likely to have abnormally high nutrient loadings and will encourage algal growth.

None of this appears to have been taken into account by the water quality assessment in the SESRO Gate 2 Technical Annex C. It is a major failing which needs to be addressed in Gate 3.

We would comment that this failing in the Gate 2 assessment of Abingdon reservoir is typical of the bias in favour of Abingdon reservoir and against the Severn to Thames transfer

[63] WRMP19 Reservoir Feasibility Report, page 435, Mott MacDonald, July 2017

in the Gate 2 reporting. Whereas, the likely water quality problems for Abingdon reservoir appear to have been given minimal attention, a highly risk-averse approach has been taken for Severn to Thames transfer water quality:

- The Netheridge wastewater treatment plant, which currently discharges to the Severn downstream of Gloucester, is deemed to require costly additional treatment before it can be discharged into the River Severn 15km upstream for use as a support source for the STT
- The Minworth wastewater treatment plant, which currently discharges to the River Tame, is deemed to require costly treatment before it can be discharged into the River Avon for onwards transmission to the STT
- All water transferred from the Severn is subject to more treatment at Deerhurst

In other words, Netheridge and Minworth effluents have to be treated twice before they can be used to support the Severn to Thames transfer, but CSO-laden high flows into Abingdon reservoir and algae-laden releases from the reservoir into the Thames in droughts require no treatment. This double standard should have been picked up in Ofwat's Gate 2 assessment and must be properly addressed in Gate 3.

3.7 Board Statement and Assurance

As shown on Figure 3, Ofwat's Gate 2 decision report has rated the Board Statement and Assurance as 'Good' and justified it as follows:

> *"We consider that the boards of Affinity Water and Thames Water have provided a comprehensive assurance statement and have clearly explained the evidence, information and external / internal assurance that it has relied on in giving the statement."*

We strongly disagree with Ofwat's assessment for the numerous reasons mentioned earlier in this section. We do not think that 'external assurance' that Ofwat refers to can be considered independent and impartial. The following statement appears in the SESRO Gate 2 main report, under the heading "10.1 Assurance approach and findings":

> *"The assurance framework used for this submission has been developed jointly by TW and AFW, to provide up to three levels of assurance across each element of the work. Due to previous stakeholder commentary on this SRO, all areas of this Gate 2 submission were considered high risk and hence received three levels of assurance.*
>
> *Atkins Limited were appointed as our external assurers. Our approach was augmented by experience that the companies gained through the Gate 1 assurance process and the sharing of best practice."*

Atkins Ltd has been extensively involved in development of previous Thames Water's WRMPs, particularly on the assessments of deployable output and drought resilience of Abingdon reservoir. They have been responsible for the original development of the stochastic river flow data and for its current use in Pywr modelling, which underpins the case for the need for Abingdon reservoir and its deployable output and resilience. They were also responsible for Water UK's 2016 report on water resources long term planning[64] which suggested the huge future water deficits that eventually led to Ofwat's £470 million programme of Strategic Resource Options Investigations and the current Gated process, in which Atkins have been heavily involved. Therefore, in GARD's opinion, Atkins should not have been considered to be an impartial external assurer. The boards of Thames Water and Affinity Water should have been well aware of this conflict of interest.

In our opinion, the Board Statement and Assurance for the SESRO Gate 2 reporting should be rated by Ofwat as 'Extremely poor'.

3.8 Ofwat recommendations for Gate 3

Ofwat's Appendix A includes a list of actions and recommendations for the Gate 3 assessment of the Abingdon reservoir option. Whereas we agree that these are all needed, we think that there needs to be much more detailed and extensive requirements for Gate 3, addressing the matters raised in this Section 3. These include:

1. Slope stability, internal drainage and foundation design for the embankment and plans for further geotechnical investigations, including a trial embankment, should be prepared and subject to independent specialist expert review in Gate 3.
2. An independent review of the provisions for dead and emergency storage and the acceptability of water quality in the reservoir at times of extreme drought and near-emergency drawdown.
3. An independent review of freeboard provision.
4. The production of an analysis of Dam Break Risk with the Flood Map for potential areas to be flooded to be made. This to be evaluated by RAPID, using independent experts, in a transparent process at an interim checkpoint before the reservoir is allowed to pass through to RAPID Gate 3Expert analysis of terrorism threat and how this will affect plans for public access and leisure facilities. An independent expert evaluation of the issues of terrorist threat to the reservoir should be made at Gate 3, to be shared with people at an appropriate level of security clearance/ responsibility, including local officials and elected representatives.

[64] Water UK, Water Resources Long Term Planning Framework, Atkins, Mott MacDonald, Nera, HR Wallingford, July 2016 https://www.water.org.uk/publication/water-resources-long-term-planning/

5. Modelling of surface and groundwater flooding impact of the reservoir to be validated by installation of modelling and made publicly available and subject to independent expert review at an Interim checkpoint before Gate 3. T**he** Abingdon Reservoir project should NOT proceed to Gate 3 without this checkpoint.

6. RAPID to commission an independent expert review of the stochastic data and Pywr modelling used to determine Abingdon reservoir and drought resilience.

7. Reassessment of the Natural Capital, Biological Net Gain and Strategic Environment Assessments, addressing the issues raised in Appendix P of this response

8. Construction planning to a sufficient level of detail to allow preparation of plans for site layout , construction facilities temporary works and accommodation of permanent features such as the Thames to Southern pipeline and water treatment works.

9. Probabilistic assessment of time to fill the reservoir after completion of construction, based historic flow records, not the unreliable stochastic data.

A number of these Gate 3 activities should be independent expert assessments of Thames Water and Affinity Water's work. If this is left to the water companies to arrange, we think it likely that the assessments will be biased by conflicts of interest, as has evidently been the case for the SESRO Gate 2 'Board Assessment and Assurance' which we criticise in Section 3.7 above. We propose that, even if this work is funded by the water companies, Ofwat should share responsibility for selection and appointment of the experts. Their reports should be made directly to Ofwat, not to the water companies. These reports should be in the public domain (as was not the case for the assurance report for the water company boards referred to in Section 3.7).

4. Severn to Thames transfer

4.1 Overall assessment of STT Gate 2 reporting

Ofwat have produced separate Gate 2 decision reports for the various components of the Severn to Thames transfer – Severn to Thames Transfer, Severn Trent Sources, Minworth Water Recycling and North West Transfer. Whereas we appreciate that this approach matches the separate Strategic Resource Options identified at the start of the £470 million investigation programme, it does not allow the Severn to Thames Transfer to be assessed as a single coherent scheme for the strategic transfer of water from the north and west of the country to the dry and heavily populated south east. GARD advocated the need for the STT to be viewed as a single scheme in our response to Ofwat's Gate 1 decisions[65] and it is disappointing that this has not been recognised in Ofwat's Gate 2 decisions.

Ofwat have described the quality of the Gate 2 report on the STT itself as:

> *"Our overall assessment for the solution submission is that it is a good submission but falls short of meeting gate two expectations in some areas including solution design, programme and planning and drinking water quality."*

Their assessment against various criteria is shown below (copied from Figure 3 in Ofwat's report), with GARD's assessments of some criteria are also shown:

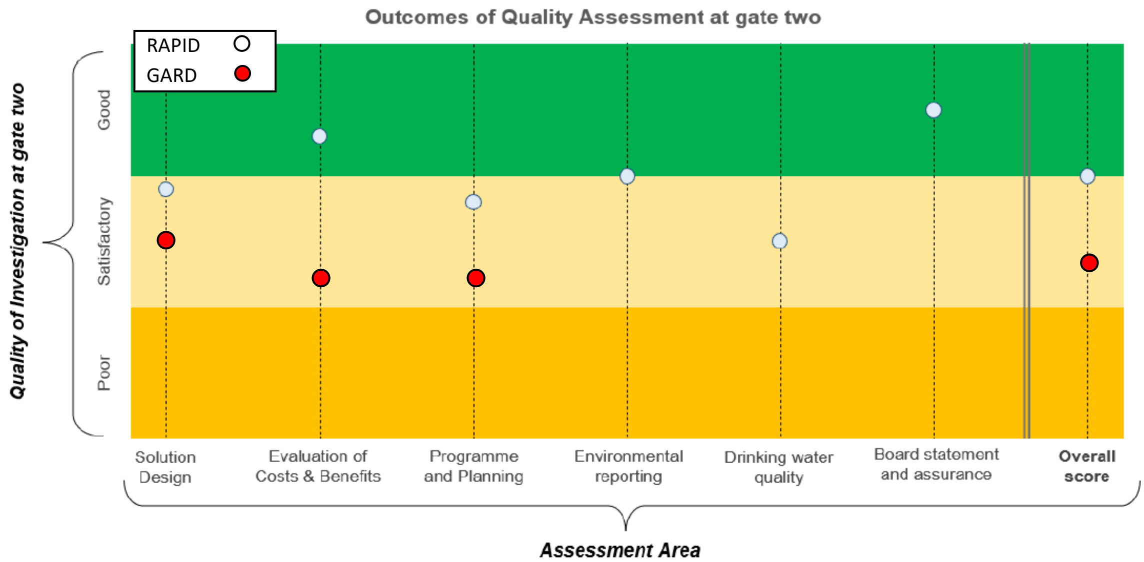


Figure 13 - RAPID and GARD quality scores for Severn Thames Transfer Gate 2 report

In our opinion, the Gate 2 reporting on the STT and its various components is a lot better than the Gate 2 reporting on Abingdon reservoir, which we have criticised at length in Section 3. In the following sections, we have provided brief comments on some of these categories.

[65] GARD response to Ofwat decisions Gate 1 reports, November 2021, pages 7 and 38 https://www.abingdonreservoir.org.uk/downloads/GARD%20Final%20combined%20Response%20to%20Gate%201%2018.11.21.pdf

4.2 Solution design

4.2.1 Overall assessment of the STT solution design

As shown on Figure 13, Ofwat have rated the solution design as 'Satisfactory' rather than 'Good', explained as follows:

"We consider Severn Trent Water, Thames Water and United Utilities (the companies) to have provided partially sufficient evidence of progress in developing the solution design for gate two. They have fallen short in providing enough evidence in the areas of utilisation, the interaction of the solution with other proposed water resource solutions, stakeholder and customer engagement, and alignment with company, regional and national plans. Alignment with company, regional and national plans require improvement.

The companies should confirm preferred volumes and configuration of the solution as soon as possible, ensuring that WRW and WRSE regional plans align. We expect an update on final alignments and proposals at the regular checkpoint in December 2023."

Overall, we agree these comments and we would also rate the quality of STT solution design as satisfactory rather than good.

4.2.2 Capacity and phasing of the scheme

We think that the proposed initial STT aqueduct capacity of 500 Ml/d, as put forward in Thames Water's preferred plan for their draft WRMP, is too high. For the reasons explained in Section 2 of this response, we think it inconceivable that this amount of transfer would ever be needed, especially if abstraction reductions for improved river flows are properly prioritised, with account taken of the costs and environmental impacts of replacement sources.

We suggest that a 300 Ml/d aqueduct capacity would be sufficient for a reasonable insurance against climate change and population growth being much worse than expected. A 300 Ml/d aqueduct could also be provided by the Cotswold canal transfer, with its potential for a lot of secondary benefits through the canal restoration, although we recognise the higher risk of this option in both construction and operation.

In our response to Thames Water's WRMP consultation, we proposed that the first phase of the scheme should comprise the 300 Ml/d aqueduct, support from Netheridge and both phases of the 115 Ml/d support from treated Minworth WWTW effluent. This would give a deployable output of 195 Ml/d using Thames Water's figures. Additional support from Vyrnwy reservoir could be added if needed and when available. However, we recognise that there could be a case for using some or all of the support available from Vyrnwy reservoir before introducing the Minworth support.

We propose that Ofwat's Gate 2 decision report should specify an interim checkpoint in Gate 3 in which the capacity, transfer method (pipeline or Cotswold canal) and sequence of support sources are pinned down. This process would require cost estimates of the various phasing and transfer options to be prepared for the scheme as a whole, rather than for the scheme components, as is currently the case.

The costs of options for the scheme as a whole would also allow a proper comparison with Abingdon reservoir.

4.2.3 The needed for extra treatment of Netheridge and Minworth WwTW effluent

The Gate 2 reports for the Netheridge and Minworth support components both assume that additional, costly and carbon intensive treatment of the WWTW effluent is needed. The Gate 2 report on the use of Netheridge WWTW effluent considers the need for additional treatment[66]:

> *"Following discussions with the EA, alternative options avoiding the need for additional treatment processes at Netheridge WwTW are currently being investigated. These could reduce carbon by up to 64,328 tCO2e and NPV by up to £163.642m, and will be considered in more detail during gate three."*

The reduction of Netheridge NPV costs by £163 million would make a large difference to the comparative costings of the STT and Abingdon reservoir options. There must also be a big question over whether the supposed water quality benefit to the River Severn between Tewkesbury and Gloucester justifies the negative carbon impact of 64,328 tCO2e.

Although not seemingly raised in the Minworth Gate 2 report, there must also be a question over the need for additional treatment of Minworth WWTW effluent, possibly needed because some of it will be discharged to the River Avon and hence the Severn estuary, rather than to the River Tame as at present.

We propose that Ofwat's Gate 2 decision report should require a separate, properly evidenced and transparent report on the need for additional treatment at the Netheridge and Minworth WWTWs. This report should consider the benefits and disbenefits of improved water quality versus the additional carbon impacts, including consideration of the potential disproportionality of the costs. If the additional treatment is needed because the WWTW's are not currently delivering acceptable effluent at their current discharge locations, the cost of any additional treatment should not be allocated to the STT scheme costs.

We propose that Ofwat's Gate 2 decisions should require this work to be done in advance

[66] Severn Trent Sources Gate 2 Report, paragraph 3.12

of the interim checkpoint that we have proposed in Section 4.2.2 at which the capacity, transfer method and sequence of support sources are pinned down.

4.2.4 Amount of regulation release discharged to the River Vyrnwy

The Gate 2 report on the NW transfer options says that the maximum amount of STT regulation release into the River Vyrnwy has been reduced to just 25 Ml/d[67]:

> *"In June 2022, the Environment Agency (EA) and Natural Resources Wales (NRW) advised that the discharge to River Vyrnwy should be limited to 25 Ml/d pending the completion of flow trials and summer surveys as part of the STT SRO, which won't be fully evidenced until Gate 3."*

Previously, the maximum amount of discharge allowed was 75 Ml/d and we provided evidence disputing the need for this limit in our response to Ofwat's Gate 1 decisions[68].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 substantial regulation releases would actually be more natural and better 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 a lot 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.

In our response to Ofwat's Gate 1 report, we proposed that the STT options considered for Gate 2 should allow for much larger regulation releases directly into the River Vyrnwy. We suggested that the STT investigation team should look for means of mitigating any impact 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.

This proposal has not been accepted and instead the maximum amount that can be released into the River Severn has been reduced still further to just 25 Ml/d, although we note that "*flow trials and summer surveys"* are being taken in Gate 3.

We propose that Ofwat's Gate 2 decision report should require a properly evidenced and transparent report justifying any limitation on the amount of regulation release that can be discharged into the River Vyrnwy. This report should consider the potentially

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[67] NW transfer SRO Gate 2 report paragraph 3.3.6

[68] GARD response to Ofwat Gate 1 decisions, pages 40 to 43 https://www.abingdonreservoir.org.uk/downloads/GARD%20Final%20combined%20Response%20to%20Gate%201%2018.11.21.pdf

disproportionate cost of the Vyrnwy bypass aqueduct (NPC £170 million) in relation to the benefit that it brings, and whether the money would be better spent on other environmental improvements like reduction in CSO spillage.

4.3 Evaluation of STT costs and benefits

4.3.1 STT deployable output and operational use

GARD modelling of STT deployable output and operational use

GARD's model has been used to determine deployable output and operational use for the 300 Ml/d capacity transfer, with various support options, using historic flow data as shown below:

			Deerhurst to Culham			
Support sources	**Sweetening flow**	**London demand met by STT (DO)**	**days of transfer per year**	**annual transfer volume**	**annual sweetening volume**	**Average total annual volume**
Unsupported only	20 Ml/d	129 Ml/d	22 days	6,006 Ml	6,860 Ml	12,866 Ml
Unsupported + 35 Ml/d Netheridge	20 Ml/d	139 Ml/d	41 days	6,864 Ml	6,480 Ml	13,344 Ml
35 Ml/d Netheridge + 57 Ml/d Minworth	20 Ml/d	174 Ml/d	44 days	8,659 Ml	6,420 Ml	15,079 Ml
35 Ml/d Netheridge + 115 Ml/d Minworth	20 Ml/d	209 Ml/d	46 days	10,568 Ml	6,380 Ml	16,948 Ml

Table 4 – GARD assessment of 300 Ml/d STT deployable outputs and operational use

Our analysis shows that the Pywr modelling has grossly under-estimated the deployable output of unsupported STT options, as explained in the Addendum to our response to Thames Water's WRMP consultation, as per volume 2 of this response[69]. Our modelling shows that the 1:100 year DO of the unsupported 300 Ml/d transfer should be 129 Ml/d compared to Thames Water's figure of about 90 Ml/d. For the 500 Ml/d unsupported transfer, we estimate the 1:100 year DO to be 182 Ml/d compared with Thames Water's figure of about 130 Ml/d.

Thames Water's under-estimation of deployable outputs is highly significant because the unsupported transfer would be a viable first phase of the STT, not dependent on the Minworth or Vyrnwy support sources. The additional London deployable output from unsupported transfers would allow all the Chilterns chalk stream abstraction reductions to go ahead as soon as the Severn to Thames aqueduct is built, potentially in the early 2030s.

The reason for Thames Water's underestimation of deployable outputs appears to be inadequacies in the stochastic river flow data which over-estimate the speed of flow recovery in the River Thames after long droughts and under-estimate the frequency of

[69] Volume 2 Addendum, Section 4.1, page 42

occurrence of long droughts, as further described in the Addendum in volume 2[70]. These deficiencies negate the unsupported STT's ability to provide substantial refill of the London reservoirs during long droughts, due to differences in geology between the Thames and Severn catchments.

We propose that Ofwat's Gate 2 decision report should state that the independent review of the stochastic data and Pywr modelling for Abingdon reservoir that we have advocated in Section 3, should include the assessment of deployable output of the unsupported STT. This should form part of the evidence needed for the interim STT checkpoint that we have advocated in Section 4.2.

The under-estimation of deployable outputs for the unsupported transfer will also affect the DOs for options with modest amounts of support, but the amount of under-estimation will diminish as the amount of support increases.

The need for Vyrnwy replacement sources

Thames Water's WRMP appears to have assumed that at least 80% of the nominal support from Vyrnwy reservoir will require replacement of deployable output through new United Utilities sources. GARD's modelling shows that only about 50% replacement deployable output is needed. This would mean that the costs of STT options with Vyrnwy support may have been inflated by the cost of up to about 70 Ml/d of unnecessary replacement sources.

Ofwat's Gate 2 decision report should require a properly evidenced and transparent assessment of the amount of United Utilities replacement sources needed for the various options for Vyrnwy support for the STT. This should form part of the evidence needed for the interim STT checkpoint that we have advocated in Section 4.2.

4.3.2 STT system costs and errors contained in the Gate 2 reporting

In section 3.3.2, we showed that there are significant errors in the evaluation of the Abingdon Reservoir NPC. This made an approximate 20% *underestimation* in the NPC of the 100 Mm^3 (chosen for evaluation as this is the 'Best Value Plan' choice of WRSE).

GARD have quantified the impact of errors in the evaluation of the STT. By far the largest error comes from the gross-overstatement of Opex in the STT NPC calculations.

Opex costs for STT have been dramatically over estimated. The calculations of NPC for STT 500, STT Minworth and STT Netheridge all use Opex costs that are close to those for 100% utilisation. This is in spite of the fact that in some of the RAPID Gate 2 documents, the STT SROs are modelled to be operated for some 24 - 30% of the time at high flow (the lower figure for the 300 Ml/d sized transfer). An example is given in table 4-1 of the Severn Trent

[70] Ibid Section 2.1

sources Gate 2 document.[71] The astonishing fact that this does not seem to have been transposed over to the cost estimates in other RAPID submissions is really a reflection of ***the way in which the STT is treated in a 'silo-ed', uncoordinated, manner in the RAPID process.*** RAPID themselves are obviously aware of the problems caused, as they would welcome a '*... deep dive across all three STT system solutions* ..[to understand comparative best-value metrics]...'[72]. GARD's view is that this call does not go far enough. ***We believe that the over-arching co-ordination of all STT options should be tasked to an in-house RAPID team***. If not, then errors like the above will be perpetrated, and largely unchecked.

In GARD's modelling to date, the usage of *all* STT options is much lower (see section 4.3.1). The *unsupported STT* operates an average of 22 days per year (about 6%) whilst the various supported options operate between 19-29 days per year (5 – 8%). This will obviously reduce the Opex still further. These final results were not available in our dWRMP24 response due to the late supply of the Pywr model to GARD by Thames Water (see Section 3.3.1), but in that reply, we used 5% unsupported operation and 9% supported operation costs using our preliminary modelling.[73]

GARD's *now-validated* modelling confirms very much lower Opex costs than in the Gate 2 reports. This is shown in below for the STT combination of a 300 Ml/d Deerhurst Aqueduct, unsupported and supported by various combinations of Netheridge and Minworth WwTWs.

Support sources	London demand met by STT (DO)	Total annual opex
Unsupported only	129 Ml/d	£7.63 m/yr
Unsupported + 35 Ml/d Netheridge	139 Ml/d	£7.80 m/yr
35 Ml/d Netheridge + 57 Ml/d Minworth	174 Ml/d	£10.17 m/yr
35 Ml/d Netheridge + 115 Ml/d Minworth	209 Ml/d	£11.07 m/yr

Table 5 - GARD modelled Opex for STT 300 options

This compares to the figure of £58.7m/yr derived for STT 500 + Minworth 115 + Netheridge

[71] https://www.severntrent.com/content/dam/sros-gate-2-documents/sts/STS-Gate-two-submission-(Final)-Redacted.pdf table 4 - 1
[72] https://www.ofwat.gov.uk/wp-content/uploads/2023/03/STT_Solution_Gate-Two_Draft-Decisions-1.pdf - section 3.4.3
[73] https://www.gard-oxon.org.uk/downloads/21.3.23%20GARD%20response%20to%20TW%20WRMP%2021.3.23.pdf – see section 6.2.3, p 118.

at ***continuous maximum*** use as per Table 10.2 of the STT cost report.[74] As the text above Table 10.2 says:

"*The flow regime is unknown and therefore the Min and Max flows are shown for comparison. The system will operate at minimum capacity, and flows will increase when needed*."

GARD's figure of £11.07 m per year is for the 300 Ml/d transfer (not 500) and with modelled average operational use of 46 days per year, during which Minworth would only be used for an average of 24 days per year, with the other 22 days coming from unsupported Severn flows. The use of the STT is very variable, with no need to use it all in over 50% of years and near-continuous use in major drought years.

We have concentrated on the STT300 aqueduct and the Minworth and Netheridge support in this section, as it was GARD's suggested first stage in our response to WRSE and Thames Water. It has the benefit of a deployable output closed to Thames Water's value for Abingdon 100 (185 Ml/d - although, as we have seen in Section 3.3.1, this value has many errors and is disputed by GARD). However, we have also modelled the results for other STT configurations, and the variation is not very large, and certainly nowhere near the Gate 2 table values. For example, if Minworth is replaced by Lake Vyrnwy support and the Shrewsbury interconnector, the Opex for 207 Ml/d is £11. 25 m/yr, whilst the 'full' STT300 supported system (Deerhurst 300 + Netheridge and Minworth + Lake Vyrnwy and Shrewsbury) has an Opex of £15.0 m/yr for a deployable output of 288 Ml/d. Note that the Deerhurst 300 aqueduct can cope with the full upgraded system if necessary.

GARD has modelled the impact of these lower Opex costs on NPC, as for these three tables.

1. The first (Table 6) is as in the Gate 2 documents.
2. The second (Table 7) has the Abingdon NPC corrected for the errors as discussed in section 3.3.2, and GARD Opex for the STT 500 + Netheridge and Minworth support.
3. The third (Table 8), is as for Table 7, but taking the case of the STT 300 Deerhurst aqueduct.

[74] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/water-transfer-from-the-river-severn-to-the-river-thames/gate-2-reports/STT-G2-S3-357-STT-Cost-Report.pdf table 10.2

£ millions	STT 500 80 year	STT Minw 80 year	STT Nether 80 year	STT Total 80 year	*SESRO 100* *80 year*
Capex	1,440	373	268	2,081	*1,741*
Costed Risk	26	15	18	59	*286*
Optimism Bias	531	116	82	729	*486*
Total	1,997	504	368	2,869	*2,513*
Depreciation	1,360	428	304	2,092	*1,155*
RCV end 2104-5	*623*	*63*	*55*	*741*	*1,546*
NPC of final RCV	*52*	*5*	*5*	*62*	*129*
Opex p.a.	37.3	17.8	3.6	58.7	*4.3*
Opex total	2,611	1,263	253	4,127	*282*
Financing Cost	3,252	712	488	4,452	*4,262*
*In use - Opex/depn**	*2035-36*	*2034-35*	*2034-35*		*2037-38*
Year zero for NPC	*2024-25*	*2024-25*	*2024-25*	*2024-25*	*2022-23*
Start 80 year	*2025-26*	*2025-26*	*2025-26*	*2025-26*	*2023-24*
End 80 year	*2104-05*	*2104-05*	*2104-05*	*2104-05*	*2102-03*
NPC	1,726	587	221	**2,534**	***1,301***
NPC from Opex	*712*	*352*	*71*	*1,135*	*71*
NPC from Depreciation	*382*	*123*	*88*	*593*	*243*
NPC from return on RCV	*620*	*108*	*62*	*790*	*986*

Notes

*1 * In use = date from which depreciation and Opex are recorded*

Table 6 - NPC comparison of STT 500 (Netheridge + Minworth support) and Abingdon (SESRO) 100 Mm^3 option as derived from Gate 2 tables.

£ millions	STT 500 80 year	STT Minw 80 year	STT Nether 80 year	STT Total 80 year	*SESRO 100* *80 year*
Capex	1,440	373	268	2,081	*1,741*
Costed Risk	26	15	18	59	*286*
Optimism Bias	531	116	82	729	*486*
Total	1,997	504	368	2,869	*2,513*
Depreciation	1,360	428	304	2,092	*1,155*
RCV end 2104-5	*623*	*63*	*55*	*741*	*1,357*
NPC of final RCV	*52*	*5*	*5*	*62*	*113*
Opex p.a.	6.1	2.4	2.6	11.1	*4.3*
Opex total	427	1,263	253	1,943	*299*
Financing Cost	3,252	712	488	4,452	*4,506*
*In use - Opex/depn**	*2035-36*	*2034-35*	*2034-35*		*2037-38*
Year zero for NPC	*2024-25*	*2024-25*	*2024-25*	*2024-25*	*2024-25*
Start 80 year	*2025-26*	*2025-26*	*2025-26*	*2025-26*	*2023-24*
End 80 year	*2104-05*	*2104-05*	*2104-05*	*2104-05*	*2106-07*
NPC	1,125	279	221	**1,625**	***1,571***
NPC from Opex	*117*	*47*	*71*	*235*	*77.6*
NPC from Depreciation	*385*	*123*	*88*	*596*	*322.8*
NPC from return on RCV	*623*	*108*	*62*	*793*	*1,170.5*

Table 7 - NPC comparison of STT 500 (Netheridge + Minworth support) with GARD Opex and Abingdon (SESRO) 100 Mm^3 option corrected as per section 3.3.2

	STT 300	STT Minw	STT Nether	STT Total	SESRO 100
£ millions	80 year	80 year	80 year	80 year	80 year
Capex	988	373	268	1,629	1,741
Costed Risk	18	15	18	51	286
Optimism Bias	364	116	82	562	486
Total	1,370	504	368	2,242	2,513
Depreciation	932	428	304	1,664	1,155
RCV end 2104-5	429	63	55	547	1,357
NPC of final RCV	52	5	5	62	113
Opex p.a.	6.1	2.4	2.6	11.1	4.3
Opex total	427	1,263	253	1,943	299
Financing Cost	2,231	712	488	3,431	4,506
*In use - Opex/depn**	2035-36	2034-35	2034-35		2037-38
Year zero for NPC	2024-25	2024-25	2024-25	2024-25	2024-25
Start 80 year	2025-26	2025-26	2025-26	2025-26	2023-24
End 80 year	2104-05	2104-05	2104-05	2104-05	2106-07
NPC	809	279	221	**1,309**	**1,571**
NPC from Opex	117	47	71	235	77.6
NPC from Depreciation	264	123	88	474	322.8
NPC from return on RCV	428	108	62	597	1,170.5

Table 8 - NPC comparison of STT 300 (Netheridge + Minworth support) with GARD Opex and Abingdon (SESRO) 100 Mm^3 option corrected as per section 3.3.2

As shown the tables, the GARD Opex reduces the NPC of the STT300 supported by the Midlands Water Treatment works *below* the corrected evaluation of the Abingdon 100 Mm^3 option.

This re-evaluation must be validated by RAPID, and we believe, a correction made to the Gate 2 documentation for Gate 3.

4.3.3 STT Scheme carbon budgets

As we have already indicated in previous sections, the STT options form a very flexible set of schemes which can be implemented in phases. To establish numbers for Carbon Footprint of the STT which can be compared with the main alternative scheme, Abingdon reservoir, we need to make scheme configuration choices. As we have shown in section 4.3.1, the STT Deerhurst pipeline can be supported, with very similar deployable output, by either:

- the Netheridge STW upgrade (for the ‘sweetening flow’ and up to 35 Ml/d support) and
- either the Minworth STW upgrade (at the full 115 Ml/d) or
- the Vyrnwy Reservoir supplying 120 Ml/d *plus* Shrewsbury Interconnector at 25 Ml/d.

These two options give very similar deployable outputs at a very similar Opex cost. GARD's modelling (see Volume 2) shows that a 300 Ml/d pipeline from Deerhurst to Culham can support the final, full STT scheme (which would include Minworth and Vyrnwy and Shrewsbury) deployable output of 288 Ml/d. In our cost and carbon comparisons we therefore use the values for the STT 300 pipeline. The deployable output for either of the above schemes feeding a 300 pipeline is around 207 Ml/d. This is somewhat higher than RAPID Gate 2's deployable output for the Abingdon 100Mm^3 reservoir.

In our response to Thames Water dWRMP and the WRSE draft Regional Plan, we chose the option without Vyrnwy support as our 'Phase 1 STT'. We will therefore analyse this in detail below, and highlight changes which would occur for the Vyrnwy/Shrewsbury supported scheme.

Capex or 'Capital' or 'Embedded' carbon

The Capital or 'Embedded' carbon for the STT Phase 1 comes from construction of:

- The 300 Ml/d Deerhurst-Culham Aqueduct (pipeline) and accompanying treatment;
- The 115 Ml/d upgrade to the Minworth STW;
- The Netheridge STW upgrade.

The carbon strategy and overview for the pipeline and treatment is given in a detailed RAPID Gate 2 report.[75] From this comes figure 4-1 (shown below as our Figure 14)

Figure 4-1 Capital Carbon for Deerhurst to Culham Interconnector (by pipeline capacity).

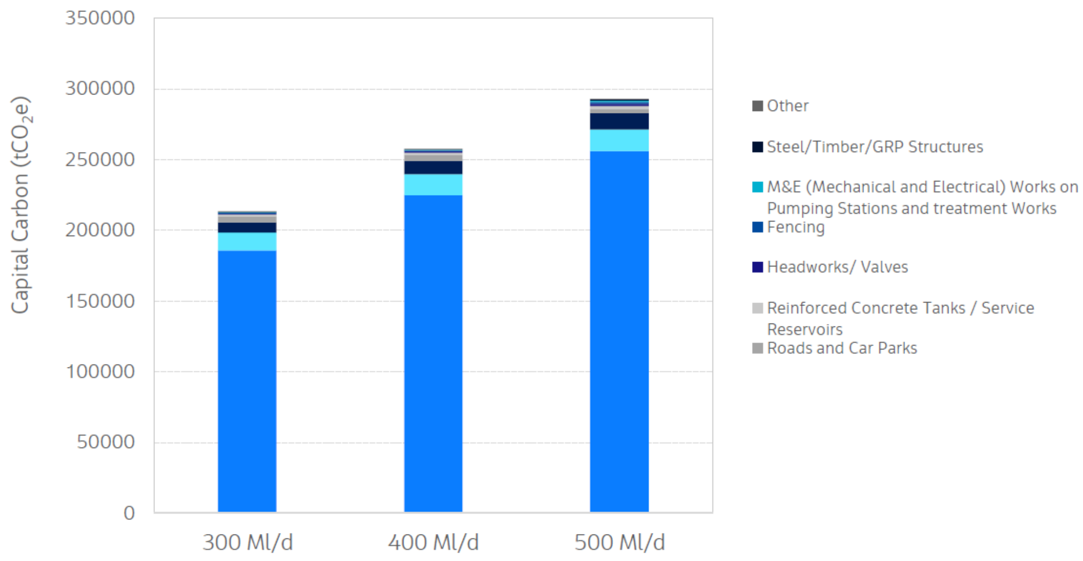

Figure 14 - Capital carbon for STT interconnector pipeline options

This shows that materials associated with the pipeline form about 87% of the capital carbon

[75] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/water-transfer-from-the-river-severn-to-the-river-thames/gate-2-reports/STT-G2-S3-360-Carbon-Strategy-Report.pdf

budget. As with the case for the Reservoir, discussed in section 3.3.3, WRSE attempt in their draft Regional Plan Annex 2[76] to motivate a path forward for capital carbon reduction. We discuss some of this in Appendix S. GARD concludes that the quoted potential reductions are similarly optimistic to those discussed for Abingdon Reservoir Capex carbon in Section 3.3.3 and Appendix P. In brief, the potential reductions before the mid-century are optimistic due to:

- the non-existence of the steel grades needed, without extensive research and material qualification;
- the roll-out to wide commercial availability of relevant steel grades, given the huge scale of the steel-plant modifications to produce the new grades.

Thus, the reduction of capital carbon for the STT is optimistic on a very similar timescale to that of the Abingdon Reservoir. When evaluating Strategic Options, both RAPID and Ofwat really need to assume that the near-term (prior to mid-2040s) programmes will proceed with the currently-evaluated capital carbon budgets (corrected for errors and omissions). In the case of the STT, the only possible conclusions are:

- to use the minimum necessary pipeline diameter; or
- to re-evaluate the Cotswold Canal version of the Severn-Thames transfer solution which limits the need for long-distance pipes.

The Capital carbon footprint for the GARD 'STT Phase 1' comes from

1. The 300 Ml/d Interconnector (including treatment) - **243,191 tCO_2eq**. (table 6.2 of STT concept design report – includes 30,000 for Maintenance),
2. The Netheridge WwTW - Gate 2 '*unmitigated*' value of[77] **36,425 tCO_2eq**.
(Here the mitigation, which would give a figure of 30,939 tCO_2eq, is at least partially due to pipeline re-routing, being discussed with the EA[78]).
3. The Minworth WwTW- Gate 2 '*unmitigated*' value of[79] **130,048 tCO_2eq**.
There are various aspirations in the Minworth report, to mitigate this by around 40%, half of which is attributed to low carbon materials. Discounting the materials option (although there is at least a low carbon roadmap for concrete[80]), there remains a '*to be discussed'* option of a 20% (26,000 tCO_2eq) due to pipeline routing optimisation (which would also reduce Opex).

[76] https://www.wrse.org.uk/media/lanejwxx/wrse-draft-regional-plan-technical-annex-2-nov-2022.pdf
[77] https://www.severntrent.com/content/dam/sros-gate-2-documents/sts/STS-Gate-two-submission-(Final)-Redacted.pdf, table 6-1.
[78] STS-Gate-two-submission-(final) para 6.30.
[79] https://www.severntrent.com/content/dam/sros-gate-2-documents/minworth/Minworth-Gate-two-submission-111122-Redacted.pdf, table 6-3.
[80] https://www.ice.org.uk/media/q12jkljj/low-carbon-concrete-routemap.pdf

Thus, we have a capital carbon footprint for the STT Phase 1 of **378,168 – 409,664 tCO_2eq** (depending on routing strategy).

The alternative, Vyrnwy/Shrewsbury supported Phase 1 has a much lower Capital carbon footprint, due to the absence of the Minworth plant. The Vyrnwy Bypass pipeline has a capital carbon footprint[81] of **6147 – 15763 tCO_2eq**, whilst the capital carbon associated with the Shrewsbury interconnector is entirely negligible. Thus, this alternative scheme has a capital carbon footprint **of 249,338 – 258,954 tCO_2eq**.

OPEX or operational carbon

There are many issues regarding evaluation of STT Opex carbon in the RAPID Gate 2 reports. The largest problem, already cited for the STT Opex costs in Section 4.3.2, is overestimation of the percentage of time that the scheme operates at full flow. In summary, the problems are:

1. The parts of the scheme operate at full-flow for different assumed percentages of the planning period:
    - for the Dewhurst pipeline, 20% operation at full flow is assumed;[82]
    - for Minworth, operation at full flow for 10% of the time is assumed;[83]
    - for Netheridge, plant operation at 35 Ml/d flow for 10% of the time (35 days per year), and at 20 Ml/d flow for 33% of the time (120 days per year).[84]
    - In contrast (see section 4.3.2), GARD models Deerhurst as operating at supporting flow for 11-14% of the time, and the supporting flow for 5-8% of the time.
2. Decarbonisation of the Grid electricity is considered in the STT Deerhurst pipeline report, showing a decrease out to 2050 and beyond. This is shown in Figure 15, taken from the STT Carbon report[85]. Uneven detail exists in the evaluation of potential of energy recovery from the 'downhill' part of the inflow/ outflow of the various schemes. Although energy recovery is assumed in all schemes, the constraints (for instance the statement that energy recovery for the STT pipeline is 'less efficient' at high flow) have not been optimised. Whilst this does not have a major effect on Opex carbon, it does affect Opex costs of electricity use. There is also

[81] file:///C:/Users/thest/Desktop/RAPID-Ofwat/Gate%202/STT-G2-S3-360-Carbon-Strategy-Report.pdf - table 4.1
[82] STT-G2-S3-360-Carbon-Strategy-Report.pdf – section 4.3.1
[83] Minworth-Gate-two-submission-111122-Redacted.pdf, - footnote 7, p 21.
[84] https://www.severntrent.com/content/dam/sros-gate-2-documents/sts/STSAnnex-A4-Carbon-Report-Redacted.pdf - section 2.2, p 9
[85] STT-G2-S3-360-Carbon-Strategy-Report.pdf, table 4-5.

(Minworth) potential for a further reduction of 156 tCO2e annually, using ahydropower scheme at the River Avon discharge, not included in these figures.[86]

3. Operational use of chemicals is assumed to remain a substantial part of the Opex carbon budget, due mainly to the assumption that the decarbonising of this sector will take a long time (and in contrast the Power grid, the other main source of carbon, has a decarbonising trajectory). ***However, given the long time-scale (70 years) for the Opex calculations, GARD feels that a 'decarbonising roadmap' calculation is needed for the chemical input.*** Whatever the limitations of this sort of analysis (see Appendix S), we feel that the Opex carbon is pessimistic as it stands in the Gate 2 reports. The Deerhurst and Netheridge carbon reports assume that the chemicals' carbon footprint remains the same until post-2050. We note that Ofwat has ruled that in both its '*High Technology'* and '*Low Technology'* common-reference scenarios, against which the companies are supposed to assess their plans, they are to assume 100% decarbonised electricity production by 2035[87] (which also affects the carbon footprint of operational materials production).

Figure 4-5 Operational carbon hotspots for all three design sub-options at the proposed sweetening flow

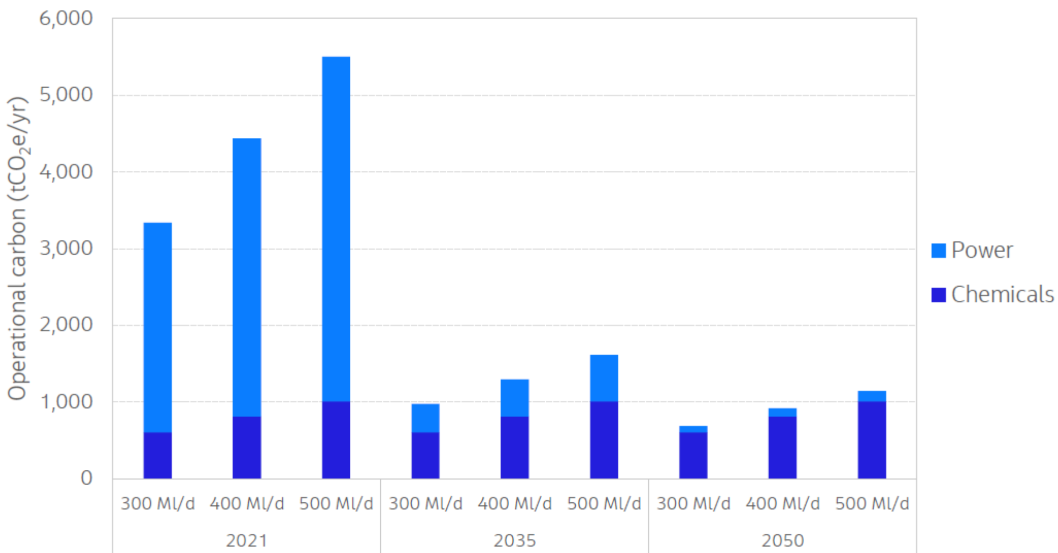

Figure 15 - Operational carbon budgets for STT Deerhurst interconnector options

4. The most important problem however, is the ***difference in assumed Operational Start date.*** This has already been noted as affecting cost comparisons, but as Figure 15 shows, there is a huge difference in Opex carbon if the Deerhurst connector had started operation in 2021, compared to an operational start date of 2035 (the earliest feasible current start date). In fact, this distorts the whole evaluation in the STT Design Report (table 6.2) the Opex carbon for the 300 Ml/d Deerhurst option is

[86] Minworth- Gate -two – two -submission – 111122-Redcated.pdf – footnote 8 p21.
[87] https://www.ofwat.gov.uk/wp-content/uploads/2021/11/PR24-and-beyond-Long-term-delivery-strategies-and-common-reference-scenarios.pdf pp33-34.

quoted as **139,258 tCO_2Eq.** This figure cannot possibly be derived from70-80 years of operation with the Figure 15 yearly Opex carbon. By 2035 the Opex carbon for Deerhurst is less than 1000 tCO_2eq per annum and reduces to around 600 tCO_2eq by 2050.

In contrast, the70-year operation of the Supporting Treatment works *appear* from the documentation, to start in 2030.

Scheme (component)	DO (Ml/d)	Gate 2 Opex Carbon(tCO2eq)	GARD Opex Carbon (tCO2eq)	Notes
STT 300 Ml/d ***Unsupported*** (Pipeline + treatment)	129	139,258 [1]	< 48,000 [2]	[1] 20% full flow ops from 2021 [2] Operation from 2035 at Gate 2 levels
Netheridge 35 Ml/d	+10	101,710 – 107,520 [3]	33,114 – 35,082 [4]	[3] Covers options in Gate 2 report -10% at 35 Ml/d; 33% at 20 Ml/d [4} 8% flow ops
Minworth 115 Ml/d	+70	168, 848 [5]	135,078 [6]	[5] 10% flow ops [8] 8% flow ops
STT Phase 1 as per GARD	**207**	**409,816 -415,926**	**<216,192-218,160**	**Dominated by chemical consumption.**
STT Phase 1 'Vyrnwy + Shrewsbury'	**207**	**139,258 [7}**	**<81,114 – 83,082**	**Vyrnwy and Shrewsbury negligible. GARD scheme assumes Netheridge support.**

Table 9 - STT Opex carbon estimations – Gate 2 compared to GARD

We have attempted to summarise this in Table 9 above, attempting to scale the Gate 2 Opex carbon figures for STT Phase 1. For the Deerhurst pipeline and treatment, we give and *upper limit, based on 15 years at 2035 operation levels (1000 tCO2eq/yr), and 55 years at 2050 levels (600 tCO2eq/yr) (Figure 15).* This is an upper limit, as the lower GARD operational profile for the transfer still needs to be factored in. For the other components of the scheme, we take the scaling relating the Gate 2 operational support levels and the GARD support levels.

Summary of flaws in the Gate 2 reports STT analysis

There are flaws in the analysis, in particular that the various possible schemes are not compared in full. The major flaws are in the Opex analysis (in order of importance):

1. Inconsistent operational starting dates for the various parts of the scheme. In particular this seriously over-estimates the Opex carbon for the STT Deerhurst connector.

2. Over-estimated scheme usage time at unsupported and supported full flow, and inconsistency in the assumed full-flow operation for different parts of the scheme.

3. No analysis about de-carbonisation potential of the chemical Opex budget. This causes over-estimation of the post-2050 Opex carbon.

4. Largely undeveloped assessment of the energy recovery potential for various scheme components. Minworth potential is not assessed at all.

If these flaws are corrected GARD estimates the Opex carbon budget for the fully

supported Phase 1 300 Ml/d STT will reduce by about 50%: from around 416 ktCO_2eq to less than 216 ktCO_2eq. We note that the 'Vyrnwy supported Phase 1' scheme has a much lower Opex carbon budget, of less than 81 ktCO_2eq under GARD's assumptions.

4.3.4 Comparison of STT vs Abingdon reservoir costs and carbon

Costs

A proper, transparent, like-for-like comparison of an Abingdon Reservoir option against an *equivalent* STT option is needed for Gate 3. At present in Gate 2, we have the errors in the NPC calculations arising from:

- the errors in the Abingdon 100 option, as discussed in section 3.3.2, amounting to an under-estimate of £271m; and
- the errors in the Operational use of the STT, resulting in an overestimate (on GARD's modelling) of somewhere in the region of £46m/yr at 2022 prices (see section 4.3.2);

There is also the continued inability of the RAPID teams to compare options of Reservoir and STT which have similar deployable outputs.

GARD has carried out such a comparison for the 'STT Phase 1' and the Abingdon Reservoir 100Mm^3 option in section 4.3.2. The results are in Table 8, which is partially-reproduced here, as table 10. We see that the STT Phase 1 is substantially cheaper, on a NPC basis than the equivalent Abingdon Reservoir.

	STT 300	STT Minw	STT Nether	STT Total	*SESRO 100*
£ millions	80 year	80 year	80 year	80 year	*80 year*
Capex	988	373	268	1,629	*1,741*
Costed Risk	18	15	18	51	*286*
Optimism Bias	364	116	82	562	*486*
Total	1,370	504	368	2,242	*2,513*
*In use - Opex/depn**	*2035-36*	*2034-35*	*2034-35*		*2037-38*
Year zero for NPC	*2024-25*	*2024-25*	*2024-25*	*2024-25*	*2024-25*
Start 80 year	*2025-26*	*2025-26*	*2025-26*	*2025-26*	*2023-24*
End 80 year	*2104-05*	*2104-05*	*2104-05*	*2104-05*	*2106-07*
NPC	809	279	221	**1,309**	***1,571***
NPC from Opex	*117*	*47*	*71*	*235*	*77.6*
NPC from Depreciation	*264*	*123*	*88*	*474*	*322.8*
NPC from return on RCV	*428*	*108*	*62*	*597*	*1,170.5*

Table 10: GARD like-for-like NPC comparison for STT Phase 1 and Abingdon Reservoir 100

Carbon

In similarity with the cost situation, a like-for-like comparison of equivalent Abingdon Reservoir and STT options is still missing. The most serious issues, which relate to the wrong operational in-service date for the STT systems and the modelled operational use of the STT, cause very large errors in the calculated Opex of the STT, whichever configuration is selected. Here we summarise the accurate situation as we understand it, for a *nearly* like-for-like combination (the 'Abingdon 100' and the GARD 'STT Phase 1' (figures to nearest ktCO_2eq):

Abingdon 100 Capex carbon[88] : 403 ktCO_2eq

- maintenance replacements over 65-year life ***included***
- Cost of water treatment plants ***not included***

STT Ph 1 Capex Carbon (Deerhurst 300 + Netheridge+ Minworth115):[89] 378- 409 ktCO_2eq

- Maintenance replacements over 70-year planning period ***included***
- Lower figure comes from re-routing options.
- We note the alternative STT Ph 1 supported by Vyrnwy/Shrewsbury) has a Capex carbon of **249 – 258 ktCO_2eq.**

Abingdon 100 Opex carbon:[90] 4 ktCO_2eq

- 65-year lifetime starting in 2037-2038;
- ***Includes*** a reduction of around 2ktCO2eq for power recovery turbine;
- ***does not include*** power operation of water treatment;
- ***does not include*** estimated Greenhouse gas emissions from reservoir (mainly CH_4) may be around 1.0 - 6.5 ktCO_2eq per year (see appendix P), ie. **65 – 420 ktCO_2eq** over the planning period.

STT Ph 1 Opex Carbon (Deerhurst 300 + Netheridge+ Minworth115)[91]: < 216-218 ktCO_2eq

- GARD figure, using operation flow usage and start date for operations of 2035;
- ***does not include*** any reduction for energy recovery/generation from downhill sections of Deerhurst pipelines[92]
- ***does not include*** Minworth potential for a further reduction of 11 ktCO_2eq over planning period, using a hydropower scheme at the River Avon discharge;[93].

[88] SESRO Carbon report – table 4.3
[89] See section 4.3.3 for list of RAPID Gate 2 references
[90] SESRO carbon report – table 4.1
[91] Section 4.3.3 – table 9.
[92] STT Carbon strategy report

- ***does not include*** any outcome of EA discussions about the possibility of dispensing with Netheridge WwTW effluent additional treatment[94], which would save around 64 ktCO_2eq, as cited in section 4.2.3.

- again, we note that GARD's calculation of the alternative STT Ph 1 supported by Vyrnwy/Shrewsbury) has an Opex carbon of **<81 – 83 ktCO_2eq.**

Carbon Summary

Comparison of Capex carbon has further work needed at Gate 3, but the situation on Opex Carbon is completely unsatisfactory. The following is needed before Gate 3:

- Comparison of the same planning period for both Abingdon and STT, and, particularly for STT, a feasible earliest start date of 2035 – not the calculation of Opex carbon from the *2020s, which seriously overestimates STT Opex carbon.*

- Realistic operational use figures for STT.

- Evaluation of the Reservoir Greenhouse gas emission carbon burden for inclusion in the Reservoir Opex carbon.

- Inclusion of energy recovery possibilities in the STT Deerhurst and Minworth components.

- Evaluation of water treatment power requirements for the Abingdon Reservoir.

- A proper Road-map evaluation of the possibilities of decarbonisation of the chemical production – consistent with the Grid decarbonisation assumptions used.

4.4 Programme and planning

Ofwat's Gate 2 report for the STT rates the 'Programme and planning' as satisfactory, rather than good, and justifies this as follows:

> *"We consider the evidence provided by Severn Trent Water, Thames Water and United Utilities regarding the programme and planning, risks and issues and the procurement and planning route strategy for the River Severn to River Thames Transfer to be partially sufficient in terms of detail and quality for gate two. However, additional work is required in the areas of:*
>
> - *risks and issues to solution progression;*
> - *the procurement and planning route strategy;*

[93] Minworth- Gate -two – two -submission – 111122-Redcated.pdf – footnote 8 p21.
[94] Severn Trent Sources Gate 2 Report, paragraph 3.12

- *subsequent gate activities with outcomes, penalty assessment criteria and incentives.*

We welcome the progress on the gate one action to "demonstrate full understanding of the risks to the solution from potential regulatory barriers, this includes risks and issues associated with the Habitats Regulations ". However, we have significant concerns about the considerable programme risk that remains because of the potential impact on the Severn Estuary Habitat Regulations site."

Whereas we appreciate the need to comply with the Habitats Directive, we would not expect this to be a show-stopper, bearing in mind the highly protective Deerhurst hands-off flow that has now been adopted and the attention being given to the possible need for additional treatment at Netheridge and Minworth WWTWs.

On the other hand, we think that the Gate 2 reporting should have given more emphasis to the potential need for rapid implementation of the STT in order to facilitate rapid re-naturalisation of flows in the Chilterns chalk streams. For this reason, we would also rate the 'Programme and planning' as satisfactory rather than good.

We propose that the Ofwat Gate 2 decision report should include a recommendation for a 'fast track' implementation programme to be considered in Gate 3, in recognition of the potential for the STT to facilitate early re-naturalisation of chalk stream flows

4.5 Ofwat recommendations for Gate 3

Ofwat's Appendix A of the STT Gate 2 decision report includes a list of actions and recommendations for the Gate 3. Whereas we agree that these are all needed, we think that there needs to be some requirements for Gate 3, addressing the matters raised in this Section 4. These include an interim Gate 3 checkpoint at which the matters below are addressed in a properly evidenced and transparent way:

9. Definition of the transfer capacity, transfer method (pipeline or Cotswold canal) and sequence of support sources.

10. The need for additional treatment at Netheridge and Minworth WWTWs, including consideration of potential disproportionality of costs.

11. Limitation on the amount of regulation release that can be discharged into the River Vyrnwy.

12. Independent review of the stochastic data and Pywr of the STT, including the assessment of deployable output of the unsupported STT. This can be part of the independent review of modelling for Abingdon reservoir that we have advocated in Section 3.8.

13. Properly evidenced and transparent assessment of the amount of United Utilities replacement sources needed for the various options for Vyrnwy support for the STT.

14. A 'fast track' implementation programme to facilitate early chalk stream flow re-naturalisation in the Thames valley.

15. The over-arching co-ordination of *comparative evaluation* of all STT options should be tasked to an in-house RAPID team. The major task would be validation of STT NPC estimates (See section 4.3.2) and the Opex carbon analysis supervision listed in 8 below.

16. The following actions (details in section 4.3.4) on Opex Carbon comparison of the STT with the Abingdon Reservoir:

    a. Evaluation of STT from a feasible earliest start date of 2035, and over the same planning period as Abingdon.

    b. Realistic operational use figures for STT.

    c. Evaluation of the Reservoir Greenhouse gas emission.

    d. Inclusion of Abingdon water treatment power requirements.

    e. Proper Road-map evaluation of the possibilities of decarbonisation of the chemical production – consistent with the Grid decarbonisation

5. Thames to Affinity transfer (T2AT)

5.1 GARD overview

Ofwat's Gate2 decision report on the Thames to Affinity transfer, Figure 3, assesses the quality of the Gate 2 reporting as uniformly 'Good' in all categories. Although we are pleased to see that this scheme is viewed positively by both Thames Water and Affinity Water, we have a number of criticisms of the investigation to date and a proposal for expansion of its scope, in brief:

1. The scheme is needed urgently to enable much needed reductions in chalk groundwater abstractions, allowing re-naturalisation of flows in the heavily over-abstracted Chilterns chalk streams. The Gate 2 report proposes that the transfer is sourced by water from Abingdon reservoir, so it has to wait until at least 2040 before it can be operational. We consider this delay to be unacceptable and unnecessary.

2. The source of water is said to be the River Thames, supported by regulation releases from Abingdon reservoir. We propose the water source should be direct connection to an existing London reservoir, so it would be a direct raw water export from the existing London supply system. Our assessment of Thames Water's supply-demand balance in Figure 1 of this response shows that the raw water transfer can be sourced by the Teddington DRA scheme and Thames Water leakage and PCC reductions, without the need for Abingdon reservoir.

3. The continuing Gate 3 investigations should include investigation of a Chilterns-based scheme similar to the West Berkshire Groundwater Scheme (WBGWS), which can operate conjunctively with the Thames to Affinity transfer, increasing London deployable output and reducing the net demand on London's supplies.

Sourcing the transfer water by direct connection to an existing reservoir and the London supply system was proposed by GARD during the finalisation of PR19 and referenced by Ofwat in the appendix to its final PR19 determination which defined the scope of the SRO investigations[95]:

> *"Thames Water to Affinity Water transfer – [GARD] propose that an alternative option incorporating a raw water transfer from an existing reservoir is considered fully for gate one."*

Followed by:

> *"We [Ofwat] note the additional information provided by GARD on technical details of*

[95] PR19 Final Determination Strategic regional water resource solutions, Appendix, page 24 https://www.ofwat.gov.uk/wp-content/uploads/2019/12/PR19-final-determinations-Strategic-regional-water-resource-solutions-appendix.pdf

several solutions. This technical analysis may be useful for the process going forward. We modify the description of the Thames Water to Affinity Water transfer slightly to consider a broader range of sub-options. We consider no further changes to solutions are necessary at this stage."

The matter was raised again in our response to the T2AT Gate 1 report[96]:

"The Ofwat/RAPID Gate 1 decision 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."

Although this comment was acknowledged in Ofwat's final Gate 1 decision report[97], there was no specific action recommended and nothing more has been done. We consider the continuing failure of Ofwat and the water companies to address these matters to be extremely disappointing. **We propose that these matters are addressed specifically in Ofwat's final Gate 2 decision report, taking account of the details below.**

5.1 Timing and scope of the transfer

GARD proposes that 50 Ml/d of the Thames to Affinity transfer should be brought forward to the early 2030s, connecting Affinity Water to Thames Water's London supply system. Combined with early implementation of 'Connect 2050' (re-naming it 'Connect 2030') and the GUC transfer, the Thames to Affinity transfer would allow all the planned upper Colne and Lea chalk stream reductions to be in place by the early 2030s. This would be much better than having to wait until 2040 (or even later) for Abingdon reservoir to be built and filled, as proposed by Thames Water.

The Concept Design Report for the Thames valley component of the T2AT describes the source of water for the transfer as follows[98]:

"The source of water for the LTR option is the River Thames. The natural flow in the river will need to be supported, especially during drought years, by the South East Strategic Reservoir (SESRO) SRO and possibly the Severn Thames Transfer (STT) SRO. SESRO is a pre-requisite for the LTR option because without SESRO the LTR option would leave Thames Water with a reduced volume of strategic storage."

In GARD's opinion, the source of water or the Thames to Affinity transfer should be a direct connection to Thames Water's London supply system, via an existing reservoir, probably the

[96] GARD response to draft Ofwat decisions on Gate 1 reports, page 47 https://www.abingdonreservoir.org.uk/downloads/GARD%20Final%20combined%20Response%20to%20Gate%201%2018.11.21.pdf

[97] Ofwat T2AT final Gate 1 decision report, page 7 https://www.ofwat.gov.uk/wp-content/uploads/2021/12/Final-decision-publication-Thames-%E2%80%93-Affinity-transfer-Cover.pdf

[98] T2AT Concept Design Report, Lower Thames Reservoir Version, paragraph 1.11

Queen Mother reservoir. The 50 Ml/d transfer to Affinity would become an additional 50 Ml/d demand on London's supply system. The existing reservoir system can provide support to the natural River Thames flows when needed in a drought, as it does for all other demands on the London supply system. By the time the T2AT transfer comes into operation in the early 2030s, the demand on London's supplies will have been reduced by about 100 Ml/d due to Thames Water's planned leakage and PCC reductions[99], and there will be additional 67 Ml/d of deployable output from the planned Teddington DRA scheme. There will be no need for any water from Abingdon reservoir or the Severn to Thames transfer.

GARD does not accept the above argument that "*SESRO is a pre-requisite for the LTR option because without SESRO the LTR option would leave Thames Water with a reduced volume of strategic storage.*" The 50 Ml/d demand from Affinity Water on the London supply system would be no different to any other London demand. If the London supply system deployable output can cover the demand, as it can with planned demand savings, leakage reduction and Teddington DRA scheme, there is no need for additional London storage.

Even accepting Thames Water's low allowance for recovery of deployable output from reduced chalk stream abstractions, the 50 Ml/d Thames to Affinity transfer doesn't need to wait for either Abingdon reservoir or the Severn to Thames transfer. With a 50 Ml/d transfer to Affinity and no support from Abingdon reservoir or STT, Figure 1 of this response shows that there would still be a substantial surplus in London's supply demand balance in the early 2030s, which could source up to 100 Ml/d of transfer to Affinity if eventually needed. This assumes GARD's population growth figures and the medium climate change scenario (starting at zero climate change loss in 2020). However, if the first phase of the Severn to Thames transfer is brought forward to the early 2030, as proposed by GARD, this would provide insurance against population growth or climate change being more than expected.

5.2 WBGWS-type scheme for the Chilterns

GARD recognises that there is uncertainty in the amount of flow recovery from the planned chalk stream abstraction reductions that can be converted into additional deployable output from London's reservoirs. However, this uncertainty can be managed, and with a possible net increase in deployable output from downstream reservoirs, if the chalk aquifer is used for drought support schemes similar to the existing West Berkshire Groundwater Scheme.

The West Berkshire Groundwater Scheme (WBGWS) was constructed in the 1970s to augment London's water supplies during severe droughts – its planned use is about once in 25 years. The scheme abstracts water from boreholes in the chalk aquifer in the upper Lambourn, Pang, Enbourne and Loddon valleys, discharging water into those rivers from where it flows down into the River Thames for later abstraction to fill London's reservoirs. It contributes about 90 Ml/d to London's deployable output.

[99] Data from Thames Water WRMP tables, London Final Plan supply demand balance

The WBGWS concept could be used in the chalk streams of the upper Colne and Lea valleys, operating in conjunction with the proposed abstraction reductions. When triggered in droughts, boreholes in the chalk tributaries would augment flows in the River Thames for abstraction into the lower Thames reservoirs. Boreholes in the Lea tributaries would supplement filling of the Lea valley reservoirs.

The recent Chalk Streams First report shows how the chalk tributaries of the Colne and Lea could be used in a WBGWS-type scheme, providing an insurance against flow recovery being less than expected[100]. Drought support releases from the Colne tributaries could be used for filling the existing lower Thames reservoirs and support from the Lea tributaries would feed into the Lea valley reservoirs.

The CSF report's conclusions from this assessment of the potential for use of the WBGWS concept in the Chilterns chalk streams were:

1. If the concept was adopted in all the upper Colne and Lea chalk streams, abstraction could be reduced by 150 Ml/d as proposed by EA, with replacement supplies as from London reservoirs and a net gain to London's supplies of possibly 55-60 Ml/d.

2. The drought support would only be needed about once in 25 years. Flows in the chalk streams in drought years would be increased by the WBGWS-type releases and would be slightly less in the following year (but still much more than with abstraction at recent levels).

3. Although the net gain in London supplies requires much more investigation, the introduction of the WBGWS concept would remove much of the doubt that currently exists over the amount of flow recovery from abstraction reductions.

4. In principle, the conjunctive use of the chalk aquifer and the reservoirs downstream appears a much better way of using the chalk water resource, with far less impact on chalk streams than continuous pumping of water supplies directly from the chalk.

5. The concept should now be investigated as a matter of urgency, with the aim of implementing one or more pilot schemes in AMP8 and full implementation in AMP9.

A similar proposal for using the WBGWS concept at a pilot scale has been put forward for the River Ivel in the upper Ouse catchment. This would entail much reduced existing abstraction for day-to-day supplies, replacement supplies brought in from Grafham reservoir, enhanced Ivel flows into the River Ouse used to augment Grafham reservoir refilling and use of the existing Ivel groundwater storage as a drought source in a similar fashion to the WBGWS. A pre-feasibility study of this proposal is currently being undertaken jointly by Affinity Water and Anglian Water, with a report due in summer 2023.

[100] Dealing with the impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys, Chalk Streams First, January 2023 https://chalkstreams.org/flow-recovery-following-abstraction-reduction/

We propose that Ofwat's Gate 2 decision report should require a Gate 3 investigation of the WBGWS concept in the Chilterns chalk streams as part of the continuing Thames to Affinity transfer development. If the concept is found to be viable, it removes most of the uncertainty surrounding river flow recovery and maintaining supplies if recovery is found to be less than expected. This would allow the proposed upper Colne and Lea abstraction reductions to proceed quickly with more confidence, being in place by 2034, without any need for a major new source like Abingdon reservoir or the Severn to Thames transfer.

6. Thames to Southern transfer

6.1 GARD overview of the scheme and call for review of need

In GARD's opinion, the Thames to Southern transfer scheme should be scrapped because it will provide minimal benefits, it will be hugely and disproportionately costly and the environmental impacts of its construction and operation will probably outweigh the minimal environmental benefits. **Now that the scheme has been developed to the point where its costs and impacts are reasonably clear, we propose RAPID should commission an independent, thorough and transparent review of the justification for the scheme, before it progresses any further.** The review should consider the points we raise below.

6.2 Planned use of the Thames to Southern transfer

Southern Water's expected use of the Thames to Southern transfer is shown below[101]:

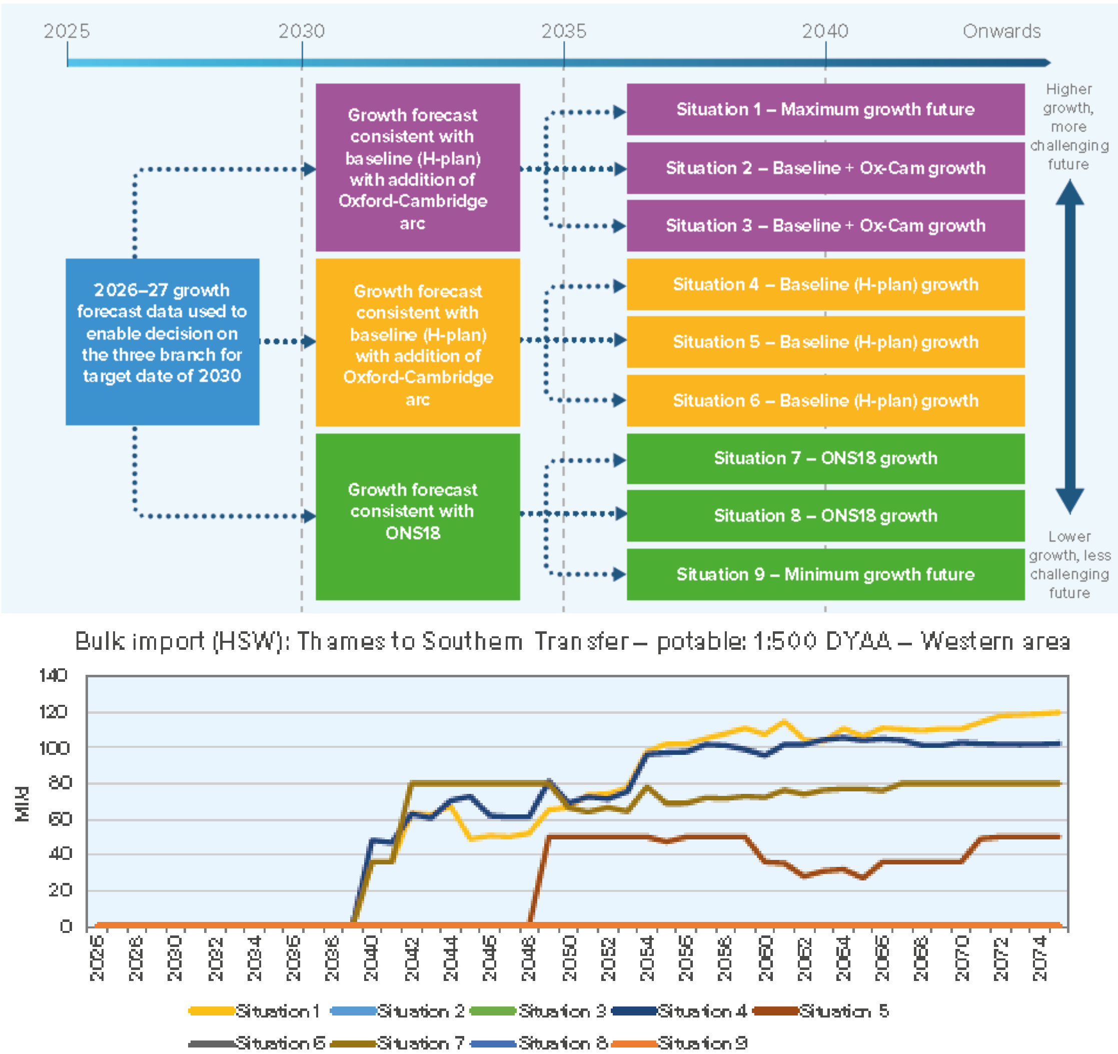

Figure 16 - Southern Water's expected use of the T2ST under different scenarios

[101] Copied from Southern Water main WRMP report, Figures 5.22 and 7.11

An example of Thames Water's modelled frequency of use of the Thames to Southern transfer is shown in Figure 17 for a typical 48-year run of stochastic data and a typical worst drought within the 48 year run[102]:

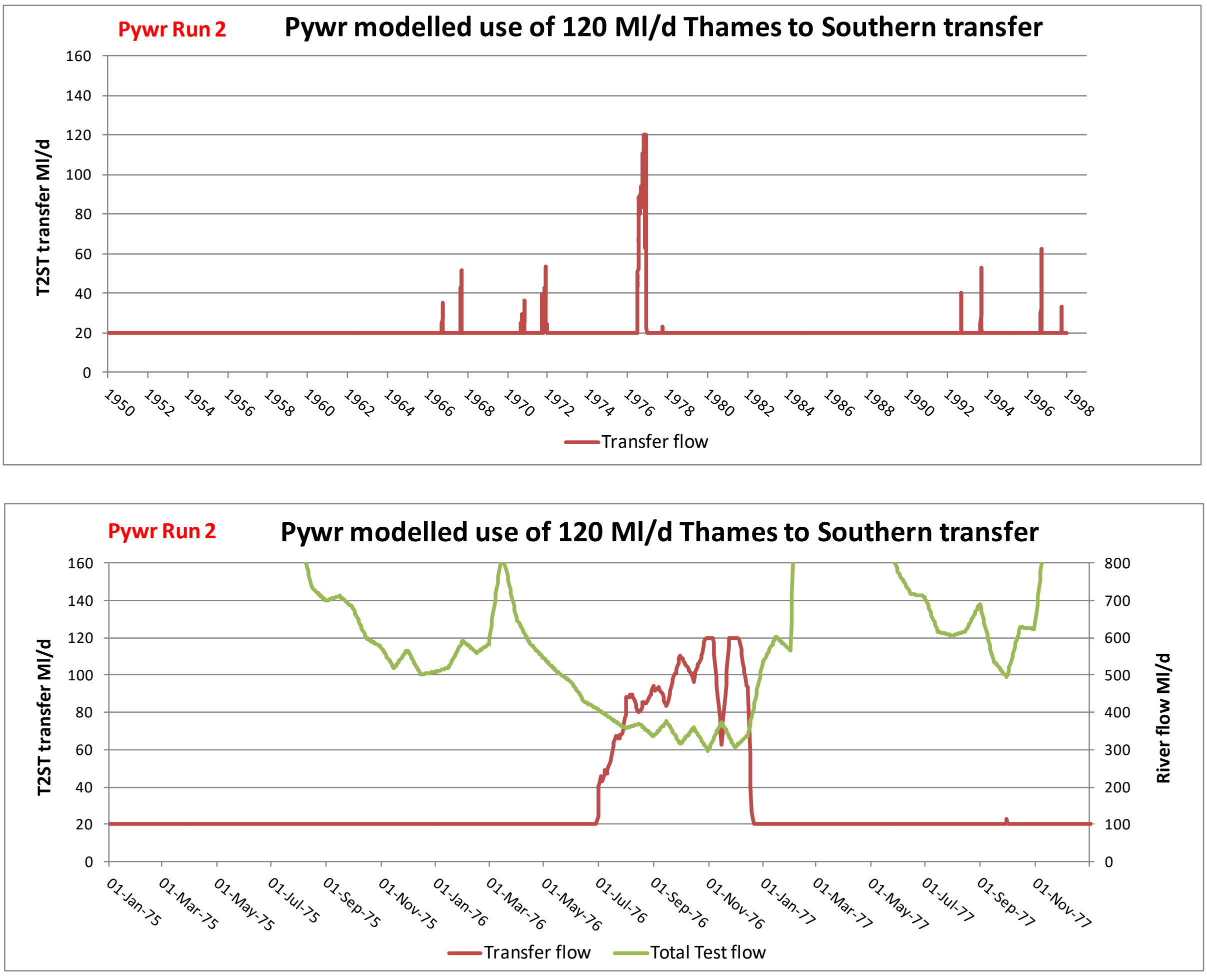

Figure 17 - Typical operational use of the 120 Ml/d Thames to Southern transfer

In major drought years, like 1976 in the example shown in the lower plot in Figure 17, the transfer could run for 6 months or more, triggered to comply with a total Test hands-off flow of 355 Ml/d, and peaking at the 120 Ml/d capacity for short periods. However, although the Pywr modelling shows drought use about once in 5 years on average, usually this will be for a relatively short period and at much less than the 120 Ml/d capacity.

The plots in Figure 17 are based on stochastic river flow data. We propose that the credibility of the modelled frequency and amount of usage should be tested by comparison with gauged flow records and historic frequency of triggering the drought permits.

At most times in most years, the transfer would run at a constant flow of 20 Ml/d. This seems too large an amount for a "sweetening flow", so it is assumed that the 20 Ml/d

[102] Pywr modelled output is from data supplied by Thames Water under EIR-22-23-390 and plotted total Test flow is the sum of stochastic data supplied by Southern Water for Testwood, Conager Bridge and Test Back Carrier

transfer would be for normal supply, probably to replace supplies lost through Southern Water's planned abstraction reductions in the Itchen valley.

6.3 The need for the transfer to enable abstraction reductions

WRSE's data in file *'GARD-09 Additional Source Level Environmental Ambition Data.xlsx'* shows about 59 Ml/d of reduction in Southern Water's Test and Itchen abstractions – 43 Ml/d from the Itchen and 16 Ml/d from the Test, as shown in Table 10:

	All in Ml/d	WRSE High Scenario					WRSE	WRSE
Source	**Catchment**	**2029-30**	**2034-35**	**2039-40**	**2049-50**	**2074-75**	**Medium**	**Low**
Andover	Upper and Middle Test		4.0	8.0	8.0	8.0	7.2	8.0
near Whitchurch	Upper and Middle Test		1.4	1.4	1.4	1.4	1.4	1.4
Overton	Upper and Middle Test		0.0	1.0	1.5	1.5	0.0	0.0
Whitchurch	Upper and Middle Test		0.0	1.1	1.6	1.6	0.0	0.0
Romsey	Lower Test and S'ton Streams		3.5	3.5	3.5	3.5	3.5	3.5
Itchen GW, SW and Twyford	Itchen		0.0	13.7	20.5	20.5	0.0	0.0
Test Surface Water	Lower Test and S'ton Streams		0.0	0.0	0.0	0.0	0.0	0.0
Alresford	Itchen		1.8	4.5	4.5	4.5	4.5	1.8
Winchester	Itchen		4.9	12.1	18.2	18.2	8.3	4.9
All	**Total DO loss**	**0.0**	**15.5**	**45.2**	**59.2**	**59.2**	**24.8**	**19.5**

Table 10 – Southern Water's planned Test and Itchen abstraction reductions

The justification for the Itchen reductions is shown in Southern Water's main WRMP report as below:

Table 3.4: Other Environmental Investigations and Drivers reflected in our Ambition

WRZ	Source(s)	Regulatory Drivers	Comments
HWZ	Alresford Winchester	Habitats Directive and SSSI investigations including assessment of CSMG flow standards	Emerging outcome of our studies of the Candover Stream is that our Alresford source will need to stop operation and we currently assume this will occur in 2030 with interim mitigation and river enhancement. Implications for our Winchester source are presently uncertain but are primarily thought to relate to Habitats Directive and SSSI investigations rather than the CSMG flow standards which are potentially compliant on the affected reach.

Table 11 - Southern Water justification of Itchen abstraction reductions

Southern Water comments suggest that the abstraction reductions are not needed for compliance with river flow standards (EFIs). The CaBA Defra-funded analysis of abstraction as a % of recharge (A%R) for the Test and Itchen catchments also shows no need for abstraction reductions in the Test and Itchen as in Table 12:

	Test catchment					Itchen catchment		
	Anton	**Bourne Rivulet**	**Upper Test to Chilbolton**	**Test to Anton confluence**	**Test to Timsbury**	**Candover Brook**	**Upper Itchen to Winchester**	**Itchen to Chandlers Ford**
Catchment area	185 km2	131 km2	453 km2	638 km2	978 km2	72 km2	280 km2	360 km2
Baseflow index	0.96		0.97		0.95			
Av. annual recharge	190.0 Ml/d	134.5 Ml/d	465.3 Ml/d	655.3 Ml/d	1004.5 Ml/d	73.7 Ml/d	469.8 Ml/d	604.1 Ml/d
Abstraction in 2017-19	12.9 Ml/d	0.9 Ml/d	5.9 Ml/d	18.8 Ml/d	24.8 Ml/d	2.8 Ml/d	13.8 Ml/d	41.6 Ml/d
A%R in 2017-19	6.8%	0.7%	1.3%	2.9%	2.5%	3.8%	2.9%	6.9%
Reduction to achieve A10%R	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**
GW consumptive licence total	0.0 Ml/d	5.7 Ml/d	27.9 Ml/d	33.6 Ml/d	61.5 Ml/d	4.5 Ml/d	18.2 Ml/d	55.7 Ml/d
Licence A%R	0.0%	4.2%	6.0%	5.1%	6.1%	6.2%	3.9%	9.2%
Licence reduction for A10%R	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**

Table 12 - Analysis of abstraction as a % of recharge for Test and Itchen catchments

The CaBA chalk stream group's A%R report concluded that no groundwater abstraction reductions were needed in the Itchen and Test catchments[103]. In the Itchen catchment, recent abstraction is only 2.9% of the average upper catchment recharge down to Winchester and 6.9% of the recharge of the catchment down to Chandlers Ford. In the Test catchment, recent abstraction is only 2.5% of the average catchment recharge. For both rivers, licensed abstraction is less than 10% of average recharge – the CaBA group proposed benchmark for acceptable abstraction. GARD concludes that the 59 Ml/d of deployable output loss planned for Test and Itchen groundwater sources is un-necessary and should be dropped, or at the very least, be given a low priority.

6.4 Need for Test and Itchen drought permits and orders

In addition to the 59 Ml/d of Test and Itchen abstraction reductions shown above, Southern Water's plans include the abolition of Test and Itchen drought orders and permits which are described in their drought plan as below[104]:

[103] A%R, Abstraction as a % of recharge in chalk streams, Figure 2, pages 52 and 63, December 2021 https://chalkstreams.org/ar-abstraction-as-a-of-recharge-in-chalk-streams/
[104] Southern Water draft Drought Plan, Table 4.11, page 143 https://www.southernwater.co.uk/media/4798/draft-drought-plan-2022.pdf

Type of action	WRZ	Summary of action	Likely benefit / saving	Risks, constraints and requirements[3]	Environmental impacts category[4]
Drought permit River Test (surface water source Drought Permit) [1]	HSE and HSW	Relax the Test Total Flow condition in the abstraction licence from 355Ml/d to 265Ml/d	80M/d max yield	Work closely with the EA when applying for, during the course of and after the end of a drought permit. EA determine the outcome of whether the drought permit is granted. Advertise drought permit and discuss with any impacted organisations. Equates to daily licence volume available if hands off flow is reduced	Up to Moderate
Drought order Candover Augmentation Scheme (groundwater source) [1]	HSE	Drought order to operate the Candover river augmentation scheme boreholes. To allow up to 27Ml/d and 3750Ml/year (20.8Ml/d over 6 months). This would enable additional DO at our River Itchen Works	14.37M/d in 1:200 drought at MDO	Work closely with Defra when applying for, during the course of and after the end of a drought order. Defra determine the outcome of whether the drought order is granted. Advertise drought order and discuss with any impacted organisations. 1 in 200 MDO benefit shown based on WRMP19 assessment, varies with drought severity	Up to Minor
Drought order Lower Itchen (SWS and PRT) (groundwater and surface water sources) [1]	HSE	SWS may need to apply for a drought order to reduce the flow condition controlling PRT's abstraction licence from 194Ml/d to 150Ml/d and reduce the flow condition in the River Itchen at Allbrook and Highbridge from 198Ml/d to 160Ml/d controlling SWS's Lower Itchen surface and groundwater sources.	38.0M/d from SWS's Lower Itchen sources	Work closely with Defra when applying for, during the course of and after the end of a drought order. Defra determine the outcome of whether the drought order is granted. Advertise drought order and discuss with any impacted organisations. Equivalent to reduction in hands off flow from 198 to 160Ml/d	Up to Moderate

Table 13 - Southern Water's current plans for Test and Itchen drought orders and permits

The primary need for the proposed 120 Ml/d Thames to Southern transfer is to eliminate the needs for these drought orders and permits, as explained by Southern Water in the summary of their WRMP, pages 24 and 27:

> *"However, we rely on drought orders and drought permits that allow us to continue abstracting water during dry weather. Our aim is to reduce our reliance on these measures and stop using them by 2040 at the latest. To do this, we need to find 120 million litres of extra water per day [page 24].*
>
> *Additionally, we are investigating a strategic pipeline which could transfer up to 120 million litres per day from Thames Water. This depends on new sources being developed in Thames Water's area, all of which are being considered through the SRO process. One of the new sources in Thames Water's area is the South East Strategic Reservoir, or SESRO. We've based our best value plan on WRSE's regional plan which includes an option for SESRO at 100Mm3, which would enable the strategic transfer into Hampshire. If the size and timing of SESRO changed it would impact our wider plans. For example, a larger reservoir could mean we need a smaller water recycling plant supplementing Havant Thicket reservoir. However, if SESRO was smaller or delayed, we may need to invest in alternative sources such as desalination or water recycling elsewhere in Hampshire [page 27]."*

In other words, up to 2/3rds of the Abingdon reservoir deployable output will be used via the Thames to Southern transfer to reduce drought impacts on Test and Itchen flows and salmon, perhaps substantially needed only once in 50 years (for example see Figure 17) and to enable the 59 Ml/d of abstraction reductions in the Test and Itchen catchments which the CaBA A%R analysis shows are unnecessary (see Table 12 and accompanying text).

The capital cost of the Thames to Southern transfer is £1.25 billion with total Opex costs of £1.1 billion, as quoted in Southern Water's draft WRMP[105]:

Thames to Southern transfer

Metric	
Capex [£m]	1,247
Financing Cost [£m]	2,071
Opex [£m]	1,139
Embodied Carbon [tCo2e]	192,811
Average operational carbon emissions [tCo2e/yr]	2,368
Total Carbon Cost [£m]	187
Average Incremental Cost (AIC) [p/m3]	105

Table 14 - Costs of Thames to Southern Transfer

As well as the carbon impacts shown above, there will be construction impacts from the c.70km pipeline, water treatment works and pumping stations. There are doubts about the practicality of shoe-horning the water treatment works into the already congested Abingdon reservoir site.

GARD recognises the importance of the Habitats Directive protected chalk streams and their salmon, but there must surely be an issue of disproportionate costs and environmental impacts, if precious Thames valley water is to be exported to Southern Water via Abingdon reservoir or the Severn to Thames transfer. WRSE's options appraisal summary report states the following[106]:

> *"The Water Resource Planning Guideline recognises that in the short term companies may need to increase use of drought management options to achieve a 1:500 year level of resilience, but in the medium and longer term the guidance is that companies should, where appropriate, use drought permits and orders less frequently, particularly in sensitive areas. Water companies have engaged with the Environment Agency around those supply side drought options to include as options to achieve the 1:500 level of resilience."*

In other words, abandonment of drought permits is discretionary, not compulsory. The same point was made by Ofwat and referred to in WRSE's response to their emerging regional plan

[105] Southern Water dWRMP Annex 13 https://www.southernwater.co.uk/our-story/water-resources-management-plan/draft-wrmp-24-technical-documents:

[106] https://www.wrse.org.uk/media/2xzjw425/wrse-options-appraisal-summary-report-with-appendices.pdf : page 18

in Spring 2022[107]:

> *"Ofwat noted the commitment to not use drought orders or permits as options after 2040, except for events in excess of the 1 in 500 year return period. It considered that WRSE should explore the cost, benefit and option selection impact of retaining the use of some drought orders and permits beyond 2040. It stated this was important to avoid unnecessary costs from resource development and to avoid the associated environmental impact that the additional development likely to arise from ruling out the use of drought orders and permits could bring."*

In response to this, WRSE said *"WRSE will look to provide additional information on the decision making around the drought options for the draft regional plan*.[108]" No such information was provided in WRSE's latest regional plan, which showed that the benefit of Test and Itchen compliance with the Water Framework Directive has been assessed as only £29 million[109], far short of the £2 billion cost of the Thames to Southern transfer.

Therefore, GARD concludes that the Test and Itchen drought permits should be maintained and there should be no planned 120 Ml/d reduction of Southern Water's deployable output in 2040.

In GARD's opinion, the Thames to Southern transfer will never be needed. The 59 Ml/d of Itchen and Test abstraction reductions are unnecessary. The proposed abandonment of Test and Itchen drought permits would bring minimal and rare benefits. ***The T2ST scheme should be abandoned at Gate 2 due to its minimal benefit and disproportionately high cost.***

[107] WRSE response to Consultation on Emerging Regional Plan, May 2022, paragraph 13.4, page 40
[108] WRSE response to Consultation on Emerging Regional Plan, May 2022 paragraph 3.13, page 41
[109] WRSE regional plan, Technical Annex 2, Table 12.1

7. Other strategic resource options

7.1 The Grand Union Canal transfer

GARD supports the Ofwat Gate 2 decisions on the GUC transfer, but we have some comments on the scope of the project and its programming.

We welcome the plan for Affinity Water to complete at least Phase 1 of the GUC transfer by 2031. This would bring "new water" into the chalk catchments which ultimately feed Thames Water's London's reservoirs. The "new water" coming into the Thames catchment via the GUC transfer emanates from Minworth STW effluent and is therefore totally resilient against severe drought, unlike Abingdon reservoir. We also note that most of the effluent treated at Minworth comes from the Birmingham area which gets much of its supplies from the Elan valley in Wales. The GUC transfer is, therefore, a truly inter-regional transfer scheme as well as being a form of effluent reuse.

Although our analysis shows that a 50 Ml/d GUC transfer would be more than enough for Affinity Water's needs and re-naturalising chalk stream flows, there would be additional security of supplies for both Affinity and Thames Water, if the GUC carrying capacity can be increased to 100 Ml/d at relatively little additional capital cost, via the 'Phase 2' of the scheme, as implemented in WRSE's plan by 2040. Our view is that this phase should be brought forward for completion by 2035. Operating costs would only be on an as needed basis.

We note that paragraph 10.256 of Thames Water's main WRMP says the following:

> *"It is possible to bring forward 1:500 resilience to 2035 with a marginal impact on cost by building a larger Grand Union Canal transfer and trading between Affinity and Thames Water. However, the Grand Union Canal scheme, Teddington DRA and existing storage are already mutually supporting each other in case of problems in their development, so to upsize that risk may not be advisable in the near-term".*

This paragraph says that there is a risk that the larger GUC transfer and the Teddington DRA scheme could be delayed beyond their planned start in the early 2030s, putting more demands on the existing London reservoirs. This is true, but the alternative of waiting for Abingdon reservoir to be complete and filled by 2040 will delay raising the resilience standard to 1:500 years by 5 years and puts a certain extra demand on the existing London reservoirs. It also carries the risk of Abingdon reservoir being delayed beyond 2040 unless it bucks the trend of delayed completion of major construction projects.

Early completion of both phases of the GUC transfer would also allow more and earlier reduction of some of Thames Water's abstractions in the lower Lea valley, which probably have a low priority, but would be feasible if the second phase of the GUC generates extra headroom for Affinity Water. The earlier reduction of Thames Water's abstractions in the lower Lea would also allow the Deephams re-use scheme to be brought forward, as described in Section 7.2.

Therefore, we propose that Ofwat's final Gate 2 decision should require investigation bringing the completion of the full 100 Ml/d transfer scheme to its earliest feasible date and by 2035 at the latest.

7.2 The Teddington DRA scheme and Deephams reuse schemes

GARD welcomes the planned Teddington DRA scheme delivering at least 67 Ml/d of deployable output for London as per Thames Water's preferred plan. Although our analysis in Section 2 and Figure 1 shows that this would not be needed after about 2040 if the Government's leakage and PCC targets are met, the early construction of this scheme would ensure water availability from London's supplies to be transferred to Affinity Water, allowing early re-naturalisation of Colne and Lea chalk stream flows. The spare headroom after 2040 shown on Figure 1 could be used to bring forward some of Thames Water's lower priority abstraction reductions in the lower Lea, which would open the door for earlier implementation of the Deepham's reuse scheme (see below).

We note that, in our response to Thames Water's draft WRMP19 in November 2018, we criticised at length the abandonment of the Teddington DRA scheme and the environmental evidence on which that was based (largely temperature effects)[110]. We are, therefore, pleased to see that the scheme has now been reconsidered and put forward again, albeit in a much smaller form than we consider its ultimate potential to be.

If more water was genuinely needed for London, we believe that a much larger version of the Teddington DRA should be reconsidered, making better use of the c. 400 Ml/d output of Mogden STW. We note that Thames Water's preferred plan only includes a 67 Ml/d deployable output scheme[111], equivalent to a nominal 75 Ml/d capacity. However, the Gate 2 report on London recycling schemes[112] says:

> *"As Gate 2 environmental investigation showed that a 100 Ml/d Teddington DRA scheme is likely acceptable, conveyance options for 100 Ml/d capacity will be reviewed in Gate 3."*

Therefore, we propose that Ofwat's final Gate 2 decision report should require that the 100 Ml/d capacity Teddington DRA scheme now proposed should also be considered as the first stage of a potentially larger scheme.

The 45 Ml/d Deephams reuse scheme was included for early implementation in Thames Water's WRMP 19, but has now been pushed back to after 2060 or the following reason[113]:

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[110] https://www.abingdonreservoir.org.uk/downloads/GARD%20%20response%20to%202nd%20Consultation%20on%20TW%20draft%20WRMP%20Rev%2029.11.18.pdf pages 65 to 79
[111] Thames Water draft WRMP24, Table 11-7
[112] Gate London Recycling Report, paragraph 8.5
[113] TW WRMP main report paragraph 7.27, first bullet

"Discussions with the EA focused on the work to identify and update the options assessments including the rationale for rejection of options; potential groundwater options, catchment, drought, inter-regional transfers and resilience options; the update to the Feasibility Report and agreement on the status of Deephams recycling which was agreed to be incompatible with the environmental ambition flow targets that the Environment Agency is seeking for the Lower River Lee (the result being the Deephams option's inclusion on the Constrained List after 2060, but exclusion up to this point)"

This states that the timing of implementation of the Deephams re-use scheme is linked to the timing of reductions in Thames Water's abstractions on the lower Lea. GARD's reassessment of Thames Water's supply demand balance plotted in Figure 1 of this response, shows that there would be spare headroom to bring forward reductions in TW's lower Lea abstractions to 2040, especially if the second phase of the GUC transfer is implemented early, as we propose in Section 7.1. Therefore, the Deephams reuse scheme could be brought forward to 2040 if needed.

Thames Water's quoted AIC costs for the Deephams reuse and Abingdon reservoir schemes are respectively 96p/m^3 and 111p/m^3. The Deephams reuse scheme is, therefore, substantially less costly than Abingdon reservoir. GARD proposes that it should be included with the Teddington DRA and GUC phase 2 schemes in the portfolio of modest sized measures that can be implemented quickly if and when the need arises. This would be a genuinely adaptable approach to meeting the uncertain future deficits, in contrast to the inflexibility of building a single-phase large reservoir at Abingdon with high cost and irreversible environmental impact.

We also note that early implementation of the Deephams reuse scheme could facilitate the abstraction reductions in the River Darent by connecting parts of the Darent supply area into the London supply system.

The Deephams Reuse scheme was not deemed a Strategic Resource Option the PR19 determination, because it was already planned for early implementation in Thames Water's WRMP 19. It has now been pushed back to 2060 implementation in Thames Water's preferred WRMP24, but it is still not considered as a Strategic Resource Option. **We propose that Ofwat's final Gate 2 report on London recycling options should include the 45 Ml/d Deephams scheme as a Strategic Resource Option in the Gate 3 investigations, with a target completion date of 2040.**

8. Proposed actions for RAPID, Ofwat and the EA for Gate 3

8.1 The need for realism in the need for Abingdon reservoir or STT

In Section 2 of this response, we criticise the gross over-forecasting of deficits in the draft WRMPs and in WRSE's regional plan. Although, the deficit forecasts are not subject to review in Ofwat's Gate 2 decision reports, the amount and uncertainty of the deficits has a major bearing on the approach to assessing the Strategic Resource Options.

In particular, our analysis in Section 2 shows that neither Abingdon reservoir nor the Severn to Thames transfer would be needed if the water companies meet their leakage and PCC targets and there is a realistic approach to abstraction reductions. We believe this scenario is much more likely than the extreme deficit growths used as the central planning assumption in the WRSE and water company plans.

However, we accept that there is a risk that leakage and PCC targets may not be met, so we have proposed that one SRO should proceed as insurance against failure to achieve the leakage/PCC targets, or climate change and population growth rising faster than forecast. We have suggested that the amount of this "insurance" should be in the region of 100-200 Ml/d.

We propose that Ofwat should specify the amount of deployable output needed from a first phase of development of an SRO in the upper Thames, assuming that the needs of Southern Water (which we have shown to be small and met at Best Value by local provision) are not to be factored in. The water companies should then be asked to focus on the best means of providing this additional resource: with emphasis on adaptability, upgradeability and drought resilience being placed alongside ***full*** cost[114] and carbon footprint implications. We realise that this would entail the direct comparison of the Abingdon Reservoir and STT options that we advocate in Section 8.3, but is more wide-ranging.

It is also an opportunity to revisit the guidelines for population growth that are the basis of so much over-estimation of future needs, especially in the south-east. We believe that Ofwat and RAPID need to take more control of decisions about the discarding of schemes by water companies. So far, in spite of the aspirations expressed in PR19, the only schemes to have been ruled out (after expenditure of huge amounts of customers' money) are those of the Fawley Desalination and the Anglian to Affinity Transfer, both of which were torpedoed by the existing Water Companies' refusal to make them parts of their programs. We have thus lost two highly drought resilient and forward-looking schemes of the sort envisaged by the National Infrastructure Commission.

In the case of Desalination, we have delayed by two to three decades the creation of a

[114] We believe this should include not just NPC/NPV but also costs to consumers from the Ofwat charging formulae as outlined in section 3.3.2.

national capability for a water resource provision which will inevitably have to be developed if climate change becomes more extreme.

8.2 The need for justification and prioritisation of abstraction reductions

In Section 2.2 of this response, we show that the largest source of over-estimated deficits is abstraction reductions for environmental improvements. In our opinion, allowances for sustainability reductions in the all the water companies' plans are unrealistically large and not economically or environmentally justifiable, especially when the costs and impacts of replacement sources are taken into account. Appendix B provides supporting evidence.

However, we propose that the universally accepted need for reductions in some ecologically sensitive chalk streams should be brought forward to the early 2030s, without needing to wait for Abingdon Reservoir.

We propose that as early as possible in Gate 3, there should be the proper and transparent prioritisation of abstraction reductions, taking account of the cost and environmental impact of replacement sources**.** This process should include interested stakeholders who have already made similar suggestions, including the Chalk Streams First group and Oxfordshire County Council. No Gate 3 decisions should be taken on the need and choice of new resource schemes until this has been done.

8.3 The need for direct comparison of the Abingdon and STT options

The choice between Abingdon reservoir and the Severn to Thames transfer as the first major scheme to be developed should be a crucial outcome of Ofwat's £470 million investigation programme. At present, there is no clarity whatsoever in how Abingdon reservoir has become the first choice scheme in Thames Water and Affinity Water's draft WRMPs.

The decision appears to have come from WRSE's draft regional plan, which is utterly lacking in transparency. Even a 1566-page technical annex to WRSE's plan titled *"Investment model draft regional plan results"* and an 83-page technical annex titled *"Option Appraisal"* are totally devoid of costs of options and there are no cost comparisons presented as evidence to show the supposed lower cost of Abingdon reservoir.

Although there is a reasonable amount of cost detail in the Gate 2 reports, there is no consistency in how option costs are presented, making option comparisons extremely difficult. For the Severn to Thames transfer, which should be considered as a single coherent scheme comparable to Abingdon reservoir, the costs of the aqueduct and support components are scattered in different reports in different formats, making assembly of a total scheme costs difficult and unreliable. Although we believe we have made significant progress on this in section 4.3, there is a need for this to become a more core part of the

SRO Gate process.

In our opinion, the chaotic presentation of costs in the Gate 2 reports and the absence of any transparent option cost comparisons is a major failing in Ofwat's investigation programme to date.

We propose that as soon as possible in Gate 3, the water companies should be instructed to collaborate in producing a detailed and publicly available like-for-like comparison of the Abingdon reservoir and STT options, with a common deployable output (eg the 100 - 200 Ml/d "insurance" we suggest in Section 8.1) and a common date for start of operation, probably 2040, which is the earliest possible date for completion and filling of Abingdon reservoir. The costs and carbon estimates should be presented in detail and using the same formats for each scheme. The metrics for other non-monetary measures should be presented side-by-side with supporting evidence for how they have been scored. We believe this should be actively co-ordinated and led by an in-house RAPID team, so that a common approach is achieved and the Gate 3 process does not open with divergent justifications.

This comparison should give due recognition to the fact that, if the first phase of the Severn to Thames transfer is completed by the early 2030s, it will a) bring forward the date for achieving 1:500 year resilience for London's supplies and b) facilitate early re-naturalisation of chalk stream flows.

8.4 The need for EA evidence to support their decisions

Throughout the Strategic Resource Option investigations, there have been a number of Environment Agency decisions which have had a profound influence on the design of the SROs and their costs. There has usually been little supporting evidence available to justify these decisions, which we suspect may have been made without full appreciation of the implications for SRO design and costs, or for the environmental impacts of other schemes needed because of these decisions.

We propose that, as part of the supporting evidence needed in Gate 3, the Environment Agency should provide detailed, publicly available evidence for the following:

1. The Deerhurst and Culham minimum required flows.
2. The 25 Ml/d limitation on the amount of regulation releases discharged to the River Vyrnwy.
3. The need for treatment of effluent from Netheridge and Minworth STWs.
4. The need for treatment of STT water at Deerhurst before transfer through the aqueduct.

5. The acceptability of discharging water from Abingdon reservoir into the River Thames without treatment, when reservoir storage is less than 15% in droughts.
6. The restriction of the Teddington DRA scheme to a maximum 100 Ml/d discharge of Mogden STW effluent.

We propose that in preparing the supporting evidence for these decisions, the Environment Agency should liaise with the water companies to understand the implications of their decisions on SRO deployable outputs and costs. Presentation of the deployable output and cost implications should form part of the supporting evidence.

Appendix A – Evidence of matters previously raised with RAPID and Ofwat

- GARD letter to Paul Hickey 19 8 20 - final
- GARD request for RAPID intervention 14 8 20_v2
- Letter to RAPID re final Gate 1 decisions 13.1.22
- Letter to RAPID re stochastic data validity Rev2 13.1.22
- RAPID letter to GARD Final 03-09-2020 (2)
- Slides for RAPID discussion 22 10 20

Group Against Reservoir Development
[redacted]

19th August 2020

Paul Hickey
Managing Director, RAPID

Dear Paul

Need for RAPID intervention in the Strategic Water Resource Investigations

Following publication of WRSE's responses to their consultations on future resource requirements and resilience, we are writing to express our concerns over the quality and transparency of the strategic resource investigations, and to request RAPID's intervention.

We are sceptical about the value added by WRSE in the regional planning process and the transparency of their work. Although stakeholders have been engaged through virtual meetings and the recent consultations, WRSE remains, effectively, a front for the 6 south-east water companies and a barrier to scrutiny of water company investigations.

In recent discussion with WRSE, it has become apparent that they have no role in many of the investigations feeding into their regional plan, and accept water company reports without checking or challenge. WRSE's responses to the recent consultations have failed to address almost all the detailed points raised by GARD. When questioned, WRSE say they cannot answer criticisms directed at water companies' work. However, the water companies have no stakeholder engagement in place other than via WRSE.

WRSE say that our consultation responses will be passed to the water companies, who will deal with the matters we have raised as they see fit. However, most of the concerns raised in our consultation responses have been raised previously in our response to Thames Water and Affinity's WRMP consultations and dismissed by them. We think it highly unlikely that the water companies will take any notice of GARD's views now, unless RAPID intervenes.

In the attached paper we have listed 15 topics where we think RAPID intervention is needed. For each topic, we have provided a brief summary of our concerns, given references to more details in our various consultation responses and stated the actions we would like RAPID to take. Copies of both our recent consultation responses to WRSE are enclosed with this letter.

The technical topics fall into seven categories:

1. The uncertainties in the supply/demand balance, the hidden safety factors, the double counting of risks and the needed for adaptable plans that minimise the risk of unnecessary resource developments (topics numbered 2,3, 4 and 5 in the attached paper).

2. The allowances for loss of supply due to climate change which do not take account of evidence that wetter winters due to climate change in the past 75 years may have increased the output of supplies in the south-east which are dependent on groundwater or rivers fed by groundwater (topic number 6).

3. The failure to allow for supplies benefiting from enhanced chalk stream flows due to sustainability reductions and increased treated waste-water effluent from rising demands (topic number 7).

4. The lack of ambition in Thames Water and Affinity's leakage reduction plans (topic number 8).

5. The justification, interpretation and implementation of the 1:500 year frequency of supply cuts specified in the EA's national framework for water resources (topic number 9).

6. Abingdon reservoir yield, resilience to long droughts and emergency storage provision (topic numbers 10-14).

7. The reliability and use of the stochastic river flow data that are being used by most water companies in the strategic investigations (topic number 15).

We would like to meet you by video conference to address the specific concerns raised in this letter and the attached paper. Please could you suggest some dates.

Yours sincerely

[redacted]

Derek Stork

Dr D Stork CPhys FinstP,
Hon Chairman,
Group Against Reservoir Development

GARD request for RAPID interventions in the Strategic Investigations

Note: Footnotes refer to GARD's responses to various consultations. Response to earlier WRMP consultations can be seen at http://www.gard-oxon.org.uk/downloads.html

GARD concerns about the role of WRSE and the lack of transparency of the strategic investigations

1. We are sceptical about the value added by WRSE in the regional planning process and the transparency of their work. Although stakeholders are consulted, WRSE remains, effectively, a front for the 6 south-east water companies and a barrier to scrutiny of water company investigations. In recent discussion with WRSE, it has become apparent that they have no role in many of the investigations and accept water company reports without checking or challenge. WRSE's responses to the consultations have failed to address almost all the detailed points raised by GARD. When questioned, WRSE say they cannot answer criticisms directed at water companies' work. However, the water companies have no stakeholder engagement in place other than via WRSE. The contrasting approach taken by WRE, to include *at Board level*, other utilities, councils and stakeholders such as the farming community, produces more opportunities for transparency and a much more credible output.

   - How will RAPID address the lack of transparency of the strategic investigations which has become apparent from WRSE's failure to address detailed technical matters raised by GARD? How does RAPID intend to standardise the regional groupings to ensure common models and methodologies, which could also reduce cost?

GARD submission to WRSE Consultation on Future Water Resource Requirements 17th April 2020

Note: GARD's response to to this consultation can be seen by the link **Future Water Resource Requirements'** on the Home Page at **http://www.gard-oxon.org.uk**

2. Neither WRSE nor the water companies are showing how their plans will accommodate a range of future deficits from low to high. There are major uncertainties (and disagreement) over future population size, climate change, demand management initiatives and sustainability reductions. The water company and WRSE approach seems to be to assume the worst case for every factor and plan accordingly.

   - How will RAPID create the environment for an adaptive approach to future requirements and the avoidance of unnecessary resource development? RAPID should require regional plans to state the range of uncertainty in all the components of the supply demand balance. Given that even the largest scheme can be brought online within 15 years, does RAPID support the approach that major investment decisions should be delayed so that small, scalable, options (scalable up or down) can be used to 'buy out' the next 20-25 years while trends on population, climate change, leakage reduction etc can actually be observed[1]? For example, the ONS population projections have each been significantly revised down in each of the last 3 iterations[2].

3. In a similar vein, headroom calculations appear to be being misused. Companies are assuming the worst case for each factor in the supply-demand balance, then applying headroom on top[3].

- Does RAPID agree that this is double counting the risks? If so, RAPID should provide guidelines on the level of risk appropriate for each assumption in the supply-demand balance (eg use of "central estimates") and how much headroom is then applied.

4. Analysis of the supply-demand balances in the six south-east WRMPs shows that under WRMP guidelines, the south-east doesn't actually expect a water deficit until 2079[4]. Introduction of 1:500 year resilience and sustainability reductions drive that date forwards. The choice of 1:500 year acceptability of supply cuts seems an arbitrary figure for which we have seen no scientific justification.

- RAPID should lead an exercise to examine the trade-off between cost (financial and environmental) and resilience. At the least, there should be an optimisation process that shows potential gains in resilience achievable at various cost points. As an extreme example, if studies showed that the cost of 1:200 could be met by the expenditure of £20 billion, but 1:500 cost £70 billion, regulators might decide that limiting occurrence of supply cuts to 1:200 years is acceptable. We think that RAPID should require water companies to review the resilience standard appropriate for each supply area and provide transparency of their decisions. RAPID should provide guidelines for this.

5. Despite the existence of WRSE, there remain large disparities between the assumptions and methodologies adopted by each water company.

- RAPID should provide regional and possibly even national guidance on issues such as population growth, climate change interpretation, expected PCC reduction etc.

6. All the south-east water companies assume substantial losses in supply outputs due climate change. However, despite the climate change that has undoubtedly occurred over the past 75 years, we have seen no evidence that the deployable output of water supplies has been reduced. On the contrary, GARD has shown evidence that

1 GARD Future Requirements response **Future Water Resource Requirements'** page 43
2 GARD Future Requirements response **Future Water Resource Requirements'** , pages 16-18
3 GARD Future Requirements response **Future Water Resource Requirements'** , pages 40-42
4 GARD Future Requirements response **Future Water Resource Requirements'** , page 11 and Figure 2

the deployable output of London's supplies has increased over the past 75 years[5]. This can be explained by the dependence of River Thames flows on winter rainfall which generates higher chalk groundwater levels in the spring and higher river flows in the following summer. This will probably be the case for all the south-east supplies which are dominated by groundwater abstraction and river flows dependent on groundwater baseflows. WRSE's response acknowledges GARD's argument that the climate change allowance is excessive, but shows no intention of addressing our concerns.

- RAPID should undertake an independent technical review of GARD's evidence and our conclusion that WRSE's climate change allowances are excessive.

7. Assumptions on sustainability reductions ignore the fact that increased chalk stream flow ends up in the Thames and is available to use from there. Likewise, about 80% of additional water supplied by TW to Affinity, or brought into the region by Affinity through other transfers would be returned to TW through waste treatment for reuse. This has been raised by GARD in the WRMP consultation responses[6] [7]. TW and Affinity say they are investigating this, but, given their previously negative response to our evidence[8] [9], we have no confidence that their investigations will be unbiased and transparent.

    - RAPID should commission an independent review of the investigations of the returns to the lower Thames from increased chalk stream flows and treated wastewater from increased demands.

8. Although Thames Water claim that their planned leakage reduction meets the Government target of 50% reduction in leakage by 2050, this is unacceptable a) because their 50% reduction relates to 2016/17 leakage rather than 2019/20, and b) their future leakage will still be at the top end of water company leakage rates[10]. Affinity only plan 40% leakage reduction by 2050, despite their leakage being currently above other water companies[11]:

    - RAPID should insist that southeast water companies plan to reduce leakage to levels consistent with good practice amongst other UK water companies and abroad, before any major new resource development goes ahead.

5 GARD Future Requirements response **Future Water Resource Requirements'** ,pages 32-40

6 http://www.gard-oxon.org.uk/downloads/GARD%20response%20to%20Affinity%20final%20-v3-23-04-19.pdf pages 56-62

7 http://www.gard-oxon.org.uk/downloads/GARD%20%20response%20to%202nd%20Consultation%20on%20TW%20draft%20WRMP%20Rev%2029.11.18.pdf pages 60-62

8 TW response to 2nd WRMP consultation, Appendix H pages 129-130

9 Affinity response to 2nd WRMP consultation, Appendix 22 page 4

10 http://www.gard-oxon.org.uk/downloads/GARD%20%20response%20to%202nd%20Consultation%20on%20TW%20draft%20WRMP%20Rev%2029.11.18.pdf pages 46-47

11 http://www.gard-oxon.org.uk/downloads/GARD%20response%20to%20Affinity%20final%20-v3-23-04-19.pdf pages 35-42

GARD submission to WRSE Consultation on Securing Resilient Water Resources for Southeast England 3rd July 2020

Note: GARD's response to to this consultation can be seen by the link **In Securing Resilient Water Resources for South East England'** on the Home Page at **http://www.gard-oxon.org.uk**

9. The Environment Agency's National Framework for Water Resources specifies the resilience standard for water supplies as follows[12]:

1.2. Building resilience to drought

Regional plans should be based on achieving a level of drought resilience so that emergency drought order restrictions, such as providing water only at certain times of the day (rota cuts) or through temporary taps (standpipes) in the streets, are expected to be implemented no more often than once in 500 years on average.

GARD's response to WRSE's Future Requirements consultation has shown there are numerous safety factors built into the water resource planning guidelines and the supply/demand balances in WRMPs[13]. There is a further hidden safety factor in the fact that demands generally rise steadily with population growth, whereas new water resources are only introduced in quite large increments, so at most times there is an over-supply while demands rise towards the available supply. Therefore, if water supplies are planned to give a positive supply/demand balance with all these safety factors in a 1:500 year drought, rota cuts and standpipes will only be needed if the 1:500 year drought coincides with a major outage at a time when a new increment in water supplies is almost needed but not quite available, and population growth, climate change, sustainability reductions, etc have all been under-estimated in the WRMPs by an amount that exceeds the headroom allowances, which are substantial.

If water supplies continue to be planned in this way to a 1:500 year drought standard, the probability of rota cuts and standpipes actually being triggered is far more extreme than 1:500 years.

- What is the RAPID view on this? Specifically, does 1:500 year avoidance of supply cuts, as specified in the EA's National Framework, equate to maintaining a positive supply/demand balance in a 1:500 drought after allowance for headroom, outages, etc? RAPID should issue a clarification of the intention of the EA's 1:500 year resilience standard and how this should be planned for by the water companies.

12 Environment Agency National Framework for Water Resources, March 2020, page 8

13 GARD Future Requirements response, **Future Water Resource Requirements'**pages 40

10. GARD's assessment of the yield gain from Abingdon reservoir is about 215-255 Ml/d if allowing only 6% emergency storage as per Thames Water, or only 180-220 Ml/d[14] when allowing 20% emergency storage (see later). This compares with 294 Ml/d assumed in Thames Water's WRMP.

In our opinion, 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.[15] Thames Water have rejected GARD's criticism of their resilience assessment of Abingdon reservoir and have made it clear that they do not intend to change their assessment of the yield gain from the reservoir.

- Thames Water have flatly rejected GARD's evidence that they have grossly over-stated the yield from Abingdon reservoir because of its lack of resilience to long duration droughts. In view of this impasse, RAPID should commission a detailed independent review of the yield of Abingdon reservoir and its resilience to droughts of over 18 months duration.

11. Thames Water have allowed for only 6% emergency storage in Abingdon reservoir. This compares with typically 12-25% emergency storage in other major UK reservoirs[16], for example:

• Clywedog reservoir	13%
• Llyn Brianne reservoir	14%
• Bristol Water (Chew, Blagdon)	18%
• Welsh Dee system	20%
• TW London reservoirs	24%
• TW Farmoor reservoir	33%

Thames Water have attempted to justify the low provision of emergency storage in Abingdon reservoir by saying it complies with their policy of allowing the equivalent

14 GARD response to WRSE's resilience consultation, **In Securing Resilient Water Resources for South East England'** pages 38-39

15 GARD response to WRSE's resilience consultation, **In Securing Resilient Water Resources for South East England'** pages 22 and 39

16 GARD response to WRSE's resilience consultation, **In Securing Resilient Water Resources for South East England'** pages 35-37

of 30 days demand. However, GARD's analysis shows that emergency storage in London's existing reservoirs would provide for at least 60 days of demand, not 30 days[17]. In our opinion, in view of the economic sensitivity of London's supplies, Thames Water should allow for at least 20% emergency storage in Abingdon reservoir, which would reduce its yield by about 15%.

- RAPID should commission an independent review of the emergency storage provision in Abingdon reservoir, taking account of normal best practice elsewhere in UK and internationally. This review should also consider whether the last 6% of water in Abingdon reservoir can be used at all, bearing in mind the very shallow water depth remaining in the large flat-bottomed lake.

12. GARD's 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[18].

- RAPID should commission an independent review of the acceptability of multi-year periods of drawdown of Abingdon reservoir, taking account of normal best practice for major reservoirs elsewhere in UK and internationally.

13. GARD have noted that all of TW's modelling of yield obtained from Abingdon reservoir has assumed no change to the existing Lower Thames Operating Agreement, despite the fact that doubling the total system storage by the addition of Abingdon reservoir will fundamentally change the risks associated with compliance with Ofwat's specified service levels and the duration of periods of very low flows at Teddington weir[19].

- RAPID should require Thames Water's strategic investigations to include assessment of changes needed to the Lower Thames Operating Agreement resulting from the addition of major new supplies to the London system, especially Abingdon reservoir.

14. GARD's analysis has shown that the duration of Level 4 supply cuts in London in the event of droughts worse than the 1:500 year standard will be much longer with

17 GARD response to WRSE's resilience consultation, **In Securing Resilient Water Resources for South East England'** page 36

18 GARD response to WRSE's resilience consultation, **In Securing Resilient Water Resources for South East England'** page 33

19 GARD response to WRSE's resilience consultation, **In Securing Resilient Water Resources for South East England'** pages 34-35

Abingdon reservoir than they would be for existing supplies or with the addition of a genuinely drought resilient source like desalination[20].

- RAPID should require Thames Water and WRSE to evaluate the economic consequences of Abingdon reservoir supplies being unavailable following a long term drought and compare these with the costs of bringing in secure supplies from other more drought resilient options.

15. In GARD's opinion, much of the weakness in Thames Water's resilience analysis results from their failure to generate reliable daily river flow data from their 15,600 years of stochastic weather data[21]. We are also concerned that the historic weather data used to generate the stochastic weather data did not include the actual period of 2000-2019, a period of rapid climate change.

- RAPID should commission an independent review of the reliability of the stochastically generated river flows which are being used by Thames Water and many other water companies, and how these flows are being used to determine compliance with the 1:500 year frequency of supply cuts specified in the EA's National Framework for Water Resources.

GARD, 19th August 2020

20

GARD response to WRSE's resilience consultation, **In Securing Resilient Water Resources for South East England'** pages 39, 41

21

GARD response to WRSE's resilience consultation, **In Securing Resilient Water Resources for South East England'** pages 23-25

Dr Derek Stork CPhys FInstP
Hon Chairman,
Group Against Reservoir Development
[redacted]

Mr Paul Hickey
Managing Director, RAPID

13th January 2022

Dear Mr Hickey

Final Gate 1 decisions

We have seen the final Ofwat/RAPID decisions on Gate 1 options. It is good to see that RAPID's reports clearly summarise most of GARD's criticisms of the water companies' Gate 1 reports. However, we are disappointed that the Gate 2 recommendations for dealing with GARD's concerns are vague, along the lines of "we will provide guidance" or "we expect that options would be identified and assessed through the regional and company planning process at WRMP24 and an update to be provided on option capacities at gate two". There are no specific recommendations for actions to address our concerns in the Gate 2 investigations.

Comparing the Appendices titled 'Actions and recommendations' in the draft and final versions of the Gate 1 decision reports, we find that there have been virtually no changes to RAPID's directions to the water companies for Gate 2. The only change we have found is this addition to the recommendations in the Final Decision on the Thames to Affinity transfer:

6	Environment	Thoroughly consider the CSF proposal for flow recovery at gate two and engage with RAPID and interested stakeholders on how this might best be accomplished.

We fully support this recommendation, but why are there not similar recommendations to numerous other points raised by stakeholders in these consultations? This applies particularly to the Abingdon reservoir (SESRO) Gate 1 decision, where there were many stakeholder responses, often expressing similar concerns, for example:

1. **Construction impacts**: In response to many stakeholder criticisms of the lack of assessment of construction impacts, the Final Decision Section 3.2.6 says:

> "The solution owners will continue to develop their environmental and other assessments of the solutions that will encompass further, more detailed consideration of construction impacts including traffic impacts, noise and vibration and air and light pollution throughout the gated process and will need to complete this work before submitting their Development Consent Order (DCO) application."

Thames Water have not undertaken adequate investigations to date, so in the absence of a specific instruction from RAPID we have no confidence that they will rectify the matter in Gate 2. Why did the Final Decision not include a specific action to be undertaken in collaboration with the local authorities responsible for managing traffic impacts, noise and vibration and air and light pollution?

2. **Landscape impact:** many stakeholders expressed concerns about the local visual impact on housing and villages close to the reservoir, including recent and planned new housing development. In response, Section 3.2.6 of the Final Decision says:

> "We have included an action in our final decision for the water companies to provide an LVIA assessment for gate two and to engage with the AONB Board on this assessment. The water companies will work with the National Appraisal Unit to determine the scope of the LVIA and begin engagement and assessment for gate two and beyond. The companies have also begun working on new visuals and schematics and will continue to refine this these through the gates."

This makes no reference to the stakeholder concerns raised over the visual impact on local housing and appears only to consider the long range visual impact on the AONB. Why did the Final Decision not include a specific action on local visual impacts to be undertaken in collaboration with the local authorities and stakeholders?

3. **Recreational benefits**: Many stakeholders have complained about Thames Water's unrealistic assessment of recreational benefits of the reservoir. In response, Section 3.2.10 of the Final Decision says:

> "The assessment of recreational benefits was considered sufficient for gate one. The solution owners will continue to develop the options and evidence surrounding them, and will reassess conservation, access, and recreation strategy at gate two as included in section 15 of their gate one submission, when the companies have more information on the size of the selected option. RAPID will provide guidance on our expectations for a more detailed examination of wider solution benefits at gate two, and any natural capital assessment should be consistent with WRMP24 guidelines supplementary guidance and regulator feedback on Regional plans and WRMPs."

We have copied below Thames Water's proposal for assessing recreational benefits for Gate 2, which was quoted above as "included in section 15 of their gate one submission"

Table 17 Gate 2 Workstreams, activities and outcomes

Workstream	Key activities
Environmental Assessment	Hydrological and geomorphological assessment; River and reservoir modelling; update G1 assessments ; Conservation, access and recreation strategy; Desk-based assessment around key environmental risks; Further benefits assessment and monetisation; Initiate permitting and licensing investigations

This extremely scant description gives us no confidence that there will be any improvement in the so far inadequate investigations of recreational benefits. Please can we see a copy of the "guidance" that RAPID have issued on this matter. Why did the Final Decision not include a specific action on assessment of the recreational benefits with reference to the concerns raised by stakeholders, which include the need for public access restrictions to avoid INNS, the use of a large part of the reservoir for solar panels and the lack of space for recreational facilities around the reservoir perimeter due to the encroachment of housing developments? Why did the Final report not include a specific action to prepare a detailed plan for recreational use, justifying the very larger monetary benefit that Thames Water are claiming

Overall, it seems to us that consultation on the draft RAPID/Ofwat Gate 1 decisions has been a window dressing exercise. It has had minimal influence on the final decisions and RAPID's directions to the water companies for their continuing Gate 2 investigations. Please could we arrange a meeting with RAPID to discuss these concerns, including representatives from other local stakeholder organisations.

We are writing to you separately about two other matters concerning the investigation programme: the lack of investigation of London desalination options and the validity of the stochastic data which are fundamental to all of the new resource schemes under investigation.

Yours sincerely

[redacted]

Derek Stork
Hon Chairman,
GARD

Cc: David Black, Ofwat
David Johnstone MP
Layla Moran MP
Councillor Liz Leffman , OCC
…….Councillor Peter Sudbury, OCC
Councillor Richard Webber, OCC
Councillor Sally Povolotsky, OCC
Councillor Emily Smith, VoWHDC
…….Councillor Andy Cooke, VoWHDC
…….Steventon Parish Council Clerk
…….East Hanney Parish Council Clerk
…….Marcham Parish Council Clerk

…….Ardington Parish Council Clerk
Trish Ampleford, Garford Parish Meeting
……Wantage and Grove Campaign Group
Helen Marshall, Director CPRE Oxfordshire
……Kat Foxhall, Chair, South and Vale Green Party

Dr Derek Stork CPhys FInstP
Hon Chairman,
Group Against Reservoir Development
[redacted]

Mr Paul Hickey
Managing Director, RAPID

13th January 2022

Dear Mr Hickey

Gate 1 final decisions – Validity of stochastic data

We have reviewed the reports on RAPID's final Gate 1 Decisions and are particularly concerned by your response to our criticism of the stochastic data being used by all water companies, which we have appended to this letter. Your report has summarised our concerns well enough:

> "inaccurate weather data for groundwater-dominated catchments; the stochastic weather base period not containing any long duration droughts; the base period excluding weather since 1997; and the geological difference in catchments not being reflected in the generated Thames and Severn flows".

However, we think RAPID's response to GARD's criticism is inadequate:

> "The use of stochastic flow data reflects the requirement to test droughts larger than those observed in the historic record, such as drought events with 1:500 year return periods. Solutions generation of stochastic flow data is expected to follow Water Resource Planning Guidelines Supplementary Guidance: Planning to be resilient to a 1 in 500 drought (England), and Supplementary Guidance: Stochastics. We will pass on the specific points raised to solution owners for consideration as they develop their deployable output assessments further"

We don't think that the validity of stochastic data is an issue just for solution owners, ie the water companies. RAPID and Ofwat should be concerned that all of their decision making could be based on unreliable stochastic data that has been generated nationally under their auspices for use by all water companies. In Appendix A to our Gate 1 response, we provided evidence of the errors that can arise in generating stochastic river flows and the bad decisions that can arise from them. If the stochastic data are substantially inaccurate, as we think they may be, the validity of the entire £470 million investigation programme will be undermined.

We propose that RAPID should specifically require the water companies to undertake the actions recommended in our Gate 1 response:

1. For the rainfall/run-off model used to convert the weather data into daily river flows used for assessing deployable output, there should be 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 should be provided, comparing the flows modelled using stochastic weather data with naturalised gauge flows.

3. For each strategic resource option, there should be comparison of the deployable output 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, noting that the risk does not apply to desalination and re-use options..

We also propose that for the Gate 2 investigations 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 recent period when climate change has been most significant, as well as the pre-1950 period, which included three droughts that were more severe for London’s supplies than any in the period 1950 to 1997. 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 (1921/22,1933/34 and 1943/44), 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.

We also suggest that in reviewing the validity of stochastic data, the water companies should not be allowed to “mark their own homework”. Nor should it be left to GARD to scrutinise the water companies workings, using whatever limited data the water companies choose to make available. This matter is so important that RAPID should appoint genuinely independent experts to review the validity of the stochastic data and the way they are used in the option investigations.

Please could you provide us with an assurance that this vital matter is being properly dealt with by RAPID, including details of the actions you are taking. If you have issued more detailed instructions or guidance to solution owners on this subject, please could we see them.

Yours sincerely

[redacted]

Derek Stork
Hon Chairman,
GARD

cc. David Black, Ofwat
Dr Chris Wilding, Chair, Steventon Parish Council

Appendix – extract from GARD's Gate 1 response, Section 2.4

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, the further work needed at Gate 2 to understand and manage the uncertainty inherent in the use of stochastic data should include:

6. 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.

7. 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.

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

9. 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.

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

We also propose that for the Gate 2 investigations 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.

Centre City Tower, 7 Hill Street, Birmingham B5 4UA
21 Bloomsbury Street, London WC1B 3HF

Dr Derek Stork CPhys FinstP
Hon Chairman
Group Against Reservoir Development
[redacted]

3 September 2020

Dear Derek

RAPID's role in the strategic investigations

I am writing in response to your request for clarification of a statement in my letter of 22 June 2020, which you sought in your e-mail of 14 July 2020 and to suggest a way forward in relation to your letter of 19 August 2020.

I explained in my letter of 22 June 2020 that RAPID's gated process would include a requirement for third party technical assurance. This will form part of the companies' submissions and so would be by consultants engaged by the companies.

RAPID will be making an assessment of information provided by companies about their solutions for the purposes of the gated process. RAPID's assessments will inform RAPID's recommendations to Ofwat regarding Ofwat's funding decisions in this process. The team of assessors will comprise members of the RAPID team and external consultants instructed by RAPID.

The purpose of the gated process is to ensure at each gate that companies are progressing strategic water resource solutions allocated funding at PR19, company costs incurred in doing so are efficient and that solutions merit continued investigation and development during the period 2020 to 2025. The gated process will run in parallel with water resources planning at regional and company levels.

You have raised a number of concerns in your letter of 19 August 2020. I suggest that before I respond to this letter, we meet to discuss the issues raised and what role RAPID can play in relation to resolving these while respecting the roles of other parties and processes involved in water resources planning. I would be grateful if you could advise as to your availability to meet. In the meantime, if you are not already doing so, you may want to consider responding to the current consultation on the draft Water Resources Planning Guideline (https://www.gov.uk/government/consultations/water-resources-planning-guideline-proposed-update).

Yours sincerely

[redacted]

Paul Hickey

Managing Director, RAPID

c.c. John Russell (Ofwat)
Margaret Read (RAPID)
Dr Toby Wilson (Environment Agency)
Dr Phil Lodge (Environment Agency)

Slides for discussion with Paul Hickey 22nd October 2020

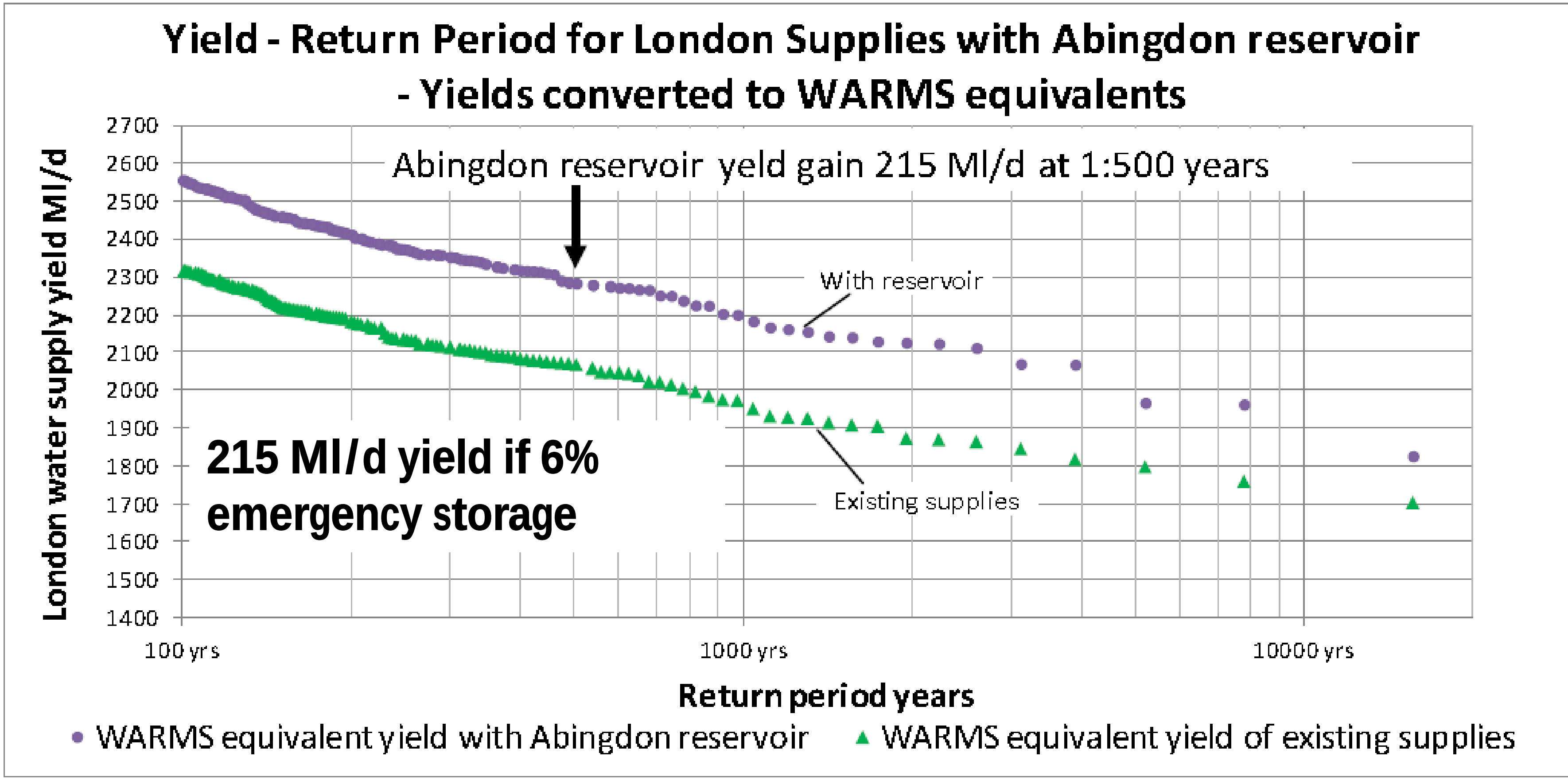
Atkins' drought library and yields

Atkins Drought Library	Drought no.	IRAS Run and Year	Base case IRAS DO	Atkins UTR yield gain	GARD UTR yield return period
1	0	187_1976	1810	260	473 yrs
	1	166_1941	1830	300	363 yrs
	2	186_1979	1830	260	400 yrs
	3	34_1980	1850	300	411 yrs
	4	176_1931	1850	300	422 yrs
	5	73_1977	1870	290	390 yrs
	6	25_1959	1890	320	223 yrs
	7	126_1978	1890	290	339 yrs
	8	44_1936	1910	310	318 yrs
	9	78_1994	1910	300	233 yrs
2	0	147_1931	1910	280	233 yrs
	1	6_1936	1950	290	200 yrs
	2	32_1924	1970	250	161 yrs
	3	103_1993	1970	280	164 yrs
	4	184_1966	1970	300	214 yrs
	5	57_1972	1990	310	171 yrs
	6	157_1935	1990	240	190 yrs
	7	0_1943	2010	180	240 yrs
	8	100_1985	2010	260	151 yrs
	9	184_1947	2010	290	113 yrs
3	0	24_1955	2030	290	127 yrs
	1	168_1922	2030	290	119 yrs
	2	193_1927	2030	270	142 yrs
	3	21_1980	2050	260	96 yrs
	4	186_1996	2050	260	125 yrs
	5	33_1981	2070	260	116 yrs
	6	1_1986	2090	320	105 yrs
	7	58_1984	2090	240	104 yrs
	8	114_1975	2090	110	200 yrs
	9	193_1955	2090	300	95 yrs

Atkins Drought Library	Drought no.	IRAS Run and Year	Base case IRAS DO	Atkins UTR yield gain	GARD UTR yield return period
4	0	25_1940	2110	320	109 yrs
	1	23_1924	2110	270	95 yrs
	2	130_1968	2110	230	92 yrs
	3	143_1969	2110	250	122 yrs
	4	7_1972	2130	260	< 99 yrs
	5	59_1958	2130	320	90 yrs
	6	109_1930	2130	120	156 yrs
	7	155_1959	2130	300	150 yrs
	8	183_1933	2130	320	98 yrs
	9	54_1993	2150	260	< 99 yrs
5	0	111_1936	2150	280	< 99 yrs
	1	6_1968	2170	300	88 yrs
	2	48_1992	2170	290	< 99 yrs
	3	144_1940	2170	310	< 99 yrs
	4	21_1977	2190	260	< 99 yrs
	5	61_1945	2190	320	< 99 yrs
	6	102_1968	2190	300	< 99 yrs
	7	16_1976	2210	290	< 99 yrs
	8	146_1940	2210	270	< 99 yrs
	9	2_1953	2230	320	< 99 yrs
6	0	17_1952	2230	120	126 yrs
	1	81_1969	2230	300	< 99 yrs
	2	97_1975	2230	270	< 99 yrs
	3	132_1929	2230	200	88 yrs
	4	171_1985	2230	330	< 99 yrs
	5	19_1922	2250	#N/A	< 99 yrs
	6	55_1989	2250	340	< 99 yrs
	7	78_1934	2250	300	< 99 yrs
	8	96_1979	2250	#N/A	< 99 yrs
	9	179_1978	2250	310	< 99 yrs

Average yield of all 60 droughts is 275 Ml/d. TW's WRMP assumes 294 Ml/d

GARD assessment of Abingdon reservoir yield



Yield falls to 185 Ml/d if 20% emergency storage allowance, instead of only 6%

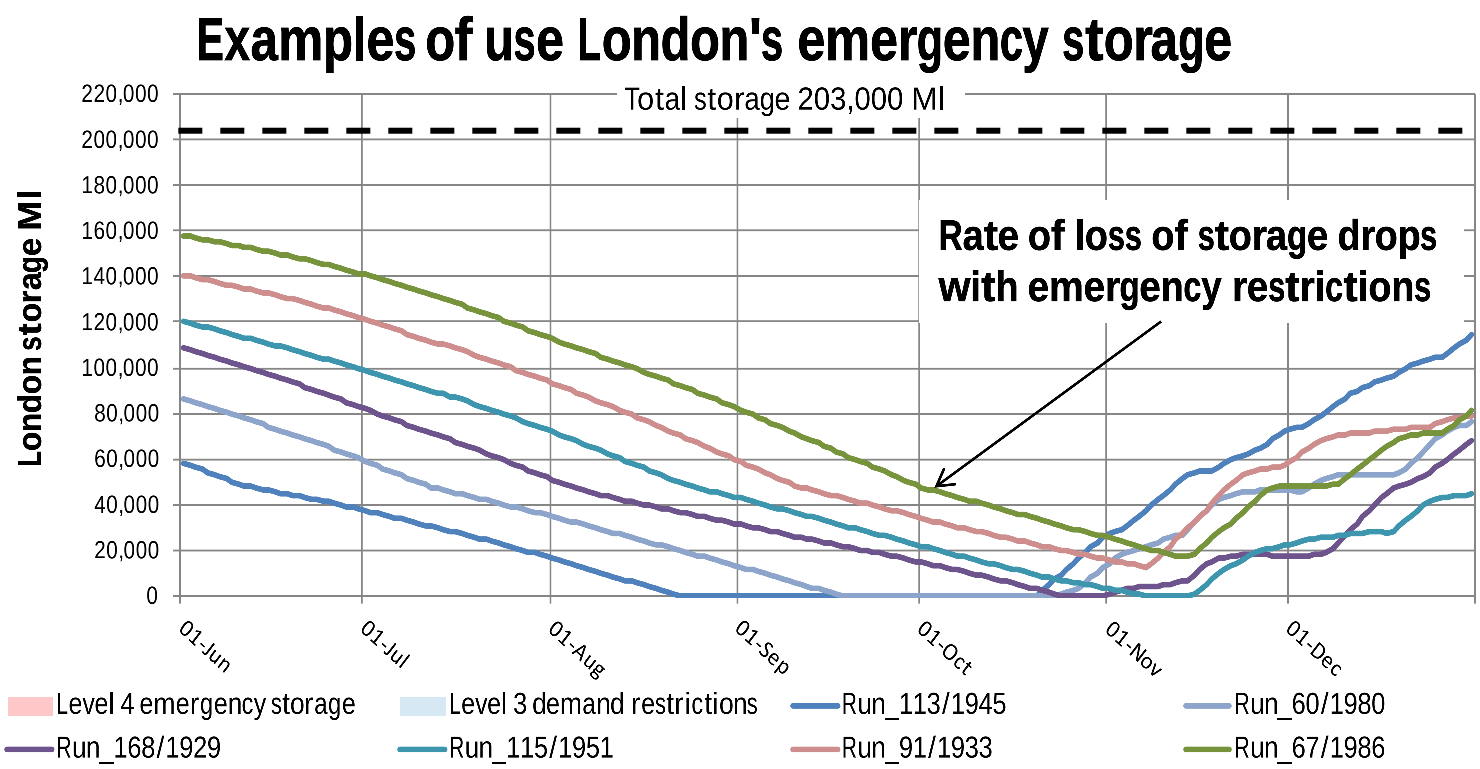
Examples of emergency storage allowances

• Clywedog reservoir	13%
• Llyn Brianne reservoir	14%
• Bristol Water (Chew, Blagdon)	18%
• Welsh Dee system	20%
• TW London reservoirs	24%
• TW Farmoor reservoir	33%

Thames Water propose 6% emergency storage for Abingdon reservoir

Would the last 6% of storage even be usable with an average depth of 1.5m for a 6 km^2 lake?

London's emergency storage – 48,000 Ml (24%)



Drought	Return period for existing supplies	Average rate of storage loss
Run_113/1945	1:1300 years	664 Ml per day
Run_60/1980	1:918 years	713 Ml per day
Run_168/1929	1:578 years	527 Ml per day
Run_115/1951	1:318 years	622 Ml per day
Run_91/1933	1:264 years	617 Ml per day
Run_67/1986	1:279 years	713 Ml per day

48,000 Ml of emergency storage gives 60 days supply at 800 Ml per day.

TW say they have only 30 days emergency storage

	Droughts in which Abingdon reservoir yield gain is less than 240 Ml/d							
	Yields of existing supplies and with Abingdon reservoir (UTR) in droughts						WARMS equivalent gross yields	
IRAS Run_year	Existing supplies gross yield Ml/d	UTR gross yield Ml/d	UTR yield GAIN Ml/d (<200)	Base case gross yield return period 1 in yrs	UTR gross yield return period 1 in yrs	Base case Ml/d	With UTR Ml/d
98_1958	2007	2076	69	188 yrs	709 yrs	2193	2251
159_1975	1497	1576	79	7800 yrs	15600 yrs	1760	1827
39_1958	2152	2253	101	101 yrs	208 yrs	2316	2402
17_1952	2272	2376	104	75 yrs	126 yrs	2418	2506
48_1940	2140	2255	115	108 yrs	203 yrs	2306	2403
136_1942	2285	2412	127	75 yrs	107 yrs	2429	2536
109_1930	2179	2316	137	86 yrs	156 yrs	2339	2455
17_1968	2220	2362	142	77 yrs	131 yrs	2374	2494
114_1975	2121	2265	144	116 yrs	200 yrs	2290	2412
104_1959	2137	2299	162	109 yrs	170 yrs	2303	2441
175_1928	1940	2105	165	240 yrs	578 yrs	2136	2276
128_1938	2115	2291	176	117 yrs	177 yrs	2284	2434
149_1941	1542	1737	195	5200 yrs	7800 yrs	1798	1964
0_1943	2025	2222	197	168 yrs	240 yrs	2208	2375
180_1981	2209	2408	199	79 yrs	110 yrs	2364	2533
50_1988	1994	2203	209	200 yrs	284 yrs	2182	2359
185_1947	2012	2231	219	179 yrs	236 yrs	2197	2383
85_1948	1722	1949	227	1040 yrs	1418 yrs	1951	2144
176_1989	1876	2109	233	411 yrs	538 yrs	2082	2279
165_1957	2146	2379	233	105 yrs	124 yrs	2311	2508
73_1977	1923	2157	234	274 yrs	390 yrs	2122	2320
151_1945	1938	2174	236	248 yrs	347 yrs	2134	2334
142_1956	2177	2413	236	88 yrs	106 yrs	2337	2537
115_1951	1906	2145	239	318 yrs	446 yrs	2107	2310
147_1955	2096	2335	239	129 yrs	139 yrs	2268	2471

Example of 30 month drought with only 101 Ml/d Abingdon yield as shown on next slides

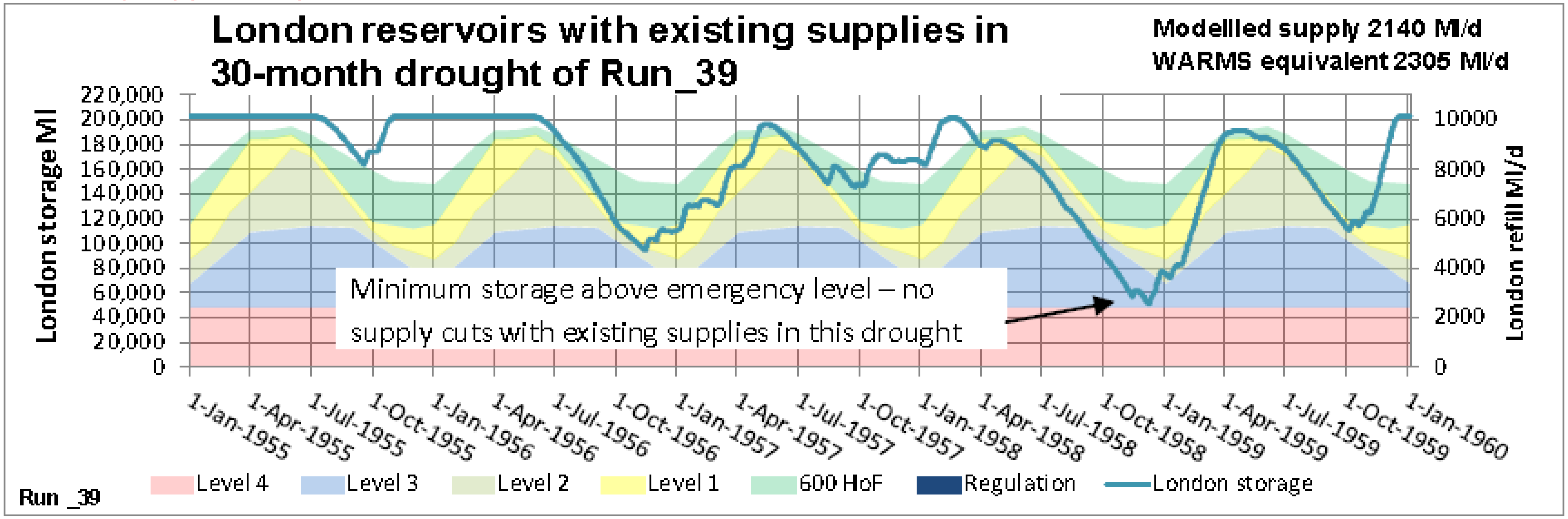
25 droughts with Abingdon yield less than 240 Ml/d

Of which 19 have gross yield return periods of 100-500 years

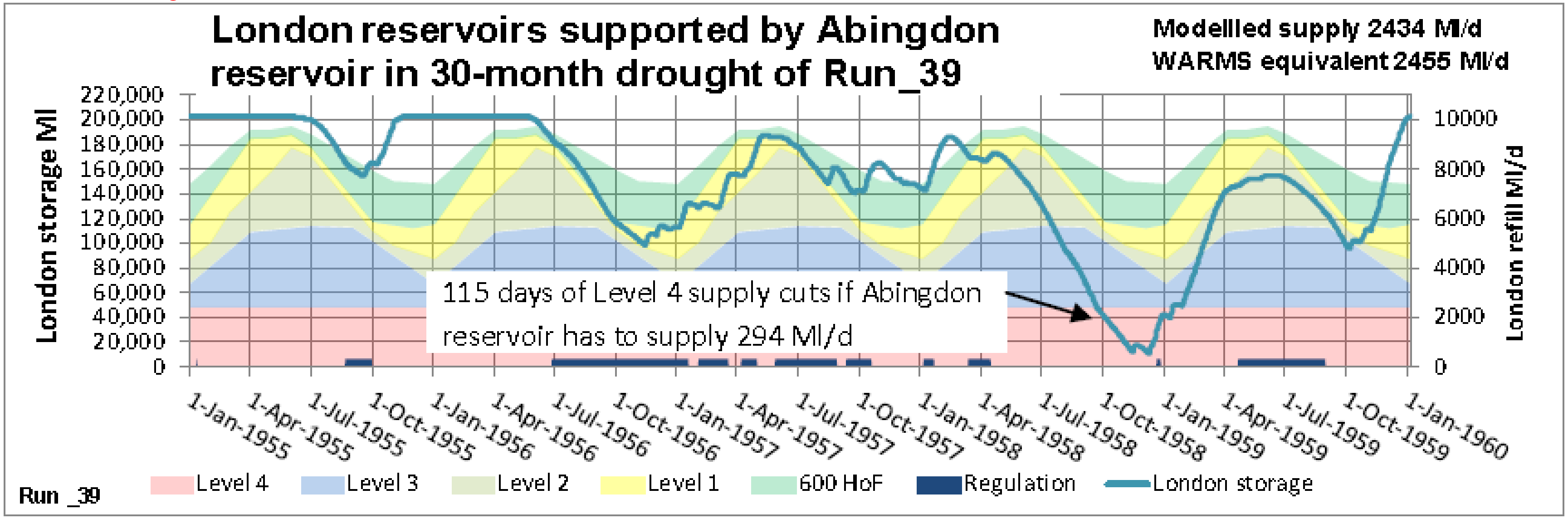
15 droughts with Abingdon yield less than 200 Ml/d

Example 30-month drought

Existing supplies at present demands:

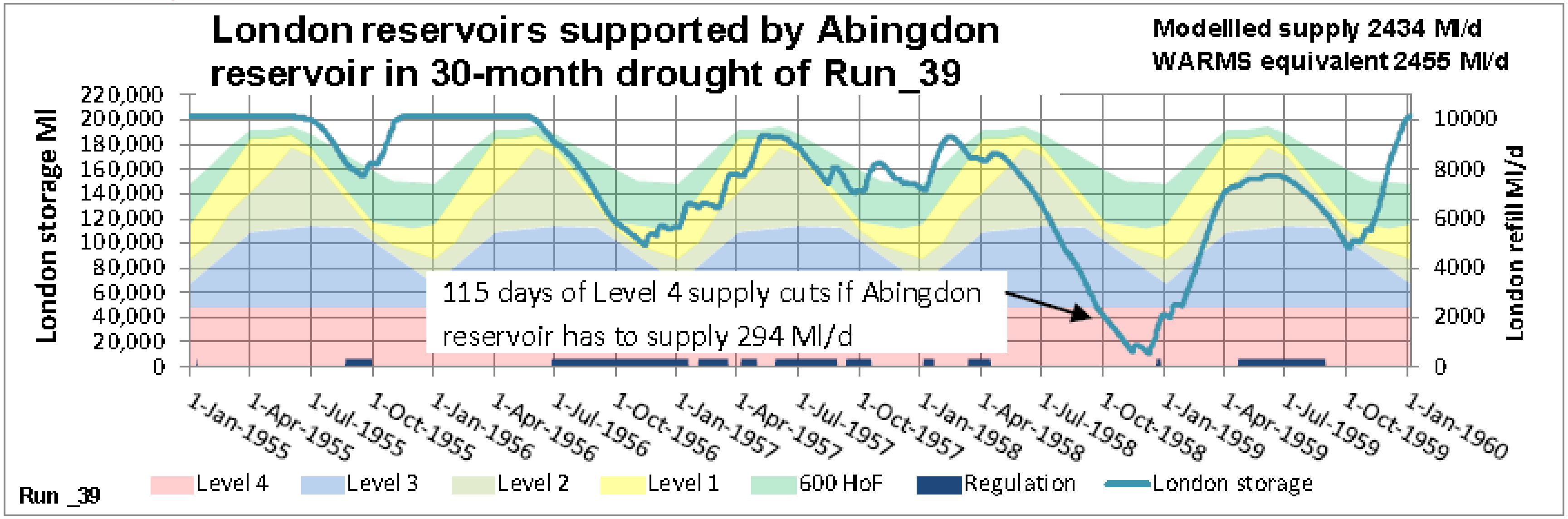


With Abingdon reservoir at 294 Ml/d additional demand:

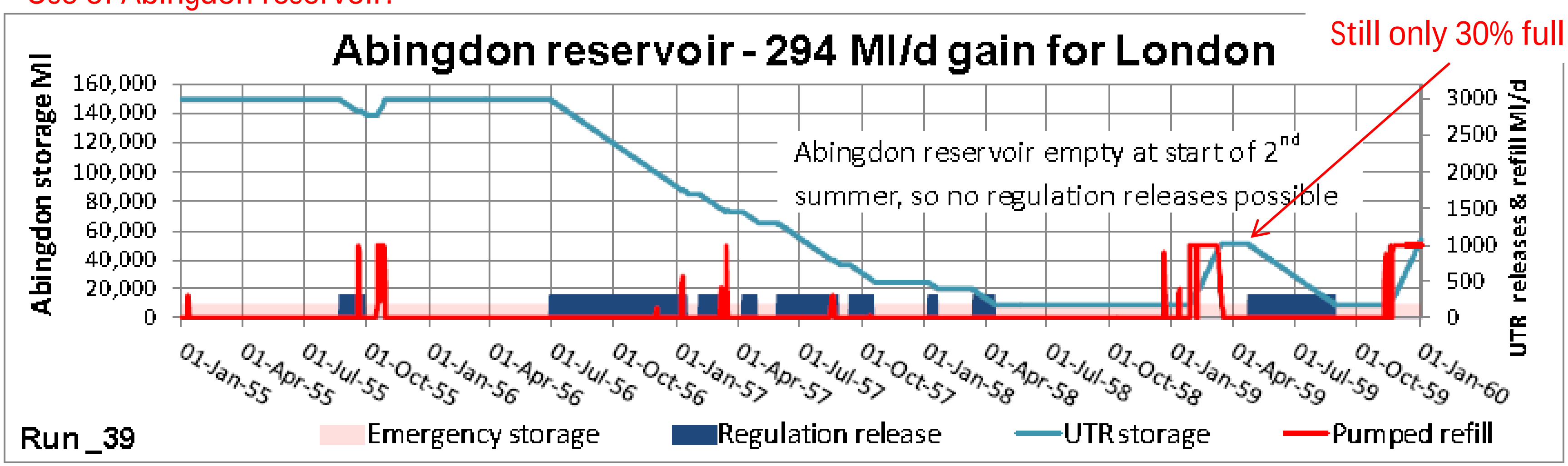


Example 30-month drought

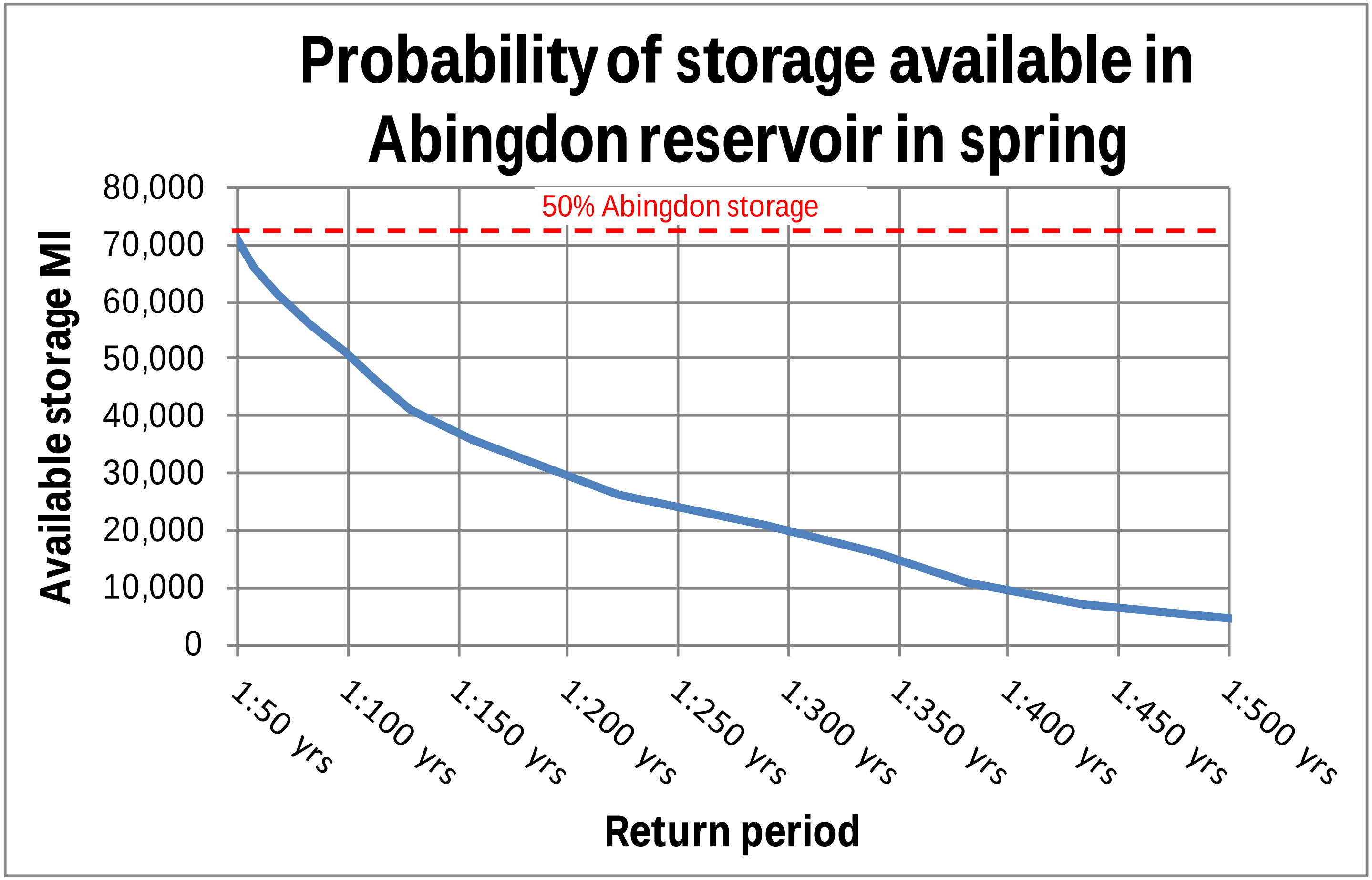
With Abingdon reservoir at 294 Ml/d additional demand:



Use of Abingdon reservoir:



What if Abingdon reservoir is less than half full at start of summer?



If Abingdon reservoir is less than half full at the start of summer, how will the threat of emergency restrictions be managed?

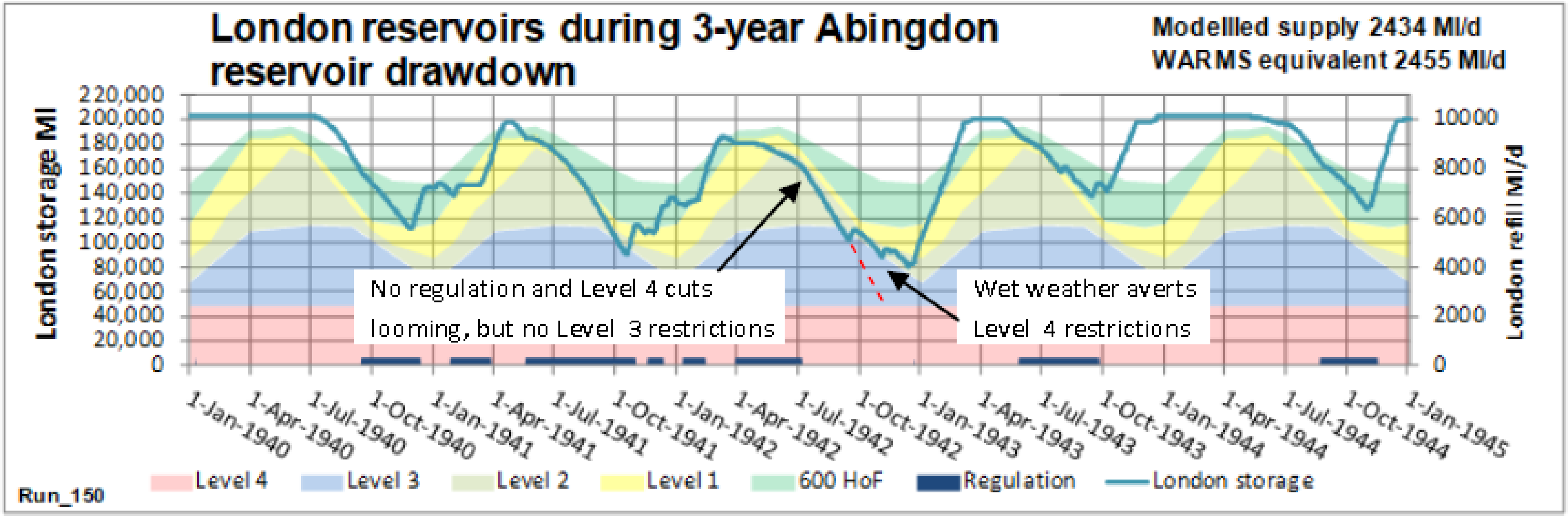
Frequency of periods of long draw- down of Abingdon reservoir

Abingdon reservoir draw-down exceeding	No of occurrences in 15,600 year record	Return period
3 years	151	1:103 years
4 years	56	1:279 years
5 years	28	1:557 years
6 years	9	1:1733 years
7 years	4	1:3900 years
8 years	1	1:15600 years

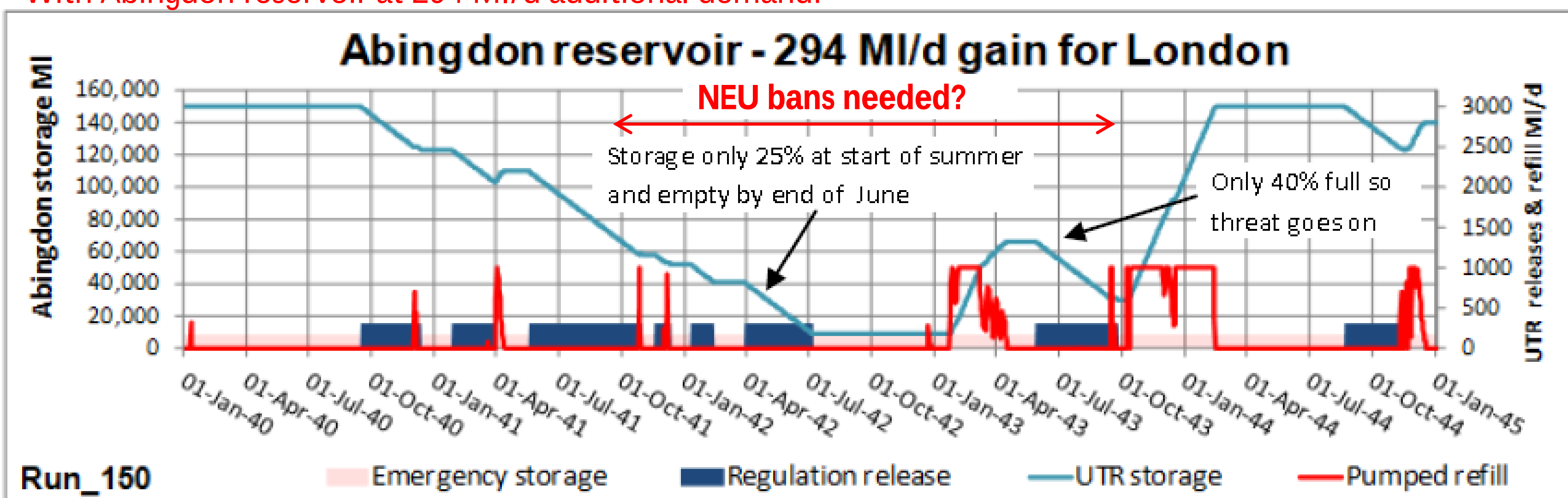
Reservoirs usually are expected to have longest draw-down less than 3 years – are these frequencies acceptable?

Example of threat of supply cuts in long draw-down

Existing supplies at present demands:



With Abingdon reservoir at 294 Ml/d additional demand:

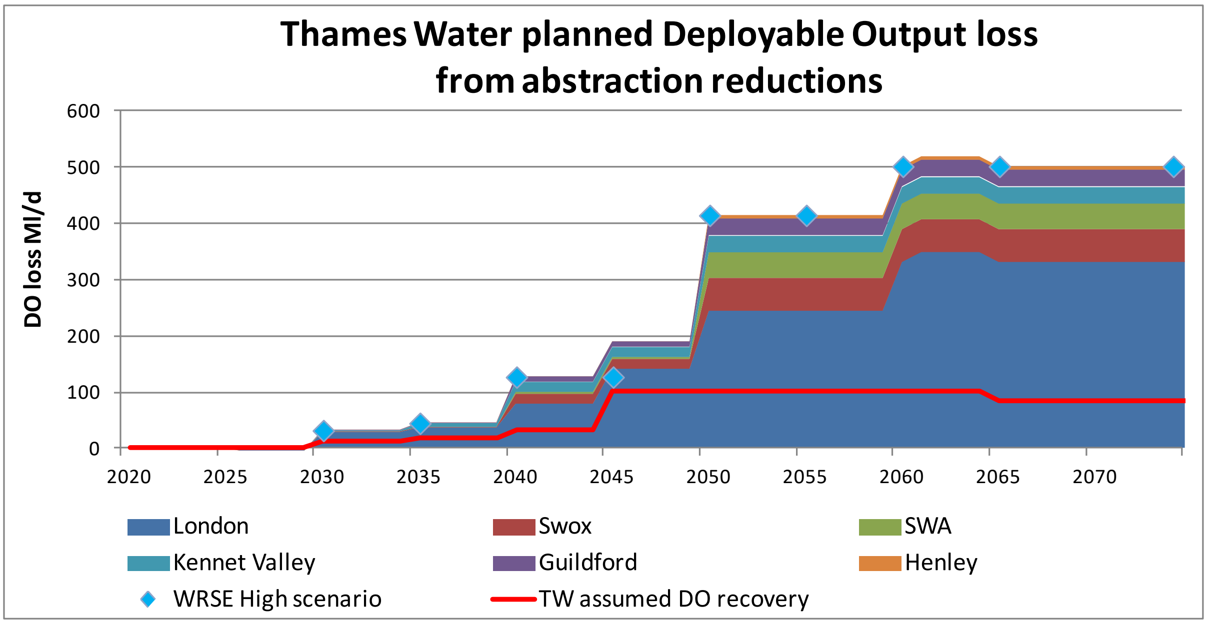


Would NEU bans be needed for 24 months continuously?

Appendix B – Evidence on the need for abstraction reductions

Thames Water loss of DO due to abstraction reductions[115]

Thames Water's planned loss in deployable output due to abstraction reductions for environmental improvements are shown in Figure B1:



Notes: 1. The TW assumed DO recovery from abstraction reductions is as provided by WRSE in file 'GARD-09 Additional Source Level Environmental Ambition Data.xlsx'
2. Plotted amounts for each zone are from TW WRMP tables, 7.2BL + 7.3BL, with DO recoveries added to give DO loss before recovery

Figure B1 - TW planned losses of DO due to abstraction reductions

Figure B1 shows that Thames Water's planned abstraction reductions almost exactly match WRSE's 'High' scenario. Thames Water describes the basis of the abstraction reduction scenarios as below[116]:

> *"the 'high' scenario was, therefore, based on the requirement to meet the EFI [Environmental Flow Indicator], while the 'low' and 'medium' scenarios were developed considering existing and previous WINEP investigations and known sensitive catchments together with some expert judgement."*

In Section 5 of the main WRMP report Thames Water describes the reasoning behind the abstraction reductions in Medium and Low scenarios as follows[117]:

> *"The prioritisation of abstraction sources to be included in the Low and Medium scenarios provided for WRSE use has been defined on the following basis:*

[115] Copied from GARD response to TW's WRMP, Section 2.3
[116] TW WRMP main report paragraph 5.33
[117] TW WRMP main report paragraph 5.39

- *Prioritisation of chalk streams taking into account the high profile of some chalk streams established through historic stakeholder concern Insight gained from sustainability reductions implemented previously at groundwater abstraction sources following investigations*

- *Insight gained from abstraction impact investigations during pre-AMP7 WINEP investigations, including those where no licence reductions were made*

- *Abstractions that have been prioritised in AMP7 for WINEP and specific WFD No Deterioration investigations*

- *Focus on priorities identified through discussions with the Environment Agency"*

In GARD's opinion, this would be a reasonable basis for prioritising abstraction reductions and the Medium and Low scenarios entail much smaller losses of deployable output than the High scenario.

However, Thames Water's preferred plan has adopted the High scenario abstraction reductions for the reasons given below[118]:

> *"Through pre-consultation discussion with our regulator, the Environment Agency, the advice that has been given to us is that we should, in the absence of findings from investigations, assume that licence reductions would need to be made where identified by EFI-based calculations in identifying the pathway for our preferred programme. This means that the "high" environmental destination scenario referred to above should be used. As such, we have followed the regulator's guidance, which in essence applies a precautionary principle in our planning of likely future licence reductions."*

In other words, Thames Water have chosen to adopt the High scenario, based on EFI compliance, rather than use their own expert judgement based on knowledge of their sources and findings of previous investigations. In our response to WRSE's regional plan, we commented at length on the inappropriateness of slavishly following the EFI "handle turning" methodology. We pointed out the dangers of excessive and unjustified abstraction reductions leading to huge costs of replacement sources, which bring their own environmental impacts[119]. Excessive expenditure on abstraction reductions will inevitably lead to less money being available for much needed improvements to sewerage and sewage treatment. The point was made succinctly in Oxfordshire County Council's response to WRSE's regional plan[120]:

> *"There should be a focus on ecologically important chalk streams and reducing abstractions to enable those environments to be rehabilitated. However, we understand*

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[118] TW WRMP main report paragraph 11.13

[119] GARD response to WRSE's regional plan Sections 2.2.2 and 2.2.5 5 https://www.gard-oxon.org.uk/downloads/Final%20GARD%20Response%20to%20WRSE%2022%202%2023%20v4.pdf

[120] Oxfordshire County Council response to WRSE consultation, paragraph 15, 2nd bullet, page 5

that the ratio of the marginal cost and utility of the highest of the three environmental options is very poor, and believe bill-payers would expect this to be weighed against the benefit of an equivalent shift in resources to reducing raw sewage discharges in other rivers. We consider that this plan should push back on any narrow focus and maximalist expectations from regulators."

In view of the dominance of environmental improvements in the resource needs of every region, no decisions should be taken on the need and choice of new resource schemes until the proper and transparent prioritisation of abstraction reductions has been completed.

GARD's comments on the abstraction reductions in TW's water resource zones are given in the following sections.

TW planned abstraction reductions in the London zone

Thames Water's deployable output losses for the London zone due to abstraction reductions under the three scenarios are shown in Table B1:

		WRSE High Scenario							WRSE	WRSE
Source	Catchment	2029-30	2034-35	2039-40	2049-50	2059-60	2064-65	2074-75	Medium	Low
Bexley	Darent and Cray		0.0	31.7	31.7	31.7	31.7	31.7	15.0	9.0
Crayford	Darent and Cray		0.0	0.0	13.6	13.6	13.6	13.6	0.0	0.0
Darenth	Darent and Cray		0.0	0.0	20.7	20.7	20.7	20.7	0.0	0.0
Dartford	Darent and Cray		0.0	0.0	3.6	3.6	3.6	3.6	0.0	0.0
Epsom Sources	London	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
Green St Green	Darent and Cray		0.0	0.0	4.5	4.5	4.5	4.5	0.0	0.0
Horton Kirby and Eynsford	Darent and Cray		3.4	6.8	6.8	6.8	6.8	6.8	3.4	3.4
Lower Lee	London		0.0	0.0	0.0	65.0	65.0	65.0	50.0	25.0
Lullingstone	Darent and Cray		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
New Gauge	Upper Lee		0.0	0.0	80.0	80.0	80.0	80.0	60.0	0.0
Northern New River Wells	London		0.0	0.0	0.0	40.0	40.0	40.0	18.0	18.0
Northern New River Wells (No Det) Licence Cap	London	18.0	18.0	18.0	18.0	0.0	0.0	0.0	0.0	0.0
Orpington	Darent and Cray		0.0	0.0	8.6	8.6	8.6	8.6	0.0	0.0
Sundridge	Darent and Cray		0.0	0.0	1.4	1.4	1.4	1.4	1.4	0.0
Waddon	London		0.0	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Wansunt	Darent and Cray		0.0	0.0	13.6	13.6	13.6	13.6	0.0	0.0
Westerham	Darent and Cray		0.0	0.0	0.9	0.9	0.9	0.9	1.0	0.0
Wilmington	Darent and Cray		0.0	0.0	19.0	19.0	19.0	19.0	0.0	0.0
	Sub-total	**28.2**	**36.1**	**78.7**	**244.5**	**331.5**	**331.5**	**331.5**	**170.9**	**77.6**
Return from TW SRs		-3.9	-3.88	-9.5	-57.8	-57.8	-57.8	-57.8	-22.6	-5.7
Returns from Colne		-5.2	-5.2	-12.1	-26.5	-26.5	-26.5	-26.5	-19.6	-11.1
Returns from Lee		-3.1	-8.9	-10.0	-17.7	-17.7	0.0	0.0	0.0	0.0
DO loss after recovery from returns		**16.0**	**18.1**	**47.1**	**142.5**	**229.5**	**247.2**	**247.2**	**128.7**	**60.8**

Table B1 - DO loses due to abstraction reductions in London zone

Table B1 shows that the deployable output losses for London zone are far higher for the High scenario than for the Medium or Low scenarios. It also shows that a lot of the deployable output losses for the London zone are due to abstraction reductions for the River Darent (and its Cray tributary), a chalkstream in Kent to the South East of London.

Without the Darent reductions, London zone abstraction reductions are shown in Table B2:

	All in Ml/d	WRSE High Scenario							WRSE	WRSE
Source	Catchment	2029-30	2034-35	2039-40	2049-50	2059-60	2064-65	2074-75	Medium	Low
Epsom Sources	London	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
Lower Lee	London		0.0	0.0	0.0	65.0	65.0	65.0	50.0	25.0
New Gauge	Upper Lee		0.0	0.0	80.0	80.0	80.0	80.0	60.0	0.0
Northern New River Wells	London		0.0	0.0	0.0	40.0	40.0	40.0	18.0	18.0
Northern New River Wells (No Det) Licence Cap	London	18.0	18.0	18.0	18.0	0.0	0.0	0.0	0.0	0.0
Waddon	London		0.0	7.6	7.6	7.6	7.6	7.6	7.6	7.6
	Sub-total	**28.2**	**28.2**	**35.7**	**115.7**	**202.8**	**202.8**	**202.8**	**145.7**	**60.7**
Return from TW SRs		-3.9	-3.88	-9.5	-57.8	-57.8	-57.8	-57.8	-22.6	-5.7
Returns from Colne		-5.2	-5.2	-12.1	-26.5	-26.5	-26.5	-26.5	-19.6	-11.1
Returns from Lee		-3.1	-8.9	-10.0	-17.7	-17.7	0.0	0.0	0.0	0.0
DO loss after recovery from returns		**16.0**	**10.2**	**4.1**	**13.7**	**100.7**	**118.4**	**118.4**	**103.5**	**43.9**

Table B2 - London zone without Darent, DO losses due to abstraction reductions

Most of these reductions are from surface water abstractions from heavily modified parts of the River Lee and its man-made diversion channel, the New River. They are not abstraction reductions from an ecologically sensitive chalk stream. The New River abstraction could be switched to the lower Lea, which would put more flow into the middle Lea with no net loss of deployable output. The reductions from the Northern New River Wells are also of questionable ecological benefit, bearing in mind that the boreholes are near the lower limit of the "classic chalk stream" part of the River Lea. Furthermore, the lower river will benefit from about 90 Ml/d of urgently needed reductions in Affinity Water's groundwater abstractions in the Upper Lea and its chalk tributaries (Mimram, Beane, etc)[121], so further flow enhancements may not be needed.

In GARD's opinion, even WRSE's Low scenario reductions for the London sources shown in Table 3 could be difficult to justify in terms of benefits versus the cost and impact of replacement sources. However, we think that, at this stage it would be reasonable for TW's preferred plan to allow for the Low scenario reduction of 60.7 Ml/d gross loss of DO, which gives a net loss of 43.9 Ml/d after allowing for Thames Water's figures for DO recovery from enhanced river flows available for filling Thames Water's reservoirs.

Reduction in abstraction at Thames Water's sources in the lower River Lea could be justified if linked to development of the Deephams reuse scheme, if it is needed.

We have left the deployable output recovery figures in Table 3 as per Thames Water's figures. However, in our opinion, DO recovery will be a lot higher for the reasons set out in GARD's response to WRSE's consultation.

In contrast to the lower Lee, the Rivers Darent and Cray are potentially "classic" chalk streams with a much stronger case for abstraction reductions. TW and WRSE scenario reductions are shown in Table 4, using WRSE data which is identical to the data in WRMP Table 5-4:

[121] GARD response to Affinity Water WRMP consultation, Table 2

	All in Ml/d	WRSE High Scenario					WRSE Medium	WRSE Low
Source	Catchment	2029-30	2034-35	2039-40	2049-50	2074-75		
Wilmington	Lower Darent		0.0	0.0	19.0	19.0	0.0	0.0
Darenth	Lower Darent		0.0	0.0	20.7	20.7	0.0	0.0
Dartford	Lower Darent		0.0	0.0	3.6	3.6	0.0	0.0
Wilmington	Lower Darent		0.0	0.0	19.0	19.0	0.0	0.0
Crayford	Lower Cray		0.0	0.0	13.6	13.6	0.0	0.0
Bexley	Lower Cray		0.0	31.7	31.7	31.7	15.0	9.0
Green St Green	Mid Darent		0.0	0.0	4.5	4.5	0.0	0.0
Horton Kirby and Eynsford	Mid Darent		3.4	6.8	6.8	6.8	3.4	3.4
Lullingstone	Mid Darent		4.5	4.5	4.5	4.5	4.5	4.5
Sundridge	Upper Darent		0.0	0.0	1.4	1.4	1.4	0.0
Westerham	Upper Darent		0.0	0.0	0.9	0.9	1.0	0.0
Wansunt	Upper Cray		0.0	0.0	13.6	13.6	0.0	0.0
Orpington	Upper Cray		0.0	0.0	8.6	8.6	0.0	0.0
	Total DO loss	**0.0**	**7.9**	**43.0**	**128.8**	**128.8**	**25.2**	**16.9**

Table B3 - DO losses due to Darent/Cray abstraction reductions

This shows that most of the planned abstraction reductions in the High scenario are in the lower Rivers Darent and Cray which are heavily urbanised. Thames Water has justifiably given these reductions a low priority by mostly pushing them back to 2050.

The high priority for reductions should be the abstractions in the middle and upper Darent where the river is in the Kent Downs AONB and has the potential to be a "classic" chalk stream. The mid and upper Darent reductions shown in Table 4 only total 18 Ml/d and, in GARD's opinion, these should all be implemented by 2035. There could also be a case for some reductions in the upper Cray catchment, even though the river is heavily urbanised. Most the other Darent and Cray reductions seem unlikely to be justifiable through the urgently needed national prioritisation of abstraction reductions which GARD has advocated in its response to the consultation on WRSE's regional plan[122]:

In our opinion, it would be reasonable for Thames Water's preferred plan to allow for the Low scenario reductions for London only, ie 43.9 Ml/d as Table 3, plus the Mid scenario for Darent/Cray, ie 25.2 Ml/d as Table 3, making a total of 69.1 Ml/d for the London zone. This compares with the 247 Ml/d allowance in the preferred plan as shown in Table B1.

Planned abstraction reductions in the SWOX zone

Thames Water's planned deployable output loss due to abstraction reductions in the SWOX zone are shown in Table B4:

[122] GARD response to WRSE regional plan, page 22

	All in Ml/d	WRSE High Scenario					WRSE	WRSE
Source	Catchment	2029-30	2034-35	2039-40	2049-50	2074-75	Medium	Low
Ashdown Park	Kennet and tributaries		0.0	0.0	1.0	1.0	0.0	0.0
Ashton Keynes	Gloucestershire and the Vale		0.0	0.0	1.7	1.7	1.7	0.0
Bibury	Gloucestershire and the Vale		0.0	0.7	0.7	0.7	3.0	3.0
Chinnor	Thames and South Chilterns		0.0	1.6	1.6	1.6	1.6	0.0
Chinnor Licence Cap	Thames and South Chilterns	1.27	1.3	0.0	0.0	0.0	0.0	1.3
Clatford	Kennet and tributaries		0.0	1.2	1.2	1.2	1.2	1.2
Farmoor	Cotswolds		0.0	0.0	35.0	35.0	15.0	0.0
Latton	Gloucestershire and the Vale		0.0	9.7	9.7	9.7	5.0	5.0
Marlborough	Kennet and tributaries		0.0	2.5	2.5	2.5	2.5	2.5
Seven Springs	Cotswolds		0.0	0.0	1.0	1.0	0.0	0.0
Syreford	Gloucestershire and the Vale		0.0	0.0	0.5	0.5	0.0	0.0
Upper & Lower Swell	Cotswolds		0.0	0.0	1.8	1.8	1.8	0.0
Watlington	Thames and South Chilterns		0.0	0.3	0.3	0.3	0.3	0.0
Woods Farm	Thames and South Chilterns		0.0	1.6	1.6	1.6	0.0	0.0
All	**Total DO loss**	**1.3**	**1.3**	**17.6**	**58.6**	**58.6**	**32.1**	**13.0**

Table B4 - DO losses due to abstraction reductions in SWOX zone

The main effect of planned abstraction reductions in SWOX zone is the loss of 35 Ml/d of deployable output from Farmoor from 2050. GARD's modelling shows that the 35 Ml/d deployable output loss corresponds to raising the Farmoor hands-off flow from 136 Ml/d to 188 Ml/d. However, raising the Farmoor hands-off flow leaves more water in the River Thames, which then becomes available for filling the London reservoirs. Our modelling shows that this would lead to recovery of 27 Ml/d of deployable output in the London zone. Therefore, the35 Ml/d loss of deployable output in SWOX zone is only a net loss of 8 Ml/d to Thames Water's supplies overall.

All the DO losses due the other groundwater abstraction reductions shown in Table 5 arise after 2040, presumably because of Thames Water's assumed need to wait for Abingdon reservoir to make replacement water available. However, as noted in Section 3.2, Thames Water's planned leakage reduction in SWOX zone is only 27%, far short of the Government's 50% target – if leakage is reduced to similar levels to other water companies in the South East, all the groundwater abstraction reductions could be brought forward, without the need for Abingdon reservoir.

Therefore, GARD proposes that the sensitive groundwater abstraction reductions in SWOX zone should be brought forward, starting in 2025 and complete by 2035.

TW planned abstraction reductions in the Thames Valley zones

Thames Water's planned deployable output loss due to abstraction reductions in the Thames valley zones zone are shown in Table B5:

	All in Ml/d	WRSE High Scenario					WRSE	WRSE
Source	Catchment	2029-30	2034-35	2039-40	2049-50	2074-75	Medium	Low
Albury	Wey (Tilling Brook)		0.0	3.6	3.6	3.6	0.0	0.0
Mousehill & Rodborough	Upper Wey		0.0	1.5	1.5	1.5	0.0	0.0
Netley Mill	Wey (Tillingbourne)	1.18	1.2	4.5	4.5	4.5	4.5	1.2
Netley Mill Licence Cap	Wey (Tillingbourne)		0.0	0.0	0.0	0.0	0.0	0.0
Shalford	Middle Wey		0.0	0.0	20.3	20.3	0.0	0.0
Sheeplands	Loddon and tributaries	0.00	0.0	0.0	6.2	6.2	0.0	0.0
Bishops Green	Enbourne		0.0	0.8	0.8	0.8	0.0	0.0
Bradfield	Pang	1.64	1.6	1.6	1.6	1.6	1.6	1.6
East Woodhay	Enbourne		0.0	3.9	3.9	3.9	0.0	0.0
Fognam Down	Lambourn		0.0	0.0	0.0	0.0	0.0	0.0
Pangbourne	Pang		5.0	5.0	5.0	5.0	5.0	5.0
Playhatch	Thames valley		0.0	6.5	6.5	6.5	0.0	0.0
Ufton Nervet	Kennet and tributaries		0.0	0.0	11.6	11.6	0.0	0.0
Bourne End	Thames valley		0.0	0.0	5.7	5.7	0.0	0.0
Datchet	Thames valley		0.0	0.0	13.1	13.1	0.0	0.0
Hampden Bottom	Misbourne		0.0	2.0	2.0	2.0	2.0	0.0
Medmenham	Thames valley		0.0	0.0	16.3	16.3	0.0	0.0
Pann Mill	Wye		0.0	0.0	7.5	7.5	7.5	7.5
Radnage	Wye		0.0	1.6	1.6	1.6	1.6	1.6
All	**Total DO loss**	**2.8**	**7.8**	**31.0**	**111.6**	**111.6**	**22.2**	**16.9**

Table B5 - DO losses due to abstraction reductions in Thames valley zones

GARD's comments on the abstraction reductions shown in Table B5 are:

1. The abstractions reductions shown as 'Thames valley' totalling 41 Ml/d, if they could be justified, are close to the River Thames and would lead to increased flows in the lower Thames and equivalent increases in deployable output for London zone. However, it is difficult to see how these reductions would lead to worthwhile ecological benefits, which is presumably why Thames Water have not included them in the Mid or Low scenarios.

2. The CaBA report on Abstraction as % Recharge showed that abstraction in the Pang catchment is only 1% of recharge[123] and no reductions are necessary, even if the Pang has been declared a Flagship catchment [124]. We also note that EA abstraction data shows that the Pangbourne licence expired in 2005 and there has been no abstraction since that date.

3. The CaBA report on Abstraction as % Recharge showed that abstraction in the Wye catchment is only 10% of recharge and reductions are barely necessary, if at all.

4. The Rivers Wey and Loddon were not covered by the CaBA report on Abstraction as % of Recharge. However, GARD is aware from local rivers trusts that there are concerns over abstraction in these catchments, although Thames Water's Loddon abstraction is close to the bottom of the river so probably has little impact. Therefore, the Upper Wey amounts shown in Table 6 are mostly justified (also probably the Enbourne and Misbourne reductions). In that case, the reductions

[123] Catchment as % Recharge, CaBA, December 2021, page 8 https://chalkstreams.org/2022/01/23/ar-abstraction-as-a-of-recharge-in-chalk-streams/
[124] Thames Water WRMP main report paragraph 5.19

should not be delayed until 2040 or 2050, presumably awaiting availability of water from Abingdon reservoir and the STT.

In GARD's opinion, it would be reasonable for Thames Water's preferred plan to allow for the High scenario reductions for the Rivers Wey, Misbourne and Enbourne, as shown in Table B5 and totalling 17 Ml/d (excluding the Shalford abstraction, which is unlikely to have a significant effect on the chalk streams upstream). These reductions should be made as quickly as possible and should not be dependent on Abingdon reservoir. They could be enabled initially by the baseline surplus in the Thames valley zones (and subsequently by the additional water that would be available if Thames Water meet Government leakage targets and match the leakage levels achieved by other companies in the South East.

Therefore, GARD proposes that the sensitive groundwater abstraction reductions in the Rivers Wey, Misbourne and Enbourne should be completed by 2035.

Conclusions from GARD's review of TW's environmental reductions

The conclusion from GARD's review of the losses of deployable output from the environmental reductions in Thames Water's preferred plan are shown in Table B6:

All in Ml/d	**Thames Water**	**GARD**	**Comments**
London zone			
London only	118	44	As TW Low scenario
Darent and Cray	<u>129</u>	<u>25</u>	Mainly upper/middle Darent, but brought forward
Total London zone	247	69	
Swox zone	59	59	Mostly Farmoor and recovered at London. GW reductions brought forward
Thames Valley zones	111	17	Only Wey, Enbourne and Misbourne, but sensitive sites brought forward
Total all zones	**417**	**145**	

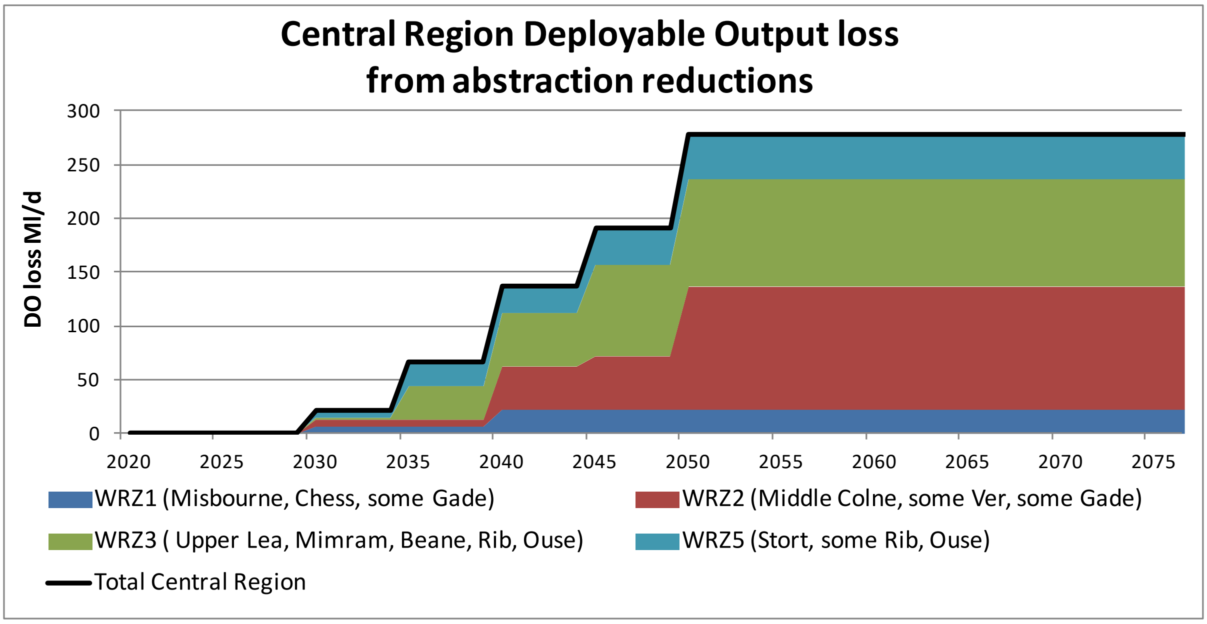
Table B6 - Summary of GARD review of TW's DO losses from environmental improvements

In summary, in GARD's opinion Thames Water have overstated their loss of deployable output for environmental improvements by about 270 Ml/d. However, that figure is based on acceptance of Thames Water's estimates of deployable output recovery from the abstraction reductions. Although no detail is given of the basis for Thames Water's recovery figures, we think that the recovery from Colne and Lee chalk stream reductions may have been underestimated and we have seen no evidence that any allowance has been made for recovery from abstraction reductions in SWOX and the other Thames valley zones.

GARD proposes that the sensitive groundwater abstraction reductions in all Thames Water's zones, particularly those in the upper reaches of chalk streams, should be brought forward, starting in 2025 and completed by 2035.

Environmental reductions in Affinity Water's draft WRMP[125]

As can be seen on Figure 3, loss of deployable output due to environmental abstraction reductions is the largest component of Affinity Water's forecast deficit in the Central Region. The deployable output loss from environmental abstraction reductions in each zone are shown in Figure B2:



Notes: 1. Data taken from Row 34 in WRMP supply demand balance tables
2. There are no planned environmental reductions in WRZ4 (Pinn) or WRZ6 (Wey)

Figure B2 - Deployable output loss due to environmental reductions in WRZs

The water resource zone boundaries do not align with river catchments, so some of the catchment reductions for individual rivers are split between two zones. Some of the reductions in WRZ3 and WRZ5 are in chalk catchments draining northwards into the River Ouse.

Data on deployable output loss in individual sources have been obtained via an information request to WRSE[126]. These data also allocated the reductions to WRZs. Comparison of the WRSE data and the data in the WRMP tables shows that Affinity Water's planned environmental reductions align exactly with WRSE's 'High' scenario for abstraction reductions.

Affinity Water reductions in the upper Colne and Lea chalk tributaries

The proposed abstraction reductions have been reviewed separately in a report for the

[125] Copied from Sections 2.3 and 2.4 of GARD's response to Affinity Water's WRMP
[126] Data supplied by WRSE in file *"GARD-03 Source Level Environmental Ambition Data.xlsx"*

Chalk Streams First (CSF) group of NGOs, which is available on the internet[127]. This showed a comparison of the abstraction reductions proposed by Chalks Stream First with the deployable output losses in Affinity Water's plan, as shown in Table B7:

		CSF Proposal		Affinity Water DO loss		
Colne catchment:	**Recent abstraction 2019-21**	**CSF proposed abstraction**	**Abstraction reduction**	**Reduction by 2034-35**	**Reduction by 2039-40**	**Reduction by 2049-50**
Misbourne	15.8 Ml/d	6.2 Ml/d	9.6 Ml/d	2.0 Ml/d	4.0 Ml/d	4.0 Ml/d
Chess	15.1 Ml/d	4.1 Ml/d	11.0 Ml/d	0.0 Ml/d	0.0 Ml/d	0.0 Ml/d
Gade	36.2 Ml/d	11.9 Ml/d	24.3 Ml/d	4.7 Ml/d	18.4 Ml/d	36.4 Ml/d
Ver	25.8 Ml/d	7.7 Ml/d	18.1 Ml/d	6.4 Ml/d	11.8 Ml/d	11.8 Ml/d
		Colne total	**63.0 Ml/d**	**13.1 Ml/d**	**34.2 Ml/d**	**52.2 Ml/d**
Lea Catchment:						
Upper Lea to Water Hall	48.4 Ml/d	7.2 Ml/d	41.2 Ml/d	4.1 Ml/d	8.9 Ml/d	38.7 Ml/d
Mimram	10.4 Ml/d	6.1 Ml/d	4.3 Ml/d	1.7 Ml/d	3.2 Ml/d	3.2 Ml/d
Beane	24.9 Ml/d	9.8 Ml/d	15.2 Ml/d	14.0 Ml/d	14.0 Ml/d	21.6 Ml/d
Rib	22.8 Ml/d	7.3 Ml/d	15.5 Ml/d	7.1 Ml/d	7.1 Ml/d	15.5 Ml/d
Ash	1.2 Ml/d	0.0 Ml/d	0.0 Ml/d	0.7 Ml/d	0.7 Ml/d	0.7 Ml/d
Stort	25.0 Ml/d	13.5 Ml/d	11.5 Ml/d	8.4 Ml/d	8.4 Ml/d	15.8 Ml/d
		Lea total	**87.6 Ml/d**	**36.0 Ml/d**	**42.3 Ml/d**	**95.6 Ml/d**
		Total	**150.6 Ml/d**	**49.1 Ml/d**	**76.5 Ml/d**	**147.8 Ml/d**

Table B7 - CSF and Affinity abstraction reduction proposals in upper Colne/Lea tributaries

The figures in Table B7 show that the CSF proposed reductions align quite well with the losses of deployable output losses assumed in Affinity Water's WRMP. The CSF and Affinity Water figures are not directly comparable because the CSF figures are reductions from recent abstraction and Affinity Water figures are losses in deployable output. This will explain some of the differences in figures for the individual chalk streams.

The comparison in Table B7 shows that Affinity Water's proposed reductions in the upper chalk streams of the Colne and Lea valleys are similar in overall amount to the Chalk Streams First proposals – a total of about 150 Ml/d. Therefore, GARD supports these proposed reductions in the upper chalk streams. However, we note that the timing of the reductions in Affinity's plan delays most of these urgently needed improvements until after 2040, presumably because of a perceived need to wait for a major new source like Abingdon reservoir or the STT – a major weakness in Affinity Water's plan.

Affinity Water reductions in the Lower Colne

In addition to the abstraction reductions in the upper chalk tributaries shown Table B7, Affinity Water's plan allows for 86 Ml/d of reductions in the main River Colne valley

[127] Dealing with the impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys, Chalk Streams First, January 2023 https://chalkstreams.org/flow-recovery-following-abstraction-reduction/

downstream of the upper chalk tributaries, at the approximate locations shown in Figure B3:

Figure B3 - Approximate locations of abstractions in the main Colne valley

Affinity Water's planned 86 Ml/d of abstraction reductions in the main Colne valley are 34 Ml/d more than the reductions from the upper catchment chalk streams shown in Table 2. Overall, it appears that Affinity plan to give up all their sources in the Colne valley, as shown by the plot of the baseline supply demand balance for WRZ2, which is reproduced below:

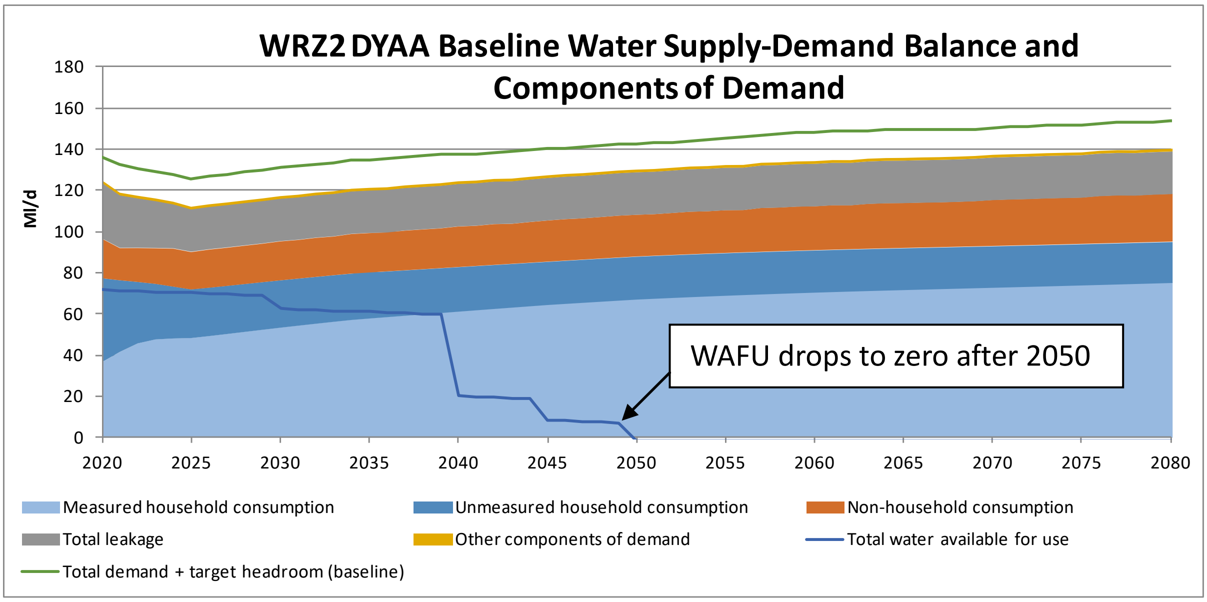


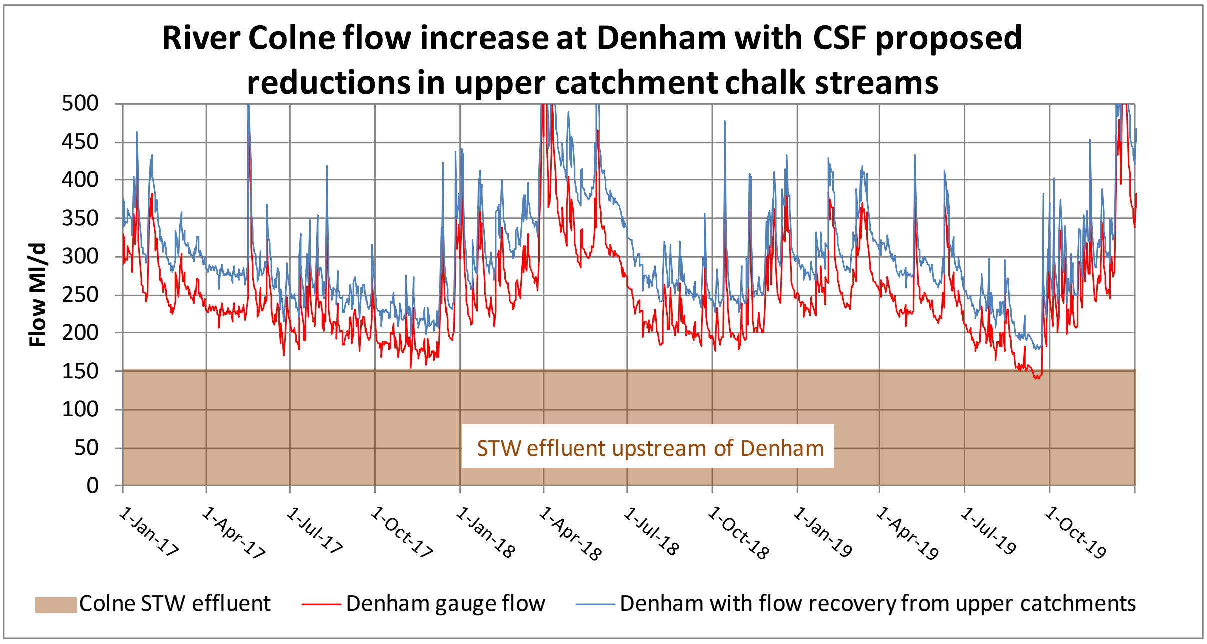
Figure B4 - Affinity WRMP baseline supply demand balance for WRZ2 (Colne)

This shows water available for use (WAFU) in the Colne zone falling to zero after 2050 as a consequence of the 86 Ml/d of abstraction reductions (which appear actually to exceed the WAFU – presumably an error).

However, whereas the abstraction reductions in the upper Colne catchment are easily justified in terms of restoring near-natural flows in iconic chalk streams, the benefits of the larger reductions in the lower Colne are highly questionable. The river weaves between gravel pits and forms part of the Grand Union Canal for a lot of this reach. It is classified as Heavily Modified from downstream of the Gade confluence. Flows from Denham down are largely effluent from Maple Lodge STW which returns much of the water abstracted further up the Colne catchment. The main River Colne is not and never will be a "classic" chalk stream.

Furthermore, the main River Colne will benefit substantially from the abstraction reductions in the upper catchment chalk streams. The flow enhancement in the main Colne from the upper chalk stream reductions during the 2017 to 2019 drought is shown in Figure B5, as modelled by Chalk Streams First[128]:

[128] Adapted from Figure 27 in Chalk Streams First report, January 2023



Note: the STW effluent amount is from EA 'recent actual' data in 2015[129]

Figure B5 - Main River Colne flow recovery from upper catchment reductions

During dry summers, flow in the main River Colne is dominated by effluent from Maple Lodge STW and a number of small STWs upstream, with little dilution by natural flows. The additional flow from the upper catchment abstraction reductions will more than double the natural summer flow contribution in the main River Colne and greatly increase the dilution of STW effluents.

The cost of replacement sources for Affinity Water's planned 87 Ml/d of abstraction reductions in the main River Colne valley would be of the order of £1 billion (roughly half the cost of Abingdon reservoir, plus additional pipelines to the demand areas). It is difficult to see how such a huge cost can be justified by the environmental benefits in the lower Colne valley, especially bearing in mind the flow benefits that will arise from the upper catchment abstraction reductions. Noting Ofwat's concerns over increases in customer bills and nationwide concerns over sewage pollution, it is suggested that the £1 billion needed for the lower Colne reductions would be much better spent on sewerage improvements.

Therefore, GARD proposes that Affinity Water's planned 87 Ml/d of abstraction reductions in the main Colne valley should be abandoned.

Affinity Water reductions in the Ouse catchment

About 35 Ml/d of Affinity Water's planned abstraction reductions are in chalk stream tributaries of the upper Ouse catchment, as shown in Table B8:

[129] From EA File *'HERTS Artificial Influences overview.xlsx'*

Company	WRZ	Source	Catchment	2034-35	2039-40	2049-50
Affinity	AZ3	BALD	Ivel	2.2	2.2	3.2
Affinity	AZ3	BOWR	Ivel	0.0	3.6	3.6
Affinity	AZ3	EAGL	Cam	0.0	0.9	0.9
Affinity	AZ3	FULL	Ivel	2.7	2.7	3.7
Affinity	AZ3	LOND	Cam	0.0	0.9	0.9
Affinity	AZ3	OFFL	Hiz	0.0	0.0	0.0
Affinity	AZ3	OUGH	Hiz	0.0	0.0	3.8
Affinity	AZ3	TEMP	Hiz	3.1	3.1	4.1
Affinity	AZ3	WELL	Hiz	0.0	0.0	0.9
Affinity	AZ3	WYMO	Hiz	0.0	0.0	1.1
Affinity	AZ5	DEBD	Cam	3.1	3.1	3.1
Affinity	AZ5	NEWP	Cam	0.0	0.9	0.9
Affinity	AZ5	UTTL	Cam	6.0	6.0	6.0
Affinity	AZ5	WEND	Cam	0.0	2.3	2.3
			Sub-total	**17.1**	**25.7**	**34.5**

Table B8 - Planned Affinity Water abstraction reductions in the upper Ouse catchments

These reductions are broadly in line with reducing abstraction in these chalk catchments to 10% of average catchment recharge, as set out in the Defra funded report on Abstraction as a percentage of Recharge (A%R)[130]. The planned 10.5 Ml/d abstraction reductions for the Ivel catchment are slightly less than the reductions proposed in a recent report, based on A10%R[131].

Therefore, GARD supports the need for Affinity Water's planned reductions in the Upper Ouse chalk catchments.

Flow recovery from Affinity Water abstraction reductions

The amount and timing of chalk stream flow recovery from abstraction reductions is crucial to avoid excessive cost and long delays in flow re-naturalisation. If the amount of recovery is high and a good proportion of extra water from the chalk catchments is available to refill the existing downstream reservoirs in droughts, there will be comparatively little additional water resource development needed. This would allow flows in the Chilterns chalk streams to be re-naturalised within a few years and at relatively low cost.

Affinity Water's plan assumes that only 17% of the flow recovery from abstraction reductions converts to increased deployable output from the London reservoirs[132].Consequently, the plan delays most of the environmental abstraction reductions until after 2040, because of the

[130] A%R, Abstraction as a % of recharge in chalk streams, December 2021 https://chalkstreams.org/ar-abstraction-as-a-of-recharge-in-chalk-streams/

[131]Alleviation of over-abstraction of chalk groundwater in the Upper River Ivel, John Lawson for RevIvel, June 2022 https://www.revivel.org/app/uploads/2022/07/Ivel-report-21.6.21-BHs-redacted.pdf

[132] Affinity WRMP24, Annex 5.6, page 13

supposed need to wait for replacement supplies from Abingdon reservoir, which cannot deliver water to Affinity Water's supply zones until after2040.

The Chalk Streams First report "Dealing with impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys"[133] examined in detail the evidence of measured flow recovery from abstraction reductions and the results of groundwater modelling. From reviews of measured flow recoveries, the conclusions were (with reference to the relevant pages in the CSF report):

1. Given sufficient time for flows to recover after genuine and maintained total abstraction reductions in a catchment, the measured flow gains will average about 80% of the abstraction reduction. The recovery will vary substantially across the range of flows, perhaps from less than 30% recovery in droughts to well over 100% recovery at times of high groundwater levels and flows (page 45).

2. This pattern of measured flow recovery is seen consistently in examples in several rivers:

   - The Friars Wash reduction in the River Ver in 1993 (pages 33 to 36)
   - Comparative flow and abstraction changes in the Rivers Chess and Ver (pages 37 to 39)
   - Comparative flow and abstraction changes in the Rivers Beane and Rib (pages 39 to 41)

3. There are no instances of flow recoveries failing to materialise when they might reasonably be expected after genuine and maintained abstraction reductions – several examples of supposed "disappointing" flow recoveries can be explained by the reductions being too small or insufficiently maintained:

   - The Bow Bridge reduction on the River Ver (pages 36 to 37)
   - The Fulling Mill reduction on the River Mimram (pages 42 to 43)

4. Short term signal tests are not a reliable way of assessing flow gains from abstraction reductions in these rivers:

   - Signal tests at Kensworth Lynch on the River Ver (pages 108 to 109)
   - Signal tests at Chesham on the River Chess (pages 197 to 201)

The CSF report reviewed modelled flow recoveries shown by the Environment Agency's Herts Regional Groundwater Model and its own lumped parameter models. These models all validate reasonably well when comparing modelled and measured historic groundwater levels and river flows (details in Appendices A to D in CSF report). As described in Chapter 4 of the CSF report, pages 46 to 52), both models show very similar patterns and amounts of flow recovery from abstraction reductions:

[133] Dealing with the impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys, Chalk Streams First, January 2023 https://chalkstreams.org/flow-recovery-following-abstraction-reduction/

1. The patterns and amounts of modelled flow recoveries are similar to the measured flow recoveries described above.

2. At average river flows, modelled river flow recoveries are in the region of 80% of the abstraction reductions. At extreme low flows, modelled flow recoveries are typically around 30-40% of abstraction reductions.

3. These conclusions are equally true in all four case study rivers (Chess, Ver, Mimram and Beane).

The modelled and measured flow recoveries are similar. They are far more than the 17% flow recovery assumed in Affinity Water's WRMP and in the draft regional plan of Water Resources in the South East.

Similar conclusions were reached in the RevIvel report on over-abstraction in the River Ivel[134]. If present abstraction of about 13 Ml/d abstraction was to stop, the modelling showed that flows in the River Ouse would rise by about 11 Ml/d on average (85% recovery) and about 6 Ml/d (45% recovery) in droughts. The increased flows in the River Ouse would boost inflows to Grafham reservoir, which could then provide replacement supplies to the areas currently fed from the River Ivel.

Benefits to downstream supplies from Affinity Water's proposed reductions

The Chalk Streams First Report, page 60, shows modelled flow recoveries from the total 151 Ml/d of CSF proposed abstraction reductions shown in Table 2. The modelled daily Colne and Lea flow recoveries since 1920 have been added to the Teddington and Feildes Weir flow records to assess the increase in London deployable output, using the GARD model of the London supply system. Details of GARD's London supply model are given in Appendix F to the CSF report. In the 100-year period 1920-2019, with the enhanced reservoir inflows, the critical drought which governs London deployable output is July 1933 to November 1934 as shown in Figure B6:

[134] Alleviation of over-abstraction of chalk groundwater in the Upper River Ivel, page 41 https://www.revivel.org/app/uploads/2022/07/Ivel-report-21.6.21-BHs-redacted.pdf

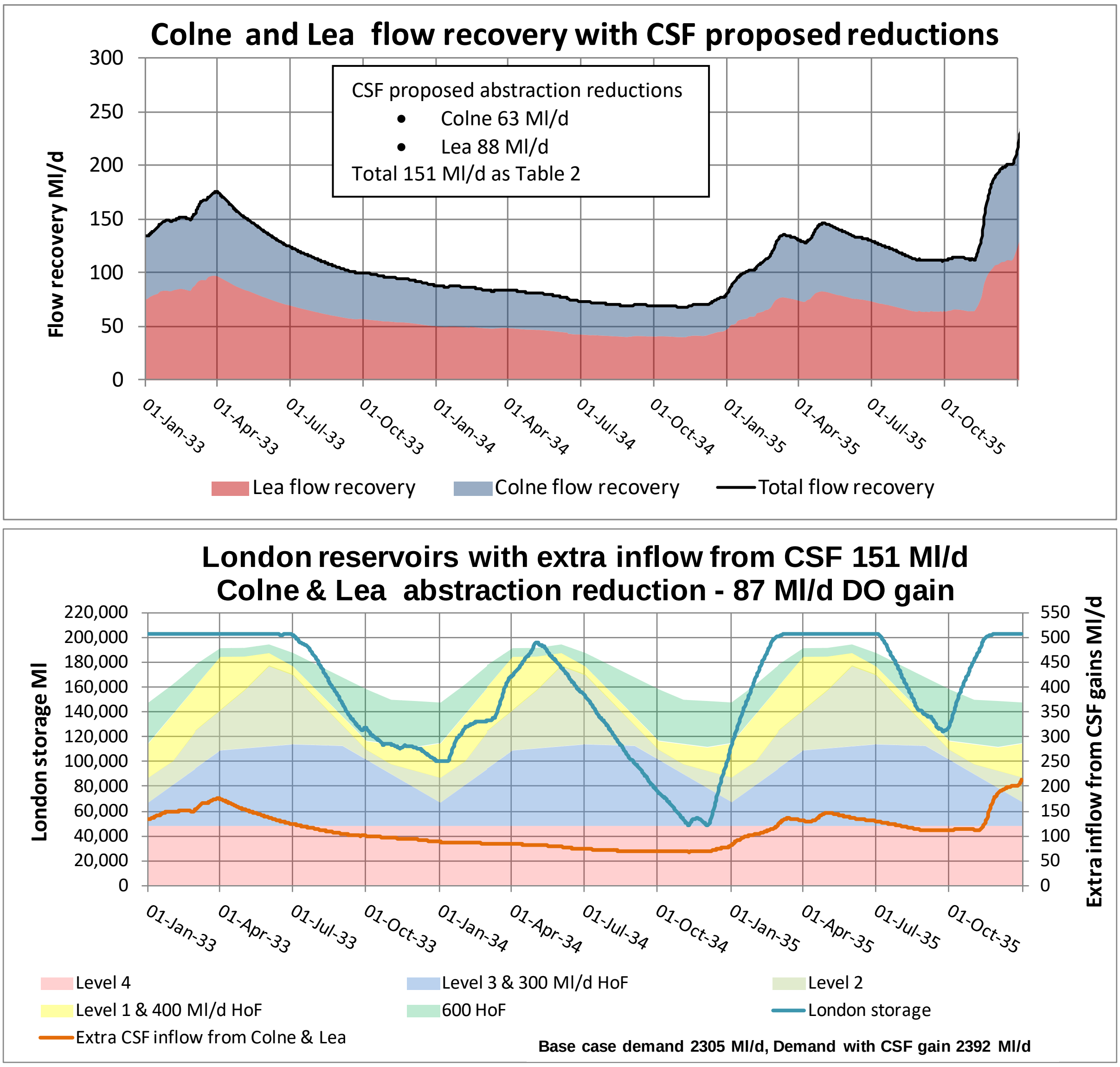


Figure B6 - Modelling of London DO gain from CSF proposed reductions in 1933-34

The modelled flow recovery in the 18-month drought starts at over 80% of the 151 Ml/d abstraction reduction at the start of the drawdown of the London reservoirs in July 1933. The modelled flow recovery percentage drops to around 40% when London storage starts to recover in November 1933. The modelled 87 Ml/d gain in deployable output is 58% of the 151 Ml/d abstraction reduction – a far higher gain than the 17% assumed in current draft water company WRMPs.

A similar analysis was carried out for the RevIvel report on alleviating over-abstraction in the River Ivel, concluding that for Grafham reservoir there would be average 64% recovery of the abstraction reduction over the duration of the critical drought, which is also 1933/34[135].

It is concluded that when considering the amount of replacement sources needed for the planned abstraction reductions in the upper Colne, Lea and Ouse chalk streams, the

[135] RevIvel report on Ivel over-abstraction, pages 55-57

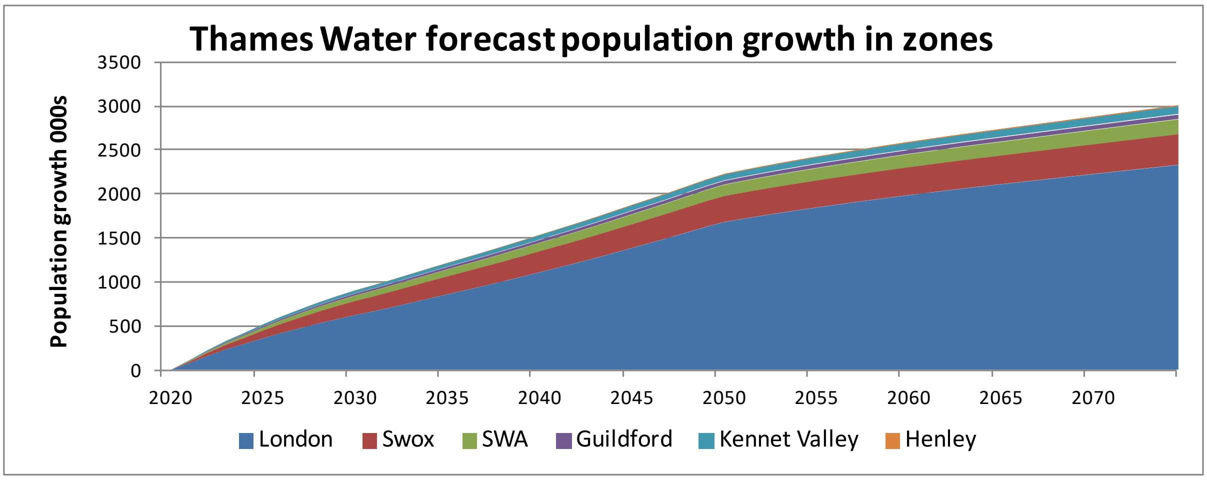
assumed deployable output recovery in the London reservoirs and in Grafham reservoir should be around 60% and not the 17% assumed in Affinity Water's plan. We recognise that the Grafham recovery would only apply to the planned abstraction reductions in the Rivers Ivel, Oughton and Hiz (see Table 3); the reductions in the Rivers Cam and Rhee do not affect flows at the intake to Grafham reservoir.

Appendix C – Evidence of over-forecasting of population growth

Thames Water's population growth forecasts[136]

For this section, paragraph numbers refer to Section 3 of Thames Water's main WRMP report – Demand.[137]

The population growth assumed in Thames Water's preferred plan is shown in Figure C1:



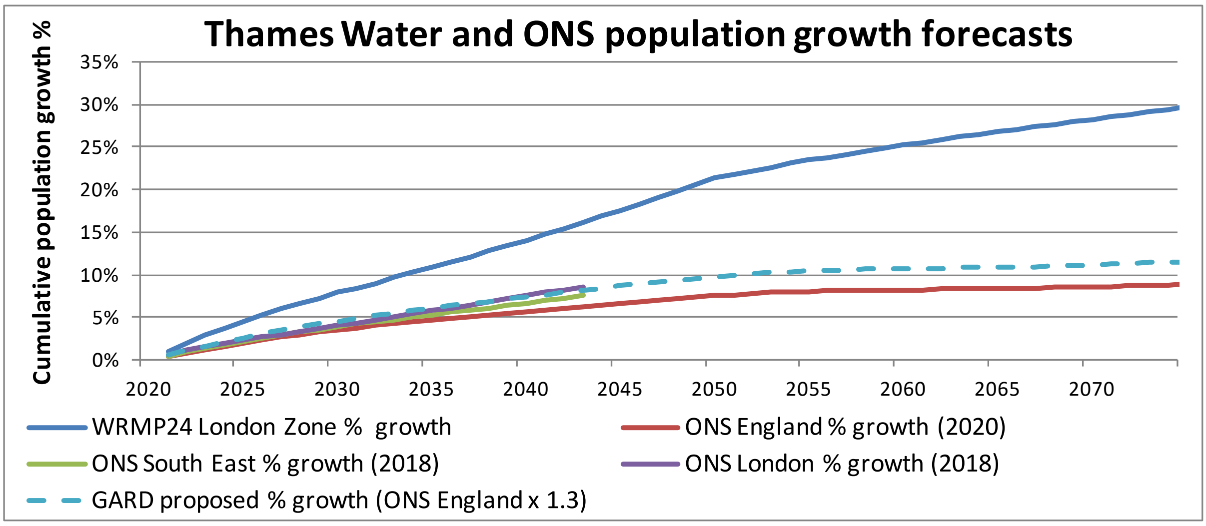


Figure C1 - Population growth assumed in TW's preferred plan

This shows population growth rates that are far in excess of ONS forecasts. Paragraph 3.78 notes that Section 6.3 of the WRPG states:

> *"Your planned property and population forecasts, and resulting supply, must not constrain planned growth. For companies supplying customers in England you should base your forecast population and property figures on local plans published by the local council or unitary authority."*

[136] Copied from Section 2.2 of GARD's response to the consultation on Thames Water's WRMP
[137] dWRMP24 Section3 - Demand, November 2022

This guideline is the root cause of much of the over-estimation of population in this and previous WRMPs. While noting that the guidance is clear that growth must not be constrained, the use of the word 'should' rather than 'must' in relation to using local plan data implies that this element is not mandatory. It should be perfectly possible to develop a model that will not constrain growth, takes account of local plans and that also takes account of, and includes, other factors. In previous discussions between GARD and Senior Ofwat staff, this approach has been outlined and not rejected.

In short, the water companies are free to propose alternate methodologies, provided they are backed up by data. Discussion with TW personnel at recent public meetings indicate that the problem with using local plan data is well known and well understood, yet is always accompanied with a statement that '*we have no choice*'. It seems odd that water companies are happy to challenge or ignore targets for pcc, leakage, sewage disposal etc, yet don't challenge and propose alternatives to a demand methodology that forces short to medium term decision making that will over-provide by up to 60%. Even worse, most local plan data are still based on ONS 2014 projections - data that has been revised downwards on each ONS update in 2016, 2018 and 2020 and are thus no longer credible.

For example, GARD and others have long argued, with evidence, that historically less than 50% of planned development is achieved. It makes more sense at the strategic level, therefore, to use a central (ONS) projection, when planning for the overall future supply requirement. As ONS note, their figures are produced for exactly this sort of purpose and are widely used in other sectors for public planning (including water in Wales). The local plans could then be used at the operational level to determine hot spots and potential pinch points, thus efficiently targeting any increases in supply that the strategic level planning has provided.

Given the propensity for Thames Water to repeatedly use high, or even worst case, estimates in its calculations (population, pcc, leakage etc), we would argue that headroom is already built in throughout the modelling. However, in the case of population, a useful discussion could be held between TW, the regulators and key stakeholders to agree any headroom element that should be applied to this part of the model. Somewhere between 10% and 20% would seem reasonable and should calm any concerns over using modified local plan data.

A change of approach such as this would allow consultancy effort to be directed to do more of its work to provide a 'most likely' outcome - a much more useful figure and around which a sensible debate could be held. There is no such discussion that can be held over the local plan data, as it is already hard against the stops of the highest worst case. When the worst case is the basis for the plan, it's hard to see how that can result in an adaptive plan as it simply directs that everything is built as quickly as possible, regardless of the real-world situation.

A central projection would allow a truly adaptive plan to be created with plans in place to produce incremental increases or decreases in supply over time, as the situation develops. The result: a more realistic (and believable) adaptive plan that didn't rely on starting to build the largest infrastructure programme (Abingdon Reservoir) immediately, thus removing any adaptability for the first 10 years of the planning period.

At para 3.104, 3 long term growth scenarios for the period 2050-2100 are presented based on low, principal and high ONS 2018 figures. We would make the following suggested changes/observations:

- The figures should be updated using ONS 2020 England data as soon as practicable. Given that UK interim 2020 based figures were published on 12 Jan 2022 and England interim 2020 on 27 Jan 2023, it is hard to see why this plan is still using data that is 5 years out of date. Use of 2020 data would highlight even more clearly, how unrealistic the local plan data is.
- Applying ONS long-term growth rates to 2050-local-plan-derived data simply continues to compound the errors introduced by using the unrealistic figures up to 2050. As an example, if using the local plan data has produced a figure that is 1 million too high in 2050, then applying a 3% (as an indicative figure only) growth rate would produce an extra non-existent 30,000 people in the first year with this error being compounded each year for the next 50 years.
- Population forecasts over the next century are being consistently downgraded in most advanced countries such as the UK. The last 3 updates to ONS have each significantly reduced expected growth. With this in mind, and with the uncertainties over how low growth will fall to, it seems pointless producing 3 long term scenarios – particularly as there doesn't seem to be any attention paid in the adaptive plan to alternative outcomes. Instead, just one principal projection, updated with each ONS update would be adequate for use beyond 2050.
- Most population experts agree that the UK population will start to fall at some point around the middle of the century. This has already happened in Italy, and Germany is thought to have peaked this year and will slowly decline from now on. The FT reported[138] that UK natural population will start to decline by 2025 and after that, any increase will be solely due to migration. The latest ONS 2020 interim principal projection indicates that, for the UK, deaths will exceed births by 2025 with a slowly increasing population due to migration until it is effectively steady from 2050, with minimal change. By 2060, growth is around 0.1%/year. None of this seems to be adequately reflected in the TW long term plan. Ignoring this means that a reservoir completed by 2040 will be a white elephant within 20 years.

[138] FT, UK natural population set to start to decline by 2025, Jan 12 2022

Using the TW WRMP baseline planning assumption of a 2020 starting population of 10,112,000 and applying ONS 2020 England growth levels, produces the population figures shown in Table C1 below (note that 2090 figures are not included). Previously, TW have argued that the South East region has higher growth rates than the rest of England, but the latest ONS projections shows this is no longer the case. The figures in the table use average England growth rates, but when sub-regional figures are released, they would be expected to be slightly lower than shown.

all in millions	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2100**
ONS 2020 Growth (Baseline 10.1)	10.6	10.9	11.1	11.3	11.4	11.6	11.8
TW Forecast (Baseline 10.1)	11.0	11.7	12.3	12.7	13	13.3	13.7
ONS 2020 Cumulative Increase from 2020	0.5	0.8	1.0	1.2	1.3	1.5	1.8
TW Plan Cumulative Increase from 2020	0.9	1.6	2.2	2.6	2.9	3.2	3.6
Difference between TW and ONS 2020	**0.4**	**0.8**	**1.2**	**1.4**	**1.6**	**1.7**	**1.8**

Table C1 - Population growth from 2020: Thames Water vs ONS 2020 figures

The effect of using over-inflated local plan figures is clearly illustrated. At each 10 year point up to 2050, the assumed growth is more than twice the ONS projection at the same point. From 2050, the ONS projection is for around an extra 100,000 people per decade, whereas the TW projection is around 300,000, due mainly to the compounding effect of starting with an inflated 2050 local plan figure as described earlier and then using outdated 2018 figures. This shows that, although the WRMP states that ONS growth levels are used after 2050, the figures generated for each decade are between 2 and 3 times the latest ONS projection. This means that the statement at para 3.111 that '*we revert to ONS based forecasts*' is simply incorrect. Similarly, the statement at para 3.112 that the ONS forecasts predict a population growth of 22% by 2100 is incorrect. The ONS 2020 England figures project a growth between 2020 and 2100 of only 17%.

Further comments on Section 3 of the WRMP include:

- The plan derived growth in the last 20 years of the century makes little sense, as the ONS projection is for flat or negative growth rates from 2080.
- The statement at para 3.111 that the local authority plan-based and ONS18 forecasts provide a good representation of upper and lower forecasts is completely incorrect. The subsequent discussion appears to use ONS 18 principal projection figures and so the figures presented represent the upper and median scenarios only. For example, para 3.112 quotes local plan and ONS figures as if they were the upper and lower forecasts referred to above. While an unspecified 'min scenario' line is shown on the graphs at Figure 3-7, they are not mentioned or discussed in the analysis.

- This is further illustrated at para 3.114 and the accompanying Figure 3-8 where just plan-based and ONS principal projection (now just called ONS Projection) are clearly presented as if they were the upper and lower boundaries of forecasts. If it is valid to consider high scenarios and incorporate them into an adaptive plan, why is it not equally valid to treat low scenarios in the same way (or at least present an argument for not doing so). The adaptive plan eventually presented, being based on the local planning figures, takes no account of even a most likely out-turn, yet alone a low projection. This makes all of the discussion on population in Section 3 rather pointless.

Inspection of para 3.115 and associated Tables 3-12 and 3-13 strongly supports the argument that the plan-based figures should be considered unusable, with the SWOX, SWA, Kennet Valley and Guildford figures clearly vastly inflated with unrealistic growth rates. The SWOX figure in particular looks to be an outlier. Using the ONS 2020 growth rates, the SWOX growth figure is more likely to be around 17% up to 2100 rather than the 40% used in the plan. Using a starting figure of 1,069,000 in 2020 would result in growth to only 1,159,900 by 2050 and 1,250,700 by 2100, a reduction of 209,000 and 243,000 respectively on the WRMP plan. These figures correlate strongly with the slight reduction between ONS 2018 and 2020 updates, and the figures presented at Table 3-13. If TW disagree with this, they should present evidence as to why this area will outgrow the rest of England by more than 100% over the rest of the century.

The debate on OxCam is largely pointless. Regardless of the rhetoric, the outcome will be a balance between political ambition and real-world practicality and affordability. Given the recent decision to delay elements of HS2 by 2 years due to cost, it is unlikely that anything significant will happen in terms of OxCam in the next decade. Supply planning with regard to OxCam should therefore be delayed until at least the next WRMP round.

The 2020 ONS England projection indicates that the TW WRMP population figures are too high by 1.2 million by 2050 and 1.8 million by 2100, as shown in our earlier Table C1. This shows that the TW figures are not fit for purpose. The entire section on population should be revisited. In the meantime, we think it would be reasonable to make a central planning assumption for population growth as for the ONS 2020 forecast for England, with an added 30% increase in the growth rate as a safety factor.

***Affinity Water's population growth forecasts*[139]**

In summary:

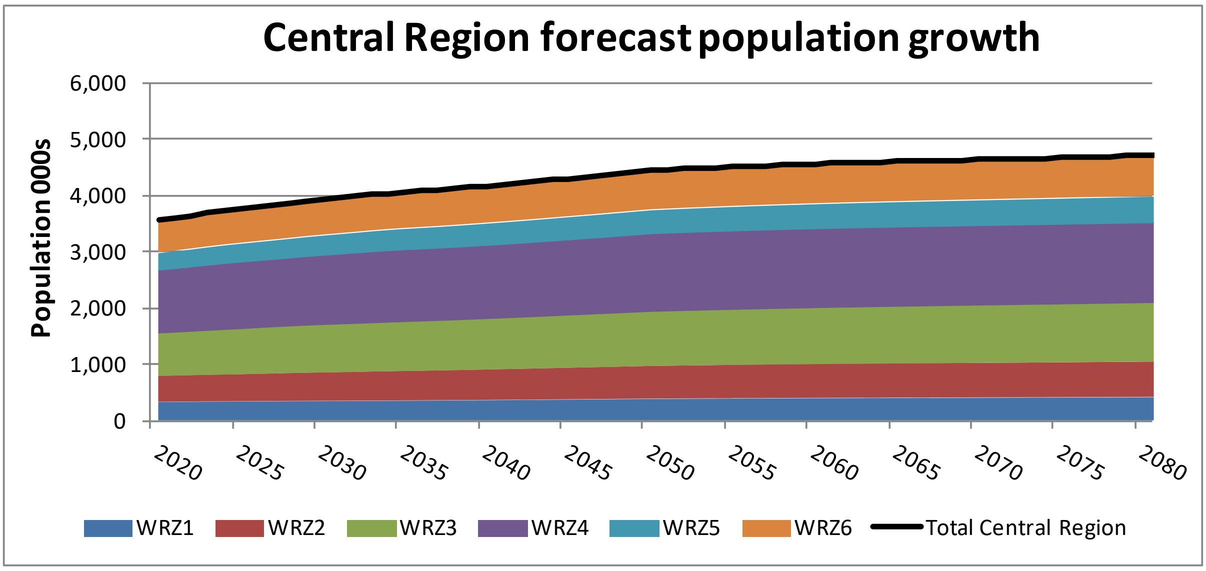
- GARD believes the population methodology used in Affinity Water's WRMP is not fit for purpose

[139] Copied from Section 2.2 of GARD's response to Affinity Water's WRMP consultation

- GARD has proposed a simple methodology that complies with the need in the WRPG to use local planning data modified by other projection data that would be simpler, easier and more widely acceptable to stakeholders

- Our calculations show that the Affinity Water population estimates may be over-stated by 632,000 by 2050 and 742,000 by 2080. At the baseline PCC of about 150 l/head/day, that is equivalent to an over-forecast of the baseline deficit by 95 Ml/d in 2040 and 111 Ml/d by 2080.

Affinity Water's forecast population growth up to 2080 in the six Central Region zones is shown at Figure C2:



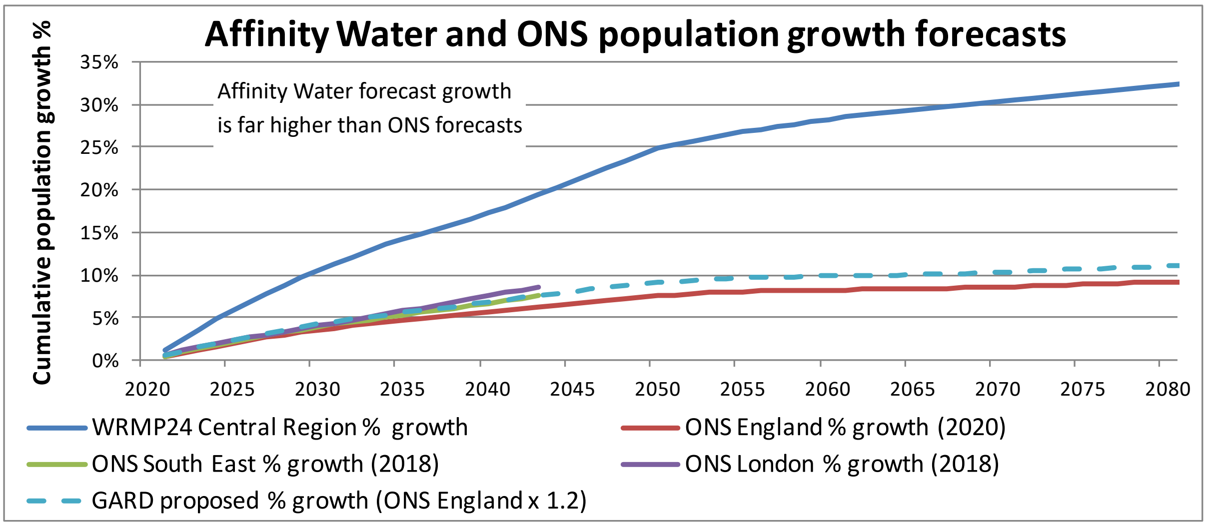
Data from Affinity Water WRMP tables

Figure C2 - Affinity Water forecast population growth in Central Region

Affinity Water's forecast rate of population growth is far higher than Office of National Statistics population growth forecasts for England[140] and for the South East and London regions[141], as shown in Figure C3:

[140] ONS population forecast for England in 2020
https://www.ons.gov.uk/file?uri=/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/z3zippedpopulationprojectionsdatafilesengland/2020basedinterim/enpppopendata2020.xls

[141] ONS regional population forecasts in 2018
https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/regionsinenglandtable1



Note: ONS regional forecasts are only available to 2043

Figure C3 - Comparison of Affinity Water and ONS population growth forecasts

The WRMP 24 Central Region % growth line is obviously and demonstrably unrealistic. The marked reduction in growth rate that occurs at around 2050 shows the perennial problem with water company population projections. The period up until 2050 represents a forecast based mostly on local area plans and CPRE and others have shown that, often, only 40% or less of any proposed development is delivered. Hence there is an alarming disparity between the WRMP Central projection and the ONS projections.

Worse, even though the projection reverts to ONS rates of growth after the end of local area plans, these rates of growth are applied to the already greatly inflated figures assumed from the local plans. Presumably this is the reason for the Central projection continuing to diverge from the ONS projection, even though, logically, it should mirror it.

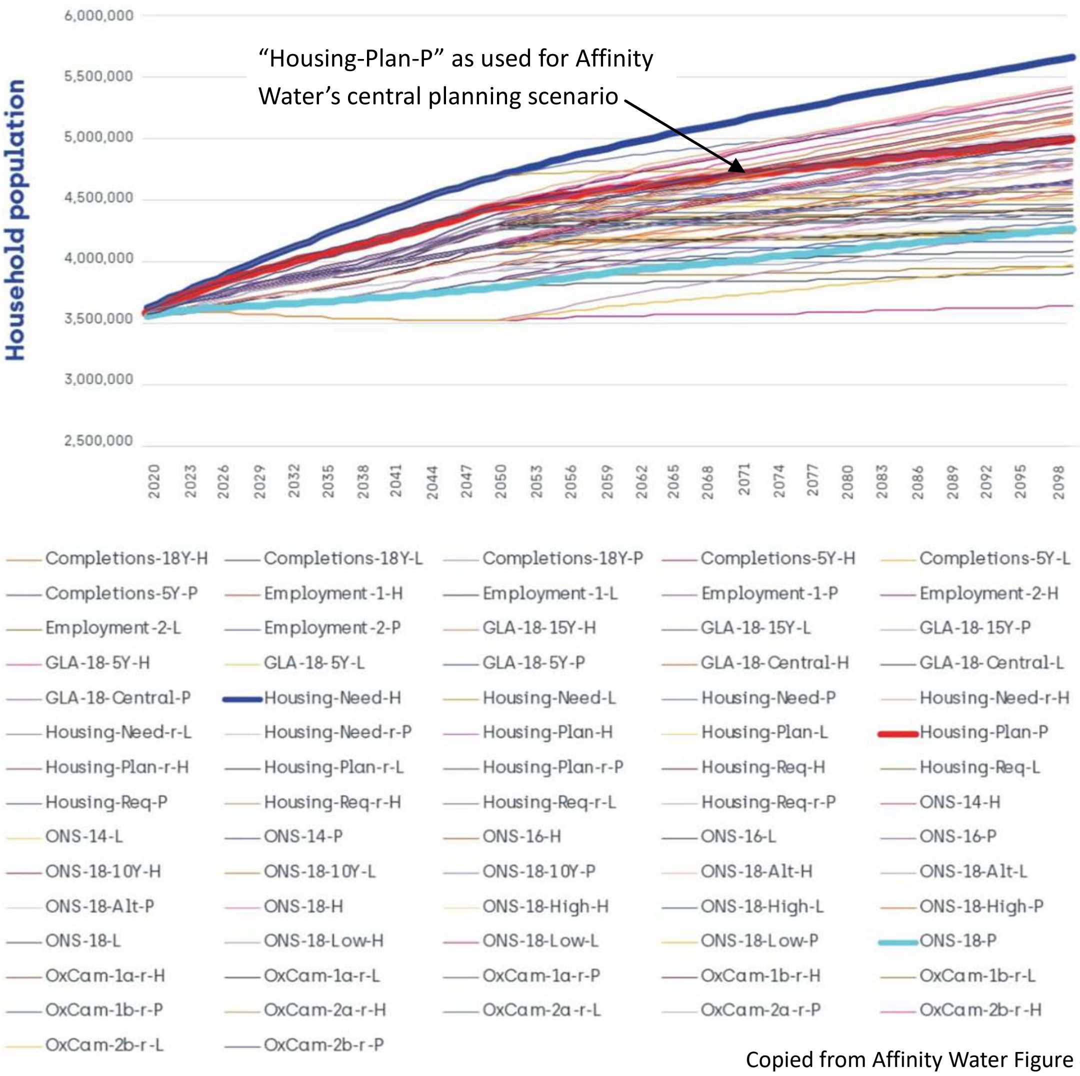
Previously, South East water companies and WRSE have argued that the South East is a special case and that growth in the region is greater than in the rest of England. This argument is not supported by the ONS sub-national population projections for England.[142] These show a growth projection across the regions of England between 2018 and 2028 of between 2.3% and 7%, with an average of 5%. The projection for the South East is 4.4% and for London 4.9%; both are below the average.

Using the projected England growth rate, a Central Region 2020 starting point of 3.6 million from Figure C3 above would, at ONS growth rates, become 3.87 million in 2050 and 4.06 million in 2080. This would mean that the respective Affinity figures were too high by 632,000 and 742,000 respectively. Our calculation uses ONS calculated rates to 2045, by which time annual growth has fallen to 0.16%, which is applied through to 2080.

[142] Table 1: Projected population change for English regions, mid-2018 and mid-2028, ONS Subnational population projections for England: 2018 based, Published 24th March 2020

In fact, growth rates are expected to be even lower than used here. In the 2020-based Principal Projection - England,[143] which covers out to 2120, the growth rate falls to 0.1% by 2051 and continues to fall to around 0.04% by 2057, before finally becoming negative by the end of the century. The BBC has reported that latest studies now expect the UK population to peak in 2063 and fall thereafter.[144] Worldwide estimates of when different countries will move from positive to negative population growth are being constantly revised forward. The implications of a steady or falling UK population, as raised by leading statisticians and analysts, are profound, but are not even mentioned yet alone addressed in this plan.

In fact, the general analysis carried out by Affinity on its population projection can only be described as naïve and simplistic. The Affinity Water makes much at paragraphs 4.49 - 4.51 and Figure 4.8 of the development of 72 different projections for each WRZ, as below:



Copied from Affinity Water Figure 4.8

Figure C4 - Affinity Water's 72 population growth scenarios

[143] 2020-based Interim National Population Projections, England, Principal, published 12th January 2022
[144] https://www.bbc.co.uk/news/health-53409521, accessed 12 Feb 2023

Affinity Water note in paragraph 4.51 that it would not be plausible to model these scenarios through the regional models, so what is the purpose of showing all these scenarios? It is impossible from the Figure to tell which is which. Would it have been too difficult to provide the list below plot in the order in which they appear? Simply layering 72 scenarios onto an unreadable graph before dismissing 71 of them does not constitute analysis. No attempt is made to discuss the implications of choosing this particular projection in terms of how it relates to the other projections listed, or why they differ by so much. In which case, why was this work carried out? Is it simply to make it look as if some attempt has been made at analysis?

A much more credible approach would have been to develop a principal, high and low projection for each WRZ. These could then have been modelled within the resources available, providing useful data that could be compared with local housing and ONS projections. Regardless, this is immaterial as at para 4.52 it is made clear that the decision was made to use local plan data simply because that is the guidance contained in the WRPG. This implies that, in the extreme, if the local plan derived projection had been a complete outlier (either above or below all the others) it would still have been chosen without question. It would have been far more honest, and saved time and resource, to simply state this at the start of the population section.

Para 4.52 is particularly disingenuous in implying that the adaptive plan will be responsive to actual outcomes that reflect the lower projections. By choosing to develop its largest infrastructure project, the Abingdon Reservoir, at the start of the plan, future low growth outcomes can no longer be accommodated.

Whilst both Affinity Water and WRSE make much of the need to follow the WRPG and use local housing data, the rest of the guidance seems to have been ignored.

The WRPG[145] states that:

'You should consider an adaptive plan where there is a significant difference in projections, particularly where this might affect your investment decisions in the first half of your plan. You should ensure your plan does not lead to over-investment or constrain planned growth. You should set out how you have developed and used alternative scenarios in your plan and the impact they have had on your plan.'

(GARD highlighting)

The guidance has a clear requirement for the Affinity Water plan to consider alternative projections where this might affect early investment decisions. By adopting a single projection, at the higher end of forecasts, Affinity has not followed this guidance.

By pursuing an inflated population projection and failing to develop a 'most likely'

[145] Water Resources Planning Guideline Version 10, Environment Agency, Ofwat, Natural Resources Wales.

population projection, or even a 'mean of different projections', both of which would be considerably below the chosen projection, Affinity Water has failed in its duty to ensure that their plan does not lead to over investment.

The WRPG further states that water companies should:

- *demonstrate how you have included other information sources and amended your forecast accordingly*
- *demonstrate that you understand the uncertainty associated with your forecasts and how you will manage it*
- *If you are using a planning period beyond 25 years and are basing decisions on this forecast, you should explain the range of uncertainties this long-range forecast will have. You should explain in your plan how you will manage this uncertainty.*

To deal with each requirement in turn:

There is no evidence that other information sources have been used to amend Affinity Water's chosen projection. Para 4.52 couldn't be clearer in stating that the adoption of the Housing-Plan-P as the central planning scenario is based on a certain understanding of the WRPG, rather than any analysis of the projections listed. Further, there is no analysis presented to show that Affinity Water have understood the uncertainty in their choice of projection. Many organisations besides GARD have raised this issue in previous consultations, so the company cannot claim to be unaware of the issue.

To discharge the wider duties imposed by the WRPG, it is incumbent on Affinity to demonstrate understanding of the uncertainty around its chosen projection and how this will be managed. It is hard to differentiate the different projections in Figure 4.8, but the central planning scenario, Housing Plan-P, appears to be the 17th highest out of 72 scenarios, with all projections above it being 'High' projections. Why is this not ringing alarm bells in the Affinity team and, indeed, at Ofwat/RAPID?

The third point is not addressed at all in the plan as presented. The imminent fall in population growth expected in the UK (2052)[146] and already experienced by many countries, including Germany (2022) and Italy (since 2017) is not even mentioned.

As such, GARD believes that the population calculations and assumptions as presented are unfit for purpose. Instead, we believe the following process would be simpler, more realistic and meet the needs of a wide range of stakeholders (including regulators).

1. The latest ONS Principal Projection should be used to determine expected overall population growth and used as the basis for strategic level planning of water provision.

[146] https://worldpopulationreview.com/countries/united-kingdom-population

2. Local housing plan data should be used to determine the location and timing of future ‘hotspots’, allowing the timing and development of infrastructure to be finessed at the operational level.

3. These first 2 steps comply with the requirement to use both local planning data AND other data and would resolve historical complaints about companies planning being based on over-inflated population projections. It would be easy to demonstrate compliance with the sometimes-conflicting guidance in the WRPG.

4. Agree a methodology for the development of single high and low variant projections, so that required investment and risk can be managed.

5. The data produced should be used in discussion with the regulators to agree what risk is acceptable and how it will be managed

    - This should result in an agreed headroom calculation to be applied to the output of Step 1. A 20% addition to the ONS 2020 growth forecast for England up to 2080 would seem reasonable. This growth is plotted on our Figure 6 and can be seen to align closely with the ONS regional forecasts for London and the South East.

    - The calculation would need an openly agreed debate and compromise between cost, customer value, shareholder value, environmental issues and risk. It is not acceptable for the regulator to make the water company responsible for this. The company has conflicting responsibilities to customers and shareholders. The regulator must take a more active part in this process.

    - This corrects the current system that forces companies to over provide while encouraging financial gaming of the ‘system’.

At the baseline PCC of about 150 l/head/day, GARD’s suggestion of using the ONS forecast growth for England plus 20% is equivalent to an Affinity over-forecast of the baseline deficit by 56 Ml/d in 2040 and 113 Ml/d by 2080.

Appendix D – Evidence of over-forecasting climate change allowance

Climate change allowances in Thames Water's preferred plan[147]

Thames Water's allowances in their preferred plan for loss of deployable output due to climate change are shown in Figure D1[148]:

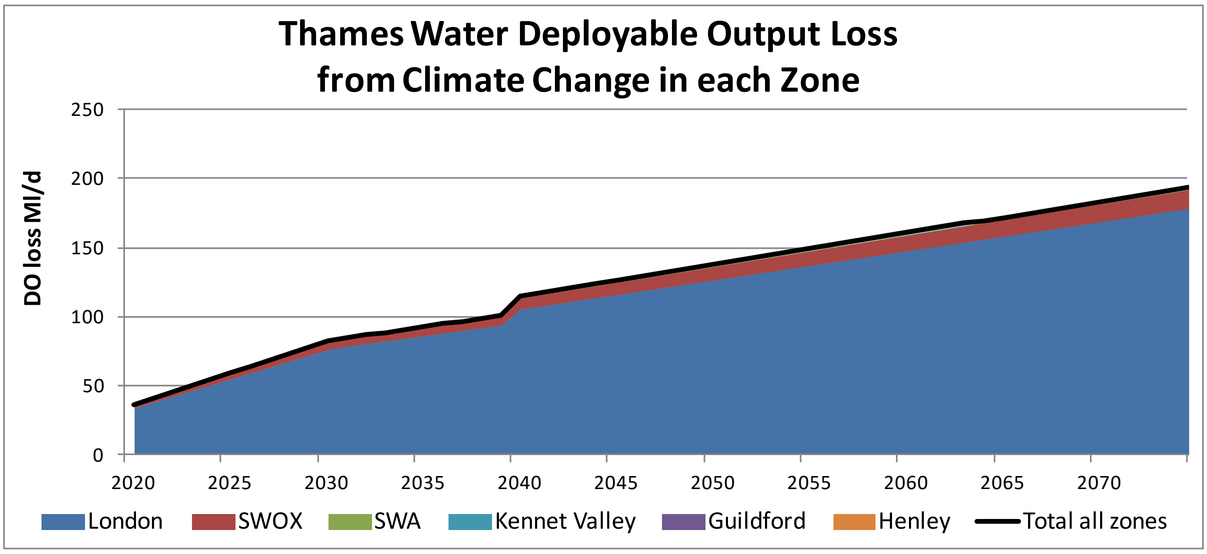


Figure D1 - Deployable output loss due to climate change in each zone

The preferred plan assumes the High scenario for climate change loss[149].

Figure D1 shows that that most of this loss is in Thames Water's London region, with smaller losses in SWOX zone. These are zones with surface water resources and reservoirs. Elsewhere, supplies are largely from groundwater from which deployable outputs are not expected to be significantly affected by climate change.

Evidence of historic climate change impacts on supplies

In GARD's opinion, London and SWOX climate change forecasts should recognise the evidence suggesting that climate change of the past 100 years has not adversely affected the deployable outputs of supplies in the South East to date. Indeed the evidence suggests that climate change to date (which GARD does not dispute) has increased the availability of water supplies for London. For example, we show below the minimum storages that would have occurred in London reservoirs since 1920, if operated at present day demand levels, together with a plot of the highest chalk groundwater level at Rockley in the spring of each year:

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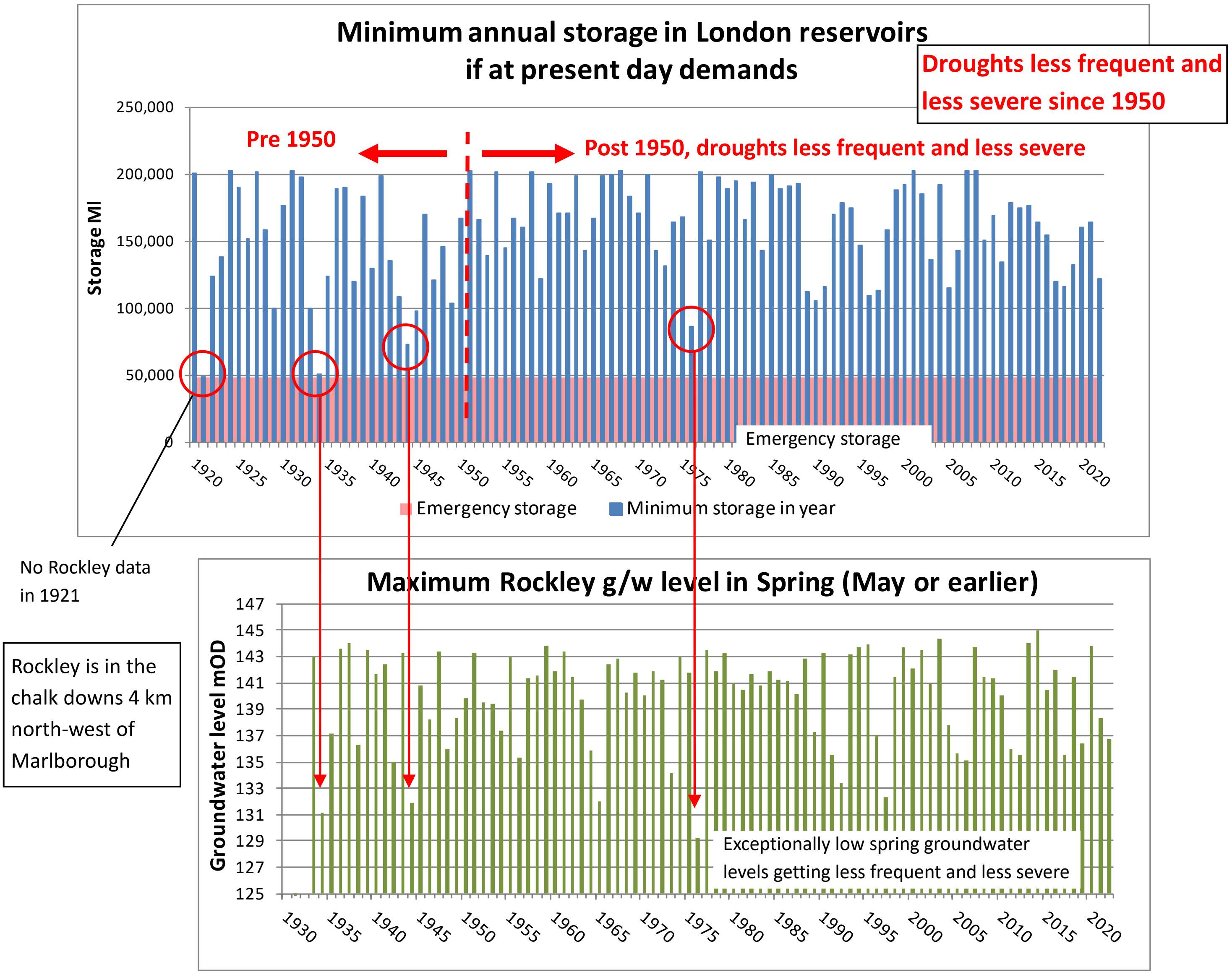
[147] Appendix C is copied from Section 2.4 of GARD's response to the consultation on Thames Water's WRMP
[148] Thames Water WRMP table, zonal supply demand balance worksheets
[149] Thames Water WRMP main report paragraphs 11.11 and 11.14



Note: Minimum London storages up to 2010 from WARMS2 modelling of 2305 Ml/d base case, using historic river flows from the actual climate since 1920. Post 2010 storages from CEH monthly hydrological summaries

Figure D2 - Minimum annual London storages and highest g/w levels in climate since 1920

The three most severe droughts of the past 100 years, in terms of impact on London's supplies, were in 1921, 1934 and 1944 – all were in the first 25 years of the past century. The most severe drought of the past 75 years, 1976, was appreciably less severe than the earlier droughts, in terms of impact on London's supplies. Droughts since 1976 have all had relatively little impact on London's supplies. Droughts of the type that would affect London's supplies, ie two summers and a winter, are getting less frequent and less severe.

The lower plot in Figure 10 shows the highest chalk groundwater level reached each year in spring at Rockley in the Marlborough downs. As can be seen comparing the upper and lower plots in Figure D2, the severe droughts affecting London's supplies are those where the chalk groundwater level is exceptionally low at the start of a summer drought. In those circumstances, the base flows in the lower Thames, which are needed to prevent rapid draw-down of the London reservoirs, become abnormally low. The critical period for London's reservoirs is two dry summers and an intervening dry winter. A combination of low groundwater levels in the spring, followed by a summer drought extending into the autumn is needed to create an exceptional drought for London's supplies.

A low chalk groundwater level in spring does not necessarily create a major drought for London's supplies – the preceding summer and the following summer and autumn need to be exceptionally dry as well. On the other hand, if the chalk groundwater level is not abnormally low in spring due to a dry winter, London's supplies are not tested, however severe the subsequent drought.

For example in 2018 –the Rockley groundwater level reached about 142 mOD in May, so the minimum storage in the London reservoirs up to the end of October was about 57%,[150] far above the emergency storage level, despite the severe summer drought which continued deep into the autumn. There was a similar picture in 2022, when minimum storage was 60% despite the severe drought.

The lower plot in Figure D2 shows that exceptionally low chalk groundwater levels in spring are becoming less frequent and less severe. This is consistent with the trend of increasing winter rainfall in England and Wales over the past 150 years shown in Figure D3[151]:

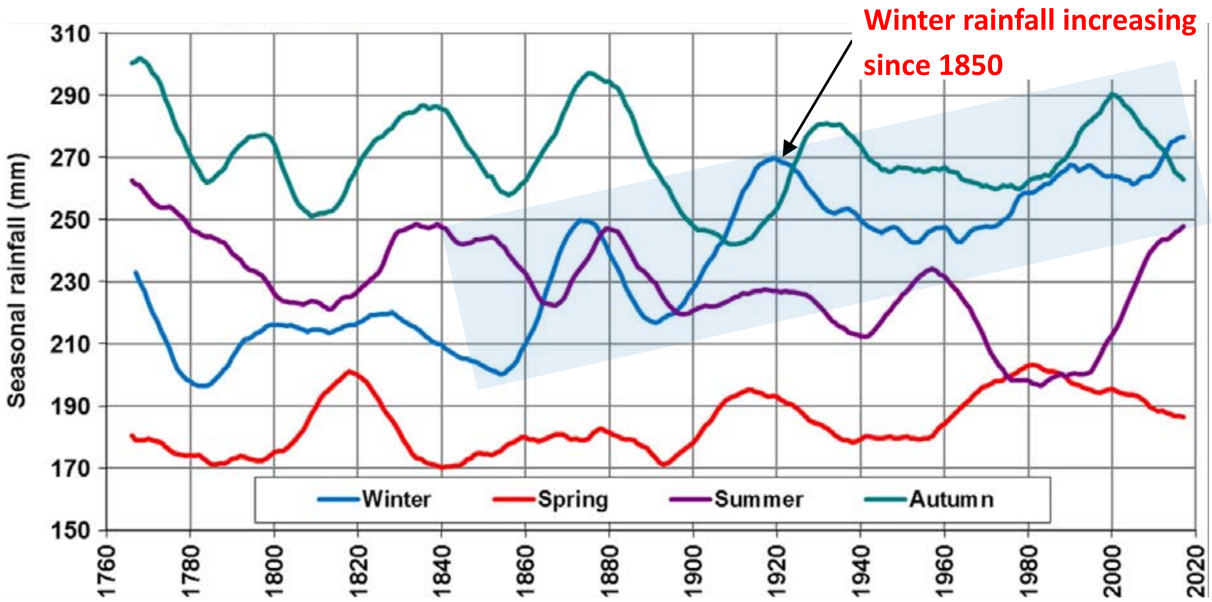


Figure D3 - Seasonal rainfall trends in England and Wales, since 1760

The increasing trend in winter rainfall improves the drought resilience of London's supplies, because the winter rain is stored in the chalk aquifer and released slowly through the summer. The falling trend in summer rainfall, as shown in Figure D3, has less of an impact on London's supplies, because most of the summer rain is absorbed by evapo-transpiration or

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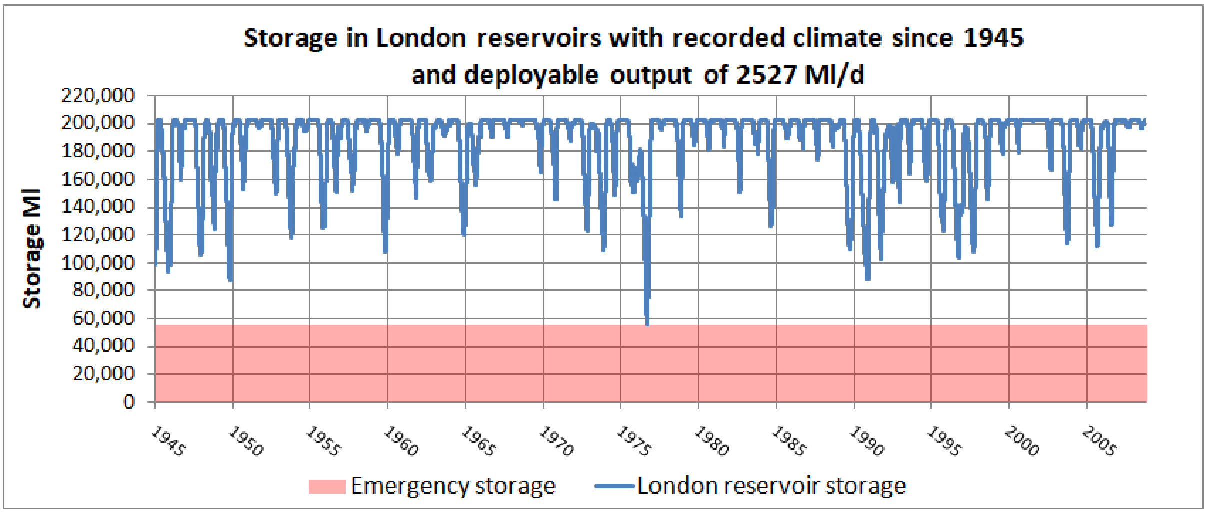
[150] Rockley groundwater levels and London storage from CEH monthly hydrological summary, October 2018
[151] State of the UK climate 2017, Volume: 38, Issue: S2, Pages: 1-35, First published: 30 July 2018, DOI: (10.1002/joc.5798. Royal Meteorological Society

slowly into the porous chalk strata that cover a large part of the Thames catchment. Figure D3 shows no evidence of a trend of reducing autumn rainfall that might extend summer droughts and threaten London's supplies.

If the deployable output of London's existing supplies is determined only using the 70 years of river flow records since the 1940s, it rises to 2527 Ml/d, 222 Ml/d more than Thames Water's present-day base case of 2305 Ml/d. The modelled drawdown of London's reservoirs supplying 2527Ml/d since 1945 is shown in Figure D4:



Note: Storages from GARD modelling of existing supply system. Emergency storage increased by 6810 Ml, giving 30 days extra for 227 Ml/d DO increase, as per TW policy

Figure D4 - London storage with existing supplies, DO 2527 Ml/d and climate since 1945

With the climate since the 1940s, London's supplies could have sustained a deployable out 227 Ml/d more than Thames Water's currently assumed deployable output of 2305 Ml/d.

The three most severe droughts of the past 100 years, in terms of impact on London's supplies, were in 1921, 1934 and 1944 – all were in the first 25 years of the past century. The most severe drought of the past 75 years, 1976, was appreciably less severe than the earlier droughts, in terms of impact on London's supplies. Droughts since 1976 have all had relatively little impact on London's supplies. For example the drought of 2022, storage in London's reservoirs never fell below 60% full[152].

Selection of climate change scenario for Thames Water's preferred plan

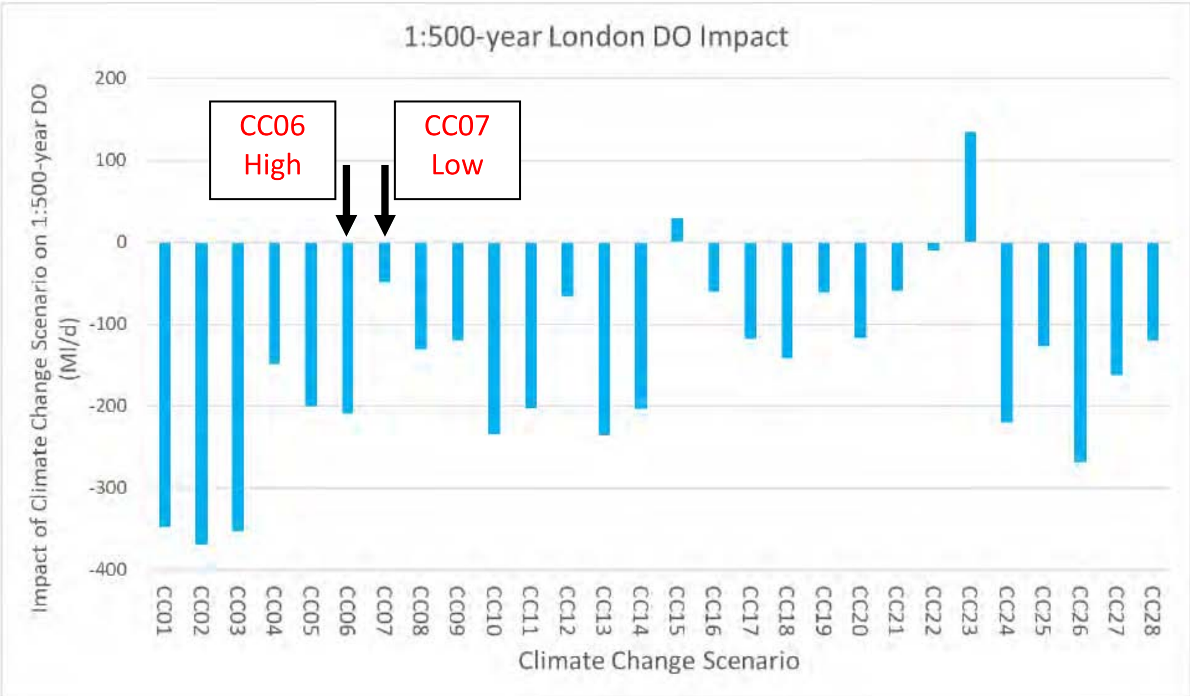
We think that Thames Water's climate change deployable output losses for London, including the allowance for 46 Ml/d loss of deployable output by 2023, have failed to recognise that severe reservoir depletion in summer droughts only occurs if chalk groundwater levels are exceptionally low in the previous spring; and that the groundwater levels in spring are dependent on winter rainfall, which appears to be increasing with climate change. We have made this point repeatedly in our response to previous Thames Water and

[152] CEH Monthly Hydrological Summary, October 2022

WRSE consultations. It is disappointing that no acknowledgement of the criticism was made in WRSE's response to the Emerging Plan consultation in May 2022. All WRSE's response says, presumably voicing Thames Water's opinion, in relation to widespread criticism of excessive deficit forecasts, including climate change allowances, is[153]:

> *"WRSE accepts that there are considerable uncertainties, particularly the further into the future the forecasts look. However, it considers that the forecasts produced and the scenarios that have been developed for the regional plan as a result are valid and robust representations of the range of futures that the South East could experience."*

The range of impacts on London's supplies from the climate change scenarios modelled by Thames Water is shown in Figure D5 [154]:



Note: DO (all CC scenarios are *variants* of the UKCP18 high RCP8.5 scenario)

Figure D5 - TW modelled impact of climate change scenarios on London

Thames Water has identified High and Low scenarios as follows[155]:

> *"Thames Water, aligned with the WRSE Regional Group, has considered a 'median' climate change scenario as the central forecast, and have considered the 6th and 7th (CC06 and CC07) of the 28 spatially coherent projections as 'High' and 'Low' climate change impact scenarios respectively."*

On that basis, Thames Water determined High, Medium and Low scenario impacts for each

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[153] WRSE response to consultation on emerging regional plan, May 2022, paragraph 5.11, page 14
[154] Thames Water WRMP main report Figure 4-6
[155] Thames Water WRMP main report paragraph 4.176

zone as below[156]:

	London	SWOX	SWA	Kennet Valley	Guildford	Henley
High Impact (Ml/d)	-168	-13	-0.4	-1.9	0	0
Medium Impact (Ml/d)	-110	-8	-0.2	-1.5	0	0
Low Impact (Ml/d)	-39	-5	-0.1	-1.1	0	0

Table D1 - TW estimates of climate change impacts in each zone

It is important to realise that the terms 'high' and 'low' applied to the CC06 and CC07 respectively in Figure D5 apply to ***variants of the 'high' UKCP18 climate change scenario RCP8.5*** taken from a special 'spatially coherent dataset' released by the Met Office.[157] Thus the lower climate change scenario is not used, because no spatially coherent version is available for it.[158] Ofwat guidance[159] is that both high ('severe' or 'business as usual') scenarios such as UKCP18 RCP8.5, and low ('benign') scenarios such as RCP2.6, should be considered equally in the planning. Unfortunately, as Thames Water observe, regarding Environment Agency guidance:[160]

> "*Although the guidance sets out a number of points on data and methods, it does not set out specific instruction regarding the following:*
>
> - *Which emissions scenario(s) should be the basis of the 'main' supply forecast, and which emissions scenario(s) should be considered in uncertainty analyses*
> - *How to appropriately combine the requirement to determine a '1 in 500-year' DO with the requirement to assess the impact of climate change on DO."*

Each of the future scenarios has a probability spread, and the Ofwat recommendation is to take the 50th percentile for each. Thames analysis shows[161] that the different UKCP18 scenarios actually make very little difference to the 1 in 500 year DO deficit by 2070. The scenarios clustering between 140 Ml/d and 160 Ml/d. Thames use the lack of availability of '*spatially coherent projections'* of RCP2.6 (*'at the time of assessment'*) to concentrate on the high scenario RCP8.5. This has spatially coherent dataset, on which Thames Water place great emphasis. The so-called 'RCP8.5 GCM' dataset does yield a much higher 1 in 500 year DO deficit (289 Ml/d at 2070). Thames speculate, without any evidence, that this dataset might be more accurate than using the 'probabilistic' versions of RCP8.5 and RCP2.6. There is no back-up for this in the Met Office guide, and Thames's assertion that the spatially

[156] Thames Water WRMP Table 4
[157] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---how-to-use-the-land-projections.pdf
[158] Ibid, page 6.
[159] Ofwat, 2022, PR24 and beyond: Final guidance on long-term delivery strategies, https://www.ofwat.gov.uk/wp-content/uploads/2022/04/PR24-and-beyond-Final-guidance-on-long-term-delivery-strategies_Pr24.pdf
[160] Thames Water dWRMP24 section 4, para 4.141, page 33.
[161] Ibid fig 4.8, page 39.

coherent dataset might be more accurate[162]:

"The spatially coherent projections, however, include projections from the newest iteration of the Hadley model, while the probabilistic projections include projections from the previous iteration of the Hadley model. It may be that the newer iteration is more reliable."

This is somewhat at variance, with the Met Office's own statement[163]:

"*The probabilistic projections typically show broader ranges of outcomes than the global and regional projections. This enables assessments across a larger set of climate futures than relying on a small set of future outcomes, e.g. only using the climate models from the Climate Model Intercomparison Project (CMIP5) that fed into the 5th Assessment Report from the Intergovernmental Panel on Climate Change*".[note the CMIP5 scenarios form 13 of the 28 scenario versions of RCP8.5 shown in Figure D5]

It remains unclear as to why these spatially coherent data are used by Thames Water, as it seems that, from their own figures, the spread of DO effects between the 25th and 75th quartiles of each of the RCP2.6 and RCP8.5 scenarios, which are of order 160-200 Ml/d, is much higher than the difference between the RCP2.6 and RCP8.5 median projections (20 Ml/d as indicated above). The combination of the two probabilistic scenarios could have clearly been achieved, with some valid Monte Carlo randomisation to obtain a median value, without any delving into other datasets (or more accurately 2 separate datasets, as the CC01-15 and CC16-28 are taken from two separate model runs , which should really not, as Thames Water have done, be randomised together[164].)

In GARD's opinion, the 'Low' climate change impact scenario shown in Table 8 is much more likely than the 'High' scenario, based on the historic evidence. We can see no justification for the 'High' climate change scenario being the central planning assumption for the climate change allowance in the preferred plan. We propose that it would be reasonable (ie reasonably cautious) to assume the 'Medium' scenario as the central planning assumption, with an allowance of about 110 Ml/d loss of London deployable output by 2075 and 8 Ml/d loss for SWOX zone.

The preferred plan assumes that the deployable output of London supplies has already been reduced by 46 Ml/d in 2023. In our opinion, this defies the evidence set out in earlier that there has to date been no adverse impact of climate change on London's supplies and, probably, a significant increase in deployable output. Therefore, we propose that the

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[162] Thames Water dWRMP main document, section 4, para 4.168.

[163] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---how-to-use-the-land-projections.pdf - page 5.

[164] To quote the Met Office guide: "*Note that the global* [ie. the spatially-coherent] *projections may not sample as broad a range of outcomes as the probabilistic projections and do not enable estimates of relative likelihood"*

allowance for climate change loss for London should start at zero in 2023, rising to the Medium scenario loss of 110 Ml/d by 2075. The value of 110 Ml/d is, coincidentally, roughly equal to the 'Ofwat-consistent' value for DO loss in 2070 from averaging over RCP2.6 and RCP8.5, minus the non-existent 46 Ml/d loss of DO predicted for 2023.

Appendix E – Derivation of revised baseline deficits

Revision to London baseline deficit

Taking account of GARD's comments on population growth, environmental reductions and climate change, the drivers of the London baseline deficit would be as shown in Figure E1:

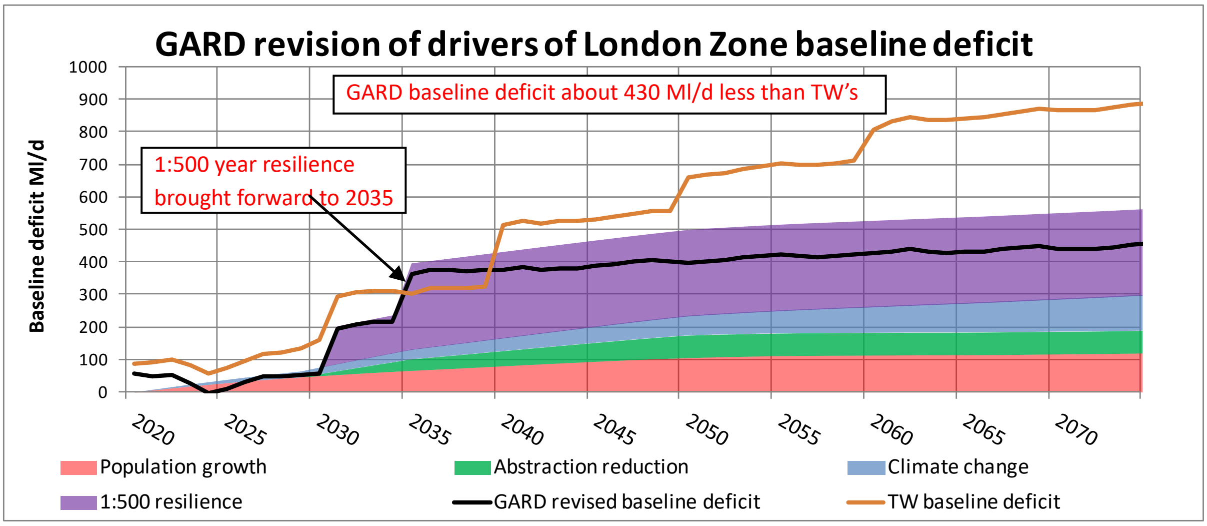


Figure E1 - GARD proposed revision to London baseline deficit drivers

The changes to the drivers of the London baseline deficit are:

1. Population growth reduced to be more aligned with ONS forecasts
2. Abstraction reductions as Table B6 in Appendix A and with sensitive chalk stream reductions brought forward
3. Climate change as per Appendix C, ie as Thames Water Medium scenario, but starting with zero loss of deployable output due to climate change up to 2023
4. Resilience standard as per TW, but 1:500 brought forward to 2035

Overall, the ultimate need for new resources for London zone is reduced by about 430 Ml/d.

Revision to SWOX zone baseline deficit

GARD's revision of the drivers of the SWOX baseline deficit would be as shown in Figure E2:

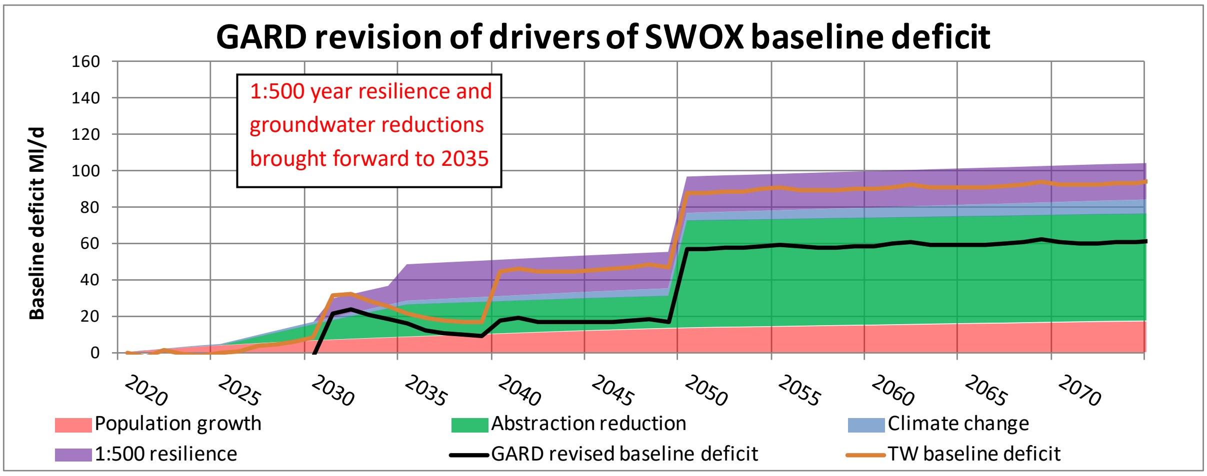


Figure E2 - GARD proposed revision to TW SWOX zone baseline deficit drivers

The changes to the drivers of the SWOX baseline deficit are:

1. Population growth reduced to be more aligned with ONS forecasts as in Appendix B.
2. Abstraction reductions as Table B6 and with sensitive groundwater reductions brought forward to start in 2025 and complete by 2035. Farmoor reduction still 35 Ml/d at 2050.
3. Climate change as per Appendix C, ie as Thames Water Medium scenario, but starting with zero loss of deployable output due to climate change up to 2023
4. Resilience standard as per TW, but 1:500 brought forward to 2035

Overall, the ultimate need for new resources for SWOX zone is reduced by about 30 Ml/d.

Revision to TW Thames Valley zones baseline deficit

GARD's revision of the drivers of the London baseline deficit would be as shown in Figure E3:

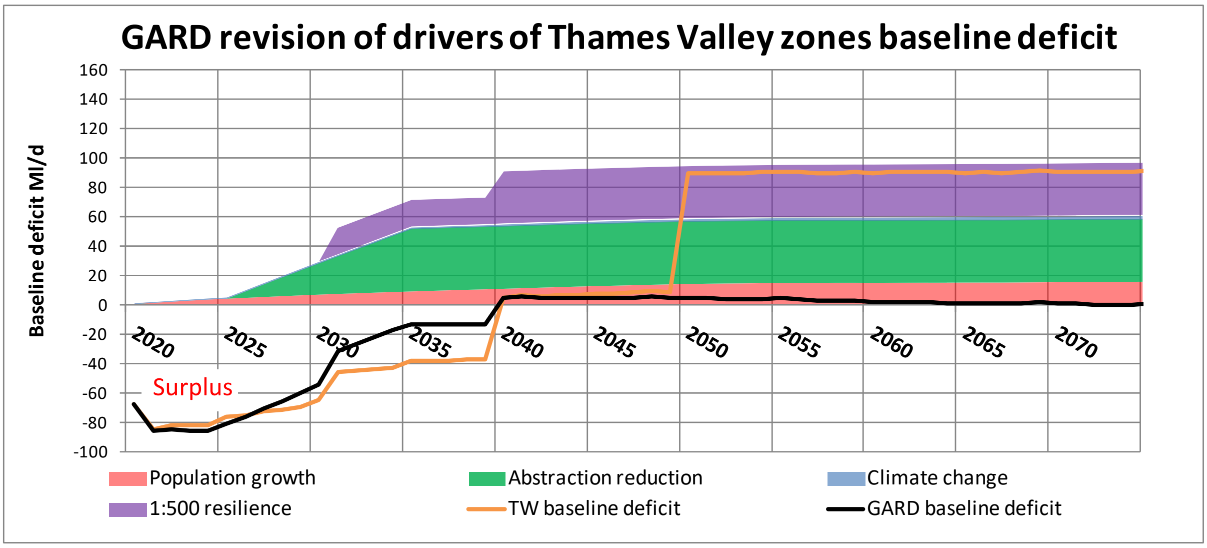


Figure E3 - GARD proposed revision to Thames Valley baseline deficit drivers

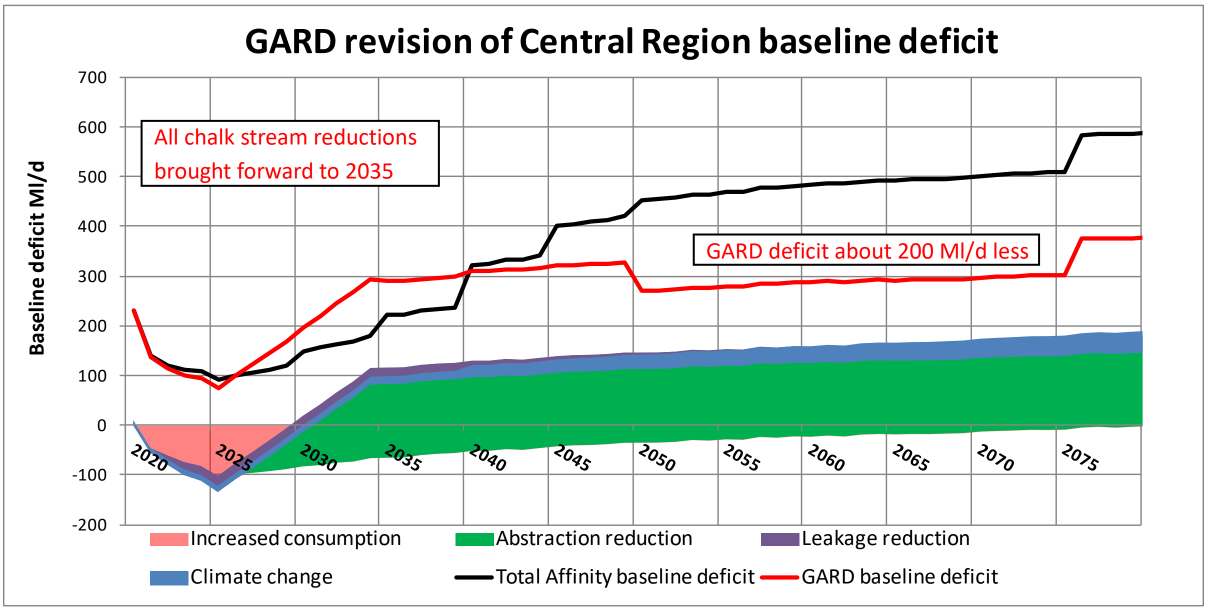
The changes to the drivers of the Thames valley baseline deficits are:

1. Population growth reduced to be more aligned with ONS forecasts as in Appendix A.
2. Abstraction reductions as Table B6, with sensitive groundwater reductions in the Rivers Wey, Misbourne and Enbourne brought forward to start in 2025 and complete by 2035.
3. Resilience standard as per TW, but 1:500 brought forward to 2035

Overall, the ultimate need for new resources for the Thames valley zones is reduced by about 90 Ml/d.

Revision to Affinity Water's Central Zone baseline deficit

Taking account of GARD's comments on population growth and environmental reductions, the make-up of the Central Region baseline deficit would be as shown in Figure E4:



Notes: 1. Population growth revised as in Appendix B.
2. Abstraction reductions reduced and brought forward as in Appendix A
3. No change in Affinity proposed climate change allowances or leakage reduction

Figure E4 - GARD proposed revision to Central Region baseline deficit

The changes relative to Affinity Water's baseline deficit are:

- Population growth is as per ONS forecast growth plus 50%
- Environmental reductions exclude 79 Ml/d of lower Colne reductions and bring all others forward for completion by 2035
- The climate change reduction is unchanged because the 79 Ml/d lower Colne abstractions are retained.

Overall, the ultimate need for new resources is reduced by about 200 Ml/d.

Appendix F – Evidence of inadequate plans to reduce PCC

Thames Water's proposed PCC reductions[165]

The planned reductions in PCC in Thames Water's supply zones are shown below:

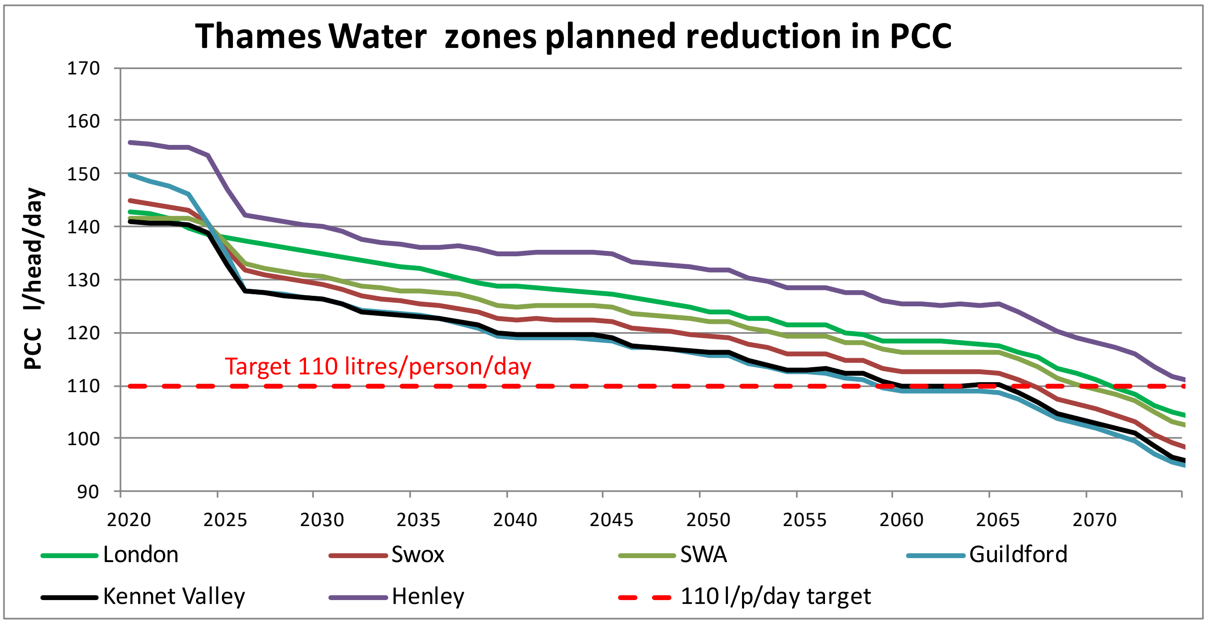


Figure F1 - TW planned reductions in PCC in each zone

WRSE's regional plan states that Government has promoted a national ambition for per capita consumption (PCC) to fall to 110 litres per person by day by 2050[166]. Thames Water misses this target in every zone. The six South East water companies' planned reductions in PCC are shown in WRSE's plan as below[167]:

Company	2017/18 Normal year PCC (l/person/d)	2050 Normal Year PCC (l/person/d)
Affinity Water	155	113
Portsmouth Water	147	109
SES Water	147	106
South East Water	144	107
Southern Water	129	106
Thames Water	146	121
WRSE	**145**	**115**

This is an error. The final plan PCC for Affinity Water's Central Region zones in 2050 is 127 l/person/day, as shown in Affinity's WRMP tables.

Table E1 - WRSE planned PCC reductions by 2050 for the six SE water companies

Thames Water falls far short of achieving the Government target of 110 l/person/day by 2050 and is largely responsible for the overall WRSE failure to meet the target. Much of Thames Water's failure to achieve 110 l/p/day by 2050 occurs in their London zone. This is shown in more detail below and compared with the planned performance of United Utilities'

[165] Copied from Section 3.2 of GARD's response to Thames Water's WRMP consultation
[166] WRSE Technical Annex 2, paragraph 5.21
[167] WRSE Technical Annex 2, Table 5.2

Strategic Zone, covering a comparably large and heavily urbanised region, including Manchester and Liverpool (data from WRMP tables):

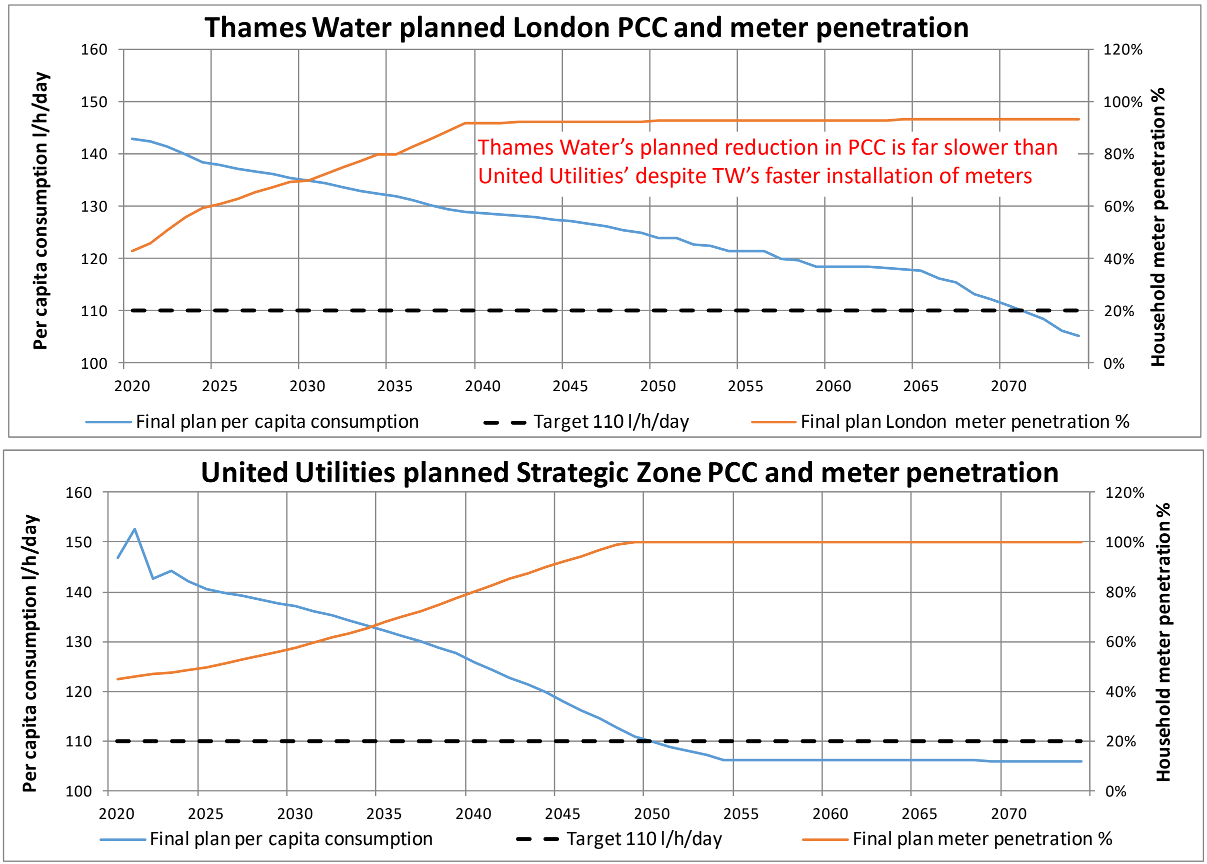


Figure F2 - Comparison of TW and United Utilities planned urban PCC reductions

Figure F2 shows a large disparity in the planned achievement of the 110 l/person/day target despite the similarity of the zones in terms of size and urbanisation. United Utilities plan to meet the target by 2050, whereas Thames Water's London PCC is still at 124 l/person/day in 2050, despite planned meter penetration of 90% by 2040.

Thames Water's planned meter penetration in all zones is shown in Figure F3:

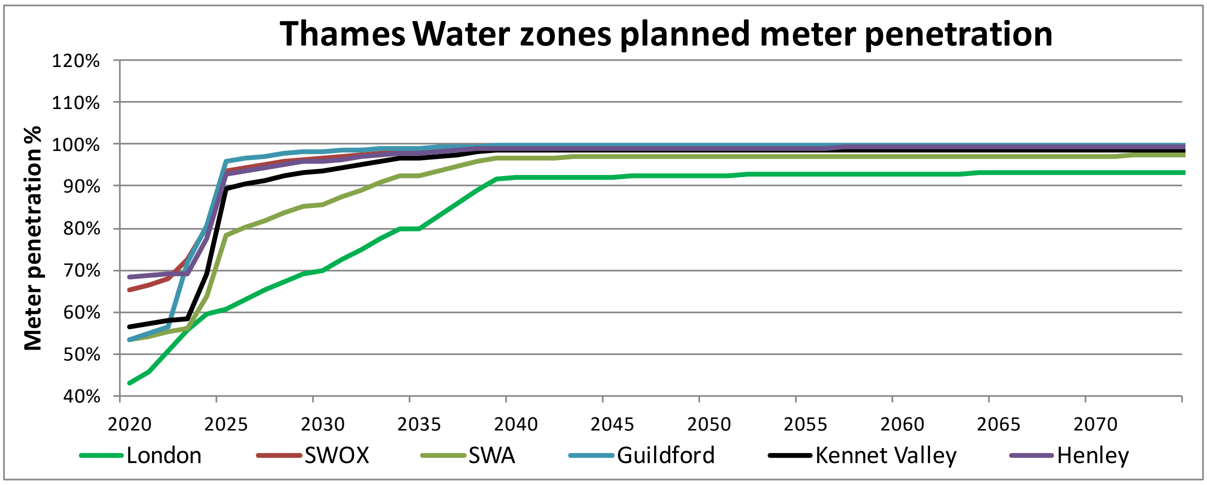


Figure F3 - Thames Water's planned meter penetration in each zone

This shows that Thames Water plan near total meter coverage in all zones by 2040, so the forecast failure to meet the 110 l/p/day target by 2050 seems unduly pessimistic. If TW say the target can be met in every zone by 2075, as shown in Figure 18, why can't this be achieved by 2050?

If Thames Water achieves the 110 l/person/day target in London by 2050, the need for new sources in 2050 is reduced by 134 Ml/d (assuming Thames Water's forecast London zone population of 9.55 million). Outside London in Thames Water's Thames valley zones, achievement of the 110 l/person/day target by 2050 would save a further 26 Ml/d compared with Thames Water's plan.

In GARD's response to Affinity Water's draft WRMP[168], we have shown that, if the Central Region PCC is reduced to 124 l/h/d by 2040 and 110 l/h/d by 2050, the Central Region demand savings would be 48 Ml/d by 2040 and 74 Ml/d by 2050 (assuming Affinity Water's population forecasts).

Thus if both Thames Water and Affinity Water meet the Government's target for reducing PCC to 110 l/person/day by 2050, the need for new supplies in areas potentially supplied from Abingdon reservoir would be reduced by a total of:

• Thames Water, London zone		134 Ml/d
• Thames Water, zones outside London		26 Ml/d
• Affinity Water, Central Region		74 Ml/d
	Total	234 Ml/d

Affinity Water's proposed PCC reductions

The Affinity Water's planned reduction in per capita consumption (PCC) and household meter penetration in the Central Region is shown in Figure F4:

[168] GARD response to Affinity Water draft WRMP24, Section 3.2

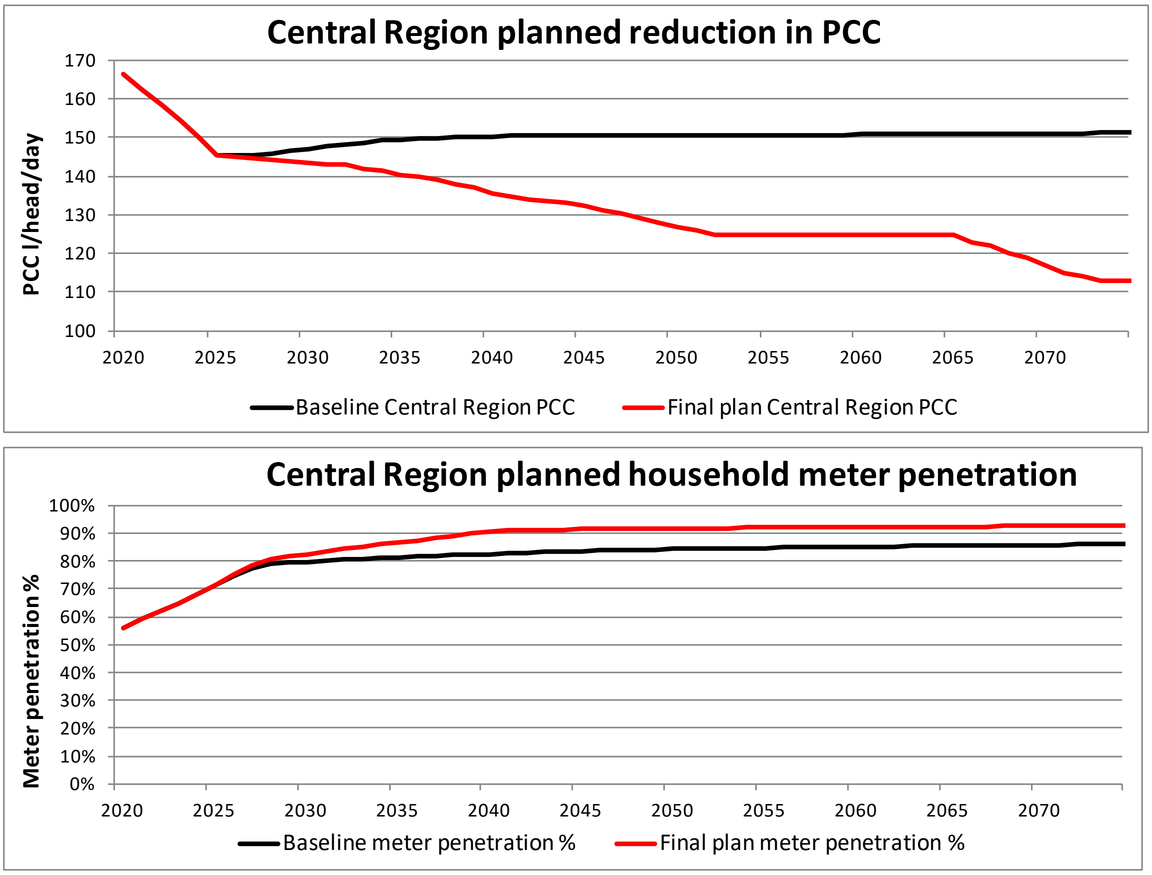


Figure F4 - Central Region planned PCC reduction and household meter penetration

Figure F4 shows that Affinity Water plan eventually to get close to the Government's 110 l/h/d target, reaching 113 l/h/day by 2075. However, by 2040, the planned PCC of 135 l/h/d is well above the Government target.

Planned meter penetration rise quickly to 80% by 2028, but then slows markedly, with 90% penetration not achieved until 2040. GARD proposes that meter installation should continue at the pre-2028 rate until 90% smart meter penetration is achieved by about 2032. This would help to achieve rapid chalk stream abstraction reductions. If Central Region PCC is reduced to 124 l/h/d by 2040 and 110 l/h/d by 2050, the Central Region demand savings would be 48 Ml/d by 2040 and 74 Ml/d by 2050 (assuming Affinity Water's population forecasts). This would provide a substantial part of the planned abstraction reductions without any need for new sources.

Appendix G – Evidence of inadequate plans to reduce leakage

Thames Water's planned leakage reductions from AMP8 onwards (post-2025) in their six supply zones are shown below[169]:

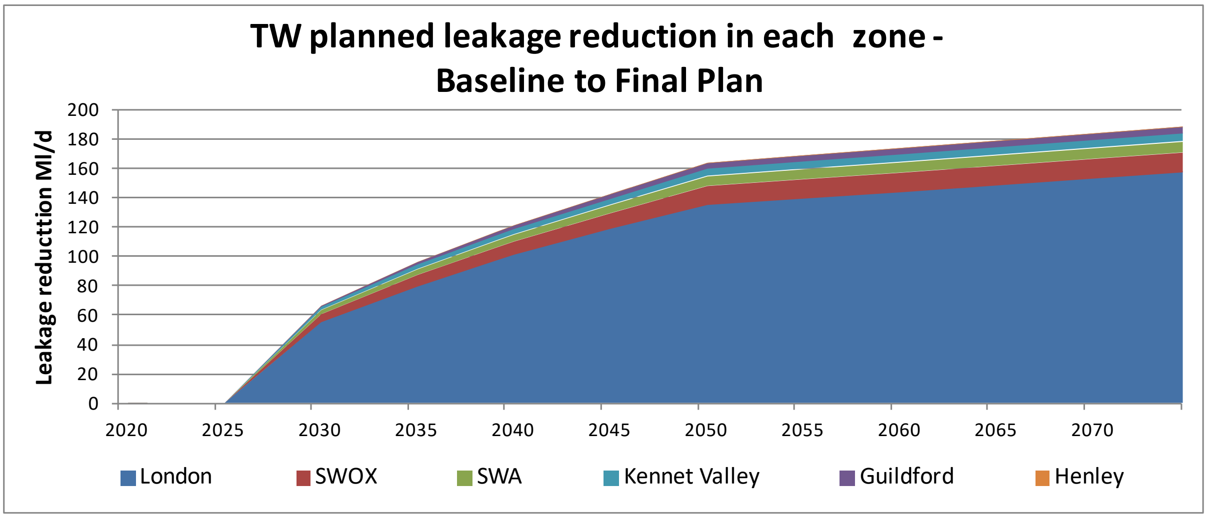


Figure G1 - Planned leakage reduction in Thames Water's supply zones post-2025

Ofwat have defined the Government's 50% leakage reduction target as follows[170]:

> *"Companies committed to the 50% reduction from 2017-18 levels in a letter from Water UK to the Secretary of State on 17/10/2018. The reduction was a recommendation from the National Infrastructure commission, 'Preparing for a drier future: England's water infrastructure needs', April 2018, p.13."*

Although Thames Water plan overall to meet the Government's target of 50% leakage reduction by 2050, there is a wide disparity in the % reductions in zones:

[169] Appendix F is copied from Section 3.3 in GARD's response to Thames Water's WRMP consultation
[170] https://www.ofwat.gov.uk/households/supply-and-standards/leakage/

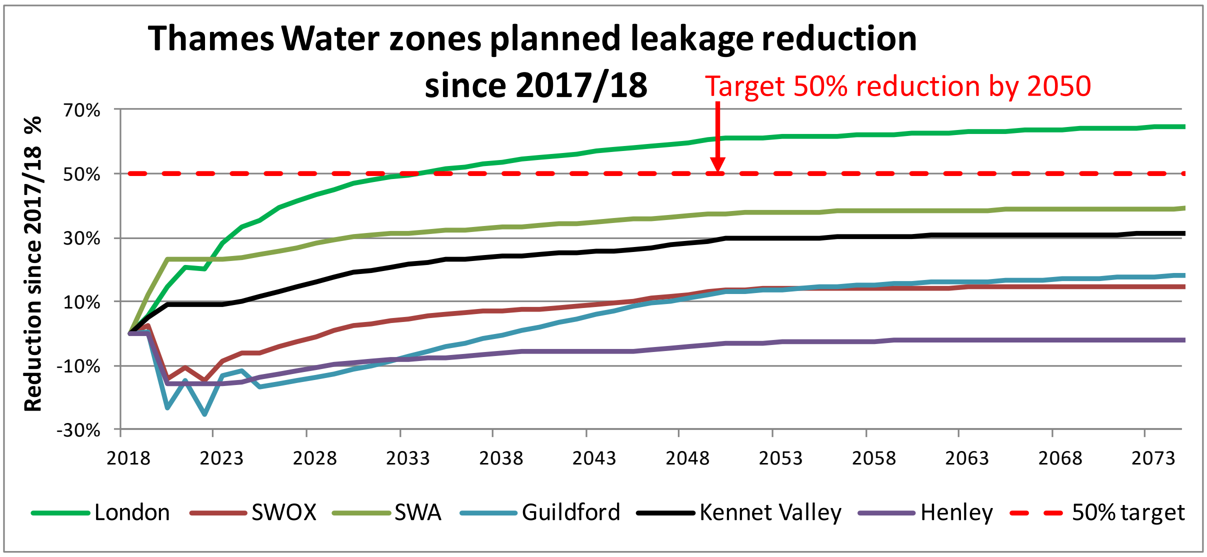
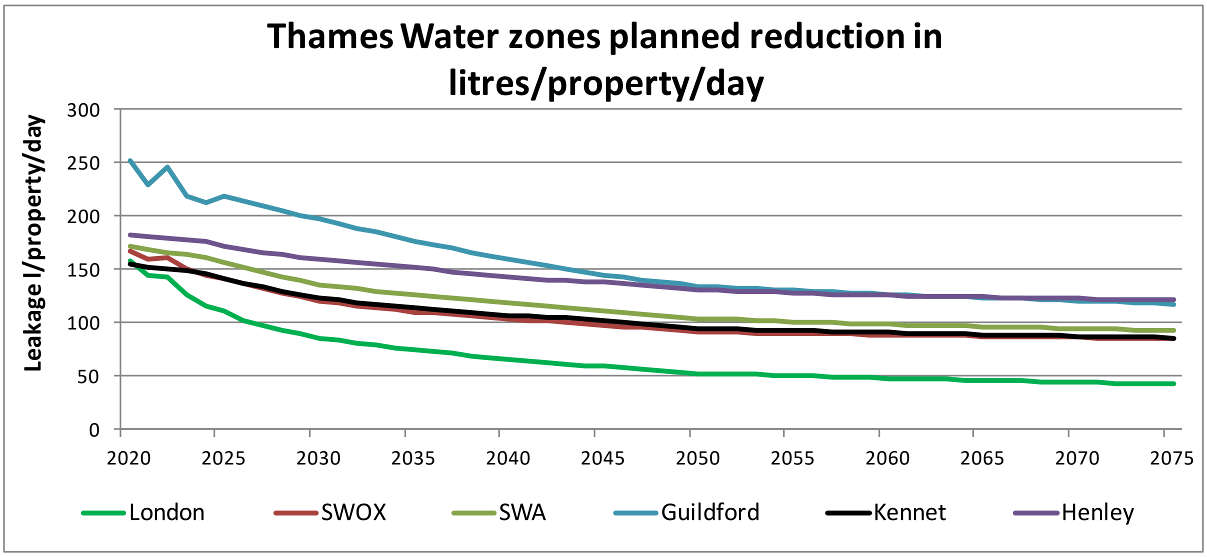


Figure G2 - Compliance with 50% leakage reduction target by zone

Most of the planned leakage reductions are in London, where the planned gross leakage reduction is from 566 Ml/d in 2017-18 to 225 Ml/d in 2050, a reduction of 60% and well ahead of the Government's 50% reduction target. GARD welcomes this and notes that the planned leakage of 53 l/property/day in 2050 is slightly less than United Utilities' planned 56 l/property/day in their similarly urban Strategic Zone.

However, Thames Water's planned leakage reductions in the zones outside London are all well short of the 50% target. Although some zones would get closer to the 50% reduction target if the base date is moved forward to 2020, the planned leakages in 2050 are still in the range 90 to 135 l/property/day and far higher than the typical 40 l/property/day elsewhere in the South East[171] as shown in Figure G3:

[171] WRSE Technical Annex 2, Table 5.1



Company	Total Leakage (% reduction)	2017/18 Leakage (l/property/d)	2050 leakage (l/property/d)
Affinity Water	53%	121	42
Portsmouth Water	50%	101	39
SES Water	56%	89	32
South East Water	51%	103	39
Southern Water	51%	90	36
Thames Water	50%	176	66
WRSE	**51%**	**140**	**52**

Figure G3 - Thames Water leakage per property per day reductions in zones

GARD proposes that leakage in Thames Water's zones outside London should be reduced to 40 litres/property/day by 2050 to be in line with the leakages planned in all other regions outside London. This would give a total saving of 74 Ml/d in SWOX and the other Thames valley zones compared to Thames Water's plan.

Appendix H – Evidence of lack of need for the Thames to Southern transfer[172]

Planned use of the Thames to Southern transfer

Southern Water's expected use of the Thames to Southern transfer is shown below[173]:

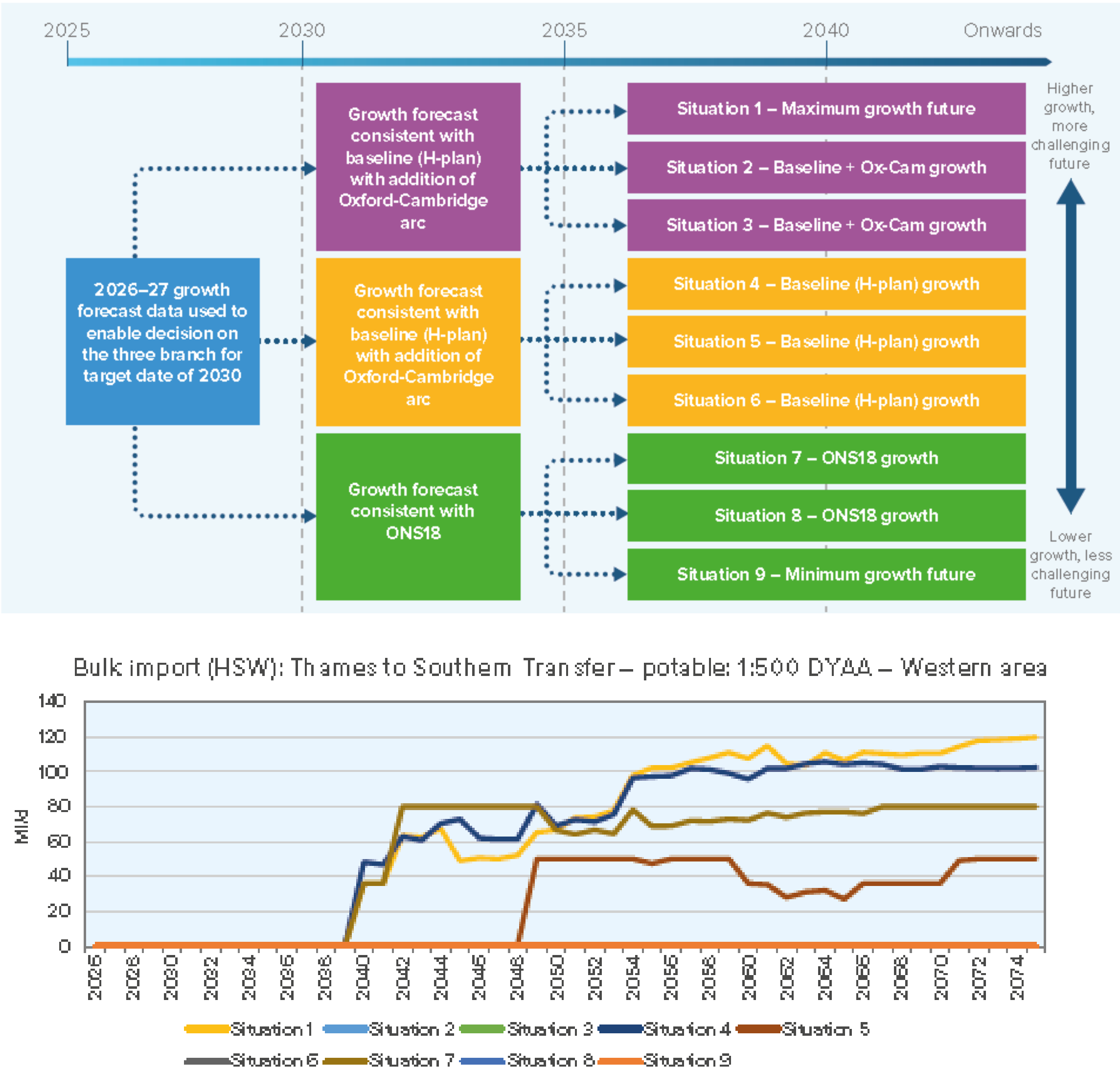


Figure H1 - Southern Water's expected use of the T2ST under different scenarios

An example of Thames Water's modelled frequency of use of the Thames to Southern transfer is shown in Figure H2 for a typical 48-year run of stochastic data and a typical worst drought within the 48 year run[174]:

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[172] Appendix G is copied from Section 3.5 of GARD's response to Thames Water's WRMP consultation
[173] Copied from Southern Water main WRMP report, Figures 5.22 and 7.11
[174] Pywr modelled output is from data supplied by Thames Water under EIR-22-23-390 and plotted total Test flow is the sum of stochastic data supplied by Southern Water for Testwood, Conager Bridge and Test Back Carrier

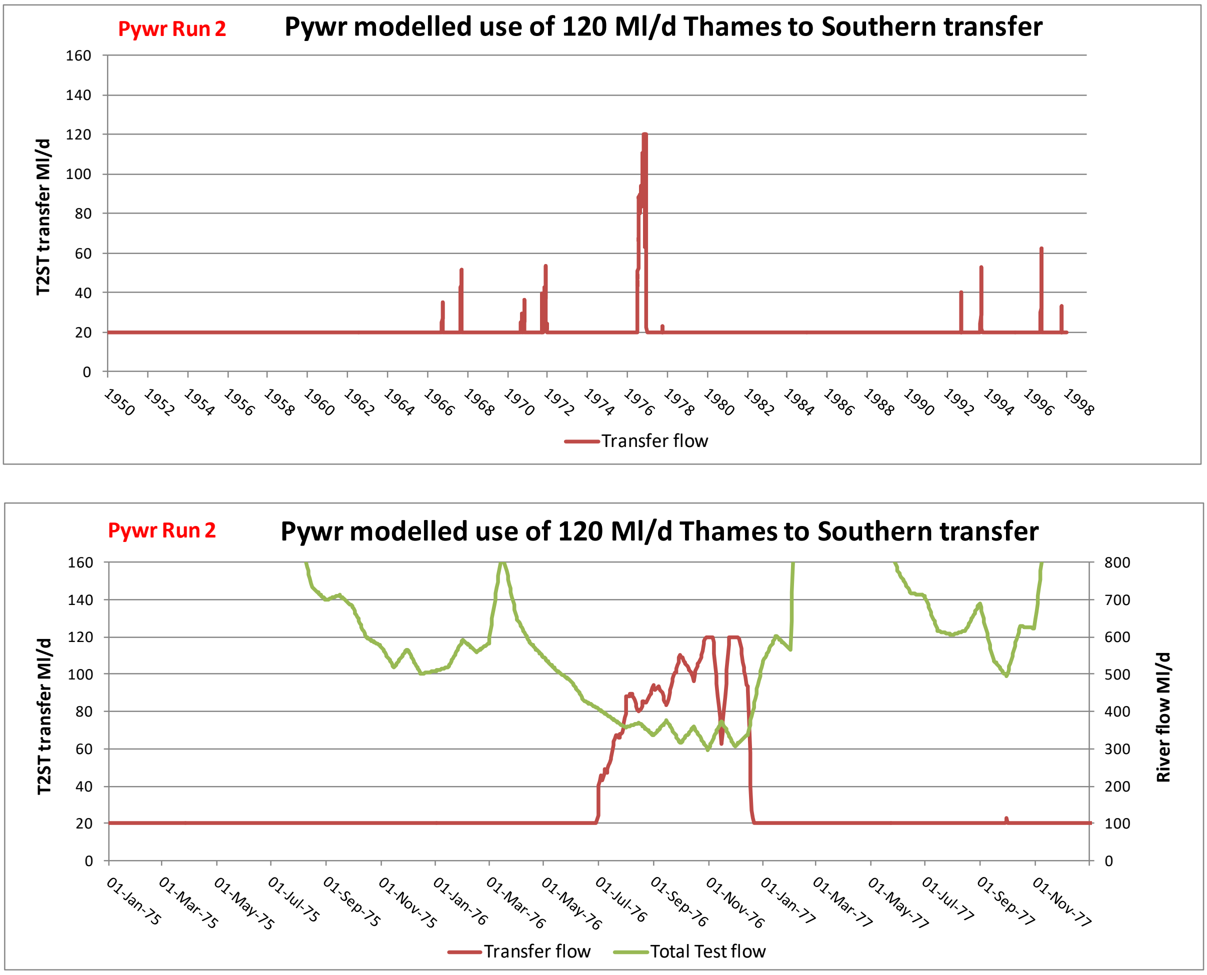

Figure H2 - Typical operational use of the 120 Ml/d Thames to Southern transfer

In major drought years, like 1976 in the example shown in the lower plot in Figure H2, the transfer could run for 6 months or more, triggered to comply with a total Test hands-off flow of 355 Ml/d, and peaking at the 120 Ml/d capacity for short periods. However, although the Pywr modelling shows drought use about once in 5 years on average, usually this will be for a relatively short period and at much less than the 120 Ml/d capacity.

At most times in most years, the transfer would run at a constant flow of 20 Ml/d. This seems too large an amount for a “sweetening flow”, so it is assumed that the 20 Ml/d transfer would be for normal supply, probably to replace supplies lost through Southern Water’s planned abstraction reductions in the Itchen valley.

The need for the transfer to enable abstraction reductions

WRSE’s data in file *‘GARD-09 Additional Source Level Environmental Ambition Data.xlsx’* shows about 59 Ml/d of reduction in Southern Water’s Test and Itchen abstractions – 43 Ml/d from the Itchen and 16 Ml/d from the Test, as shown in Table H1:

	All in Ml/d	WRSE High Scenario					WRSE	WRSE
Source	Catchment	2029-30	2034-35	2039-40	2049-50	2074-75	Medium	Low
Andover	Upper and Middle Test		4.0	8.0	8.0	8.0	7.2	8.0
near Whitchurch	Upper and Middle Test		1.4	1.4	1.4	1.4	1.4	1.4
Overton	Upper and Middle Test		0.0	1.0	1.5	1.5	0.0	0.0
Whitchurch	Upper and Middle Test		0.0	1.1	1.6	1.6	0.0	0.0
Romsey	Lower Test and S'ton Streams		3.5	3.5	3.5	3.5	3.5	3.5
Itchen GW, SW and Twyford	Itchen		0.0	13.7	20.5	20.5	0.0	0.0
Test Surface Water	Lower Test and S'ton Streams		0.0	0.0	0.0	0.0	0.0	0.0
Alresford	Itchen		1.8	4.5	4.5	4.5	4.5	1.8
Winchester	Itchen		4.9	12.1	18.2	18.2	8.3	4.9
All	**Total DO loss**	**0.0**	**15.5**	**45.2**	**59.2**	**59.2**	**24.8**	**19.5**

Table H1 – Southern Water's planned Test and Itchen abstraction reductions

The justification for the Itchen reductions is shown in Southern Water's main WRMP report as below:

Table 3.4: Other Environmental Investigations and Drivers reflected in our Ambition

WRZ	Source(s)	Regulatory Drivers	Comments
HWZ	Alresford Winchester	Habitats Directive and SSSI investigations including assessment of CSMG flow standards	Emerging outcome of our studies of the Candover Stream is that our Alresford source will need to stop operation and we currently assume this will occur in 2030 with interim mitigation and river enhancement. Implications for our Winchester source are presently uncertain but are primarily thought to relate to Habitats Directive and SSSI investigations rather than the CSMG flow standards which are potentially compliant on the affected reach.

Table H2 - Southern Water justification of Itchen abstraction reductions

Southern Water comments suggest that the abstraction reductions are not needed for compliance with river flow standards (EFIs). The CaBA analysis of abstraction as a % of recharge for the Test and Itchen catchments also shows no need for abstraction reductions in the Test and Itchen as in Table H3:

	Test catchment					Itchen catchment		
	Anton	**Bourne Rivulet**	**Upper Test to Chilbolton**	**Test to Anton confluence**	**Test to Timsbury**	**Candover Brook**	**Upper Itchen to Winchester**	**Itchen to Chandlers Ford**
Catchment area	185 km2	131 km2	453 km2	638 km2	978 km2	72 km2	280 km2	360 km2
Baseflow index	0.96		0.97		0.95			
Av. annual recharge	190.0 Ml/d	134.5 Ml/d	465.3 Ml/d	655.3 Ml/d	1004.5 Ml/d	73.7 Ml/d	469.8 Ml/d	604.1 Ml/d
Abstraction in 2017-19	12.9 Ml/d	0.9 Ml/d	5.9 Ml/d	18.8 Ml/d	24.8 Ml/d	2.8 Ml/d	13.8 Ml/d	41.6 Ml/d
A%R in 2017-19	6.8%	0.7%	1.3%	2.9%	2.5%	3.8%	2.9%	6.9%
Reduction to achieve A10%R	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**
GW consumptive licence total	0.0 Ml/d	5.7 Ml/d	27.9 Ml/d	33.6 Ml/d	61.5 Ml/d	4.5 Ml/d	18.2 Ml/d	55.7 Ml/d
Licence A%R	0.0%	4.2%	6.0%	5.1%	6.1%	6.2%	3.9%	9.2%
Licence reduction for A10%R	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**

Table H3 - Analysis of abstraction as a % of recharge for Test and Itchen catchments

The CaBA chalk stream group's A%R report concluded that no groundwater abstraction reductions were needed in the Itchen and Test catchments[175]. In the Itchen catchment, recent abstraction is only 2.9% of the average upper catchment recharge down to Winchester and 6.9% of the recharge of the catchment down to Chandlers Ford. In the Test catchment, recent abstraction is only 2.5% of the average catchment recharge. For both rivers, licensed abstraction is less than 10% of average recharge – the CaBA group proposed benchmark for acceptable abstraction. GARD concludes that the 59 Ml/d of deployable output loss planned for Test and Itchen groundwater sources is un-necessary and should be dropped, or at the very least, be given a low priority.

Need for Test and Itchen drought permits and orders

In addition to the 59 Ml/d of Test and Itchen abstraction reductions shown above, Southern Water's plans include the abolition of Test and Itchen drought orders and permits which are described in their drought plan as below[176]:

[175] A%R, Abstraction as a % of recharge in chalk streams, Figure 2, pages 52 and 63, December 2021
https://chalkstreams.org/ar-abstraction-as-a-of-recharge-in-chalk-streams/
[176] Southern Water draft Drought Plan, Table 4.11, page 143
https://www.southernwater.co.uk/media/4798/draft-drought-plan-2022.pdf

Type of action	WRZ	Summary of action	Likely benefit / saving	Risks, constraints and requirements[3]	Environmental impacts category[4]
Drought permit River Test (surface water source Drought Permit)[1]	HSE and HSW	Relax the Test Total Flow condition in the abstraction licence from 355Ml/d to 265Ml/d	80M/d max yield	Work closely with the EA when applying for, during the course of and after the end of a drought permit. EA determine the outcome of whether the drought permit is granted. Advertise drought permit and discuss with any impacted organisations. Equates to daily licence volume available if hands off flow is reduced	Up to Moderate
Drought order Candover Augmentation Scheme (groundwater source)[1]	HSE	Drought order to operate the Candover river augmentation scheme boreholes. To allow up to 27Ml/d and 3750Ml/year (20.8Ml/d over 6 months). This would enable additional DO at our River Itchen Works	14.37M/d in 1:200 drought at MDO	Work closely with Defra when applying for, during the course of and after the end of a drought order. Defra determine the outcome of whether the drought order is granted. Advertise drought order and discuss with any impacted organisations. 1 in 200 MDO benefit shown based on WRMP19 assessment, varies with drought severity	Up to Minor
Drought order Lower Itchen (SWS and PRT) (groundwater and surface water sources)[1]	HSE	SWS may need to apply for a drought order to reduce the flow condition controlling PRT's abstraction licence from 194Ml/d to 150Ml/d and reduce the flow condition in the River Itchen at Allbrook and Highbridge from 198Ml/d to 160Ml/d controlling SWS's Lower Itchen surface and groundwater sources.	38.0M/d from SWS's Lower Itchen sources	Work closely with Defra when applying for, during the course of and after the end of a drought order. Defra determine the outcome of whether the drought order is granted. Advertise drought order and discuss with any impacted organisations. Equivalent to reduction in hands off flow from 198 to 160Ml/d	Up to Moderate

Table H4 - Southern Water's current plans for Test and Itchen drought orders and permits

The primary need for the proposed 120 Ml/d Thames to Southern transfer is to eliminate the needs for these drought orders and permits, as explained by Southern Water in the summary of their WRMP, pages 24 and 27:

> *"However, we rely on drought orders and drought permits that allow us to continue abstracting water during dry weather. Our aim is to reduce our reliance on these measures and stop using them by 2040 at the latest. To do this, we need to find 120 million litres of extra water per day [page 24].*
>
> *Additionally, we are investigating a strategic pipeline which could transfer up to 120 million litres per day from Thames Water. This depends on new sources being developed in Thames Water's area, all of which are being considered through the SRO process. One of the new sources in Thames Water's area is the South East Strategic Reservoir, or SESRO. We've based our best value plan on WRSE's regional plan which includes an option for SESRO at 100Mm3, which would enable the strategic transfer into Hampshire. If the size and timing of SESRO changed it would impact our wider plans. For example, a larger reservoir could mean we need a smaller water recycling plant supplementing Havant Thicket reservoir. However, if SESRO was smaller or delayed, we may need to invest in alternative sources such as desalination or water recycling elsewhere in Hampshire [page 27]."*

In other words, up to 2/3rds of the Abingdon reservoir deployable output will be used via the Thames to Southern transfer to reduce drought impacts on Test and Itchen flows and salmon, perhaps substantially needed only once in 50 years (for example see Figure H2) and to enable the 59 Ml/d of abstraction reductions in the Test and Itchen catchments which the CaBA A%R analysis shows are unnecessary (see Table H3 and accompanying text).

The capital cost of the Thames to Southern transfer is £1.25 billion with total Opex costs of £1.1 billion, as quoted in Southern Water's draft WRMP[177]:

Thames to Southern transfer

Metric	
Capex [£m]	1,247
Financing Cost [£m]	2,071
Opex [£m]	1,139
Embodied Carbon [tCo2e]	192,811
Average operational carbon emissions [tCo2e/yr]	2,368
Total Carbon Cost [£m]	187
Average Incremental Cost (AIC) [p/m3]	105

Table H5 - Costs of Thames to Southern Transfer

GARD recognises the importance of the Habitats Directive protected chalk streams and their salmon, but there must surely be an issue of disproportionate costs and environmental impacts, if precious Thames valley water is to be exported to Southern Water via Abingdon reservoir or the Severn to Thames transfer. WRSE's options appraisal summary report states the following[178]:

> *"The Water Resource Planning Guideline recognises that in the short term companies may need to increase use of drought management options to achieve a 1:500 year level of resilience, but in the medium and longer term the guidance is that companies should, where appropriate, use drought permits and orders less frequently, particularly in sensitive areas. Water companies have engaged with the Environment Agency around those supply side drought options to include as options to achieve the 1:500 level of resilience."*

In other words, abandonment of drought permits is discretionary, not compulsory. The same point was made by Ofwat and referred to in WRSE's response to their emerging regional plan in Spring 2022[179]:

> *"Ofwat noted the commitment to not use drought orders or permits as options after 2040, except for events in excess of the 1 in 500 year return period. It considered that*

[177] Southern Water dWRMP Annex 13 https://www.southernwater.co.uk/our-story/water-resources-management-plan/draft-wrmp-24-technical-documents:

[178] https://www.wrse.org.uk/media/2xzjw425/wrse-options-appraisal-summary-report-with-appendices.pdf : page 18

[179] WRSE response to Consultation on Emerging Regional Plan, May 2022, paragraph 13.4, page 40

WRSE should explore the cost, benefit and option selection impact of retaining the use of some drought orders and permits beyond 2040. It stated this was important to avoid unnecessary costs from resource development and to avoid the associated environmental impact that the additional development likely to arise from ruling out the use of drought orders and permits could bring."

In response to this, WRSE said *"WRSE will look to provide additional information on the decision making around the drought options for the draft regional plan*.[180]" No such information was provided in WRSE's latest regional plan, which showed that the benefit of Test and Itchen compliance with the Water Framework Directive has been assessed as only £29 million[181], far short of the £2 billion cost of the Thames to Southern transfer.

Therefore, GARD concludes that the Test and Itchen drought permits should be maintained and there should be no planned 120 Ml/d reduction of Southern Water's deployable output in 2040.

In GARD's opinion, the Thames to Southern transfer will never be needed. The 59 Ml/d of Itchen and Test abstraction reductions are unnecessary. The proposed abandonment of Test and Itchen drought permits would bring minimal and rare benefits. **The T2ST scheme should be abandoned at Gate 2 due to its minimal benefit and disproportionately high cost.**

[180] WRSE response to Consultation on Emerging Regional Plan, May 2022 paragraph 3.13, page 41
[181] WRSE regional plan, Technical Annex 2, Table 12.1

Appendix I – Evidence of the need for the Thames to Affinity transfer

Affinity Water's need for the Thames to Affinity transfer

In GARD's response to the consultation on Affinity Water's draft WRMP, we show that Affinity Water's ultimate need for new resources is over-estimated by about 200 Ml/d. In our proposed revision to the baseline deficit, the changes relative to Affinity Water's baseline deficit are:

- Population growth is as per ONS forecast growth plus 20%[182]
- Environmental reductions exclude about 80 Ml/d of lower Colne reductions and bring all others forward for completion by 2035[183]

GARD proposes that 50 Ml/d of the Thames to Affinity transfer should be brought forward to the early 2030s, connecting Affinity Water to Thames Water's London supply system. Combined with early implementation of 'Connect 2050' (re-naming it 'Connect 2030'), the Thames to Affinity transfer and the Grand Union Canal transfer would together allow all the planned upper Colne and Lea chalk stream reductions to be in place by the early 2030s.

On this basis, we showed in our response to Affinity Water's WRMP that all their needs to 2075 could be met by a 50 Ml/d Thames to Affinity transfer combined with the GUC transfer and metering to achieve the Government's 110 l/p/day PCC target[184].

If flow recovery is realistically allowed for, the Thames to Affinity transfer doesn't need to wait for either Abingdon reservoir or the Severn to Thames transfer.

Flow recovery from abstraction reductions

The amount and timing of chalk stream flow recovery from Affinity Water's abstraction reductions is crucial to avoid excessive cost and long delays in flow re-naturalisation. If the amount of recovery is high and a good proportion of extra water from the chalk catchments is available to refill the Thames Water's existing reservoirs in droughts, there will be comparatively little additional water resource development needed. This would allow flows in the Chilterns chalk streams to be re-naturalised within a few years and at relatively low cost.

Affinity Water's plan assumes that only 17% of the flow recovery from abstraction reductions converts to increased deployable output from the London reservoirs[185].Consequently, the plan delays most of the environmental abstraction reductions until after 2040, because of the supposed need to wait for replacement supplies from Abingdon reservoir, which cannot deliver water to Affinity Water's supply zones until after2040.

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[182] GARD response to Affinity Water WRMP, page 11 https://www.gard-oxon.org.uk/campaign%202023/GARD%20response%20to%20Affinity%20WRMP%2020%202%202023.pdf
[183] GARD response to Affinity Water WRMP, page 26
[184] GARD response to Affinity Water WRMP, Section 3.4 and Figure 18, page 25
[185] Affinity WRMP24, Annex 5.6, page 13

The Chalk Streams First report “Dealing with impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys”[186] examined in detail the evidence of measured flow recovery from abstraction reductions and the results of groundwater modelling. From reviews of measured flow recoveries, the conclusions were (with reference to the relevant pages in the CSF report):

1. Given sufficient time for flows to recover after genuine and maintained total abstraction reductions in a catchment, the measured flow gains will average about 80% of the abstraction reduction. The recovery will vary substantially across the range of flows, perhaps from less than 30% recovery in droughts to well over 100% recovery at times of high groundwater levels and flows (page 45).

2. This pattern of measured flow recovery is seen consistently in examples in several rivers:

   - The Friars Wash reduction in the River Ver in 1993 (pages 33 to 36)
   - Comparative flow and abstraction changes in the Rivers Chess and Ver (pages 37 to 39)
   - Comparative flow and abstraction changes in the Rivers Beane and Rib (pages 39 to 41)

3. There are no instances of flow recoveries failing to materialise when they might reasonably be expected after genuine and maintained abstraction reductions – several examples of supposed “disappointing” flow recoveries can be explained by the reductions being too small or insufficiently maintained:

   - The Bow Bridge reduction on the River Ver (pages 36 to 37)
   - The Fulling Mill reduction on the River Mimram (pages 42 to 43)

4. Short term signal tests are not a reliable way of assessing flow gains from abstraction reductions in these rivers:

   - Signal tests at Kensworth Lynch on the River Ver (pages 108 to 109)
   - Signal tests at Chesham on the River Chess (pages 197 to 201)

The CSF report reviewed modelled flow recoveries shown by the Environment Agency’s Herts Regional Groundwater Model and its own lumped parameter models. These models all validate reasonably well when comparing modelled and measured historic groundwater levels and river flows (details in Appendices A to D in CSF report). As described in Chapter 4 of the CSF report, pages 46 to 52), both models show very similar patterns and amounts of flow recovery from abstraction reductions:

1. The patterns and amounts of modelled flow recoveries are similar to the measured flow recoveries described above.

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[186] Dealing with the impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys, Chalk Streams First, January 2023 https://chalkstreams.org/flow-recovery-following-abstraction-reduction/

2. At average river flows, modelled river flow recoveries are in the region of 80% of the abstraction reductions. At extreme low flows, modelled flow recoveries are typically around 30-40% of abstraction reductions.

3. These conclusions are equally true in all four case study rivers (Chess, Ver, Mimram and Beane).

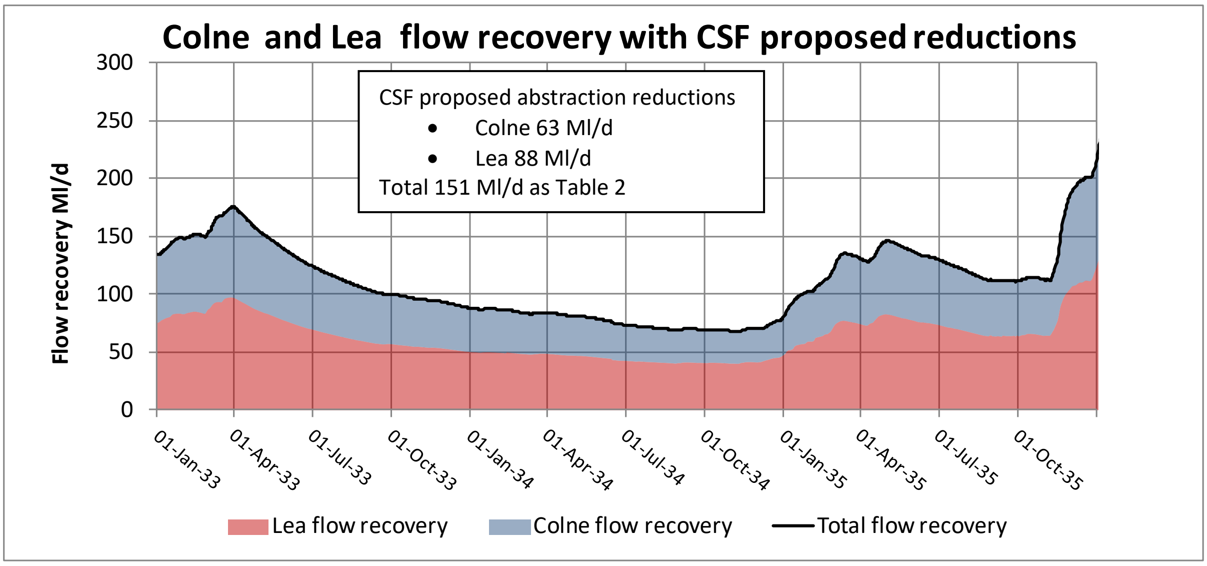
The modelled and measured flow recoveries are similar. They are far more than the 17% flow recovery assumed in Affinity Water's WRMP and in the draft regional plan of Water Resources in the South East.

Similar conclusions were reached in the RevIvel report on over-abstraction in the River Ivel[187]. If present abstraction of about 13 Ml/d abstraction was to stop, the modelling showed that flows in the River Ouse would rise by about 11 Ml/d on average (85% recovery) and about 6 Ml/d (45% recovery) in droughts. The increased flows in the River Ouse would boost inflows to Grafham reservoir, which could then provide replacement supplies to the areas currently fed from the River Ivel.

Benefits to London supplies from Affinity Water abstraction reductions

The Chalk Streams First Report, page 60, shows modelled flow recoveries from the total 151 Ml/d of CSF proposed abstraction reductions in the upper Colne and Lea chalk streams. The modelled daily Colne and Lea flow recoveries since 1920 have been added to the Teddington and Feildes Weir flow records to assess the increase in London deployable output, using the GARD model of the London supply system. Details of GARD's London supply model are given in Appendix F to the CSF report. In the 100-year period 1920-2019, with the enhanced reservoir inflows, the critical drought which governs London deployable output is July 1933 to November 1934 as shown in Figure H1:

[187] Alleviation of over-abstraction of chalk groundwater in the Upper River Ivel, page 41 https://www.revivel.org/app/uploads/2022/07/Ivel-report-21.6.21-BHs-redacted.pdf



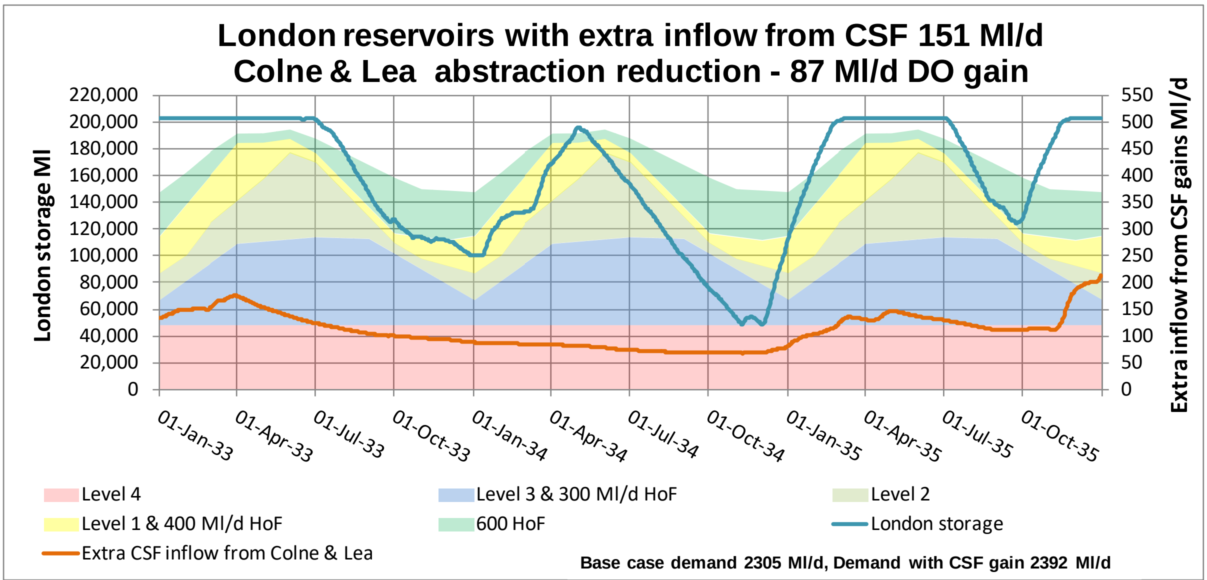


Figure H1 - Modelling of London DO gain from CSF proposed reductions in 1933-34

The modelled flow recovery in the 18-month drought starts at over 80% of the 151 Ml/d abstraction reduction at the start of the drawdown of the London reservoirs in July 1933. The modelled flow recovery percentage drops to around 40% when London storage starts to recover in November 1933. The modelled 87 Ml/d gain in deployable output is 58% of the 151 Ml/d abstraction reduction – a far higher gain than the 17% assumed in current draft water company WRMPs.

A similar analysis was carried out for the RevIvel report on alleviating Affinity Water's over-abstraction in the River Ivel, concluding that for Grafham reservoir there would be average 64% recovery of the abstraction reduction over the duration of the critical drought, which is also 1933/34[188].

It is concluded that when considering the amount of replacement sources needed for

[188] RevIvel report on Ivel over-abstraction, pages 55-57

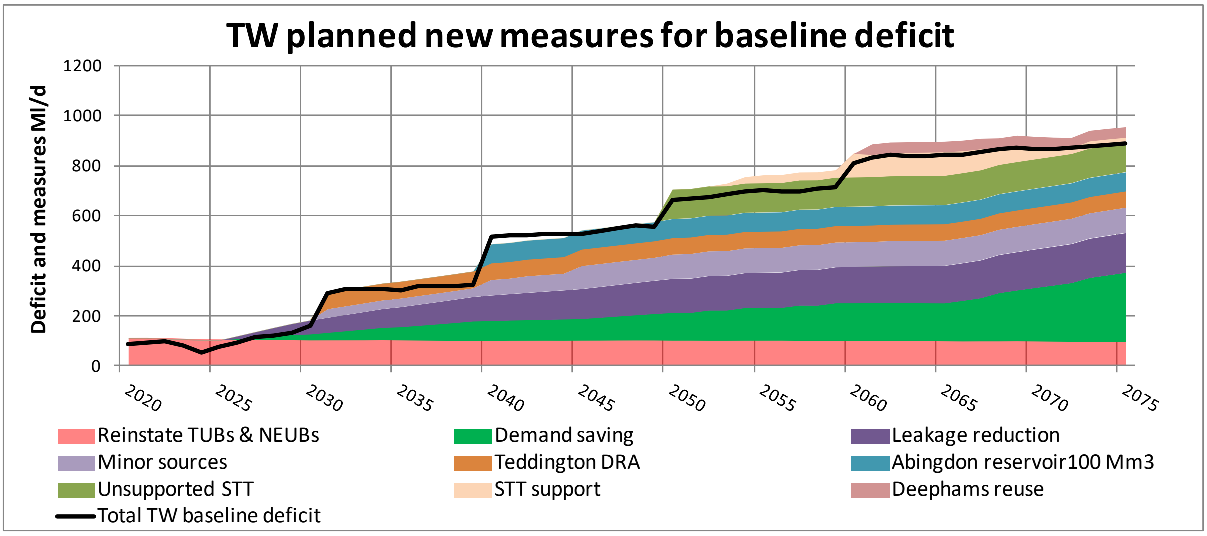
Affinity Water's planned abstraction reductions in the upper Colne, Lea and Ouse chalk streams, the assumed deployable output recovery in the London reservoirs and in Grafham reservoir should be around 60% and not the 17% assumed in Affinity Water's plan.

GARD recognises that there is uncertainty in the amount of deployable output recovery for London from the enhanced chalk stream flows arising from the Colne and Lea abstraction reductions. An insurance against deployable output recovery being less than expected should be provided by introduction of WBGWS-type drought support schemes in the upper Colne and Lea chalk streams.

Appendix J – Evidence showing measures needed for revised baseline deficits

Need for strategic resource options for Thames Water's London zone[189]

Thames Water's plan for dealing with the London baseline deficit is shown in Figure J1:



Note: 1. Amounts and timing of sources taken from 'Options benefits' tab for 'preferred' scenario in WRMP tables
2. Small mismatch between deficit and total sources, because no allowance for minor changes to imports/exports

Figure J1 - TW planned measures for dealing with the London baseline deficit

In Appendices A to D, we provide evidence that Thames Water have over-forecast the London baseline deficit by about 140 Ml/d in 2040 and 430 Ml/d in 2075. The over-forecast primarily arises from over-estimation of population growth, unnecessarily conservative allowance for climate change and, especially, grossly excessive and unjustifiable allowances for abstraction reductions for 'environmental improvements'.

In Appendix E, we provide evidence that if Thames Water meets the Government's PCC target of 110 l/p/day by 2050, the need for strategic resource options for London is reduced by a further 134 Ml/d.

In Appendix H, we show that Affinity Water's needs, including re-naturalisation of flows in the upper Colne and Lea chalk streams, can be met with a 50 Ml/d transfer via the Thames to Affinity strategic resource option, with a direct connection into the London raw water supply system.

Taking account of these factors on London's supply demand balance, GARD's proposal for closing the balance and new sources is shown in Figure J2:

[189] Copied from Section 3.6 of GARD's response to Thames Water's WRMP consultation

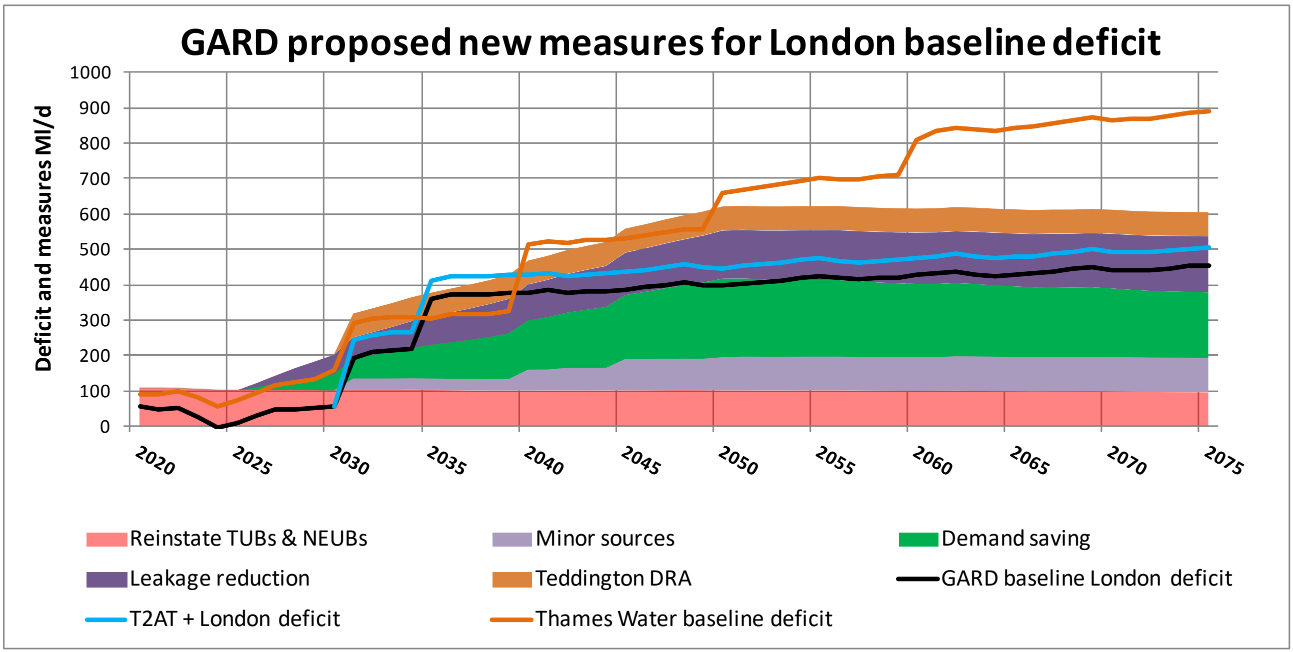


Figure J2 - GARD proposed measures for the London baseline deficit

The basis of the reassessment of London needs shown in Figure J2, including meeting Affinity Water's needs via the Thames to Affinity transfer, is as follows:

- GARD baseline London deficit as Appendix D
- 1:500 year resilience brought forward to 2035
- 50 Ml/d transfer to Affinity by direct connection to a London reservoir and brought forward to 2031 for early chalk stream relief, as Appendix H,
- Reinstatement of TUBs and NEUBs as per TW Final Plan
- Leakage reductions as per TW's final plan
- PCC reduced to 110 l/p/day by 2050, as per Government target, then remaining at 110 l/p/day until 2075 (the demand saving reduces after 2050 because TW assumed that the baseline PCC would continue to fall after 2050)
- Teddington DRA scheme by 2031 as per TW preferred plan
- Minor sources include various GW sources and Didcot licence reallocation as per preferred plan

Figure J2 shows that neither Abingdon reservoir nor the Severn to Thames transfer is required to meet the needs of London and Affinity Water, even bringing forward the 1:500 year resilience to 2035, apart from a small deficit between 2035 and 2040. Moreover, it should be noted that in the balance shown in Figure J2, no allowance has been made for additional recovery of deployable output from enhanced chalk stream flows, as discussed in Appendix H. Nor has there been any allowance for the London recovery of deployable output from the 35 Ml/d loss of deployable output from Farmoor reservoir due to restriction of its refilling.

Even without either Abingdon reservoir or the Severn to Thames transfer, Figure J2 shows that there would be a surplus of about 150 Ml/d in London's supplies continuously from 2040, if leakage and PCC reduction are on a trajectory to meet the Government targets by 2050. This shows the danger of creating a costly and environmentally damaging white elephant, if a decision to build Abingdon reservoir is made in the current cycle of business planning.

On this basis there is an argument that there should be no *decision* on Abingdon reservoir or the Severn to Thames transfer before 2035. The potential needs of the area by 2050, from realistic population growth, prioritised environmental improvements (abstraction reductions) and reasonably cautious allowance for climate change, can all be met if Thames Water (and Affinity Water) meet the Government's PCC and leakage targets.

However, GARD recognises that there is uncertainty over the amount and timing of the leakage and PCC reductions, mainly arising from the performance of Thames Water in meeting targets in the past. Therefore, it could be prudent to provide extra supply capacity to the London and the Thames valley *as early as possible.* This has the maximum strategic, environmental and drought resilience impact and would give a cushion against accelerating climate change effects. It would also bring forward the date at which 'true' 1 in 500 year drought resilience is can be guaranteed (not done until post-2040 in Thames Water's plan).

On that basis, we propose the following schemes should go ahead, even if not strictly needed under our realistic assessment of reduced future needs:

<u>By early 2030s</u>:

- The Teddington DRA scheme (67 Ml/d), already planned to be due by 2031
- The first phase of the GUC transfer (50 Ml/d), already planned to be due by 2031
- The 50 Ml/d Thames to Affinity transfer to allow early chalk stream relief

<u>By 2035/36</u>:

- 1st phase of Severn-Thames transfer, only 300 or 400 Ml/d aqueduct, with Netheridge and, possibly, Minworth support
- 2nd phase of GUC transfer, or possibly included in the first phase GUC transfer

Thus about 300-400 Ml/d of 'over-provision' would be deployed early to bring forward environmental benefit, including lower priority abstraction reductions, and to provide a large 'hedge' against climate change or population growth being substantially higher than the ONS forecasts. Further considerations in the 2035-2039 AMP could decide on what, if any, additional new supplies would be needed up to 2050. The presence of the Severn to Thames transfer aqueduct from the early 2030s would allow additional support sources to be added relatively quickly, if eventually needed.

Need for additional supplies in the SWOX zones

The Thames Water and GARD assessments of the SWOX baseline deficit are discussed respectively in Appendix D, showing 2075 deficits of 94 Ml/d and 62 Ml/d respectively. Thames Water's plan shows the SWOX deficit being met as shown in Figure J3:

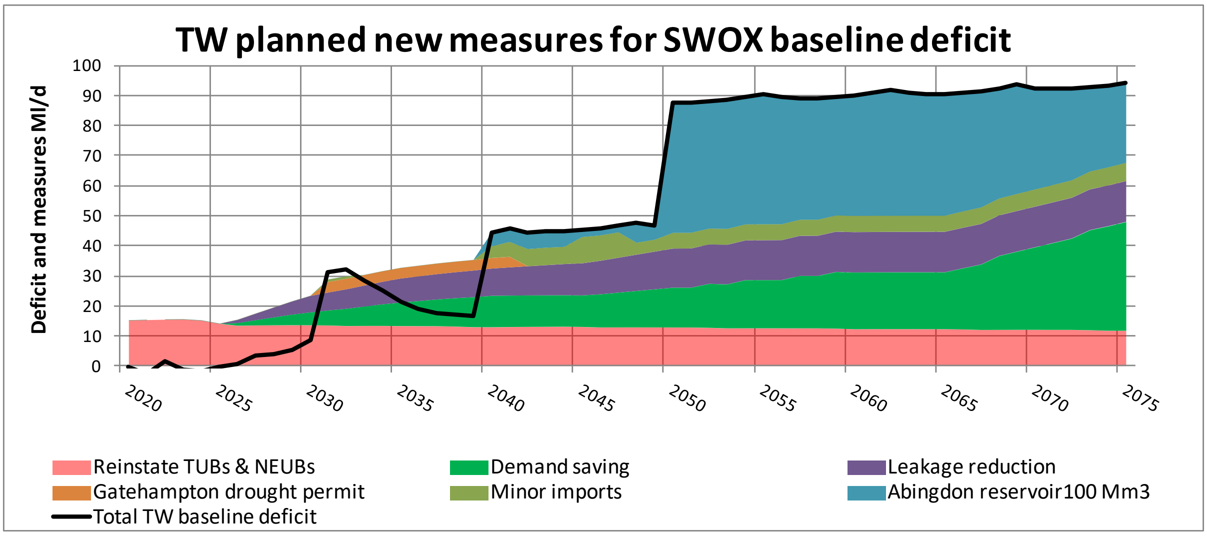


Figure J3 - TW planned measures for the SWOX baseline deficit

Apart from some minor imports from Wessex Water and the SWA/Henley zones and a small drought permit for the Gatehampton source, most of the deficit would be made up by Abingdon reservoir. Thames Water's supposed need for Abingdon reservoir to supply SWOX is a maximum of about 50 Ml/d in 2050, after which the need falls as PCC continues to fall towards the target of 110 l/p/day.

All of the 62 Ml/d baseline deficit assessed by GARD can be met without any supply from Abingdon reservoir, if the Government's leakage and PCC targets are met in the SWOX zone, as shown in Figure J4:

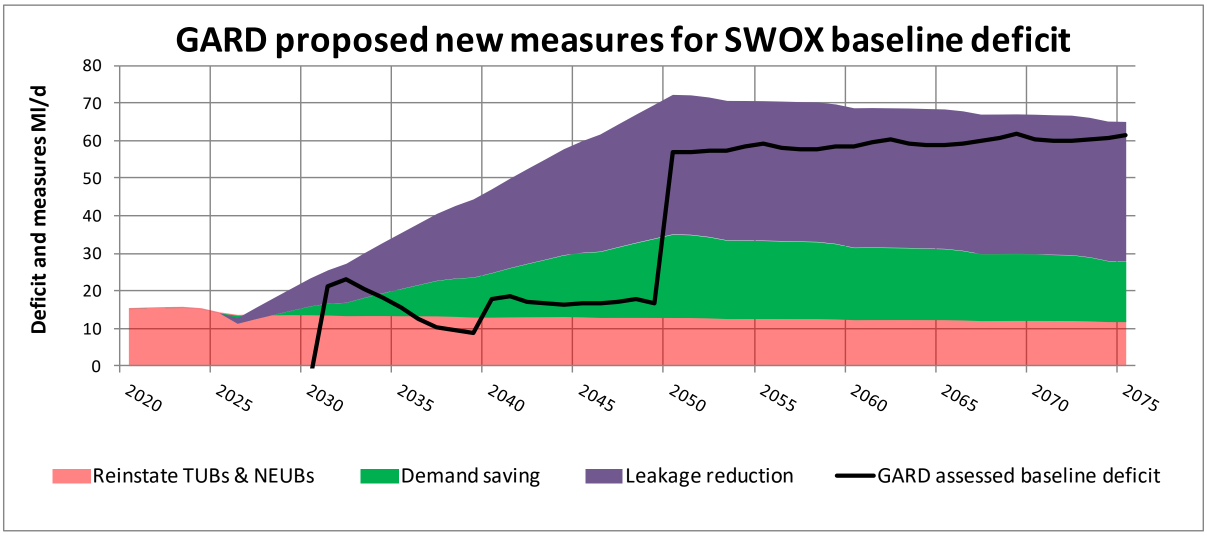


Figure J4 - GARD proposed measures for the SWOX baseline deficit

Even with the loss of 35 Ml/d due to the planned reduction in abstractions for filling Farmoor in 2050, there would be a surplus in SWOX zone if the Government's leakage and PCC targets are met. There would be no need for any supply from either Abingdon reservoir or the Severn to Thames transfer.

However, recognising the uncertainty over Thames Water's ability to meet these targets, the early construction of the Severn to Thames aqueduct with at least Netheridge support would provide insurance against Thames Water's failure to meet the targets, as we have proposed for the London zone.

Need for additional supplies in the Thames valley zones

Thames Water's baseline deficit in the Thames valley zones as shown on Figure 5 is a surplus up to 2050 and then a deficit of 90 Ml/d arising largely due to planned abstraction reductions. Thames Water plan to meet about half of this deficit through their planned PCC and leakage reductions and the remainder from imports of raw and potable water from SWOX zone.

GARD's reassessment shows that no new resources are needed for the Thames valley zones, even with the planned abstraction reductions in the Wey, Enbourne and Misbourne brought forward to 2025-35, as shown in Figure E3 in Appendix E.

Appendix K – Evidence for Abingdon reservoir dead and emergency storage

In our main response to the consultation on Thames Water's WRMP24, we proposed that TW's proposed 6% emergency storage allowances for Abingdon reservoir should be increased to be in line with the emergency storage allowances in other major UK reservoirs as below:

- Clywedog reservoir 13%
- Llyn Brianne reservoir 14%
- Bristol Water (Chew, Blagdon) 18%
- Welsh Dee system 20%
- TW London reservoirs 24%
- TW Farmoor reservoir 33%

Thames Water says that the allowance of 6% emergency storage, ie 9,000 Ml for the 150 Mm^3 reservoir, is equivalent to 30 days of supply from the regulation release of 300 Ml/d, which they claim is in line with UK normal practice. However, there appears to have been no consideration of the minimum average depth of water required for acceptable water quality. Thames Water's themselves agree that an average water depth of less than 5m will be likely to lead to water quality problems[190]:

> *"The 28m water depth noted in the [GARD's] comment is the depth of the live storage (51m AOD to 79m AOD), there is a further 5m depth of dead storage in the central trench underneath (46m AOD to 51m AOD). We agree that a water depth of less than 5m would likely lead to water quality issues, hence the definition of such water as dead storage."*

Therefore there should be a minimum average depth of 5m of water when the emergency storage is <u>empty</u>. Figure 21 shows a cross-section of the reservoir and borrow pit[191]:

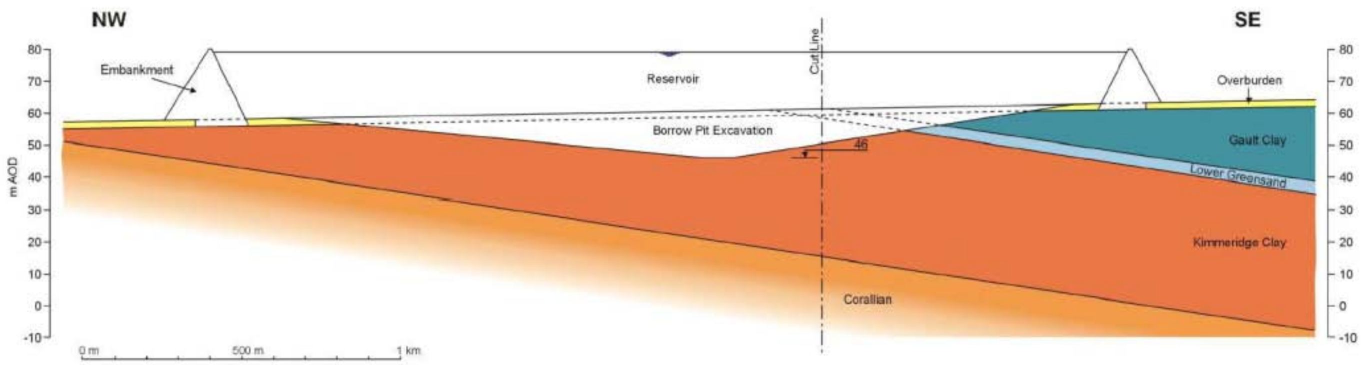


Figure K1 - Cross-section of reservoir showing borrow pit

This shows that the maximum depth of the borrow pit is about 5m so the average depth is

[190] WRMP19 Reservoir Feasibility Report, page 435, Mott MacDonald, July 2017
[191] Gate 2 Concept Design Report Figure 2.1

only about 2.5m, not 5m. The average depths of water for the dead storage and Thames Water's proposed emergency storage are shown in Table K1:

Reservoir dimensions from 2017 reservoir feasibility report[192]	**150 Mm^3 reservoir**	**100 Mm^3 reservoir**
Gross storage	165,000 Ml	110,000 Ml
Live storage	150,000 Ml	100,000 Ml
Dead storage	15,000 Ml	10,000 Ml
TW emergency storage (6% of live storage)	9,000 Ml	6,000 Ml
Area at full supply	675 ha	404 ha
Embankment perimeter	10.3 km	7.9 km
Area at base of embankment	551 ha	309 ha
Average depth of dead storage	2.72 m	3.23 m
Maximum depth of TW emergency storage	1.63 m	1.94 m
Average depth, dead + maximum emergency	**4.35 m**	**5.17 m**

Table K1 - TW proposed water depths for dead and emergency storage

This shows that Thames Water's planned volumes of dead and emergency storage fail to meet their own criterion for a minimum average depth of 5m for useable water. None of Thames Water's proposed emergency storage for the 150 Mm^3 reservoir would be useable because it would all have to come from an average water depth of less than 5m. Only 0.17m depth of the proposed 6,000 Ml of emergency storage for the 100 Mm^3 reservoir would be useable, equivalent to just 525 Ml.

Thames Water's emergency storage proposals ignore their own concerns about future water quality as stated in the main WRMP24 report[193]:

> *"By looking at the resilience of our raw water storage and supply network we have found that the change in algal bloom severity and duration is dependent on individual reservoir characteristics, including their physical structure and management. For example, deeper reservoirs have better control measures to manage the raw water quality and therefore are more resilient to the impacts of climate change.*
>
> *Nevertheless, as well as future raw water resource availability, the water quality challenge and how this may change in future climates is an important factor to account for in planning. Evidence indicates that the impact of climate change is increasing the range of species of algae that can cause a bloom event in our reservoirs and also increasing the period of year for which our reservoirs are at risk of algal bloom."*

Recognising the increasing threat of algal blooms and poor reservoir water quality, we propose that the allowances for dead and emergency storage should be:

- Dead water should be based on an average residual water depth of 5m

[192] WRMP19 Reservoir Feasibility Report, PDF pages 242-243 and 248-249
[193] TW WRMP24 main report, paragraphs 4.129 and 4.130

- Emergency storage should be 15% of live storage to be in line with Llyn Brianne, Clywedog and the Welsh Dee regulating reservoirs

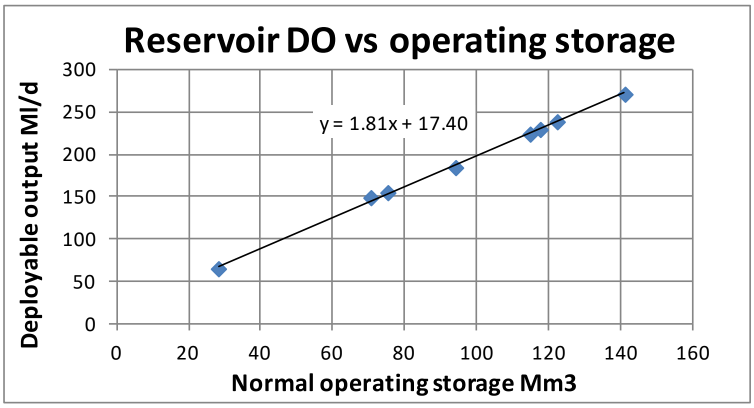
In our opinion, these would be reasonably cautious allowances to make, in line with the precautionary water quality measures being adopted for the STT, including the treatment of all transferred water at Deerhurst and high levels of treatment planned for Minworth and Netheridge effluent.

The reassessed dead and emergency storage volumes would then be as below:

GARD reassessment of dead and emergency storage	Nominal capacity 150 Mm^3 reservoir	Nominal capacity 100 Mm^3 reservoir	Comment
Gross storage	165,000 Ml	110,000 Ml	As per 2017 feasibility report
Dead storage with average 5m depth	27,570 Ml	15,460 Ml	Bottom area ha x 5m depth
Live storage, including emergency	137,430 Ml	94,540 Ml	Gross storage less dead
Emergency storage 15% of live storage	20,615 Ml	14,181 Ml	15% typical for regulating reservoirs
Storage available for normal operation	**116,816 Ml**	**80,359 Ml**	Live storage less emergency
Average depth of dead storage	5.0 m	5.0 m	TW stated minimum acceptable
Average depth of GARD emergency storage	3.7 m	4.6 m	Emergency storage ÷ bottom area
Average depth dead + emergency	**8.7 m**	**9.6 m**	Depth remaining at start of emergency

Table K2 - GARD reassessment of dead and emergency storage allowances

The relationship between normal operating storage and reservoir deployable output assuming median climate change is as below, using the same data from the SESRO modelling technical note as used in our Table K3 [194]:



Storage Nominal Mm3	Storage Normal operation Mm3	DO Ml/d
30	28.2	65.5
75	70.5	149.2
80	75.2	155.1
100	94.0	184.6
122	114.7	224.0
125	117.5	229.5
130	122.2	238.6
150	141.0	271.0

Figure K2 - Abingdon reservoir deployable output vs normal operating storage

Combining the changes in normal operating storage shown in Table K2 with the trendline relationship between storage and DO shown in Figure K2, the impact on Abingdon reservoir DO of GARD's proposals for dead and emergency storage is shown in Table K3:

[194] Technical Note Enhanced RSS Modelling of SESRO and Thames to Affinity Transfer Schemes, Table 6-1

	Normal operating storage			
Option	TW	GARD	Difference	DO reduction
150 Mm^3 reservoir	141,000 Ml	116,816 Ml	24,185 Ml	43.8 Ml/d
100 Mm^3 reservoir	94,000 Ml	80,359 Ml	13,641 Ml	24.7 Ml/d

Table K3 - Reservoir DO reduction with GARD proposed dead and emergency storage

With GARD’s proposals for dead storage and emergency storage, Table K3 shows that the deployable outputs for the 150 Mm^3 and 100 Mm^3 reservoir would reduce by 43.8 Ml/d and 24.7 Ml/d respectively.

Appendix L – Evidence for Abingdon reservoir freeboard

Section 4.5.5 of GARD's response to Thames Water's WRMP consultation is reproduced here in full
https://www.abingdonreservoir.org.uk/downloads/21.3.23%20GARD%20response%20to%20TW%20WRMP%2021.3.23.pdf

Design of the height of the Freeboard and the related issue of the protection of the inner face of the Embankment against wave-erosion

Figure 2.1 of the Conceptual Design Report shows Reservoir cross sections and indicates that the crest of the reservoir will have the following characteristics:

> Crest 8m wide with cycle/footpath, low
> wave wall available for seating. Crest level
> 1m higher than maximum water level.

As usual in the Thames Water documents on Abingdon Reservoir design, more attention is paid to the issue of where visitors will sit or ride their bikes than how safe the design is. As indicated in the section on terrorism above, the height of the crest above maximum water level is thought to be too low. This opinion has also been expressed by ex-Reservoir Panel engineers to whom we have shown the design.

Minimising the crest height is important to the aspirations of Thames Water because of the criticism of the imposing height of the Reservoir overlooking the surrounding housing, and the need to have launch sites for sailing and areas for fishing. It is GARD's view that these have been more important than the design to avoid wave overtopping in high winds.

GARD has consulted the design advice document from HR Wallingford relating to reservoir crest design,[195] In common with other sources, the design recommendations cover design against overtopping in a period of subjection to the "*50-year wind*", ie the wind conditions expected (from historical measurements) to occur once in every 50 years. At present, there are no clear predictions from climate change models about the frequency of high winds, so we adopt this standard. There are (SR459, equation 2.3) factors to apply to the wind values according to:

- the '*fetch*' or distance over open water of the wind before it reaches the retaining wall (as wind speeds up over open water) – this figure is significant for Abingdon reservoir, as there are distances of around 2.5 km or more over open water;
- the '*duration*' of the wind speed (20-30 mins is considered appropriate for reservoirs – the wind speed map being quoted as averaged over one-hour) – shorter durations give higher waves;

[195] *Reservoir Dams: wave conditions, wave over-topping and slab protection,* A J Yarde, L S Banyard and N W H Allsop, HR Wallingford report SR459 (1996)

- the ‘*altitude’* of the reservoir (wind speed maps are at ground level);
- the ‘*repeat time*’ of the significant wind (we take 100 years as reasonable considering the reservoir lifetime, but this only results in a 5% increase);
- the *‘direction’* of the prevailing wind, relative to the measurement direction (relative to 240°, or WSW) – this is irrelevant for an ‘all-round embankment like Abingdon.

The combined effects of these factors is to change the wind speed for consideration of the *significant wave height* from 20 m/s to 27 m/s (=U)[196]. From this, the significant wave height becomes (equation 2.6 of SR459)

$H = 0.00178\sqrt{F}/\sqrt{g}$ metres where F is the fetch length (metres) and g is the acceleration due to gravity (m/s^2).

Giving $H = 0.67m$.

SR459 considers that a factor for ‘*no wave surcharge carry over’* of 1.67 should be applied to the significant height giving a wave design height of 1.15 m.

This value can be lowered by facing the run up with rip-rap (as in the Conceptual Design) and, for a 1 in 6 slope (as CDR) with rip-rap a factor of 0.6 is used (figure 3.1 of SR459) leading to a final wave design height of H_D = 0.69 m.

If we take from SR459 fig 3.4, the value for ‘safe’ overtopping of the wall as 2 l/s/metre wall length, and apply formulae as in Box 5.3 of the document, we derive a freeboard height of around 1.5 m. This still seems low (and we should bear in mind the comments regarding Terrorist threats above), but is higher than the CDR value.

We make the following observations:

- even at this value ‘safe overtopping’ value, there would be an overtopping of around 7.2 tonnes (7.2 m^3) of water per hour over a 100m stretch of wall where the wind speed might exist – the downstream slope of the bund needs to take this into account;
- the freeboard height minimisation is heavily dependent on the use of rip-rap protection. This is foreseen in the conceptual design, but we note that the ‘brochure’ and ‘Facebook picture’ depiction of a smooth concrete slope for launching boats is at variance with what a rip-rap protected slope actually looks like. Sailing boat launching over a ‘rip-rap field’ of considerable extent with such a shallow slope would not be a simple task.

  Whilst these figures have been established in a relatively rudimentary fashion, we believe that WRSE and Thames Water need to justify explicitly their selection of a 1.0m

196 This corresponds to the upper end of Storm Force 10 on the Beaufort Scale. It is somewhat higher (10-20%) than the *mean* inland wind speeds recorded in the south-east in the October 1987 Storms.

high crest. We believe that this has been selected with leisure activities, rather than safety against high waves, in mind.

Appendix M – Evidence for Abingdon reservoir dam breach analysis

Section 4.5.3 of GARD's response to Thames Water's WRMP consultation is reproduced here in full https://www.abingdonreservoir.org.uk/downloads/21.3.23%20GARD%20response%20to%20TW%20WRMP%2021.3.23.pdf

Major Dam wall fault and Emergency evacuation/drawdown

The *Likelihood* of a major fault developing in a dam wall constructed under modern practice is regarded as '*unlikely' or 'rare',* but nevertheless given the *high impact* of such a fault, the *Risk* (as usually evaluated as a 'product' of *Likelihood x Risk*) has to be evaluated, and there is an obligation for owners proposing to build dams to establish the effects of a major catastrophic breach on the local population and infrastructure. Defra's 'Small Reservoirs Simplified Risk Assessment Methodology'[197] states that dams are classified as '*High Risk*' in the relevant legislation if they have an above-ground volume of greater than 10,000m^3. In this case the process has to involve the provisions of the Reservoirs Act of 1975, as cited in the WRSE text above. The 100 Mm^3 Abingdon Design has an above-ground water volume of at least 67 Mm^3 (taking the Thames Water quoted 'borrow pit' in the Conceptual Design), so it clearly is a '*High Risk*' facility within the terms of the Act. However, the DEFRA advice on assessing safety on 'small dams' (<25,000m^3 as defined in Defra's methodology) contains formulae and procedures which can be used to scope out the situation for larger dams. GARD has employed these formulae and procedures These formulae and procedures give an idea of the area and severity of damage for a catastrophic dam wall breach (as defined in Defra's methodology). The DEFRA procedure very quickly moves to recommend that:

> "*Larger dams are likely to have greater engineering input into their siting and design, such that this rapid screening would be of less value*".

In the absence of any published 'greater engineering input into … siting and design' regarding safety, the best GARD can do is to use DEFRA's Simplified Method to make an assessment of the risks and impacts of the reservoir ourselves.

The special issues which make the Abingdon Reservoir a higher-than-normal safety hazard regarding reservoir-wall breach are:

- the much longer perimeter impounding wall of this Reservoir (around 8.7 Km for the Abingdon 100 design) compared to most impounding wall dams[198];

[197]Defra Small Reservoirs Simplified Risk Assessment Methodology https://assets.publishing.service.gov.uk/media/603390fc8fa8f54334a5a673/small_reservoirs_simplified_risk_assessment_methodology_guidance.pdf

[198] Most earth dam wall reservoirs have only a front wall of only 400-500m. Even the only other comparable size reservoirs (Kielder and Rutland Water) have impounding walls of around 1 km length.

- the size of the above-ground water volume compared to the majority of reservoirs, exacerbating the length of the Emergency Drawdown, and period of Emergency evacuation;
- the issue of accelerating climate-change and its rising temperatures on the micro-fissure creation in the embankment;
- the relative proximity of some surrounding communities, especially when one considers the '*all-round*' nature of the possibility of a breach

Details of the procedure used are given in Appendix M1.

The procedure takes the simplified analysis developed by HR Wallingford for DEFRA.[199] The procedure uses equations from Frohlich,[200] and assumes for each breach position, that water flows out with a quantity (Q_p) over a width (W) as defined in the Froehlich flow with 'typical' friction applied to the flow. The procedure takes an extreme breach, but this is necessary to define what is the worst *deterministic* accident. In this sense, the DEFRA procedure has a similar philosophy to a Nuclear installation '*Design Basis Accident*'[201], an assessment necessary to define the off-site consequences, and hence precautions, for a catastrophic incident.

The procedure has been used to establish the quantity DV (Depth x Velocity) of the flow from a catastrophic breach opposite various communities around the Reservoir. The value of this parameter would then be used in the DEFRA procedure to establish level of casualties in each location (assuming no warning).

As GARD's calculations are still in a relatively simple form, we do not intend to publish detailed maps of the calculated flooding/damage/fatalities. However, we note our main conclusions from Appendix M1 are:

5. Several locations are at '*High Risk*' (defined as DV > $3m^2$/sec) from a breach, as to be expected, these locations are the 'perimeter communities' nearest the Reservoir crest (the edges of Steventon, East Hanney and the South Drayton houses south of the A34).***The situation for these communities should be modelled by Thames Water with some urgency.***
6. Many locations can be defined as safe from either flood or damage, by simple equations considerations and on examination of the area contour map. Most of this

[199] H.R.Wallingford Ltd. 'Small reservoirs simplified risk assessment methodology: Guidance Report. '(2014) and 'Research Report '(2013), For DEFRA and the Environment Agency.

[200] Froehlich, D.C. (1995) Peak outflow from breached embankment dam. *ASCE Journal of Water Resources Planning and Management* 121(1), 90-97.

[201] Essentially, if something *can happen* this DEFRA analysis assumes it *will happen*, irrespective of probability.

‘safe’ labelling arises because of the inability of even catastrophic flood to flow a significant distance ‘uphill’.

7. There are areas where ‘*Medium Risk*’ (3 > DV > 2 m^2/sec), or ‘*Flood risk*' (without fatality) where DV is less than 2m^2/sec but greater than zero. These are, in general, communities at a greater distance than the peripheral communities, but where the water from a breach in general has to flow ‘downhill’. The situation with such communities, given the duration of the flow from a catastrophic breach (over 3 hours) is such that flooding, without high damage, cannot be ruled out. ***The situation for these communities should be modelled by Thames Water with some urgency.***

8. Finally, there is a very significant set of communities where the flood water will have to flow via the River Ock and into the Thames. Appendix M1 makes comments about these (South Abingdon, Culham, Sutton Courtenay, Appleford). These communities will almost certainly be in the flood-affected zone, but the situation, with curved trajectories, and with competing gravitational acceleration of the flood fighting against a complex friction force slowing over variable terrain and through built-up

   Areas, is simply too complex for the models used in Appendix M1. Indeed, Appendix M1 procedures are emphatically ***not*** the way of addressing the problem. ***The situation for these communities should be modelled by Thames Water with some urgency*.**

The problems outlined in 1-4 above and in Appendix M1 can only be, and should already have been, addressed fully by Thames Water in consultation with qualified reservoir engineers. It is their responsibility to define the extent of risk and provide appropriate mitigating design features and procedures. We see no sign of that happening.

The communities covered in paras 1,3 and 4 above will almost certainly lie in the Reservoir Flood Risk Area, as defined in the EA’s maps.[202] It is these areas which would have to be evacuated in the event of a major fault being detected. Such an event happened in the case of a much older earth dam at Whaley Bridge, Derbyshire[203] in 2019. The 1500 population of the town of Whaley Bridge spent 6 days out of their homes whilst the threatened breach was made safe.

From the initial studies, given in more detail in Appendix M1 the communities in the ‘long list’ in danger of some level of flooding or damage from a major breach somewhere around the ‘Abingdon 100’ perimeter, would include Steventon, East Hanney, Drayton, Marcham, Milton, parts of South Abingdon, Culham, Sutton Courtenay and Appleford.

All the communities listed in the ‘long-list’ are expected to be in a potential Flood Risk

[202] https://check-long-term-flood-risk.service.gov.uk/map
[203] https://www.bbc.co.uk/news/uk-england-derbyshire-53580768

Area.[204] Flood zones for major reservoirs can be very extensive. The figures M1(a) and M1(b) show the area for Rutland Water, taken from the Gov.uk site.

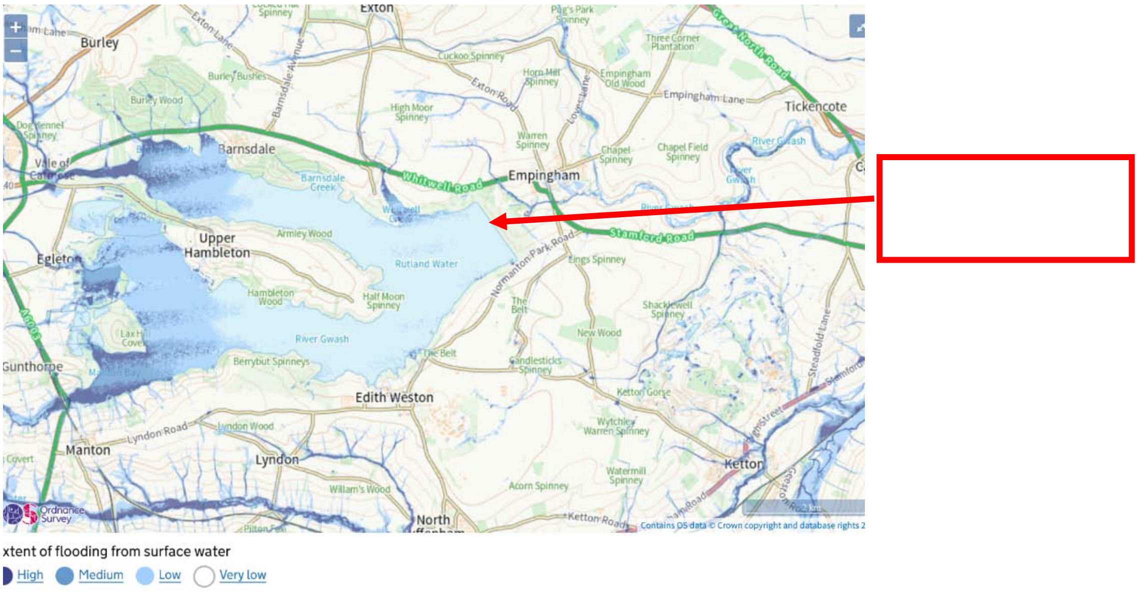


Figure M1(a) - Rutland Water: showing areas susceptible to river flooding (source [https://check-long- term-flood-risk.service.gov.uk/map](https://check-long-term-flood-risk.service.gov.uk/map))

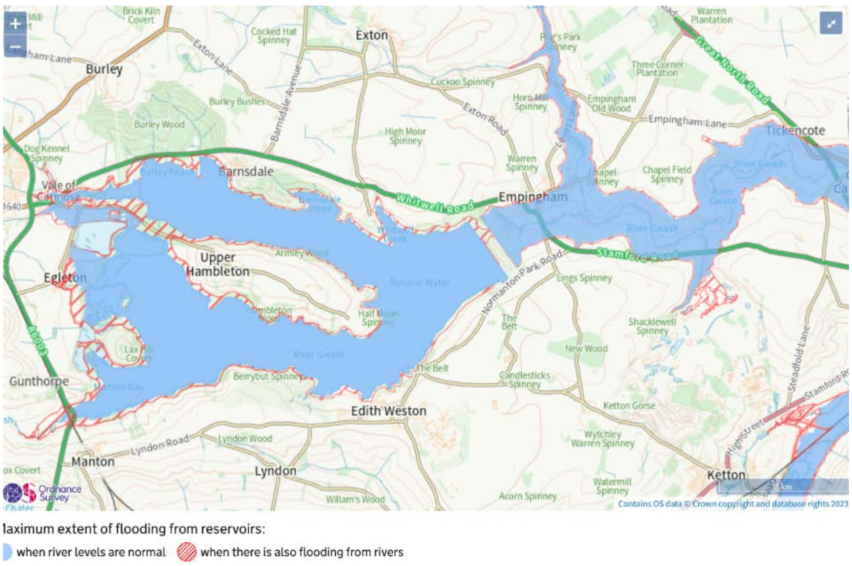


Figure M1 (b) - Rutland Water: showing areas in the Reservoir Flood Risk Area (source as Figure M1(a)). Note this map only shows the zones within a radius of around 5 km – the risk area extends for a considerable downstream distance.

The evacuation duration for a community threatened by the major breach would be potentially long (the Whaley Bridge episode lasted much longer than anticipated). At an

[204] Clearly, a breach would affect communities in an arc opposite the breach, thus a breach opposite South Abingdon would leave Steventon, East Hanney, and Milton largely unscathed, but the Flood Map must take into account all possible locations.

Emergency Drawdown rate of 1 m per day, as quoted above, it would take 10-15 days to bring the Reservoir water level to something which could be regarded as safe. Thus, in the worst case, 10-20,000 people would have to be provided with emergency accommodation for up to a fortnight. ***GARD is calling for a full assessment of the Flood Map to be made before the Reservoir is allowed to pass the RAPID Gate 2 process.***

Emergency Drawdown capability

As a corollary, we note that the amount of water passing through the pipes in an emergency drain-down is around 63 m^3/sec, assuming a 1 m per day drawdown of the 100 Mm^3 reservoir. This is more than the natural flow-rate of the Thames at Sutton Courtenay for about 85% of the year.[205] Indeed, if the flow were released between December and March, about 20% of the time the resulting flow in the Thames would be close to historical maxima, and flooding would almost certainly result. Thus, the flooding effect of the Emergency Drain-down itself needs evaluation at this stage.

The issue of Emergency Drawdown itself cannot be taken as a solved problem for a Reservoir as large as Abingdon 100. Rutland Water was commissioned in 1975. In 2005 a study[206] concluded that the Emergency Drawdown should be 50% in 10-20 days. By 2011, the calculations on the Emergency Drawdown system for Rutland Water concluded drawdown would take 75 days. The situarion was not rectified until after 2016. Thus the Emergency Drawdown of one of the most modern dams in England was inadequate for at least 40 years. This shows the dangers of not considering the safety systems at an early stage.

[205] https://nrfa.ceh.ac.uk/data/station/meanflow/39046
[206] https://britishdams.org/2012conf/papers/Construction-newdamsandupgrades/Papers/6.6%20Tam%20-%20Improving%20Anglian%20Waters%20emergency%20response%20for%20reservoir%20safety.pdf - references therein.

Appendix M1: DEFRA Reservoir flood assessment – Simplified Method

Applied to the proposed Abingdon Reservoir

Items enclosed within black borders are directly taken from the relevant DEFRA publications[207], which were produced by DEFRA's water engineering consultants HR Wallingford Ltd. All flood spreading and flow equations used in this appendix were developed by HR Wallingford Ltd.

DEFRA's Guidance Report defines the following Risk Category table:

Table : Typical reservoir risk classification types

Risk Category	Typical reservoir types
High	• Reservoirs in dense urban areas • Reservoirs with high dams (>5m) or large volumes of water (>100,000m^3) • Reservoirs perched on hillsides above properties
To be determined	• Any reservoir where it is not immediately obvious that it could pose a danger to people and property if the dam were to fail suddenly **Use this guide to help you better understand the risk posed by your reservoir**
Not high	• Reservoirs in remote or rural areas • Reservoirs with low dams (<2m) or small volumes of water (<10,000m^3) • Reservoirs surrounded by flat land far away from any properties

The proposed Abingdon Reservoir, with a dam height of ~20m and a water volume of at least 67Mm^3, falls immediately into the **High Risk** category, without further consideration. DEFRA also note, in the same document that;

It was decided that the size of reservoir covered by this project would be reservoirs not exceeding 100,000m^3, and dam height not exceeding 10m, on the basis that:

- ·This is a typical range of size of new small reservoirs;
- ·Larger dams are likely to have greater engineering input into their siting and design, such that this rapid screening would be of less value.

In the absence of any published 'greater engineering input into … siting and design' regarding safety, the best GARD can do is to use DEFRA's Simplified Method to make an assessment of the risks and impacts of the reservoir ourselves. This Appendix investigates, at successive levels, what High Risk equates to in terms of impact on local communities, as estimated by DEFRA's Simplified Method. DEFRA define 3 High Risk tests[208]

[207] H.R.Wallingford L.t.d. 'Small reservoirs simplified risk assessment methodology: Guidance Report. '(2014) and 'Research Report '(2013), For DEFRA and the Environment Agency.

[208] Binnie & Partners, (1991) *Estimation of flood damage following potential dam failure: guidelines*. 1989 Report for DOE. FR/D 0003. Foundation for Water Research, Marlow.

Test 1 uses an approach defined by the Health and Safety Executive (HSE) as the risk to an individual person, and is based on research undertaken on the depth and velocity of flows that would cause structural damage to houses (Binnie 1991). Tests 2 looks at the extent of the flooding, and Test 3 looks at the combined risk to the society or community downstream.

We note that there is also a 'High Risk Additional Test' which evaluates the impact on critical infrastructure and the environment, which we shall also briefly address.

DEFRA require the risk assessment to assume 'catastrophic failure' in order to quantify a breach in the 'dam wall' and the resulting rate of water flow through it; after a number of breach simulations by computer they conclude;

Runs undertaken using a range of erodibility considered applicable to the UK shows that certain reservoir combinations, and in particular small non-impounding reservoirs built of high plasticity clay, are unlikely to erode at a rate that would lead to a catastrophic failure.

However, as this project relates to government regulation of dam safety it has been agreed with Defra that the Guide would provide peak breach flows resulting from catastrophic failure for all dam sizes. This is in effect acknowledgment that at any individual dam there may be site specific failure modes that could lead to rapid failure (for example, physical damage by digger, aircraft impact etc.), and that to demonstrate beyond reasonable doubt that none could lead to catastrophic failure at a specific dam it would be necessary to carry out a full failure modes analysis for all credible failure modes. For the purposes of this project, catastrophic is defined as a time base for the breach hydrograph similar to that for a breach hydrograph defined using Froehlich (1995).

Which leads to the following definition of the peak flow rate Q_p released from the reservoir[209];

Example of the Environment Agency RIM method for calculating the potential release of water from a reservoir

The reservoir flood risk maps are created from numerical modelling of potential flood flows. Prediction of the catastrophic release of water from the reservoir is made by assuming reservoir conditions and applying a simple formula for predicting how large the rate of release of water might get.

The Environment Agency assumes that at the point of failure, water levels in the reservoir will be above the dam crest level by 0.5m. The height of the dam plus 0.5m is then used in the following equation, along with the estimated volume of water stored when the water level is at crest level plus 0.5m:

$$Q_p = 0.607 V_w^{0.295} H_w^{1.24}$$

Where:

Q_p	Peak flow rate released from the reservoir
V_w	Volume of water stored above ground level at the time of failure
H_w	Height of the water level above ground level at the time of failure

This equation (Froehlich, 1995) is based upon analysis of historic dam failures. It provides an approximate estimation of potential flow rate, but does not take into account site specific dam and topographic features. It therefore provides an initial estimate for consideration and emergency planning, rather than an exact prediction.

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209 Froehlich, D.C., (1995) *Peak outflow from breached embankment dam*. ASCE Journal of Water Resources Planning and Management 121(1), 90-97.

For the Abingdon Reservoir in flood V_w ~ 94M m^3 and the flooding 'dam crest level' is ~20.5m.[210] With those values, the above equation for the estimated peak flow rate gives

$$Q_p = 0.607 \times 224.9 \times 42.32 = 5778 \ m^3/sec$$

We note that this is an <u>average</u> value for Q_p and, for a specific community, the base height at the reservoir crest closest to that community may differ from the average, leading to a different H_w, V_w and Q_p; this important detail is addressed later, below.

<u>High Risk Test 1</u>

Test for determining high risk		Comments
Test 1 - Force of inundation	If the velocity of the flow of water escaping from the reservoir, multiplied by the depth of water at an individual house is high enough to cause structural damage to the property, the reservoir is high risk. This is taken to be greater than $3m^2/s$.	This is not necessarily the first house downstream of the reservoir. The velocity of the flow of water can increase if the valley narrows or steepens further downstream.

> In a detailed analysis it would be the depth and velocity of water at the individual house (or other occupied space) that would be used in assessing risk. However, for this simplified screening method detailed ground levels and thus variation of flood level across the flow path are not available, so instead the maximum depth and average velocity across the flow path are used for Test 1.

DEFRA use a simplified flow model, where the water spreads over a horizontal angle of 45 degrees (Ω = 0.79 radians) in front of the breach, so at distance r from the breach the flow front has flooded width $W = \Omega r = 0.79r$. The average depth-velocity (DV) across the flooded width is Q_p/W, but the local depth varies between zero at the left and right extremes of that flooded width, reaching a maximum in the centre of the flow front, directly opposite the breach. That maximum is taken as $1.5Q_p/W$ in DEFRA's simplified method (shaded paragraph above).

DEFRA's *flow equations* for computing the velocity v(r) and the depth d(r) at distance r from the breach are;

$$d = \left(\frac{13}{3}\frac{n^2 Qp^2}{\Omega^2}\right)^{3/13} r^{-3/13}$$

$$v = \sqrt{\frac{3}{13}} d^{7/6} n^{-1} r^{-1/2}$$

[210] Assuming a 'borrow pit' volume of 33M m^3 below ground level, leaves ~94M m^3 up to flooding crest level.

and include the (Manning's) Friction coefficient 'n', which is tabulated below. Note that the above 2 equations multiply to give (after some algebra) d x v =

$$DV = Q_p /(\Omega\ r) = Q_p / W \qquad \text{(the \textit{spreading equation})}$$

so the above factor 1.5 must be applied to this DV for Test 1.
Note also that 'n' cancels in the multiplication of d by v, so friction does not change the resulting DV; increasing friction reduces v and therefore increases d, so that DV at fixed r remains constant and unaffected by friction, but new communities at slightly higher altitudes may become vulnerable as a consequence of that change.

Type of surface of surrounding land	Friction coefficient, n
Bare soil (agricultural land)	0.020 – 0.040
Short grass (tended playing fields)	0.025 – 0.035
Long grass (wild meadows)	0.030 – 0.050
Woodland (forest)	0.080 – 0.120
Concrete and tarmac (urban areas)	0.012 – 0.017

Since the areas between the Abingdon Reservoir and nearby towns/villages are mainly open fields, with a few roads but little woodland/forest, We take a value of n intermediate between the minimum, 0.02 for bare soil and the maximum, 0.04 for agricultural land and long grass or meadows: n = 0.03 .

The critical High Risk depth-velocity is DV=3 m^2/sec, (e.g. 3m deep water moving at 1m/sec). With no flood warning it leads to a fatality rate of 3% and a building destruction rate of 20%; DV=7 m^2/sec (e.g. 3.5m deep water at 2m/sec) leads to 16% fatalities and 100% building destruction. At DV=20 m^2/sec the fatality rate is 100%. These DEFRA figures are based on many studies of actual dam and reservoir failures, and fatalities, at those observed DV rates (see High Risk Test 3, below).

Assuming a flat environment, DV=3 can be converted into a critical distance Rc, within which all communities are at High Risk, given the above Q_p=5778 m^3/sec, n=0.03 and averaging over the perimeter of the reservoir. The result is DV>3 within Rc = 3.7km from the breach. (This simple average will be replaced by a location specific Rc when the risks for specific communities are analysed in section B5).

Communities within that range include Steventon (population 2268)[211], Drayton (2987) and East Hanney (1070) and, with >20% chance of buildings being destroyed, the Reservoir fails High Risk Test 1 and we need go no further according to DEFRA. However, since there seems to be no 'greater engineering input' available to carry the study further, we will continue to the next level of DEFRA tests.

[211] Population figures, taken from official sources, may not be the most recent so are approximate.

High Risk Test 2

Test 2 - Extent of Inundation	If more than 200 people (~83 houses) or 20 businesses would be flooded by the escaped water from the reservoir, the reservoir is high risk.	Within the flood outline from the reservoir count the number of properties and businesses within the flooded area in order to estimate the number of people that could be affected. (See Note 1.)

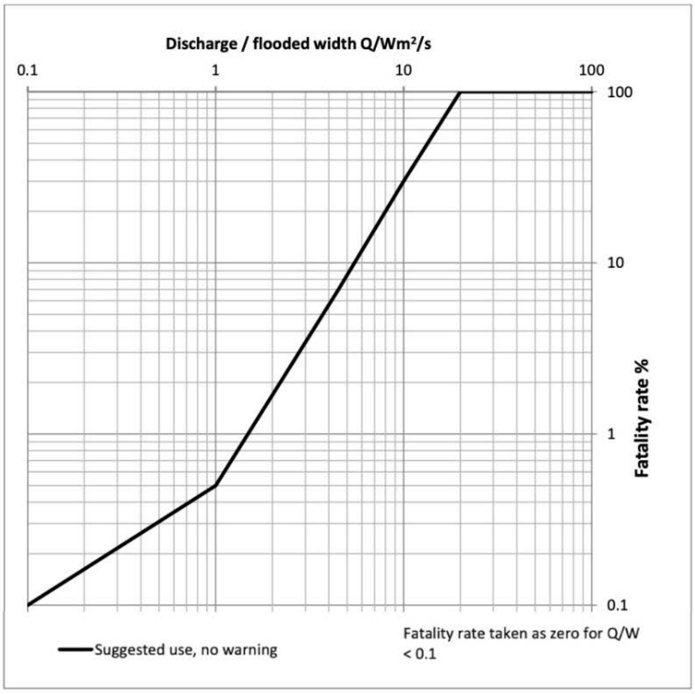
Note that this test considers the whole community affected by the flood from the breach, not just those facing the centre peak of the flood. Thus the average depth across the flood front is used, and the factor 1.5 multiplying depth in the previous test is dropped. This test concerns which communities the flood water reaches, without specific focus on damage to property of injury to individuals.

Several communities would be flooded, apart from those above at identified High Risk, including Marcham (population 2470), Milton (1396), Abingdon (34569), Culham (453), Sutton Courtenay (2952) and Appleford (250), which again (unsurprisingly) confirms the Reservoir as High Risk.

High Risk Test 3

Test 3 - Likely Loss of Life	If the combined risk to life (the 'Likely Loss of Life' or LLOL) within the flood is greater than 1.0 fatality, the reservoir is high risk.

Figure is taken from the Interim Guide (ICE, 2004) with the suggested line being for no warning and being a best fit to observed fatalities in flash floods and dam failures provided in the US Bureau of Reclamation Report no DSO -99-06.



Fatality rates for Q/W (no warning)

Using the above figure and the computed Q/W for any location within the DV=3 High Risk zone enclosing the Reservoir, it is possible to estimate the LLOL for every affected community. Suffice to say that, with a number of nearby villages in that zone (see High Risk Test 1) with a fatality rate > 3%, the average LLOL from a single breach is significantly greater than 1 so the Reservoir fails High Risk Test 3. Specific cases will be considered in section B5.

<u>High Risk Additional Test(s)</u>

Additional Test(s)	There may be other unusual factors that can lead to a high risk designation such as the potential damage to critical infrastructure or the environment. The Environment Agency will consider all such factors on a case by case basis.	This could for example include destruction of a busy road or railway line with a moving population, or the destruction of a chemical plant leading to the release of a hazardous substance.

The proposed Abingdon Reservoir will be surrounded by major roads (A338, A34, A415, A417) and the London-Bristol railway line, all potential ‘moving populations’ within the DV>3 High Risk zone, and the Reservoir itself would constitute <u>critical water resource Infrastructure</u> if we believe TW/WRSE’s justification for its construction. Thus the Reservoir also fails the High Risk Additional Test(s).

Specific Cases of High Risk

The DEFRA analysis outlined in B1 above uses DEFRA's *spreading equation* to compute DV and explains how 1.5xDV>3 is the zone of High Risk to individuals and buildings. We define DmaxV = 1.5xDV in what follows. DV reduces in proportion to 1/r as the flood moves away from the breach. We invert that equation to obtain the distance (call it Rc) within which DmaxV is greater than 3 m^2/sec. The result is

$$Rc = Q_p / (2\,\Omega)$$

We compute Q_p for any point around the mapped crest of the Reservoir and project outwards from a model breach at that point by the above distance Rc. The result is the dotted black boundary shown in the following Figure B1.

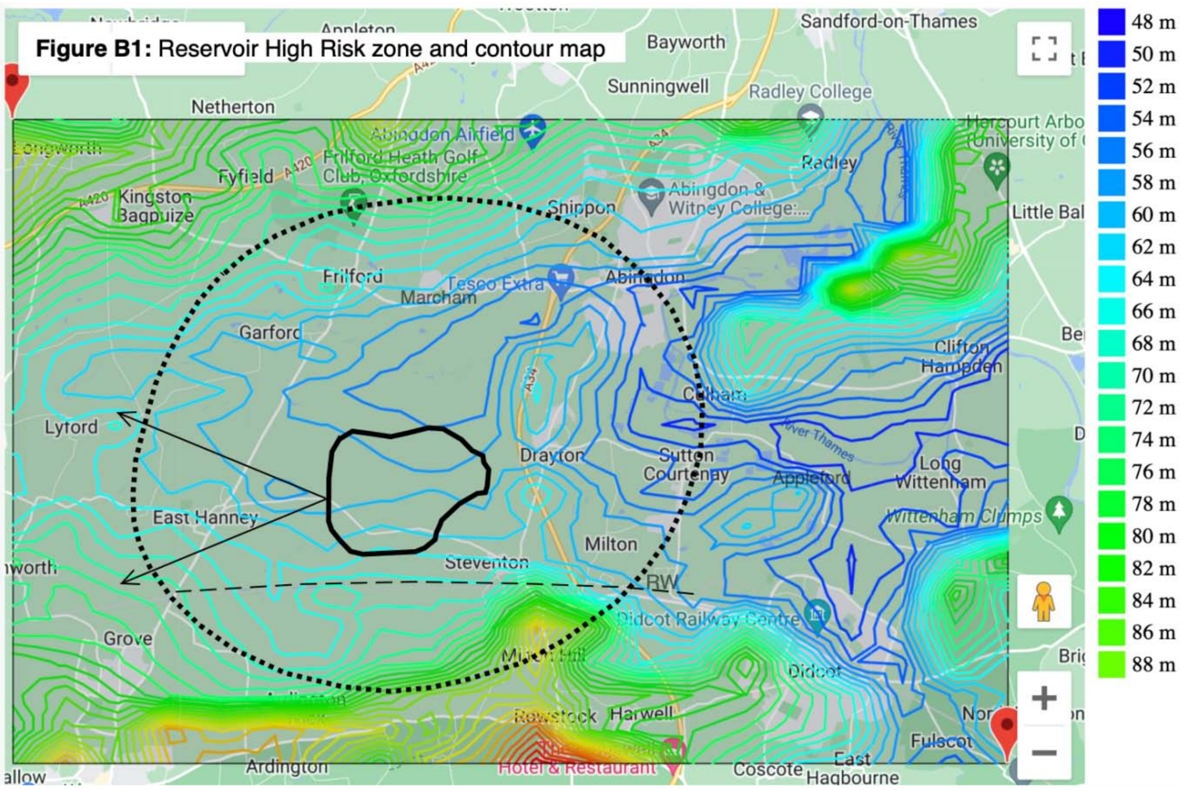


Figure B1: Reservoir High Risk zone and contour map

Every location within that boundary is potentially at High Risk with DmaxV >3 m^2/sec. The figure also includes the Reservoir's crest (solid black boundary[212]) superimposed on a contour map of the region (altitude contour colour coding on the R). The flow zone from a breach opposite a single community (e.g. East Hanney) is also shown; the model flood water moves in the direction of and between the two arrows, with opening angle Ω = 45 degrees.

Communities outside the High Risk zone and at higher altitude than the Reservoir may be safe. Altitudes above 78m, the altitude of the water surface in the flooding Reservoir, are certainly safe. Those above 68m are also safe according to DEFRA's simplified model as explained below.

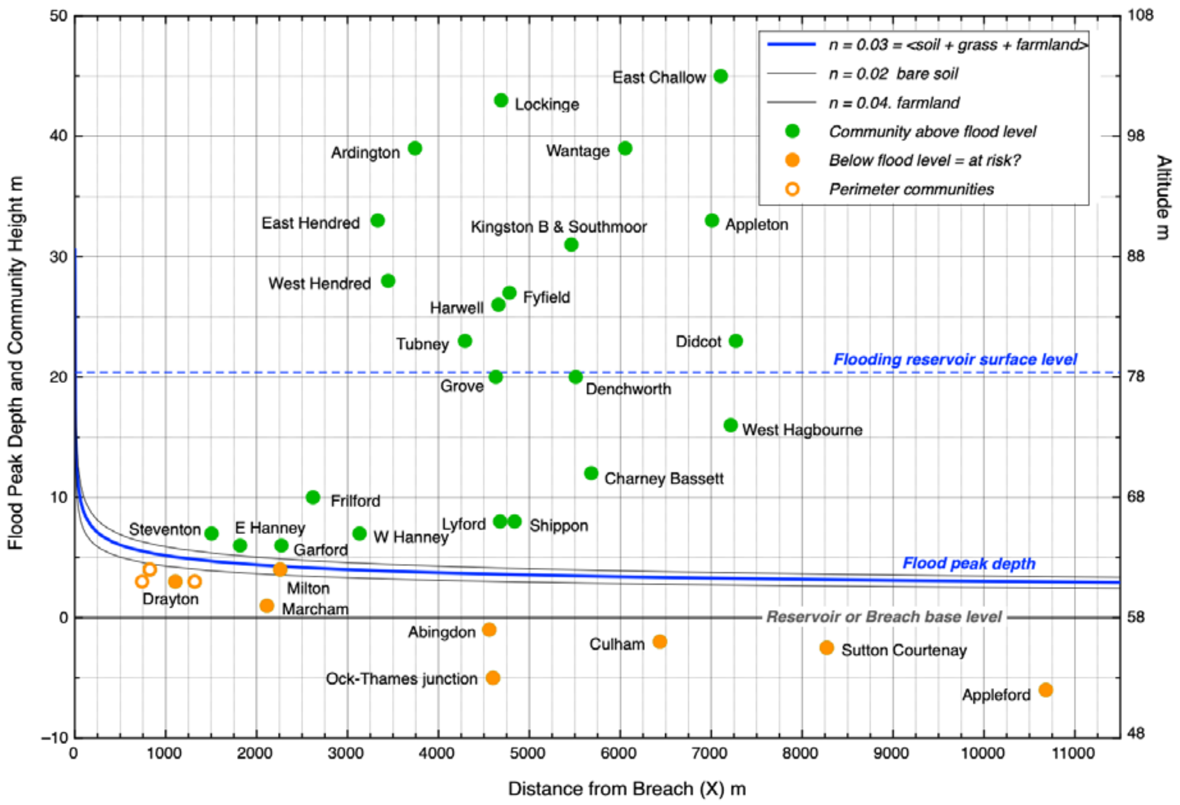
[212] Thames Water and Affinity Water. South East Strategic Reservoir Option (SESRO) Supporting Document A-1: Concept Design Report (2022); *Appendix A.3 Indicative layout plan - 100 Mm^3 capacity reservoir; Drawing Title: Site Overview 100Mm^3 Option.*

Communities outside that zone but at lower altitude than the reservoir (lower than 58m, dark blue contours) may still be in danger (South Abingdon and downstream Thames villages) and ***their risks must be properly addressed by Thames Water, because the Thames valley topography is too complex for the DEFRA Simplified Method we apply here***.

We now consider a vertical projection of the problem in order to further isolate and identify those communities that are most at risk, by excluding those whose altitude is above the flood's surface.

The following Figure B2 shows an overview of all communities possibly affected directly by a breach of the Reservoir. It uses the above DEFRA analysis to display (solid blue line, LH scale) the peak depth (i.e. average x 1.5) of the floodwater as a function of distance (X) from the breach in the reservoir wall. The central point of each community is shown at its distance (X) to the closest point below the Reservoir crest, with its height above the nominal base level of the Reservoir on the LH scale and its altitude above mean sea level on the RH scale:

Figure B2: Flood Peak Depth & Community Height vs Distance from Breach



The displayed depth is computed for the average breach with the flood progressing over flat terrain and takes no account of possible obstructions to flow, such as major roads or local topography. It is intended to be indicative only, allowing us to eliminate those communities not at High Risk, in order to focus on those most at risk. With those qualifications, communities above the peak flood level, which are Indicated by a green marker, are unlikely to be flooded at High Risk; communities below the peak flood level, indicated by an orange marker, are likely to be directly affected by the flood and might be at High Risk.

To err on the side of caution, after also studying possible variation in depth due to friction (the thin black lines) and the fact that a community typically spans a range in distance and altitude, we identify those communities above 68m altitude as out of danger, and concentrate on those below and including Frilford.

Of those communities we choose the three which are closest to the Reservoir crest, with flat open fields and no obstruction to the flood between breach and community, for which DEFRA's Simplified Method is most appropriate. Each of them is on the perimeter of one of the named communities on the above plot and they are represented (but unnamed) there by the open orange circles: 'West' Steventon, 'East' East Hanney and 'South' Drayton.

For each community the distance and <u>base altitude</u> of the closest possible breach point are determined[213], these are used to define community specific values of H_w, V_w and Q_p , and the resulting flood is transported <u>at that base altitude</u> to the target community, using the DEFRA procedure above. The effective flood depth D'max at the community is then defined by subtracting the height of that community from the peak depth of the flood water and this is used to compute an effective D'maxV for estimation of risk and impact.

The results are shown in the Table B1 below:

These perimeter communities each consist of dozens of houses, every community having a

Table B1: Flood model results for perimeter communities.

Location	X m	Altitude m	Br Altitude m	Hw m	Vw Mm3	Qp m3/s	W m	DV m2/s	D m	V m/s	Dmax	D'max	D'maxV	D'(V=0)	Alt-Altbr	%Fatal
E.East Hanney	1319	61.0	59.0	19.4	89.9	5325.7	1055.3	5.05	3.11	1.62	4.66	2.66	4.32	2.79	2.00	6.3
W.Steventon	825	62.0	61.0	17.4	80.6	4506.5	665.4	6.77	3.21	2.11	4.81	3.81	8.05	4.04	1.00	20.2
S.Drayton	740	61.0	60.0	18.4	85.2	4910.2	599.6	8.19	3.42	2.39	5.13	4.13	9.89	4.42	1.00	29.4

population of order 60, so that the likely loss of life in a single breach (unwarned) would be about 11. For an unexpected catastrophic breach the time to first impact of the flood-wave at those 3 communities would be very short,

E.East Hanney 8 minutes ; W.Steventon 4 minutes ; S.Drayton. 3 minutes

So unless the warning anticipated the breach there would be little time for residents to save themselves.

Other 'orange' communities on the above plot are also likely to be at risk, but calculation of flood impact for them is more challenging, due to topographic features e.g. the flood must cross the river Ock to reach Marcham. Man made obstructions, such as the A34 will also shield some communities, but at the expense of others (including those in vehicles on the A34), as the obstruction diverts or slows (deepens) the flood. However, the shielding will be temporary, since the water will eventually find its way, following natural watercourses, into the Thames.

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[213] Distances measured by https://www.google.co.uk/maps/ , Altitudes using https://routecalculator.co.uk/elevation

Catastrophic breach of the Reservoir's N embankment would release at least 94M m^3 of water at about 6k m^3/second in the direction of Marcham and Abingdon. When that flow enters the Thames at the Ock-Thames junction, it might exceed the average flow at Abingdon by a factor of over 200, with potentially disastrous consequences for residents around St Helen's Wharf and Caldecott. Even as far as Appleford-on-Thames the effects of a breach will certainly be felt, gravity assisting the water down the 7.7m fall in 10.7km along the Thames valley, flooding St Peter's and St Paul's Church, which is only 200m from the Thames and ~1m above it. DEFRA's procedures are too simplified to accurately predict D and V down a complex valley, at that distance.

The problems outlined in the last paragraph and this appendix can only be, and should already have been addressed fully by Thames Water in consultation with qualified reservoir engineers. It is their responsibility to define the extent of risk and provide appropriate mitigating design features and procedures. We see no sign of that happening.

Appendix N – Evidence of terrorist threat to reservoir security

Terrorism as a threat to the Reservoir security

The issue of a terrorist threat to the Reservoir, as to all water infrastructure, is not something that should be taken lightly. One would expect Thames Water to have sought advice on this from the relevant authorities, even at this stage. Whilst one might not expect the advice to be made public, there are nevertheless aspects which one would expect to see informing the Conceptual Design, even at this stage. The most important of these aspects, from the point of view of Thames Water trying to paint the Reservoir as part of a 'Best Value Plan' relate to the effect on visitor access to the Reservoir site, something which figures heavily in Thames Water's attempts to attribute positive '*Natural Capital*' outcome to constructing the Reservoir. As was admitted in the RAPID Gate 1 documents for the Abingdon Reservoir[214]

> The reported positive change in natural capital value is primarily due to the significant increase in Recreation value expected for the site, which outweighs the decrease in ecosystem value of food production – although improvements in all the other services are also reported in comparison to the baseline, without recreation they are insufficient both alone and in combination to outweigh the loss in Food production value;

The positive Natural Capital assessment is essential to the Best Value argument, and even more to Thames Water's attempts to spin a positive view of the Reservoir (always seen in juxtaposition with pictures of sailing boats).

There are occurrences of the access to the London Thames Water reservoirs for sailing being restricted at the height of the IRA campaigns in the 1980s. GARD has taken advice from an expert in counter-terrorism issues relating to Infrastructure. Although this briefing is 'off the record', we include the outline of it here as part of GARD's Thames Water response. From now we would like to note:

1. The ***National Risk Register*** *rates* potential hazards such as diseases, major accidents and societal risks in terms of their *Impact (I)(Severity) and likelihood (L)(probability*) in terms of a 5 x 5 matrix with 1 being the lowest score and 5 the highest. The current National Risk Register[215] rates an attack on infrastructure as I = 3 and Likelihood of L = 2. UK Govt definitions are not stated in the document but typically:

2. An impact score of 3 would indicate limited loss of life, structural damage and long-term delays to delivery. A Likelihood score of 2 would suggest that such an event would be unlikely to occur but there are examples of this sort of event. This would suggest a risk score of 2 x 3 = 6, a typical definition would suggest that the risk is ***tolerable*** where resources are not available to treat or mitigate (but ***the risk should***

[214] https://www.thameswater.co.uk/media-library/home/about-us/regulation/water-resources/strategic-resource-solutions/new-reservoir-in-oxfordshire/environmental-assessment-report.pdf – sect 11.1.5, p 163

[215] UK_National_Risk_Register_2017.pdf

be entered into an appropriate risk register for future treatment/mitigation)[our emphasis].[216] It is intended to allow recreational sailing (and fishing) in the reservoir. Of concern is the vulnerability of the bund. Particularly of concern would be a Vehicle Borne Improvised Explosive Device (VBIED) this could be say a 500kg device of Home-Made Explosive

3. [Referring to the Conceptual Design Report – fig 2.1]***,*** a freeboard of 1.0m looks inadequate, more appropriate for a dam on a rural farm (we shall further discuss this below). Although a legitimate terrorist target, the risk would be assessed as low (currently) and *terrorist considerations alone would not preclude construction*. Having said that a medium sized VBIED could easily cause a breach at the dam crest, with subsequent rapid erosion of a section of the downstream earthfill and total embankment breach, with resulting loss of life and publicity and so sensible mitigating features should be included.

Recreation is seen as a key benefit. However, even if the project assessment requires that boats should be able to be launched and recovered from the bund, the Terrorist threat considerations could well specify this should be done only from specific locations and that, ***apart for maintenance, vehicles should not be permitted on the bund*** Access to vehicles and plant onto the bund could well be physically restricted, and any slipways provided should be designed to prevent breach from a VBIED and access controlled: this would be a challenge.

GARD's view is that the Freeboard of the bund is indeed too low in the current design (for the issue of wave-overtopping in high winds, as discussed in section 4.5.5). It is also our view that the issue should be investigated and that the project's Natural Capital assessment, and social use definition ***must*** be settled, including the knock-on effects on design and cost, before the project is allowed to pass through this stage of either the draft Regional Plan, the dWRMP24 or the RAPID Gate 2 process.

[216] Note that this risk is to infrastructure in general and not specifically for water related assets.

Appendix O – Evidence of flooding safety of the Abingdon reservoir

Introduction

The Gate 1 report on Abingdon reservoir claimed that the latest flood modelling showed the reservoir would lead to a reduction in flood risk for Abingdon.[217] It is difficult to see how this could be the case, particularly as Thames Water had not (and still have not) released this modelling. In the Thames Water WRMP19 submission back-up reports, the reservoirs above 75 Mm^3 size received 'Red' ratings[218] as it was stated there was insufficient flood storage area on the reservoir site to compensate for the loss of floodplain.

An examination of the Gate 2 reports show that the situation has not moved forward significantly, in spite of local calls for a rigorous examination of flood-risks. This is of course, mainly Thames and Affinity Water's faults, but is also just one example of the lack of response by RAPID to stakeholder concerns.

The real problem, of course, is that there is still an approach, even at this stage where a 'conceptual design' is claimed, that is dominated by modelling. As the '*Conceptual Design Report*' says (para 4.30 and 4.31)[219] :

> *"To allow updates to the fluvial flood modelling in Gate 3 it is recommended that a topographic survey along the main watercourses is carried out. This would include sections of the River Ock and key tributaries that are within the model extent. River gauge flow monitoring at selected locations across the model extent is also recommended.*
>
> *A range of flood return periods and durations would need to be considered in the Gate 3 modelling. Therefore, the basis for the hydrology should be agreed with the Environment Agency. This would also include for potential future changes to climate change uplifts."*

Further down, on *Groundwater Flood effects*, the CDR admits[220] (para 4.35):

> *'There is considerable uncertainty in the conceptual understanding of groundwater flows and hence the modelling that has been undertaken to date, which is not informed by observation data.'*

The document also recommends taking measurements (para 4.36)[221]- it recommends:

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[217] https://www.gard-oxon.org.uk/downloads/july%202021%20-%20gate-one-submission-sesro.pdf – downloaded November 2021.

[218] Thames Water WRMP19 Resource Options. Reservoir Feasibility Report, Appendix V, July 2017 – but re-released July 2018, Thames Water Utilities Ltd . Appendices R, S and T

[219] Thames Water and Affinity Water. South East Strategic Reservoir Option (SESRO) Supporting Document A-1: Concept Design Report (2022) "CDR" paras 4.30 and 4.31

[220] CDR para 4.35

[221] CDR para 4.36

- *“Observation boreholes are installed or recommissioned to monitor groundwater levels in the superficial deposits and Lower Greensand aquifers.”*
- *“Spot flow gauging is undertaken to improve the understanding of surface water flow across the study area and contributions from Chalk springs.”*
- *“New observation data are used to refine and update the model.”*
- *“Sensitivity testing is undertaken to understand the impact of assumptions made in the groundwater modelling, particularly to investigate the potential connectivity between the superficial deposits aquifer and the Lower Greensand and the conductance of the drain and river cells.”*

GARD obviously supports the gathering of data, and does not believe that the models being used will be believable unless they are validated by data. We are however, *very late* in this process. We are 25 years into the proposal of the Abingdon Reservoir project, including an examination at a Public Inquiry in 2010, at which these matters were raised and criticised. ***In GARD’s view, the Abingdon Reservoir project should NOT proceed to Gate 3 without an interim expert examination of modelling validated by acquired data.***

Below we comment on some of Thames Water’s assertions from their model results.

Fluvial Flooding

Although the main Abingdon Reservoir Gate 2 document[222] cites (para 4.24) assessments of fluvial flooding using Environment Agency ‘River Ock’ models, the details are absent, in spite of a reference that they can be found in the Gate 2 Appendix 1 technical document,[223] there are precious few details. Some of the ‘conclusions’ made about the Reservoir impact on fluvial flooding are tendentious.

Contrary to the Gate 2 document assertions, the severe fluvial floods in the area have a 1 in 60 year frequency (not 1 in 100 year as assumed), even without climate change, and in the last two major events (1947 and 2007) the rainfall fell over a huge catchment area, of which the reservoir surface area forms only a small part.

Examination of the records from the 2007 Flood, shows that 10 cm of rain fell on 20th July 2007.[224] Thus, over the 6.5 sq km of the Abingdon 150 reservoir, the rainfall caught by the Reservoir would be 0.65 million cu metres (Mm^3). The response of the Thames flow at Sutton Courtenay is shown in Figure O1, taken from NRFA records.[225]

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[222] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/SESRO-Gate-2-Main-Report-FINAL.pdf para 4.24
[223] Thames Water and Affinity Water. South East Strategic Reservoir Option (SESRO) Supporting Document A-1: Concept Design Report (2022)
[224] http://www.radleyvillage.org.uk/heavy-rain-brings-flooding-to-oxfordshire-but-radley-escapes-the-worst/
[225] https://nrfa.ceh.ac.uk/data/station/liveData/39046

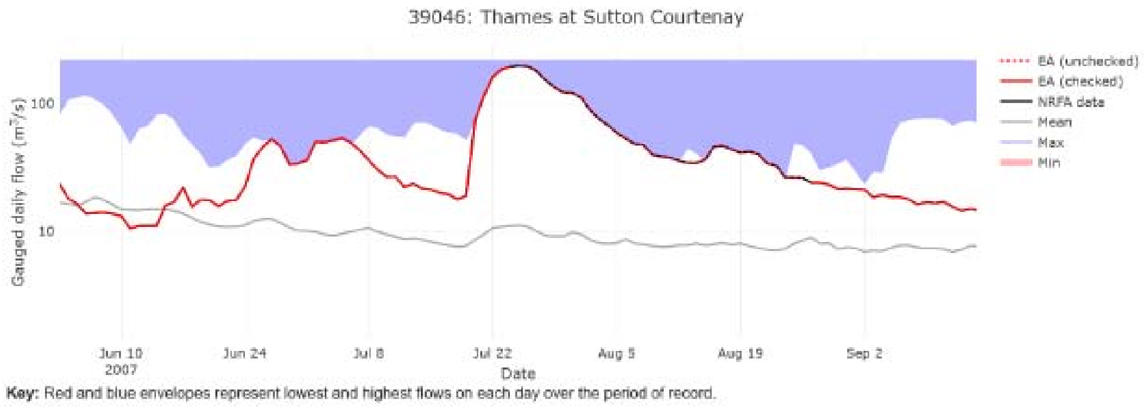


Figure O1 - Thames flow at Sutton Courtenay around the date of the 2007 floods

It can be seen that the flow at Sutton Courtenay responded immediately to the local rainfall, and was recorded as 74.2 m^3/sec on the 20th (up from 18.9 m^3/sec on the 19th). This rapid jump arose principally from flow from the Ock. The CDR (para 2.89) quotes its modelling of the Ock flow in a 1 in 100 year flood as 42.5 m^3/sec, without the Reservoir and 37.2 m^3/sec with the reservoir. The amount attributed to the undisturbed Ock area geography may be consistent with the immediate 2007 jump of 53 m^3/sec in the recorded flow (if there are around 10 - 20 m^3/sec of other local sources), but appears to be an under-estimate. The authors attribute the origin of the reduction attributed to the presence of the reservoir, something which is roughly consistent with the amount of water which would have been 'captured' in 2007, if evenly spread over 24 hours[226]. The statement is made (para 2.89):

> *"This reduction in peak flow is considered to be due to 6.5 km² surface area of the reservoir being removed from the overall River Ock catchment (as precipitation that would fall onto the surface of the reservoir would no longer be passed into the River Ock)."*

This statement is only valid *if* the rainfall is uniform. The numerical similarity between the reduction 'modelled' as due to the Reservoir (5.3 m^3/sec) and that assumed to fall on the reservoir (7.5 m^3/sec) is not indicative of anything else but this assumption. It becomes quite badly in error if the majority of the rainfall occurs closer to the Downs, in the very large catchment area.

There would also be the additional water source of run-off from the bunds (mentioned in the Abingdon Reservoir Environmental Report in 2021). Such run-off from a similar height hill above Steventon copse was one of the principal sources of flooding in the 2007 incident in Steventon. The bunds would be a significant source of *re-direction* of the flood water. If we take an example for one of the closest locations, the bund area opposite Steventon and Drayton is approximately 1 sq. km. In the conditions of the July 2007 flood, the rainfall on that area would be around 0.1 Mm^3 in 24 hours. This corresponds, assuming uniform

[226] 0.65 Mm^3 over 24 hours corresponds to about 7.5 m^3/sec.

precipitation, to around 1.15 m^3/sec. A reasonable assumption of a 2:1 peak to mean precipitation shows there could be up to 2.3 m^3/sec flow *towards* these areas at an angle to the normal drainage direction. This should be modelled to establish whether the run-off phenomena encountered in the 2007 floods would be exacerbated by the reservoir presence.

The Main Gate 2 Report makes a play of over-optimistic assertions which then have to be scaled back. For instance, in para 4.30,[227] it mentions the 'opportunity' of:

> "*Changing the operating protocols of the* [Reservoir operation] *scheme, to abstract during peak flood periods to help attenuate the downstream flood hydrograph"*

but almost immediately has to admit that:

> ' *Modelling suggests that this alternative pumping arrangement could result in a reduction of up to 550 Ml/d (2 – 2.5%) to the peak of large floods at Culham'*.

This negligible effect can easily be seen for, eg. the 2007 flood (Figure O1). The Thames flow at Culham reached values of 192 m^3 /sec.[228] This is to be compared with the maximum pumping capability of the Abingdon Reservoir of 1000 Ml/day (ie. 11 m^3/sec). The Thames flow exceeded 100 m^3/sec for 11 consecutive days, by which time over 1 billion litres of turbid, low quality water would have been pumped by the Reservoir with knock-on consequences, caused by an attempt to make an entirely negligible contribution to flood control.

Groundwater Flooding

As indicated above, the reports admit that there is '*considerable uncertainty…*' in even understanding the *conceptual* issues of groundwater flow in the area. Residents are very familiar however with the high level of the water-table in the surrounding villages. Remarkably, there are no measurements yet in place in this 'round' of Reservoir investigations.

All the issues were aired at the 2010 Public Inquiry and Thames Water (which had arranged access to the area before then) should have answers[229]. Now we see that their modelling (para 2.101 of Conceptual Design Report)[230]:

> '*Introduction of the reservoir footprint to the model leads to an increase in groundwater levels generally across the study area, with areas to the east most affected by the*

[227] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/SESRO-Gate-2-Main-Report-FINAL.pdf para 4.30
[228] https://nrfa.ceh.ac.uk/data/station/liveData/39046
[229] There is a very worrying trend in evidence here, that Thames Water appear to have no mechanism for retention of expertise and knowledge gained from previous investigations.
[230] CDR para 2.101

increase in groundwater levels. Groundwater levels are widely still controlled by existing surface and subsurface drainage.'

The impact of the Reservoir is to:

"…lead[s] to an increase in groundwater levels generally across the study area, with areas to the east most affected by the increase in groundwater levels"

With mitigation:

"…by the presence of the proposed toe drain, flood storage area and watercourse diversions"

And:

"…the additional groundwater drain..[giving]….further reductions in groundwater levels… however, the impacts are local to the groundwater drain"

Overall:

"Limited impacts on groundwater levels are expected at Steventon, East Hanney and West Hanney; however, the preliminary modelling indicates that the presence of the reservoir may lead to an increase in groundwater levels around Drayton. Further model development and investigation into the impacts to the east of the reservoir will be undertaken at Gate 3 as more data is collected and becomes available to inform the modelling."

As we know very well the groundwater issues in the area, we have no confidence in an assertion of 'limited impact' by Thames Water, and the word limited is not even used for Drayton. **GARD calls for the data collection to inform this modelling to be put in place at the earliest opportunity and for a full examination of the validated modelling to occur BEFORE the Abingdon Reservoir is allowed to proceed to Gate 3.**

Appendix P - Environmental assessments and carbon footprint

1. Introduction

In this Appendix, we cover the Gate 2 assessments of Abingdon reservoir against its impacts on Natural Capital and Biodiversity, on its Embedded and Operational Carbon footprints and the assessments under the Strategic Environmental Assessment (SEA) process.

The assessments of Natural Capital (NCA), of Biodiversity Net Gain (BNG) and of the SEA are all essentially desk-based, with no significant fieldwork, nor are they based on any detailed design proposal, which would seem to be a prerequisite. That this is the case 25 years into the proposal of this scheme is a scandal. There has been ample opportunity to develop the real-world data needed to allow stakeholders to properly analyse the proposal and conceptual design. This leads to the SEA, NC and the BNG analysis all being in terms of 'metrics' which, whilst useful as a first scoping out of the issues, should long ago have been superseded by more detailed approach. We remain concerned that, with the proposal as currently presented, Ministers may be 'bounced' into making a determination without the data they need to make a balanced decision.

We also note that there have now been three versions of NCA, BNG and SEA studies (WRSE, Thames Water dWRMP24 and now Gate 2) all published within a month of each other, and all containing different analyses and, in many cases tables quoting different monetised quantities with different numerical values, which are not straightforward to relate to one another. Although essentially contemporary with the dWRMP, conversations with Thames Water representatives at 'drop-in' sessions[231] have led to the information that the RAPID Gate 2 submissions are 'more up-to-date' than the dWRMP in many respects. The situation has to be clarified, an essential job for RAPID. We recommend that only the *accepted* analyses following the Gate 2 process be regarded as evidence in these highly subjective areas, and this should be made plain to Stakeholders on the RAPID website, and mandated as inputs to be used by further plan iterations by WRSE and the water companies.

2. Natural Capital Assessment of the Reservoir

Details of the Natural Capital Assessments (NCA) of the Abingdon Reservoir variants (from 150 Mm^3size down to 75 Mm^3) are given in a Gate 2 technical appendix document.[232] GARD commented in the Thames Water dWRMP24 consultation[233] on their equivalent Appendix AA of the draft Plan.[234]

[231] Eliot Simons, Project Manager, SESRO, statements at drop-in session, Steventon, 18th February, 2023.
[232] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/B-2---SESRO-EAR-Terrestrial.pdf
[233] https://www.gard-oxon.org.uk/downloads/21.3.23%20GARD%20response%20to%20TW%20WRMP%2021.3.23.pdf section 4.3
[234] https://thames-wrmp.co.uk/assets/images/documents/technical-appendices/AA-Natural-Capital-and-Biodiversity-Net-Gain-Assessment.pdf

In keeping with the metrics of DEFRA and similar bodies, the ecosystem services reviewed to assess the impact on natural capital include:

- Carbon Sequestration (Climate Regulation)
- Natural Hazard Management
- Water Purification
- Water Regulation
- Food production
- Air Pollutant Removal
- Recreation & amenity value
- Biodiversity and Habitat

The analysis then considers the site (or at least a 'database version') for the different types of habitat, pre- and post-construction, and attributes metrics to the various habitat types against the particular ecosystem service. The Biodiversity and Habitat 'service' is analysed through the Biodiversity and Net Gain (BNG) metrics (see section 3). The other services are then monetised (except for water regulation).

The key problem with this analysis is the *state of the site post-construction* (which also applies to the BNG analysis). A great deal of fudging of the issue can, and we believe does, occur in the over-optimistic portrayal of the post-construction situation. This is particularly true of a reservoir project, and the larger the project, the more scope there is for the 'brochure culture' to take over. Recent presentations to local communities have heightened our concerns, with several presentations on potential amenities presented as fact, despite a complete lack of any supporting evidence as to how, or by who, these will be provided.

There is one clear issue with NCAs from reservoir projects, that is that the very creation of a '*Lake and Standing water*' (code for the Reservoir in this case) has a positive NC value. This 'special pleading' for Reservoirs is used whatever the form of the Reservoir, and whatever its actual *natural* state is. This comes from the positive value assigned to the '*Recreation and amenity value*' metric for an NCA on a particular proposal. The actual value attributed to this NCA item is not a straightforward value, and, as GARD highlighted in our response to the WRSE draft Regional Plan[235]:

> "*The reality is that reservoirs do have very different possibilities of exploitation for 'Natural Capital'. It does not take much imagination to realise that large bunded reservoirs with all-round concrete walls and extensive rip-rap-enclosed shorelines and possible security and invasive species issues, have less Natural Capital possibility than 'classic' flooded valley reservoirs with more natural shorelines. Indeed, there seems to have been an acknowledgement of this to a certain extent in the WRSE figures...* [the

[235] https://www.gard-oxon.org.uk/downloads/Final%20GARD%20Response%20to%20WRSE%2022%202%2023%20v4.pdf section 4.3.6

WRSE report gives]… *comparison figures for the Havant Thicket Reservoir (described as a 'classic' reservoir) and the Abingdon 100 Reservoir. The values for Recreation and Amenity are quoted as:*

Havant Thicket	*£335,412*
Abingdon 100Mm^3	*£249,021"*

Havant Thicket holds 8.7 Mm^3 of water, and is in no way comparable to Abingdon on all other criteria, but the simple result that the NCA Recreation and Amenity for a small classic reservoir (with an area of 1.6 km^2 a construction phase of about 3 years,[236]) will result in 50% more Recreation and Amenity value than the Abingdon project with a capital cost more than 10 times higher, a construction phase 3 times longer and an area nearly 4 times larger. The implication of a result like this is that the NCA Recreation and Amenity value of Abingdon reservoir is nowhere near as high as a much smaller classic reservoir, and would, on its own, be regarded as rather poor value for money.

Turning to our comments on the individual metrics in the Gate 2 report. A summary of the monetised '*Present value*' change in benefit following the construction of the Reservoir for the various options is shown in Figure P1[237]

Plate 9.2: Change in present value benefit for each ecosystem service (£) - 2022 prices.

Figure P1 - Change in present value for ecosystem services (£) for the Reservoir options – 2022 prices

236 https://havant-thicket-reservoir.uk.engagementhq.com/planning-and-construction/widgets/44605/faqs#question13305

237 B-2---SESRO-EAR-Terrestrial report – plate 9-2

These values are over the 100 year period following construction of the reservoir, using discounted rates (Treasury Greenbook). The 100 years *includes* the construction period, as stated in para 9.33. The assessment of these Ecosystem services is extremely complicated, and uniformity across competing strategic projects will not be possible where Water Resource Planning Guidelines (WRPG) or All (Water) Company Working Group (ACWG) recommended methodology does not exist (in fact such guidance is only followed for Natural Hazard Regulation and Water Regulation).

Carbon Sequestration (Climate Regulation)
All Reservoir options are deemed to give net positive value in this service. The smaller the reservoir, the bigger the value (essentially a reflection of the amount destroyed in construction). The positive value is deemed to derive from the replacement of agricultural land be more diverse wetland and improved grassland and woodland habitat. However, although the report states it is important to link these figures to the construction and operation carbon production associated with the Reservoir,[238] this is done nowhere in the report or anywhere else we could find in the Gate 2 documentation. We will perform the linkage in section 3.5.6. Also, the analysis does not take any account of greenhouse gas emission from Reservoirs (see section 3.5.6 below).

The positive value only kicks in after the construction period, and, even then it takes decades, as vegetation matures before it becomes of significant value (Figure P2 below).

Table 9-9: 'Snapshot' monetary values for climate regulation benefits – 2022 prices.

Option	'Snapshot' monetary value (£) at years				
	10	15	25	50	100
150Mm³	-£85,000	-£77,000	£5,000	£45,000	£38,000
125Mm³	-£94,000	-£85,000	£1,000	£54,000	£47,000
100Mm³	-£87,000	-£29,000	£8,000	£58,000	£49,000
75Mm³	-£82,000	-£23,000	£13,000	£62,000	£52,000

Figure P2 - 'Snapshot' monetised climate regulation benefit values – 2022 prices

Again, we emphasise that this is a 'desk-based' study, not based on a detailed plan

Natural Hazard Management
The evaluation of this extremely important ecosystem service is very tendentious in the Report. As table 9.1 admits:[239] the Gate 2 assessment does not use the Environment Agency

[238] B-2---SESRO-EAR-Terrestrial report – para 9.52
[239] B-2---SESRO-EAR-Terrestrial report – table 9.1

flood-risk areas to identify flood-zones and relevant habitats, but uses the '*project's own hydraulic modelling*' – this is at variance with what is quoted in our response section 3.2.6, and surely an example of unacceptable lack of co-ordination across the whole Abingdon Reservoir Gate 2 activity. Even worse, the smaller variants are not assessed to a conceptual design plan, but merely '*scaled [up] from the largest SESRO option'.* We conclude that this exercise has no real basis in evidence.

The net benefit of the construction of the Reservoir is deemed Negative for this ecosystem benefit. The above just serves to highlight what has already been pointed out in our response section 3.2.6, that there is still no proper flooding analysis of the effects of the Reservoir build on the flooding risk in the area surrounding the Reservoir. Indeed, the negative benefit derived is mainly due to the loss of woodland on the site. There is a further concern that the 'discounting' of the benefit by the Treasury's inflation accounting mechanism, is almost certainly not valid in a situation where climate change is making flash-flooding more frequent.

Water Purification

The net benefit for Water Purification is assessed as positive, which is mainly attributed to the ending of agricultural pesticide run-off arising from the arable land which is lost from construction of the site. Another contributing factor is the purification caused by wetland creation. However, the timeline for the creation of a positive value seems to be optimistic. Consideration of Figure P3[240] shows that the positive effects of the water purification apparently are present (at 10 years) even though the construction period has not finished and substantial site pollution from construction work will be present.

Table 9-13: 'Snapshot' monetary values for water purification benefits (£) – 2022 prices.

Option	'Snapshot' monetary value at years				
	10	15	25	50	100
150Mm³	£54,000	£46,000	£56,000	£30,000	£11,000
125Mm³	£53,000	£45,000	£56,000	£30,000	£11,000
100Mm³	£49,000	£48,000	£54,000	£29,000	£11,000
75Mm³	£46,000	£45,000	£52,000	£28,000	£10,000

Figure P3 - Snapshot of monetised values for water purification benefits (£) – 2022 prices

We conclude this is another example of optimistic time-line to try to achieve a positive value over 100 years.

[240] B-2---SESRO-EAR-Terrestrial report – table 9.13

Water Regulation

The dangers of the NCA approach are highlighted by the statement in table 9-1 referring to Water Regulation:

> '*…the estimated reductions in abstractions in other locations as a result of SESRO were sought out, but are currently unavailable. As such, quantifying and monetising the value of water left in the environment for other users is not possible at this stage.*'

GARD totally rejects the approach of using off-site saving as a positive ecosystem benefit for Water Regulation. This omits the assessment of the issue as to whether the SRO is either the quickest, or best value, or most resilient way of reducing abstractions in other vulnerable areas. As GARD has pointed lout in the WRSE[241] and Thames Water dWRMP24[242] consultations, the Reservoir is the *slowest way* of achieving critical abstraction reductions in fragile Chalk Stream environments. Water transfers (Grand Union Canal and Severn Thames Transfer) can be realised much more quickly and cheaply: water efficiency and Leakage Reduction are cheaper and more resilient to climate change. The analyses submitted by GARD and others have shown that this is a bogus method of calculating benefit. This does not stop an attempt to do so in ***We believe RAPID should make it clear that 'off-site' trading of Ecosystem Benefits is not acceptable as a metric.***

Food production

This ecosystem benefit is heavily impacted by the construction of the Reservoir, and is strongly negative. It is worth noting that, even here, the assessment seeks to make unjustified positive contributions by citing that certain areas of the site will be returned to agricultural production after the construction phase. Quite how this would be achieved, after a 10+ year period where the farmers on the land had been forced to take the compulsory purchase money and leave, is stretching the bounds of credibility. We believe the negative impact on Food Production will be higher than the Gate 2 estimate.

Air Pollutant Removal

The impact on Air Pollutant removal is negative for all Reservoir options. This is deemed to result from the net loss in woodland and large swathes of agricultural land. There is a poorly-explained reduction of negativity for the large (150 Mm^3 and 125 Mm^3 versions due to the '*expected*' (sic) creation of more scrubland, but since this is not even based on an outline concept for the 125 version, one can have little confidence in this aspiration. Once again the smallest Reservoir performs best.

Recreation & amenity value

Ever since the Gate 1 assertion that

[241] https://www.gard-oxon.org.uk/downloads/Final%20GARD%20Response%20to%20WRSE%2022%202%2023%20v4.pdf

[242] https://www.gard-oxon.org.uk/downloads/21.3.23%20GARD%20response%20to%20TW%20WRMP%2021.3.23.pdf section 4.3

> The reported positive change in natural capital value is primarily due to the significant increase in Recreation value expected for the site, which outweighs the decrease in ecosystem value of food production – although improvements in all the other services are also reported in comparison to the baseline, without recreation they are insufficient both alone and in combination to outweigh the loss in Food production value;

Thames Water have been desperate to 'big-up' the Recreation and Amenity value of the site. The Gate 2 reports are no exception, and visitors to Thames Water 'drop-in' events are left in no doubt that the budget for designing yacht marinas and visitors centres far outweighs the amount of effort on Reservoir Safety issues. As we indicate in our response section 3.2.5, and Appendix N, there are issues of security which will severely limit access to the Reservoir crest and its purported facility. This will seriously limit its Recreation and Amenity value and we have already remarked how a 'like for like' comparison with the much smaller Havant Thicket reservoir shows bad value for the investment.

There are no justifications of the assumed visitor numbers for the Reservoir site. We cannot find any explanation of the substantial jump in recreational value (£462,829 at 2019 prices – a jump of about 44%) over the Gate 1 estimate. Also, alone of the monetised NCA benefits, there is no time line or 'snapshot' year, to compare the 'snapshot' quoted figure in the Thames Water dWRMP,[243] which equates to that quoted from WRSE above.

The above leads us to believe that the Recreational Value NCA is not fit-for-purpose or transparent. As this amenity is being used (so far unsuccessfully) to bribe local opinion, ***GARD demands to see a transparent, annotated explanation***.

Current value of the Reservoir site
We note that the present recreational value of the site has not been re-evaluated since Gate 1, although every other aspect of the NCA has been substantially revised.

We also note currently that the farming community on the land is beginning to take advantage of District Council grants to create wetland habitats – something which is being achieved with investments of the order of £100k or less, so there really is no need to spend £1.8 Billion and ten years to achieve the same end.

3. Biodiversity Net Gain Assessment of the Reservoir

In the assessment of Biodiversity, in addition to the desk-based aspect, there seems to be no attempt to discuss the effects of '*scale-length*' of habitat destruction, or '*time-duration*' of disturbance. Both are important when considering the prospect of returning 110% of the pre-construction site biodiversity (necessary for a net gain of 10% to comply with DEFRA guidelines). Clearly the site bio-diversity is completely shattered for a decade, and over a scale-length that is large compared to the radius of most invertebrates and small mammals.

[243] https://thames-wrmp.co.uk/assets/images/documents/technical-appendices/AA-Natural-Capital-and-Biodiversity-Net-Gain-Assessment.pdf table 3.10.

The 2-3 km scale-length of destruction will be much harder to reverse than a 25m scale width of a pipeline water transfer project. The time-duration omission was admitted as not being taken into account by the WRSE draft Regional Plan[244]:

> *"The duration of disturbance and timeline for habitat creation has not been included in the assessment. Durations of disturbance, including proposals for creating habitats in advance of disturbance, will need to be refined with greater design detail at later stages to refine the accuracy of the BNG calculations for each option".*

With these caveats, we saw that the BNG assessments in the dWRMP were not actually consistent with the Gate 2 documents submitted on the Abingdon reservoir strategic option to the RAPID process. There does indeed appear to be some discussion of concepts of 'time to maturity' for a habitat which is to be created, in the supplementary Appendices of the RAPID Gate 2 documents. Table 6.5 in the Abingdon Reservoir RAPID Gate 2 document is reproduced below[245].

Table 6.5 Summary of BNG assessment

Reservoir Option	Biodiversity Units	Total Net Unit Change	Total % Change
150 Mm³	Habitat Units	1629	33%
	Hedgerow Units	-96	-22%
	River Units	70	16%
125 Mm³	Habitat Units	1768	37%
	Hedgerow Units	-86	-20%
	River Units	102	24%
100 Mm³	Habitat Units	2005	45%
	Hedgerow Units	-52	-13%
	River Units	99	25%
75 Mm³	Habitat Units	2196	52%
	Hedgerow Units	-43	-11%
	River Units	129	35%
100+30 Mm³	Habitat Units	2265	46%
	Hedgerow Units	-85	-19%
	River Units	74	17%
80+42 Mm³	Habitat Units	1942	39%
	Hedgerow Units	-105	-24%
	River Units	64	15%

Figure P4 - BNG gain/loss for Abingdon Reservoir versions from RAPID Gate 2 submission

The results show that the BNG improves as the Abingdon Reservoir size reduces down to 75 Mm^3, and the main net loss item (Hedgerows) becomes of less importance. Irrespective of the accuracy of the BNG habitat improvements, at least these results have the value that they are logical, and point in the direction that local residents have always insisted upon,

[244] https://www.wrse.org.uk/media/gfbbnqjn/wrse-draft-regional-plan-sea-er-natural-capital-assessment-and-biodiversity-net-gain.pdf -section 2.3.

[245] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/B-6---SESRO-BNG.pdf

that *the larger the Reservoir the more destructive the biodiversity loss and the more difficult the restoration and improvement will be.* The dWRMP on the other hand, purports to show (tables 3.4 and 3.12 of Appendix AA) that the 150 Mm^3 Reservoir produces more habitat gain than the 100 Mm^3 version

For now we note that the RAPID Gate 2 documents show in many places that the dWRMP documents are full of errors and unjustified favourable comments about the NCA and BNG of the larger Abingdon Reservoir configurations. Just one example is the statement in the RAPID documentation,[246] regarding the BNG issues for the 150 Mm^3 reservoir:

> "*Under the current proposals for the scheme, 45.39 ha of lowland mixed deciduous woodland will be lost and only 17 ha will be retained. This equates to a loss of 939.57 units of habitat which have not been accounted for within the metric. As the metric Trading Summary states that habitats of high distinctiveness must be replaced with the same habitat type (taking into account the risk multiplier), only planting of lowland mixed deciduous woodland would rectify this issue. As there is no space within the site to create 939.57 units of this woodland type, the habitat may need to be created off-site or habitat units bought to compensate for the loss.*"

Once again, the situation is better for the smaller reservoirs, but the reader of the NCA/BNG appendix of the dWRMP would be given to understand that the creation of this habitat was a foregone conclusion for the 150 Mm^3 version[247].

We conclude that:

- the Biodiversity Net Gain assessment suffers from many aspirational and unfounded assertions of habitat creation *in all documents* (even the Gate 2);
- in the case of the dWRMP documents, there are many inconsistencies and errors;
- there is a lack of transparency in the BNG documents (it should not be necessary for stakeholders to plough through XL spreadsheets of values to get an informed view of the issues);
- at least some of the errors and inconsistencies, and some of the opaqueness is removed if the stakeholder reads the RAPID Gate 2 documents.

Thames Water should be asked to revisit this work and make it consistent with the RAPID Gate 2 documentation in accuracy and transparency.

[246] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/B-6---SESRO-BNG.pdf para 4.25
[247] TW dWRMP24 Appendix AA, Table3.1

4. Strategic Environmental Assessment of the Reservoir

GARD is not explicitly commenting on the SEAs of the Reservoir, except where comparisons with the Severn to Thames Transfer are concerned. This is partly because aspects of the SEAs are doubly analysed and counted in other assessments, eg. those covered in Sections 2 and 3 above, or by carbon footprint and sequestration analyses as discussed in Section 4 below. It is also because, as GARD has observed on many occasions, there are hopelessly exaggerated, unproven assessments of any possible benefit of the Reservoir (eg. the recreational and tourism value, or the biodiversity enhancement without a design plan), coupled with a sharp tendency to downplay any dis-benefits (eg, the very long and disruptive construction period). In spite of GARD's comments over the years, this has never been acknowledged or seriously addressed. This seems to be perpetrated in the Rapid Gate 2 documents.[248]

In our view, the SEA has only improved by the findings of the newer methods of NCA and BNG analysis. This is to be welcomed, although we still see enough evidence of 'company spin' creeping in. ***GARD believes that RAPID should insist on a more transparent demonstration of the thinking behind the SEA markings, and needs to mount a much stronger challenge***.

5. The Gate 2 assessment of reservoir carbon footprint

We focus our analysis of the Carbon Footprint of the Reservoir on the RAPID Gate 2 documents. As these are more up-to-date than the dWRMP material, we have not cross-checked to see any anomalies between the two sources. Indeed, it is obvious from a text search on 'carbon' or '*decarbonisation*' or '*carbon sequestration*' through the main dWRMP reports, that the mentions are almost entirely of the aspirational or corporate aims type, and not useful for analysis.

Straightforwardly, the Abingdon Reservoir is the project which has the largest carbon footprint in the construction phase ('*Embedded carbon*' or '*capital carbon*') and the 150 Mm^3 version has the largest of these footprints. Moreover, it is clear that Abingdon is a single project, and should only be compared with a '*like for like*' deployable output (DO) scheme. If the overall scheme in the comparison is one which can be implemented in stages, then a feasible first stage with DO equal to the version of Abingdon, should be the one entered in the comparison. The Severn Thames Transfer (STT) is, as we will show in Sections 5 and 6 of our main response (and as is admitted by Thames Water) such a phaseable scheme. However, Thames Water avoid, wherever possible, a direct comparison, tending to compare the *whole STT network* with Abingdon Reservoir.

[248] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/B-7---SESRO-SEA.pdf

As the RAPID Gate 2 report on the Abingdon Reservoir shows[249], the various versions of the project have the Embedded carbon breakdown as Figure P5 The carbon footprint is dominated by the construction of the embankment works, which includes all earth moving equipment emissions and transport to site of materials such as rip-rap. This forms about 70% of the 150Mm^3 version and around 60% for the WRSE Best Value Plan choice of the 100 Mm^3 version.

Operational carbon is low for the Reservoir and is shown in Figure P6 (copied from figure 6.2 of the Gate 2 report). The carbon budget is dominated (66%) by the energy needed to pump the water from the River Thames into the Reservoir. This energy is partially recovered by using low-head electricity generation turbines on the release of the water. Of course, with the intermittent use of the Reservoir, this is a balance over the lifetime of the Reservoir, rather than a within-year balance, but the comparison over the '*lifetime*' (calculated over 2022-2101) is a valid one.

Figure 6.1 Capital carbon emissions for SESRO options

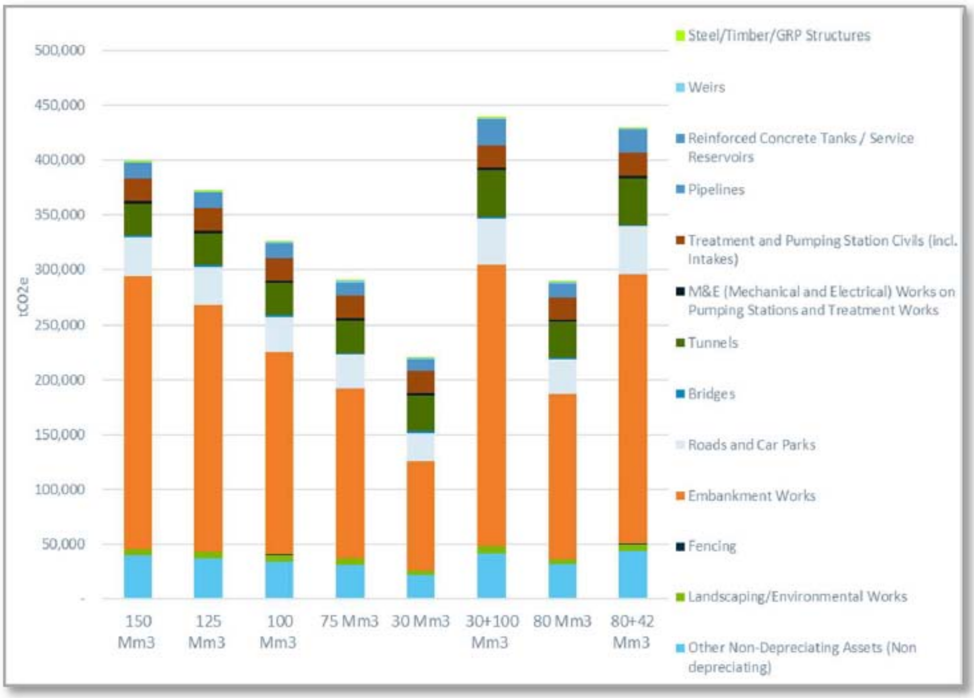


Figure P5 - Embedded or capital carbon budget for Reservoir options

[249] SESRO Gate 2 report – Figure 6.1 https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/SESRO-Gate-2-Main-Report-FINAL.pdf

Figure 6.2 Total Annual Operational Carbon for all options (at 2040)

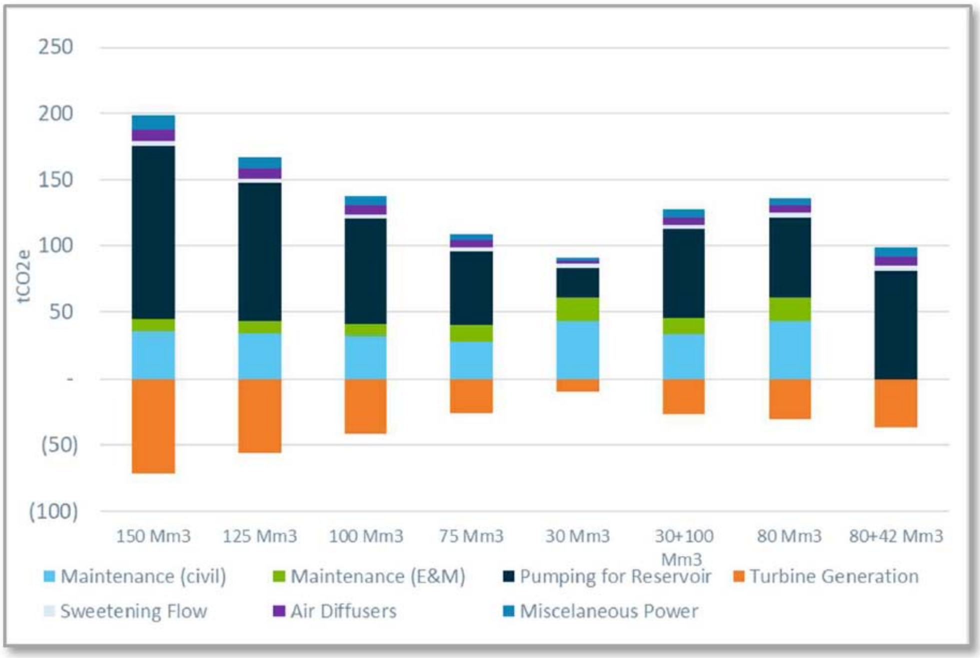


Figure P6 - Lifetime operational carbon budget of the Reservoir options

Finally, when adding in the maintenance/replacement requirements, the whole-life carbon budget of the Reservoir versions is given by the RAPID Gate 2 documents as in Figure P7 (taken from table 6.7 of the Gate 2 report)

Table 6.7 Summary of the whole life carbon emissions and net present value whole life carbon costs

Option (Mm³ storage)	150	125	100	75	30	30+100	80	80+42
Whole life Carbon footprint (tCo2e) – ***based on estimated long-term average utilisation, as discussed in Section 8***								
Capital and Replacement Carbon	479,939	451,378	403,152	366,035	285,762	507,413	362,222	504,747
Operational Carbon	5,624	5,103	4,664	4,114	3,286	5,913	4,464	6,057
Total	**484,356**	**455,498**	**407,008**	**369,522**	**288,777**	**511,810**	**366,046**	**508,860**
Whole life Carbon footprint (£M) – ***based on estimated long-term average utilisation, as discussed in Section 8***								
Total whole life carbon	**87**	**82**	**73**	**65**	**50**	**82**	**65**	**86**

Figure P7 - Whole life carbon estimates for Reservoir versions

5.1 Attempts at carbon offsetting or carbon budget reduction

There are various attempts to claim potential reduction in the carbon budget figures. They can be divided into Technological Developments and Carbon sequestration possibilities.

Technological developments

The carbon strategy for the Abingdon Reservoir is discussed in a '*Carbon Report*' Technical

Annex to the Gate 2 report. [250] There are various attempts to claim potential reduction in the carbon budget figures. They can be divided into Technological Developments and Carbon sequestration possibilities.

The Carbon Report addresses this by citing[251] the '*All Company Working Group (ACWG)*' study. GARD has already assessed this in its response to the WRSE draft Regional Plan.[252]

WRSE state in section 11 of Annex 2 of the draft Regional Plan

> *"As most of these* [strategic resource] *schemes will not be built until several years from now, time is available to work with the supply chain (e.g. steel and concrete manufacturers) to find new lower carbon solutions to construction. The All Company Working Group (ACWG), made up of the water companies with Strategic Resource Options (SROs), have engaged with the supply chain to estimate just how much progress with reducing emissions might occur over the next 60 years. This engagement has produced emission reduction estimates for most facets of construction, ranging from the types of construction equipment moving around on site, to the type of steel that might be used in future pipelines. Three different scenarios have been produced, a worst case, middle case and best case scenario; to allow for the industry moving slower or faster than expected."*

The All-company working group report can be accessed at,[253] and whilst such an exercise is genuinely to be welcomed, the conclusions drawn by WRSE (note, not necessarily by the ACWG itself) are very over-optimistic.

GARD's response covers the over-optimism on construction materials such as steel (for pipelines) and concrete. This of course applies to all SRO projects, but the fundamental issue is the lack of any *timetabled technology-development roadmap* for any of these materials.

Again, WRSE cite the Low Carbon Concrete Routemap,[254] but this has few dates in it and, whilst it can point to the existence of some materials, the roll-out to industrial capability is largely aspirational. This routemap at least has the major benefit that it assesses development according to *Technology Readiness Level* (TRL) and *Commercial Readiness Level* (CRL), but even the highest TRL9 grading ('*System Approved*') only corresponds to the stage CRL2 ('*small scale commercial trials*'). There are still stages after that for progress to CRL4 and 5, where commercial competition ensures good value for project contracts. The

[250] SESRO Carbon Report https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/A-3---SESRO-Carbon-Report.pdf
[251] Carbon Report section 5.3
[252] https://www.gard-oxon.org.uk/downloads/Final%20GARD%20Response%20to%20WRSE%2022%202%2023%20v4.pdf, section 4.4.1
[253] https://www.wrse.org.uk/media/muvl5thv/acwg-low-capital-carbon-alternatives.pdf

[254] https://www.ice.org.uk/media/q12jkljj/low-carbon-concrete-routemap.pdf

Figure 4.2 of the Routemap shows only one 'low-carbon' cement of the 27 cement types 'existing' is qualified to BS standards (effectively TRL8 stage).

The third major area of the ACWG report concerns large-scale earthworks and the emissions from heavy petrol and diesel-fuelled quarrying/construction/transport vehicles involved which dominates the embodied carbon for a reservoir.

The breakdown of sources of embedded carbon in the ACWG report differ in details from those in the Abingdon Gate 2 report, but this is presumably because the earlier ACWG study did not have the conceptual Reservoir design to hand. Nevertheless, the qualitative conclusions about embankment realisation dominating the embedded carbon is maintained.

Although the reader can see GARD's conclusions in our WRSE response, it is worth repeating them here, if only to show that the ACWG's highly dubious conclusions are still the state of the art.

The ACWG report purports to analyse how the embodied carbon might be reduced in the project, but the 'analysis' is woefully lacking in substance and hopelessly optimistic. It is also uneven in quality and philosophy when compared to that carried out for the pipe material and cement cases in the report. There are thus no details of technology existing (as with the pipework and cement), or industry-accepted roadmaps, or TRL discussion (as with the cement), or indeed of anything that could not be found from a Google search. Instead, anecdotal discussions are cited with two manufacturers *"…indicate that prototype* [hydrogen powered] *large excavators (21T and 35T) and dozers are being developed and <u>potentially available</u> in the next 2 years*" (ie. the *prototype* might be available). Such 'analyses' are used to derive an astounding (for its *chutzpah*) conclusion that a '*mid-case*' scenario (the one taken by WRSE) could result in a 60% reduction in embodied carbon in the 2025-2040 timeframe. This analysis excludes an analysis of transport by rail (currently diesel along the Great Western Line identified for bringing the 5+ megatonnes of Rip-rap to the site), as it only mentions HGVs in the text. It depends on the availability of Hydrogenated Vegetable Oil (HVO) fuelled vehicles, to provide 50% of the fleet, in spite of the fact of admitting that:

> *"Currently the UK's supply of HVO is underdeveloped. Although construction plant technologies operating with HVO are available, the risk of a secure supply of HVO may limit its applicability nationwide".*

All this to 50% market penetration by 2027! There are currently no diesel train fleets with HVO-powered vehicles. The changeover to HVO, not even considering the expensive need to write off plant which is far from life-expired, will not even start on any scale until the HVO fuel supply-chain is settled.

There are even more risible items in the '*analysis*. This whole section of the ACWG report has the air of being written by a Reservoir fanatic (something shared quite commonly across the Abingdon 100 Mm^3 analyses). We conclude that this is not worth consideration, as although it shows the steps required, the only possible conclusion can be that Reservoir construction is best delayed until at least 2035 -2045 timeframe.

We conclude that the RAPID Gate 2 report team do themselves no favours by citing this dubious material, and there is really no support for their attempt to use this material to derive an alternative 'low carbon' construction phase for the Abingdon Reservoir variants. (see for instance Figure 5.1 in the SESRO Carbon Report).

5.2 Carbon Sequestration

Claims are made for the carbon sequestration possibilities of the post-construction period, and improvements over the 'present' site (from a 'desk-based' assessment). Para 8.1 of the RAPID Gate 2 report asserts:

> *"The NCA analysis also includes an assessment of the impacts of the reservoir proposals on carbon sequestration. In qualitative terms, arable land is generally considered to be a source of carbon emissions rather than a sink. Each option involves a substantial area of land, particularly arable and horticulture, being taken out of agricultural use and partially replaced with land capable of sequestering carbon. Woodland is likely the most substantial carbon store and carbon sequestering habitat present. Net losses of woodland habitat are expected under each option, though the carbon impacts are likely to be counteracted by the potential for the creation of new habitats, such as the substantial area of floodplain wetland mosaic and native species-rich hedgerow with trees. This can be seen from the indicative Gate 2 Master Plan."* [GARD highlighting]

Once again, a great deal of emphasis is placed on the *possible* gains post-construction, and the post-construction site descriptors are tending to the 'brochure speak' level, even in this relatively dispassionate document. We make the following observations:

1. The post-construction carbon sequestration 'natural capital' is, even on this optimistic assessment valued at only £1.9m for the Abingdon 150 Reservoir, against the whole life carbon budget of £87m for the project (see Table 20). Even for the 75Mm^3 version, the sequestration against impact is only £3.1m to £65m (Figure P7) therefore just a few percent effect.

2. Even the sequestration will only begin to be effective with a 20-25 year delay, (Figure P2).

3. The '*species rich*' hedgerows merely replace a linear amount of hedgerow lost during the construction[255] It is of course possible, at a very modest cost, to make the

[255] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/B-2---SESRO-EAR-Terrestrial.pdf table 9-6.

existing hedgerows just as ‘species rich’ as the post-construction site. On a ‘desk-based’ analysis it is in any case hard to see how the assessors can give any quantification to the species value of the site. In a similar vein, as noted in Section 1 of this Appendix, currently the farming community on the land is beginning to take advantage of District Council grants to create wetland habitats – something which is being achieved with investments of the order of £100k or less, so there really is no need to spend £1.8 Billion and ten years to achieve the same end.

4. Reservoir waters themselves are now known to be a source of Greenhouse Gas Emission (See below).

We conclude that the carbon sequestration ‘opportunities’ are limited and uncertain, and not larger than local initiatives (funded by new DEFRA rules and Local Authorities) could achieve.

6. Sources of the net carbon footprint omitted in the reports

1. We conclude that the carbon sequestration ‘opportunities’ are limited and uncertain, and not larger than local initiatives (funded by new DEFRA rules and Local Authorities) could achieve.

2. Whilst it is GARD’s view that the T2ST scheme should not be progressed, this is not what the Thames Water draft Plan policy assumes. It is also the case that water treatment of returned water to the Thames might be needed. There is, as GARD has previously highlighted (most recently in main response Section 3.2.2) a risk that the water quality in Abingdon after prolonged high drought would be very poor indeed and laden with algal bloom.

   GARD calls for the carbon budgets for the Abingdon Water Treatment Works to be included with the Reservoir budget, as the justification of the Reservoir requires this item as part of the Baseline case.

3. Around 40 MW of solar farm generating capacity is torn up by the construction site of the Abingdon Reservoir. The Gate 2 reports make it clear[256] that there is no intention to re-site these on the post-construction site. There had previously been an assumption by local residents that a floating solar farm would be created on the Reservoir, but this is now ruled out be Thames Water.[257] It now seems that the ‘*Master Plan*’ includes the creation of islands in the South-west corner of the Reservoir surface, in order to attempt to create enough bio-diversity net gain. The generating loss caused by the destruction of the solar panels needs to be factored into the carbon balance for the project (it is unlikely that the panels can be usefully located to another site, and may well end up being scrapped).

[256] Table 6.8 of SESRO Gate 2 main report
[257] Statements (by Phil Stride of Thames Water) at the Thames Water ‘drop-in’, Steventon, 18th February 2023.

Recent research has shown[258] that reservoirs are net carbon sources, and their calculated carbon footprint can be increased by over 50%. The recommendation of other supporting references[259] is that Greenhouse Gas (GHG) Emissions from reservoir surfaces should be included in the anthropogenic emissions of the operational reservoir cycle. The evidence is increasing that reservoirs do not sequester carbon. These issues are completely absent from consideration in both the Thames Water dWRMP documents and the RAPID Gate 2 reports.

Here we give an idea of the magnitudes. The study by Harrison et al.[260], (2020) provides an average annual "per-unit-reservoir-per-area" GHG production rate. For the Abingdon reservoir latitude of 152-1000 g CO_2e for the 6.75 km^2 surface area of the Abingdon reservoir this is 1026 – 6750 tonnes CO_2e per year. This is (from Figure P7) 16-100 times the operational carbon from pumping. From the same study, the distribution of CO_2 and methane emissions from temperate latitude reservoirs was effectively 50:50. This distribution, compared to high boreal and tropical latitudes, is due to temperature and solar radiation differences between the regions. The composition between degassed and ebullient methane production is also different for different latitudinal zones, with temperate zones having just 5% of total methane emissions from degassing, the remainder from methane ebullition.

While CO2 diffusion from reservoirs is the single dominant flux, CO2 ebullition and more importantly, methane degassing and ebullition is by far the major GHG CO_2e per area of reservoir.

Several recent studies[261] [262] [263] have reported strong correlations between primary production and methane emissions. There is a causal link for this, by providing organic Carbon and creating the anoxic (oxygen deficient) conditions that favour methane production, any plant production in reservoir surface waters will fuel higher rates of methane emission, leading to higher emissions from eutrophic (increase in plant and other nutrients) systems than oligotrophic (lack of nutrients and oxygen rich) systems. The

[258] *Global carbon budget of reservoirs is overturned by the quantification of drawdown areas*, Keller, Marce, Obrador, Koschorreck, Nature Geoscience 14, 402-408 (2021),

[259] *Greenhouse Gas Emissions from Reservoir Water Surfaces: A New Global Synthesis* by B R Deemer, et al, BioScience, Volume 66, Issue 11, 1 November 2016, Pages 949–964]

[260] Harrison, J.A., Prairie,Y.T., Mercier-Blais, S. & Soued, C. (2021). Year 2020 reservoir CH4 and CO2 emissions as predicted by the G-res model. Zenodo https://doi.org/10.5281/zenodo.4632428.

[261] Beaulieu,J.J., DelSantro,T. & Downing, J.A. (2019). Eutrophication will increase emissions from lakes and impoundments during the 21st century. *Nature Communications* https://doi.org/10.1038/s41467-019-09100-5.

[262] Deemer, B.R., Harrison, J.A., Li, S., Beaulieu, J.J., DelSantro,T., Barros,N., et al. (2016). Greenhouse gas emissions from reservoir water surfaces: A new global synthesis. *BioScience* http://doi.org/10.1093/biosci/biw117

[263] DelSontro, T., Beaulieu, J.J. & Downing (2018). Greenhouse gas emissions from lakes and impoundments: Upscaling in the face of global change. *Limnology and Oceanography Letters* **3:3**, 64-75. https://doi.org/10.1002/lol2.10073.

continuing dumping of raw sewage into UK rivers, including the Thames, the pumping of those waters into the reservoir, will provide the labile carbon and nutrients (eutrophication) for both the production of surface algal and vegetation matter, and as the detritus sinks to the bottom of the reservoir, it becomes the source of extra GHG emissions – mainly methane. The creation of algal blooms will have a devastating effect on the biodiversity of both the reservoir and those visiting the reservoir (insects, birds, etc). When detritus from the algal bloom descends into the water column, bacteria communities rapidly increase which initially creates CO_2 emissions, but as the water oxygen is exhausted, reservoir inhabitants (fish, insects) will die and the emissions become largely methane. This process in stagnant water can produce the toxin producing blue green cyanobacteria harmful to many species including humans who drink the water or use its facilities.[264] This threatens the design aim that the original landscape biodiversity will be replaced by a new "wetland" biodiversity.

GARD calls for the GHG emissions for the Abingdon Reservoir to be included with the Reservoir budget, and a statement regarding the treatment of water pumped into the Reservoir and the policy for extraction from the Thames at times of sewage spills to be explicitly stated.

[264] www.nhm.ac.uk(https://www.nhm.ac.uk/discover/news/2021/november/the-deadly-effects-of-sewage-pollution-on-nature.html

Appendix Q - Errors in TW's calculation of Abingdon Reservoir NPC

Following GARD's responses to WRSE and Thames Water's dWRMP, GARD received an answer to its request, made on January 15th, for additional information to enable us to confirm the details of the calculation of Net Present Cost (NPC) for SESRO 100 Mm^3.

This information was only provided on 14th April 2023[265], too late for us to use in our dWRMP24 and WRSE responses. However, whilst we have had limited time to use the understanding gained, we have been able to analyse the calculation of NPC for SESRO and to calculate NPCs for GARD's preferred STT option.

Although, NPC as mandated by Ofwat and the EA is a very peculiar and flawed methodology,[266] we have nevertheless used it to examine the calculations in the RAPID Gate 2 Cost Report for the Abingdon Reservoir 100 Mm^3 variant.

In the time available, we have been able to identify and quantify very material errors and inconsistencies in the calculation of costs for SESRO . Cumulatively these amount to approximately £270 million.

Below are details of the errors and inconsistencies that GARD have identified thus far:

1. Thames Water did not included depreciation on Costed Risk in their calculation of the NPC for SESRO[267]. GARD believe this to be a simple error. We can see no valid reason for omitting it. Costed risk totals £286m, and the annual depreciation on it is £2.6m p.a. Thus, £**189**m of depreciation has been omitted in the 80-year planning horizon of the RAPID and dWRMP processes. Despite the magnitude of this error, GARD calculate that the impact on the NPC appears to be relatively muted understatement of **£17m** (the impact of the omission of depreciation being offset to an extent by a compensating error resulting from the reduction in Regulated Capital Value, and the return thereon, when depreciation is included) .

2. As GARD pointed out in Appendix B of its WRSE response, possibly the clearest deficiency in the NPC methodology when used to evaluate projects with a long life, is that it just cuts off after 80 years - ignoring any cash flows beyond that time and any value remaining in the assets after 80 years. This is a remarkable deficiency. The information provided by Thames Water on 14th April confirmed that the Regulated Capital Value of SESRO in 2102-03, at the end of their 80-year planning period was **£1,380 million**[268]. This value, and all other costs incurred after 2102-03, appear to

[265] Email and spreadsheet provided by Anthony Owen of Thames Water on 14th April, "SESRO 100 - Financing Cost Query Check 13Apr23".
[266] See Appendix B - Criticism of Net Present Cost as a comparator for project costs, p82 of Final GARD Response to WRSE 20 2 23 v3.pdf
[267] In the spreadsheet provided by Thames Water on 14th April, "SESRO 100 - Financing Cost Query Check 13Apr23", Note 1 in cell B35 states that "Finance Cost …. excludes any Risk depreciation".
[268] This is in agreement with GARD's calculations.

have been entirely omitted from the NPC based evaluation of the reservoir. The very minimum that would appear necessary to adjust for this omission is to add this value discounted the discount factor used to calculate NPC in 2102-03 (0.08327). This results in an addition of **£128.8m** to the NPC of the reservoir.

3. There is another bias in the way NPC is calculated, in favour of the SESRO reservoir option because of its longer construction period and later in use date. No opex or depreciation costs are recorded, or included in the NPC calculation, until 2037-38, when the asset is in use (although water is not available until the reservoir is filled after a further 2 years). By 2037-38, the NPC methodology reduces all such costs by a factor of **62% (t**he NPC methodology completely ignores the timing of the initial capex which has all been incurred before that date). Thus, for SESRO only 66 years of Opex and depreciation are included in the 80-year planning horizon and included in the calculation of NPC. In contrast, STT is penalised for its shorter construction period and earlier in use date and Opex and depreciation are charged from 2035-36. This means that 70 years of Opex and depreciation are included in the calculation of NPC for STT. It is hard to know how to remedy this deficiency in the NPC methodology which allocates 4 more years of costs to STT than to SESRO, given the limited time available. In an attempt to compare like with like, GARD have added an additional 4 years to the NPC calculation for SESRO (extending it to 2106-7). This certainly understates the correction required – given that the difference occurs earlier, around of 2035-36. This change adds **£20m** to the NPC of the reservoir.

6. There is final a peculiarity hidden in the details of the NPC calculations that produces a bias in the NPC numbers in favour of SESRO and against STT. The start year for discounting the 80-year time frame for SESRO is 2022-23 (for example, the discount factor for cashflows in 2023-24 is 0.966, and that for cashflows in 2025-26 is 0.902). In contrast, the start date for discounting for STT is 2024-25 (so that the discount factor for cashflows in 2025-26 is 0.966). Whilst this difference may appear insignificant, the 2-year difference in start date has the effect of reducing the NPC calculated for SESRO 100 Mm3 by **£104m** when compared to the NPCs calculated for the STT variants. Consequently, £104m needs to be added to the SERSO NPC to make it consistent with the STT calculations. This highly material change illustrates the importance of RAPID ensuring consistency of approach between the SROs.

4. The NPC of SESRO is shown as **£1,300m** in the SESRO Gate 2 document, but it should be **£1,570m,** that i**s £270m** higher**,** when the above adjustments are applied to correct errors and to evaluate SESRO on the same basis as STT. This is set out in the table below:

Starting NPC per TW		**1,300,855,737**
Adjustments		
1 Include depreciation on Costed Risk	16,759,631	1,317,615,368
2 Include impact of RCV in final year	128,772,080	1,446,387,447
3 Adjust for 70 year in use period	19,807,808	1,466,195,255
4 Adjust for consistent start date	104,429,757	1,570,625,012
Total Adjustments	269,769,275	
Final NPC per GARD		**1,570,625,012**

5. SESRO plans do not appear to have been worked on for many years. Specifically, the cost estimates appear to be based upon high level work done several years ago. We anticipate an increase in these costs analogous to the increase in the Thames Tideway Tunnel, where the estimated cost doubled from £2bn to £4bn when detailed work was done after the project was approved.[269]

[269] New Civil Engineer "Thames Tunnel sewer costs rise up to £2bn" 16th September 2010

Appendix R - The Regulatory Regime as a Driver of Capital Schemes – the GARD Financial Model

1. Criticisms of the Process and the Financial Regulatory Regime

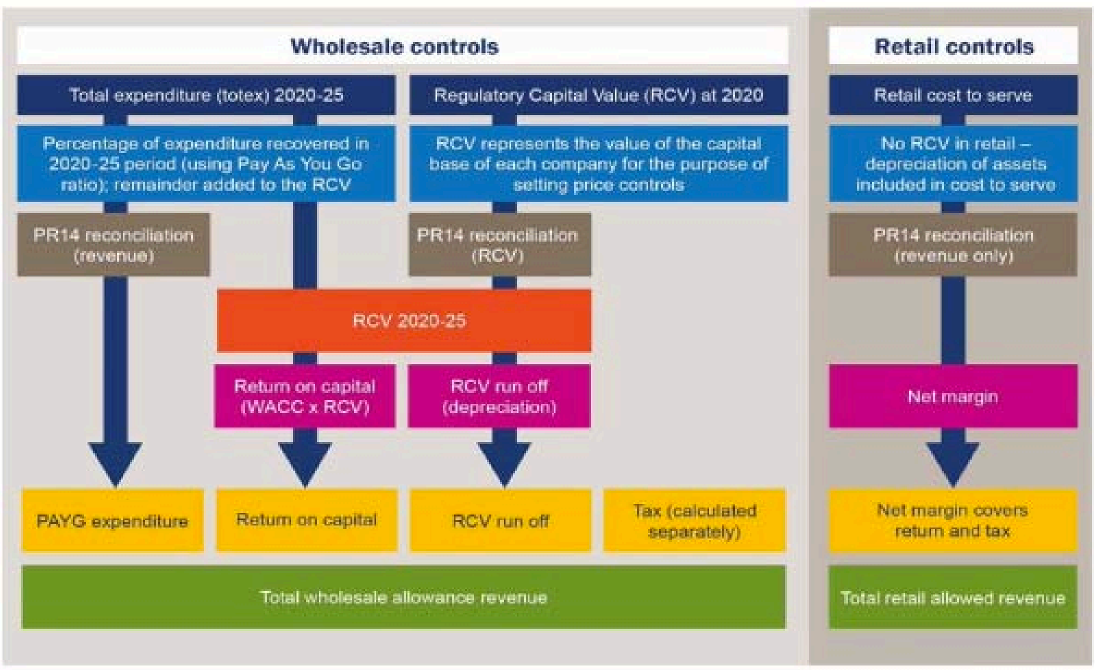
A. Introduction: Water Company finances and water industry regulation in relation to the proposed Abingdon reservoir.

Below is a coherent and damning description of Water Company finances, the regulatory regime and regulatory incentives since privatisation in 1989 that helps explain why Thames Water has been proposing to build a reservoir in Abingdon since 1995 and why, together now with its fellow water companies, Thames Water continues to keep proposing it.

There is a great deal of useful authoritative and publicly available information on Water Company financing and water industry regulation on which this is based. The issues are complex as this document illustrates but the underlying story is simple. The Competition and Markets Authority investigated and reported on the market and specifically the price control mechanism at the request of four water companies that appealed Ofwat's PR19 price control determinations. Its Reports and Determinations are of particular use in understanding the regulatory regime and the role of OFWAT is setting price controls. Figure 2-2 of the Competition and Markets Authority's '*Final Report*', reproduced below, sets out diagrammatically the major components that determine the total revenue that Water Companies are allowed to charge their customers.

2.105 This is illustrated in Figure 2-2.

Figure 2-2: Determination of overall revenues from the building blocks



Source: Ofwat

This information is relevant to all the current processes: WRSE Regional Plan, Water Company dWRMPs, and the RAPID Gated process.

GARD has created a spreadsheet, described below, which computes the very large financial returns that would accrue to Water Company shareholders if the reservoir were to be built. We compare this to the absence of any similar return from spending additional money improving operations - including specifically additional operating expense to reduce leakage and per capita consumption earlier and more rapidly. It is clear that the regulatory regime creates extremely large incentives for Water Companies to favour large capital projects like the reservoir, to the detriment of improving operations. Initial results which demonstrate this are discussed below.

Summary

1. There is a fundamental and extremely perverse incentive in the Water Industry regulatory regime that encourages investment in "big concrete" projects as the solution to any and all problems. This is widely acknowledged and has been stated by many authoritative experts including Sir Ian Byatt, former Director General of Ofwat, and Professor Sir Dieter Helm of Oxford University and UK Government adviser on regulation.

2. In simple terms and as shown in Figure 2.2 above, all expenditure by a Water Company that can be classified as being of a capital nature, including for example, building a reservoir and including the cost of developing proposals for a such capital asset, gets added to the water company's Regulatory Capital Value (RCV) and the company has a statutory right to make a real return on that RCV in all future years.

3. These perverse incentives in the regulatory environment specifically favour very long-life assets such as a reservoir in contrast to alternative methods of securing water for the southeast. The alternatives to the reservoir include the Severn Thames Transfer, desalination and increased effort in reducing water wastage by leakage reduction in the distribution pipework system. All these alternatives involve lower capital expenditure and shorter life assets, but consequently, these alternatives look less attractive from the perspective of Water Company shareholders.

4. If the reservoir were to go ahead, Water Company shareholders would still be earning their guaranteed return on the reservoir in 250 years' time. The asset lifetimes used for regulatory return calculations (and for accounting depreciation) significantly favour reservoirs (250-year life) over tunnels, pipelines and other water network assets (80 – 100 year lives).

Almost all Water Companies have highly geared balance sheets with very high levels of borrowings, which constrains financial flexibility and in order to reduce gearing favours the expenditure on assets which increase their RCV, eg. currently net debt to regulatory capital value (RCV) for Thames Water is at above 80%. These high levels of borrowings which have all been incurred since privatisation have largely been used to fund payments to previous shareholders. As a consequence of their corporate structures coupled with high levels of borrowings, most Water Companies have paid no or very low levels of corporation tax, for many years.

B. The perverse financial incentives in the Water Industry Regulatory Regime

Since the setting up of Ofwat in the 1989, the concept of the Regulated Capital Value (RCV) and Regulatory Asset Base (RAB) has been used as a key element in determining the charges that water companies can levy on their customers. As described above, in simple terms, expenditure that can be classified as being of a capital nature (eg a reservoir - and including the cost of developing proposals for a reservoir) is added to the water company's RCV and the company is allowed to charge customers a guaranteed inflation-proof return on that RCV in all future years.

This is succinctly expressed by Professor Sir Dieter Helm of Oxford University, writing in Sept 2021[270]:
"*the companies had an incentive to find hard physical capital solutions (concrete) rather than seek out natural capital options and find common interest outcomes that took account of the wider catchment costs and benefits. The way the capital base was determined (and the RABs) formed part of the attraction of the concrete route to investors*".

"*It is not exaggerating to say that this is a scandal of financial engineering, aided by OFWAT*."

And in October 2022:

"Failure to overhaul the regulatory regime won't make the companies behave any better, because it will not change the incentives they face."[271]

Sir Ian Byatt who was the head of the UK water regulator Ofwat after the industry was privatised in 1989, was equally forceful when quoted in the Financial Times in 2017 [272]:

"[Sir Ian says] ***THE SYSTEM REWARDS COMPANIES FOR SPENDING MONEY ON CAPITAL INVESTMENTS WHETHER OR NOT IT IS IN THE INTEREST OF CUSTOMERS.*** *This often comes*

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[270] http://www.dieterhelm.co.uk/natural-capital/water/floods-water-company-regulation-and-catchments-time-for-a-fundamental-rethink-2/

[271] http://www.dieterhelm.co.uk/natural-capital/water/water-a- new-start/

[272] The Financial Times "The Big Read Thames Water PLC Thames Water: the murky structure of a utility company. As raw sewage poured into London's rivers, the water supplier awarded huge dividends to Thames Water's Investors" Gill Plimmer and Javier Espinoza May 4, 2017. https://www.ft.com/content/5413ebf8-24f1-11e7-8691-d5f7e0cd0a16

AT THE EXPENSE OF MORE MUNDANE OPERATIONAL TASKS, such as ***PREVENTING SEWAGE FROM SEEPING INTO THE WATER, STOPPING LEAKS ON ITS 10,000 MILES OF PIPES AND INSTALLING WATER METERS – one of the most effective means of preventing water waste****."*

*"If they had remained [..*public limited companies..*] they would have retained a corporate governance code. But* ***WHAT PRODUCES DIVIDENDS NOW IS GETTING THE CAPITAL BASE UP****."*

GARD asked Cathryn Ross, Head of Ofwat at the time of Sir Ian's quote (and since 2020 Thames Water's Director of Strategy and External Affairs), if she accepted Sir Ian's criticism. She said that she had discussed this criticism with Sir Ian and pointed out to him that she had changed the Regulatory Regime to alter the method used to determine which expenditure is classified as Opex and which as Capex. GARD do not believe that this change affects the criticism. And, indeed, Ms Ross admitted that some of the criticism was still valid.[273]

This regulatory environment further creates additional incentives in favour of the reservoir in comparison to alternative methods of securing water for the southeast which involve higher operating expenditure (specifically the Water Transfers but also Desalination and Demand Management measures like Leakage Reduction). The alternatives do not look anywhere near as attractive from the perspective of Water Company shareholders, having lower CAPEX, shorter depreciation periods, and a higher proportion of operating expenses.

C. <u>Advantages of an Abingdon-sized Reservoir to Water Companies</u>

Water Company representatives have stated on several occasions that the Abingdon (SESRO) Reservoir was preferred because it was a simple, straightforward scheme when compared with Severn Thames Transfer (STT) which would be more difficult to implement and more complex to operate.

From these statements, GARD believe that the reservoir is preferred by the Water Companies, over the STT for the reasons set out below, none of which relate to it being the lowest cost or best value solution, but just to it being easy to understand and implement**:**

- The reservoir requires less co-ordination with third parties – the majority of the construction works are on a single self-contained site, all within the Thames Water region.
- The reservoir results in a self-contained easily identifiable asset – the reservoir will be a completely new asset capable of clear delineation and against which specific debt finance could be raised**.**

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[273] Spotlight Session discussing Regulatory Finance in the Water Industry, 20th April 2023. Organised by the Thames Rivers Trust at Thames Water's offices, Clearwater House Reading

- **The raw water source** is entirely within Thames Water's sole control – there is no need for raw water from another company, nor for price negotiations on the cost of such water.
- The reservoir will have a long service life, with steady cash flow. In contrast, any charging mechanism for the STT would have a fixed and variable element, with in some years less water required than others. This would make any income from the asset less predictable and make the project harder to borrow against.
- The reservoir would create a larger and longer lasting addition to the Water Companies Regulated Asset Bases – thereby creating a larger return for their shareholders.
- The export of a majority of the deployable output of the reservoir to provide the needs of Affinity Water and Southern Water provides a guaranteed income stream.
- Because of all the above, Abingdon Reservoir would be a more 'Bankable' scheme against which finance could be raised relatively straightforwardly.

2. Financial Model

GARD created a financial model using cost and other data contained in the RAPID Gate 2 document for Abingdon Reservoir and the Thames Water dWRMP. The model also used data from the CMA determination on the elements of WACC. GARD have used this model to calculate the cashflows arising from over the 250-year life of the reservoir, 2022 to 2285. Specifically, GARD used this model to calculate the following:

1. The increase in Shareholder Value that would immediately arise and benefit the Shareholders in the three Water Companies who would jointly own the reservoir if it were to be given the go ahead (Thames Water, Affinity Water and Southern Water).

Our calculations show that the immediate increase in Shareholder Value created by any decision to approve the reservoir would be ***£846 million***. This arises from the return on the increase in Regulated Capital Value (RCV) resulting from the £1,878 million Capital Expenditure on the reservoir. All these numbers are fixed in 2022 currency.

2. GARD separately calculated the increase in Shareholder Value that would arise if the same amount of money identified as the initial construction cost of the reservoir, £1,878 million, were instead to be spent on increased operating expenses over the same period, to reduce leakage and to reduce demand. We believe that the answer is zero.

There is therefore a **staggering £846 million incentive** within the Regulatory Regime to build the reservoir rather than to accelerate the reduction of leakage rates and water consumption.

3. The additional cost that Water Company customers would pay for the reservoir. ***The numbers are absolutely staggering: £4,829 million over the 80-year WRSE planning horizon and £13,673 million over the 250-year life of the reservoir.*** Again, all these numbers are fixed in 2022 currency.

   - In contrast, the additional cost that Water Company customers would pay for an additional £1,878 million of operating expenditure to reduce leakage and to reduce demand, is only £1,878 million. ***The reservoir would therefore cost customers an additional £3,041 million over the 80-year planning horizon of the WRSE process. This increase in cost to customers is a result of the return on Regulated Capital Value allowed to water company shareholders.***

4. GARD have used £1,878 million here to illustrate the differing financial consequences to customers of the same value of expenditure on different things. Furthermore, figures 11-3, 11-4, 11-5 and 11-6 in Thames Water's dWRMP together with tables 5-1 and 5-2 in WRSE's "Draft Regional Plan Technical Annex 2 (Nov2022)" show that accelerating Thames Water's plans to reduce leakage and reduce per capita consumption would provide a reduction in demand equal to or greater than the deployable output of the Abingdon Reservoir 100 Mm^3 option. This is quite apart from the improvement in resilience from reducing demand. The benefits of regulators setting more aggressive demand reduction targets are illustrated in this quote from the EU: *"Whilst water loss management is often pictured as the implementation of technological solutions to a hidden problem, this is really only part of THE REAL SOLUTION, which is all ABOUT MANAGING UTILITY PEOPLE TO PERFORM. It is about empowering them with the responsibility, training, practical tools and proven techniques, MOTIVATING THEM TO PERFORM, and inspiring them to believe that they can make a difference."*[274]

5. It needs to be stated that the building of the reservoir is on all measures worse than the alternative examined here of reducing leakage and consumption: it is specifically more expensive for customers, has a materially worse carbon footprint, is in the wider context more environmentally damaging and by bringing in no new water supplies to the South East is not drought resilient.

[274] EU Reference document Good Practices on Leakage Management WFD CIS WG PoM 2015 https://op.europa.eu/en/publication-detail/-/publication/3ff6a13c-d08a-11e5-a4b5-01aa75ed71a1/language-en

Appendix S - Potential for reduction of capital carbon in SRO projects

Introduction

Much effort is devoted to the attempts to justify the potential for 'Capital' or 'Embodied' Carbon footprint in constructing the 'Strategic Resource Options'. We note, however, that no attempt is made to make a comparison with a Leakage Reduction of a Demand Management program. This is a major failing in WRSE, the WRMP and the RAPID processes.

WRSE state in section 11 of Annex 2

> *"As most of these schemes will not be built until several years from now, time is available to work with the supply chain (e.g. steel and concrete manufacturers) to find new lower carbon solutions to construction. The All Company Working Group (ACWG), made up of the water companies with Strategic Resource Options (SROs), have engaged with the supply chain to estimate just how much progress with reducing emissions might occur over the next 60 years. This engagement has produced emission reduction estimates for most facets of construction, ranging from the types of construction equipment moving around on site, to the type of steel that might be used in future pipelines. Three different scenarios have been produced, a worst case, middle case and best case scenario; to allow for the industry moving slower or faster than expected."*

The All-company working group report can be accessed at,[275] and whilst such an exercise is genuinely to be welcomed, ***the conclusions drawn by WRSE (and by the ACWG itself) are very over-optimistic.*** Although numerical values have changed by Gate 2, as more analysis of project construction has taken place, the ACWG report is still the main reference.

Capital carbon in Reservoir projects – construction equipment.

As the RAPID Gate 2 report on the Abingdon Reservoir shows[276], the various versions of the project have the Embedded carbon breakdown as Figure S1. The carbon footprint is dominated by the construction of the embankment works, which includes all earth moving equipment emissions and transport to site of materials such as rip-rap. This forms about 70% of the 150Mm^3 version and around 60% for the WRSE Best Value Plan choice of the 100 Mm^3 version.

[275] https://www.wrse.org.uk/media/muvl5thv/acwg-low-capital-carbon-alternatives.pdf

[276] SESRO Gate 2 report – Figure 6.1 https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/SESRO-Gate-2-Main-Report-FINAL.pdf

Figure 6.1 Capital carbon emissions for SESRO options

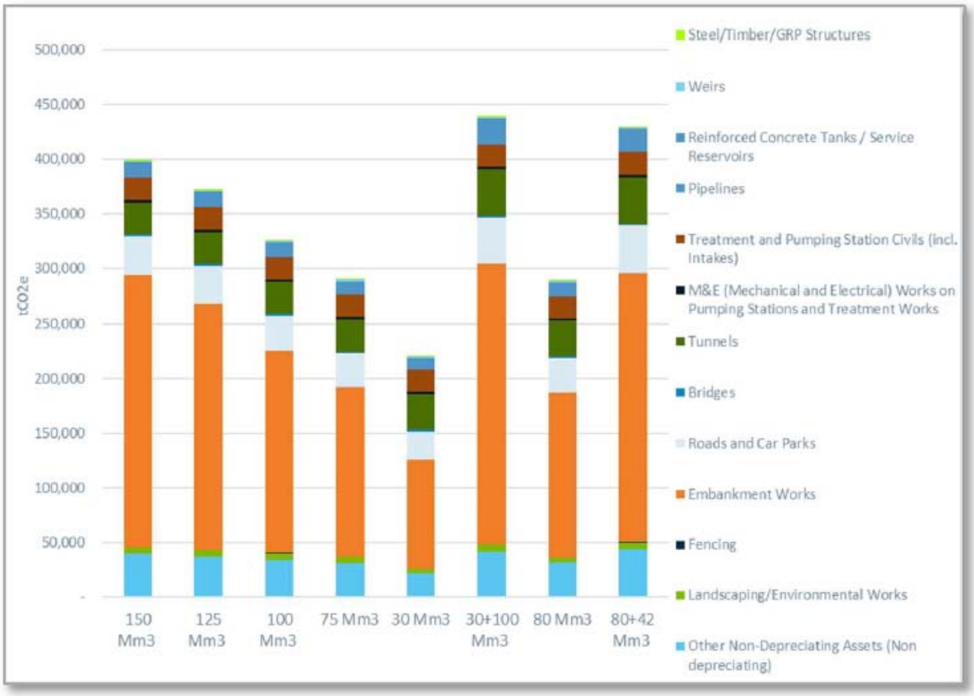

Figure S1 - Embedded or capital carbon budget for Reservoir options

A similar conclusion was reached in the ACWG Report, with quarrying added in explicitly (it is not clear how this is addressed in the Gate 2 reports), to give an even more dominant contribution.

The analysis in the ACWG is totally unfit-for-purpose and fanciful, and must be improved upon for Gate 3.

The report purports to analyse how the embodied carbon might be reduced in the project, but the 'analysis' is woefully lacking in substance and hopelessly optimistic. It is also uneven in quality and philosophy when compared to that carried out for the pipe material and cement cases below. There are thus no details of technology existing, or industry-accepted roadmaps, or Technology Readiness Level (TRL) discussion, or indeed of anything that could not be found from a Google search. Instead anecdotal discussions are cited with two manufacturers *"…indicate that prototype* [hydrogen powered] *large excavators (21T and 35T) and dozers are being developed and potentially available in the next 2 years*" (ie. the *prototype* will be available). Such 'analyses' are used to derive an astounding conclusion that a '*mid-case*' scenario (the one taken by WRSE) could result in a 60% reduction in embodied carbon in the 2025-2040 timeframe. This analysis excludes an analysis of transport by rail (currently diesel along the Great Western Line identified for bringing the 5+ megatonnes of Rip-rap to the site), as it only mentions HGVs in the text. It depends on the availability of Hydrogenated Vegetable Oil (HVO) fuelled vehicles, to provide 50% of the fleet, in spite of the fact of admitting that:

"Currently the UK's supply of HVO is underdeveloped. Although construction plant

technologies operating with HVO are available, the risk of a secure supply of HVO may limit its applicability nationwide".

All this to 50% market penetration by 2027! There are currently no diesel train fleets with HVO-powered vehicles. The changeover to HVO, not even considering the expensive need to write off plant which is far from life-expired, will not even start on any scale until the HVO fuel supply-chain is settled.

This whole section of the ACWG report has the air of being written by a Reservoir. We concluded in our WRSE and dWRMP24 responses that this is not worth consideration, as although it shows the steps required, the only conclusion could be that Reservoir construction is best delayed until at least 2035 -2040.

Capital carbon in Water Transfer projects – steel and concrete

Over their 'Best Value' program and the materials cited, WRSE claimed 26% mitigation in embodied carbon from such measures implemented over the program from 2021 to 2075. GARD concluded that this was really highly optimistic and to achieve it one would have to severely *back-load* the program, which might destroy the Risk Mitigation characteristics of the infrastructure.

Figure S2, shows the capital carbon for the various Deerhurst pipeline options for the STT, taken from the RAPID Gate 2 report.[277] (figure 4-1)

Figure 4-1 Capital Carbon for Deerhurst to Culham Interconnector (by pipeline capacity).

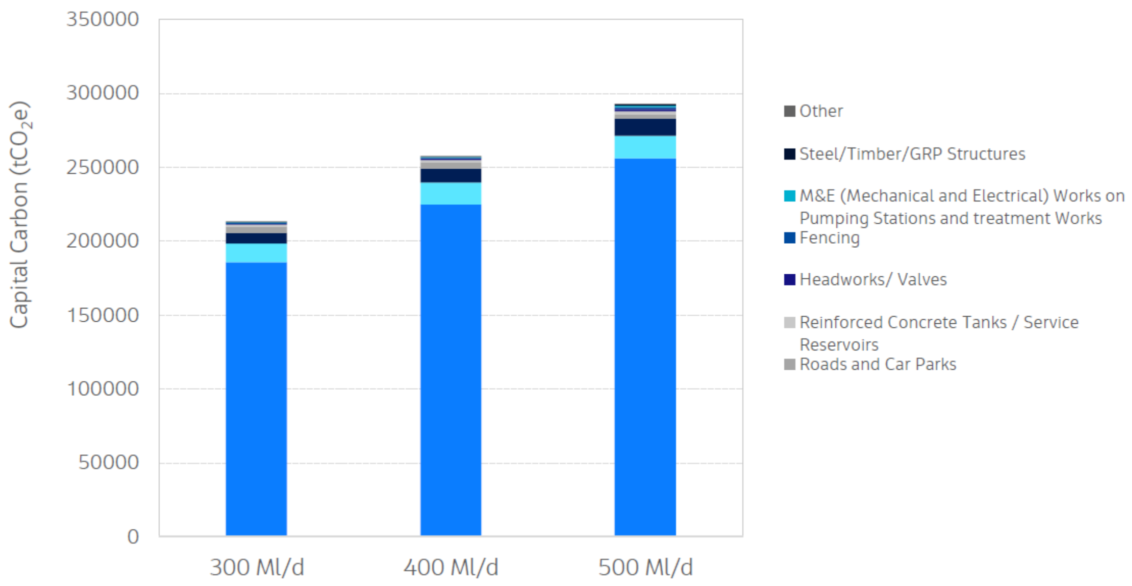

Figure S2: Capital carbon for STT interconnector pipeline options

[277] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/water-transfer-from-the-river-severn-to-the-river-thames/gate-2-reports/STT-G2-S3-360-Carbon-Strategy-Report.pdf

This shows that materials associated with the pipeline form about 87% of the capital carbon budget. As with the case for the Reservoir, discussed in section 4.4, WRSE attempt in their draft Regional Plan Annex 2[278] to motivate a path forward for capital carbon reduction, eg. from section 11.13: :

> *" … [an example of] this approach is for pipelines. For many large pipelines conveying vast quantities of drinking water around the region, 70% of the capital carbon emissions are attributed to producing the pipeline material itself3. In the middle case (a moderate level of ambition), estimates by the ACWG indicate that 7% of carbon could be reduced in the manufacture of ductile iron pipes in the next 15 years, increasing to 39% in 15 to 35 years. Physically this would mean manufacturers of iron deploying stove flue or top gas recycling in most blast furnace-basic oxygen furnace sites, which is a transition the water companies can help promote by requiring contractors to use lower carbon materials thereby generating demand for these new materials"*

The report excludes alternative pipeline materials to iron and steel, whilst although they offer significant embodied carbon reductions and are, in some cases, widely available, they are '*not suitable for large diameter pipeworks*' involved in SROs. This seems reasonable, though we note in passing that these pipe diameters and materials would be suitable for Leakage reduction.

These figures for iron/steel are optimistic in the medium to long term, as it not only requires some research to be completed (not all iron grades are developed yet), but also testing and qualification programs (including long-term testing) and roll-out of factory refurbishment over a massive industrial plant complex (much of which is overseas[279] and on which UK Water companies have little leverage). Studies in other fields such as nuclear power[280] have shown that it takes around 15 years to take an iron/steel variant from existence to the presence of *some* manufacturing capability. If the authors of the ACWG report cannot identify an actual *qualified* alloy available *now*, then it is highly unlikely to be available to contribute before a project start date of 2038-40. This emphasises not only the urgency to develop the materials, but also to revisit parts of SRO projects requiring long pipelines, and re-examine (eg. in the case of the Cotswold Canal version of the Severn-Thames transfer) solutions which limit the need for long-distance pipes (see also section 3.4.1).

> *"Likewise, concrete is another building material with a large carbon footprint, and many of the assets needed in the SROs include concrete. Again, WRSE cite:"Building on the work of the Low Carbon Concrete Routemap281, the ACWG estimates that by optimising current practice in manufacturing and using supplementary cementitious materials, 20%*

[278] https://www.wrse.org.uk/media/lanejwxx/wrse-draft-regional-plan-technical-annex-2-nov-2022.pdf
[279] Including in countries whose governments are not fully-committed to the COP26 agreement.
[280] See for example, D Stork et al., *Materials R&D for a timely DEMO: Key findings and recommendations of the EU Roadmap Materials Assessment Group*, Fusion Engineering and Design 89(7-8) (2013) 1586-1594. http://dx.doi.org/10.1016/j.fusengdes.2013.11.007 and references cited therein.
[281] https://www.ice.org.uk/media/q12jkljj/low-carbon-concrete-routemap.pdf

of carbon emissions generated when building tanks could be eliminated if built within the next 15 years."

The low-carbon route map for concrete has few dates in it and, as whilst it can point to the existence of some materials, the roll-out to industrial capability is largely aspirational. The routemap at least has the major benefit that it assesses development according to *Technology Readiness Level* (TRL) and *Commercial Readiness Level* (CRL), but even the highest TRL9 grading ('*System Approved*') only corresponds to the stage CRL2 ('*small scale commercial trials'*). There are still stages after that for progress to CRL4 and 5, where commercial competition ensures good value for project contracts. The figure 4.2 of the Routemap shows only one 'low-carbon' cement of the 27 cement types 'existing' is qualified to BS standards (effectively TRL8 stage). The carbon content is very variable (typically 30% difference between maximum and minimum values, but the variant offers guaranteed (min of cohort – max of the low-carbon type) of some 20%. This is still a thin base on which to derive a construction program benefit.

Conclusions

GARD's conclusions are*:*

- ***There has been no worthwhile evaluation of reduction of capital carbon in the construction of major SROs. The best 'analysis' is for concrete, but even that is still sketchy.***
- ***The SROs, if needed at all, are only justified as 'insurance' against failed demand management action and more extreme climate change. As such, they are needed by 2035, and <u>technology improvements have little chance of being implemented if they are not in the market now</u>.***
- ***RAPID and Ofwat should commission their own study before Gate 3. <u>This should include technology as applied to Leakage Reduction and Water Efficiency</u>.***
- ***The capital carbon footprints should be compared more accurately and based on more detailed plans than exist at Gate 2, <u>with use of existing technology</u>.***